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Assessing the Environmental Footprint: A Life Cycle Assessment of Greenhouse Gas Emissions from Energy Consumption in 3 and 4-Star Hotels in Pontianak, West Kalimantan

Kajian Dampak Lingkungan: Siklus Hidup Emisi Gas Rumah Kaca dari Konsumsi Energi di Hotel Bintang 3 dan 4 di Kota Pontianak, Kalimantan Barat

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ABSTRAK

Persebaran usaha penginapan di Indonesia hingga tahun 2021 terus meningkat, di mana 48,95% merupakan hotel berbintang. Pada operasionalnya, hotel memerlukan energi dari berbagai jenis bahan bakar yang menghasilkan emisi berupa gas rumah kaca. Studi ini dilakukan pada kasus di Hotel X (bintang 4) dan Hotel Y (bintang 3) di Kota Pontianak, Kalimantan Barat yang menggunakan energi dari batubara, gas alam cair, dan bahan bakar minyak. Tujuan penelitian ini adalah untuk menganalisis dampak lingkungan dari gas rumah kaca menggunakan metode analisis daur hidup. Data inventori dilakukan terhadap jenis sumber energi, jumlah alat, dan lama penggunaan pada tiap fasilitas yang tersedia di hotel. Aplikasi OpenLCA 1.11.0 dan database CML-IA baseline digunakan untuk menganalisis dampak lingkungan yang dihasilkan. Kategori dampak yang dianalisis yaitu potensi dampak pemanasan global, penipisan abiotik, dan potensi oksidasi fotokimia. Dampak lingkungan terhadap pandemik COVID-19 dan strategi manajemen gas rumah kaca juga didiskusikan. Hasil penelitian menunjukkan bahwa jumlah tamu, fasilitas dan jenis bangunan berpengaruh pada emisi yang dihasilkan. Jumlah tamu pada tahun 2020 merupakan jumlah terkecil dibandingkan tahun 2019 dan 2021, yang sejalan dengan jumlah konsumsi energinya. Jumlah fasilitas pada Hotel X yang lebih banyak dibandingkan Hotel Y juga menyebabkan Hotel X menghasilkan lebih banyak emisi dibandingkan Hotel Y. Rekomendasi dari penelitian ini berupa perencanaan strategi pengelolaan konsumsi energi yang lebih baik, terutama pada penggunaan lampu dan pendingin ruangan. Untuk mengurangi konsumsi energi dari penggunaan alat tersebut dapat diterapkan sistem sensor untuk aktivasi listrik, serta penggunaan elektronik dengan daya yang lebih rendah. Diharapkan hasil riset ini dapat memberikan solusi bagi perencanaan strategi pengelolaan energi yang berkelanjutan di hotel berbintang dan diperlukan inventarisasi detail untuk mengetahui dampak lingkungannya secara komprehensif.

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ABSTRACT

The distribution of Indonesia lodging businesses in 2021 has been continuously increase, with 48.95% being star-rated hotels. In their operations, hotels require energy from various types of fuels that produce emissions in the form of Greenhouse Gases. This study was conducted on the cases of X Hotel (4-star) and Y Hotel (3-star) in Pontianak, West Kalimantan, which utilize energy from coal, liquefied natural gas, and oil fuels. The research objective is to analyze the environmental impact of greenhouse gases using the life cycle analysis method. Inventory data were collected for the types of energy sources, the number of appliances, and the duration of usage for each facility available in the hotels. OpenLCA 1.11.0 application and CML-IA baseline database were employed to analyze the resulting environmental impact. The impact categories analyzed include the global warming potential, abiotic depletion, and photochemical oxidation potential. The environmental impact of the Covid-19 pandemic and greenhouse gas management strategies are also discussed. The research results indicate that the number of guests, facilities, and building types influence the emissions produced. The number of guests in 2020 was the smallest compared to 2019 and 2021, correlating with the energy consumption. The higher number of facilities in X Hotel compared to Y Hotel also results in X Hotel producing more emissions than Y Hotel. Recommendations from this research include better planning for energy consumption management strategies, especially in the use of

lighting and room cooling. To reduce energy consumption from lighting and air conditioning, the implementation of sensor systems for electrical activation and the use of electronic devices with lower power consumption can be applied. It is hoped that the findings of this research can provide solutions for sustainable energy consumption management strategies in star-rated hotels, and a more detailed inventory is needed to comprehensively understand its environmental impact.

1. INTRODUCTION

1.1 Background

Indonesia's first highest density of hotels is in Java, followed by Bali and Kalimantan. In 2021, there were 27,607 accommodation businesses with a total of 718,898 rooms. Among them, 48.95% are star hotels, 36.49% are non-star hotels, and 14.5% are non-hotel (BPS-Statistics Indonesia 2022). In Pontianak, there are 55 hotels consisting of 27 star hotels and 28 non-star hotels (Youth, Sports and Tourism Department of West Kalimantan, 2022). A hotel is a type of accommodation that provides accommodation, food, and beverage services for everyone and is managed commercially or for the purpose of making a profit (Krestanto, 2019). Pontianak underwent hotel development as well, as the city's tourism potential started to increase. The increase in hotel occupancy is generally directly proportional to the emissions generated from the hotel's operational activities. The resulting emissions come from energy use for hotel operational activities, which have no other purpose than to serve guests. The most dominant energy used in hotel operations is electric power. Hospitality activities require much electrical energy, considering that hotels are synonymous with a comfortable and luxurious atmosphere, which includes sufficient lighting and comfortable temperature (Abed, 2017). Greenhouse Gases (GHG) are gas emissions from the warming of the earth that are released into the ambient air, where ambient air is free air on the earth's surface in the troposphere (Kweku et al., 2017).

The electricity used in Pontianak comes from the coal power plant. The usage of coal has a number of detrimental effects, the climate crisis being one of the most significant. This is a concern for many countries to replace power generation resources from coal with alternative energy. Based on data obtained from The Indonesia National Board for Disaster Management (2022), one of the impacts of the climate crisis is that there have been as many as 5,402 disasters in 2021. The number of these disasters continues to increase compared to 2020, which was 4,650 events, and in 2019 there were 3,814 disaster events. Meanwhile, according to PT. PLN (2021), Indonesia will still use coal as an energy source for the next 10 years. Based on the government's plan to build 13,8 gigawatts of new coal power plants by 2030, which is 43% of the existing coal power plant.

The COP26 climate conference resulted in several important decisions. The 3 most prominent decisions are to gradually reducing coal energy power plants, keeping the earth temperature from rising more than 1.5°C, and accelerating climate crisis mitigation by reviewing 2030 emission reduction commitments through the NDC (Nationally Determined Contribution) of each country. This decision is expected to extend the life of the earth. The objective is to lessen global warming brought on by greenhouse gases that produce the greenhouse effect, based on the three primary outcomes of the agreement. The greenhouse effect is naturally needed so that the temperature during the day and night does not differ much. However, due to human activities that produce greenhouse gases on a big scale, the earth's temperature rises more quickly. It causes various problems such as climate change, ozone depletion, decreased fossil fuel resources, etc (United Nations Framework Convention on Climate Change, 2021).

Based on the Greenhouse Gas Inventory Report (GHG) and Monitoring, Reporting, Verification (MRV) by The Ministry for Environment and Forestry (2021), greenhouse gas emissions in 2019 by the energy sector amounted to 638.808 kg CO_2e consisting of 3 types of gases, as in 93% CO_2, 6% CH_4, and 1% N_2O. These emissions come from the industry that produces energy for the power and heat generation industry, oil refineries, and coal processing, as well as the use of fuel for transportation and manufacturing processes. Energy use is thought to avoid, especially in an era of rapid technological advancement and development. Since alternate sources are still relatively expensive, fossil fuels remain the primary energy source. Greenhouse gas emissions cause the greenhouse effect. In general, these gases absorb some of the heat to the earth's surface, which is called radiation, and causes the temperature during the day and night to not be much different. At some time, some are reflected out from the atmosphere. However, under current conditions, the production of greenhouse gas emissions is excessive. The gas causes heat to be trapped in the atmosphere and increases the earth's temperature or known as global warming (Pratama, 2019). The total amount of greenhouse gas emissions that enter the atmosphere as a result of human activities is called the carbon footprint (Wandana, et al. 2021). Emissions resulting from human activities are divided into two types: primary and secondary carbon emissions (Wiratama et al., 2016).

The Life Cycle Assessment (LCA) can be used to assess the impact of various activities, particularly those that come from hotels. This assessment can aid in decision-making for reducing the effects on the environment regarding SNI ISO 14040:2016 and SNI ISO 14044:2017. The LCA document based on regulation of The Ministry for Environment and Forestry No. 1/2021 is one of the assessment aspects in the green document PROPER (Public Disclosure Program for Environmental Compliance). Therefore, through the LCA study, effective preventive measures can be determined through environmental, economic, and social-based development so that emissions from hotel activities in Pontianak can be controlled. The novelty of this research is the analytical method in formulating air pollution control strategies by integrating calculations using the LCA method and dominant emission management strategies from hotel activities.

1.2 Purposes

The purpose of this research is to analyze the environmental impact using the LCA method on X and Y Hotel's operational activities on each facility and to examine the X and Y Hotel's operational activities based on the class difference, as well as to formulate an environmental management strategy for controlling environmental pollution due to an increase in greenhouse gases from energy consumption during the operational activities of the X Hotel and Y Hotel in Pontianak.

2. METHODOLOGY

2.1 Environmental Footprint Analysis

Data from emissions caused by hotel activities were quantitatively examined using openLCA 1.11.0 software. The first stage of data analysis was to set the goal and scope. In this study, the system units observed were hotel operational activities that were directly related to guest services. Functional units of this research are energy consumption from electricity, fuel, and LPG, as well as the amount of greenhouse gas impact produced per guest and night. This study uses a life cycle energy assessment to concentrate on how much energy is used over a year by a hotel.

The data in this research was obtained from interviews with hotel managers and engineering staff at both hotels. The data was then cross-checked for its consistency with the conditions in the field. The data inventory includes the hotel profile, hotel activities, number of electronic devices, usage time, and amount of fuel that used for hotel operations. The collected data will be calculated through the Life Cycle Inventory (LCI) with the ecoinvent 3.8 database as input-output energy emissions data. This database provides data from various countries and has wide scope, such as energy supply, metals, agriculture, and waste management. The data assessed the potential impact of the Life Cycle Impact Assessment (LCIA) stage based on the hotel activity unit using the CML-IA baseline method. Based on the results of this analysis, it is possible to identify the activity units that contribute the most to emissions and the types of impacts that are caused so that an appropriate management strategy can be given. Then, using the openLCA program, determine the key problems with the scope of the impact coming from analysis. Therefore, the effect assessment from the LCIA stage and the inventory data from the LCI stage are appropriately correlated.

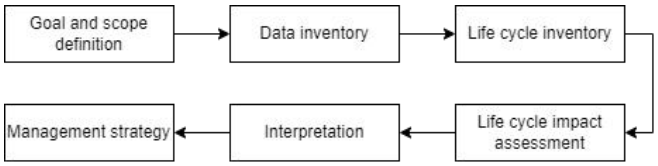

Figure 1. Flow Diagram of Environmental Footprint Analysis

2.2 Proposed Management Strategy

The proposed management strategy refers to a document by Indonesia Clean Energy Development (ICED) (2015), which is divided into several systems, such as the building envelope system, air conditioning system, hot water system, building electricity and transportation system, and building automation system. The consumption of power, specifically from the usage of lights and air conditioners, is the primary factor that generates the most significant emissions, as can be seen from hotel operational operations in general. Installation of lights with automatic sensors for efficient use of electricity.

3. RESULTS AND DISCUSSION

3.1 Categories of Hotel Activities

Hotel operational activities consist of 4 phases of guest cycle such as the pre-arrival, arrival, stay, and departure phases (Abed, 2017). Types of operational activities in hotels have differences depending on the class. Hotel X, which is a 4-star hotel, has more complete facilities than Hotel Y, which is a 3-star hotel. The type of building also affects energy use in its operations, especially the lighting. Hotel Y's lobby has walls made of glass so that during the day the use of lights can be minimized. Hotel X consists of 4 floors and has a total of 155 rooms. X Hotel serves as both a hotel and a convention center, which is frequently utilized for a variety of events like meetings, congresses, parties, and even weddings. Other than the rooms, the facilities in this 4-star hotel include basic and supporting facilities, such as a lobby, kitchen, restaurant and bar, swimming pool, spa, gym, laundry, and transportation. Meanwhile, Y Hotel, which is a 3-star hotel has 106 rooms. Hotel Y has 12 floors, of which the top 2 floors, are allocated as cafes and restaurants. Unlike the X Hotel, the facilities only consist of a lobby, rooms, kitchen, bar, laundry, and transportation.

Annual inventory data used in this research provided by the hotels and then cross-checked the suitability with the conditions at that time. However, it would be better if the data were available in every month because the occupancy rate and number of guests are different each month, so the amount of energy usage will also be different in each month. It would develop a clearer image of energy use for each month of the year.

3.2 Analysis of Hotel Activities

In 2019, the Hotel X consumed 4.716.110 kWh of electricity. From the lobby to transportation, hotels use electricity to run their activities. The 2 main emissions are carbon dioxide (CO_2) and methane (CH_4) in the GWP category. Facilities that produce the most significant emissions are lobby corridors, deluxe rooms, and executive rooms. The facilities that contribute the least to gas emissions are the garden pool, transportation, and meranti meeting rooms. The emission of gas is the result of burning coal which the coal power plant to produce electricity. In the ADP-f category, there are several types of fuel, such as coal, natural gas, and oil. Different materials are utilized as fuel for different uses. Oil serves as the primary abiotic resource for transportation infrastructure as well since it is used as a gasoline. 2 types of coal are most widely used is brown coal and hard coal. Brown coal is a type of lignite and bituminous coal that is often used for power plants. This type of coal includes low-calorie coal, which has calories <5,500 kcal/kg.

While hard coal, is an anthracite coal which is type of high-calorie coal that is > 7,200 kcal/kg (Wibowo & Widarta, 2020).

In the PCOP category, the most dominant gas emission is sulfur dioxide (SO_2). Beyond SO_2, carbon monoxide (CO) and methane (CH_4) were the gases that almost all facilities produced in the greatest amounts. For transportation facilities, because the main fuel is gasoline, the biggest emissions are SO_2, CO, and ethanol. Lobby facilities produce the most emissions, followed by deluxe and executive rooms. Figure 3 below shows the impact on each X Hotel facility. For the GWP impact category in Y Hotel, compared to the lobby corridor, the facilities that produce the most emissions are deluxe rooms. This is due to the fact that in addition to the lobby building being surrounded by a glass wall, the lobby's space is also smaller than that of the X Hotel. So, energy use for lighting can be reduced, especially during the day. The ADP-f impact results also reveal that, out of all the facilities at Hotel Y, the deluxe rooms emit the most emissions. The resulting emissions come from the use of electricity which has fuel in the form of coal.

Based on the use of coal, several emissions have the potential to cause the formation of photochemical smog, especially from coal which has low calories. Low-calorie coal will produce a lot of emissions, such as carbon, sulfur, and nitrogen (Supendi et al., 2021). The production of sulfur dioxide (SO_2) is the largest emission from the combustion process. The facility with the greatest contribution to producing emissions that cause the effects of photochemical oxidation is the deluxe room. The total SO_2 gas produced by the deluxe room is almost equivalent to the total SO_2 gas produced by all the facilities. Its contribution to emissions from the use of LPG and oil is less than 1%. Based on Figure 3, transportation facilities contribute at least less than 1%. The kitchen-restaurant facility in the ADP-f impact category has a greater contribution than the other two impact categories, this shows that the use of LPG affects the depletion of fuel sources. The main facilities that contribute the most are room facilities by 60-62% in the three categories.

3.3 Environmental Impacts Analysis

In this study, X and Y Hotel used electricity, diesel, LPG, and gasoline to help each facility function properly, consisting of various process stages. Both use electricity from PT. PLN Pontianak which uses coal power plants. Starting with the raw material extraction, the mining process involves stages like land clearing, where catchment areas are converted to mining areas, which have the potential for disasters. During the transportation process, it also produces emissions from transportation equipment in the form of air emissions, such as dust, gas pollutants, and increased noise. The processing procedure comes next, which includes a washing stage, that if it is not correctly controlled, will contaminate the water quality when discharged.

Furthermore, these raw materials enter the power plant to be processed into a source of electricity which during the stages also produces pollutants. The existence of emissions such as CO_2, SO_2, NO_2, CH_4, will pollute the environment, such as water, air, and soil. The impacts can be in the form of acidification, eutrophication, depletion of the ozone layer, and increased global warming. These things end up affecting human health, both physical and mental health. Of the 3 impact categories, this is the interpretation of the emissions with the biggest influence from each impact category. The use of coal has an impact on greenhouse gas emissions, which cause global warming. Also, the process of obtaining coal through a mining process causing natural resources are depleted. The combustion process to produce electricity from coal also released pollutant gases, one of which is SO_2, which is the main factor in the occurrence of acid rain that can disrupt the photosynthesis process and pollute clean water.

Table 1. X Hotel Inventory Result

X HOTEL			
	GWP (kg CO_2 eq)	**ADPf (MJ)**	**PCOP (kg C_2H_4)**
	Carbon dioxide, fossil	**Coal, brown, in ground**	**Sulfur dioxide**
Lobby-Corridor	1,565,070	13,576,600	205,141
Ballroom	56,440	489,604	7,398
Meeting Room	34,019	295,104	4,459
Meeting Room Mer.	12,281	106,537	1,610
Kitchen-Restaurant	552,982	4,796,970	72,482
Deluxe Room	1,416,470	12,287,500	185,663
Superior Room	650,391	5,641,970	85,250
Executive Room	749,513	6,501,820	98,242
Suite Room	183,250	1,589,650	24,019
Family Room	203,502	1,765,330	26,674
Park-Pool	402	3,487	0.053
Laundry	26,909	233,425	3,527
Gym	33,667	292,054	4,413
Spa	57,873	502,036	7,586
	GWP (kg CO_2 eq)	**ADPf (MJ)**	**PCOP (kg C_2H_4)**
	Carbon dioxide, fossil	**Oil, crude, in ground**	**Sulfur dioxide**
Transportation	1,759	243,989	0.448

Table 2. Y Hotel Inventory Result

	HOTEL Y		
	GWP (kg CO_2 eq)	**ADPf (MJ)**	**PCOP (kg C_2H4)**
	Carbon dioxide, fossil	**Coal, brown, in ground**	**Sulfur dioxide**
Lobby-Corridor	378,072	3,279,680	49,556
Kitchen-Restaurant	188,801	1,637,800	24,747
Deluxe Room	799,335	6,934,020	104,772
Superior Room	199,923	1,734,280	26,205
Suite Room	22,197	192,555	2,909
Laundry	49,108	425,998	6,437
	GWP (kg CO_2 eq)	**ADPf (MJ)**	**PCOP (kg C_2H4)**
	Carbon dioxide, fossil	**Oil, crude, in ground**	**Sulfur dioxide**
Transportation	211	29,269	0.054

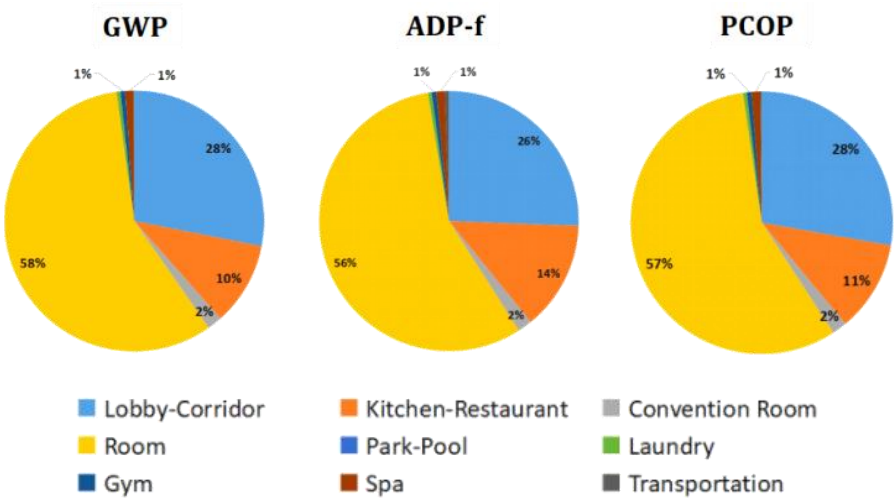

Figure 2. X Hotel Environmental Impact per Facility in 2019

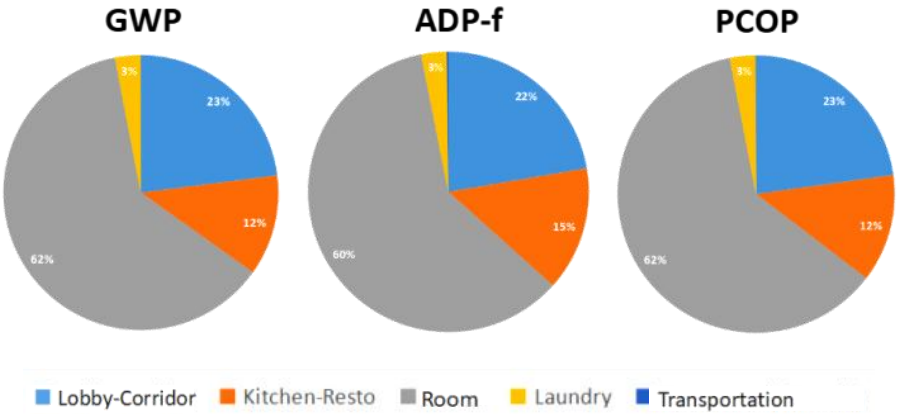

Figure 3. Y Hotel Environmental Impact per Facility in 2019

3.3.1 Global Warming Potential

Global warming is caused by an increase in the concentration of greenhouse gases in the atmosphere which changes the absorption of infrared radiation that impacts climate patterns changes and increases the earth's temperature (Florides & Christodoulides, 2009). The GWP impact category units are kg CO_2 eq. CO_2 gas is the most common gas that causes an increase in the earth's temperature and is emission from various activities; one of the sources is the use of energy such as the use of electricity and fuel. CO_2 is the result of the process of burning fossil fuels, such as coa, which is a source of raw material for steam power plant, and diesel and gasoline. Each hotel facility has the same inputs and outputs, they use electricity from a coal power plant and diesel fuel used for the generator set as inputs. The generator set is only used during periodic power outages by the National Electricity Company (PLN). The output is in the form of electrical power used for guest services in each facility according to usage. Some

facilities have different energy inputs, such as in the kitchen and restaurant facilities, where Liquefied Petroleum Gas (LPG) is used for cooking activities on stoves. For transportation facilities, the input energy source is gasoline (pertalite) for cars.

The impact of increasing greenhouse gases in addition to rising temperatures is climate change. Climate change occurs naturally, but since the pre-industrial, human activity has been the main cause of climate change. This climate change causes several natural phenomena, such as rising sea levels, the extinction of several species, and the occurrence of extreme floods and droughts. Natural disasters such as floods and droughts certainly affect the agricultural sector, causing limited food availability. Human health is also affected by the presence of greenhouse gases. Pollution caused by the use of fuel, both from transportation, industrial and household activities, such as the presence of CO, CO_2, NOx, SOx, CH_4, CFC, O_3, and PM, can cause respiratory problems (Masson, 2018).

3.3.2 Abiotic Depletion Potential

Abiotic depletion potential is divided into 2 type, non-fossil (ADPn) and fossil (ADPf). Although non-fossil abiotic depletion also includes fossil fuels, the assessment focuses more on minerals and other non-renewable abiotic. Meanwhile, abiotic fossil depletion focuses on fossil fuels including all their sources. The use of fuel continuously will cause the depletion of natural resources, especially coal (Oers & Guinee, 2016).

For the category of abiotic depletion fossil impacts, the most used resource is bituminous coal, which is included in brown coal. Pontianak has 2 coal power plant units with a load of 35 MW, which operate for 24 hours. That unit requires coal as much as 26.75 tons/hour. So that, per day it requires 1,284 tons of coal to produce electricity that will be used for Pontianak services. The electricity used in the hotel's operations, which is the main energy source, comes from coal. The demand for coal results in emissions not only from the process of converting it into electricity but also, long before that, from the mining process, which causes various types of emissions and environmental impacts. The primary impact resulting from coal mining is land degradation. This land degradation is caused by the excavation process that damages the soil layers. There is also a change in land use where areas that initially served as green open spaces or water infiltration zones transform into barren mining areas. As a result, when it rains, there are no infiltration zones, leading to natural disasters such as floods and landslides.

3.3.3 Photochemical Oxidation Potential

Photochemical oxidation or photochemical smog is a pollutant gas formed from gases such as NOx, VOCs, and Peroxy Acetyl Nitrate (PAN) which, reacts with UV light in the atmosphere to form a brown haze that is often seen in the morning and evening, especially in areas with dense population and warm geography (Bhartendu, 2013). The use of fuel as the operational energy source in hotels involves a combustion process. This combustion process generates gas emissions, namely SO_2, CO, CH_4, and several other gases. The most significant gas emission is sulfur dioxide (SO_2) that both hotels produce that causes photochemical oxidation effects.

This SO_2 is the emission from the combustion process, of burning coal and oil. The impact caused by the high SO_2 gas on the environment is that it can damage the leaf structure which will interfere with the process of photosynthesis, thus inhibiting plant growth. The high level of SO_2 also affects the formation of acid rain. Water from this acid rain will contaminate clean water sources and be dangerous if consumed by organisms. As for humans, this gas can also cause eye irritation, visual disturbances, and respiratory problems.

3.3.4 The Environmental Impact on Pre-Pandemic, Pandemic, and Post-Pandemic

The hotel's energy consumption is influenced by the number of facilities and the number of guests. The data used in the study is from 2019, 2020, and 2021. This data was chosen to analyze energy usage during normal times before the COVID-19 pandemic, during the pandemic, and after COVID-19 became endemic. Prior to the COVID-19 outbreak in 2020, the number of guests and the use of hotels as event venues has also drastically reduced due to the Large-Scale Social Restrictions (PSBB). Its purpose is to prevent the spread of COVID-19 by prohibiting public activities in places such as offices, places of worship, shopping areas, tourist zones, and so on.

The decrease in incoming guest not only affect on energy consumption, but also affect the hotel operational system. They need to do energy savings to ensure the hotel business can survive through the pandemic due to reduced income. The decrease in energy consumption also results in a decrease in the environmental impact. However, in 2021, the global economy, especially in Indonesia, is slowly starting to recover, particularly in the tourism sector, which impacts hotel operations and the number of incoming guests. The following is a comparison of energy consumption and the number of guests served by the X Hotel in 2019-2021.

Table 3. Total Energy Consumption and Guests X Hotel in 2019-2021

Year	Energy Consumption (kWh)	Guests (people)
2019	4,026,131	473,627
2020	3,285,299	367,884
2021	3,854,149	391,427

Table 4. Total Energy Consumption and Guests Y Hotel in 2019-2021

Year	Energy Consumption (kWh)	Guests (people)
2019	1,189,394	35,138
2020	965,606	25,998
2021	1,110,066	31,123

The amount of energy consumption is directly proportional to the number of guests served. Energy consumption in 2019 was 4,026,131 kWh for a total of 473,627 people. Whereas in 2020, there was deflation, especially from March to April, which was the peak of the COVID-19 pandemic. In 2020, 367,884 people consumed 3,286,299 kWh of energy. Then in 2021 when COVID-19 had started to enter the endemic phase, the number of guests again increased to 391,427 people followed by an increase in energy consumption of 3,854,149 kWh. As is the data in Table 5, shows a comparison of the magnitude of the impact generated by the X Hotel per guest per night from 2019 to 2021. In the three impact categories, there are differences in the resulting impact. In the lobby-corridor facility in 2021, the value of the impact are the largest compared to the 2 previous years. This is because the number of guests in 2021 is not much different from the guests served in 2020, but with 100% operational conditions. The 100% service condition referred to is that there are no efforts to reduce electricity consumption such as turning on lights and air conditioning. For the number of guests in 2021 of 391,427 people, the resulting global warming impact is 0.0111 kg CO_2 eq/person/night from energy consumption of 1,136,829 kWh/year.

In 2019 with 100% operation, the resulting impact was 0.00921 kg CO_2 eq/person/night with a total of 473,627 guests. Whereas in 2020, to reduce energy consumption during the COVID-19 pandemic, Hotel X reduced electricity usage by 35% for 5 months, from April to August. So that only 75% of the operational electricity causes an impact of 0.0109 kg CO_2 eq/person/night. The difference in numbers is not that significant when compared to 2021 because the difference in guests is only 23,543 people, and guests in 2020 were 367,884 people. In 2020, there will also be facilities that will have the greatest impact compared to 2019 and 2021, such as ballrooms, suite rooms, and family rooms. This is because the energy consumption generated in the room when it is used is the same as 100% but with fewer guests, related to the social distancing policy that activities in public areas are limited to only 50% of the full quota. the impact produced by 1 person per night is greater than the years during the pre-pandemic and post-pandemic. In 2019-2021, Hotel Y also underwent a decrease in the number of guests and energy consumption due to the pandemic. In 2019, the number of guests was 35,138 people, not only the guests that rent a room but also guests who used restaurant facilities that were open to the public. In 2020, the number of guests dropped to 25,998 people, bringing energy consumption to just 965,606 kWh. Then in 2021, there is an increase in energy consumption because the number of guests has also increased to 31,123 guests. This is a comparison of energy consumption and guests of Y Hotel in 2019 to 2021 .

Based on energy consumption, 2019 is the largest hotel operational energy consumption to 2020 and 2021. However, based on the calculation of the impact generated from each guest per night, 2019 produces the smallest impact due to the amount of energy consumption in public facilities that operate regularly. Public facilities include the lobby-corridors, kitchen-restaurant, and laundry. This is because the number of guests does not affect the operation of the facility. The number of visitors has a significant impact on how much energy is used by in-room amenities because more people mean more energy is used. From 2019-2021, the facilities that have the most impact from the three categories are deluxe rooms. Even though in 2020 there were 25% electricity savings, the impact in those years was relatively the same. Deluxe rooms are generally occupied by 1 person per room, so it is assumed that the number of rooms is the same as the number of guests. Unlike the suite rooms which can generally be filled with 2-3 people, during the pandemic, it was only filled with 1-2 guests, so the impact per person per night was bigger. This is the comparison of the impact categories from 2019 to 2021 in Table 5. Emissions generated by the tourism sector globally in 2008 produced 5% of GHG emissions. These emissions increased to 8% in 2009-2013 and are expected to increase in 2030 to 25%. In 2020-2021 there will be a decrease in global GHG by 7% and will decrease in the number of tourists globally from 850 million to 1.1 billion people (Herrero et al., 2022). The decline in the global tourism sector also occurred in Pontianak, such as a decrease in occupancy and the number of guests which resulted in a decrease in energy consumption.

3.4 GHG Management Strategy for Hotel Operational Activities

For X Hotel, the lobby-corridor facility is the facility that has the greatest contribution to generating impact. The energy consumption comes from the use of electricity from coal power plants. The electricity is used for air conditioning and lights. The use of AC for large rooms is also difficult to reduce, especially in the lobby which is an open space without a partition in the form of a door so the airflow from the AC is needed. Energy efficiency can be applied to the lobby corridor by using a timer or rotating system of air conditioning in the corridor section. so that the AC can be turned on within <20 hours and on each floor. The second facility that has the biggest impact is the deluxe room. The use of bunch type of lamps can be reduced considering that apart from those lamps there are general lamps on the ceiling of the room.

However, from the impact generated per guest per night, the spa and gym facilities have the greatest impact. The number of guests using these facilities is very small, so when there are no guests, it is recommended to use air conditioning and lights to be dimmed. These can be applied to spa facilities where there are employees who are ready to be at the spa facility. For gym facilities, in general, no employees are supervising in that area, so a sensor system can be used so that electricity is only active when there are guests who are going to use the facilities.

Hotel Y has a deluxe room facility that has the most significant impact. In the room facilities, there is a kettle jug that has 600 watts, this type of kettle jug can be replaced with a lower power type so that it can reduce the energy consumption of room facilities. Reducing electrical energy can also be optimized from corridor facilities by implementing a timer or shift system on air conditioners and lights in the area so that all electronic devices do not operate all at once for 20 hours.

Table 5. X and Y Hotel Inventory Result

X HOTEL

Facilities	Global Warming (kg CO_2 eq/person/night)			Abiotic Depletion (MJ/person/night)			Photochemical Oxidation (kg C_2H_4 eq/person/night)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Lobby-Corridor	0.0092	0.0109	0.0111	0.0747	0.0950	0.0974	0.0000013	0.0000015	0.0000016
Kitchen-Restaurant	0.1128	0.0081	0.1471	1.3181	0.0072	1.6123	0.0000175	0.0000012	0.0000231
Convention Room	0.0007	0.0009	0.0008	0.0061	0.0940	0.0071	0.0000001	0.0000001	0.0000001
Ballroom	0.0005	0.0108	0.0006	0.0041	0.0944	0.0055	0.0000001	0.0000015	0.0000001
Meeting Room	0.0014	0.0314	0.0018	0.0122	0.2747	0.0157	0.0000002	0.0000044	0.0000003
Meeting Room Meranti	0.0074	0.0008	0.0082	0.0649	0.0072	0.0712	0.0000010	0.0000012	0.0000012
Room	0.1400	0.1280	0.1686	1.2233	1.1183	1.4733	0.0000198	0.0000181	0.0000238
Deluxe	0.1613	0.1619	0.1705	1.4096	1.4150	1.4898	0.0000228	0.0000229	0.0000241
Superior	0.1580	0.1612	0.0743	1.3812	1.4092	0.6489	0.0000223	0.0000228	0.0000105
Executive	0.1013	0.1941	0.1859	0.8857	1.6960	1.6248	0.0000143	0.0000274	0.0000262
Suite	0.1577	0.1758	0.0438	1.3779	1.5363	0.3824	0.0000223	0.0000248	0.0000063
Family	0.1424	0.2020	0.1229	1.2444	1.7656	1.0743	0.0000201	0.0000285	0.0000174
Park-Pool	0.0006	0.0010	0.0004	0.0050	0.0090	0.0038	0.0000001	0.0000001	0.0000001
Laundry	0.0588	0.0859	0.0764	0.5138	0.7507	0.6676	0.0000083	0.0000121	0.0000108
Gym	0.1840	0.1213	0.2398	1.6082	1.0604	2.0956	0.0000260	0.0000171	0.0000338
Spa	0.2529	0.1669	0.3286	2.2099	1.4582	2.8715	0.0000357	0.0000236	0.0000464
Transportation	0.0098	0.0097	0.0081	0.7638	0.7554	0.6334	0.0000046	0.0000045	0.0000038

Y HOTEL

Facilities	Global Warming (kg CO_2 eq/person/night)			Abiotic Depletion (MJ/person/night)			Photochemical Oxidation (kg C_2H_4 eq/person/night)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Lobby-Corridor	0.0233	0.0287	0.0262	0.2032	0.2509	0.2290	0.000003	0.000004	0.000004
Kitchen-Restaurant	0.0476	0.0602	0.0545	0.5198	0.6114	0.5692	0.000007	0.000009	0.000008
Room	0.0839	0.0837	0.0838	0.7334	0.7318	0.7325	0.000012	0.000012	0.000012
Deluxe	0.0829	0.0829	0.0829	0.7248	0.7248	0.7242	0.000012	0.000012	0.000012
Superior	0.0828	0.0829	0.0829	0.7235	0.7243	0.7248	0.000012	0.000012	0.000012
Suite	0.1864	0.1910	0.1719	1.6288	1.6690	1.5021	0.000026	0.000027	0.000024
Laundry	0.2016	0.2464	0.2255	1.7620	2.1534	1.9710	0.000028	0.000035	0.000032
Transportation	0.0022	0.0014	0.0026	0.1723	0.1117	0.2038	0.000001	0.000001	0.000001

4. CONCLUSION

X Hotel and Y Hotel are star hotels in Pontianak with the status of Y Hotel being 3 stars and X Hotel being 4 stars. The activities of both hotels are quite similar, namely that they both have a lobby, kitchen, restaurant, room, laundry, and transportation facilities. The different is on the type of room and other additional facilities, such as Hotel X providing spa, gym, and swimming pool facilities, apart from that Hotel X also functions as an event and meeting venue, while Hotel Y does not have additional facilities. In the category of impact produced by each facility, whether global warming, abiotic depletion, or photochemical oxidation, the X and Y Hotel facilities with the greatest impact are rooms that are an accumulation of various types. However, from the total impact of the room facilities, the deluxe type is the room with the greatest contribution. Based on the impact per guest per night, for the X Hotel the largest facilities are the spa, and for the Y Hotel is a laundry facility. This is because of spa and laundry facilities, only ±1-2% of the guests were served from the total of guests, so the impact generated per guest is greater than for room facilities whose number is more or less the same as the number of guests served.

The most important management strategy for both the X and Y Hotels is the usage of lights and air conditioning by using a sensor system. In the spa facilities at the X Hotel, when there are no guests to be served. For the gym, a sensor system can also be implemented to activate electricity in the area. For deluxe rooms at the X Hotel, the types of lamps can be reduced. For Y Hotel, in the deluxe room, the electronic device with the greatest power is a kettle jug that has 600 watts. This type of kettle jug can be replaced with a lower-power type on the market.

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