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Light Intensity Distribution in the Room Using Light Dependent Resistor: Through the Engineering Design Process

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ABSTRACT

This paper aims to determine the distribution of light intensity values in a room at a certain time using a Light Dependent Resistor (LDR) sensor by comparing the light intensity and sensitivity of the LDR in conditions of changing dark to light in the room. The distribution of light intensity is measured using a light sensor assisted by Arduino application, the results of the average light intensity value when changing from dark to light conditions will automate the lights to turn on and off. Thus, it is hoped that it can save electricity. This experiment was integrated with the engineering design process through the following stages: 1) Identification of the problem, 2) Discussion of problem-solving, 3) Designing, 4) Creating, redesigning, and evaluation tests, and 5) Sharing solutions. Indoor light intensity measurements were carried out for 7 days, from 00.00, to once every 3 hours the distribution of the light intensity values read was checked. The research results provide new findings that the average distribution of light when changing from dark to light at 05.36 - 05.37 indoors shows a value of 105-135 lx, while from light to dark at 18.07 - 18.08 shows a value of 75 - 88 lux. These results can be used in further research to determine values that can be input into coding to control LDR sensor automation in product development.

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1. INTRODUCTION

The paradigm for applying sensor-based technology has developed rapidly over time, where sensor technology is used to assist human work by providing minimal stimulation to tools. Technological tools that are often used using a sensor base include Arduino (Samsugi *et al.*, 2020; Ramdan, 2020; Ogunlela *et al.*, 2019). The use of this sensor-based technology provides convenience and efficiency in the performance of the tool. There are many examples of sensor-based tools designed to make daily work easier, including temperature regulation (Chaudry, 2020), battery monitoring systems (Bradley & Wright, 2020; Roslan & Muda., 2020), electric light control (Siregar *et al.*, 2022).

The large amount of research carried out in designing sensor-based products which are carried out in learning or education units as a form of improving students' thinking processes, is mostly carried out in the process of designing tools that are simple and needed in everyday life such as making automatic sprinklers (Azzaky & Widiantoro, 2020), smart parking (Barriga *et al.*, 2019; Al-Turjman & Malekloo, 2019; Fahim *et al.*, 2021), automatic door trainer (Jenaro *et al.*, 2021), automatic lights (Alamsyah *et al.*, 2021) etc. The design given for this simple product is carried out. Thus, the process carried out is adjusted to the specified time duration, apart from that the coding used is basic coding and programming. This is done as a stimulus and character-building in making products. Thus, in the end, students will be able to innovate in making advanced products that are more complex and useful in everyday life. Many types of simple sensors are often used, including ultrasonic, buzzer sensors, soil moisture sensors, temperature sensors, and light sensors. LDR sensors are often used in simple circuits as light sensitivity sensors and are often used to automate electrical equipment. Thus, they can save on electrical energy usage both at home and in industry (Faisal *et al.*, 2021; Susanto & Kusumawati, 2023).

Whole the world must face. One of the energy crises that is very worrying is the use of electrical energy. Electricity consumption in Indonesia continues to increase every year along with increasing national economic growth. The total electricity demand in Indonesia is the accumulation of electricity demand in each energy-using sector in PLN's 22 electricity marketing areas. Over 17 years (2003 to 2020) it is estimated to grow by 6.5% per year from 91.72 TWh in 2002 to 272.34 TWh in 2020 (Siregar, 2019). Meanwhile, the total installed capacity according to data from the Central Statistics Agency is 51647.39 MW. Apart from the problem of electricity needs not being met, another problem is related to increasing electricity rates. It is necessary to always make efforts to save electrical energy consumption. Two approaches can be taken, the first is an energy-saving lifestyle, for example by always turning off electricity that is not in use and choosing appliances with low wattage consumption. The second approach is to regulate electrical energy consumption using technology. Almost all sectors, whether at home, office, school, industry, etc., require and consume large amounts of electricity. Especially for lighting needs. One effort that can be made to save electricity consumption is to control the light intensity in the room according to needs. It is necessary to design a lighting control system in a room or at home. Thus, it can save electrical energy consumption by controlling the room lighting level automatically according to the existing light conditions and the specified target lighting level, where users need different light intensities in different places. Sometimes the light intensity from outside is sufficient. Thus, we do not need to turn on any lights. But sometimes users leave but forget to turn off the lights. These factors lead to energy waste. Therefore, some power management.

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Controlling light in a house is very necessary to save energy. The lights are usually controlled by an on/off switch. The use of the switch is also usually lost when the room is left, therefore we can control it with the help of a microcontroller which can control anywhere (Saputri & Rahawarin, 2022), without using the switch manually. When there are many sources of light from outside, especially from sunlight, then the lighting level of the lamp is reduced or it will even be automatically turned off. Changes in the light intensity of the lamp can be controlled using a microcontroller that utilizes input from the light sensor (in this case using an LDR sensor). If in the room the light intensity received is below the lux standard, the microcontroller will automatically increase the light intensity of the lamp. Conversely, if the light intensity received in the room is above the lux standard, the microcontroller will order the lights automatically to reduce the light intensity. This is done to save energy while maintaining the level of lighting in the room. Because the lights get brighter, the electrical power consumption also increases.

The design of light control in open spaces was previously carried out by Atmaja (Atmaja *et al.,* 2021) who aimed to build a prototype of an automatic light control and monitoring system based on the Internet of Things. This system controller uses a Wemos D1 microcontroller with an integrated ESP8266 Wi-Fi module which functions to send and receive data input on the Internet of Things (IoT) platform, namely Firebase. The input devices in this system are two types of sensors, namely LDR sensors and PIR sensors, where the LDR sensor functions as a light intensity meter and the PIR sensor functions as a human movement detector in a room. This system uses 2 lamps as the output device, where the lamps are placed in a clear plastic box that is shaped like a room. In room 1, the lights will turn on if human presence is detected. In room 2, the lights will turn on if the room lighting conditions are dim or dark and humans are detected. Apart from that, this lighting control and monitoring system can also be controlled via an Android application without a certain distance and only requires an internet connection.

The core control processor of this system is STM32F103C8T6 from ARM company, which consists of two core control boards, namely the information acquisition board and the information transmission board. This system is equipped with microwave sensors and other additional sensors to detect human vehicles. NBIOT module realizes wireless data transmission to the cloud server; Then, minimum modularization of lighting area and dynamic programming control algorithm are introduced. Thus, remote intelligent control of street lights is realized, energy consumption is greatly reduced, and intelligent management is perfected. The designed control system is adapted to several room conditions (bright, slightly bright, dimly lit, dim, and dark) by combining natural (halogen lamps) and artificial (TL lamps) light sources. From the research results it is known that the designed system can provide stable room lighting conditions. Designed a lighting model using an automatic dimmer based on an ATMega8 microcontroller, a PIR (Passive Infrared Receiver) sensor, and an LDR (Light Dependent Resistor) sensor (Nanal *et al.,* 2019). The working principle of the PIR sensor is to detect a person's movement which results in changes in body temperature, while the LDR sensor functions to regulate changes in light intensity. Based on the design of this tool, results were obtained in a room measuring (2.5x2.5) m before using a dimmer with a lighting intensity of 0 – 350 lux. To meet national standards for lighting in a room measuring (2.5x2.5) m, it is 100 - 250 lux, whereas in this study it was able to produce a lighting intensity of 135 - 180 lux. One of the technological developments that supports the development of smart homes or smart buildings is wireless sensor networks (WSN). Several studies have been carried out, for example regarding protocols (Saleem *et al.,* 2019), increasing system effectiveness (Bhuiyan *et al.,* 2021), and authentication techniques (Hartmann *et al.,* 2022).

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Applications are also wide, for example, related to energy use management (Machorro-Cano *et al*., 2020). The communication standards used can use wireless communication standards such as Zigbee, and WiFi, and can also be combined with power line communication (Rashid *et al*., 2021). In previous research, a tool was produced that can control the intensity of light in a room.

After a lot of research on controlling lights using sensors, either wirelessly or remotely, no one has explained in detail the distribution of light intensity values as reflected in the sensitivity results of the LDR sensor used. Thus, we can determine the right intensity value to control suitability. Light intensity requirements in the room to turn the lights on and off (Mahmoud, 2021). This is expected to provide more understanding and knowledge to designers and students in designing sensor-based tools according to their needs. In this research, a simple light sensor design will be carried out, where the light design that is assembled is automatically detected and can be controlled based on the light sensor. We installed an LDR sensor in the circuit to check the amount of light intensity entering the room at any time, and for a certain light intensity number that is detected it will control the light on the lamp, the intensity value that is detected. The input can be observed on the monitor, and at certain times, if we need lighting from lamps or sufficient sunlight, then limiting the amount of incoming intensity will control the turning off and on of the lighting on the lights in the circuit by controlling it using an Arduino kit.

Therefore, this research is expected to provide some information, including: (i) describing the design of the LDR light sensor in a series used indoors for a specified period; (ii) explaining the distribution of light intensity values presented from the LDR sensitivity results used in the circuit we designed at a certain time; (iii) analyze the light intensity value entering the LDR sensor when changes in darkness and light occur in the room at a certain time or vice versa; and (iv) conclude the selection of light intensity limiting values that need to be set to control the automatic turning off and turning on of lights in closed rooms. Also, to complete this study, we added bibliometric analysis. We hereby give a comprehensive collection of bibliometric articles, as indicated in **Table 1**, with references to earlier bibliometric studies and our investigations into earlier bibliometric analysis.

Table 1. Previous studies on bibliometrics.

Author	Title	Result
Shidiq *et al.*, (2021)	The use of simple spectrophotometer in STEM education: A bibliometric analysis	The study, which made use of the VOSviewer program, found that modified spectrophotometers are frequently used in chemistry and STEM teaching, providing prospects for future research.
Nordin, (2022)	Correlation between process engineering and special needs from bibliometric analysis perspectives.	VOSviewer, a process engineering tool for mapping analysis, experienced a decrease in publications on "process engineering special demands" between 2017 and 2021.
Bilad, (2022)	Bibliometric analysis for understanding the correlation between chemistry and special needs education using VOSviewer indexed by Google.	An analysis of articles on chemistry and special education using VOSviewer and Publish or Perish showed a decline in publications in 2017 and a rise in 2021.
Riandi *et al.*, (2022)	Implementation of biotechnology in education towards green chemistry teaching: A bibliometrics study and research trends	With journals being the most prevalent source, the study bibliometric analysis of research trends on biotechnology in education revealed four study concept potentials.

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Table 1 (continue). Previous studies on bibliometrics.

Author	Title	Result
Al Husaeni, (2022)	Bibliometric analysis of briquette research trends during the Covid-19 pandemic.	A review of 973 pertinent papers on briquettes was analyzed using VOSviewer, bibliometric analysis, and data mapping; the results showed a decline in research over the previous three years as a result of the COVID-19 pandemic.
Ragadhita & Nandiyanto, (2022)	Computational bibliometric analysis on publication of techno-economic education.	A study on science and Islamic research that employed data from the Scopus database from 2012 to 2022 and VOSviewer for bibliometric analysis found a reduction in research, mainly in Indonesia and Malaysia.
Al Husaeni & Nandiyanto, (2022)	Bibliometric computational mapping analysis of publications on mechanical engineering education using VOSviewer	A study that used VOSviewer to chart the development of nano propolis research over the last ten years found a spike in research on nanoparticles and propolis.
Nandiyanto *et al*., (2023)	Particulate matter emission from combustion and non-combustion automotive engine process: review and computational bibliometric analysis on its source, sizes, and health and lung impact	This study discusses the growth trend of scientific publications on the topic of particulate matter identified based on several categories such as the most cited, publisher, author, country, and affiliation.
Nandiyanto *et al*., (2023)	Involving Particle Technology in Computational Fluid Dynamics Research: A Bibliometric Analysis	This research was conducted to determine (i) the growth in the number of scientific publications in the field of particle technology in computational fluid dynamics (CFD), (ii) top citations based on the number of citations, publisher, and country, (iii) visualization of the most productive author, and (iv) publication development map based on keywords.
Al Husaeni *et al*., (2022)	How Language and Technology Can Improve Student Learning Quality in Engineering? Definition, Factors for Enhancing Students Comprehension, and Computational Bibliometric Analysis	The research aims to review developments in language and technology research that can improve the quality of teaching and learning in engineering. Several factors that can influence the teaching and learning process are explained, supported by a bibliometric analysis (with keywords "Language" AND "Engineering Learning" from Google Scholar from 2020 to 2022).
Nandiyanto *et al*., (2023)	Bibliometric data analysis of research on resin-based brakepads from 2012 to 2021 using VOSviewer mapping analysis computations	This study aims to analyze and demonstrate step-by-step bibliometric data analysis using VOSViewer completely and systematically. The analysis was carried out with the number of publications obtained, relating to the predetermined topics totaling 88 documents in 2017-2021.
Ruzmetov & Ibragimov, (2023)	Past, current and future trends of salicylic acid and its derivatives: A bibliometric review of papers from the Scopus database published from 2000 to 2021	Theoretical and practical interest in salicylic acid and its derivatives has increased over the last two decades, and with it, academic study in the field has been burgeoning. Most scientometric studies have only focused on a specific property of the topic compounds.
Susilawati *et al*., 2023	Things for science teachers: A bibliometric analysis	This study aims to analyze research trends in STEM Learning with the Internet of Things for science teachers.
Susilawati *et al*., 2022	Research Trends about internet of things in Science Education: A bibliometric analysis	Research on IoT in science education is still very low, and only a few countries have just researched IoT in science education.

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2. LITERATURE REVIEW

2.1. Light Intensity

Light is part of the electromagnetic wave radiation spectrum that can be observed by the human eye. Normally visible white light (also called visible light or visible light) consists of all the color components of the light spectrum (see **Figure 1.**). The light spectrum is divided based on the range (regional boundaries) of wavelengths. Different wavelengths are interpreted by the human brain as colors (Boes *et al.*, 2023).

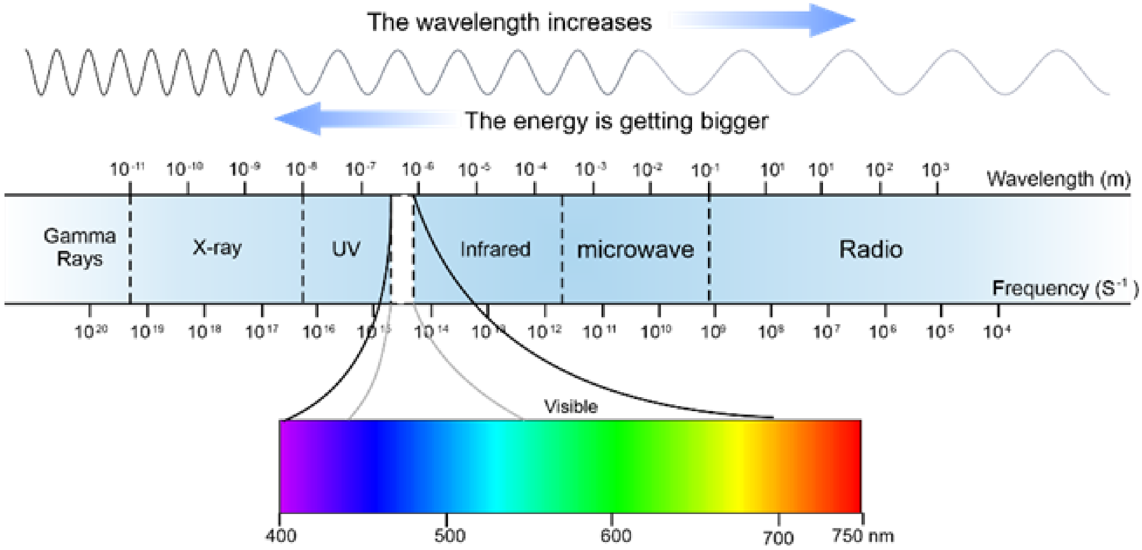

Figure 1. Light spectrum (Boes *et al*., 2023).

The lighting needs for each room in the household are sometimes different, as in **Figure 2**, where everything depends on the activities carried out. Several investigations regarding the relationship between productivity and lighting state that adequate lighting for this type of work can produce maximum production and reduce costs (Pamungkas *et al.*, 2015). Good lighting is lighting that allows us to see the object we are working on clearly. The amount of light intensity needs to be known because basically, humans need sufficient lighting. Light intensity greatly influences the conditions of a place, for example, humidity, temperature, and so on. The tool for measuring light intensity is a lux meter.

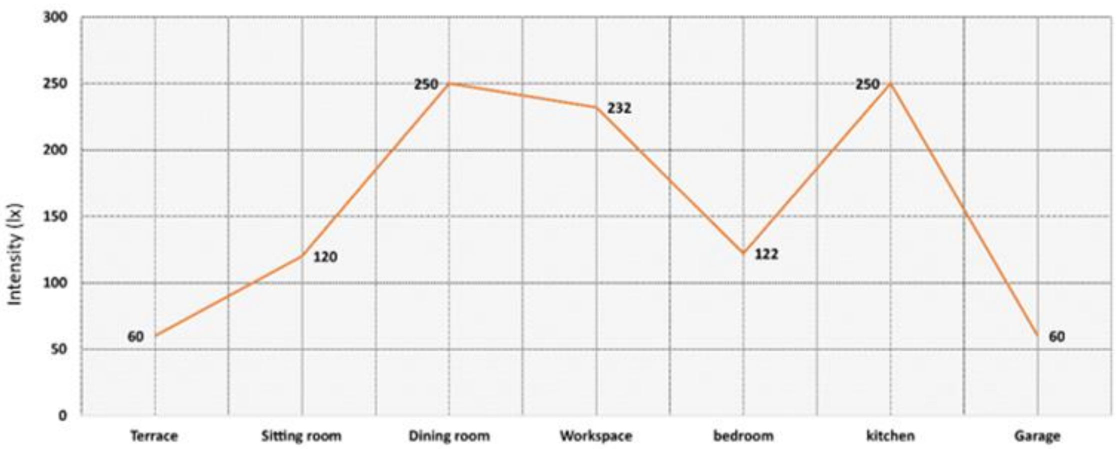

Figure 2. Light intensity requirements in residential houses.

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2.2. Light Sensor using Arduino

Controlling a lighting system via a Light Dependent Resistor (LDR) and Arduino simultaneously is a concept that can be used in everyday life, such as street lighting systems which are Passive Infrared receivers, and a few are LDR-based but are controlled via timers and analog circuits (Hao & Gao, 2018). Some are controlled by wireless GSM/GUI networks. Despite this, no paper combines all lighting systems into one umbrella and uses the LDR system and Arduino as the basic architecture to control them. In **Figure 3**, we can see LDR and how it works.

Ancient Lighting Systems were limited to two on-and-off options, as they had their drawbacks. This kind of operation means a loss of energy due to continuous operation at maximum voltage even though the actual need may be less, depending on the outdoor lighting conditions. The simplest solution is to calibrate the lamp according to outdoor lighting conditions. This is the basis for creating a smart lighting system designed using an Arduino-based LDR.

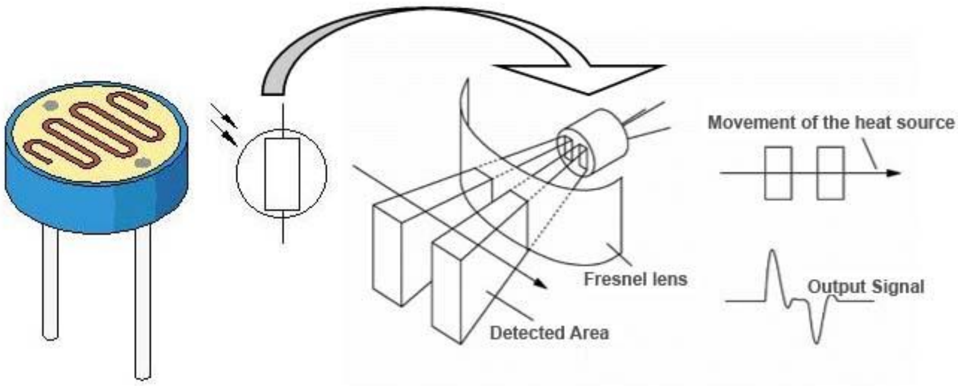

Figure 3. Light-dependent resistor and how it works.

2.3. Engineering Design Process

The engineering design process, also known as the engineering method, is a common series of steps that engineers use in creating functional products and processes. The process is highly iterative – parts of the process often need to be repeated many times before another can be entered – through the part(s) that get iterated and the number of such cycles in any given project may vary. It is a decision-making process (often iterative) in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation (Nguyen & Macchion, 2023). It's important to understand that there are various framings/articulations of the engineering design process. Different terminology employed may have varying degrees of overlap, which affects what steps get stated explicitly or deemed "high level" versus subordinate in any given model. This, of course, applies as much to any particular example steps/sequences given here.

One example framing of the engineering design process delineates the following stages: research, conceptualization, feasibility assessment, establishing design requirements, preliminary design, detailed design, production planning and tool design, and production (Baldassarre *et al.*, 2020). Others, noting that "different authors (in both research literature and in textbooks) define different phases of the design process with varying activities occurring within them," have suggested more simplified/generalized models – such as problem definition, conceptual design, preliminary design, detailed design, and design communication (Siqueira *et al.,* 2021). Another summary of the process, from European engineering design literature, includes clarification of the task, conceptual design, embodiment design, and detail design. (NOTE: In these examples, other key aspects – such as concept evaluation and prototyping – are subsets and/or extensions of one or more of the listed steps.

An understanding of the design process is important to manage design activities and to help improve product quality. It is suggested that understanding these processes relative to the creative process will provide insight into where and when resources should be focused to improve creative performance as well as the resulting 'quality' of the product being designed. There are many striking differences between design models in design, of particular interest are the divergent-convergent models, which include controlled convergence (Viveros *et al.,* 2020) and the double diamond (Saad *et al.,* 2020). The convergent divergent model differs from the traditional linear model style by assuming some form of integrated evaluation and selection of ideas and concepts. This is potentially a useful view of design from a creativity perspective, as separating the periods of generation and evaluation is considered good practice for lateral thinking and brainstorming (Weisberg, 2021). Another slightly unusual form of representation can be described as a 'knowledge space model'. Here it is assumed that a certain amount of knowledge must be acquired for each phase of the process to complete the design. These spaces can be filled in any order or random sequence, although there are certain dependencies embedded in every design project, namely that one space cannot be filled with more relevant information until knowledge is gained in another space. The main example of this type of representation from theory (Le Masson *et al.*, 2019) which describes design as a process of movement between a concept of space and a space of knowledge. Such models may be valid and representative of actual design activity, although it is clear that their high-level description makes them less useful for designers. The engineering process consists of four main design phases: 'task analysis, 'conceptual design', 'embodiment design' and 'detail design'. Preceding these four Phases is the 'Define Requirements' phase, where the design driving factors are identified. With few exceptions (Karim Jallow *et al.,* 2014), it appears that almost all processes assume a market-driven to technology-driven process.

3. METHODS

This research process is a type of quantitative descriptive research, where we created a simple project to show the value of light intensity in a room. Thus, it can turn on and off automatically to save time, namely by making a series of light sensors using an Arduino kit. The process from work to collection of data was carried out using the Engineering design process method.

3.1. Bibliometrics about Engineering Process Design Research Trends for the Last 10 Years

Engineering process design has been known since the 19th century, this is shown in the Scopus data document, an article about transistor circuit design developed by Raymond, *et al* in 1957. Research on engineering process design in the last 10 years has shown many researchers have developed to reach 15,582 documents recorded in Scopus. This can be confirmed in **Figure 4.** The number of articles publishing EDP themes on Scopus can reach thousands every year, with the highest peak in 2019 reaching 1698 documents, until 2023 The number remains at 1545 documents, this data obtained from the results of analysis of documents published on Scopus until February 17, 2024, at 03.31 West Indonesian time.

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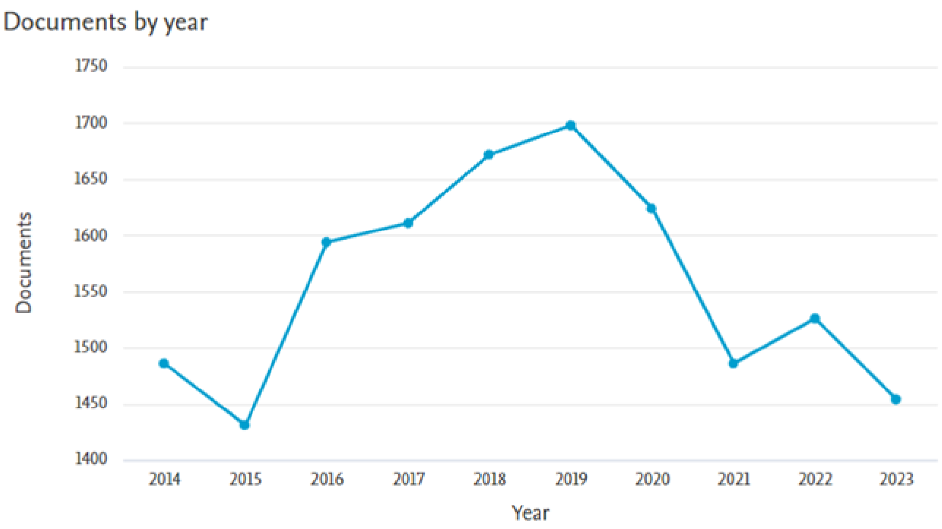

Figure 4. Research trends about EDP from 2014-2023.

The largest country that studies research on EDP is the US, while in Indonesia, based on Scopus data from the last 10 years, only 158 documents have been published that discuss engineering design as in **Figure 5.** This is a concern for the progress of education and the engineering process. Indonesia still needs to improve. Thus, it can follow the success in making products from process engineering results developed by developed countries. Therefore, the creation of the project in this research was carried out using engineering process design.

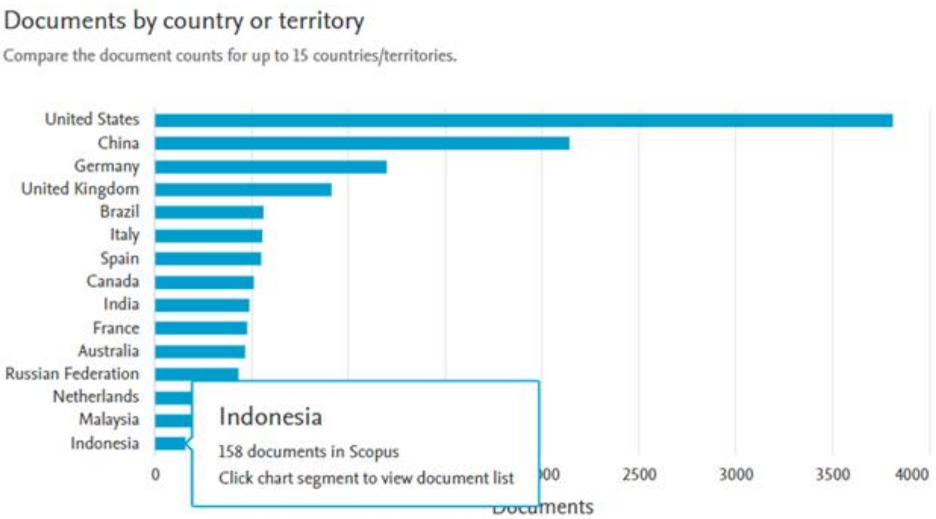

Figure 5. The position of the number of studies on EDP in Indonesia compared to other countries based on Scopus data.

3.2. Steps of Engineering Process Design

The stages are engineering design process which has five stages, including (i) Identification of the problem, (ii) Discussion of problem-solving, (iii) Designing, (iv) Creating, redesigning, and evaluation tests, and (v) sharing solutions (such as presented in **Figure 6**).

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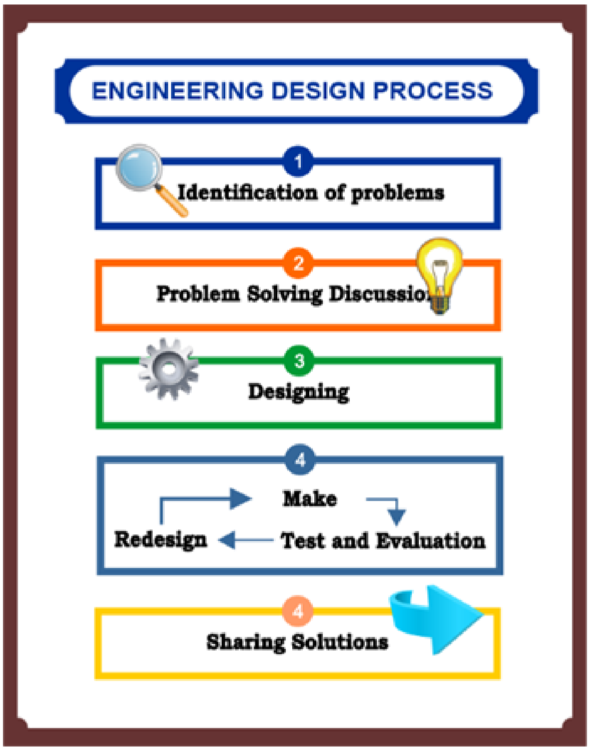

Figure 6. Engineering process design.

3.2.1. Identification of the Problem

At this stage, we identify problems regarding problems that exist in everyday life. The problem raised in this research is the problem of the very large use of energy in Indonesia. which is obtained from several data, such as data from BPS which projects in 2045 Indonesia's population will increase to 318.9 million, which will further encourage an increase in energy consumption in Indonesia. Various economic activities require energy, such as production, distribution, and consumption activities (Oswald *et al.,* 2020). This shows that energy in the long term can influence economic growth. **Figure 7** shows that the increase in energy consumption in Indonesia was quite high between 2000-2020. Energy consumption in Indonesia in 2000 reached 4.24 Joules, increasing by 91 percent to 8.1 exajoules in 2020. The trend of increasing energy consumption is in line with the increase in CO_2 emissions, where over the last 20 years the increase in emissions has increased by 108 percent, namely from 278 .15 $MtCO_2$ in 2000 to 579.9 $MtCO_2$ in 2020. This shows that the energy supply in Indonesia is currently still dominated by fossil energy, where intensive use of fossil energy will cause an increase in pollutants in the global atmosphere and this will threaten severe environmental damage to the ozone layer, this will result in global warming (Evey, 2021).

Energy intensity is used to describe the level of energy efficiency. Energy intensity is inversely proportional to energy efficiency, that is, the less energy required to produce one unit of output, the more efficient the use of energy. However, the energy intensity measure does not fully describe overall energy efficiency, but at least it can illustrate that a smaller ratio indicates a country is getting better at transferring energy into its production. Thus, energy intensity can be a proxy for measuring the level of energy efficiency (Asensio & Delmas, 2016). **Figure 8** depicts energy consumption per capita based on energy intensity in various countries. Indonesia has the highest intensity compared to other countries, but the energy consumption per capita is the lowest. This is a concern. Thus, Indonesian citizens must be wiser in using energy. If you look at the projected energy consumption used in Indonesia,

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the highest consumption is electricity compared to other energy consumption, this is shown in **Figure 9.**

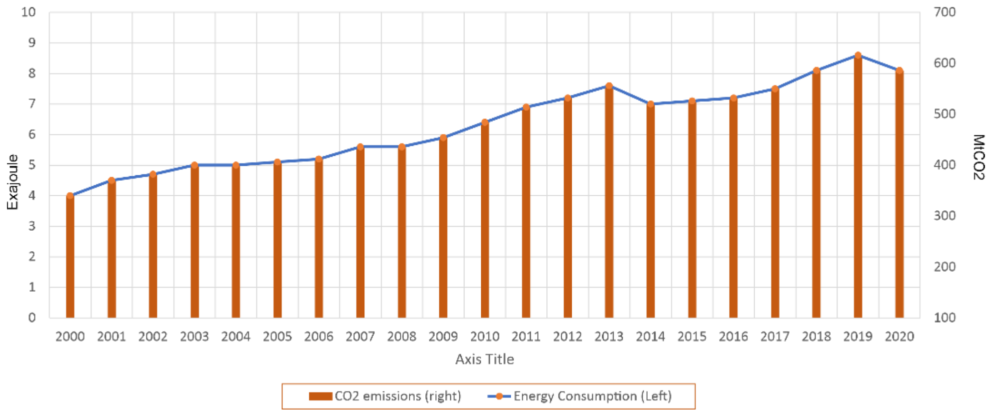

Figure 7. Energy consumption in Indonesia was quite high between 2000-2020.

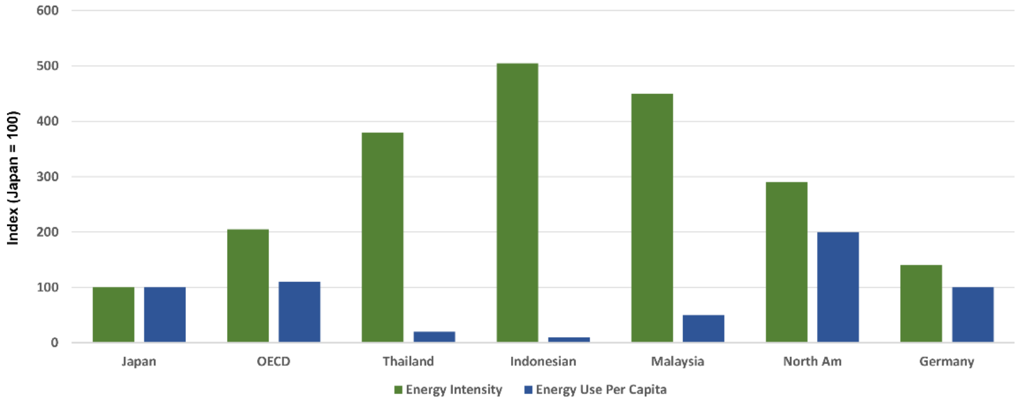

Figure 8. Comparison of energy consumption per capita in several countries.

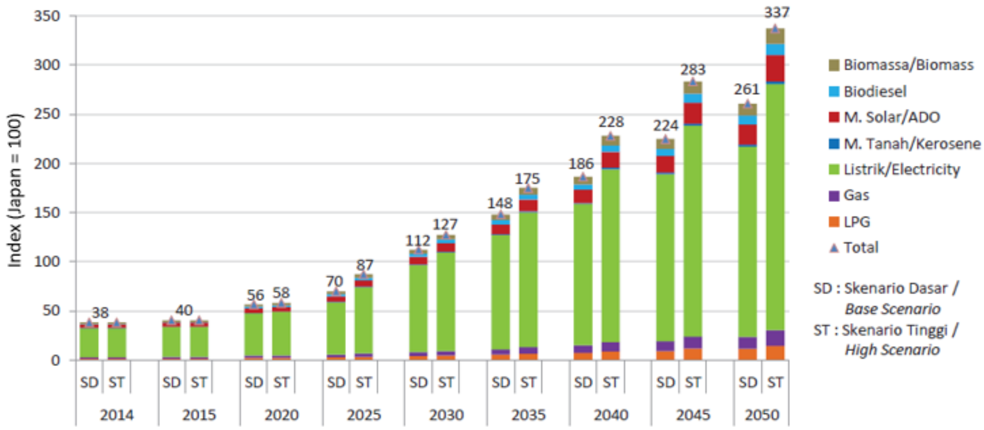

Figure 9. Energy consumption in Indonesia.

The comparison of the highest amount of electricity used compared to other uses of electricity is in line with the projection of Indonesia's electricity consumption per capita which continues to increase (see **Figure 10**). There is a need for action to reduce the use of excess electrical energy, such as making tools that can save electricity usage.

Electrical energy that is often used is the output of various sectors such as households, industry, business, social, government offices, and street vendors. According to the results of research on energy consumption data in the Special Region of Yogyakarta (one of the cities in Indonesia), the results showed that the largest consumption of electricity in 2017 was from the household sector (See **Figure 11**). If we look at the use of electricity, it can be obtained

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from its distribution, such as a comparison of industrial and household availability, then the type of electrical energy used, the length of time electricity is used, and the bad habits that are often carried out in excessive electricity use. If this has been reviewed, we can analyze the problems that occur in the use of electricity, and there is a need for a solution to be able to save on the use of electrical energy.

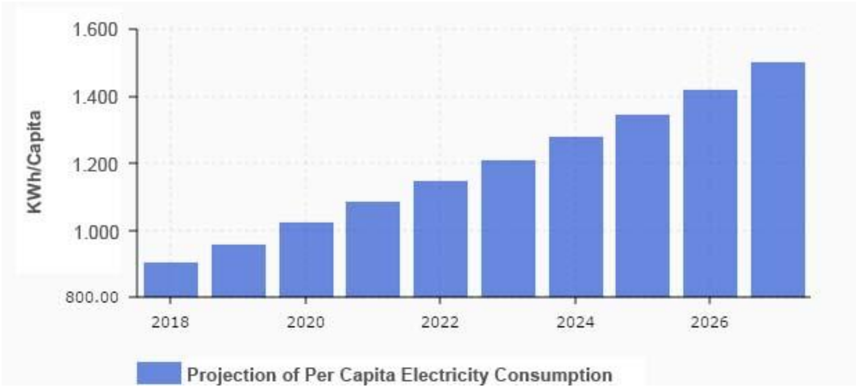

Figure 10. Projection of electricity consumption per capita in Indonesia (2018-2027).

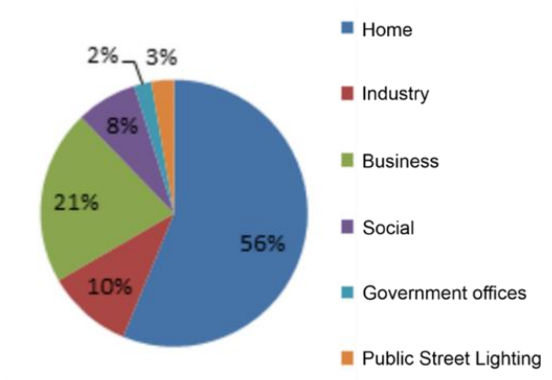

Figure 11. Energy consumption data from the special region of Yogyakarta, Indonesia.

3.2.2. Discussion of Problem-Solving

Analysis of documents available on Scopus from 2013-2023, it was found that Indonesia is the country with the most publications about problems in the use of excess electrical energy (**Figure 12)**. If we review further, several problems that often arise regarding the use of electricity in Indonesia and the solutions offered include (see **Table 2.**)

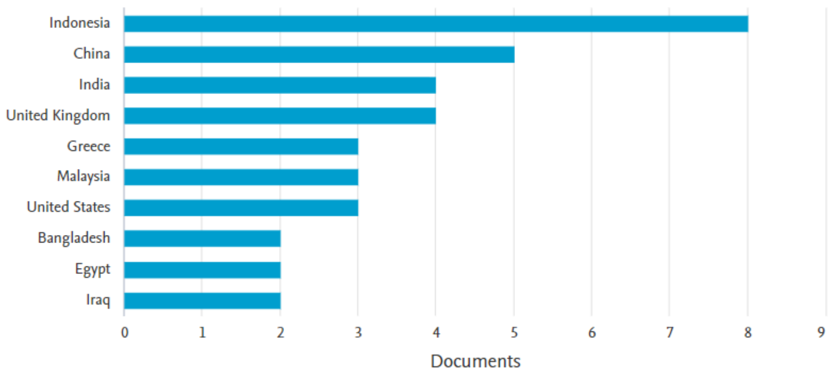

Figure 12. Ten countries published problems with the use of electricity in daily life in Scopus.

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Table 2. Research on electricity problems in Indonesia.

No.	Title	Results	Ref
1.	**Design of Buck-Boost Converter as A Voltage Stabilizer on Solar Power Plant at PPNS Baruna 01 Crewboat**	Problem: As time goes by, the need for electricity will increase due to the increase and development of population, investment, and technological developments. The use of coal as the main fuel for electricity generation is also increasingly becoming non-renewable. One solution to overcome this problem is the use of renewable energy. One type of renewable energy is environmentally friendly to meet solar energy electricity needs. Solution: The existence of very abundant solar energy is one solution to reduce fossil fuels which are currently running low. On the PPNS Baruna 01 Crewboat, the DC electricity source used comes from a total of two Solar Panels and each has a power of 300WP. As we know, solar energy fluctuates (goes up and down), therefore a DC-DC converter is needed. Thus, the resulting voltage is stable. The DC-DC converter used in this research is a buck-boost converter.	(Nugraha *et al.*, 2024)
2.	**Analysis of Solar Power Plant Design Using RETScreen and PVSyst in Pekanbaru-Indonesia**	Problem: Renewable energy is an important source for maintaining energy availability in the future, considering the increasingly depleting current energy sources based on oil and gas, coal, and other non-renewable energy sources. Solution: The energy emitted by the sun can be used as a form of renewable energy, namely solar energy. One implementation is by utilizing a series of photovoltaic (PV) cells which can convert solar energy into electrical energy for daily life. Indonesia is a country located on the equator, causing the overall temperature to be relatively higher than the world average temperature. This high temperature brings Indonesia's huge potential to process solar radiation (solar energy) as a renewable energy source. The construction of solar power plants in Indonesia can help in the distribution of electricity to meet domestic electricity needs. In this research, examiners will solve the problem of utilizing energy in the surrounding environment, by building a solar power plant in Indonesia. This research will carry out analysis based on simulations using RETScreen and PVSyst software.	(Saputri *et al.*, 2023)
3.	**A Fast Electrical Distribution Fault Predictor using Knowledge Growing System (KGS)**	Problem: Disruptions to the distribution of electric power will disrupt its reliability which will impact the supply of electricity to various sectors. Situations like this often occur at the State Electricity Company (SEC) Lambung Mangkurat unit on Kalimantan Island. Predictions of electricity distribution disturbances that cause disturbances can be made in advance to reduce electricity supply problems. Solution: We propose a new fast prediction technique called Knowledge Growing System (KGS) to predict electricity distribution disruptions. KGS is an intelligent agent that can generate knowledge about the phenomena it observes and use the resulting knowledge to make predictions. By knowing 11 electrical disturbance patterns at electricity distribution locations, KGS can predict that the disturbance most likely to occur is a Short-Circuited Primary Coil Burned (FSPCB) disturbance with a probability of 0.2830. With quick predictions, the SEC unit can develop appropriate plans to overcome disruptions and restore power supply more quickly.	(Syamsiana *et al.*, 2022)

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Table 2 (continue). Research on electricity problems in Indonesia.

No.	Title	Results	Ref
4	**Effect of (SnO_2:TiO_2) nanoparticles on charging performance of integrated dye-sensitized solar cell-supercapacitor**	Problem: Many disadvantages arise for separate devices, for example. loss of energy converted from solar cells or require other expensive devices for conversion of unused energy. To overcome this problem, this needs to be done by combining solar cells and storage in one integrated system. In this report, we show the charging performance of electrical energy from the DSSC to the supercapacitor. Solution: Outlines the synthesis of various kinds of SnO_2:TiO_2 composite nanoparticle photoanodes for various wt% TiO_2 fractions, namely 0, 9, 18, 27, 36, and 100%. The film has been made using the screen-printing method followed by mixing with β-carotene dye and combining an additional layer of ZnO symmetric supercapacitor to build a solar supercapacitor. TiO_2 and SnO_2 particles were found successfully synthesized with grain sizes ranging from 8.9 nm to 26 nm. The difference in energy produced by SnO_2/TiO_2. composite nanoparticles are 3.07 to 3.15 eV. The addition of TiO_2 nanoparticles increases the efficiency of solar cells. The optimal performance of SnO_2:TiO_2 composite nanoparticle solar cells demonstrated by 36 wt% TiO2 devices with Jsc, Voc, Fill factor, and efficiency are 0.388 mA, 0.806 V, 0.452, and 0.819% respectively. Charging from DSSC to Supercapacitors is measured to obtain their capacitance. This shows that the supercapacitor part can store energy produced by the conversion of light into electricity in the solar cell.	(Diantoro *et al.,* 2020)
5	**Maximum PowerPoint tracking using Lagrange interpolation method to optimize photovoltaic on DC microgrid system**	Problem: However, solar panel sources have weaknesses. The output power from solar panels still fluctuates depending on environmental temperature and sunlight on the solar panels. Irradiation is a beam of energy that comes from the sun. Solution: To overcome this problem, Maximum PowerPoint Tracking is needed. Thus, the solar panels can work according to their optimal point function. This Maximum PowerPoint method finds the largest current and voltage read by the solar panel using the Lagrange Interpolation method. By using Maximum PowerPoint Tracking, the output power is expected to be optimal with constant voltage and current. Thus, the battery life is not quickly damaged. This method can track the Maximum PowerPoint every time a change in irradiation occurs. The converter used in this Maximum PowerPoint Tracking is a SEPIC Converter. This converter can change the DC voltage into a higher or lower DC input voltage without changing the polarity. In this paper, the Lagrange Interpolation method has an average error in output power of 1.96%.	(Murdianto *et al.,* 2019)
6	**Design and implementation of unipolar SPWM full-bridge inverter using fuzzy Sugeno in DC microgrid isolated system**	Problem: The need for electrical energy has so far depended on fossil energy, while the availability of fossil energy is decreasing along with the increasing need for electricity in society. Solution: To overcome this problem, a microgrid system is implemented. The electricity source in this microgrid system is a DC (Direct Current) electricity source originating from PV and batteries which is then distributed to the DC bus with a voltage that is maintained constant at 400 Volts dc by a DC-DC converter. The voltage source originating from the DC bus will be converted into AC (Alternating Current) 220 volts. To save energy in the system, an inverter is needed that consumes less power in the conversion process and uses methods that can increase efficiency in its use. In this case, the unipolar switching technique has high process efficiency.	(Sudiharto *et al.*, 2018)

Table 2 (continue). Research on electricity problems in Indonesia.

No.	Title	Results	Ref
7	**Performance Analysis of a PV/FC Hybrid System for Generating Electricity in Iraq's Remote Areas**	Problem: A reliable supply of electrical energy is a prerequisite for improving the economic level and quality of life of a country. As in many countries, Iraq is home to many remote villages. Since it is uneconomical to connect these villages to the existing power grid, installing independent power generators has become common practice. As a result, diesel power plants are widely used in remote areas. While fit for purpose, these power plants unfortunately have several drawbacks, including the volatility of day-to-day oil prices and many environmental concerns. The application of a PV/FC hybrid electric power system could be a potential alternative to help overcome this problem. Solution: This paper will present a PV/FC system control strategy along with information related to the performance of the system components, based on a case study conducted in Al-Gowair, Iraq.	(Nawawi *et al.,* 2016)
8	**Generating electricity using PV/FC hybrid system**	Problem: A reliable supply of electrical energy is a prerequisite for improving the economic level and quality of life of a country. As is the case in many countries, connecting these villages to the existing power grid is not economical, and installing stand-alone power generators has become common practice. As a result, diesel power plants are widely used in remote areas. While fit for purpose, these power plants unfortunately have several drawbacks, including the volatility of day-to-day oil prices and a number of environmental concerns. Solution: The application of a PV/FC hybrid electric power system could be a potential alternative to help overcome this problem. Therefore, this paper presents a PV/FC system control strategy. This study is very important in order to estimate future energy supply needs. By using HOMER, the proposed control strategy and recommended PV/FC system components will be able to provide satisfactory results.	(Nawawi *et al.,* 2015)

The results of research published in Scopus regarding the problem of using electrical energy are that it does not save electrical energy even though the fuel used to generate electricity uses a lot of non-renewable natural resources (Guo *et al.,* 2023; Adewuyi & Awodumi, 2017; Djellouli *et al.,* 2022; Roy, 2024). Therefore, the solutions provided are more utilizing renewable energy sourced from renewable energy such as solar (Hoang & Nguyen, 2021; Kabir *et al.,* 2018), and PV/FC hybrid power (Sedaghati & Shakarami, 2019). Apart from that, several problems that can be obtained from the use of electrical energy in households include Electrical equipment often used at homes high-power electrical equipment such as refrigerators, televisions, dispensers, lights, and air conditioning, which is the largest power consumption by PLN customers (Muhammad *et al*., 2021), lack of monitoring of daily use of electrical energy (Pela *et al*., 2021; Ance *et al*., 2023), excessive use of electrical energy or overload exceeding the energy capacity owned (Tanjung *et al*., 2016), lack of understanding about the effectiveness of using electrical energy (Kilis, 2019; Patabang *et al.,* 2023), and lack of awareness of saving electrical energy (Sony & Mekoth, 2018).

The solutions provided are very diverse, such as providing education to the public about the use of electrical energy and a culture of saving electrical energy in the hope of increasing public awareness of the implementation of saving electricity. Ortega *et al.* (2020), Qazi *et al.* (2019), Broadbent *et al.* (2021), making automatic tools to regulate the on/off of electrical equipment. Thus, they are used according to needs (Jasim & Rikabi, 2021; Irawan & Wahyuni, 2021; Karthick & Chandrasekaran, 2021; Kambale, 2023), making automated tools that can check the capacity of electrical energy use at home (Leitao *et al.,* 2020; Stolojescu-Crisan *et al.,* 2021), and use of applications to manage electricity use at home (Dileep, 2020; Hui *et al.,* 2020). Several solutions that have been implemented, apart from providing information on understanding to the public and the use of automation tools, require the use of solar energy to regulate the automation of the use of electrical equipment, namely by using a Light Dependent Resistor (LDR) which can regulate the intensity of incoming light and automate the lights on. according to the intensity read.

2.2.3. Designing

The flow of designing a lighting automation tool using an LDR is shown in **Figure 13.** The steps are 1) prepare the tools and materials needed **(Figure 14)**, 2) create a circuit **(Figure. 15)**, 3) carry out coding through the application, 4) run, 5) check the distribution of incoming intensity values on the LDR from the monitor, 6) check the success of turning on and off the lights according to the code given by adjusting the light and dark around the LDR by approaching and moving away from the hand on the LDR, and 6) make revisions if the error still occurs.

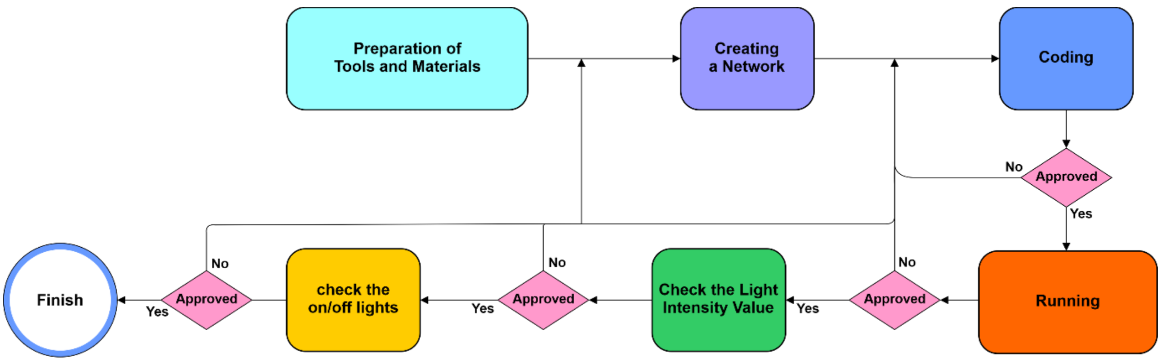

Figure 13. The flow of designing a lighting automation tool using LDR.

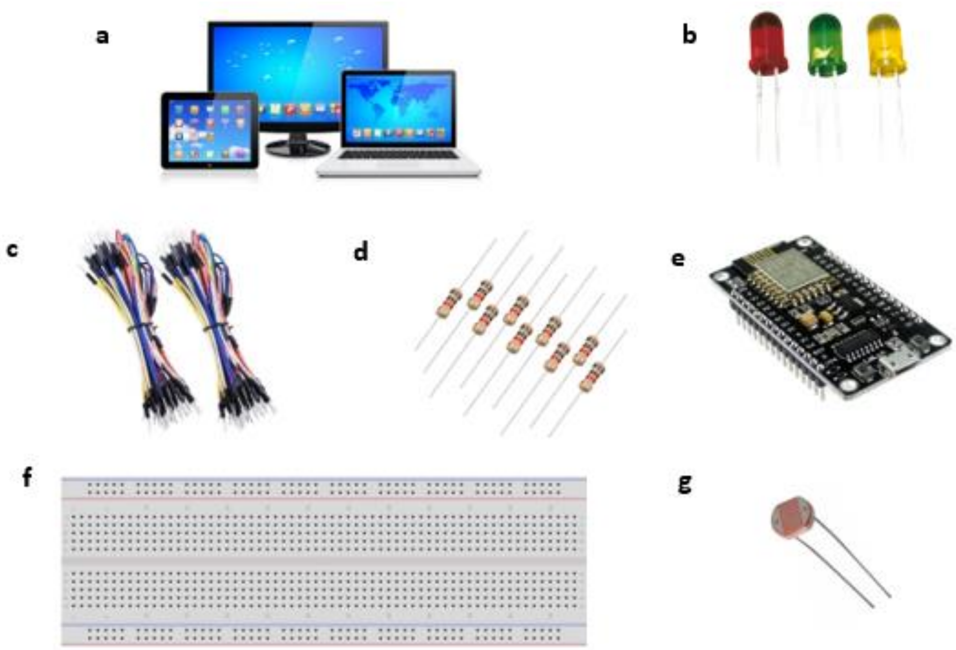

Figure 14. Tools and materials used: (a) Laptop/PC/Tablet for coding, (b) LED, (c) Jumper cables, (d) Resistors, (e) ESP8266, (f) Breadboard, and (g) LDR.

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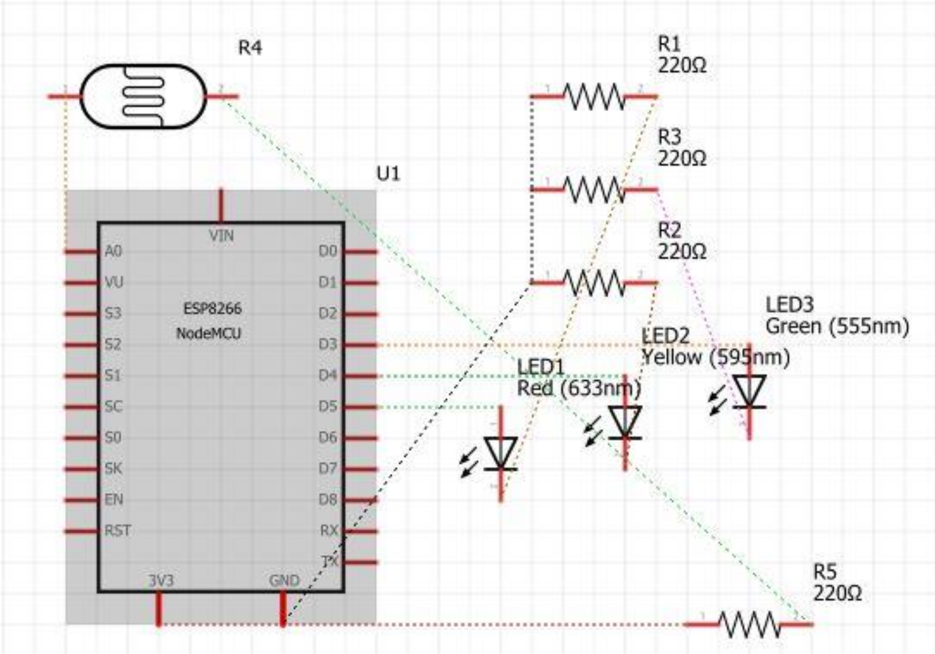

Figure 15. Schematic arrangement of resistors, lights, LDR, and ESP8266.

2.3.4. Creating, Redesigning, and Evaluation Tests

In the initial stages, after the design is made, then the tools and materials are prepared, and a circuit is made as in **Figure 16.** Then the circuit is tested to see whether it can function well or not, if it works then it can be continued with the coding process which can be created in the Arduino software application which has been created. installed on the device.

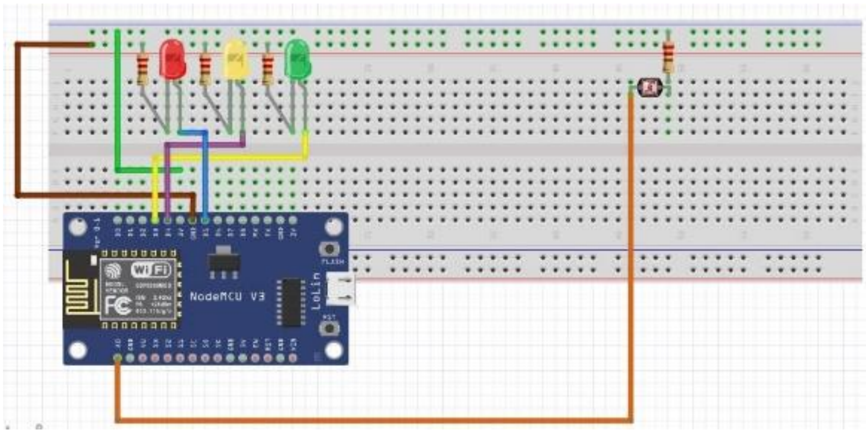

Figure 16. LED storage circuit, ESP8266, and LDR in the circuit.

The results of the design trials and whether the coding is running or not are made according to our needs, so several aspects are done during the testing process and changes or revisions based on the test evaluation, including:

(i) Changes to the use of a tool that originally only used one light and was given a delay of 50 ms. When tested, the use of one light was still very limited. To increase creativity and use varied coding, a challenge was given in the form of controlling 3 lights. Thus, when they are on or when they light up, there will be a flickering change in the light. Apart from that, giving a light delay of 50 ms was deemed too fast, so the delay was changed to 1000 ms.

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(ii) Changes to the circuit and the use of additional devices in the form of resistors for each path of the light and sensor circuit as an effort to stabilize the strength of the incoming current.

(iii) Changes in the storage of circuits and devices to control the work of sensors which are stored on a set of tables in a room that is tested under several conditions, namely the circuit or set of tables is stored in the main room (**Fig. 17a**) and the second room (**Fig. 17b**), 4 meters distance from the window in the living room (**Fig. 17c**), then change it closer to the window, 2 meters away (**Fig. 17d**), then change it back closer, 1 meter away from the window (**Fig. 17e**). The results obtained are more optimal in capturing light intensity well at a distance of 1 meter from the window in the main room.

Based on the results of trials and designs carried out to measure the light intensity value in a room at any time using an Arduino kit using an LDR sensor, several things that need to be evaluated are obtained, including:

(i) Tools and materials used apart from the main tools such as ESP8266, LDR, LED, Cable Jumper, and device, additional resistors in each circuit that connect each LED and LDR need to be added to stabilize the current value entering the circuit, then the use of a breadboard makes it easier to arrange series for beginners or learners.

(ii) When coding, it is better to give the LED a relatively long delay to turn it on and off. Thus, you can distinguish the changes that occur. Apart from that, using more than one LED gives an interesting feel when the intensity of the incoming light is low and the LEDs light up alternately.

(iii) The kit on the work desk and the device needs to be stored in a room that can provide information on the reception of light intensity entering the LDR. In this research, it was found that optimal reception was obtained when the kit was stored 1 meter away from the window in the living room.

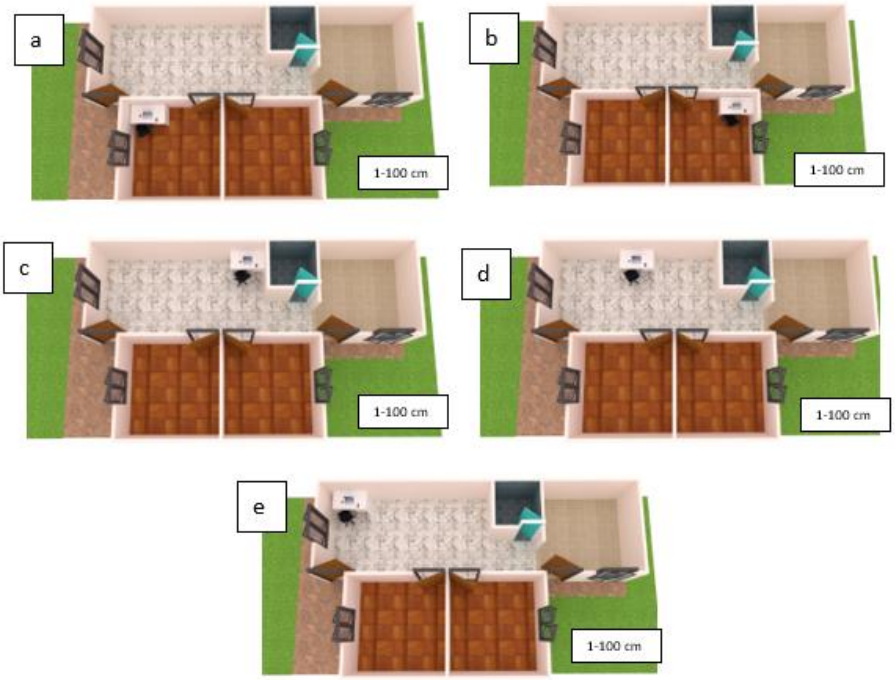

Figure 17. Redesign the storage of table sets (circuits and devices) in the room; (a) Kit in the main bedroom, (b) Kit in the second bedroom, (c) Kit in the living room (4 m from windows), (d) Kit in the living room (2 m from windows), and (e) Kit in the living room (1 m from windows).

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2.3.5. Sharing Solutions

Explaining that designing to save electricity using LDR sensors can be a solution to regulate the turning on and off the lights in the house according to the intensity of the incoming light by limiting the intensity value in the coding.

4. RESULTS AND DISCUSSION

4.1. Describe the Design of an LDR Light Sensor in a Circuit that is Used Indoors for a Specified Period

The design and design of using LDR light sensors in a circuit is carried out through the engineering process design stages, with a process that has been explained in the previous discussion and is depicted in Figures 6 to 20. After the circuit design has been made, the designed device is stored in the room with an explanation of the room conditions and Tool storage is presented in **Figure 18**. Where tools are stored at a certain distance from sources of sunlight through windows. The device is deliberately kept in an empty room (a house that is not occupied and not lit). Thus, the light that will influence the change in light intensity read on the LDR only comes from sunlight, and then at a certain intensity value, it will automatically turn on and dim the lights in the circuit. This is intended to determine the intensity of light that enters and is read at a certain time, a detailed description of the circuit design connected to the software to see the intensity values that are read (see **Figure 19**). Thus, changes can be obtained, and whether or not the automatic process of the tool that has been created is working.

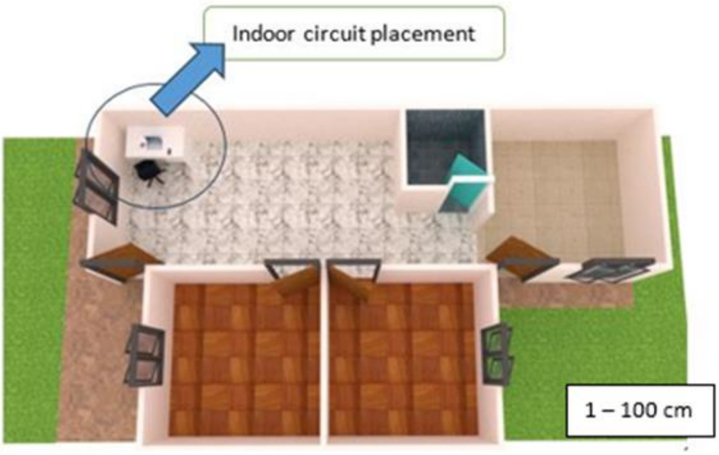

Figure 18. Indoor circuit storage scheme.

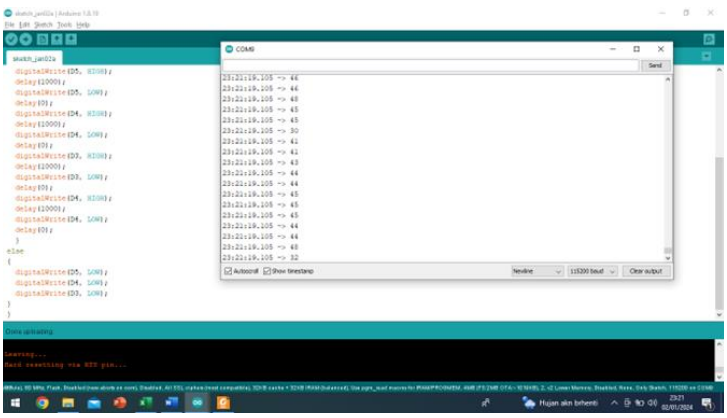

Figure 19. The software displays the results of the light intensity that is read.

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4.2. Explaining the Distribution of Light Intensity Values Presented from the LDR Sensitivity Results Used in the Circuit We Designed at a Certain Time

The results of the coding carried out will limit a certain intensity value to control the turning on and off of the lights in the circuit. The minimum value limit is 120, so if the value shows a number above 120 then the light will turn off. This limiting value is still taken as an arbitrary value, only to test the success of the automation work, to check and ensure the correct value to be used as a limit, it is necessary to test the light intensity value distributed at a certain time.

Testing to find the read intensity values from changes in dark to light or light to dark was carried out for 7 days from 28 December 2023 - 03 January 2024, from 00.00, once every 3 hours the distribution of the light intensity values read was checked. Several studies state that weather conditions and temperature in the atmosphere or room can influence the value of the intensity of sunlight entering the room (Ganesh *et al.,* 2021). Thus, researchers make observations of weather and room temperature based on data from the Meteorology, Climatology, and Geophysics Agency (BMKG) from 28 December 2023 – 03 January 2024 (see **Table 3**).

Table 3. Weather conditions and average room temperature.

Day, Date	**Weather and temperature**			
Thursday, December 28, 2023	Morning Sunny  28°	Day Sunny  33°	Night Medium Rain  26°	Early Morning Medium Rain  23°
Friday, December 29, 2023	Morning Sunny  28°	Day Cloudy  33°	Night Medium Rain  26°	Early Morning Medium Rain  23°
Saturday, December 30, 2023	Morning Sunny  28°	Day Cloudy  34°	Night Cloudy  26°	Early Morning Medium Rain  22°

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Table 3 (continue). Weather conditions and average room temperature.

Day, Date	Weather and temperature			
Thursday, December 28, 2023	Morning Sunny  28°	Day Sunny  33°	Night Medium Rain  26°	Early Morning Medium Rain  23°
Friday, December 29, 2023	Morning Sunny  28°	Day Cloudy  33°	Night Medium Rain  26°	Early Morning Medium Rain  23°
Saturday, December 30, 2023	Morning Sunny  28°	Day Cloudy  34°	Night Cloudy  26°	Early Morning Medium Rain  22°
Sunday, December 31, 2023	Morning Sunny  28°	Day Cloudy  32°	Night Cloudy  26°	Early Morning Rain  23°
Monday, January 1, 2024	Morning Cloudy  29°	Day Cloudy  36°	Night Cloudy  26°	Early Morning Medium Rain  25°
Tuesday, January 2, 2024	Morning Cloudy  28°	Day Cloudy  33°	Night Cloudy  27°	Early Morning Medium Rain  26°

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Table 3 (continue). Weather conditions and average room temperature.

Day, Date	Weather and temperature			
Wednesday, January 3, 2024	Morning Sunny  28°	Day Cloudy  34°	Night Cloudy  25°	Early Morning Medium Rain  26°

The average light intensity that was read in the room for 6 days is presented in **Table 4.** and for the distribution of intensity values, we can find in **Figure 20.** We can see that Sunday, 31 December has a value intensity lower than the other, but Monday has the highest intensity every time.

Table 4. The average value of light intensity that is read every three hours.

Day, Date	00:00	03:00	06:00	09:00	12:00	15:00	18:00	21:00	Average
Thursday, December 28, 2023	31	45	109	529	950	478	84	60	285.75
Friday, December 29, 2023	31	44	111	487	945	476	85	65	280.50
Saturday, December 30, 2023	40	41	101	594	999	506	86	70	304.63
Sunday, December 31, 2023	30	32	101	467	886	396	76	59	255.88
Monday, January 1, 2024	49	47	127	774	1015	562	88	74	342.00
Tuesday, January 2, 2024	31	35	104	487	1000	500	88	60	288.13
Wednesday, January 3, 2024	40	43	109	630	961	530	85	72	308.75

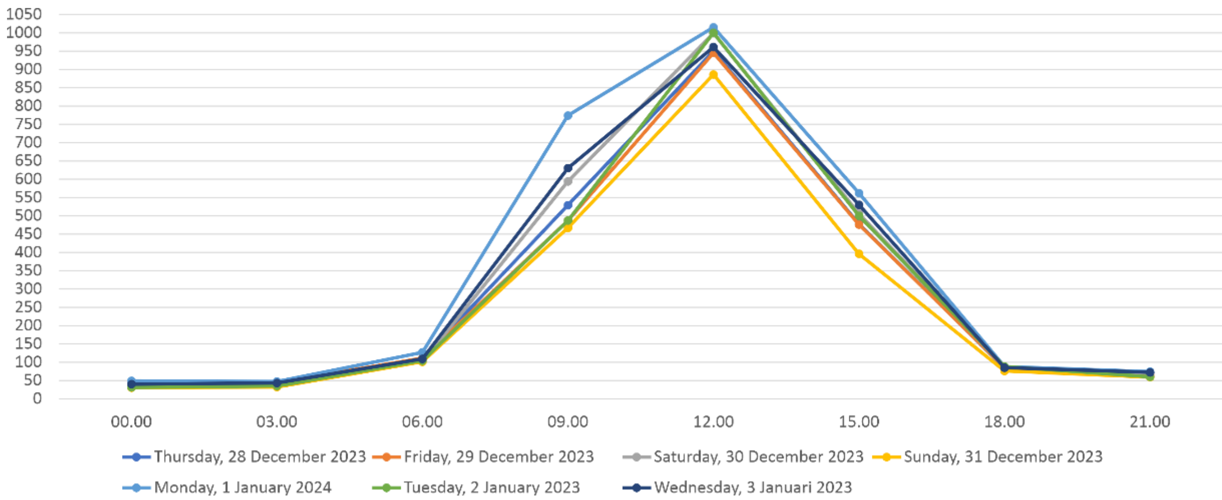

Figure 20. The distribution average of intensity values read in the room.

4.3. Analyzing the Light Intensity Value Entering the LDR Sensor When Changes in Darkness and Light Occur in the Room Within a Certain Time

Analysis of the light intensity value entering the LDR sensor is carried out at a certain time, apart from reading the distribution every three hours, apart from that, checking the

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distribution of the light intensity value when changing from day to night or called sunset and changing from night today, sunrise. This is done to identify the distribution of average values that enter when the environment changes from dark to light and from light to dark. If the average value is obtained, it will be a benchmark for coders in determining the minimum value that the LDR can read to turn the lights on and off automatically. Because at sunrise or sunset, everyone, especially in households, often turns off the lights at sunrise and turns on the lights at sunset (Alberini *et al*, 2019).

Before the average light intensity value is taken, first, we identified the sunrise and sunset times from the 7 days when the test was carried out, based on the BMKG distribution of sunrise and sunset times and the distribution of intensity values read from 28 December 2023 to 3 January 2024 (shown in **Table 5**).

Table 5. Light Intensity distribution when changes in darkness and light occur in the room.

Day	Time		Light Intensity Distribution (lx)											x̄
Thursday,	Sunrise	05:36	105	105	105	105	108	109	109	109	109	110	110	109
12/28/2023	Sunset	18:07	82	82	82	84	85	85	85	85	86	86	86	84
Friday,	Sunrise	05:37	112	112	112	111	111	111	111	112	111	112	112	111
12/29/2023	Sunset	18:08	83	83	83	84	84	84	85	85	85	85	85	84
Saturday,	Sunrise	05:37	105	105	105	105	106	106	106	105	105	106	106	105
12/30/2023	Sunset	18:08	87	86	86	86	87	88	88	88	87	88	88	87
Sunday,	Sunrise	05:37	135	135	135	135	135	135	135	135	135	135	135	135
12/31/2023	Sunset	18:08	71	72	72	72	78	78	75	75	75	76	76	75
Monday,	Sunrise	05:37	125	125	125	125	125	125	125	125	125	127	127	125
01/01/2024	Sunset	18:08	89	88	88	89	89	88	88	89	89	89	89	89
Tuesday,	Sunrise	05:37	116	116	116	116	116	117	117	117	117	117	117	116
01/02/2024	Sunset	18:08	88	88	87	89	87	88	88	88	89	87	87	88
Wednesday,	Sunrise	05:37	109	109	109	109	109	109	109	109	109	109	109	109
01/03/2024	Sunset	18:08	86	86	80	80	83	86	86	84	84	85	85	84

Noted: Based on the distribution results, the average value of light intensity at sunrise is 116, while at sunset it is 84. This intensity value was taken for 7 days from 28 December 2023 to 3 January 2024.

4.4. Concludes the selection of light intensity limiting values that need to be set to control turning off and turning on lights automatically in closed rooms.

The conclusions obtained from the results of this research include:

(i). The light intensity value that can be used to limit the ability of lights to turn on and off automatically is 100. This is taken from the average change from dark to light and light to dark, namely, an average of 116 sunrises and 84 sunsets if averaged. average the value to get a value of 100. This corresponds with research from Hassan about observations that led us to get some estimates about morning twilight, as it is necessary to determine the time of the True Dawn (Hassan *et al.,* 2021), The ultimate aim of smart lighting research is to introduce low energy efficiency and high user comfort (Putrada *et al.,* 2022).

(ii). This average value was obtained in a closed room measuring 4 m x 2.5 m, with a roof height of 3 m, where the LDR sensor storage in a series is 1 meter from a window measuring 1 m x 0.5 meters, which is 2 windows. It is important to know this. Thus, you can adjust the selection of light intensity values to the conditions of the room that will be set to turn on and turn off the lights installed in the room, following Lighting controllers that integrate occupancy and luminosity sensors to improve energy efficiency have been proposed (Park *et al.,* 2019; Dong *et al.,* 2019).

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(iii). The time taken for testing is at any time for 7 days from 28 December 2023 to 3 January 2024, with an average room temperature of 30o C with sunny weather conditions in the morning, cloudy in the afternoon, and moderate rain in the afternoon. Evening. Temperature and weather conditions can also usually influence the distribution of light intensity in the room (Knoop *et al.,* 2020).

5. CONCLUSION

Indoor light intensity measurements were carried out for 7 days, each testing day starting from 00.00 – 23.55 or full day. for the change from night to day (sunrise) we take data at 05.30, and from 18.00 for the change from day to night (sunset). The research results provide new findings that the average distribution of light when changing from dark to light at 05.36 - 05.37 indoors shows a value of 105-135 lx, while from light to dark at 18.07 - 18.08 shows a value of 75 - 88 lux. These results can be used in further research to determine values that can be input into coding to control LDR sensor automation in product development.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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