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The Applications of Environmental Technologies in Hotels

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Abstract

This paper investigates the use of environmental technologies in the hotel industry. Data was collected via a series of in-depth, semi-structured interviews with hotel professionals. The research findings reveal that the environmental technologies most commonly used in the sampled were light-emitting diode lights, T5 fluorescent tubes, motion sensors, the key card system and water-cooled chillers. When not faced with budget or technical constraints, the hotel professionals preferred solar-based renewable energy-related technology, food waste decomposers and energy saving chillers. This study provides a framework for hospitality researchers and practitioners to better understand the use of environmental technologies in the hotel industry. This study offers theoretical and practical implications.

Key words:

Environmental technologies, hotels, qualitative study, facilities.

1. Introduction

Many hotels did not place emphasis on environmental practices in the past. They, instead, focused on the quality of its accommodation and food & beverage which determined business success. However, the escalating number of environmental laws and increasing pressures from the market have raised their environmental awareness. Many hotels and other hospitality businesses now implement environmental programs to save energy and water, reduce waste and improve their environmental performance, in response to increasing pressure from green customers, local government, business partners and the shareholders of their holding companies (DiPietro, Cao and Partlow, 2013; Rahman, Park and Chi, 2015). For instance, Manaktola and Jauhari (2007) have mentioned that increasing numbers of hotel customers including event organizers and travel agencies etc., would consider whether a hotel is implementing eco-friendly practices or not when selecting the place. An environmentally-friendly hotel image is unquestionably one of the contributing factors in hotel customers' decision-making processes and behavioural intentions nowadays (Chan, 2014; Prendergast and Man, 2002). Because of increasingly serious environmental problems such as global warming, governments in different countries, desiring to have a less polluted and healthier environment, have introduced stricter environmental regulations and given incentive to force/encourage companies to protect our planet (Aragon-Correa, Martin-Tapia, and de la Torre-Ruiz, 2015; Jones, Hillier and Comfort, 2016; Pereira-Moliner et al., 2015; Prud'homme and Raymond, 2016).

The Hong Kong SAR government, for example, is also becoming more responsive in providing more resources to enforce environmental legislation (Chan and Wong, 2006). Due to the stricter legislation, it is believed that more and more hotels need to consider the adoption of environmental protection activities such as installing environmental technologies. On the other hand, the success of hotel business depends on providing safe and attractive surroundings, and therefore environmental protection matters the industry (Chan and Wong, 2006; Kasim, 2015; Pereira-Moliner et al., 2015). As a matter of fact, more and more "green hotels" have appeared in the market. Holjevac (2003) predicted that the hotel of the future would be an 'eco-hotel', with its location, construction, equipment, products and services selected and developed under the principle of preserving nature and the environment.

Following the technology-based revolution and the optimization of environmental performance, some hotel companies have changed their hardware systems, installing environmental technologies which is defined by Shrivastava (1995: p.185) as 'production equipment, methods and procedures, product designs, and product delivery mechanisms that conserve energy and natural resources, minimize environmental load of human activities, and protect the natural environment' despite the expected high costs. For instance, Holiday Inn Express SOHO in Hong Kong has installed many innovative environmental technologies and green materials were used in the construction of the building. The Holiday Inn Express SOHO's green strategy implies that the service production and protection of environment in the hotel industry

require the adoption of technology, and there is no doubt that the use of technologies such as environmental technologies can bring about a major revolution in the hotel industry.

Despite the benefits, not all hotels widely use environmental technologies. Many hotels do not intend to take a lead in implementing new environmental technologies, as hotel managers are not often well educated in these technologies, causing the hotel industry to lag behind in their use (Chan, 2008; Chan and Hawkins, 2012). However, hotel operators need updated management know-how and the latest environmental technologies to manage their primary facilities, such as their heating, ventilation and air conditioning (HVAC) systems, lighting systems and water systems, and to optimize their environmental performances.

Previous research on environmental technologies in the hotel industry has been limited. Most of the existing studies have focused on other industries. For example, Klassen and Whybark (1999a) studied the effect of environmental technologies on manufacturing performance, Tseng, Wang, Chiu, Geng and Lin (2013) used the printed circuit board manufacturing firms in Taiwan to study the relationship between green technology innovation and the performance, Masciangioli and Zhang (2003) studied nanoscale environmental technologies, Vachon (2007) studied the selection of environmental technologies used in the Canadian and United States package printing industry and Loppinet-Serani, Aymonier and Cansell (2010) investigated the use of supercritical water in environmental technologies. Ghisetti and Quatraro (2013) further found that the generation of green technologies was significantly caused by environmental performance.

As environmental technologies have been changing rapidly, it is beneficial to explore the latest applications for the hotel industry. This exploratory study aims to investigate the common uses of environmental technologies in the Hong Kong hotel industry. According to the Hong Kong Tourism Board's Visitor Arrivals Statistics (Hong Kong Tourism Board, Dec 2014), the total tourist arrivals to Hong Kong exceeded 60 million in 2014, an increase of 12.0% from 2013, and the average room occupancy rate of Hong Kong hotels was 90%. This rapid growth has brought about an increase in hotel accommodation, from 225 hotels (70,017 rooms) in December 2013 to an estimated 305 hotels (83,769 rooms) in 2019 (Hong Kong Tourism Board, 2013; 2015). Some hotels in Hong Kong have been implementing different strategies, for instance, by obtaining the environmental protection certificate, to promote green image and attract green travellers because of the keen competition in the industry (Chan, 2013). However, some hotel managers and owners' response to environmental policies, facilities and technologies may be different from many manufacturers that have developed the green products (Chan, Yueng, Chan and Li, 2013; Kim, Park and Wen, 2015). Environmental management, especially environmental technology, is therefore an important area of research, as it may help improve hotel services and reduce the consumption of energy and water, thus saving costs. In particular, this study aims to:

1. Identify the environmental technologies commonly used in the hotel industry;
2. Identify where such environmental technologies are used in hotels;

3. Examine benefits derived from the usage of the identified environmental technologies; and
4. Understand the environmental technologies mostly preferred by hotel operators

2. Literature Review

2.1. Energy, Water and Waste in the Hotel Industry

Hotels generally have higher environmental footprints than other buildings of similar size (Bohdanowicz, Simanic and Martinac, 2005). Approximately 6% of a hotel's total operating costs are energy costs and nearly 75% of a hotel's total energy use can be attributed to space heating, water heating, lighting and cooling (Energy Star, 2007). Hotels consume energy through electricity, gas and diesel (Chan, 2005a), but both the energy consumption and cost are dominated by electricity. On average, over 50% of the electricity consumption in hotels is used for HVAC systems. As hotels consume so much electricity, Shiming and Burnett (2002) suggested that hotel operators implement energy management programs using technically advanced energy efficient equipment such as lights, chillers and efficiency motors to reduce the consumption of electricity. This reflects the importance of the use of environmental technologies in the hotel industry.

Water management cannot be separated from energy management, as energy is used to heat water. The water-related facilities in hotels, such as spas, swimming pools and laundry plants, would be unavailable without water. Wise water usage and quality control are essential and important in hotels. Deng and Burnett (2002) investigated water use in Hong Kong hotels and found that hotels' water use was directly influenced by the number of guests staying in the hotel, the amount of food made and the laundry load. The hotels' water bills also included sewage charges. Deng and Burnett (2002) also suggested that water management programs should be established to save water costs.

The food waste and other types of solid waste, such as plastics, glass and paper, generated during hotel operations is also a severe problem in the hotel industry. For instance, the hotel industry's share of sewage control costs has increased dramatically in recent years. Chan (2005b) studied the environmental costs generated by hotels and found that costs increased six-fold from 1990 to 1999. An increase of approximately 100% in the environmental costs was attributable to solid waste alone. It is obvious that the generation of waste in the industry has become more serious. Chan (2005b) recorded an increase in the overall environmental control costs of 145% from 1990 to 1999 in the hotel sector.

Hotels have therefore begun to use some environmental technologies and saving facilities to deal with these problems. For instance, Mehta (2007: 421) suggested that energy conservation gadgets, such as low-wattage light fittings, energy saving kitchen equipment and solar, wind and geothermal power technology, be used to reduce energy consumption in hotels. Mehta indicated that water conservation technologies, such as low-flow showerheads and grey-water irrigation, can

be used. Solid waste can be sorted, kitchen waste can be composted and dry decomposing toilets can be used to reduce waste costs. It is obvious that environmental technologies can help hotels to reduce their energy and water use and their waste production.

Despite the benefits of environmental technologies, Parisi (2012) stated that many hotel owners and investors remained skeptical. This may contribute to hotel operators' poor knowledge of environmental technologies. It was also found that hotel managers' poor knowledge of information technologies caused them to be reluctant to accept and adopt new technologies in their operations (; Law and Jogaratnam 2005; Law, Buhalis and Cobanoglu, 2014; Mihalic and Buhalis, 2013). They were worried that the technologies would affect their role of providing personalized service to their hotel guests, and had reservations about the applications. Because of the importance in understanding the development and adoption of technology, the adoption of technology has been a major topic for many researchers in the past. And some theories have been widely used to explain the acceptance process of technology. They are (1) theory of planned behavior (TPB) by Ajzen (1991); technology acceptance mode (TAM) by Davis (1989), and theory of reasoned action (TRA) by Fishbein and Ajzen (1975). Among these theories, it seems that TAM is the most influential one to explain the technology adoption behavior in which perceived usefulness, perceived ease of use, attitudes, and intention to use the new technology are the four main constructs.

On the other hand, Leonidas (2004) indicated that hotel customers especially those who are environmentally-friendly (Baker, Davis and Weaver, 2014) were increasingly demanding sustainable, environmentally designed hotels, while some customers were willing to pay a higher price for eco-facilities in hotels (Chan, 2013; Rahman, Park and Chi, 2015). Kasim (2004) studied tourists visiting Penang Island, Malaysia and found that the tourists were willing to accept hotel guest rooms with water-saving and energy saving features, whereas Millar and Baloglu (2011) found that an energy-controlling key card system was uncommonly used by hotel guests, and would represent a substantial maintenance cost for hotels.

Apart from the customers, the environmental attitude of hotel employees cannot be neglected. The introduction of environmental technologies may result in employees' resistance due to the changes of habitual operations (Chan, Hon, Okumus and Chan, in press). However, staff morale and satisfaction could be enhanced by the implementation of some environmental initiatives (Chan and Hawkins, 2010; Park and Levy, 2014; Poksinska, Dahlgaard, and Eklund, 2003), while implementing the environmental management system, which is sometimes in conjunction with environmental technologies to achieve better environmental performance (Chan, Okumus and Chan, in press), is a good strategy to enhance employee-employer cohesiveness (Chan and Hawkins, 2010: p.645). Therefore, it seems likely that hotel operators will need to determine what environmental technologies are available for them to use, which are effective and acceptable by customers and employees, and what savings they offer, regardless of how reluctant the operators are to accept new technologies.

2.2. Environmental Technologies Used in Hotels

Technology is regarded as a way of enhancing the competitive edge of a company (Buhalis, 1998; Porter and Kramer, 2011) and usually includes both hardware and software aspects (Rogers, 1995). Kirk and Pine (1998) further classify the technology utilized in the hospitality industry in different types namely: (1) building technology, (2) environmental management technology, (3) food production and service technology, and (4) information technology. It is obvious that technology can help differentiate and improve service quality in the hotel industry (Lee, Barker and Kandampully, 2003; Sheldon, 1997). Hoteliers can use technology in a number of ways, from taking guest reservations to saving energy and water in hotel guest rooms. Energy and water saving require environmental technologies. Examples of environmental technologies related to the hotel sector are a key card system for energy saving, a centralized air conditioning system that can reset a guest-room's temperature to the hotel's established temperature when integrated with a building management system to save energy, light-emitting diode (LED) lights and heat pumps. In addition, many advanced environmental technologies have entered the market, such as solar heat pumps, solar control film, solar batteries, light pipes, energy efficient lighting, light sensors and dimmers (Chan 2005a), different types of food decomposers and water-saving devices.

According to Klassen and Whybark (1999b), environmental technologies can be categorized into pollution prevention, pollution control and management systems. Pollution prevention technologies normally reduce pollution at the source by using cleaner alternatives than those currently in place (Freeman, Harten, Springer, Randall, Curran, & Stone, 1992). The new washing machines with eco-labels are an example of a pollution prevention technology. Pollution control technologies reduce the release of pollutants, rectify environmental damage and ensure proper waste disposal. Pollution control technologies can be categorized as remediation or end-of-pipe control. Remediation is usually driven by regulation and refers to the clean-up of environmental damage. End-of-pipe control refers to environmental facilities for isolating pollutants and waste before discharge. Food decomposers for handling leftover food are an example of end-of-pipe control. Management systems are infrastructural investments that help to improve environmental performance. Employee training for energy, water and waste reduction and environmental awareness, green scheduling and the International Organization for Standardization's environmental management system (EMS) training are examples of management systems. According to Cheung and Fan (2013), environmental technologies are usually used in hotels in the following areas:

- Lighting
- Air conditioning – related control
- Water heating/cooling
- Equipment associated with motors
- Electricity generation
- Heat energy generation, &
- Water supply

A review of previous literature revealed some environmental technologies employed by hotels. The identified environmental technologies listed in Table 1 helped develop a framework which would form the basis of the fieldwork investigation to understand what environmental technologies are adopted and where/ how they are utilized in a hotel context.

(Pls. insert Table 1 here)

3. Method

A qualitative approach was used in this study to allow the authors to stay close to the empirical world (Blumer, 1969). In-depth interviews with senior executives, chief engineers, EMS managers and hotel green committee members from different types of member hotels (as shown in Table 2) of the Hong Kong Hotels Association were conducted to explore the use of environmental technologies in the hotel industry, which could provide a rich database for analysis. For confidentiality, the titles of the informants have been slightly amended.

(Please insert Table 2 here)

The selected informants had worked for the hotel they were currently employed at for at least one year, and were full-time employees, to maximize the richness of the information obtained. With the assistance of gatekeepers in the hotels and the purposive and snowball approaches, which ensure a wide range of hotel executives were represented in the sample and allow the authors to employ the research into the informants' networks to access specific populations. 23 informants agreed to be interviewed. These informants were selected because of their high level of involvement in hotel facilities planning, including the use of environmental technologies and their knowledge of EMS in hotels. First, 20 of the informants were interviewed and the interview findings were preliminary analyzed. When the authors felt that data saturation was reached, additional three interviews were undertaken. In total, 23 in-depth semi-structured interviews were undertaken for this study. The number of informants was considered reasonable, in view of business work schedules, the managers' heavy workloads and the length (1-1.5 hours) of the interviews.

Semi-structured interviews were the main data collection method, which allow us certain flexibility to explore the research topic. An interview schedule listing the topics for the interviews and a list of data needs were prepared to prompt the informants if they faltered. The interview guide was piloted before the fieldwork started in which five hotel managers with experience in hotel environmental management were involved. To encourage informants to tell their versions about the applications of environmental technologies in hotels and related issues, it was decided informants would be asked general questions and allowed to tell their versions. However, it was also decided that when necessary, probing questions related to the environmental technologies identified in the pilot test and literature review would be asked. The interview schedule was divided

into warm-up, development and closing sections. The warm-up section aimed to give the informants an overview of the research project and to establish an informal environment and the trust needed for a comfortable interview (Hammersley, 1993). The informants were briefed about the research aims, the structure and length of the interviews, the confidentiality of the collected data and the informants' anonymity. The informants were then asked general questions about their backgrounds, their roles in their hotels and their experience. In the development section, the informants were asked about their views on use of energy and water, environmental and waste management and their understanding of environmental technologies. We also explored what and where environmental technologies were used in the informants' hotels and related issues in hotel business applications. Overall, we aimed to develop a channel leading to knowledge with regard to the applications of environmental technologies in hotels. In the closing stage, the informants were asked whether they would like to add anything related to the use of environmental technologies. Before closing, the informants were asked whether they could recommend any relevant company documents on the use of environmental technologies and any other key information.

The interviews were conducted in the informants' office. For those who did not have their own office, a private place in the company was arranged for the interview, such as a training room where the researchers could talk without interruption, while the informant would feel relaxed. The interviews were recorded, and then transcribed verbatim. All informants agreed to be recorded, as they were allowed to switch off the recorder whenever they wanted. Some documents on the operational details of some environmental technologies were obtained and analyzed to validate the accuracy of the interview data. During the analysis, the Non-numerical Unstructured Data Indexing, Searching and Theorising (NUD*IST) software package was used to code the transcribed interviews into concepts, to identify patterns and themes. The software was selected as it is particularly useful on research projects involving large numbers of interviews with the same interview schedule. It allowed the authors to conduct a thematic analysis within and between documents while it was also a very useful tool for the purpose of comparison between interviews. The inductively oriented and theoretically driven approaches were used to analyze the qualitative data (Miles, Huberman and Saldaña, 2013). When doing the open coding in the process of analysis, the keywords, adjectives, qualifiers, and the key phrases were identified and underlined to single out the main message. The "more is better" attitude was employed during the open coding process to ensure well-grounded coding. The results were then verified by looking for the concepts, attributes, and characteristics related to the themes identified, which were then validated if mentioned by different informants.

4. Findings

4.1 Profiles of the Informants and Their Hotels

Table 3 summarizes the demographic profiles of the informants. The 23 informants comprised five general managers, eight chief engineers (one of whom was also an EMS manager), one EMS manager and nine other department heads (two of whom were also EMS managers or green committee members). Eighteen hotels were represented, as we interviewed two managers from each of two hotels and three managers from a third hotel. The informants were fairly well educated. Over 73% of the informants held university degrees or above. The informants all had many years of hotel working experience: nearly 70% had worked in the industry for at least 11 years and 21.7% had over 31 years working experience.

(Please insert Table 3 here)

4.2. Environmental Technologies and Hotel Environmental Management

Almost all the informants stated that environmental technologies have become more important in recent years as the technologies have matured and offer help to hotel operations. A hotel financial controller commented that 'a*ll of these technologies will come to the market very fast … such as the paperless systems to control check-in and check-out … our hotel operations will soon or later need to adapt to the trend*'. The hotel managers' positive attitude toward the adoption of environmental technologies definitely increases the applications in the hotel context (Davis, 1989). The informants further suggested that environmental technologies can be used to help monitor and improve a hotel's environmental performance, especially the energy efficiency, even if there is no close supervision. For instance, an EMS manager stated that '*for example, the building management system helps us control many hotel facilities … such as the room temperature, … which is closely monitored by the system, although we don't always inspect physically … I feel it is quite convenient*'. A general manager of a 300+ room hotel also urged that '*having environmental technologies in the hotel can help get the EMS standard accredited'*.

It was clear from the data that environmental technologies can contribute to hotel environmental management and can definitely help enhance a hotel's environmental performance and achieve savings that cannot be matched by human efforts (e.g., heat exchangers). If no environmental technologies are used, then, as another hotel general manager stated that '*you need to implement the management of behaviour … that is … turn off the lighting when leaving a room, and other best practices must be established for your employees to follow*'. These findings echo that the contributing role of perceived usefulness mentioned in Davis' TAM model of environmental technology adoption is unquestionable. The findings are also in line with González and León (2001), who concluded that there is a market incentive for a company to improve its profits through the use of environmental measures, such as high-cost technologies and innovations.

4.3. The Environmental Technologies Commonly Used in Hotels

Based on the key categories and themes that emerged from the interview findings, the environmental technologies commonly used in hotels interviewed in this study can be categorized as (1) lighting control, (2) air-conditioning-related control, (3) equipment associated to motors, (4) electricity control, (5) in-room electricity control, (6) water control, (7) food and solid waste control, (8) other management systems and (9) building envelope-related control.

4.3.1. Lighting control

Energy efficient lighting, such as LED lights, T5 fluorescent tubes and motion sensors or pattern recognition energy saving solutions were normally used to help save energy in the hotel light systems, according to the informants.

LED lights

LED lights do not generate much heat when turned on, thus reducing the load on air conditioners. Nearly all informants in this study stated that their hotels had installed LED lights in their hotel guest rooms, food and beverage outlets and other public areas to replace incandescent lamps and halogen light bulbs. An EMS manager stated that '*our hotel has replaced the spotlights installed in the hotel guest elevators and lift lobbies on different floors of the hotel building and the check-in lobby'*.

In general, a LED light uses approximately 70% less energy than the incandescent lighting which used to be commonly found in hotel guest rooms. This significant cost saving can allow most hotels to recoup the costs of a LED project in as little as a year. By using LED lights, '… *a full-service hotel would normally save up to 80% - 90% of the electricity when compared with quartz lights*', according to one hotel's EMS manager. The manager further added that '*with the installation of LED lights, our hotel … achieved annual savings of about 60,000 kWh*'. A chief engineer of a deluxe hotel echoed that '*by changing the lighting … of our exterior hotel logo from neon light to … 100,000 LEDs, we reduced our power consumption by about 60%*'.

Our findings indicated that LED lights were widely used in different areas in the hotels, but were not used in guest rooms by some hoteliers as the output of light could not be dimmed. Generally, 60% to 90% electricity savings can be achieved depending on the brand of product, its lifespan and duration of use. It echoes the advocacy by Craine and Lawrance (2003) pointing out that the saving can be up to 90%. We believe that LED lights will be widely used in the industry in the near future as a result of the dramatic decrease in price and the maturity of the technology, including dimmable LED lights and LED lights with different wattages and colors. In addition to the wider applications, the maintenance costs can likely be reduced as a result of long lifespan.

T5 fluorescent tubes

T5 fluorescent tubes have an average life of 20,000 hours. They are still used in many hotels despite the popularity of LED lights. The 'T' refers to the tubular shape of the fluorescent tubes. The number '5' indicated the diameter of the tubes in eighths of an inch. Over two-thirds of the respondents mentioned that their hotels had used T5 fluorescent tubes for the back of house, such as offices, plant rooms, kitchens, corridors, staircases and other back of house public areas. An engineer explained '*the LED tubes are not reliable so that we cannot use the tubes for the back of house.'* In terms of savings, a general manager of a 3-star hotel with 250+ rooms suggested that his '*hotel can save up to 5,800 kWh/year*' with their installation. An EMS manager of a full-service hotel with 600+ rooms indicated that '*the energy saving can reach to … more than 300,000 kWh per year!*' In general, the findings indicated that fluorescent tubes were mainly used in the hotels' back of house areas, probably because their appearance and the color of the light was not preferred by the hotel customers in addition to the unreliability of LED tubes in the market. In fact, the replacement of incandescent lamps with the fluorescent lighting can save up to 80% (Popović-Gerber, Oliver, Cordero and Harder, 2012).

4.3.2. Air-conditioning-related control

The consumption of energy by a hotel's HVAC system is significant. Stipanuk (2001) suggested that the temperature setting of the system should be adjusted in accordance with the room status and the outdoor temperature. According to a hotel chief engineer, the electricity used by the system can contribute up to 70% of the total electricity bill. A hotel manager of a 240-room hotel indicated that '*the electricity consumption of the air conditioner is the most*'. The hotels in this study used different HVAC-related technologies to help reduce the energy consumption by their HVAC systems. Water-cooled chillers, heat-pump water heaters, heat exchanger, fresh air control and carbon dioxide detectors were found being used.

Water-cooled chillers

It is no doubt that water-cooled chillers is more energy efficient than air-cooled chillers. Nearly two-thirds of the informants' hotels used water-cooled, probably because of more sources of water for Hong Kong nowadays. A chief engineer urged that '*water supply was very scarce 15-20 years ago, but it is different now … more commercial buildings including hotels can employ the water-cooled chillers to save electricity.*' According to a hotel general manager of a 250+ room hotel, the energy savings reached 370,000 kWh/year in his hotel. A chief engineer roughly estimated that *'when compared with the air-cooled model, the water-cooled model can save about 40-50% of the electricity used*'.

Heat pumps

Heat pumps are used to save on heating energy and reduce the cooling load on chiller plants. This system allows cooling of the room space while hot water is boiled by the heating energy released for other uses. According to Lam and Chan (2003), some hotel owners replaced boilers fuelled by diesel oil, electricity or town gas with heat pumps that extracted heat from a heat source

(e.g., the chiller plant) and transferred the collected heat energy to boil water in another tank, supplying hot/warm water for employees and hotel guests to use. Half of the respondent hotels used heat pumps and some indicated that their hotels were planning to use heat pumps to help reduce the pollution from traditional oil or gas-fired boilers, as heat pumps have zero carbon dioxide emissions.

Heat exchanger

A specialized device normally used together with heat pumps, the heat exchanger, was commonly used (40%) to facilitate heat transfer from one fluid to the other. One chief engineer explained that exchangers installed in their hotel HVAC systems and hot water systems took advantage of the heat generated from transferring chilled water from a central chiller to hotel guest rooms to heat the fluid used in the same process. The engineer further stated that the technology had also been used to supply 'warm water' to the hotel swimming pool.

Fresh air control system

A fresh air control system was installed by one hotel to reduce fresh air to unoccupied rooms, such as hotel employees' offices, to save cooling energy during low demand periods. The system was designed for the back of house, corridors and public areas where traffic was low. This system was used by 5.6% of the informants' hotels.

Carbon dioxide detector

Similarly, a carbon dioxide detector was installed in one hotel's meeting room to control the fresh air supply. The hotel general manager explained that *'we have a meeting room about 145 sq meters … we installed a carbon dioxide detector to detect the level of carbon dioxide … if the level is high, the system will automatically increase the fresh air to the room … if low, we will reduce the fresh air supply so that the air-con load can be reduced while the indoor air quality can be monitored'*.

Chilled headboard

A hotel positioning itself as a green hotel also installed a chilled headboard. A cooler installed inside the headboard automatically turns on when the guest room light diminishes, decreasing the temperature around the bed by 2-3°C. With this technology, the hotel general manager stated that the air conditioning energy used when sleeping was reduced while maintaining an optimal temperature for sleeping hours. He added that *'about 3% of the conditioning energy can be saved … it is not significant, but this is very innovative*'.

4.3.3. Equipment associated with motors

Intelligent fan coil unit

To save energy used for air conditioning, the above-mentioned green hotel also used an intelligent fan coil unit with a highly efficient magnet motor and control driver for all of its air conditioning units, saving about 16,000 kWh/year.

Variable speed drives

Variable speed drives (VSD) are designed to save energy by using energy according to demand. According to our findings, nearly half of the informants' hotels had installed variable speed drives to control the energy use of the chillers according to demand. In addition, an engineer in this study mentioned that his hotel used a variable speed drive to control the speed of their water pumps to meet the changing demands on the water supply in the morning, lunch/dinner and overnight. The engineer found that with this installation, '*we can save up to 23% of the electricity consumption*'.

4.3.4. Electricity control

Motion sensors/Pattern recognition energy saving solutions

Motion sensors and pattern recognition energy saving solutions can help save energy by recognizing body movement via sensors or an existing surveillance system, such as CCTV, and turning off the lights and air conditioning in unoccupied areas. Over 70% of the informants reported that their hotels had installed motion sensors. Sensors are normally used in hotel public areas, such as corridors. '*The installation of motion sensors to control lighting in public area can achieve a 15-20% saving…*,' a chief engineer stated. Another chief engineer added that '*our hotel also installed motion sensors to control our hotel's escalators in public areas … it slows down the … escalator in case of no use for a certain period'*.

Pattern recognition energy saving technology was rarely used, in comparison with motion seniors. Only one hotel used the technology at the time of this study. The general manager at this hotel proudly stated that '*we simultaneously use motion sensors and CCTV to tackle the problem of motion sensors which sometime cannot detect the movement of guests who do not "move" in the served area, for instance*'. However, this technology was only installed in the hotel's public areas, such as the lift lobby, because of privacy issues.

4.3.5. In-room electricity control

Kasim (2004) found that 80% of his respondents believed that it was important to have energy saving features in hotel guest rooms. On average, 90% of electricity wastage occurs in hotel guest rooms (Green Lodging News, 2006). Environmental technology must be used to save the energy consumed in guest rooms. In-room electricity control, such as room occupancy sensors, key card

systems, master switch devices and intellectual auto closing curtains were generally used by the informants' hotels to help save energy in their guest rooms.

Room occupancy sensors

Like motion sensors, room occupancy sensors were installed in over one-fifth of the hotels' guest rooms. These sensors turn off some in-room electrical appliances, such as the lighting system, air conditioning, TV and radio, if no body movement is detected. An upscale hotel uses similar technology to turn off the lighting when occupants are not detected. A chief engineer who is also a member of the Hotels Association green committee commented that '*the sensor is not commonly used ... you have electricity sometime and sometime ... you don't ... depending on the movement of the people in the room. The guests find that uncomfortable*'. This comment helps to explain why sensors are not widely used in the hotel industry despite their effectiveness in saving electricity. It also echoes the finding by Millar and Baloglu (2011) concluding that the guest use of guest room occupancy sensors is far uncommon to the hotel industry.

Key card system

The key card system was widely used by the informants' hotels (72.2%) to reduce energy consumption in guest rooms. The system is activated when a guest inserts a room key card into the key pouch. The master control switch is normally installed next to the door entrance. Once inserted, the room status is 'occupied' and the HVAC system in the room shifts from the economy to the comfort setting. Other electrical appliances integrated with the system, such as the TV and lighting, are also turned on automatically. All of the appliances are turned off when the key card is removed upon leaving the guest room. This technology can result in savings of 25% to 40% on guest room energy bills. However, one hotel EMS manager stated that the system was only used to '*re-adjust the in-room temperature to the hotel established temperature of 23°C and reduce the fan speed to save electricity consumption'* in their hotel. This is understandable, as the consumption of electricity by the HVAC system is substantial.

Intellectual auto closing curtain

The intellectual auto closing curtain can help enhance controllability and serviceability during management operations, according to a hotel general manager. The curtain is made of blackout fabric with high solar reflection to reduce overall energy loading. When integrated with a hotel's key card system, the curtain is automatically shut in guest rooms when the guests remove their entrance smart card. The in-room air conditioning load is reduced, as the in-room temperature is not affected by the outdoor temperature. Over one-tenth of the informants' hotels used this technology. Instead of relying on housekeeping staff to close guest room curtain when appropriate, installing the technology to help reduce the load to air-conditioning system is relatively effective.

4.3.6. Water control

Water flow control technology, such as water restrictors and auto-sensing water devices, were generally used to control water flow, thus reducing the quantity of water used in the hotels.

Water restrictors

This technology was very popular, as nearly all of the informants' hotels used water restrictors. The restrictors were normally installed in the shower head of the bathroom in the guest rooms and saved water by reducing the water flow and pressure. A hotel director of housekeeping stated that '*we are able to save up to 26% of the water used by installing water restrictors just in the guest room shower heads*'.

Auto-sensing water devices

Auto-sensing water devices, such as infra-red water taps, were also commonly used (55.6%) to help save water in the hotels. According to an EMS manager, this water-saving device was commonly installed in public and staff rest rooms. It was sometimes used in hotel guest rooms but not in hotel kitchens, as food production efficiency may be affected.

Water recycling systems

Very few of the hotels had water recycling systems, such as rainwater storage tanks, water conserving fixtures in swimming pools or water reuse systems for watering plantations that reuse grey water from the kitchen and laundry plant. This is probably because these systems are expensive and require substantial installation space.

4.3.7. Food and solid waste control

Compressor/packaging machines

Compressor/packaging machines are used to compress paper and empty plastic bottles for recycling. When joining recycling programs, hotels must find space to store identified recyclable items before collection, such as fine papers and empty plastic bottles. To minimize the storage space, compressor/packaging machines are commonly used to reduce the size of the items. However, only one hotel in this study used a machine to compress paper before sending it to the recycling company.

Food waste decomposers

Food waste decomposers are used to handle hotels' leftover food. They transform leftover food into soil conditioner, liquid waste or water. An informant mentioned that their decomposer was shared with their corporate office, which had other properties/facilities that could also use the

decomposer. Not many of the hotels used food decomposers to handle their leftover food. Only one hotel had installed a decomposer. The chief engineer of an airport hotel mentioned that '*the technology is not currently used in this hotel … we recycle the food leftover daily … the quantity is not too much … we control the food every day, the control is very good'*. Another engineer and EMS manager added, *'After the pilot provided by the supplier, we decided to stop using the decomposer because of the smell produced during the process … it affected the hotel service areas*'. The engineers' comments help to explain why decomposers were not popular.

4.3.8. Other management systems

Building maintenance system

A building maintenance system was used by nearly one-third of the hotels to monitor hotel equipment performance and instantly notify the hotel engineers of any technical problems. The system also controls an algorithm to improve HVAC plant efficiency, thus saving a significant amount of energy. A deluxe hotel's director of engineering stated, that '*our building maintenance system can schedule on/off operation of air conditioners and fans with time programme … that eventually helps reduce electricity consumption*'. One hotel integrated the system with a comprehensive online system that helps to reduce energy consumption by monitoring, responding to, analyzing, identifying and improving the consumption of energy in the hotel.

A few of the hotels also used other management systems to control the consumption of energy and water, such as a hotel environmental system, transcendent maintenance system and intelligent lighting system to optimize energy consumption.

Paperless systems

An iPad/iPod was used as a menu in some of the hotel food and beverage outlets, as a directory for guests to use and as a survey tool. An EMS manager stated that '*all of our food and beverage outlets are using iPad menus … without the hard copy, we can save the printing cost, reduce the use of paper … and be able to change the menu items more efficiently*'. As the 'i' products are so popular with the public, nearly one-third of the informants' hotels used these devices. It is expected that the use of the 'i' products to provide better customer service and reduce the use of paper will continue to increase in the near future.

Paperless reservation check in/out systems were used by nearly a quarter of the hotels to save paper. All of the reservation correspondence, check-in and check-out records was stored in a data mining system. Each reservation used on average four pages of paper for correspondence, according to the chief engineer and EMS manager of an upscale hotel with 250+ rooms. During the check in/out process, at least one registration card for each guest in each room and one hotel invoice page could be saved. The engineer stated that *'we have saved nearly 480,000 pages of*

paper so far … and 2.39 tons of paper … in one year of operations'. A director of housekeeping added that '*By using the e-housekeeping system, a hotel can arrange roster assignments, prepare VIP lists for floor supervisors/room attendants to use, and check and update room status, etc., without wasting any paper.'*

4.3.9. Building envelope-related control

Indoor temperature control devices, such as sun shading systems, sun control window films and low-emissivity glass were used. The devices were used to maintain the in-room/in-door temperature, which is affected by the outdoor temperature and solar energy. A general manager stated that *'the installation of low-emissivity glass can help reduce about 3% of solar transmitting to in-door of our hotel building'.* A chief engineer stated that *'with the installation, the difference in the in-door temperature can be 20°C lower, which reduces the load to the air conditioner very much … but, the whole building must be installed with the device to optimize the outcome'.* According to our findings, over 15% of the informants' hotels installed low-emissivity glass windows. Notwithstanding this, about one-third used sun control window films to reduce solar energy, probably because of its relatively cheaper price.

(Please insert Table 4 here)

4.4. The Three Most Popular Environmental Technologies

Table 5 shows the informants' ratings of the ten most popular environmental technologies used in their hotels. LED lights (94.4%), T5 fluorescent tubes (72.2%), motion sensors (72.2%), key card systems (72.2) and water-cooled chillers (66.7%) were mentioned most frequently by the informants as the three most popular environmental technologies used in hotels. According to the research findings, the three most popular environmental technologies are related to the saving of electricity. Others mentioned frequently, water restrictors (61.1%), water auto-sensing devices (55.6%) and heat pump water heaters (50%), were related to HVAC systems and water saving. All of these technologies are either pollution prevention or pollution control technologies, as described by Freeman et al. (1992).

In general, the findings indicated that the environmental technologies for energy and water saving and HVAC systems were commonly used in Hong Kong hotels. The most commonly used environmental technologies were those designed for saving energy from the lighting systems of hotel guest rooms, public areas and the back of the house, and from the water restrictors normally installed in guest room shower heads. These devices are relatively low-cost and result in a significant energy and water saving. In addition, when comparing with other technologies, the

devices are easy to install and operate. The perceived ease of use factor mentioned in Davis' TAM model could help explain why the technologies are commonly used in Hong Kong hotels, as the factor is closely associated with attitude toward use (Davis, 1989).

(Please insert Table 5 here)

4.5. The Most Preferred Environmental Technologies

When asked which environmental technologies they most wanted to install in their hotels, if they had no budget or technical constraints, the technologies mentioned most frequently were, in order, solar-based renewable energy, food waste decomposers and energy saving chillers, which was very different from the three most popular environmental technologies in Table 4. Some of the informants felt that hotels can save a lot by using free solar energy, if the technology can be used. Solar energy can be used to power lighting systems or to heat the water supplied for employee and customer use. Food waste decomposers were also desired by some hotel managers despite the high costs and the technical constraints mentioned above. When compared to other types of waste generated by hotels, food waste is a very serious problem. In Hong Kong, about 3,500 tonnes of food are wasted every day, one third of which is from the commercial and industry sectors (EPD, 2012). Handling food waste is thus always at the top of a hotel's agenda. A food waste decomposer can transform leftovers to soil conditioner or substances for other purposes. For instance, some hotels send their food waste to biotechnology companies for processing into fish feed, which cuts fish feed imports and saves the energy required for transportation. Energy saving chillers can save energy costs significantly, as more than 50% of the total electricity use in hotels is by the HVAC systems (Deng and Burnett, 2002). This could explain why the hotel managers wanted this expensive machine.

4.6. The Future of Renewable Power in Hotels

One general manager stated that his hotel used solar-based renewable energy. The solar energy-related technology was mainly installed to supply power for lighting and water heating systems. An EMS manager of another hotel indicated that *'our hotel has used solar-based lighting for the outdoor area of our cafe … the small panels of each light stores the sunlight energy during the daytime to supply power to the light during night time … the light level is strong enough for the patrons to read the menu*'. However, a chief engineer stated that *'large scale solar energy-related technology can hardly be used … as its payback period is about 20-30 years!*' None of the informants mentioned wind-based renewable energy. It was clear from the findings that the use of renewable energy systems was very low. The findings confirm the investigators' observation that very few hotels in Hong Kong used technologies that can help harness free, clean energy. The large investment cost could be the reason behind the low rates of use. The unpopularity of these systems requires further investigation.

5. Discussion and Conclusions

The primary purpose of this study was to investigate the use of environmental technologies in the hotel industry. This is the one of the first studies in the hospitality and tourism field investigating this area of enquiry. Several conclusions can be drawn from this study. This research aims to identify which environmental technologies are commonly utilized in a hotel context. The study findings suggest that the most commonly used environmental technologies are LED lights, T5 fluorescent tubes, motion sensors, key card system and water cooled chillers. Another important research objective in this study is to examine where the environmental technologies are used and the benefits obtained from the usage. According to the study findings, LED lights are normally used in hotel guest rooms, food and beverage outlets and other public areas such as hotel lobby and parking areas, as the device can help a full-service hotel save up to 80% - 90% of the electricity when compared with quartz lights. T5 fluorescent tubes are mainly used in back of house, corridors and staircases etc. to replace the incandescent lamps, which can help save up to 70% -80% of the electricity. Motion sensors are normally used in staff toilets, staff changing rooms and staff entrance in order not to influence guest services. Key card system is utilized to turn power to guest rooms on and off resulting in possible savings of 25% to 40% on guest room energy bills.

Water cooled chillers, a main component of the centralized air-conditioning system are also commonly installed to supply cool air to hotel buildings. When compared with air-cooled model, the chillers can save about 40-50% of the electricity used. It is clear that the hoteliers appeared to focus on first saving energy, rather than saving water and reducing solid/food waste, when considering using environmental technologies to improve their operation efficiency. A research objective is to investigate which environmental technologies are most preferred by hotel managers. The study finds that if hotel managers had no budget or technical constraints, most of them most wanted solar-related technologies that result in free energy for use in hotel operations. It is also worthy to note that when purchasing electrical appliances, such as refrigerators, mini-bars, dishwashers, washing machines, dryers, computer fax machines, printers, scanners and photocopying machines, nearly all of the informants indicated that their hotel considered eco-appliances first despite the higher price.

The study findings can help hotel owners and operators understand which environmental technologies are commonly installed in the hotel industry and to gather information on other possible environmental technologies that can be used in hotel operations. By looking at the use of environmental technologies from multiple perspectives, this research contributes to the existing knowledge. Most of the current research on environmental management focuses on why and how organizations implement different environmental programs, seek green awards or apply formal EMS. However, none of these studies attempted to investigate how environmental technologies are applied in hotels. We identified the common environmental technologies used in hotels and

elaborated on the locations served and the cost savings achieved, based on the experience of hotel professionals.

5.1.Theoretical Implications

This study builds on previous research studies on environmental management and technologies to identify areas that must be addressed by hotel managers, which is a valuable contribution to the literature. The findings and discussions can help further expand the body of research on hospitality environmental management as well as the environmental technology applications in hotels. This study identifies the environmental technologies commonly used by hotels, based on the experiences of hotel professionals. This is one of the first studies that provides such a list based on empirical research study. It offers some insights to hotel managers, which is useful when selecting environmental technologies for hotels. The knowledge of the benefits that could be gained from some environmental technologies would be particularly useful for hotel managers who need to select and decide what environmental technologies should be adopted in hotels. Hotel managers can utilize this list and compare its operations to our findings and use them help its management to determine whether to begin using environmental technologies.

It is important for hotel operators to proactively incorporate environmental technologies into their daily operations to improve their environmental performances. We found that the Hong Kong hotels studied were able to use environmental technologies to improve their business operations and save operating costs. Due to the business nature, the key card system is commonly-employed in respondent hotels to help save the consumption of electricity in guestrooms, which is different from the practices in other industries. Notwithstanding, the solar/wind-based renewable energy technology increasingly utilized in other industries is seldom employed in hotels. It is probably because of the high investment cost and the constraint of physical environment, which requires further investigation. This study also lays a foundation for further in-depth research, particularly to understand the motivations and barriers to the use of environmental technologies in hotels.

5.2. Practical Implications

Traditionally, hotel operators are not equipped with environmental technology knowledge, but with the knowledge to improve the service quality and sales of their hotels (Chan, 2008; Chan 2011; Kasim, 2015; Lin, 1995). Hotel managers should remain in close contact with the environmental technology industry to keep abreast of the latest developments. Hotel operators can use this up-to-date information to study the feasibility of integrating the technologies into their hotels to maintain their competitiveness. As they are very involved in the environmental activities of hotels, chief engineers, EMS managers and green committee members need to be more aggressive and actively participate in supplier contacts to obtain the latest information on the

environmental technologies currently on the market. The managers can observe and realize the benefits of employing an environmental technology and how the technology can help improve their hotel environmental performance and even guest services. The information obtained can be shared with hotels' non-technical managers and senior management to explore the possibility of adoption.

Hotel managers are often under pressure to improve their hotels' profitability and customer services. Protecting the environment may not be the top priority. However, with the pressure to minimize operating costs and increase competitiveness, integrating environmental technologies into hotel operations to reduce costs and improve efficiency could be a good business strategy. Therefore, hotel managers can re-consider/design the hotel organizational structure to allow chief engineers, EMS managers and the chair of the green committee to participate more at all levels of business decision-making in their hotels.

From the findings, room occupancy sensors are not widely used by hotels when compared with key card system despite their same function to control the consumption of in-room electricity. This is mainly due to the impact of room occupancy sensors on guest services. Therefore, hotel managers should ensure that they keep abreast of guest acceptance of an environmental technology in the service encounter when considering the application in their hotel. They may consider employing some environmental technologies that have a minimal effect on guest services.

The research findings also indicate that most of the hotels in this study initially focused on electricity saving when using environmental technologies. This is understandable, as a full-service hotel, normally with food and beverages outlets, a swimming pool and other primary facilities, requires a significant amount of electricity during its around-the-clock operations. The consumption by a hotel can be 200-300% more than by an office building. Using environmental technologies to control/reduce the consumption of electricity is a very effective strategy to implement and could be a starting point for hotel managers. We suggest that HVAC-related environmental technologies such as heat pumps and heat exchanger should take priority over others because of the high consumption of energy by the HVAC systems. Hotel managers can then use the savings obtained to persuade their corporate office/owners to consider other environmental projects that may contribute smaller benefits to the company but protect the environment. Hotel managers must realize that the benefits gained from environmental technologies would lead to better hotel environmental performance, which, in turn, will improve the operational efficiency. It is believed that when operational efficiency can be increased, the applications of environmental technologies in hotels will become voluntary.

Limitations and Future Research

It is important to note that the sample was drawn exclusively from Hong Kong hotels. Accordingly, the results should not be generalized to hotel managers in other hotels and other parts

of the world. Despite this caveat, we fully expect that other researchers will be able to validate the conclusions of this study in larger samples of hotels over longer periods. We suggest that further studies should be conducted on lower-ranked and smaller hotels, as these types of hotels may experience greater challenges in using environmental technologies.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes 50*, 179-211.

Aragon-Correa, J. A., Martin-Tapia, I., & de la Torre-Ruiz, J. (2015). Sustainability issues and hospitality and tourism firms' strategies: Analytical review and future directions. *International Journal of Contemporary Hospitality Management*, *27*(3), 498-522.

Baker, M.A., Davis, E.A., & Weaver, P.A. (2014). Eco-friendly attitudes, Barriers to participation, and differences in behavior at green hotels. *Cornell Hospitality Quarterly 55* (1), 89-99.

Blumer, H. (1969). *Symbolic Interactionism: Perspective and Method*. Englewood Cliffs, NJ: Prentice-Hall.

Bohdanowicz, P., Simanic, B., & Martinac, I. (2005). Sustainable hotels - environmental reporting according to Green Globe 21, Green Globe Canada/Gem UK, IHEI benchmark hotel and Hilton environmental reporting, *the World Sustainable Building Conference*, Tokyo, Japan, 1642-1649.

Buhalis, D. (1998). Strategic use of information technologies in the tourism industry. *Tourism Management 19* (5), 409-421.

Chan, E.S.W. (2008). Barriers to EMS in the hotel industry. *International Journal of Hospitality Management 27* (2), 187-196.

Chan, E.S.W. (2011). Implementing environmental management systems in small- and medium-sized hotels: Obstacles. *Journal of Hospitality & Tourism Research 35* (1), 3-23.

Chan, E.S.W. (2013). Managing green marketing: Hong Kong hotel managers' perspective. *International Journal of Hospitality Management 34*, 442-461.

Chan, E.S.W. (2013). Gap analysis of green hotel marketing. *International Journal of Contemporary Hospitality Management 25* (7), 1017-1048.

Chan, E.S.W. (2014). Green marketing: Hotel customers' perspective. *Journal of Travel & Tourism Marketing 31* (8), 915-936.

Chan, E.S.W., & Hawkins, R. (2010). Attitude towards EMSs in an international hotel: An exploratory case study. *International Journal of Hospitality Management 29* (4), 641-651.

Chan, E.S.W., & Hawkins, R. (2012). Application of EMSs in a hotel context: A case study. *International Journal of Hospitality Management 31* (2), 405-418.

Chan, E.S.W., & Wong, S. C.K. (2006). Motivations for ISO 14001 in the hotel industry. *Tourism Management 27* (3), 481-492.

Chan, E.S.W., Okumus, F., & Chan, W. (in press). Barriers to environmental technology adoption in hotels. *Journal of Hospitality & Tourism Research*, Nov 8, 2015, doi: 10.1177/1096348015614959.

Chan, E.S.W., Hon, A.H.Y., Okumus, F., & Chan, W. (in press). An empirical study of environmental practices and employee ecological behavior in the hotel industry. *Journal of Hospitality & Tourism Research,* Sep 22, 2014, doi:10.1177/1096348014550873.

Chan, W.W. (2005a). Predicting and saving the consumption of electricity in sub-tropical hotels. *International Journal of Contemporary Hospitality Management 17*(3), 228-237.

Chan, W.W. (2005b). Partial analysis of environmental costs generated by hotels in Hong Kong. *International Journal of Hospitality Management 24* (4), 517-531.

Chan, W.W., Yueng, S., Chan, E., & Li, D. (2013). Hotel heat pump hotel water systems: impact assessment and analytic hierarchy process. *International Journal of Contemporary Hospitality Management 25* (3), 428-446.

Chan, W., Wong, K., & Sing, C. (2005). Environmental measures undertaken in Hong Kong hotels' room division. In: Suh, S.J. and Hwang, Y.H. (Eds.), *Proceedings, The 11th APTA Conference* (pp. 812-818). Korea International Exhibition Centre, Goyang, Gyeonggi Province.

Cheung, M., & Fan, J. (2013). Carbon reduction in a high-density city: A case study of Langham Place Hotel Mongkok Hong Kong. *Renewable Energy 50*, 433-440.

Craine, S., & Lawrance, W. (2003). Pico power-lighting lives with LEDs. *Journal of Electrical & Electronics Engineering, Australia 22* (3), 187-194.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly 13*, 319-340.

Deng, S.M., & Burnett, J. (2002). Water use in hotels in Hong Kong. *International Journal of Hospitality Management 21* (1), 57-66.

DiPietro, R., Cao, Y., & Partlow, C. (2013). Green practices in upscale foodservice operations: customer perceptions and purchase intentions. *International Journal of Contemporary Hospitality Management*, *25*(5), 779-796.

EPD (2012). Waste: problems and solutions. Retrieved 21 March 2014 from http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/owt_food.html.

Energy Star (2007). Facility type: hotels and motels. Energy Star Building Manual.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitudes, intentions, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Freeman, H., Harten, T., Springer, J., Randall, P., Curran, M.A., & Stone, K. (1992). Industrial pollution prevention: a critical review. *Journal of the Air and Waste Management Association 42* (5), 617-56.

Ghisetti, C., & Quatraro, F. (2013). Beyond inducement in climate change: Does environmental performance spur environmental technologies? A regional analysis of cross-sectoral differences. *Ecological Economics 96*, 99-113.

González, M., & León, C.J. (2001). The adoption of environmental innovations in the hotel industry of Gran Canaria. *Tourism Economics 7* (2), 177-190.

Green Lodging News (2006). Energy eye introduces wireless radio frequency energy. Retrieved 8 April 2014 from http://www.greenlodgingnews.com/Energy-Eye-Introduces-Wireless-Radio-Frequency-Energy-Management-Solution.

Hammersley, (1993). *The Politics of Social Research*. Sage Publications, London.

Holjevac, I.A. (2003). A vision of tourism and hotel industry in the 21st century. *Hospitality Management 22* (2), 129-134.

Hong Kong Tourism Board (2013). *Hotel Supply Situation – as at Dec 2013*. Author. Hong Kong SAR, China.

Hong Kong Tourism Board (2014). *Monthly Report – Visitor Arrivals Statistics: Dec 2014*. Author. Hong Kong, China.

Hong Kong Tourism Board (2015). *Hotel Supply Situation – as at Mar 2015*. Author. Hong Kong SAR. China.

Jones, P., Hillier, D., & Comfort, D. (2016). Sustainability in the hospitality industry: some personal reflections on corporate challenges and research agendas. *International Journal of Contemporary Hospitality Management*, *28*(1).

Kasim, A. (2015). Environmental management system (EMS) Postulating the value of its adoption to organizational learning in hotels. *International Journal of Contemporary Hospitality Management*, *27*(6), 1233-1253.

Kasim, A. (2004). Socio-environmentally responsible hotel business: Do tourists to Penang Island, Malaysia care? *Journal of Hospitality and Leisure Marketing 11* (4), 5-28.

Kim, H. J., Park, J., & Wen, J. (2015). General managers' environmental commitment and environmental involvement of lodging companies: The mediating role of environmental management capabilities. *International Journal of Contemporary Hospitality Management*, *27*(7), 1499-1519.

Kirk, D., & Pine, R. (1998). Research in hospitality systems and technology. *International Journal of Hospitality Management* 17, 203-217.

Klassen, R.D., & Whybark, D.C. (1999a). The impact of environmental technologies on manufacturing performance. *Academy of Management Journal 42* (6), 599-615.

Klassen, R.D., & Whybark, D.C. (1999b). Environmental management in operations: the selection of environmental technologies. *Decision of Science 30*, 601-631.

Lam, J., & Chan., W. (2003). Energy performance of air-to-water and water-to water heat pumps in hotel applications. *Energy Conversion and Management 44* (10), 1625-1631.

Law, R., & Jogaratnam, G. (2005). A study of hotel information technology applications. *International Journal of Contemporary Hospitality Management 17* (2), 170-180.

Law, R., Buhalis, D., & Cobanoglu, C. (2014). Progress on information and communication technologies in hospitality and tourism. *International Journal of Contemporary Hospitality Management*, *26*(5), 727-750.

Lee, S.C., Barker, S., & Kandampully, J. (2003). Technology, service quality, and customer loyalty in hotels: Australian managerial perspectives. *Managing Service Quality: An International Journal 13* (5), 423-432.

Leonidas, N. (2004). Creative hotel design. Newsletter of Perspective. Retrieved 14 January 2013 from http://www.sonnbichler.com/downloads/pspnewsletter_final_07_10_04.pdf.

Lin, C.M. (1995). The significance of ISO 14000 environmental standards for Asia-Pacific. *APO Productivity Journal 4*, 65-82.

Loppinet-Serani, A., Armonier, C., & Cansell, F. (2010). Supercritical water for environmental technologies. *Journal of Chemical Technology and Biotechnology 85* (5), 583-589.

Manaktola, K., & Jauhari, V. (2007). Exploring consumer attitude and behavior towards green practices in the lodging industry in India. *International Journal of Contemporary Hospitality Management 19* (5), 364-377.

Masciangioli, T., & Zhang, W.X. (2003). Environmental technologies at the nanoscale. *Environmental Science and Technology 37* (5), 102A-108A.

Mehta, H. (2007). Towards an internationally recognised eco lodge certification. In Black, R. and Crabtree, A. (Eds.), *Ecotourism series, number 5: Quality Assurance and Certification in Ecotourism* (pp. 415-434). London: CABI Publishing.

Mihalic, T., & Buhalis, D. (2013). ICT as a new competitive advantage factor-case of small transitional hotel sector. *Economic and Business Review 15* (1), 33-56.

Miles, M.B., Huberman, A.M., & Saldaña, J. (2013). *Qualitative Data Analysis: A Methods Sourcebook*. SAGE Publications.

Millar, M., & Baloglu, S. (2011). Hotel guests' preferences for green guest room attributes. *Cornell Hospitality Quarterly 52* (3), 302-311.

Olsen, M., & Zhao, J.L. (1997). New management practice in the international hotel industry. *Travel and Tourism Analyst 1*, 53-73.

Parisi, S. (2012). Hotel energy reduction strategies, Eco green hotel supporting hospitality sustainability. Retrieved 13 January 2013 from http://www.ecogreenhotel.com/blog/tag/hotel-energy-saving-ideas.

Park, S. Y., & E. Levy, S. (2014). Corporate social responsibility: perspectives of hotel frontline employees. *International Journal of Contemporary Hospitality Management*, *26*(3), 332-348.

Pereira-Moliner, J., Font, X., Tarí, J. J., Molina-Azorin, J. F., Lopez-Gamero, M. D., & Pertusa-Ortega, E. M. (2015). The Holy Grail: Environmental management, competitive advantage and business performance in the Spanish hotel industry. *International Journal of Contemporary Hospitality Management*, *27*(5), 714-738.

Poksinska, B., Dahlgaard, J.J., Eklund, J.A.E. (2003). Implementing ISO 14000 in Sweden: Motives, benefits and comparisons with ISO 19000. *International Journal of Quality & Reliability Management 20*, 585-606.

Popović-Gerber, J., Oliver, J.A., Cordero, N., & Harder, T. (2012). Power electronics enabling efficient energy usage: energy savings potential and technological challenges. *Power Electronics, IEEE Transactions 27* (5), 2338-2353.

Porter, M.E., & Kramer, M.R. (2011). Creating shared value. *Harvard Business Review 89* (1/2), 62-77.

Prendergast, G., & Man, H.W. (2002). The influence of store image on store loyalty in Hong Kong's quick service restaurant industry. *Journal of Foodservice Business Research 5* (1), 45-59.

Prud'homme, B., & Raymond, L. (2016). Implementation of sustainable development practices in the hospitality industry: a case study of five Canadian hotels. *International Journal of Contemporary Hospitality Management*, *28*(3).

Rahman, I., Park, J., & Chi, C. G. Q. (2015). Consequences of "greenwashing" Consumers' reactions to hotels' green initiatives. *International Journal of Contemporary Hospitality Management*, *27*(6), 1054-1081.

Rogers, E.M. (1995). *Diffusion of Innovations* (4th Ed.). New York, NY: The Free Press.

Sheldon, P. (1997). *Tourism Information Technology*. New York, NY: Cab International.

Shiming, B., & Burnett, J. (2002). Energy use and management in hotels in Hong Kong. *International Journal of Hospitality Management 21* (4), 371-380.

Shrivastava, P. (1995). Environmental technologies and competitive advantage. *Strategic Management Journal 16* (3), 183-200.

Stipanuk, D.M. (2001). Energy management in 2001 and beyond: operational options that reduce use and cost. *Cornell Hotel and Restaurant Administration Quarterly 42* (3), 57-70.

Tseng, M.L., Wang, R., Chiu, A.S.F., Geng, Y., & Lin, Y.H. (2013). Improving performance of green innovation practices under uncertainty. *Journal of Cleaner Production 40*, 71-82.

Vachon, S. (2007). Green supply chain practices and the selection of environmental technologies. *International Journal of Production Research 45* (18-19), 4357-4379.

Zhao, X., Ma, C., & Gu, P. (2012). Energy saving methods and results analysis in the hotel. *Energy Procedia 14*, 1523-1527.

Table 1. Some common environmental technologies

Areas of use	Items	Sources
Lighting	• Light-emitting diode (LED)	Cheung & Fan (2013); Energy Star (2007)
	• T5 fluorescent tubes	Chueng & Fan (2013); Zhao, Ma, & Gu (2012)
	• Light/Occupancy sensors	Chan (2005a); Energy Star (2007); Millar & Baloglu (2011)
	• Energy-efficient lighting	Chan (2005a); González & León, (2001); Millar & Baloglu (2011)
	• Compact fluorescent lamps	Cheung & Fan (2013); Energy Star (2007); Zhao, Ma, & Gu (2012)
	• Halogen bulbs	Cheung & Fan (2013)
Air-conditioning-related control	• Heat pump	Chan, Yueng, Chan, & Lee (2013)
	• Solar heat pump	Chan (2005a)
	• Heat recovery technology	Zhao, Ma, & Gu (2012)
	• Intelligent low-voltage power-saving technology	Zhao, Ma, & Gu (2012)
Equipment associated with motors	• Variable speed drives	Cheung & Fan (2013)
Electricity control	• Key card system that turns power to the room on and off	Millar & Baloglu (2011)
	• Solar-based renewable energy	Mehta (2007); Cheung & Fan (2013)
Heat energy generation	• Solar thermal panels	Mehta (2007); González & León, (2001)
Water control	• Low-flow water fixtures	Mehta (2007); Millar & Baloglu (2011)
	• Auto-sensing water devices	Millar & Baloglu (2011)
	• Flushing-saving devices	González & León, (2001)
	• Localized irrigation systems	González & León, (2001)
Building energy-saving materials	• Wall insulation materials	Zhao, Ma, & Gu (2012)
	• Glass laminating materials	Zhao, Ma, & Gu (2012)

Table 2. Hotels' profiles

Hotel	Scope/ reputation	Brand	Stars	No. of rooms	Levels of service	EMS	EP
1	Local	Local	3	529	Mid-range service		Y
2	Local	Local	3	240	Limited service		Y
3	International	American	5	559	Full service		Y
4	Local	European	5	665	Full service	Y	Y
5	Local	Local	5	492	Full service	Y	Y
6	Local	Local	3	320	Mid-range service		Y
7	International	European	4	550	Mid-range service		Y
8	International	Asian	5	565	Full service	Y	Y
9	International	American	5	614	Full service	Y	Y
10	International	Asian	4	283	Mid-range service	Y	Y
11	Local	Local	5	117	Full service		Y
12	Local	Local	5	815	Full service		Y
13	International	Asian	5	688	Full service	Y	Y
14	International	American	4	274	Full service	Y	Y
15	Local	Local	4	262	Full service		Y
16	International	American	5	658	Full service	Y	Y
17	International	Japanese	5	462	Full service	Y	Y
18	International	American	5	782	Full service		Y

Remarks:
EMS = Formal Environmental Management System
EP = Ad hoc environmental program

Table 3. Profile of the respondents

Variable		Frequency	%
Gender			
	Male	19	82.6%
	Female	4	17.4%
Age range			
	16-24 y	0	0.0%
	25-34 y	3	13.0%
	35-44 y	9	39.1%
	45-59 y	11	47.8%
	over 60 y	0	0.0%
Job position			
	Chief Engineer	7	30.4%
	General Manager	5	21.7%
	Director of Housekeeping	5	21.7%
	Financial Controller	2	8.7%
	EMS Manager	1	4.3%
	Chief Steward and Green Committee Member	1	4.3%
	Human Resources Manager and EMS Manager	1	4.3%
	Chief Engineer and EMS Manager	1	4.3%
Education level			
	Postgraduate school	10	43.5%
	University/college	7	30.4%
	Secondary/high school	6	26.1%
	Less than secondary/high school	0	0.0%
No. of years working for current hotel			
	1-5 y	14	60.9%
	6-10 y	6	26.1%
	over 10 y	2	8.7%
	Unknown	1	4.3%
No. of years of experience in the hotel industry			
	1-10 y	5	21.7%
	11-20 y	6	26.1%
	21-30 y	5	21.7%
	31-40 y	5	21.7%
	Unknown	2	8.7%

Table 4. The installation locations of the environmental technologies

Category	Sub-category	Environmental technologies	Installation areas
Energy control	**Lighting**	LED light	Guest rooms, lobby, public areas, parking areas, corridors
		T5 fluorescent tube	Back of house corridors, public areas
		Timer/dimmer	Parking areas, restaurants
		Motion sensor	Staff toilets, staff changing rooms, staff entrance
	In-room energy control	Room occupancy sensor	Guest rooms
		Key card system	
		Master switch	
		Intellectual auto closing curtain	
	HVAC system	Water-cooled chiller	Centralised HVAC systems
		Heat pump water heater	
		Heat exchanger	
		Variable speed drive	
		Chilled headboard	
		Room fresh air control	
		Intelligent fan coil unit	
	Other eco-electrical appliances	Eco catering / laundry equipment	Guest room mini bars, kitchen dishwashers and freezers, laundry plant washing and drying machines
		Eco office equipment	Computers, printers, scanners, photocopying and fax machines
Water control	**Flow control**	Water restrictor	Back of house, public rest rooms, guest bathrooms
		Auto-sensing devices	Staff and public rest rooms
	Water recycle/reuse	Recycle water storage tanks to store rainwater	Roof of buildings
		Recycle water storage tanks to collect condensed water from fan coil units	Air conditioning units
		Recycle water storage tanks to collect water from swimming pool	Swimming pool
Waste control (solid/food)	**Solid waste**	Compressor/packaging machine	Garbage areas
		Compactor	Garbage areas
	Food waste	Food waste disposer/decomposer	Garbage areas, staff canteens
Management systems	**Energy and water control**	Building management system	Engineering and served areas
		Hotel environmental system	Engineering and served areas
		Maintenance management system	Engineering and served areas
		Intelligent lighting system energy optimisation solution	Engineering and served areas
		Control system of water quality and use	Engineering
Paperless devices/systems	**Paperless devices**	iPad/iPod used as a menu, directory and survey	Front offices, food and beverages outlets, lobbies

	Paperless systems	Paperless check-in and check-out system	Front offices
		e-housekeeping	Housekeeping
		Paperless inter-conference	Administration offices
Building envelope	**Sun protection**	Energy efficient windows	Windows
		Sun shading devices	Windows
		Sun control window film	Windows
Renewable energy	**Solar-based renewable energy**	For lighting	Outdoor outlets, public areas
		For heating water	Hot water collector systems

Table 5. Ten most popular environmental technologies in the hotel industry

Item	Rank	Environmental Technologies	Num.	%	Category
1	1	LED light	17	94.4	Lighting
2	2	T5 fluorescent tube	13	72.2	Lighting
3		Motion sensor	13	72.2	Lighting
4		Key card system	13	72.2	In-room energy control
5	3	Water-cooled chiller	12	66.7	HVAC system
6	4	Water restrictor	11	61.1	Flow control
7	5	Water auto-sensing device	10	55.6	Flow control
8	6	Heat pump water heater (reuse the heat generated by the chiller)	9	50	HVAC system
9	7	Variable speed drive	8	44.4	HVAC system
10	8	Heat exchanger	7	38.9	HVAC system