CHAPTER I

PREFACE

1.1. Research Background

With the advancement of technology, human activities have been helped and supported in numerous ways. However, along with the increase in population and economic growth, global energy consumption has risen excessively. In the case of Indonesia, the primary energy has increased by 560 TWh from 2021 to 2022 as seen in Figure 1.1 [1]. Based on the figure, the energy consumption trend in Indonesia has leaped rapidly. The final energy consumption of this country according to the Plan Energy Scenario (PES) is estimated to rise threefold by 2050 with the main source of oil [2]. This issue has become a great concern since fossil fuels cause environmental problems such as global warming, climate change, greenhouse gas emissions, pollution, and others [3], [4].

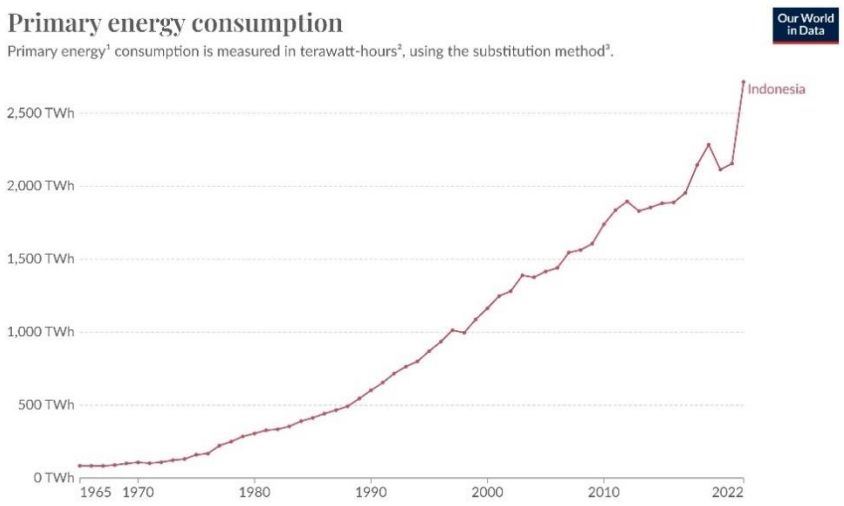

Figure 1.1 Primary Energy Consumption Trend in Indonesia from 1965 to 2022 [1]

Looking at these major problems, Indonesia has committed to reaching net zero emissions by 2050 [5], [6]. In response, Green Building Council Indonesia (GBCI), also participating in WorldGBC's Advancing Net Zero (with the purpose of

decarbonization by 2050), developed a program called Greenship Net Zero rating tool along with training and education provision [6]. The crucial factors that must be considered in taking into this program are providing passive design (natural ventilation and natural lighting), active design (air conditioning, lighting, and other systems), a healthy and comfortable environment as well as renewable energy (onsite, offsite, and offset). Net Zero Healthy is one of the programs that must be considered when designing a building. Designs for natural ventilation, air conditioning systems, natural and artificial lighting systems as well as other systems must be considered, planned, and made according to criteria for comfortable and healthy building as well as reaching zero carbon emissions. The future steps of Net Zero Healthy consist of meeting EUI standards and comfort compliance, compliance with renewable energy generation, building an automation system (to collect performance and present data digitally), reduction below zero in carbon caused and balance as well as healthy requirement compliance. Thus, it is highlighted that buildings that have reached Net Zero Healthy are highly efficient in energy use, accompanied by a healthy environment and renewable energy implementation.

Lighting systems, as mentioned, are one of the factors in the Net Zero Healthy program. The significance of lighting systems in a building design is correlated with health in many ways. Fundamentally, physical comfort based on thermal, humidity, and lighting as well as other aspects play an important role in ensuring the well-being of building occupants [7], [8], [9], [10]. For instance, the study by [7] shows that the temperature designed based on the standard comfort methodologies does not comply with the preference of hospital patients based on the clothing insulation and activities inside the room. For humidity, a study by [8], [9] shows that an imbalance of relative humidity greatly impacts the spread of viruses and bacteria indoors, causing health risks. Lighting systems show a similar concept in which based on a study by [10], the use of proper lighting will prevent sicknesses such as headache, blurred vision, and even stress, etc. Hence, making the best designs,

especially in lighting, will help in improving performance on visual tasks-related and avoid negative health impact [11], [12], [13]. As an example, it is shown that symptoms of affective disorder and depression can be reduced by lighting therapy [14].

However, with the current behavior of humans, which is spending time mostly in indoor environments, exposure to outdoor daylight is reduced and in contrast, light is exposed to occupants even in the hours of natural darkness [15]. This will affect circadian rhythms and health. Many other terms are also used to provide detailed descriptions of this issue. One of the helpful terms is called sick-building syndrome (SBS), which is defined as symptoms in building occupants caused by low air quality, inadequate ventilation systems, and work environment factors [16], [17], [18], [19]. Low air quality is usually caused by temperature, lighting, CO2 levels, humidity, air pollutants, biological pollutants, chemical pollutants etc. [16], [19], [20], [21]. Symptoms of SBS appear in occupants such as nausea, eye irritation, olfactory disturbances, dry skin, sore throat, difficulty in concentrating, flu, and many others that greatly towards their performance [17], [20].

Thus, the Net Zero Healthy program offers the criteria for standardized lighting systems of building design. According to GBC Indonesia, the pre-requisite for Health and Comfort (P1A) of a building includes air circulatory flow, thermal comfort, and visual comfort in which specifically, the lighting system must follow the latest edition of SNI 03-6197 for illuminance according to the Indoor Health and Comfort (IHC) 5 New Building 2.0 [6]. Another standard (P2D) that must be fulfilled is the light power density of artificial lighting according to the latest SNI 03-6197. This standard itself also refers to several documents such as SNI 03-2396 for natural lighting on buildings, International Organization for Standardization or ISO 50015:2014 for management energy system measurement and verification of organization's energy performance as well as ANSI/ASHRAE/IES Standards 90.1-2019 for Energy Standard for Buildings Except Low-Rise Residential Building (I-

P Edition) [22]. The value of the standard for both variables is strongly adherent with room function, one such example like classroom criteria with 350 lux and 7.53 Watt/m^2 for illuminance and light power density respectively. Hence specific and careful measurements for both cases must be well executed to get the expected result.

Following the measurement strategy, for lighting systems, another standard can be used, namely SNI 7062-2019 for the measurement of illuminance in the working environment. Corresponding to the standard, the measurement method using a lux meter must meet several conditions and can be divided into general and specified measurements. For general measurement, this is based on the area of the room with the classification of below 50 m^2, 50-100 m^2, and above 100 m^2. Whereas for specified measurements, the locations of the measurements are taken in the working environment such as around certain machines and systems. Whilst for light power density, technical data such as the room area, number of lamps, and the power consumed for the lighting is needed. The result will be in Watt/m^2.

With the measurement method provided, a determination of how good a lighting system in a building design can be made. Moreover, to the necessity for Indonesia's buildings to reach Net Zero Healthy as priorly mentioned, this research is conducted to contribute to support and reach a healthy environment in a building as well as become the basis and findings, especially in visual comfort, to promote energy efficiency and renewable energy implementation further. This research will be conducted from February to May 2024 in UMN's C and D Tower by collecting pre-requisite data, location survey, administrative processing, measuring visual comfort based on illuminance and light power density, analyzing, and finally concluding and resulting in recommendations.

This research will also use results from similar previous research and findings to serve as the basis. One such is the building of United Tractors achieved was the first private office that is certified as Greenship Net Zero Healthy [23], [24]. This

building, designed and built based on environment factors that satisfy the green area criteria, included CO_2 sensors, having mechanism for ventilation and water building cycle as well as using 69.83% of area for natural lighting system and the rest by laminating glass to increase daylighting exposure as well as reducing energy usage [23], [24]. Other buildings that receive similar achievements are the primary schools which are SDN Duren Sawit 14 East Jakarta, SD Grogol Selatan 09 South Jakarta, SDN Ragunan 08 and 09 South Jakarta, and SMAN 96 Cengkareng West Jakarta, seen in Figure 1.2. [25]. These schools have satisfied the criteria for natural ventilation and lighting as well as renewable energy implementation [26]. Finally, the airport of Banyuwangi also received Net Zero Healthy Ready certificate by designing the airport to fulfill the criteria such as using skylight as the natural lighting system and so on [27].

Figure 1.2 SDN Ragunan 08

Source: Tempo (https://s.id/243l2)

Currently, UMN PK Ojong Tower (D) falls into the category of Net Zero Ready with the condition of as long as energy efficient measures are applied, and renewable energy is used at a minimum threshold [6]. Accordingly, this tower along with New Media Tower (C) had applied a unique design based on a double skin facade to help in building energy efficiency. In this case, the double skin facade has optimally helped in allowing the natural lighting into the building while controlling overexposure of light and heat through its design filtering method as seen in Figure

1.3. This means that it helps in giving controlled natural lighting which will reduce the usage of artificial lighting that consumes energy, supporting energy efficiency. In addition, it also helps in regulating air flow and heat transfer between the outside and inside parts of the tower, giving sufficient fresh air and preferable temperature for occupants without having to avoid overdependence on mechanical air conditioning systems.

a) b)

Figure 1.3 Double Skin facade View of UMN's C and D Tower from Inside of Classroom

Hence, following the achievements of different types of buildings upon the Greenship Net Zero Healthy certification as well as based on the conditions for UMN building, this research is intended as a media for field assessment towards the readiness of UMN's C and D towers since the facilities fulfill the criteria for Net Zero Building are presented such as natural ventilation on the class corridor, natural lighting systems such as sky well and so forth. The findings of this research are expected to contribute significantly to enhancing preparedness and serve as valuable scientific contributions. It is hoped that these insights will inspire further research in similar domains, thus fostering the advancement of Net Zero initiatives in Indonesia.

1.2. Problem Formulation

Based on the issues depicted priorly, several points highlighted that can serve as the basis for this MBKM Research program include:

1. Does the current condition of the lighting system design in UMN's C and D Towers satisfy the criteria from Greenship Net Zero and Healthy Building?
2. How does the passive design of UMN's C and D Tower support the visual comfort criteria satisfaction?
3. What are the outcomes based on the existing lighting design of UMN's C and D Tower that can be used as recommendations to increase the building's performance?

1.3.Research Objectives

The objectives of this MBKM Research can be explained by points of achievement below:

1. Measuring the existing lighting system performance of UMN's C and D Tower based on illuminance and light power density for Greenship Net Zero and Healthy Building fulfillment purposes.
2. Analyzing the measurement data of the lighting system of UMN's C and D Tower to provide findings related to passive design effect on visual comfort criteria satisfaction.
3. Evaluating and recommending findings to improve visual comfort for buildings' performance.

1.4.Research Urgency

Based on the commitment of the government and reports from GBC Indonesia there is a need to reach net zero in 2050 as well as the fact that UMN's building can be certified with the full condition of criteria fulfillment as long as there are energy efficiency application and renewable energy implementation within the threshold, this research is made with the urgency to quickly response to the problems mentioned. This research is also conducted to support the fulfillment of the government policy (*Peraturan Pemerintah* or *PP Nomor 33 Tahun 2023 Tentang Konservasi Energi*) that states the use of more than 500 TOE/year by buildings must execute energy conversation and management, government program on utility with

energy efficient label (*Standar Kinerja Energi Minimum* or *SKEM* label) as well as the Sustainable Development Goals or SDG specifically on point 3 (Good Health and Well Being) and point 11 (Sustainable Cities and Communities).

1.5. Research Outputs

The output of the research is intended as a scientific article in ULTIMA COMPUTING that presents the assessment for UMN buildings, specifically C and D tower, in regards with lighting aspect towards Greenship Net Zero and Healthy Building for building in Indonesia.

1.6. Research Benefits

The benefit of the research can be explained based on the perspective of UMN, country, students as well as industries which can be specified below:

1. For the university (UMN):

   This research aims to provide valuable insights into the status of current lighting systems, the influence of passive design on visual comfort, an evaluation of UMN's preparation for Greenship Net Zero and Healthy Building Certification, and potential contributions to scientific literature in engineering departments.

2. For the country:

   This research is intended to serve as a foundational study at the university level, focusing on aspects such as visual comfort, Net Zero Health Building concepts, energy efficiency, passive design integration in buildings, and other related scopes within the realm of building science for the country.

3. For the students:

   This research is anticipated to serve as a valuable reference and a source of information for students, particularly in the context of UMN buildings, encompassing topics such as energy efficiency, passive design strategies, Net Zero concepts, and considerations related to visual comfort.