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Implementation of Carbon Accounting in Green Buildings at the Ministry of Public Works and Public Housing (PUPR)

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Abstract---*This research aims to describe the implementation of carbon accounting in green buildings in the Ministerial Building of the Ministry of PUPR. This research explores more deeply how carbon accounting practices can be applied and provide benefits in efforts to reduce emissions in green buildings. This study used qualitative research methods. This research uses a case study approach as an in-depth qualitative methodology. The location of this research is the Ministerial Building of the Ministry of PUPR which is located at Jl. Pattimura No. 20 South Jakarta. For the validity of this research data, researchers used triangulation techniques. The results of research on the implementation of carbon accounting and the amount of carbon produced in the Ministerial Building of the Ministry of PUPR, namely the amount of carbon accounting from electricity use in 2023 was recorded at 1,829.3 tonco2e, the amount of carbon accounting from water use in 2023 resulted in carbon accounting of 8.07 tonco2e, the implementation of reduction Carbon emissions and the intensity of building use cause an increase in emissions in the 2019-2023 period. Trend analysis of carbon emissions from water use peaked in 2013 at 10,556 kgco2e. Steps to reduce carbon emissions in the Ministerial Building of the PUPR Ministry have had a positive impact in reducing emissions which in turn has also had a positive impact on accounting for the carbon produced. Continuous efforts and the application of new, more efficient technologies are necessary to achieve environmental sustainability goals.*
Keywords---*Carbon Accounting, Green Buildings, Ministry of Public Works, Public Housing.*

Introduction

Climate change and the global environmental crisis have driven the importance of carbon accounting in the era of sustainable development. Carbon accounting is a process that involves measuring, calculating, monitoring, reporting, and auditing greenhouse gas emissions at the organizational, process, product, or supply chain level. Activities related to accountancy carbon have been ongoing for the last twenty years, covering various aspects from measuring to auditing greenhouse gas emissions (Csutora & Harangozo, 2017).

Carbon accounting plays an important role in providing accurate and measurable data regarding carbon emissions, which is a crucial factor in tackling climate change. In connection with reducing carbon dioxide (CO2) emissions in the Gulf Cooperation Council (GCC) countries, Al-Muhanadi et al. (2020), state that the accounting

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profession has a strategic role in achieving sustainable development goals through participation in decision-making processes and reporting quality information, which has an impact on the environment and society.

The importance of carbon accounting becomes clear in global and local contexts, especially in the face of climate change. Efforts to achieve sustainable development goals (SDGs) require a strong focus on managing carbon emissions and sustainability strategies, which are priorities for all countries. Cities, as centers of human activity that accommodate more than half of the world's population, play a vital role in climate change mitigation efforts. Cities are responsible for three-quarters of global energy consumption and greenhouse gas emissions, making them the focus of emissions reduction strategies (Satterthwaite, 2008).

On a more specific scale Carbon accounting in urban areas, such as Jakarta, is picking up a role important in Indonesia's national strategy for sustainable development. Based on a press release from the Coordinating Ministry for Economic Affairs, the Indonesian government has designated a green economy and low-carbon development as the main strategy for medium- and long-term economic transformation (Ekon.go.id, 2022). This initiative confirms Indonesia's commitment to sustainable development and responsiveness to climate change, by targeting growth that is not only fast but also environmentally friendly.

The Indonesian government has taken strategic steps to reduce greenhouse gas emissions through reducing deforestation and peatland degradation as part of the National Action Plan (Meehan et al., 2019). In addition, efforts to develop a sustainable city through the Transit-Oriented Development (TOD) concept in Palembang show a similar commitment to reducing carbon footprints (Asriana & Koerniawan, 2020). Although efforts have been made at urban and national levels, challenges related to the issue of carbon emissions remain significant, such as what happened in Jakarta. On August 13, 2023, Jakarta faced very bad air quality problems, with the air quality index (*Air Quality Index* -AQI) reaching 169, making it the city with the worst air quality in the world at that time (Kompas, 2023). This condition shows the high level of pollution and carbon emissions in the Indonesian capital, which has a significant impact on public health and the environment. This situation strengthens the urgency to take strategic steps to reduce carbon emissions, including implementing stricter environmental policies and developing green infrastructure. Through Nationally Determined Contributions (NDC), Indonesia is committed to reducing greenhouse gas (GHG) emissions by 29% on its own or 41% with international assistance by 2030 from business-as-usual conditions (Ministry of Energy and Mineral Resources, 2021).

Associated with challenges regarding the issue of carbon emissions, a very important thing is a deeper understanding of the scope of carbon accounting. Carbon accounting includes three main types of scope, each of which plays a specific role in the process of measuring and managing emissions. Scope 1 includes all direct emissions originating from sources owned or controlled by the entity, such as emissions from burning fuel in the company's operations. Scope 2 relates to indirect emissions resulting from the consumption of purchased energy, such as electricity, heating, and cooling, which, although not produced internally, are the responsibility of the organization. Scope 3, the broadest, includes all other indirect emissions that occur in an organization's value chain, including emissions from raw materials procured, products transported, and the way products are used and disposed of by consumers (https://www.epa.gov/, 2023).

Moving on from strategic efforts to integrate carbon accounting practices in the construction sector, the Ministry of Public Works, and Public Housing (PUPR) have taken steps to support the transition towards sustainable development. In progress, The PUPR Ministry has socialised PUPR Ministerial Regulation Number 21 of 2021 concerning Green Building Performance Assessment and Number 9 of 2021 about Guidelines for Implementing Sustainable Construction (PUPR Ministerial Regulation No. 9 of 2021, 2021; PUPR Ministerial Regulation No. 21 of 2021, 2021). This regulation is the Ministry of PUPR's contribution to fighting the climate change crisis, by stipulating that the provision of construction services for constructing buildings and/or civil structures must implement sustainable construction that maintains environmental preservation.

Currently, the implementation of green buildings in the PUPR Ministry is showing significant development. The PUPR Ministry has succeeded in receiving an award for the PUPR Ministerial Building, which was completed in 2012, in the Federation Internationale des Administrateurs de Biens Conseils Immobiliers (FIABCI) Indonesia-Real Estate Indonesia (REI) Excellence Award 2022 (Ministry of PUPR, 2022) The award received indicates recognition of the PUPR Ministry's efforts in developing outstanding property projects, including the application of green building principles.

In line with efforts to address climate change, some findings study previous reinforce the importance of green buildings as a key strategy in reducing carbon emissions and advancing environmental sustainability. Green buildings have been recognized as one of the most effective strategies in reducing carbon emissions, not only creating a healthier and more comfortable environment for occupants but also contributing significantly to global efforts to reduce the impact of climate change. Eo & Kim (2014) show that buildings, especially in urban areas, are responsible for most national greenhouse gas emissions, and reducing emissions from public buildings can lead cities towards low carbon and green. Wong et al. (2019) highlight that although carbon accounting practices have not yet been fully implemented compulsorily in the construction industry in Australia, their potential to influence building design decisions is significant. By emphasizing the implementation of carbon accounting, building designs can not only achieve higher energy efficiency but also minimize carbon consumption during the construction phase.

Understanding green buildings includes more than just reducing energy consumption and carbon emissions. Teddy & Priatman (2018) shows that Buildings P1 and P2 of Petra Christian University in Surabaya have significant potential to save water use, by implementing the principles of water conservation in green buildings through the application of technologies such as air conditioning, rainwater harvesting and gray water reuse. Permana et al. (2020) show that energy-efficient Micro House designs in the Net Zero Energy Buildings (NZE-Bs) program can achieve energy independence that is to meet its own energy needs without relying on external energy sources by optimizing the use of renewable energy sources and energy efficiency. This shows the importance of careful planning and design in achieving green building goals.

Seeing the increasing phenomenon of global warming and climate change, research on the implementation of carbon accounting in green buildings, especially at the PUPR Ministry, is very important. Carbon accounting, which is the process of measuring, managing, and reducing carbon emissions, plays a crucial role in global efforts to face today's environmental challenges. In green buildings, carbon accounting focuses not only on reducing carbon emissions but also on energy efficiency, saving resources and contributing to environmental sustainability (Mustaffa & Ibrahim, 2021; Li et al., 2020).

Green Building Council Indonesia (GBCI) is an independent (non-government) institution tasked with assessing green buildings in Indonesia (Regina et al., 2019). The assessment of green buildings in this country is carried out through a rating system created by GBCI, known as Greenship. Greenship is an assessment tool developed by GBCI to determine whether a building meets the requirements to be certified as a "green building". The Greenship assessment system was designed specifically for Indonesia, this system was developed taking into account Indonesia's local conditions, climate and needs, so certain aspects of Greenship may differ from green building assessment systems in other countries.

This research introduces a new approach that has not been widely studied in green building research, with a focus on indirect emissions analysis (scope 2) of those related to green buildings, especially in the PUPR Ministry. This approach was chosen because indirect emissions originating from purchased energy consumption, such as electricity and water, play an important role in the total carbon emissions from buildings. Although green buildings have long been established in the PUPR Ministry as a solution to reduce environmental impacts, ironically there is still a lack of research that specifically examines whether these buildings are truly effective in reducing carbon emissions. It is hoped that this research will fill the gap by providing an in-depth case study of how effective green buildings are in reducing carbon emissions. Refers to the duties and functions of the PUPR Ministry in Indonesia, which focuses on providing quality infrastructure and housing to support sustainable development.

Given the urgency and relevance of carbon accounting in addressing global environmental problems, the novelty of this research is that it presents an *approach* new in carbon accounting studies in Indonesia by implementing indirect emissions analysis (scope 2) on green building, an approach that has never been explored before in the country (Wong et al.,2015; Zhang & Xu, 2015). By taking the PUPR Ministry as the object of study, this research offers *close* news in identifying and managing the carbon footprint originating from purchased energy consumption in green buildings, providing valuable insight into the potential for emissions reductions in the infrastructure sector. Based on the background that has been presented, this research aims to dig deeper into how carbon accounting practices can be applied and provide benefits in efforts to reduce emissions in green buildings (Schaltegger & Csutora, 2012; Ascui & Lovell, 2012).

Methods

This study used qualitative research methods. This research uses a case study approach as an in-depth qualitative methodology. The location of this research is the Ministerial Building of the PUPR Ministry which is located on Jl. Pattimura No. 20 South Jakarta. The Ministerial Building of the PUPR Ministry consists of 17 floors with a building area of 26,646 m2.

This research uses primary data sources and secondary data. Primary data comes from direct interviews by researchers with stakeholder informants and building users as well as observations. Primary data in this research is data on the number and use of electronic devices, building management, employees occupying, and building maintenance activities to date. This data is used to determine the amount of electrical energy consumption, the amount of CO2 emissions in building Minister of PUPR and the comfort of building users. In this research, secondary data is information regarding electricity usage and water usage at the Ministerial Building of the PUPR Ministry. This information will be used to calculate the equivalent carbon accounting secondary in research (Shao et al., 2014).

The data collection technique was carried out using methods appropriate to the objectives. The data is divided based on how it was obtained, namely interviews. Researchers prepare questions in a semi-structured and open-ended manner designed to elicit views and opinions from participants (Creswell, 2015). The purpose of the interview was to obtain identification data on electrical equipment, the number of electrical equipment, electricity consumption, use of electrical equipment and water usage in building minister.

The informants in this research are stakeholders involved in building projects as well as users of the PUPR Minister's Building as many 2 persons. Following are several informants who were chosen because he was directly involved with the implementation and management of the Ministerial Building of the Ministry of PUPR (table 1).

Table 1
Stakeholders Involved in Green Building Projects

No	Research informant	Institution	Information
1.	Head Building Manager	PT. Airkon Pratama	Building management
2.	Technician	Public Bureau of the Ministry of PUPR	Implementing operations for the PUPR Minister's Building

Source: author's preparation (2024)

Researchers collected data through direct observation of the process of using electrical equipment and water within 5 working days (Monday – Friday) at 08.00 – 09.00 and 17.00 – 18.00, in this process the observer will collect information in the form of the use of lifts, use of lighting, use of meeting rooms and use of sanitary without the knowledge of the people at the time of the observation.

For the validity of this research data, researchers used triangulation techniques, which involve the use of various data sources, methods, or theories to verify the truth of the data. This research uses data source manipulation: to explore the truth of certain information through various methods and sources of data acquisition. Validity in this research by describing and categorising the results of interviews with informants. The researcher carries out a comparison of interview results and obtains supporting data sources such as documents shown by informants as evidence so that data/information from the informant is more accurate.

Results and Discussion

Civil Servants in the Ministerial Building of the Ministry of Public Works and Public Housing

The Ministerial Building of the Ministry of Public Works and Public Housing with a total of 968 civil servants (PNS) in 2024 spread over 17 floors and 1 semi-basement. Placement of employees on each floor in the Ministerial Building of the PUPR Ministry. Based on data on the distribution of civil servants in the PUPR Ministry Building, it appears that this building accommodates 968 employees spread across various floors and work units. The use of electrical energy in this building is greatly influenced by the number of employees working on each floor, considering that the use of electronic devices such as computers, air conditioning and lighting will be more intensive in areas with a high number of employees, such as on the 4th floor with 121 employees and the 16th floor and 17 each with more than 100 employees. In addition, sanitation use will also be high, especially on floors with many employees, due to the need for facilities such as toilets and sinks. For example, the 4th floor with 121 employees and the 16th and 17th floors with more than 100 employees will have high levels of sanitation usage, meaning water and energy consumption for water processing and distribution will also increase (Zhang et al., 2018).

Inventory Electrical equipment and Sanitary

The need for electrical equipment to support office operational activities such as: lighting, air conditioning (AC), and electronic equipment in Ministry Minister Building PUPR was fulfilled by PT. State Electricity Company (PLN) Bulungan with the required electricity is supplied 1500 kVA 2 units, and 2 generators are also provided as electricity backup with a supply of 1500 kVA each, while for water needs from PT. PAM JAYA. is the person responsible for electricity use and payment electric range

Air Conditioning (HVAC) in the Ministerial Building of the PUPR Ministry

In the PUPR Ministry's Ministerial Building, one of the facilities that has been installed is an air conditioning system, better known as air conditioning (AC). The aim of installing this AC is to increase the comfort of building occupants by regulating room temperature and humidity. At the PUPR Ministry, the AC system used is following table 4.4, which is operated 14 hours per day, from 06.00 to 20.00 WIB from Monday to Friday, but on certain days it is used later than 20.00 WIB for overtime work activities. Based on the results of interviews with Airkon, it was stated that electrical equipment such as Chillers, Chiller Water Pumps, Cooling Water Pumps and Fan Coil Units use diesel power sources for their use, so the calculations for the PK units are unknown.

Lighting in Green Buildings at the Ministry of PUPR

Lighting is an important element in creating a safe and comfortable environment, which directly affects human productivity. There are two types of lighting: natural lighting, which comes directly from the sun, and artificial lighting, which comes from light sources that are not the sun. In the Ministerial Building of the PUPR Ministry, lighting facilities include both natural and artificial lighting. For artificial lighting, TL lamps and CFL lamps (Essential) are used, which operate for 10 hours per day.

Use of Computers in the Ministerial Building of the Ministry of PUPR

In the Ministerial Building of the PUPR Ministry, desktop computers are used by all employees for their work needs, with the calculation that each Civil Servant (PNS) desk has 1 desktop computer unit. Employees also have laptop units, but laptops are usually used for daily activities for meetings or business trips.

Use of Exhaust Fans in the Ministerial Building of the PUPR Ministry

Exhaust fans are used to improve air circulation and ensure good air quality in the Ministerial Building of the Ministry of PUPR. Exhaust fans play an important role in removing dirty and smelly air, as well as helping to regulate the room temperature to keep it cool and comfortable.

Use of Water Pumps in the Ministerial Building of the Ministry of PUPR

In the Ministerial Building of the PUPR Ministry, the use of energy-efficient water pumps is an important part of green building infrastructure. These pumps are tasked with distributing water efficiently for cooling, heating, and sanitation systems, supporting sustainable water resource management efforts. The pump's advanced technology allows output to be adjusted based on actual needs, which optimizes energy consumption and reduces waste, contributing to the overall efficiency of the building. Specific information regarding the number and specifications of pumps is available in the building documentation in table 1.

Table 1
Inventory Water pump

No	Equipment Data	Location	Capacity (Watts)	Number of units)	Brand
A	Clean Water Pump				
1	Transfer Pump Office	R. Pump	37,000	2	Grundfos
2	Filter Pump	R. Pump	1,500	2	
3	Drain Pump	R. Pump	5,500	1	Paco
4	Booster Pump Office	Roof Office	1,500	2	Grundfos
B	Dirty Water Pump				
1	Blower Motor	R. STP	3,700	1	TECO
2	Filter Pump	R. STP	1,500	2	
3	Effluent Pump	R. STP	1,500	1	Grundfos
			3,700	1	Ebara
4	Transfer Pump Office	R. STP	4,000	2	Grundfos

No	Equipment Data	Location	Capacity (Watts)	Number of units)	Brand
5	Parking Pump Transfer	R. STP	840	2	
C	Submersible Pump				
1	Sump Pit Pump 1	Basement	2,200	1	Grundfos
			750	1	
2	Sump Pit Pump 2	Basement	750	2	Grundfos
3	Sump Pit Pump 3	Basement	750	2	Grundfos
4	Sump Pit Pump 4	Basement	750	2	Grundfos
5	Sump Pit Pump 5	Basement	750	2	Grundfos
6	Sump Pit Pump 6	Basement	5,500	2	Grundfos
7	Sump Pit Pump 7	Basement	750	2	Grundfos
8	Sump Pit Pump 8	Basement	750	2	Grundfos
9	Sump Pit Pump 9	Basement	1,500	2	Grundfos
10	Sump Pit Pump 10	Basement	2200	2	Grundfos

Source: Airkon, 2024

Use of the Elevator in the Ministerial Building of the Ministry of PUPR

Lifts play a vital role in ensuring the accessibility and efficiency of vertical transportation. In the Ministerial Building of the PUPR Ministry, there are six lifts which are used to optimize traffic distribution between floors. Three of them specifically serve even floors, while the other three are intended for odd floors, making it easier for visitors and staff to reach their destination quickly and efficiently. In addition, a special lift is provided for direct access to the basement, strengthening the overall function of the lift system in supporting environmentally friendly and effective building operations. This facility is important in supporting green building principles which emphasize efficient energy use and minimal environmental impact. Data related to elevators in the Ministerial Building of the Ministry of PUPR is shown in Table 2.

Table 2
Inventory Equipment Elevator

No	Type	Location	Electrical power	Number of units	Technical specifications
1	Executive Elevator	Gd. Minister	3,700 Watts	1	
2	Passenger Elevator	Gd. Minister	1,200 Watts	6	Mitsubishi
3	Elevator Service	Gd. Minister	8,000 Watts	1	

Source: Airkon, 2024

Use of Sanitary ware in the Ministerial Building of the Ministry of PUPR

Sanitation in the Ministerial Building of the Ministry of PUPR has an important role in sustainably managing water consumption. In the PUPR Ministry's Ministerial Building, sanitary facilities are designed to maximize water use efficiency. Based on the results of interviews with the Airkon team, it is known that most of the water supply for sanitation needs comes from the rainwater storage system located on the building's rooftop. This initiative was taken considering that the water discharge from local water service providers (PDAM) is relatively small, so rainwater utilization is an effective solution to meet the building's daily water needs. The use of rainwater not only reduces dependence on the city's water supply but also underscores the building's commitment to sustainable practices that reduce environmental impact. Sanitary inventory data in the Ministerial Building of the Ministry of PUPR (table 3).

Table 3
Sanitary Inventory

No	Floor	Closet Flush Valve	Tube Closet	Urinals	Sink	Sink Faucet	Ablution Faucet	Shower
1	Basement	11	-	5	12	12	4	-
2	Base	-	5	3	8	10	4	
3	2	5	3	3	10	10	4	1
4	3	5	6	3	10	10	4	1
5	4	5	2	3	10	10	4	1
6	5	5	1	3	10	10	4	1
7	6	5	1	3	10	10	4	1
8	7	5	1	3	10	10	4	1
9	8	5	1	3	10	10	4	1
10	9	5	1	3	10	10	4	1
11	10	5	2	3	10	10	4	1
12	11	5	1	3	10	10	4	1
13	12	5	2	3	10	10	4	1
14	13	5	2	3	10	10	4	1
15	14	5	2	3	10	10	4	1
16	15	5	3	3	10	10	4	1
17	16	5	3	3	10	10	4	1
18	17	7	1	3	11	11	4	-
Total		93	37	56	181	183	72	15

Source: Airkon, 2024

Electrical Energy Conservation

Electrical energy consumption data in this research was obtained from calculating the energy use of electronic devices in the Ministerial Building of the PUPR Ministry. To calculate this energy consumption the amount of power used by each piece of equipment is taken and multiplied by the duration of use per day. The duration of use of electronic equipment in the Ministerial Building of the PUPR Ministry varies, depending on the needs of each user.

Electrical Energy Consumption in HVAC

Air conditioning in the Ministerial Building of the PUPR Ministry uses several AC models. Electrical energy consumption from using this AC is calculated based on the installed electrical power capacity and the specified operational time. On average, AC usage in the Ministerial Building of the Ministry of PUPR is turned on for 14 hours a day, namely 06.00 – 20.00 WIB. In practice, daily use of AC in the Ministerial Building of the PUPR Ministry often exceeds standard working hours. This is due to the policies of each work unit leader on each floor, which increases the workload and requires the use of AC until overtime. As a result, energy consumption for cooling increases, which contributes to high carbon emissions from electricity use in the building. Detailed calculations of AC electricity consumption are presented in table 4 and AC consumption calculations.

Table 4
Electrical Energy Consumption in HVAC

No	HVAC Type	Floor	HVAC electrical energy consumption		
			kWh/Day	kWh/Month	kWh/Year
1	AC Split Control Room	B Floor	252	5,040	60,480
2	AC Split Workshop	B Floor	252	5,040	60,480
3	AC Split Office HK	B Floor	126	2,520	30,240
4	Warehouse Split AC	B Floor	189	3,780	45,360
5	AC Standing R. Public Services	D Floor	630	12,600	151,200

No	HVAC Type	Floor	HVAC electrical energy consumption		
			kWh/Day	kWh/Month	kWh/Year
6	Standing AC	R. UPS	1,080	21,600	259,200
			1,080	21,600	259,200
7	Standing AC	17th floor	270	5,400	64,800
			270	5,400	64,800
			108	2,160	25,920
			108	2,160	25,920
8	Split AC	Office Elevator	540	10,800	129,600
			405	8,100	97,200
			540	10,800	129,600
			180	3,600	43,200
9	AC Standing R. Meeting	Roof Top	378	7,560	90,720
10	AC VRV R. HUB	Gd. Minister	252	5,040	60,480
Total			6,660	133,200	1,598,400

Source: processed by researchers (2024)

Electrical energy consumption data for the HVAC system in the Ministerial Building shows significant variations in energy use between units, reflecting different operational needs on each floor. For example, on floor B, electricity consumption for Split ACs in the Control Room, Workshop and Office HK ranges from 126 to 252 kWh per day, with the warehouse slightly higher at 189 kWh, indicating uniform temperature regulation to maintain equipment. On floor D, the Standing AC in the Public Service Room consumes up to 630 kWh per day, indicating higher energy requirements in this high-traffic area to provide service and comfort to visitors. Meanwhile, the Standing AC which operates 24 hours for the UPS Room recorded the largest usage at 1,080 kWh per day, to support building control and monitoring functions. Roof Meeting Rooms usually use AC, especially for large events that require comfortable conditions for more participants.

Electrical Energy Consumption in Lights

Based on the results of observations, it was found that electricity consumption from lights on each floor of the Ministerial Building of the PUPR Ministry varied. This variation occurs due to differences in power, number and type of lights installed on each floor of the building. Observation results also show that the lights in the Minister's Building are used on average for 10 hours/day. However, on floors 2 and 3 the lights are often used longer than on other floors due to additional activities related to the duties of the Minister and Secretary General. In addition, although most of the lights in buildings use PLC types that use motion sensors, there are still some lights that are operated manually. Data regarding electricity consumption from lights installed in the Ministerial Building is presented in table 5.

Table 5
Electrical Energy Consumption in Lights

Location	Electrical Energy Consumption of Lights		
	kWh/Day	kWh/month	kWh/year
Basement	0.05	1.06	12.76
Base	0.04	0.71	8.52
2	0.03	0.68	8,10
3	0.04	0.73	8.76
4	0.04	0.72	8.64
5	0.08	1.52	18.18
6	0.04	0.70	8.44
7	0.05	1.03	12.31
8	0.04	0.81	9.69
9	0.05	1.03	12.31
10	0.06	1.16	13.93
11	0.06	1.16	13.93
12	0.05	0.95	11.44

Location	Electrical Energy Consumption of Lights		
	kWh/Day	kWh/month	kWh/year
13	0.04	0.81	9.70
14	0.07	1.44	17.30
15	0.08	1.60	19.15
16	0.06	1.14	13.65
17	0.05	1.06	12.67
17(meeting room)	0.05	1.06	12.72
P Roof	0.09	1.74	20.89
Total	1.05	21.09	253.10

Source: author's preparation (2024)

Electrical energy consumption data for lighting in the Ministerial Building of the PUPR Ministry reveals significant variations between floors, with the roof floor consuming the highest energy at 20.89 kWh per year, indicating intensive activity, this location uses 1000-Watt lamps for building lighting. Meanwhile, the 2nd floor is the lowest with 8.10 kWh per year, indicating minimal activity, even though this floor is the PUPR Minister's room. Floors 5 and 15 also show high consumption, as they are used for green garden space and building lighting. With a total usage of almost 37.33 kWh per year for lighting alone, there is a huge opportunity for efficiency improvements, such as replacing old lamps with more energy-efficient ones and installing automatic control systems such as motion sensors.

Electrical Energy Consumption in Computers

In the Ministerial Building of the PUPR Ministry, electricity consumption for computers is calculated based on individual usage, with the average operating time set at 8 hours per day according to working hours. Based on a field survey, employees in this building use HP All-in-One type desktop computers. The electrical power required for an HP PC is 100 watts. The total electricity consumption data from the computer is presented in table 6.

Table 6
Electrical Energy Consumption on Computers

Floor	Electrical Energy Consumption		
	kWh/day	kWh/month	kWh/year
Basement	7.2	144	1728
Base	9.6	192	2304
2	26.4	528	6336
3	4.8	96	1152
4	96.8	1936	23232
5	37.6	752	9024
6	40.8	816	9792
7	31.2	624	7488
8	43.2	864	10368
9	59.2	1184	14208
10	55.2	1104	13248
11	31.2	624	7488
12	52.8	1056	12672
13	43.2	864	10368
14	76.8	1536	18432
15	80.8	1616	19392
16	82.4	1648	19776
Total	779.2	15584	187008

Source: author's preparation (2024)

The electrical energy consumption data above shows significant variations in computer usage on different floors of a building. The lowest usage was recorded in the basement and 3rd floor, with only 7.2 kWh and 4.8 kWh per day respectively, indicating more limited activity or a smaller amount of equipment. On the other hand, the 4th floor experiences the highest energy usage, reaching 96.8 kWh per day, which is because on this floor there are 2 work units, namely the State Property Bureau and the Public Communications Bureau. Other floors such as 15, 16, and 14 also show relatively high consumption, ranging from 76.8 to 82.4 kWh per day, due to the organizational unit in the form of an Echelon 1 unit. Overall, the total electricity consumption for computer uses in the building. This reaches 779.2 kWh per day, with an annual total of 187,008 kWh.

Electrical Energy Consumption in Exhaust

During a survey at the Ministerial Building of the PUPR Ministry, exhaust fans were installed which are generally located in the toilets and basement of the building. The use of this exhaust fan is designed to ensure good air ventilation and reduce humidity, especially in areas that lack natural air circulation. Based on observations, this exhaust fan operates around 10 hours per day, which is intended to meet the health and comfort standards of building occupants during working hours. These activities are also important for preventing mould formation and reducing odour buildup, keeping the work environment fresh and healthy. The existence and operation of exhaust fans is an important part of a building's efforts to maintain cleanliness and comfort, especially in critical areas such as toilets and basements which have a high risk of poor air quality. Data on total electricity consumption from the exhaust is presented in table 7.

Table 7
Electrical Energy Consumption in Exhaust

Equipment Type	Location	Electrical Energy Consumption		
		kWh/day	kWh/month	kWh/year
Pressurized Fan	Roof Office	440	8800	105600
Fresh Air	Roof Office	40	800	9600
Toilet Exhaust Fan	Roof Office	40	800	9600
Exhaust RAM	Basement	44	880	10560
Exhaust Fan R. Pump	Basement	7	140	1680
Exhaust Fan R. Generator	Basement	3.5 7.5	70 150	840 1800
Exhaust Fan R. chiller	Basement	7	140	1680
Exhaust Fan R.STP	Basement	3,2	64	768
Exhaust Fan R. Transformer	Basement	11 1.8	220 36	2640 432
Exhaust Toilet	Basement	1.8	36	432
Exhaust Toilet	B Floor	1.8	36	432
Exhaust Toilet	2nd Floor	1.8	36	432
Exhaust Toilet	3rd floor	1.8	36	432
Exhaust Toilet	4th floor	1.8	36	432
Exhaust Toilet	5th floor	1.8	36	432
Exhaust Toilet	6th floor	1.8	36	432
Exhaust Toilet	7th floor	1.8	36	432
Exhaust Toilet	8th floor	1.8	36	432
Exhaust Toilet	9th floor	1.8	36	432
Exhaust Toilet	10th floor	1.8	36	432
Exhaust Toilet	11th floor	1.8	36	432
Exhaust Toilet	12th floor	1.8	36	432
Exhaust Toilet	13th floor	1.8	36	432
Exhaust Toilet	14th floor	1.8	36	432
Exhaust Toilet	15th floor	11	220	2640
Exhaust Toilet	16th floor	11	220	2640
Exhaust Toilet	17th floor	11	220	2640
Total		665	13300	159600

Source: author's preparation (2024)

The data shows significant variations in energy consumption between floors, with the Pressurized Fan on the roof office consuming the largest amount of energy, namely 440 kWh per day, while the Exhaust Fan R. Genset in the basement only 3.5 kWh. In the basement to 14th-floor toilets, most floors had a consistent consumption of 1.8 kWh per day, but there was a marked increase to 11 kWh per day on floors 15 to 17, indicating a higher need for ventilation or greater intensity of use. This data is important for evaluating energy efficiency, where building managers can consider adjusting exhaust fan operations or even replacing them with more efficient equipment to optimize energy consumption without sacrificing comfort, especially on floors 15 to 17.

Electrical Energy Consumption in Water Pumps

The water pump in the Ministerial Building of the Ministry of PUPR is designed to support daily water distribution needs, with operations running for an average of 10 hours every day, according to observation results. Apart from that, there are also fire pumps that are designed with a higher power capacity. These pumps, despite their large capacity, are only used in emergencies as part of a building's fire extinguishing system. Data on total electricity consumption from the water pump is presented in table 8.

Table 8
Electricity Consumption in Water Pumps

No	Equipment Data	Location	Usage		
			kWh/day	kWh/month	kWh/year
A	Clean Water Pump				
	Transfer Pump Office	R. Pump	740	14800	177600
	Filter Pump	R. Pump	30	600	7200
	Drain Pump	R. Pump	55	1100	13200
	Booster Pump Office	Roof Office	30	600	7200
B	Pump Fire Fighting				
	Electric Pump	R. Pump	250	250	250
	Jockey Pump	R. Pump	5.5	5.5	5.5
C	Dirty Water Pump				
	Blower Motor	R. STP	37	740	8880
	Filter Pump	R. STP	30	600	7200
	Effluent Pump	R. STP	15	300	3600
			37	740	8880
	Transfer Pump Office	R. STP	80	1600	19200
D	Submersible Pump				
	Sump Pit Pump 1	Basement	22	440	5280
			7.5	150	1800
	Sump Pit Pump 2	Basement	15	300	3600
	Sump Pit Pump 3	Basement	15	300	3600
	Sump Pit Pump 4	Basement	15	300	3600
	Sump Pit Pump 5	Basement	15	300	3600
	Sump Pit Pump 6	Basement	110	2200	26400
	Sump Pit Pump 7	Basement	15	300	3600
	Sump Pit Pump 8	Basement	15	300	3600
	Sump Pit Pump 9	Basement	30	600	7200
	Sump Pit Pump 10	Basement	44	880	10560
	Total		1888	33010	393370

Source: author's preparation (2024)

The data presented shows that various types of pumps are used in certain locations, including clean water pumps, fire pumps, dirty water pumps, and submersible well pumps located in the basement. For clean water pumps, there are four different types with usage varying from 30 kWh to 740 kWh per day, indicating a high frequency of use at the Transfer Pump Office compared to other pumps. Fire pumps such as the Electric Pump and Jockey Pump have very low usage, reflecting use only during emergencies. Meanwhile, the sewage pump at the wastewater treatment site

(STP) shows regular use and the building's water management system requires significant energy to ensure continuous water supply and efficient wastewater management. Infiltration well pumps in the basement showed variations in use, with Sump Pit Pump 6 recording the highest use, indicating areas with greater or more frequent water accumulation.

Electrical Energy Consumption in Elevators

In the Ministerial Building of the PUPR Ministry, elevators are used intensively to facilitate access to all floors. Based on observations, the average use of the elevator is around 10 hours per day. The lifts used by employees are divided into two groups: three lifts serve even floors and the other three serve odd floors. This division maximizes efficiency and reduces waiting times, ensuring that access to the required floors can be achieved quickly and efficiently. Data on total electricity consumption from the water pump is presented in Table 9.

Table 9
Electricity Consumption in Elevators

No	Equipment Data	Location	Usage		
			kWh/day	kWh/month	kWh/year
1	Executive Elevator	Gd. Minister	37	740	8880
2	Passenger Elevator	Gd. Minister	720	14400	172800
3	Elevator Service	Gd. Minister	80	1600	19200
	Total		837	16740	200880

Source: author's preparation (2024)

The Executive Elevator, which is specifically for the use of Ministers, Secretary Generals, and special guests, consumes 37 kWh/day. On the other hand, the Passenger Elevator has a much higher energy consumption, namely 720 kWh/day, indicating that this lift is the most widely used, according to its role in serving the number of users from floor Base to floor 17. To reduce energy consumption and carbon emissions, it is recommended to adopt energy-saving elevator technology, carry out routine maintenance, and install sensors and automatic control systems.

Results of CO2 Emission Calculation Analysis from Electrical Energy Consumption from Electrical Equipment

Annual electrical energy consumption data from each electronic equipment is presented in Table 10 and then used to calculate total CO2 emissions. This calculation is namely multiplying electrical energy consumption by the default emission factor for the electrical energy sector. The default factor used is 0.877 kgCO2/kWh.

Table 10
Electrical Energy Consumption in One Year

Location	Electricity Consumption (kWh/Year)					
	HVAC	Light	Computer	Exhaust	Water pump	Elevator
Basement	714960	12.76	1728	20832	386170	
Base	550800	8.52	2304	432		192000
2	60480	8,10	6336	432		8880
3		8.76	1152	432		
4		8.64	23232	432		
5		18.18	9024	432		
6		8.44	9792	432		
7		12.31	7488	432		
8		9.69	10368	432		
9		12.31	14208	432		
10		13.93	13248	432		
11		13.93	7488	432		
12		11.44	12672	432		
13		9.70	10368	432		
14		17.30	18432	432		

Location	Electricity Consumption (kWh/Year)					
	HVAC	Light	Computer	Exhaust	Water pump	Elevator
15		19.15	19392	2640		
16		13.65	19776	2640		
17	181440	25.40		2640		
Roof	90720	20.89		124800	7200	
Total	1598400	253.10	187008	159600	393370	200880

Source: Author's Preparation (2024)

Based on the electricity consumption data, it is then multiplied by the emission factor, and a secondary CO2 emissions calculation will be produced based on scope 2. Table 11 describes the amount of CO2 emissions produced by electronic equipment in the Ministerial Building of the PUPR Ministry.

Table 11
CO2 Emissions from Electrical Equipment

Location	CO2 emissions (kgCO2/kWh)					
	HVAC	Light	Computer	Exhaust	Water pump	Elevator
Basement	622015,2	11.1019	1503.36	18123.84	335967.9	
Base	479196	7.410312	2004,48	375.84		167040
2	52617.6	7,047	5512.32	375.84		7725.6
3		7.623288	1002.24	375.84		
4		7.5168	20211.84	375.84		
5		15.82078	7850.88	375.84		
6		7.343496	8519.04	375.84		
7		10.70726	6514.56	375.84		
8		8.427168	9020.16	375.84		
9		10.70726	12360.96	375.84		
10		12.11875	11525.76	375.84		
11		12.11875	6514.56	375.84		
12		9.951408	11024.64	375.84		
13		8.439696	9020.16	375.84		
14		15.05448	16035.84	375.84		
15		16.65806	16871.04	2296.8		
16		11.87654	17205.12	2296.8		
17	157852.8	22,098		2296.8		
Roof	78926.4	18.17813		108576	6264	
Total	1390608	220.20	162697	138852	342231.9	174765.6

Source: author's preparation (2024)

Results of CO2 Emission Calculation Analysis of All Electrical Energy Consumption 2013 – 2023

The Ministerial Building of the PUPR Ministry, which began construction in 2011 and was completed in 2012, has been actively used since 2013 as an office building. The use of electrical energy in this building is strictly monitored through monitoring carried out by the Airkon team every two hours. This monitoring activity is important to ensure energy efficiency and detect any potential energy waste that may occur in all areas of the building.

In daily activities, Airkon divides electricity usage records into two main periods: during working hours which last for 10 hours and non-stop operations for 24 hours. The difference in energy consumption between the two periods is significant, especially for some electrical equipment that is operated throughout the day such as lights, elevators, HVAC, and exhaust compared to equipment that is only active during working hours. This shows an adaptation of energy use that is responsive to fluctuating building operational needs, including unscheduled activities such as overtime, meetings, conferences, and other important activities.

Some electrical units still require manual operation, such as turning off the AC or room lights, which are sometimes left on by employees after working overtime, considering that office hours usage patterns can be very varied. These manual operations, while providing greater control over equipment operations, also pose challenges in standardizing energy use and operational efficiency. Based on electricity consumption data for the PUPR Ministerial Building from 2013 to 2023, there are significant variations in electricity use which can be explained by several specific events and conditions during that period. Starting with a consumption of 2,187,630 kWh in 2013, this consumption decreased in the following years until it reached its lowest point in 2018 of 1,444,670 kWh.

However, there has been a consistent increase in electricity use starting in 2019, and this increase becomes sharper in 2021. This increase is potentially largely influenced by the impact of the COVID-19 pandemic which began in 2020. During the pandemic, there may be changes in building use such as increased use of sanitation equipment that requires electricity, such as more intensive air ventilation systems to reduce the risk of spreading the virus, as well as more use of digital and telecommunications equipment due to the implementation of working from home which then shifted to hybrid working. This decline occurred because the PUPR Ministry implemented a moratorium on civil servant employees in 2015-2018 (Kompas, 2014), and increased usage in 2019 due to the acceptance of CPNS, this was also confirmed by the results of an interview from the General Bureau, Mr Dhoni.

> "*The use of electricity at the PUPR Ministry is closely related to the number of employees who use electrical equipment. In 2015 - 2018 there was a moratorium on employees, in 2019 we reopened the acceptance of CPNS and during Covid, although not all employees did not come to the office, office activities were continuing to run so that electricity use cannot be avoided.*"

In addition, 2020 and 2021 also saw an increase in energy consumption due to adjustments to workspaces to meet health protocols, such as the use of air purifiers, all of which added to the electricity load. After conditions began to return to normal and activity in buildings increased in 2022 and 2023, electricity consumption remained high due to the return to full activity and the adoption of new technology implemented during and post-pandemic which also consumed energy as well as an increase in the number of employees within the Ministry of PUPR. The total use of electrical equipment from the equipment identification results shows results that are more or less the same as the data obtained from Airkon in 2023, namely 2,209,375 kWh, this shows that the identified electrical equipment information is appropriate even though there is still other electrical equipment in the park and parking lots which are part of green buildings but are not counted in this research.

Analysis of electricity usage data in the Ministerial Building of the PUPR Ministry from 2013 to 2023 shows a pattern of fluctuation and growth in energy consumption throughout the decade. In 2013, electricity consumption started at a high level of 3,261,041 kWh, then decreased in 2014 to 2,846,601 kWh. However, there was a gradual increase almost every subsequent year, starting from 3,028,515 kWh in 2015 to a peak in 2023 with 4,412,840 kWh.

This increase in electricity use reflects the growth of activities in the building, an increase in the number of employees, or the existence of policies on each floor due to leadership changes. Such increases could also signal the need for a review of energy management policies and efficiency strategies to ensure optimal and sustainable use of resources in the future.

Based on the electricity consumption data collected, calculations were then carried out to determine the concentration of secondary CO_2 emissions produced in the Ministerial Building of the PUPR Ministry. This calculation involves using an emissions factor to convert the amount of electricity consumption into equivalent CO_2 emissions, the default factor used in this study is 0.87 $kgCO_2/kWh$.

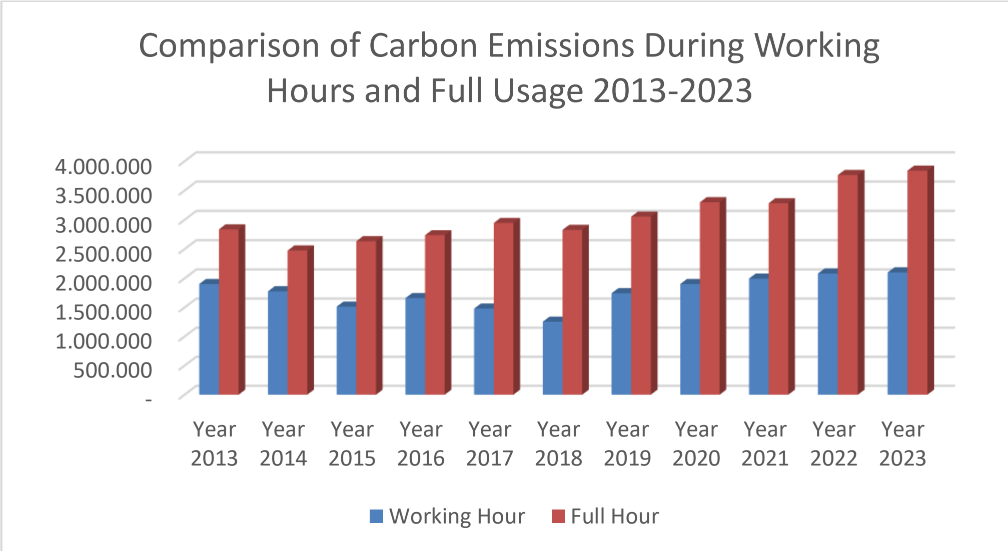

Figure 1. Comparison of working and full-hour carbon emissions
Source: author's preparation (2024)

Based on carbon emission data in the Ministerial Building of the PUPR Ministry from 2013 to 2023, it was revealed that energy use patterns varied between use during working hours and full use (24 hours). Starting in 2013, carbon emissions during working hours were recorded at 1,903,238 kg CO2/kWh, while full usage reached 2,837,105.7 kg CO2/kWh. This shows that activities outside of working hours still require significant amounts of energy, indicating that the building is used not only for daily routine activities but also for operations that may take place at night or ongoing use of the facility. Activities outside working hours include overtime work by employees to complete important tasks, routine maintenance, or repairs to building infrastructure such as HVAC systems and elevators, as well as 24-hour security and surveillance system operations. Apart from that, cleaning activities by the cleaning service team, use of public facilities such as meeting rooms and auditoriums for events or meetings, as well as ongoing server and IT infrastructure operations, also contribute to energy use outside of working hours.

This pattern indicates that although there are efforts to reduce emissions during working hours, the need for continuous operations in the building limits the effectiveness of these efforts. Other contributing factors may include the addition of new equipment or technology that requires more energy. The significant increase in energy use and carbon emissions from year to year also shows the challenges in maintaining a balance between building operations and environmental sustainability. To overcome this challenge, building managers are advised to adopt energy-saving technology, such as using LED lights and more efficient HVAC systems, as well as utilizing renewable energy sources such as solar panels. In addition, the implementation of a smart energy management system that can monitor and optimize energy use in real-time, as well as education and training programs for employees regarding energy-saving practices, can help reduce carbon emissions more effectively and support the environmental sustainability of buildings in the future.

Water Energy Conservation

Referring to data collected through direct observation and interviews with Airkon, as well as based on standards set out in green building regulations, this analysis will calculate the amount of water consumption on each floor of the Ministerial Building of the Ministry of Public Works and Public Housing (PUPR) (Leung et al., 2012).

The clean water and dirty water distribution system in the green building of the Ministerial Building of the Ministry of Public Works and Public Housing (PUPR) is designed to optimize water use and manage wastewater efficiently. Clean water used in buildings comes from two main sources: PDAM and deep wells. After being filtered through a sand filter, the water flows into a ground water tank and is then pumped using a transfer pump to a clean water tank located on the roof of the building. From the clean water tank on the roof, water is distributed to all floors of the building via a clean water line equipped with a booster pump to ensure sufficient water pressure (Herawati et al., 2023).

Clean water is used in various facilities such as jet spray, ablution areas, wash basins and sinks. Wastewater from this facility is collected and channelled through dirty water lines to the Wastewater Treatment Plant (WWTP) and the Sewage Treatment Plant (STP). After processing, wastewater is channelled to a recycled water tank to be reused for needs that do not require clean water quality, such as watering gardens and flushing toilets.

This system also includes collecting rainwater that falls on the roof of the building, which is then channelled to a treatment system for reuse. To ensure efficiency, this system is equipped with a Pressure Reducing Valve (PRV) to regulate water pressure as needed, avoiding waste. Separate pathways for clean water, dirty water, gray water, and recycled water help monitor and manage water use efficiently. This water management system is explained in Figure 2.

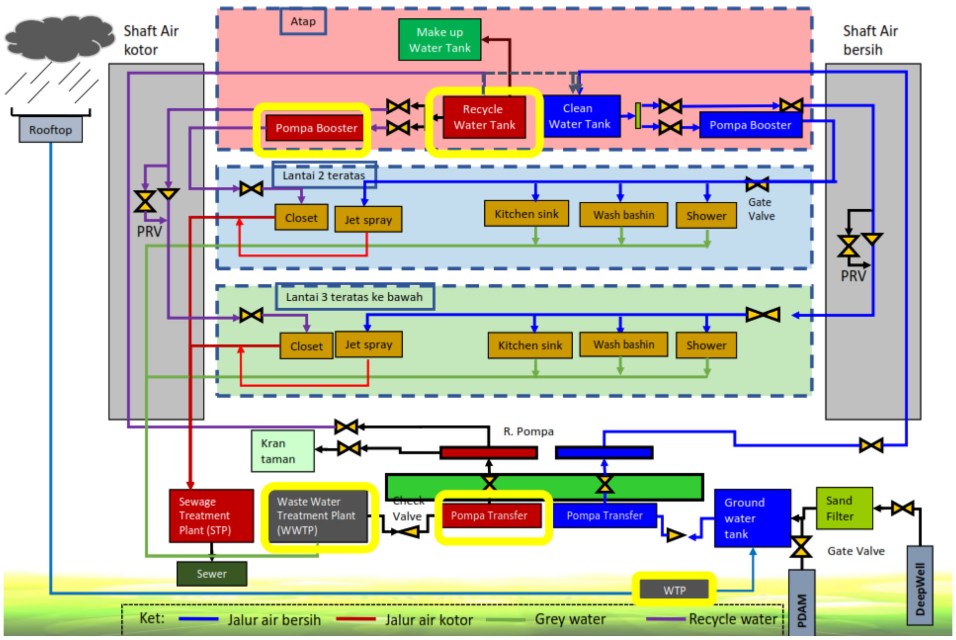

Figure 2. Flow of Water Use in Green Buildings of the Ministry of PUPR
Source: KSO. PP - BRANTAS

Water Consumption in Sanitation

Based on field data, it is known that the use of clean sanitary water is only used for ablutions, washbasins, and showers, so based on the formula equation what is used is the number of users multiplied by the water capacity multiplied by the base unit factor. The following calculations for sanitary use are presented in table 4.19.

Use of sink = (968 people x 100%) x 6 lt/flush x 0.15 = 871 m^3
Use of ablution faucets = (968 people x 25%) x 6 lt/flush x 0.5 = 726 m3
Shower use = (15 people x 5%) x 9 lt/flush x 5 = 45 m3

Table 12
Water consumption in sanitation

Sanitary	User	capacity	base factor	Total
Sink	968 people	6 lt/flush	0.15	871 m3
Ablution faucet	242 people	6 lt/flush	0.5	726 m3
Shower	1 person	9 lt/flush	5	45 m3
Total water consumption for the Ministerial Building				1,642 m3

Source: author's preparation (2024)

Based on available data, the use of sinks by 968 people results in total water consumption of 871 cubic meters (m^3) per year. The use of a sink contributes to significant water consumption. In addition, the ablution faucets used consume a total of 726 m³ of water per year. Water conservation in these facilities can be done by installing automatic faucets that reduce water flow when not in use or using faucets with lower water flow. Even if the shower is only used by one person, the total consumption is 45 m³ of water per year, indicating quite significant water use per user.

All sanitation equipment uses clean water, while the remaining wastewater is recycled for use in the toilet. This is an important step in reusing water that has been used, thereby reducing the waste of clean water, and supporting the concept of sustainability. Overall, total water consumption in the Ministerial Building reaches 1,642 m³ per year. Steps that can be taken to reduce water consumption include installing water-saving devices such as more efficient faucets and showers, increasing building users' awareness of the importance of conserving water through pamphlets and monitoring programs, as well as carrying out regular monitoring of water use and evaluating the effectiveness of measures conservation measures that have been implemented.

Sanitary Carbon Emission Calculation Analysis Results

After finding the value of sanitary use in the Ministerial Building of the PUPR Ministry, carbon emissions related to water use were then calculated. This emission factor includes the energy used to pump, process, and distribute water. Water emission factors vary based on location and water treatment system efficiency. In this study, the emission factor used was 0.34 kgCO2/m³ water.

Table 13
Carbon Emissions in Sanitary ware

Sanitary	Consumption (m3)	Base Factor	Carbon EmissionskgCO2e/m³
Sink	871	0.34	296
Ablution faucet	726	0.34	247
Shower	45	0.34	15
Total Ministerial Building Sanitary Carbon Emissions			558

Source: author's preparation (2024)

The use of a sink results in water consumption of 871 (m³) per year, with carbon emissions of 296 kgCO2e/m³. The ablution faucet used produces carbon emissions of 247 kgCO2e/m³. In addition, shower carbon emissions are 15 kgCO2e/m³. Overall, total water consumption in the Ministerial Building results in total carbon emissions of 558 kgCO2e/m³. These carbon emissions result from the energy used in the production, processing and distribution of clean water used in buildings.

To reduce environmental impacts, it is important for the Ministerial Building of the PUPR Ministry to continue implementing water conservation measures, such as installing water-saving devices and water recycling systems.

In addition to these steps, several new approaches can be implemented to further improve water efficiency and reduce carbon emissions. One effective way is to install faucets and showers that are equipped with automatic sensors to control water flow. This sensor technology ensures that water only flows, when necessary, for example when your hand is under the tap. In this way, water waste can be reduced significantly, especially in places with high frequency of use.

Another very important approach is the implementation of a real-time water usage monitoring and analysis system using Internet of Things (IoT) technology. This system allows for quick identification of leaks or inefficient water use and helps in making better decisions regarding water management. With real-time data, building managers can immediately take corrective action if anomalies occur in water use, as well as analyze usage trends to plan more effective water-saving strategies in the future.

Analysis of CO2 Emissions from All Water Consumption in 2013 – 2023

Based on the results of interviews conducted, the use of a water recycling system for water conservation activities in the Ministerial Building of the Ministry of Public Works and Public Housing (PUPR) has become part of efforts to save and water efficiency. However, several factors cause fluctuations in water use and associated carbon emissions. One of the causes of the increase in water consumption and carbon emissions is the increase in the number of employees. An increase in the number of staff causes an increase in water requirements for various daily activities, such as using sinks, ablution faucets and showers.

Apart from increasing the number of employees, other factors that influence water consumption and carbon emissions include increased operational activities and use of building facilities. For example, holding large events or meetings can increase water consumption significantly. However, a significant decrease in carbon emissions was seen in 2020 and 2021, which can be attributed to the COVID-19 pandemic. The pandemic caused many employees to work from home and reduce activity in buildings, which contributed to a drastic reduction in water consumption and carbon emissions. To calculate carbon emissions from water use in the Ministerial Building of the Ministry of PUPR, presented in figure 3.

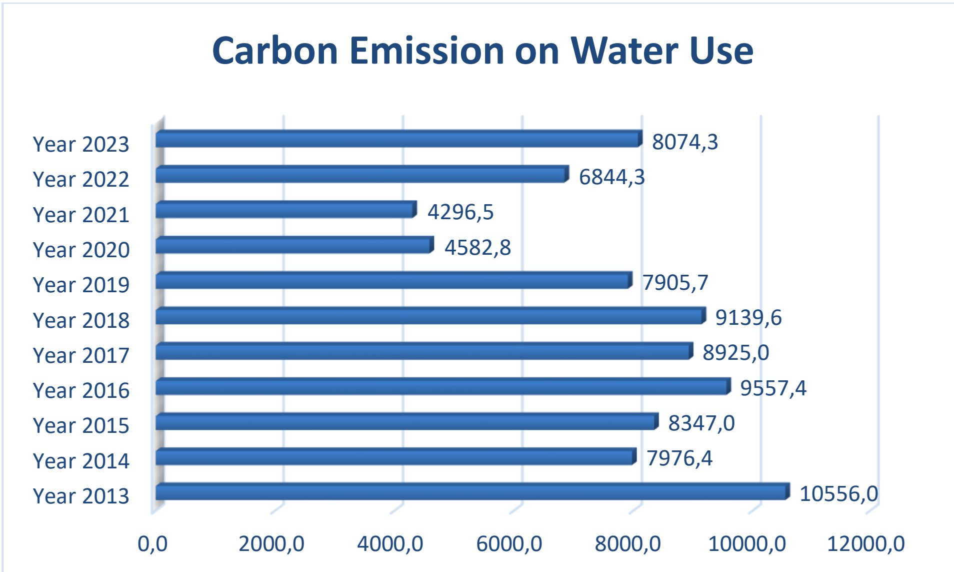

Figure 3. Carbon Emission Diagram on Water Use
Source: author's preparation (2024)

Analysis of this data shows that carbon emissions peaked in 2013 at 10,556 kgCO2e/m3 and experienced fluctuations over the following years. The most drastic decline occurred in 2020 and 2021, when the COVID-19 pandemic forced many employees to work from home, reducing activity in buildings and overall water consumption.

In 2022, when the situation begins to return to normal and employees return to work in the office, carbon emissions will again increase to 6,844.3 kgCO2e/m3 and increase again in 2023 to 8,074.3 kgCO2e/m3. This shows that increasing the physical presence of employees and operational activities in buildings has a direct impact on water consumption and carbon emissions.

Analysis of Equivalent Carbon Accounting Calculations in Electrical Energy

The Ministerial Building of the Ministry of Public Works and Public Housing (PUPR) has calculated electricity consumption from 2013 to 2023, by converting from kilograms (kg) to tons of carbon dioxide (CO2). This calculation uses an emissions factor equivalent to 1 kilogram of carbon equivalent per kilowatt-hour (kWh) of electrical energy used. The following is carbon equivalent data in tons of CO2e in table 14.

Table 14
Equivalent Carbon in Electrical Energy

Year	Carbon Emissions (kgCO2/kWh)	Carbon Equivalent (tonCO2e)
2013	1,655,817	1,655.8
2014	1,547,918	1,547.9
2015	1,317,273	1,317.3
2016	1,445,998	1,446.0
2017	1,288,987	1,289.0
2018	1,093,471	1,093.5
2019	1,518,969	1,519.0

Year	Carbon Emissions (kgCO2/kWh)	Carbon Equivalent (tonCO2e)
2020	1,655,863	1,655.9
2021	1,736,652	1,736.7
2022	1,813,693	1,813.7
2023	1,829,294	1,829.3

Source: author's preparation (2024)

In 2013, the carbon equivalent of electricity consumption in the Minister's Building was recorded at 1,655.8 tons of CO2e. During the period 2013 to 2015, carbon equivalent showed a decreasing trend, with the lowest figure in 2015 amounting to 1,317.2 tones CO2e, indicating significant energy efficiency efforts. This effort includes several important steps taken by building management. One of the main steps is the implementation of a retrofit program for the lighting system, in which conventional lamps are replaced with more energy-efficient LED lamps. In addition, replacing old equipment with more energy-efficient equipment, such as air conditioners and office machines, also contributes to reducing carbon emissions. An energy awareness program for employees was also launched, involving education about energy-saving practices and encouragement to turn off electronic devices when not in use. The combination of these various initiatives succeeded in reducing carbon equivalent significantly until 2015.

In the period 2019 to 2023, carbon equivalent increased again with a peak in 2023 reaching 1,829.2 tonnesCO2e. This increase was caused by an increase in the number of employees, a higher intensity of building use, and an increase in the use of electronic devices. During the COVID-19 pandemic in 2020 and 2021, even though many employees worked from home the carbon equivalent remained high, amounting to 1,655.8 tonsCO2e and 1,736,652 tonsCO2e respectively, which was because even though employees carried out WFH, some employees worked in the office and office activities must continue.

Analysis of Water Energy Equivalent Carbon Accounting Calculations

Based on data related to carbon emissions from water use in the Ministerial Building of the Ministry of Public Works and Public Housing (PUPR), the equivalent carbon accounting calculation is carried out by converting the emission results from kilograms (kg) to tons (t). The following is a conversion diagram of carbon emissions from various sanitary facilities used in the building.

Table 15
Water Equivalent Carbon Accounting

Year	Carbon Emissions kg/CO2	Carbon Equivalent (tons/CO2e)
2013	10556.0	10.56
2014	7976.4	7.98
2015	8347.0	8.35
2016	9557.4	9.56
2017	8925.0	8.93
2018	9139.6	9.14
2019	7905.7	7.91
2020	4582.8	4.58
2021	4296.5	4.30
2022	6844.3	6.84
2023	8074.3	8.07

Source: Author's Preparation (2024)

Based on this data during the period 2013 to 2019, there were fluctuations in the amount of carbon emissions, with the overall trend tending to decrease, for example, in 2019 it reached 7.91 tonnesCO2e. Drastic reductions were seen in 2020 and 2021, where carbon emissions fell to 4.58 tonsCO2 each and 4.30 tonnesCO2e. This decline was caused by the COVID-19 pandemic which resulted in many employees working from home and reducing activities in the building.

However, carbon emissions will increase again in 2022 to 6.84 tonnesCO2e and will continue to increase in 2023 to 8.07 tonsCO2e. This increase reflects the return of operational activities to normal levels after the pandemic. This analysis shows that increasing the number of employees and increasing operational activities, such as meetings and large events, are the main factors causing the increase in carbon emissions. In contrast, the significant decline during the pandemic shows the effectiveness of reducing activity in buildings in reducing carbon emissions.

The use of water recycling systems for water conservation activities has helped reduce freshwater consumption and associated carbon emissions. However, to achieve better efficiency, it is necessary to continue to install water-saving devices and carry out regular monitoring and evaluation. It is hoped that these measures will help manage water consumption and carbon emissions more effectively in the future, as well as better support environmental sustainability goals.

Electrical Energy and Water Problems

Electricity is currently one of the main sources of energy that is needed by humans. In Indonesia, almost everyone uses electricity 24 hours a day to help with various daily activities. If previously electricity was only considered a secondary need for night lighting, now electricity has become a primary need in people's lives. Sudden loss of electricity due to natural disasters, flow disruptions, or power outages in an area of Indonesia can cause unrest among the community, disrupt daily activities, cause losses for entrepreneurs, and even trigger anger. This shows how vital electricity is in the lives of Indonesian people.

Currently, electrical energy still relies heavily on fossil energy sources such as coal, oil, and natural gas. As electrical energy consumption increases, the use of fossil energy also increases, which ultimately leads to the depletion of natural resources because fossil fuels are non-renewable resources. Apart from that, uncontrolled use of electricity also has a negative impact on the environment. The process of generating electricity from fossil energy contributes to increasing greenhouse gas emissions. This increase in greenhouse gases can trigger global warming, which is known as Global Warming.

Apart from electrical energy problems, water use also faces big challenges. The availability of clean water is decreasing along with increasing water consumption in urban areas, including Jakarta. The rapid growth of office buildings and malls causes an increase in water demand, while inefficient water use, leaks in distribution networks, and pollution of water sources exacerbate the water crisis. The decline in groundwater due to over-exploitation is also a serious problem, resulting in subsidence of the land surface which makes Jakarta more vulnerable to flooding. In addition, poorly planned infrastructure development and a lack of rainwater management systems also contribute to the increased frequency of flooding.

Based on the results of field observations, several significant problems were found related to the use of electrical energy and water, which specifically contributed directly to the increase in energy consumption.

The first is electrical energy: (a) Operating the AC even if no one is in the room. This practice is often found on some floors after overtime work, where the air conditioning remains on when the room is left unattended. This habit is inefficient because turning off the AC when it is not needed can save energy and reduce the impact of global warming. (b) Turn on the air conditioner with the door or window open. This habit can occur in various places and is very inefficient because cold air comes out so the room will not cool quickly and causes a waste of electrical energy. (c) Leaving electronic equipment such as computers turned on even when not in use. It's best to turn these devices off if they haven't been used for a while and turn them back on when necessary.

Next Water energy: (a) Excessive use of water for landscaping: Inefficient use of water for watering plants or landscaping can increase water consumption. (b) Use of water facilities without sensors: Facilities such as faucets and toilets that are not equipped with automatic sensors often cause water to continue flowing even when not in use, resulting in a wastage of water.

Apart from that, some things cause a general increase, namely: (a) The increase in the number of civil servants occupying the ministerial building of the Ministry of PUPR, which results in the use of electrical energy and water also increasing.(Communication Bureau, 2020; Liputan 6, 2018). (b) Changes in leadership policies, especially Echelon 1 or Echelon 2 in each work unit or organizational unit, greatly influence the work policies that must be carried out. (c) Unexpected events or occurrences, such as the COVID-19 pandemic. The pandemic changed work patterns, with many employees working from home. However, energy requirements for ventilation, sanitation and cleanliness in buildings remain high, even increasing to maintain stricter health standards. (d) Every year, the Ministry of PUPR receives an increasing infrastructure budget. This year, the ministry received the largest share of the budget, triggering an increase in the number of projects and activities (Son et al., 2024). The large number of activities that must be completed often require additional working hours or overtime, which ultimately increases the need for electricity and water in the building. Additionally, this budget increase could also lead to the purchase and use of more electronic equipment and new infrastructure that requires additional energy.

Mitigation of Electrical Energy and Water Problems

Mitigation steps to deal with the problems described above can be carried out by reducing the electricity sector's dependence on fossil energy and increasing the efficiency of energy use within the framework of the concept of saving electrical energy. Reducing the use of fossil energy can be achieved by looking for alternative electricity generation that is more environmentally friendly and economical.

Energy saving means using energy efficiently and optimally according to needs. On the other hand, energy waste occurs when electrical energy is used excessively without need. By implementing good energy management, it is hoped that we can save energy and avoid energy waste, both caused by human behavior (non-technical) and environmental factors technical (Ramadhani, 2012).

Electricity waste can occur due to two main factors: human behavioral patterns in consuming electrical energy and technical factors related to the way the electronic equipment used is installed. In general, about 80% of energy waste problems are caused by human factors and 20% by technical factors.

Therefore, it is important to adopt a more sustainable approach to the use of technology, which not only addresses energy consumption behavior but also utilizes environmentally friendly technologies to reduce overall energy waste. As technology advances, the use of environmentally friendly technology becomes increasingly important to save electrical energy, reduce excessive power use, and maximize the use of available resources. Several mitigation measures can be implemented at the Ministerial Building of the PUPR Ministry, including:

1) Green computing generally refers to the practice of using technology, especially computer devices, to reduce electrical energy consumption. Application of green computing according to (Warjiyono, 2016) include: (a). Choose electronic devices, especially computers, that have the Energy Star logo. (b) If the PC/laptop has not been used for a long time and does not want to be turned off, use the Sleep mode feature to save 70% of electric power, Standby to save 90% of electric power and hibernate to save 98% of electric power. Using a screen saver alone does not save energy because the electricity consumption is the same as when the device is on. (c) If possible, use a rental computer or recycle an old computer that can still be upgraded, rather than buying a new one. To save the Ministry's procurement budget, avoid throwing away PCs that are no longer used. It is better to recycle or donate it as part of a Corporate Social Responsibility (CSR) program. (d) Use the power saver feature to save battery power, which is already available in the Windows operating system. (e) Reduce the screen brightness because a high brightness level will consume more electricity, use a screen with a low brightness and adjust it as needed. (f) Turn off Bluetooth, Wi-Fi, and other wireless networks when not in use.
2) Using automatic sensors on lights and HVAC, it is hoped that these sensors will turn off the AC and lights when not in use.
3) The use of automatic sensors in sanitation, by installing faucets and toilets with automatic sensors to avoid wasting water. This sensor will ensure that water only flows when needed, even though you initially used a water sensor on the sink.
4) There are incentives for civil servants who use stairs: To reduce the use of lifts and save electrical energy, an incentive program could be introduced. Civil servants who choose to use the stairs instead of the elevator, especially to travel between adjacent floors, may be given incentives in the form of points that can be exchanged for prizes or other rewards. This program not only helps reduce electrical energy consumption but also encourages a healthier lifestyle among employees.
5) Appeal to civil servants to use stairs when going up or down 1-2 floors: To reduce the burden of using elevators, it is hoped that all civil servants will use the stairs when only going up or down 1-2 floors. Placing posters and reminders in strategic areas such as near lifts and stairs, as well as regular announcements via email or internal meetings, can help increase awareness and participation in this initiative. This step not only saves electrical energy but also reduces elevator waiting times and increases the efficiency of vertical transportation in the building.
6) Using recycled water for meetings: As part of the green building concept, using recycled water in meetings and other events in the building can greatly help reduce carbon emissions resulting from the production and distribution of bottled water, which is often used in meetings. By reducing reliance on bottled water, buildings can minimize plastic waste and associated carbon emissions, supporting environmental sustainability.
7) Periodic Energy and Water audit/evaluation: To identify areas of waste and opportunities for improvement, it is important to conduct regular energy and water audits. This evaluation will provide a clear picture of how electrical energy and water are used in the building, as well as to find any leaks or inefficiencies that may occur. With the data obtained from audits, building managers can plan and implement more effective

measures to save energy and water, reduce operational costs, and improve overall efficiency. Regular audits also help ensure that all systems and devices work optimally according to green building sustainability standards.

Implementation of Carbon Accounting at Green Building Applications

In its implementation, the management and building management have carried out preventive activities to ensure the implementation of green buildings and the comfort of the employees who occupy them. Several steps have been implemented, including:

1) Appeal to turn off electronic equipment during long holidays: Every time there is a long holiday, the building management routinely gives an appeal via loudspeaker to all employees in the Ministry Building to turn off all electronic equipment. This step aims to reduce electrical energy consumption while the building is not operating, prevent energy waste, and reduce the risk of fire due to devices left on.
2) There are green gardens on the 5th floor and 17th floor: The Ministry Building has a green garden located on the 5th floor and potted plants on the 17th floor. These gardens not only function as relaxation areas for employees but also help improve the air quality inside the building, reducing heat effects, and providing green space that can absorb CO2. The existence of this green park supports the green building concept by reducing carbon emissions and improving the welfare of building occupants.
3) Installing stickers or pamphlets inviting energy saving on the ground floor: To increase awareness about the importance of saving energy, building management places stickers or pamphlets encouraging energy saving in strategic areas, such as the ground floor. This information reminds employees and visitors to always turn off lights, air conditioning and other electronic equipment when not in use, as well as educating them about the benefits of saving energy for the environment.
4) Use of elevators after working hours is limited to two units: After working hours, only two elevator units remain operational in the Ministry Building. This policy aims to reduce electrical energy consumption by limiting unnecessary use of lifts when there are fewer users. With this step, buildings can save energy significantly without reducing the comfort of users who are still in the building.

Conclusion

Based on the results of the analysis that has been carried out regarding the implementation of carbon accounting in the Ministerial Building of the Ministry of PUPR, the following is an overview of the implementation of carbon accounting and the amount of carbon produced in the Ministerial Building of the Ministry of PUPR.

The carbon accounting amount of electricity use. Carbon accounting for electricity use in ministerial buildings in 2023 was recorded at 1,829.3 tonco2e. This trend shows an increase in carbon emissions from 2020, which is largely caused by an increase in the number of employees and intensity of building use.

The amount of carbon accounting from water use, water use in ministerial buildings in 2023 produces carbon accounting of 8.07 tonco2e. This number has increased compared to the previous year due to increased operational activities in buildings following the COVID-19 pandemic. The implementation of reducing carbon emissions, implementing a retrofit program for lighting systems by replacing conventional lamps with LED lamps, succeeded in reducing carbon emissions until 2015, however, the increase in the number of employees and the intensity of building use caused an increase in emissions in the 2019-2023 period.

Using a water recycling system and installing water-saving devices helps reduce water consumption and carbon emissions, but there are still fluctuations in emissions due to operational factors and the number of employees. Analysis of carbon emission trends, carbon emissions from electricity use show a decreasing trend in the 2013-2015 period but experienced an increase again in the 2019-2023 period due to increased activity and the number of employees. Likewise, carbon emissions from water use peaked in 2013 at 10,556 kgco2e and decreased drastically in 2020-2021 due to the pandemic. However, emissions will increase again as normal activities in buildings return in 2022 and 2023.

Overall, the implementation of carbon emission reduction measures in the Ministerial Building of the Ministry of PUPR has had a positive impact in reducing emissions which in turn has also had a positive impact on accounting for the carbon produced, however, challenges remain, especially related to increasing the number of employees and operational activities. Continuous efforts and the application of new, more efficient technologies are necessary to achieve environmental sustainability goals.

In the process of conducting this research, several limitations might influence the results obtained. One of the limitations is the limited research time, energy, and abilities of researchers. These factors may limit the scope and depth of analysis that can be performed. This research only includes an assessment of electricity and sanitation use, while other factors that may influence carbon accounting have not been studied in depth. Therefore, further research is needed that can explore the influence of these other factors. The conclusions drawn in this research are based on secondary data analysis. Thus, there is a need for further research covering scope 2 in the implementation of carbon accounting in green buildings.

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