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Conference on Smart Power & Emerging Technologies

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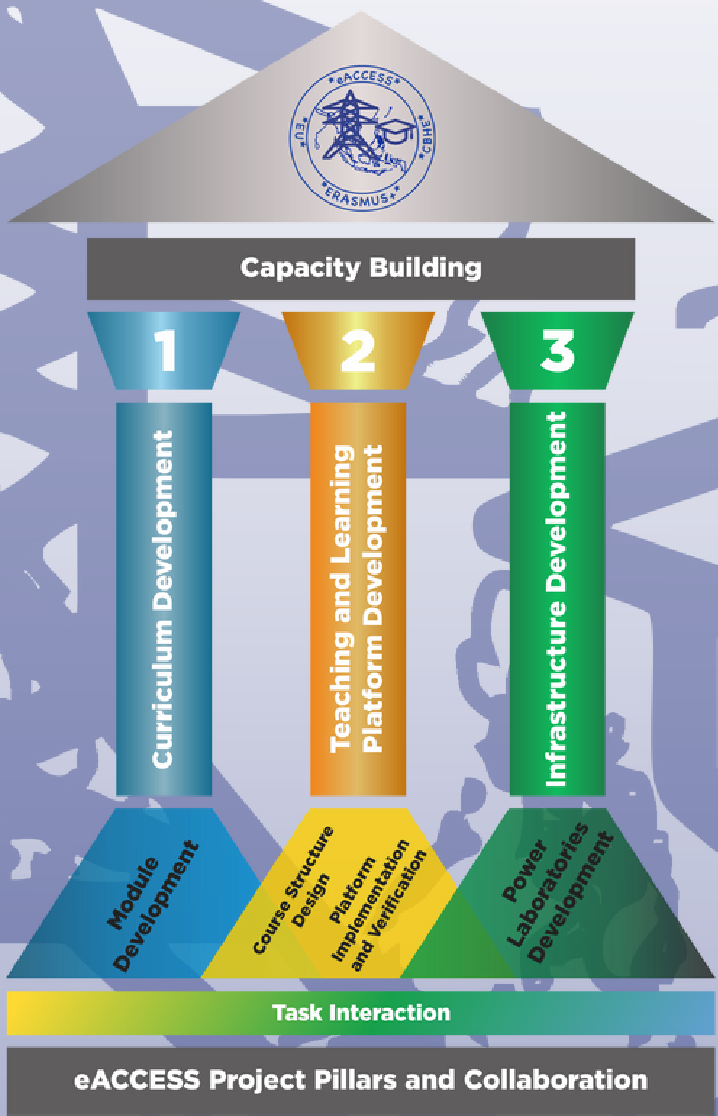
Faculty Of Engineering, Atma Jaya Catholic University of Indonesia



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WELCOME MESSAGE FROM
THE DEAN OF FACULTY OF ENGINEERING
ATMA JAYA CATHOLIC UNIVERSITY OF INDONESIA

On behalf of the Faculty of Engineering, Atma Jaya Catholic University of Indonesia, I welcome you to this special and memorable conference, the eACCESS Conference on Smart Power & Emerging Technologies (eACCESS-SPET) 2023. The eAccess-SPET Conference is the closing ceremony of the ERASMUS+ project by the European Union which aims at developing and modernizing the Undergraduate and Postgraduate curriculum in Power and Electrical Engineering for partner Asian universities. The increasing need for electricity nowadays creates complex networks of the electricity ecosystem, which must be managed and maintained. Knowledge and skills in modern power systems are beneficial in providing an efficient and sustainable electricity landscape. The eACCESS Conference on Smart Power & Emerging Technologies 2023 will be a remarkable platform for all of us to share the latest knowledge, the latest trends, and the current deficits of skills in modern power systems.

We are honored to have Dr. Parag Vichare from the University of the West of Scotland of UK, Filda Citra Yusgiantoro Ph.D., Chairperson at Purnomo Yusgiantoro Center, Muhammad Reza PhD, Director of PLN Nusantara Power, Sim Budiman, CEO of PT. Surya Utama Putra and Dr. Ir. Lukas IPM, Chairman of Indonesia Artificial Intelligence Society (IAIS), to deliver the keynote speech at eACCESS-SPET 2023. I hope the insight shared by these keynote speakers will bring future collaboration between universities, research institutions, and industries locally and internationally.

The Faculty of Engineering has a strong commitment in pursuing the vision of Atma Jaya Catholic University of Indonesia to be an excellent university both locally and internationally. Therefore, this international conference will be a special event to increase our contribution in shaping the excellent academia and professionals.

Finally, I congratulate all the organizing committees for their hard work and patience in organizing this conference. And to all the participants, keynote speakers, and organizing committees, I wish you success in this conference, and may you feel enjoy and comfortable during this conference.

Sincerely,

Prof. Dr. Ir. Djoko Setyanto

Dean of Faculty of Engineering
Atma Jaya Catholic University of Indonesia

WELCOME MESSAGE FROM THE CONFERENCE CHAIR Of eACCESS-SPET 2023

It is both our great pleasure and honor, to welcome you all at the eACCESS Conference on Smart Power & Emerging Technologies (eACCESS-SPET) 2023, at Century Park Hotel, Jakarta.This conference is organized by the eACCESS Erasmus+ Project consortium, which consists of eight universities from Europe and Asia, Lodz Technology University of Poland, The University of the West of Scotland of UK, Aristotle University of Thessaloniki of Greece, Kantipur Engineering College of Nepal, Pokhara University of Nepal, Royal University of Bhutan, Atma Jaya Catholic University of Indonesia, Soegijapranata Catholic University of Indonesia.

Under the theme of “Smart Power and Emerging Technologies,” this conference aims to bring together scholars, practitioners, educators, and students to share and exchange knowledge, outcomes, and experiences related to smart and modern power systems and other emerging technologies. As smart power systems become more important in providing efficient and reliable electricity, our goal is to explore innovative approaches and solutions that foster the development and deployment of clean energy technologies which can enhance socioeconomic well-being while considering the various aspects of sustainability, affordability and a cleaner environment.

We are delighted to have the invited speeches presented by Dr. Parag Vichare from the University of the West of Scotland of UK, Filda Citra Yusgiantoro Ph.D., Chairperson at Purnomo Yusgiantoro Center, Muhammad Reza PhD, Director of PLN Nusantara Power, Sim Budiman, CEO of PT. Surya Utama Putra and Dr. Ir. Lukas IPM, Chairman of Indonesia Artificial Intelligence Society (IAIS). On behalf of the committee, I would like to thank the keynote speakers for their willingness to take part in this conference. I believe this conference will provide an excellent opportunity of exchanging research ideas and collaboration between universities and industries in the future.

I would like to express my sincere gratitude to our Dean of Faculty of Engineering and Rector of Atma Jaya Catholic University of Indonesia for their continuous support that this event is possible to be held. And also I would like to give great appreciation to all committee members, my colleagues, and my students for their valuable time and contribution to this excellent arrangement for this conference.

Finally, on behalf of the committee of eAccess-SPET 2023, I wish all the participants a very successful conference with fruitful discussions and a memorable experience at this conference.

Sincerely,

Dr. Marsul Siregar, M.Eng

Chairman

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Thorium – Nuclear Power Plant as Option to Solve The Problems of Climate Change and Energy Availability

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***Abstract*— World continues to experience rapid growth in various sectors. It should be realized that behind the rapid pace of development there is a big demand especially in electricity sector. An assessment has been conducted to demonstrate the comparison between the three subjects conducted through a literature study methodology which is expected to illustrate that the option to include the Thorium-Nuclear Power Plant (NPP-Thorium) in the National Energy Policy (Indonesia) is a multilevel step to solve climate change problems and energy availability because it has exceptional efficiency with very little waste. And it is the most appropriate step in supporting the Government of Indonesia towards sustainable development commitments with the most cost-effective projections compared to other energy sources.**

Keywords— NPP, Thorium, National Energy Policy (KEN)

IV. Introduction

According the results of a study from the Comprehensive Assessment of Energy Sources for Electricity Generation in Indonesia (CADES), in 2025 energy needs in Indonesia will be 2 times higher than in 2000, especially for electrical energy needs will increase 4 times. Of course, the fulfillment of this energy is impossible to provide only from fossil energy sources, considering that its availability will not last more than 150 years. Not to mention the environmental problems arising from the use of fossil fuel power plants which, based on literature studies, have serious impacts such as: depletion of resource reserves, global warming, acid rain, and other derivative impacts such as tidal waves, climate change, ecosystem damage, etc. -other.[1]

To solve this problem, the Indonesian government has attempted a concept of sustainable development which means that in order to improve human quality, it must be accompanied by attention to environmental factors so that future generations can also enjoy the quality and quantity of natural resources that we enjoy now. These efforts are realized through the preparation of policies carried out with an integral approach to all development sectors by paying attention to conservation issues and the carrying capacity of the environment. These policies have been compiled and contained in the National Energy Policy (KEN).

V. Background

The National Energy Policy (KEN) has big challenges ahead to be able to meet national energy targets and demands while maintaining the concept of sustainable development.

The reason is that for industrial sector alone, according to data from the Ministry of Industry, the industrial sector is the largest absorber of energy in Indonesia, reaching 39 percent of total national energy use, and will continue to increase considering the government's target to be able to meet the industrial contribution target to Gross Domestic Product (GDP) at 30-40%. To reach this range, an installed electricity capacity of more than 500Watt/person is required. Meanwhile, currently Indonesia's installed capacity is 210 Watts/person, still far below Malaysia's 982 Watts/person, Thailand's 802 Watts/person and Singapore's 2028 Watts/person. With an estimated population of 300 million people in 2025, Indonesia must be able to achieve this target by growing national installed electricity capacity of 10 GigaWatt/year.[4]

To meet energy needs in 2025, the concept of using all available energy (mixed energy) must be applied, without discriminating against existing and available energy sources.[1)] In accordance with the mandate of Presidential Decree Number 5 of 2005 concerning the 3 principles of National Energy Policy, namely energy diversification, energy intensification and energy conservation. Diversification means reducing dependence on only a few energy sources (oil and gas) and then replacing them with other sources. Intensification means increasing and developing exploration of energy sources available in the country, conservation means economical use of energy and increasing the efficiency of energy production.

In line with policies in the energy sector, namely intensification, diversification and conservation, important steps need to be taken in order to formulate alternative strategies in the energy sector which is a determining pattern for national energy development in the future. Implementation of energy policy includes several aspects, one of which is the use of appropriate technology. The technology must be:

A. *Technology that produces a substitute for oil, as oil is a non-renewable energy.[1]*

B. *Technology that supports sustainable energy supply.[1]*

C. *Clean and efficient energy technology to support environmental conservation.[1]*

An energy breakthrough and innovation is absolutely necessary to guarantee the provision of energy that is safe, clean, environmentally friendly, sustainable, large-scale, cheap and can be built in a short time.

The presence of the Thorium-NPP is a breakthrough and innovation as well as a challenge for Indonesia because the world is competing to be the first country to use Thorium as fuel for their NPP, which is then very relevant for solving energy availability problems and automatically helping to overcome environmental problems.

Indonesia has a potential thorium content estimated to reach 210.000 – 270.000 tons. So if the Thorium-NPP can be developed, Indonesia will not only be a country that is ready to become a country with strong energy security for more than 1.000 years, but will also be able to supply electrical energy internationally. Thorium power plants have higher efficiency than even coal and uranium. The calculations are that 7 tons of thorium can produce 1.000 Mega Watts or 1 Giga Watt per year, while coal requires 3.5 - 4 million tons, while uranium is 200-250 tons.[4]

In this article, we will discuss the study of the environmental impact of using fossil fuels and consideration of Thorium being used as a nuclear fuel for electricity generation, so that we can find out its advantages and disadvantages in terms of sustainable development as well as its reliability in solving the problems of climate change and energy availability.

VI. METODOLOGY

Study of this paper was carried out using the following methods: literature review, secondary data collection (data resulting from existing research and studies), and discussion/consultation with experts/researchers who understand and comprehend the field.

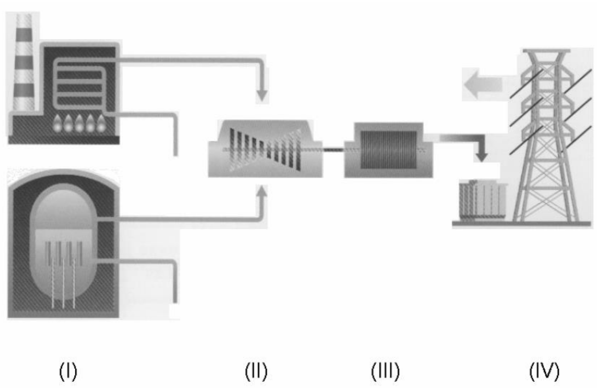
VII. RESULT

A. Working Principles of NPP and SPP

The working principles of NPPs and SPPs are almost the same, namely consisting of: (I) Steam generator system, (II) Turbine, (III) Electric Generator which will produce electric power which then enters the distribution network (IV). The steam produced by the steam generator system will be used to rotate the turbine system which is coupled with an electric generator which will convert kinetic energy into electrical energy. The electricity produced then enters the distribution network to be distributed to consumers.[1]

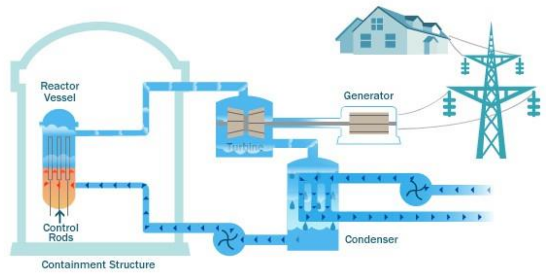
The difference between NPP and SPP is only in the steam generator system as shown in Figure 1. In SPP the steam generator system used is a conventional system, namely steam is produced from a boiler which is heated using fossil fuels. Meanwhile, nuclear power plants utilize the fission reaction (the splitting of atomic nuclei into new, lighter nuclei while releasing energy) that occurs in nuclear reactors as a "stove" or boiler heater to produce steam. There are several types that are most widely used in the world, including the BWR (Boiling Water Reactor) type, namely steam produced from a steam generator as well as a nuclear reactor and the PWR (Pressurized Water Reactor) type where steam is produced from a steam generator consisting of a boiler equipped with a nuclear reactor as a heater. [1]

Fig. 1. Comparison of steam generator systems. At conventional power plant and nuclear power plants. [1]



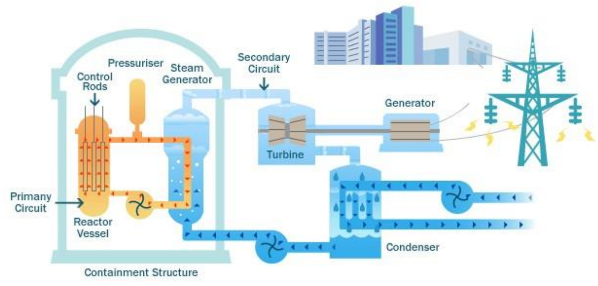
The differences between BWR and PWR type NPPs are shown in Figures 2 and 3 below.

Fig. 2. BWR type nuclear power plant.



Source : *CLP Power Low Carbon Energy Education Centre*

Fig. 3. PWR type nuclear power plant.



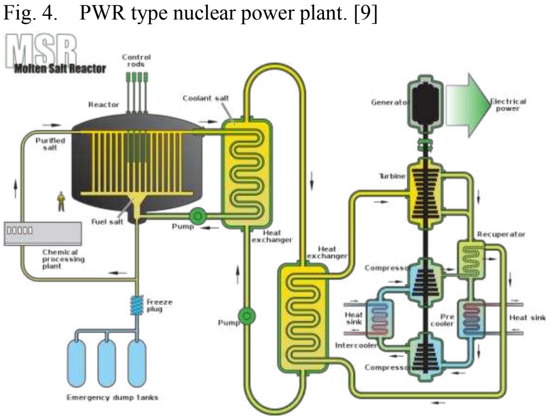
Source : *CLP Power Low Carbon Energy Education Centre*

B. Thorium dan Molten Salt Reactor (MSR)

Thorium is an element with atomic number 90 which is solid like crystals and other minerals, has a silvery color and has radioactive properties which can be used as fuel for nuclear reactors. Thorium is found in large quantities in the earth compared to gold, silver and tin, and is found in almost every country in the world.[2] In Indonesia, Thorium can be found in Bangka Belitung as a follow-up to tin and according to the National Nuclear Energy Agency (BATAN) there are around 121.500 tons of Thorium reserves in Bangka Belitung (only Bangka Belitung, not all of Indonesia) which can provide 121 Gigawatts of power for 1000 years.

Molten Salt Reactor (MSR) is a nuclear technology that uses liquid fuel where the working principle of MSR technology is no different from the principle of using nuclear energy in nuclear power plants, namely using energy (heat) released in the fission (splitting) process of atoms to heat water to a temperature above 500ºC where the steam produced in the process is used to spin a turbine and produce electricity as can be seen in Figure 4.[9]

Fig. 4. PWR type nuclear power plant. [9]



MSR technology is not a newly emerging technology, but an old technology that has been proven but forgotten. The MSR design was first created by Alvin Weinberg in 1954 to create a nuclear-powered airplane so that it could fly continuously without having to refuel. This design emerged in response to the emergence of a nuclear submarine (USS Nautilus) which could dive continuously without having to refuel for 6 months. This design was developed at Oak Ridge National Laboratory in 1965-1969 using Thorium. This reactor was shut down in 1969 and its development lost momentum because the radioactive waste did not produce plutonium, which is the basic material for making nuclear weapons, which at that time was needed for military purposes.[9]

The author believes that MSR technology is the most established and experienced technology in utilizing thorium as a fuel, so that it can be applied in Indonesia in order to fulfill national energy and ensure sustainable development for the following reasons:

1) Almost 100% of the fuel used means less waste is produced.[2]

2) The remaining waste is only radioactive for 300 years, in contrast to the current nuclear waste which lasts for thousands of years.[9]

3) The small amount of waste released cannot be used as a nuclear weapon. It should be noted that the waste produced by nuclear power plants is currently Plutonium 239 which can be used to make nuclear weapons. But the waste produced by MSR will not produce isotopes that can be used to make nuclear weapons.[9]

4) Using liquid fuel, the gas produced in the fission process can come directly out of the salt solution and be stored in a separate container. This will make the pressure generated inside the reactor the same as the pressure outside so that it does not require a special barrier that can accept high pressure. Because the pressure inside the reactor is equivalent to the pressure outside (atmospheric pressure), there is no need to worry about it exploding as happened in the reactor at Fukushima.[9]

C. Environmental Impact of Fossil Fuel Power Plants

1) Impact on Natural Resources.

Energy resources, especially non-renewable ones such as oil, gas, coal (fossil energy), will continue to decrease over time in line with increasing use. This will cause an energy crisis in the future, especially for future generations. Data on proven energy reserves in Indonesia shows that oil energy is only 10 years old, gas is 30 years old, and coal is 146 years old, assuming the proven reserves remain constant and there is no increase in production as shown in Table 1

TABLE I. FOSSIL ENERGY RESERVES IN INDONESIA IN 2005. [1]

Energy	Total Reserves	Proven Reserves	Production	Comparison
Oil	9.6 Billions bbl	5 Billions bbl	0.5 billions bbl	23 years
Gas	170 TSCF	87 TSCF	2.9 TSCF	62 years
Coal	38 Billions Ton	6.5 Billions Ton	73 Millions Ton	146 years

The primary energy diversification policy that has been implemented so far, especially towards dependence on petroleum, has reduced oil consumption from 88% in 1970 to 57.2% in 2000. However, this diversification still relies on other fossil energy sources, namely the use of gas and coal which began to be intensified, increasing from 6% to 27.2% for gas and 1% to 10.1% for coal in that period. This will of course also reduce the limited existing gas and coal energy reserves.[7]

The use of nuclear fuel is relatively small compared to the use of coal or other fossil fuels for generating electricity with the same power. Apart from that, from an operational perspective, nuclear power plants can be operated continuously for one year without replacing them with new fuel. This will increase the efficiency of using existing natural resources.[1]

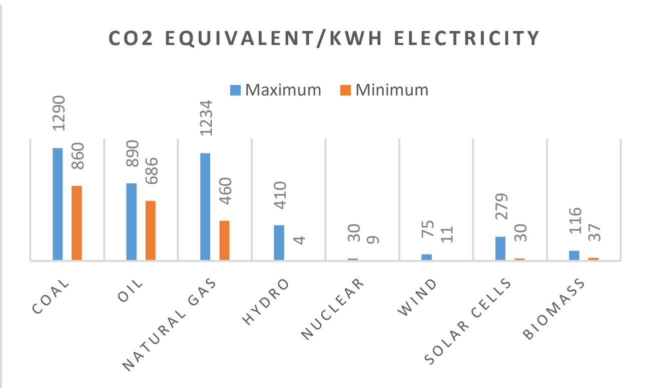
2) Impact on the Environment.

- CO_2.

One of the waste products emitted by fossil fuel power plants is carbon dioxide (CO_2), which is a greenhouse gas, called a greenhouse gas, because it has the properties of a greenhouse, meaning it reflects radiation from Earth back to Earth again, which functions to maintain The Earth's temperature is at a temperature suitable for living creatures to live in. However, global carbon dioxide (CO_2) concentrations have continued to increase since the start of the industrial revolution, and currently there is sufficient scientific evidence to show that increasing CO_2 concentrations in the atmosphere are the main cause of global change and climate change. With CO_2 gas concentrations reaching 379 ppm in 2005, this resulted in an increase in the average temperature of the earth's surface of up to 0.74°C, in addition there was a rise in sea level of 0.17 m, and a reduction in snow cover of 7%. If the CO_2 concentration continues to experience a stable increase reaching around 550 ppm, it is estimated that there will be an increase in temperature of around 3°C, which according to the United Nations Framework Convention on Climate Change, if the earth's average temperature has reached more than 2.5°C, then 20%-30% of plant species will and animals will be threatened with extinction.[8]

From the data it is found that the CO_2 gas produced by power plants is mostly sourced from fossil fuel power plants, namely coal, petroleum or diesel and natural gas as seen in Figure 5.

Fig. 5. CO2 output of each type of power plant. [7]

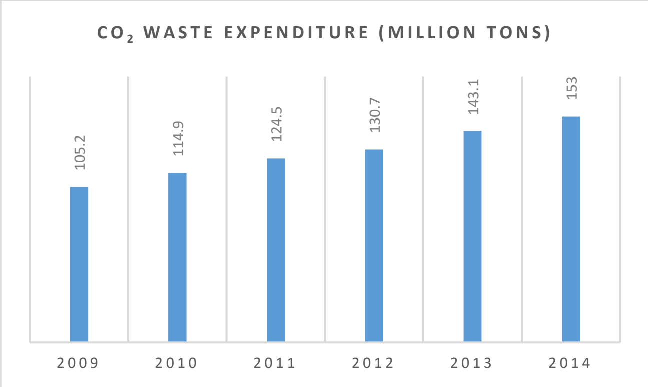


And nuclear power plants are champions with an average CO_2 gas output of only 10.5 equivalents per kWh of electricity.

- SO_2 and NO_x.

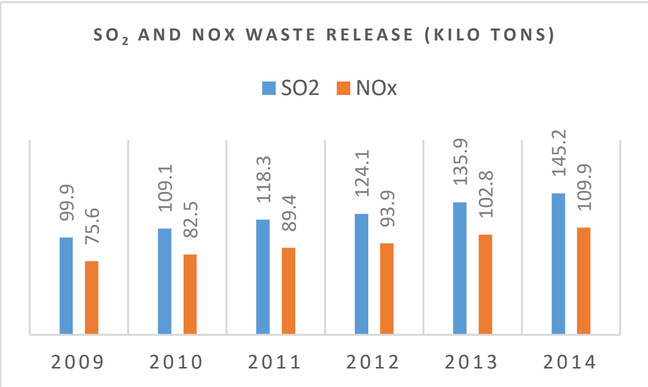
According to the electricity production data above, with the average percentage of fossil energy use in Indonesia's total electricity production each year being 89.49582%, the data on CO_2 waste expenditure each year will be as can be seen in Figure 6.[8]

Fig. 6. CO_2 Waste Expenditure (Million tons).



As well as SO_2 and NOx expenditure every year as can be seen in Figure 7.

Fig. 7. SO_2 and NOx Waste Release (Kilo tons).



Sulfur Oxide (SO_2) and Nitrogen Oxide (NOx) gas are sources of acid deposition. The reaction mechanism for acid deposition is as follows:

$$2SO_2/NO_x + H_2O \longrightarrow 2H_2SO_4/HNO_3 \quad (1)$$

These acidic pollutants will fall from the atmosphere to the earth's surface in a wet and dry way, which is called wet deposition and dry deposition. Wet deposition occurs when acidic substances dissolve through rain, snow and fog before falling to the earth's surface. Dry deposition occurs when acidic substances in the form of fine grains are blown by the wind and then fall to the earth.[1]

The impact of this acid deposition is very broad, namely on living creatures, vegetation and building structures as in Table 2.

TABLE II. IMPACT OF ACID DEPOSITION. [1]

Impact On	Explanation
Organism	• The extinction of several types of fish. • Disrupts the food cycle. • Disrupting the use of water for drinking water, fisheries, agriculture.
	• Cause health problems. • Respiratory and skin irritation.
Vegetation	• Changes in the balance of nutrients in the soil. • Interfere with plant growth. • Damaging crops. • Fertilizes the growth of honey fungus which disrupts plant growth.
Building Structure	• Dissolves calcium carbonate on concrete, marble floors. • Dissolves copper and steel. • Accelerates corrosion in water pipes. • Eroding temple buildings and statues.

D. Comparison of Fossil, Renewable and Nuclear Energy

The comparison between fossil, renewable and nuclear energy will be carried out through two aspects which are considered to be the main priorities that determine human welfare, namely health and the economy.

1) Health Aspect.

- Fossil Energy

Power generation systems that burn fossil fuels require a lot of fuel that needs to be mined, transported and burned. Coal, oil and natural gas miners, as well as their transportation, tend to experience frequent accidents.[8]

The coal sector is used as the main example to represent fossil fuels because in 2012 coal was the fuel most widely used to produce electricity, and has been proven to show a very extraordinary impact with the percentage of coal usage reaching 54.7%, namely around 222 million bbl. And it will continue to rise until it is projected that in 2035 it will reach 70.2% (1,348.3 million bbl) for the basic scenario and 76.5% (1,989.2 million bbl) for the high scenario.[6]

The International Energy Agency (IEA) revealed that coal fossil fuels contribute 44% of total global CO_2 emissions. Coal burning is the largest source of green house gas emissions, which trigger climate change.

Coal burned in Steam Power Plants (PLTU) emits a number of pollutants such as NOx and SO_2, the main contributors to the formation of acid rain and PM2.5 pollution. The scientific and medical community has revealed the health dangers caused by fine particles (PM2.5) from these air emissions. Coal power plants also emit dangerous and deadly chemicals such as mercury and arsenic.[3]

These very dangerous pollutant particles currently cause premature deaths of around 6.500 people per year in Indonesia. Estimates made by Harvard University in the 2015 Greenpeace Indonesia report show that the main causes of premature death include stroke (2.700), ischemic heart disease (2.300), lung cancer (300), chronic obstructive pulmonary disease (400), as well as respiratory and respiratory diseases. other cardiovascular (800). The estimated figure is expected to increase to around 15.700 people/year in line with plans to build a new coal-fired power plant.[3]

This comparison is far from using Thorium-NPP as energy because it only has a power of 90 deaths/trillion-kWh. Meanwhile, the use of coal contributes to a death rate of up to 100.000 deaths/trillion-kWh. When compared with other energy sources, the risk of using thorium is much safer and environmentally friendly.[4]

- Renewable Energy

Renewable energy such as sun, water, geothermal, bioenergy and wind are energy sources that are easy to find in almost every place, and are planned to replace fossil-based energy sources in the future. However, renewable energy has 3 weaknesses, namely the intermittency factor, low energy density and unreliability.[2]

So far, these weaknesses have been answered by increasing the battery capacity to accommodate electrical power and increasing the number of installations. What can be done is by increasing the generating capacity. These efforts actually add new problems to the development of renewable energy. These installations require extensive materials and labor to construct. The main risks are work safety and accidents when transporting building materials. Accidents in the production of photovoltaic cells can cause dangerous contamination because they contain arsenic, cadmium and silicon, all known to cause cancer in humans. There is also the problem of disposal of chemicals once the photovoltaic installation is not in use. The actual operation of the new renewable energy system is practically risk-free to the public, although the blades can come loose from the windmill, the light and heat of the solar power can cause injury to involuntary bystanders, and the noise generated from the windmill is forced placed in a place far from the residence. Hydroelectric power can cause ecological damage, with impacts on local aquatic life and food supplies and can also cause catastrophic dam failures. Renewable new energy can also come from bio-mass fuels such as wood, plant materials and other organic waste materials, although currently such fuels contribute little to electricity generation. There are physical dangers involved in obtaining, handling and transporting such biomass fuel.[8]

- Nuclear Energy

Nuclear has a high concentration of energy in its fuel, so it only requires a small amount of fuel and emits little waste. But both fuel and waste require processing and transportation. The possibility of accidents during the transportation of radioactive waste is of general concern, because there are still unresolved long-term safety issues for storing radioactive waste, because the fuel is found in low concentrations in the layers of the earth, its extraction is labor intensive and there is a risk of accidents and diseases (mainly lung and cancer) for workers who mine and process these mining materials is very high.[8]

Although accidents at nuclear reactors are rare, they pose serious potential risks to the health of nuclear power plant workers and their surroundings, perhaps even to residents who live very far away. Nuclear optimists anticipate new improvements for risk reduction in reactor technology (including passive self-monitoring designs, safety mechanisms), safe underground disposal of high-level radioactive waste and also the use of waste-free nuclear fusion. Meanwhile the wider community remains distrustful and worried (this can also be detrimental to health).[8]

2) Economic Aspect.

A comparison between fossil energy, new renewable energy and nuclear energy in economic terms will be carried out through three points of consideration, namely, estimated manufacturing costs (/kW), costs during the operational period (60 years) and price (/kWh).[5]

Fig. 8. Estimated Cost of Building a Power Plant.

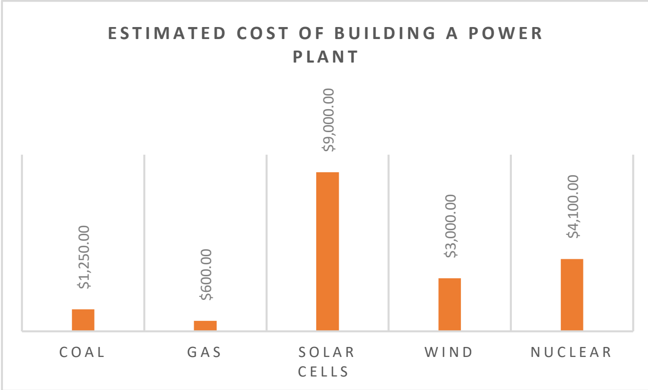


Fig. 9. Estimated Operational Period Costs (60 Years).

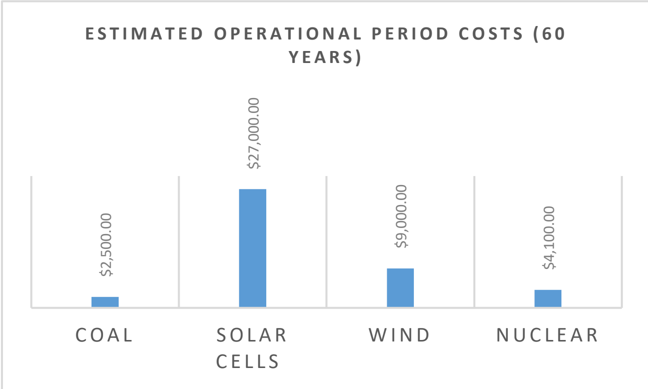


Fig. 10. Estimated Price (/kWh).

The figures above are still within estimates which are adjusted through various sources and with various differences in various countries, so the calculations are made in general terms.

From the three points of comparison, an analysis can be carried out that fossil energy sources have the lowest costs, from manufacturing, operations to market prices. Meanwhile, nuclear energy has the same medium cost, namely 4,100 $, both in manufacturing and operational costs because the standard for building a reactor must last for 60 years, and the market price is relatively high.

It cannot be denied that new self-dispersing energy has the highest costs both in terms of development, operations and market prices because it requires very large and numerous installations to be able to produce electrical energy as desired.

VIII. CONCLUSION

1) The need for electrical energy in Indonesia will continue to increase in line with the increasing rate of population growth, economic development and especially industrial development, which is shown by the results of studies that in 2025 it will be 4 times more than in 2000.

2) The use and utilization of fossil fuel power plants to meet future energy needs is no longer relevant to continue to be developed in the National Energy Policy because it has a large impact, both in terms of health which is responsible for approximately 6.500 premature deaths, and the environment which is a responsible factor. responsible for the phenomenon of global warming which leads to climate change. And it clearly contradicts the concept of sustainable development.

3) The use of nuclear power plants, especially those made from thorium, is a promising step for the government to guarantee the concept of sustainable development starting from its abundant availability in Indonesia, high effectiveness of the energy produced and projections of efficient and long-term financing, compared to with fossil energy sources and other new and renewable energy sources.

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Partial Characteristics Discharge in Air Insulation Test Using Needle and Plate Electrodes

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Abstract — **The electric power system has a protection system. Isolation is one of the electrical protection systems. *Partials Discharge* is a local release of electrical charge that bridges some of the insulation between conductors which occurs both on the surface and inside the conductor. This study aims to determine the initial symptoms and *partial characteristics discharge* using a plate needle electrode with air as a medium. So the method used is determining the background, problem, research objectives, collecting several relevant studies, making tools and collecting data, verifying data, processing and analyzing data, and finally making conclusions. *Partial* detection *This discharge* is carried out by applying voltage to the electrode medium via a *step up transformer* where the needle electrode is a high voltage electrode and an electrode plate as ground . The research results showed that the first PDIV value that appeared was PDIV negative 1.8 kV, while PDIV positive was obtained at a value of 1.85 kV. *Partial* characteristics *discharge* using a needle- plate electrode in air media, it was shown that the VPP value continued to increase due to voltage spikes. *Partial* signal *discharge* continues to increase when the voltage is increased .**

Keywords — Electrical Energy Distribution Systems, Electrical Power Protection, Isolation, Isolation Faults, Partial Discharge

I. INTRODUCTION

Technological developments are increasingly rapid, from manual use to modern and increasingly easy to use [1]. Electrical energy is a form of energy that humans need to support various activities. The increasing need for electrical energy means that the quality of distribution must be improved and reduce any disturbances [2]. The disturbance with the largest percentage of occurrence is disturbance from insulation failure [3].

Insulation failure is a phenomenon that occurs because the insulation is unable to withstand voltage surges. Partials discharge is one of the phenomena of insulation failure that may occur [4]. Partials Discharge is a localized release of electrical charge in the insulation system, so that if it occurs continuously it allows the quality of the insulation system to deteriorate. [5].

What needs to be done to determine the condition of good insulation and the breakdown voltage value in a high voltage system is to carry out a partial test discharge. There is a way to detect partial discharge namely by electrical methods and methods non-electric, the electric method is the best way efficient [6].

This research will try to carry out partial measurements discharge that can be used to diagnose the occurrence of partial discharge by using electrical methods and knowing the *partial* characteristics discharge in the needle plate electrode test on air insulation using a sensor, it is high frequency current transformer (HFCT). This sensor is used as a comparison for testing.

II. LITERATURE REVIEW

A. Failure Isolation

Isolation failure is related to Partial Discharge. Insulation failure in high voltage system equipment causes system instability in the operation of the equipment. Partials discharge can occur in solid insulators, liquid or gases [7].

1. Failure Isolation Gas

The basic process for gas or air isolation failure is ionization which collides with atoms which can free up more electrons. The process of insulation failure is characterized by a sudden spark . The ionization resulting from these collisions is a fundamental failure of the isolation of air or gas. The process of gas rupture is characterized by a sudden spark, this spark can be produced by emissions in the gas. [8].

2. Failure Isolation Congested

Damage Which caused by type And temperature material with remove factorexternal factors such as pressure, electrode material, contamination, pocket air. Damage This occurs when voltage is applied to material raised so that potential electricity reaches a certain value and in a certain amount [9].

3. Failure Isolation Liquid

Isolation form fluid prone to to dirt or other substances for example bubble air , particles foreign , etc. as as a result level its purity non- so high , p This can reduce resilience isolation search to failure isolation [10].

B. Partials Discharge

IEC Standard, IEC 60270 a local electrical discharge phenomenon that partially or partially connects the insulation between conductors and which occurs both on the surface of the conductor and inside the conductor [11].

Partials discharge has long been known as an important indicator of the equipment insulation condition voltage tall. With measure partial discharge , diagnosis is possible made from level damage and isolation conditions can be maintained longer [12].

C. Types Partials Discharge

1. Discharge Cavity

This discharge occurs due to the presence of air bubbles contained in a dielectric material. In general, the strength of gas insulation (air bubbles) is much smaller than solid insulation. When a solid dielectric material experiences electrical pressure, the gas will bear a greater electric field pressure than solid insulation [13].

2. Discharge Surface

Discharge This happen Discharge that occurs in an area that is directly connected (parallel) to the dielectric surface, where this area experiences very high (excessive) electric field pressure, thus triggering a discharge. This discharge will most likely occur if the surface strength of the dielectric material is smaller than the strength of the insulation in direct contact with the dielectric material. [14].

3. Discharge Corona

Discharge This happen consequence happen incident rate ionization in lower pressure electric field. This ionization is caused by changes in the structure of neutral molecules or atoms neutral Which happen Because collision betweenNeutral atoms with free electrons present in air [1 5].

D. Partial Measurement Parameters Discharge

1. Background Noise Off (BGN Off)

The main purpose of BGN off measurements is to determine the noise condition when the measurement circuit is still in off mode [16].

2. Background Noise On (BGN On).

BGN measurement on The aim is to determine the noise condition when the voltage source is turned on but is still at 0 kV. [17].

3. Partial Discharge Inception Voltage (PDIV)

Partials discharge inception voltage is the lowest voltage at which a partial discharge occurs in the test circuit when the test voltage is gradually increased from a lower value. [18].

III. RESEARCH METHODS

Study This done in a number of stage Which visualized in form diagram flowas following:

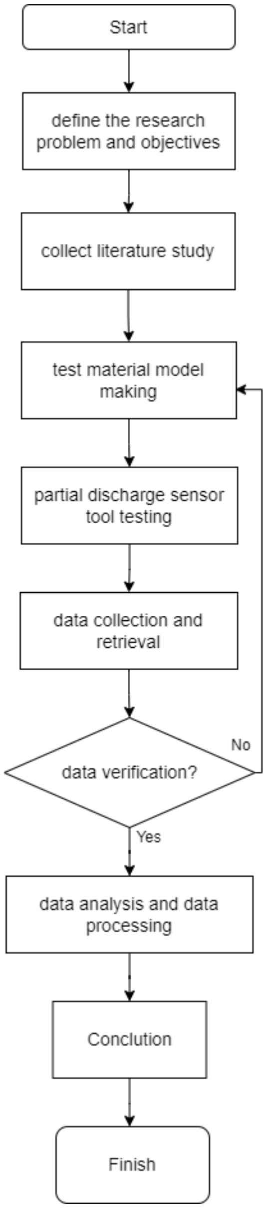

Figure 1. Diagram Channel Study

A. Instruments Help Test Partials Discharge

A number of instruments or tool Which required For support process detection *partial* discharge , as following:

1. Controls Desk

Figure 2. Control Desk

Specification:

Figure 3. Specification Control Desk

2. Transformer Step - up

Figure 4. Transformer

Specifications :

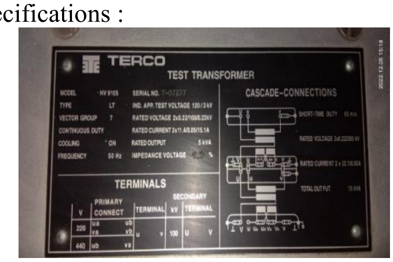

Figure 5. Specification Transformer

3. Resistors Barrier

Figure 6. Resistors Barrier

Specification:

- Brand : Terco
- Prisoner : 280 MΩ
- Voltage : 140 kV

4. Coupling Capacitor

Figure 7. Coupling Capacitors

Specification:
- Brand : Terco
- Capacitance : 100 pF
- Voltage : 100 kV

5. Electrode Plate- Stem

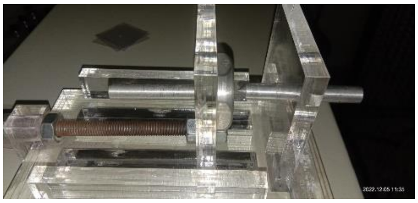

Figure 8. Electrodes Plate -Stem

6. HFCT (*High Frequency CurrentTransformers*)

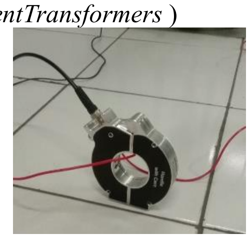

Figure 9. HFCT sensor

Specification:
- Type Installation : Portable/ Permanent
- Transfer PMI : 2.7 Ω
- HFCT : 100/50 HC
- Internal Arpeture : 45 mmm
- External Arpeture : 110-150 mmm

7. Oscilloscope

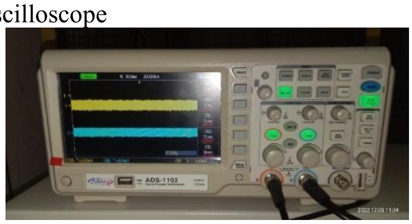

Figure 10 . Oscilloscope

B. Method Taking Data

Several stages of partial data collection steps discharge according to the diagram below :

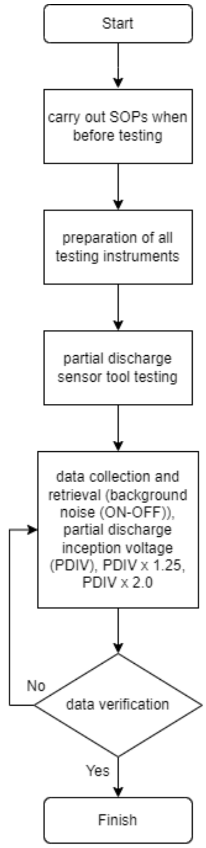

Figure 11. Flow diagram data retrieval

The stages of the data collection procedure are carried out with several types of measurements, namely BGN off , BGN on , PDIV, PDIV x 1.25 or 2.5.

1. Trial Operational Standards:
   a. Pray before starting the experiment.
   b. Carry out the SOP first before the experiment, such as checking grounding , checking test materials.
   c. Tempelken grounding stick at the output of the step- up transformer .
   d. Prepare the oscilloscope, HFCT and loop antenna.
   e. Create a series as shown in the picture. Create a test series as shown in the following picture:

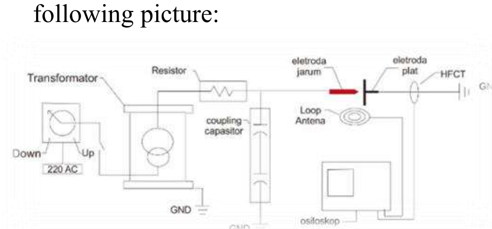

Figure 12. Suite test

f. Make settings on the oscilloscope:

a. Before using the oscilloscope, calibrate it first.
b. Press auto set and turn on channels 1 and 2.
c. In the menu for each channel , select AC coupling and turn off the invert function .
d. On the aquire menu , select peak detect and set memory length to 12500.
e. Channel used is HFCT.

f. Channel used Loop antenna

2. Procedure Storage Data:

a. Install the flash disk as a place storage data from oscilloscope.
b. Make sure internal oscilloscope circumstances " stop ".
c. Go to menu save / rec , Then save files all
For taking picture And files *csv* .

Figure 13. Save/recall menu display

C. Processing Data

Data that has been stored on flash disk then input _ to the laptop to arrange later processed use application Microsoft Excel and Origin Pros . Results form processing in the form of average value, standard deviation value, and form curve. Process This in accordance on Figure 14.

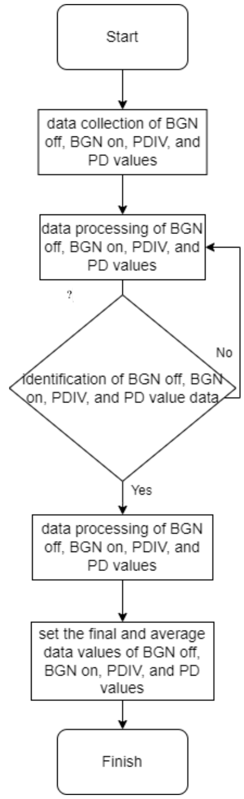

Figure 14. Flow diagram data processing

IV. RESULT AND DISCUSSION

A. Partial Discharge Inception Voltage Values in Air Insulation Using Needle Electrodes - Plate

The partial discharge (PD) experiment was carried out on a needle-plate electrode with a distance of 2.5 mm in air using an HFCT (High Frequency Current Transformer) sensor. Test done as many as 10 trials .

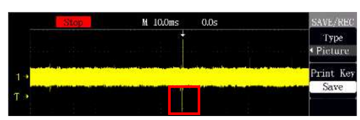

Figure 15. PDIV negative HFCT sensor

Figure 15 shows PDIV appearing and being received by the oscilloscope . The first color sensor yellow is an HFCT sensor .

Table 1. PD voltage results on air insulation

Data Partial Discharge				
Data	Tegangan (kV)	Vmin (mV)	Vmax (mV)	Vpp
BGN OFF	0	-3,25	2,89	4,51
BGN ON	0	-3,31	2,96	4,59
PDIV Negatif	1,8	-3,89	4,28	8,18
PDIV Positif	1,85	-2,35	2,86	5,21
PDIV X 1,25 Negatif	2,25	-5,99	8,96	15
PDIV X 1,25 Positif	2,31	-2,67	6,09	8,76
PDIV X 2,5 Negatif	4,63	-24,76	12,93	37,7
PDIV X 2,5 positif	4,65	-18,86	16,63	35,5

The PDIV value that appears first at a voltage of 1.8 kV on the negative side , followed by side positive voltage 1.85 kV. By negative PDIV theory will appear first time because exists electron in the air produced by emissions Medan existing electrodes _ so that Intermediate discharge appears load negative (electrode) in the air with load positive dielectrode . PDIV appears at a voltage of 1.8 kV with a distance of 2.5 mm to get a value of 0.72 kV/mm. The emergence of PDIV at a voltage of 1.8 kV can be seen that the safe limit for air insulation in this study with a gap of 2.5 mm is 1.8 kV.

B. Characteristics of Partial Discharge Waves in Air Isolation Using Needle-Plate Electrodes

To look for the characteristics of partial discharge waves in air isolation using a needle plate electrode, researchers took several data such as values such as BGN ON, BGN OFF, PDIV and also PD voltage values. The values obtained will be processed and the average value and standard deviation will be found. 10 partial detections were carried out discharge .

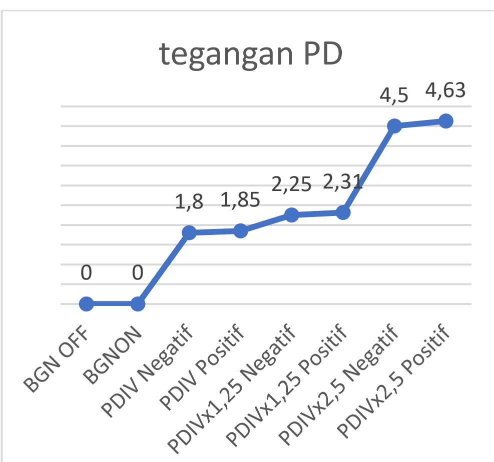

Figure 17. Partial discharge voltage

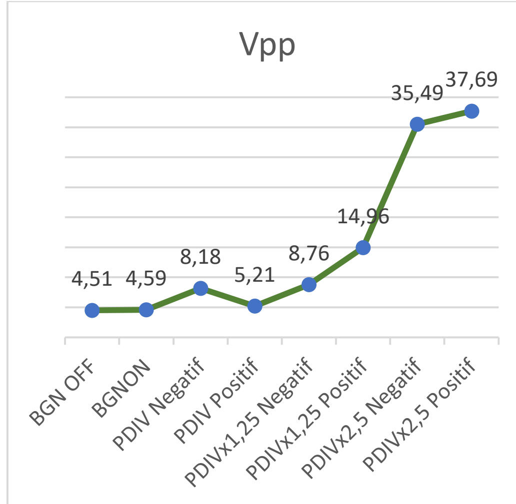

Figure 18. Vpp measured Partial discharge

From the picture above shows that the characteristics are partial The first discharge that appears in negative data occurs at a voltage of 1.8 kV with a vpp value of 8.18 mV . For negative data PDIV x 1.25 occurs at a voltage of 2.25 kV with a vpp value of 14.96 mV . For negative data PDIV x 2.5 occurs at a voltage of 4.5 kV with a vpp value of 37.69 mV . Partials The discharge that first appeared in positive data occurred at a voltage of 1.85 kV with a vpp value of 33.14 mV . For positive data PDIV x 1.25 occurs at a voltage of 2.22 kV with a vpp value of 34.21 mV . For positive data PDIV x 2.5 occurs at a voltage of 4.6 kV with a vpp value of 35.49 mV . From this data it can be proven that the higher the voltage, the higher the vpp value , this means that the voltage value is directly proportional to the vpp value . When the applied voltage is increased , the electric field strength will increase, so that the ionization that electrons receive to escape is greater. Continuously increasing the voltage can cause the temperature increase in the insulating material to become a partial phenomenon the discharge gets bigger. And from ten partial trials discharge with each voltage variation on the detection sensor using needle- plate electrode media , it was found that the standard deviation value showed smaller results than the average value . This proves that the research is partial discharge in air insulating media with this needle- plate electrode has a minimum error value and a high level of accuracy

V.CONCLUSION

From research conducted regarding Partial Discharge uses a plate needle electrode in an air insulating medium using an HFCT sensor and loop antenna , it can be concluded as follows:

1. Partial Value The first discharge (PD) in air insulation with a distance between electrodes of 2.5 mm was negative PDIV at a voltage of 1.8 kV and positive PDIV at a voltage of 1.85 kV. This is in accordance with the theory that negative PDIV values appear first than positive PDIV. The needle- plate electrode with a distance of 2.5 mm appeared partial discharge at a voltage of 1.8 kV it gets a value of 0.72 kV/mm. It can also be concluded from this study that the safe limit voltage value for air insulation with a distance between electrodes of 2.5 mm is 1.8 kV.
2. Partial characteristics The first discharge appearing in negative data occurs at a voltage of 1.8 kV with a vpp value of 8.18 mV . For negative data PDIV x 1.25 occurs at a voltage of 2.25 kV with a vpp value of 14.96 mV . For negative data PDIV x 2.5 occurs at a voltage of 4.5 kV with a vpp value of 37.69 mV . Partials The discharge that first appeared in positive data occurred at a voltage of 1.85 kV with a vpp value of 33.14 mV . For positive data PDIV x 1.25 occurs at a voltage of 2.22 kV with a vpp value of 34.21 mV . For positive data PDIV x 2.5 occurs at a voltage of 4.6 kV with a vpp value of 35.49 mV . From this data it can be proven that the more the voltage is increased , the higher the Vpp value , influenced by the large voltage which causes excess charge to occur causing the electric field strength to increase, as can be seen from the Vpp value which gets higher with each increase in voltage.

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Determination of the Shortest Route with Stagecoach Method in SMEs

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***Abstract*—Today's micro-scale economic growth is increasing, this is indicated by the development of home-based businesses such as the OL shop business. This study aims to determine the optimum route for cost minimization using the stagecoach method. The data is based on direct observation of the object of research in namely Niea OL Shop. The results showed that the optimal route at Niea OL Shop with the shortest distance was A→C→D→E→J→M→N with a total distance of 22.55 km.**

Keywords—Dynamic programs, stagecoach, online store.

I. INTRODUCTION

Today, microeconomic growth is increasing. This is indicated by the development of home-based businesses such as the OL shop business (Arianto, 2020)(Halim, 2020)(Sarfiah et al., 2019). OL shop is an online-based business with a marketing system that is marketed through electronic media in the form of websites, and social media such as Facebook, and Bukalapak. For active smartphone users, it can be done through applications such as BBM, and WhatsApp. This research is focused on Niea OL Shop's business. The products sold at the Niea OL shop are shoes, sandals, clothes, bags, girl accessories, etc. Where the goods sold are taken directly from the agent without a courier, which is located in the Bangil area, precisely in Kolursari(Taufiq et al., 2019) (Nawagusti et al., 2018)(Gautama & Hermanto, 2020).

Benjamin Franklin said time is money with the principle that time management is needed, especially in the supply of goods, so analysis is needed to find the shortest route to assist in taking products from agents using the Stage Coach method with manual calculations (Krener, 2020)(Fadillah et al., 2017). The purpose of this study is to determine the optimum route from the owner's house to the location located in Kolursari, Bangil by using the stagecoach method, both manual calculations so that the shortest distance is known(Izzatillah, 2021)(Yunita & Ali, 2017).

A. Dynamic programs

Dynamic Programming is a mathematical technique used to optimize the double-step decision-making process, where one problem will be divided into several parts (stages), then each stage will be solved optimally by considering the conditions (state) until all problems are solved (Beppu et al., 2020)(Tzortzis & Charalambous, 2020)(Mas'ud, 2019). The final decision on all these problems as a collection of optimal decisions throughout the stages is called the optimal policy decision (Lebedev et al., 2020). From the above understanding, there are 3 (three) important things related to this dynamic program:

- Stage of the problem faced and want to find a solution.
- State (Conditions) which are the decision-making factors for each stage.
- Decisions that must be taken from each stage to arrive at the optimal policy.

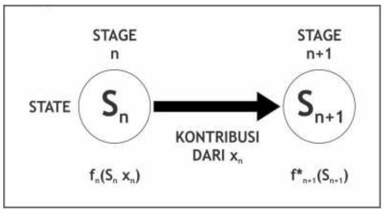
In another sense, a dynamic program is a series of procedures that optimize the results, in the form of an objective function depending on the conditions (state) to minimize or maximize, at each stage (stage) without looking at the decisions of the previous stages but will affect the course of the compiled procedures, as long as they are interconnected (Skarman et al., 2020)(Novitasari & Mas'ud, 2020). Problem-solving procedures in dynamic programs are carried out recursively, meaning that each time a decision is made, it must pay attention to the conditions generated by the previous decision and become the basis for the next decision (Makinde et al., 2020)(Xu et al., 2020). To complete this dynamic program recursive procedure, there are two ways of calculation, namely:

- Forward recursive equation
- Backward Recursive Equation

One method in dynamic programming is "stagecoach". The stagecoach method is a method of determining the route of travel from a starting point to the end point of the trip. Therefore, the travel route from the starting point to the endpoint can be taken through many routes, the problem is which travel route should be chosen so that the cost, distance, or travel time is most efficient (Liu & Ge, 2020) (Byun et al., 2020).

B. Deterministic Dynamic Programs

A state in which the state at the next stage is determined entirely by the state and decisions at the current stage (Firdausiyah et al., 2020)(Ghasempour & Heydecker, 2018). At stage n the process will be in a state Sn. The decision xn then moves the process to the Sn+1 state at the n+1 stage.



Information:

N = number of steps xn* = optimal decision xn (known Sn)

n = label for the current stage (n=1,2,3,…,N)

fn(Sn xn) = stage contribution n, n+1, …,

N to the objective function if the system starts from state Sn at stage n.

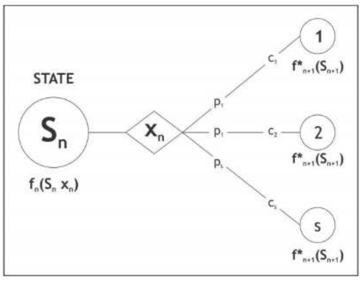
Sn = current state for stage

n fn*(Sn)=fn(Sn xn) = optimal decision is made after decision xn

xn = decision for stage n

C. Probabilistic Dynamic Programs

There is a probability of a future state whose probability distribution will still be determined by the previous state and decision(He et al., 2019).



Information:

Sn = current state for stage n c1, c2,

cs = contribution of stage n to the objective function if the state changes to state i p1, p2, ps = distribution of the probability of occurrence of a condition

f*n+1(Sn+1) = the minimum number of expectations from stage n forward, given status and decisions at stage n, respectively Sn and xn.

II. RESEARCH METHOD

To find out and study the determination of the route to be taken to obtain complete initial information and determine the problems raised in the study. This research was conducted by taking the route from Sengonagung to Kolursari, Bangil which is the OL Shop owner's route to the agent's location. The information was directly obtained from the owner of the OL Shop.

At this stage, a literature review is also carried out, namely data collection activities through related references from books, the internet, journals, and other documents. The study of literature aims to get an overview of the theories and concepts related to the problems faced and to show the stages of solving them. This study was conducted by exploring books, journals, research, and other related sources.

In this study, the variable to be studied is distance. The data taken includes distance data from cities/areas that are passed from Sengonagung to Kolursari with visualization observed from Google Maps. This stage consists of six stages, including determining the route, determining the location of the gathering point, determining the node, sorting the gathering point for each space, determining the distance from each room to the gathering point, and determining alternative routes.

III. RESULTS AND DISCUSSION

Several routes can be passed from home or start to the location or rather the village of Kolursari (figure 1).

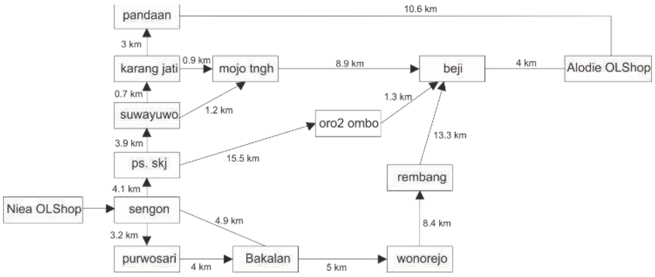


Fig. 1. Route graph from Sengonagung to Kolursari

TABLE I. NODE LOCATION

Node	Location
A	Niea OLShop
B	Purwosari
C	Sengonagung
D	Pasar Sukorejo
E	Suwayuwo
F	Karangjati
G	Pandaan
H	Bakalan
I	Oro-oro Ombo
J	Mojotengah
K	Wonorejo
L	Rembang
M	Beji
N	Alodie OLShop

Determination of nodes is done after making the route that is passed from Sengonagung to Kolursari. The node is determined to determine the path distance to the final location. The node is a rectangle with a letter symbol in the middle. There are 14 nodes from Sengonagung to Kolursari. Based on the table above, the graph for the travel route from the start/home to Kolursari is shown in Figure 1.

TABLE II. DISTANCE FROM THE ORIGIN NODE TO THE DESTINATION NODE

Node	Distance
A-C	0,45 km
C-B	3,2 km
B-H	4 km
H-K	4,8 km
K-L	8,4 km
L-M	13,3 km

Node	Distance
M-N	1 km
C-H	4,9 km
C-D	4,1 km
D-I	15,5 km
I-M	1,3 km
D-E	3,9 km

Node	Distance
E-J	1,2 km
J-M	8,9 km
E-F	0,7 km
F-J	0,9 km
F-G	3 km
G-N	10,6 km

Stage I | min f1(x1)

Entering the travel time from G and M to N

From	to	f1(x1)	X1*
	N		
G	10,6	10,6	G→N
M	4	4	M→N

Stage II | Min [f2(x2)+f1*(x1)]

- The objective of this stage is to minimise the distance travelled by adding the distance travelled in stage 2 and the best time in stage 1(x1*)
- f2(x2) is selected from the best distance and described in column x2* which is the best route
- f2(x2) is the best distance and route from the calculation of this stage.

From	To		f2(x2)	x2*
	G	M		
F	3+10,6	-	13,6	F→G
J	-	8,9+4	12,9	J→M
I	-	1,3+4	5,3	I→M
L	-	13,3+4	17,3	L→M

Stage III | Min [f3(x3)+f2*(x2)], Stage IV| Min [f4(x4)+f3*(x3)] (table

From	To				f3(x3)	x3*
	F	J	I	L		
F	-	0,9+12,9=13,8	-	-	13,8	F→J
E	0,7+13,6=14,3	1,2+12,9=14,1	-	-	14,1	E→J
D	4,6+13,6=18,2	-	15,5+5,3=20,8	-	18,2	D→F
K	-	-	-	8,4+17,3=25,7	25,7	F→L

Stage IV| Min [f4(x4)+f3*(x3)]

From	to		F4(x4)	X4*
	E	K		
D	3,9+14,1=18	-	18	D→E
H	-	5+25,7=30,7	30,7	H→K

Stage V | Min [f5(x5)+f4*(x4)]

From	To		F5(x5)	X5*
	D	H		
C	4,1+18=22,1	4,9+30,7=35,6	22,1	C→D
B	-	4+30,7=34,7	34,7	B→H

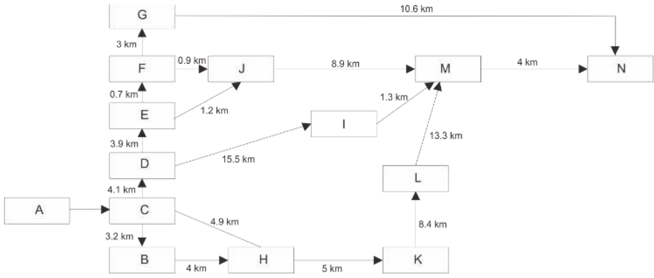
Stage IV | Min [f6(x6)+f5*(x5)]

From	To		F6(x6)	X6*
	D	B		
C	4,1+18=22,1	3,2+34,7=36,9	22,1	C→D

Stage VII | Min [f7(x7)+f6*(x6)

From	To	F7(x7)	X7*
	C		
A	0,45+22,1=22,55	22,55	A→C

The calculating the most optimal route Route= A→C→D →E→J→M→N, Distance = 22.55 km



IV. CONCLUSION

The results of processing and analyzing the shortest path search data are very useful for determining the shortest route to a place. So that it can arrive on time to the destination, the results of the above calculations are known by the stagecoach method as the optimal route with the shortest distance is A→ C→D→E→J→M→N with a total distance of 22.55 km.

TABLE III. TABLE TYPE STYLES

Table Head	Table Column Head		
	Table column subhead	*Subhead*	*Subhead*
copy	More table copy[a]		

[a] Sample of a Table footnote. (*Table footnote*)

Fig. 2. Example of a figure caption. (*figure caption*)

ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g". Avoid the stilted expression "one of us (R. B. G.) thanks ...". Instead, try "R. B. G. thanks...". Put sponsor acknowledgments in the unnumbered footnote on the first page.

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Mapping 18 Symptoms in DSM 5 to Variables for VR Game Application

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Abstract—**Attention Deficit and Hyperactivity Disorder (ADHD) is one of the most common health disorders found in children. Worldwide it ranges from 3% to 15%. With the advancement of the current digital era, applications can be used as tools to help with diagnostics of these children. The general diagnosis of ADHD is through interviews and observations of parents and children. An innovative ADHD diagnostic tool can be an alternative tool that can help diagnose. Virtual reality (VR) is a significant technology that can provide virtual immersive environments and can provide the illusion of participation in an artificial environment for children with ADHD. So, developing an ADHD diagnostic tool using VR based on DSM 5 diagnostic criteria with machine learning applications will give another tool option. The platform used is Oculus and the application is built using Unity and the data is stored in MongoDB while data processing uses decision trees. In this research, it will only focus on how to convert 18 symptoms in DSM 5 to variables that will be used in the game. Thus, the aim of this research paper is to list all possible variables that could be used based on 18 symptoms. In conclusion, only 14 symptoms have been mapped to 14 variables. Several symptoms use multiple variables.**

Keywords—virtual reality, adhd, dsm 5, 18 symptoms, variables

I. INTRODUCTION

The gaming industry has turned into one of the fastest growing industries in the world. In 2019, Newzoo, a market intelligence provider covering e-sports, global gaming, and the mobile phone market, released the Global Games Market report [1]. The report states that around 2 billion gamers in the world spent USD 148.8 billion in 2019. Newzoo estimates that the world market will grow around 6.2% towards 2020 and reach revenues of USD 128.5 billion [2].

Along with the rapid development of games, many media have issued warnings about the dangers of digital game addiction. There are also digital games that can lead to violence and aggressiveness, especially in children and teenagers. Most psychological research on the effects of gaming focuses more on negative impacts such as potential harm related to aggression, addiction, and depression [3, 4, 5]. But in the field of research, many researchers see many potential benefits of children's cognitive, motivational, social, and emotional development from children's play. The medical field is starting to explore the positive effects of games [6], this can be seen with the publication of the Games for Health Journal. Researchers and medical practitioners are beginning to realize the power of video games to encourage and, ultimately, to improve patient health [7].

The use of video games to help in the medical field is certainly supported by a lot of technology. Some technologies that are starting to be widely used today is Virtual Reality (VR). VR technology can be used to reduce or even eliminate real world distractions while playing and can also create a virtual environment that helps users focus their attention and increase concentration. VR technology can help maintain patient attention for longer periods of time than other methods because VR is immersive, interactive, and imaginary [8].

Currently, as in Indonesia, to diagnose whether children have ADHD or not, there is often a diagnostic approach primarily relying on parent report questionnaires, psychiatric interviews, and observation and treatment considerations limited to interpersonal psychotherapy and medication. In Indonesia, what is commonly used for early detection is the Abbreviated Conners Scale Parent Teacher Rating Scale, which is a questionnaire consisting of 10 questions filled in by the child's parents or caregivers, apart from that there is also Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM 5) which is also commonly used which has 18 symptoms that must be observed in children. Filling out the questionnaire allows for an element of subjective assessment. Therefore, it would be very helpful if there were other tools that could detect children with ADHD more objectively. If the tool is in the form of a game, it will certainly be more interesting for children.

In developing computer-based game applications, you must also know the relationship between the computer and its users, especially children who have ADHD. Children generally like playing, including playing using computers. Many games on the market are aimed at children. Of course, when building an application for children, several rules are needed so that the game application is suitable for children to play, especially if the child has ADHD. Several studies show several rules that can be applied to the development of game applications, including the following: neat and uncluttered design layout in the application, a 'calm' atmosphere, with calming colors, orderly arrangement of items or objects, and differentiating information. important by putting it in bold or color [9].

To help doctors support the diagnosis of children with ADHD, a VR game application was designed and developed. In designing the game, input from doctors is certainly needed to determine what parameters need to be measured in the game; the results will be stored in a database and then processed to diagnose children with ADHD. The parameters will refer to the 18 symptoms contained in the ADHD diagnostic criteria in the DSM 5 [10]. Each assessment of each question must be matched with the values of certain parameters resulting from the game. The objective of this research is to map those 18 symptoms in the ADHD diagnostic criteria in the DSM 5 to appropriate game mechanic in VR game application.

II. Theoretical Framework

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

A. Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is one of the most common health disorders found in children. Worldwide it ranges from 3% to 15% [11, 12]. Generally it is a mixture of symptoms, such as Asperger's syndrome, Tourette's syndrome, anxiety disorders, and so on, only collectively known as ADHD [13]. Children who experience ADHD usually exhibit one of three behavioral patterns [14]:

a. Hyperactive type: Individuals in this case are more physically hyperactive.
b. Inattentive type: has difficulty concentrating and is easily distracted.
c. Combined type: has symptoms of hyperactivity and inattention.

B. Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM 5)

DSM is a book that is currently widely used by doctors and psychiatrists, especially in the United States, to diagnose mental illnesses. This book was published by the American Psychiatric Association (APA), the DSM contains all categories of mental health disorders found in adults and children [10]. The DSM contains descriptions, symptoms, and other criteria necessary to diagnose mental health disorders. It also contains statistical data regarding which gender is most affected by the disease, initial symptoms, effects of treatment, and commonly used treatments.

DSM-5 contains a number of significant changes from DSM-IV [10]. The most immediately visible change was the change from using Roman numerals to using Arabic numerals. The most prominent change is that DSM-5 eliminates the multiaxial system found in DSM IV.

The DSM-5 criteria for ADHD are people who demonstrate a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development. Based on the type of symptoms, in general, DSM-5 divides ADHD into three subtypes, namely [10, 15]:

a. Symptoms are dominated by hyperactive and impulsive behavior. Children are detected as having this subtype if they have greater or equal ($\geqslant$) 6 symptoms of hyperactivity and impulsivity.

b. Symptoms are dominated by the inability to concentrate (inattention). Children are detected as having this subtype if they have greater or equal ($\geqslant$) 6 symptoms of inattention.

c. A combination of both or a combination of hyperactivity-impulsivity and inattention. Children are detected as having this subtype if there are $\geqslant$ 6 symptoms of hyperactivity and impulsivity and $\geqslant$ 6 symptoms of inattention.

C. Virtual Reality (VR)

VR is the use of computer technology to create a simulated environment [16]. Unlike traditional user interfaces, VR places the user inside the experience. Instead of looking at a screen in front of them, users are immersed and can interact with a three-dimensional world. By simulating as many senses as possible, such as sight, hearing, touch, even smell, computers are transformed into intermediaries into this artificial world. The only limitation of the VR experience that still exists today is the availability of sufficient content and also the cheap price.

III. Related Works

So far there is no game that directly applies all 18 symptoms listed in DSM-5 into its gameplay or game mechanics. Also, until now, there has been no single test and tools that accurately used to diagnose ADHD. Instead, doctors rely on several things, including interviews with the parents, relatives, teachers, or other adults; personally, watching the child or adult; questionnaires or rating scales that measure symptoms of ADHD and psychological tests [17].

H. W. Loh et al. stated based on their literature reviews that there were seven types of ADHD diagnostic tools utilized to develop Artificial Intelligence (AI) models. Brain MRI is the most broadly studied modality for automated ADHD diagnosis, with 39 out of the 92 studies analyzing brain MRI images of ADHD patients and normal control. Then 24 studies utilized physiological signals to detect ADHD [18]. Yet, still no one uses a VR game as a tool to detect children with ADHD tendency.

Many researchers that try to help children with ADHD tendency are more concerned to do the theraphy. Cho et al. [8] designed and created an Attention Enhancement System (AES) using VR technology and Electroencephalogram (EEG) biofeedback to treat children with ADHD who experience attention difficulties. Research conducted by Nouchi et al. [19] in healthy adolescents using computer game applications such as 'Tetris' and 'Brain age' 5 times a week; Within 4 weeks of training, it was able to improve the executive function of working memory in these teenagers. Meanwhile, in a meta-analysis study on the effectiveness of training with computer-based games in children with ADHD with a duration of 4-14 weeks or 3-36 sessions with an average duration of 30 minutes per session [20], the results obtained stated that training had an effect on the working memory of children with ADHD but did not affect the clinical symptoms of ADHD so it was suggested that training using computer-based games should also be accompanied by administration of medication.

IV. Design and Methods

There are several parts to creating this game application, creating a game application using Unity, mapping the symptoms, creating a machine learning design and creating a database design. But in this research paper, it will discuss the mapping from 18 symptoms in DSM 5 to variable in VR game application.

A. Virtual Reality Game Application

This VR game application also uses machine learning. Currently machine learning is still separate from VR applications. Data from VR will be stored in a database, then from the database, the data will be processed using machine learning. VR game applications developed with Unity application, which is later converted into an .apk file and installed on Oculus. All game data will be stored in Mongo DB database.

The room design in VR is a classroom in an elementary school with an Indonesian nuance. This selection is based on the number of children in elementary schools who have symptoms of ADHD and testing will be carried out on elementary school children. The area of the room is around 5 x 5 meters while the game area is around 3 x 3 meters. The goal of the game is how many the player can put the ordered objects into the box accurately. There are 2 types of instructions in this game plus a tutorial at the start of the game in the menu section.

B. Game Mechanics

a. Menu and Tutorial Section

When the player starts the game, a menu section will appear. All players will be asked to do a tutorial before entering the game. The tutorial stage is to see the player's understanding of interacting with VR equipment using Oculus. Players are asked to put objects into the box according to the instructions that appear in front of the player. The player must correctly put the object into the box at least 8 out of 10 times to continue the game. The box is in the middle of the table, objects 1 ball (random size and color) and 1 book ball (random size and color) appear to the right and left of the box, after the instructions are seen on the board.

Instructions are written on the board and there are voice instructions at the start that tell the player to look at the board. Each instruction on the board only displays 1 object, the player puts the correct object into the box and the program will detect whether the player entered correctly or incorrectly and save the data in the database. If after playing, the player cannot reach 80%, the player must restart the tutorial game, otherwise the player can choose visual or audio instructions game.

b. Games with visual instructions

In this part, a player is asked to put objects into the box correctly. The objects included are books (random size and color) and balls (random size and color) that appear in the room. The box is in the center of the table and cannot be moved (Figure 1). At the start of the game there will be an audio instruction tone to ask the player to look at the instructions on the board. The instructions on the board are only displayed for 10 seconds.

Fig. 1. Layout of game with visual instruction

In each instruction, there are 3 objects that players must put into the box in order. The instructions written on the board have only 4 possibilities: place 3 balls in sequence into the box; put sequentially 2 balls and 1 book into the box; put sequentially 1 ball and 2 books into the box or put 3 books in sequence into the box.

Right after 3 objects enter the box (right or wrong) there are 2 things the program does, namely displaying new instructions on the board, with audio prompting the player to see the new instructions on the board and the program will detect whether the instructions are executed correctly or false and saves the data to the database. The game at this level will stop when the total time reaches 10 minutes.

There are sound distractions during play at this level, distractions can include the sound of children playing outside, the sound of doors being opened, and other sounds that are common in elementary schools. This is intended to detect whether the player can concentrate during the game or is distracted.

c. Games with audio instructions

The game is almost the same as games with visual instructions. The only difference is in the instructions, which are not visible on the board, but through voice instructions. Players are asked to listen to instructions, after the instructions are completed, players can put objects into the box in sequence.

C. Develop the Game Application Framework

This research used the Game Development Life Cycle (GDLC) developed by Ramadan and Widyani to develop the game application. They proposed six stages, namely Initial concept, Preproduction (creation of design and prototype), Production (formal details, refinement, implementation), Testing (bug reports, improvements, change requests), Beta Testing (testing by third parties), and Release (Ramadan et al., 2013). The GDLC model can be seen in Figure 2. It can also be seen that in the Production cycle section there is Preproduction, Production and Testing which iterates until approval is obtained.

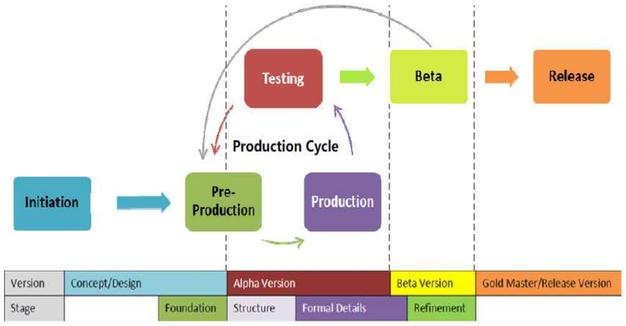

Fig. 2. GDLC from Ramadan and Widyani

D. *Symptom Mapping with Measurable Behavior*

In designing VR game applications, the data obtained is stored in a database. The data stored are various measurements or variables in the game. These data will be used to predict the tendency of a player to have ADHD tendency or not. The basis for creating parameters or variables in this VR game application are the 18 symptoms in DSM 5.

The first step taken to obtain parameters and variables was to conduct a Focus Group Discussion (FGD) with 11 psychiatrists (medical doctor who specializes in mental health). This FGD is needed to get input from psychiatrists on what behaviors or symptoms in DSM 5 can be observed or measured using games.

There are two stages, the first stage is to collect all opinions from psychiatrists for a description of observable behavior (Table 1). In Table 1, 18 symptoms are shown but symptom number 17 cannot be measured in the game. Apart from that, input from the FGD obtained that symptom 7 (often losing objects) also cannot be measured using the VR game application. FGD participants provide input descriptions of behavior that can be observed in the game application. Each symptom gets multiple inputs.

The next stage is to discuss again and select from all input descriptions of observable behavior. Some behavioral descriptions that were less suitable for inclusion in a game application were omitted (with * and ** in Table I). The final results are given to the authors who create VR game applications.

TABLE I. STAGE 1, INPUT FROM FGD PARTICIPANTS

No.	Symptoms of ADHD – DSM 5	Description of observable behavior
1	Frequently fails to pay full attention to details or makes careless mistakes on schoolwork, at work, or during other activities (e.g., ignoring or missing details, inaccurate work).	1. The length of time needed... no 1. The number of tasks successfully completed correctly during a certain period of time/throughout the examination (according to the instructions given/verbal and auditory stimuli). 2. Number of errors made during the examination (not in accordance with the instructions given; auditory and/or verbal) 3. Number of missed assignments.
2	Often has difficulty maintaining attention in tasks or play activities (for example, has difficulty staying focused during lectures, conversations, or reading for long periods of time).	1. The length of time needed to complete each task given during a certain period of time/throughout the examination (starting from the verbal and auditory instructions/stimulus given until the task is completed). Then add it all up. 2. Number of errors made during the examination (not in accordance with the instructions given/auditory and verbal stimuli). 3. Number of behaviors that show being distracted by external/internal stimuli. 4. Number of missed assignments.
3	Often does not seem to be listening when spoken to directly (e.g., thoughts seem elsewhere, even in the absence of obvious distractions)	1. Number of errors made during the examination (not in accordance with the instructions given/auditory and verbal stimuli) 2. The number of tasks successfully completed correctly during a certain period of time/throughout the examination (according to the instructions given/verbal and auditory stimuli).* 3. Number of missed assignments.
4	Often does not follow instructions and fails to complete schoolwork, assignments (e.g., starts assignments but quickly loses focus and is easily distracted).	1. Number of errors made during the examination (not in accordance with the instructions given/auditory and verbal stimuli). 2. The length of time needed to complete each task given during a certain period of time/throughout the examination (starting from the verbal and auditory instructions/stimulus given until the task is completed). Then add it all up. 3. Percentage of tasks/instructions that can be completed.
5	Often has difficulty organizing tasks and activities (e.g., difficulty managing sequential tasks; difficulty storing materials and items neatly; messy, disorganized work; has poor time management; fails to meet existing deadlines).	1. The total number of sequence errors in carrying out the verbal and auditory instructions given. 2. The total number of correct sequences of each verbal and auditory instruction. * 3. The number of tasks successfully completed correctly during a certain period of time/throughout the examination (according to the instructions given/verbal and auditory stimuli).
6	Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework; for teens and older adults, preparing reports, filling out forms, reviewing long papers).	1. The number of tasks successfully completed correctly during a certain period of time/throughout the examination (according to the instructions given/verbal and auditory stimuli). 2. The total number of correct sequences of each verbal and auditory instruction. 3. The total number of sequence errors in carrying out the verbal and auditory instructions given.
7	Frequently loses things needed for assignments or activities (e.g., school materials, pencils, books, tools, wallet, keys, school assignments, glasses, cell phone).**	Number of tasks completed completely*
8	Often easily distracted (for older teens and adults, may include unrelated thoughts).	1. The number of tasks successfully completed correctly during a certain period of time/throughout the examination (according to the instructions given/verbal and auditory stimuli).

		2. Number of errors made during the examination (not in accordance with the instructions given/auditory and verbal stimuli)* 3. The amount of time used to complete tasks/activities. 4. The number of behaviors that show being distracted by the stimulus provided.
9	Often forgetful in daily activities. (e.g., doing chores, running errands; for older teens and adults, calling back, keeping promises).	1. The number of tasks successfully completed correctly during a certain period of time/throughout the examination (according to the instructions given/verbal and auditory stimuli). 2. Number of errors made during the examination (not in accordance with the instructions given/auditory and verbal stimuli).
10	Often fidgets with or taps hands or feet, or squirms in seat.	1. The total number of movements while carrying out the instructions given (Starting from verbal and auditory instructions given until the task is completed and in between).** 2. Total time required to complete a given verbal/auditory instruction/stimulus. 3. Draw each child's movement patterns.** 4. Reaction time from completion of instructions given (verbal and visual) to completing the first task.
11	Frequently leaves seat when a sitting situation is expected (for example, leaving his/her place in the classroom, in the office or other workplace, or in other situations that require staying in place).	1. The total number of movements while carrying out the instructions given (Starting from verbal and auditory instructions given until the task is completed and in between).** 2. Total time required to complete a given verbal/auditory instruction/stimulus. 3. The number of steps each child takes during the activity.**
12	Often runs about or climbs in situations where it is not appropriate.	1. The total number of movements while carrying out the instructions given (Starting from verbal and auditory instructions given until the task is completed and in between).** 2. Total time required to complete a given verbal/auditory instruction/stimulus. 3. The number of steps each child takes during the activity.** 4. Percentage of time pacing in a given situation (doing nothing).
13	Is often "on the go" acting as if "driven by a motor" (e.g., unable or uncomfortable remaining still for long periods of time, such as in a restaurant, meeting; may be experienced by others as restless or difficult to follow).	1. The total number of movements while carrying out the instructions given (Starting from verbal and auditory instructions given until the task is completed and in between).** 2. Total time required to complete a given verbal/auditory instruction/stimulus. 3. The number of steps each child takes during the activity.**
14	Often unable to play or take part in leisure activities quietly.	1. Observations while running a VR examination. Can it be calm or does it tend to be 'busy'?** 2. The total number of movements while carrying out the instructions given (Starting from verbal and auditory instructions/stimuli given until the task is completed and in between).** 3. The number of activities that can be participated in correctly.
15	Often talks excessively.	How much time does it take from the time the verbal and auditory instructions/stimulus are given and the activity begins?
16	Often blurts out an answer before a question has been completed (e.g., finished someone's sentence; could not wait for their turn to talk).	1. How many tasks are completed before the verbal and auditory instructions are completed? 2. How much time does it take from the time the verbal and auditory instructions/stimulus are given and the activity begins?
17	Often has trouble waiting their turn.	Not in the game*
18	Often interrupts or intrudes on others (e.g., enters conversations, games, or activities; may start using other people's things without asking or receiving permission).	1. How many tasks are completed before the verbal and auditory instructions are completed? 2. How much time does it take from the time the verbal and auditory instructions/stimulus are given and the activity begins? 3. How many tasks were performed in a different order with verbal and auditory instructions/stimuli provided? * 4. The number of activities interrupted during a given task.

*) Inaccurate description of behavior for this symptom
**) Hard to measure in VR games

From the input of the FGD participants, tables were created that explained how to measure VR game applications and what data had to be obtained and stored from the game into variables which were then stored in the database. Some existing variables can be used in several behaviors or symptoms.

Below are tables explaining the variables that store data from the game. If a symptom has several variables, these variables will be combined. Below, Table II to Table V are shown 4 examples which data will be stored in database for the inattention type symptoms (total 9 symptoms), while Table VI to Table IX are shown 4 examples which data will be stored in database for the hyperactive, impulsive type symptoms (total 9 symptoms).

TABLE II. DATA THAT CAN BE SAVED ON SYMPTOM 1

Description of observable behavior		Measured in VR apps	Stored in the database
1	The number of tasks successfully completed correctly during a certain period of time/ throughout the examination.	• Number of instructions that can be done correctly within 10 minutes. • The correct order of objects and total number of objects are put into the box	• Total the correct and incorrect instructions. • At each instruction, count the total of objects put correctly and incorrectly into the box.
2	Number of errors made during the examination.	The number of objects put incorrectly, it could be the wrong object or in the wrong order.	Total objects placed in the box, but not correct per instruction
3	Number of missed assignments	The number of incomplete or incorrect instructions	Total unexecuted instructions

TABLE III. DATA THAT CAN BE SAVED ON SYMPTOM 2

Description of observable behavior		Measured in VR apps	Stored in the database
1	The length of time needed to complete each task given during a certain period of time/throughout the examination. Then add it all up.	Total time (per task/instruction, per type) used to complete each instruction correctly	• Time starts counting after the instruction is completed or the player moves to take the object. • The time will be counted from holding the object until put it correctly. • There will be a time limit

2	Number of errors made during the examination.	The number of objects put incorrectly, it could be the wrong object or in wrong order.	Total objects placed in the box, but not correct per instruction
3	Number of behaviors that show being distracted by external/internal stimuli	Total time not holding an object after instructions, holding an object but stand still, picking up another object that pops up	• The time counted from the end of instruction until the first time hold the correct object. • Variables that count player holding incorrect objects and variables that count the length of time they hold them
4	Number of missed assignments	The number of incomplete or incorrect instructions	Total unexecuted instructions

TABLE IV. DATA THAT CAN BE SAVED ON SYMPTOM 3

Description of observable behavior		Measured in VR apps	Stored in the database
1	Number of errors made during the examination.	The number of objects put incorrectly, it could be the wrong object or in the wrong order.	Total objects placed in the box, but not correct per instruction
2	Number of missed assignments	The number of incomplete or incorrect instructions	Total unexecuted instructions

TABLE V. DATA THAT CAN BE SAVED ON SYMPTOM 4

Description of observable behavior		Measured in VR apps	Stored in the database
1	Number of errors made during the examination.	The number of objects put incorrectly, it could be the wrong object or in the wrong order.	Total objects placed in the box, but not correct per instruction
2	The length of time needed to complete each task given during a certain period of time/throughout the examination (starting from the verbal and auditory instructions/stimulus given until the task is completed). Then add it all up.	Total time (per instruction)	• Time starts counting after the instruction is completed or the player moves to take the object. • Time will stop when the instruction is completed. • The time will start counting again once the next instruction is started or the player moves to take the object. • There will be a time limit
3	Percentage of tasks/instructions that can be completed	The number of instructions that can be completed correctly is compared with the total number of instructions	Percentage of correct instructions divided by 10 * 100%

TABLE VI. DATA THAT CAN BE SAVED ON SYMPTOM 10

Description of observable behavior		Measured in VR apps	Stored in the database
1	The total number of movements while carrying out the instructions given	Requires additional equipment (Apple Watch)	Cannot be implemented in VR game application
2	Total time required to complete a given verbal/auditory instruction	The total time after all instructions can be completed.	Calculate the total number of times each instruction was correct and incorrect
3	Draw each child's movement patterns	Requires additional tools (Pedometer/ Heat-Map)	Cannot be implemented in VR game application
4	Reaction time from completion of instructions given (verbal and visual) to completing the first task.	The total time, start from when the player presses start on the visual instructions or after the audio instructions finish until they pick up the first correct object	• Variable that stores the time from instruction until take a correct object per instruction. • Variable that stores the time from take an object correctly to until put in the box per instructions

TABLE VII. DATA THAT CAN BE SAVED ON SYMPTOM 11

Description of observable behavior		Measured in VR apps	Stored in the database
1	The total number of movements while carrying out the instructions given	Requires additional equipment (Apple Watch)	Cannot be implemented in VR game application
2	Total time required to complete given verbal/ auditory instructions	The total time after all instructions can be completed.	Calculate the total number of times each instruction was correct and incorrect
3	The number of steps each child took during the activity	Requires additional equipment	Cannot be implemented in VR application

TABLE VIII. DATA THAT CAN BE SAVED ON SYMPTOM 12

Description of observable behavior		Measured in VR apps	Stored in the database
1	The total number of movements while carrying out the instructions given	Requires additional equipment	Cannot be implemented in VR game application
2	Total time required to complete a given verbal/auditory instruction	The total time after all instructions can be completed.	Calculate the total number of times each instruction was correct and incorrect
3	The number of steps each child takes during the activity	Requires additional equipment	Cannot be implemented in VR game apps
4	Percentage of time pacing in each situation (doing nothing)	Total time not holding an object after instruction, holding an object but stand still, picking up another object that pops up	• The time counted after the instruction until the first time to hold the correct object. • Variables that count player holding incorrect objects and variable that count the length of time to hold them

TABLE IX. DATA THAT CAN BE SAVED ON SYMPTOM 13

Description of observable behavior		Measured in VR apps	Stored in the database
1	The total number of movements while carrying out the instructions given	Requires additional equipment	Cannot be implemented in VR application
2	Total time required to complete a given verbal/auditory instruction	The total time after all instructions can be completed.	Calculate the total number of times each instruction was correct and incorrect

3	The number of steps each child takes during the activity	Requires additional equipment	Cannot be implemented in VR application

V. Results and Discussions

In the previous tables, of the 18 symptoms in DSM 5, it has been shown what data will be stored in variables and which will later be stored permanently in the database. There are 14 variables needed to store the data. Some symptoms use multiple variable inputs. Multiple variables are used across multiple symptoms.

A. Data Stored in Variables

Below is the data stored in variables which will be saved permanently to database of the VR game application:

1. Total objects entered correctly, each box
2. Total consecutive correct entry sequences
3. Total incorrectly entered objects, each object
4. Total consecutive incorrect entry sequences
5. Total objects remaining after time expires (per object)
6. Total time from completion of instruction (visual/audio) until the player holds the first object
7. Total time from holding the object to inserting it correctly (every time you hold the object)
8. Percentage of the total objects entered into the box correctly compared to the total of all objects entered incorrectly and correctly
9. Percentage of total objects entered into the box incorrectly compared to the total of all objects entered incorrectly and correctly
10. Counts the time the player places an object into the appropriate box (per object), each time
11. Total time of entering objects into appropriate boxes (all times)
12. Stores the time from not holding an object to holding the object (per object), each time
13. Percentage of time not holding any object (total) compared to 3 minutes
14. Total number of objects entered correctly, before the audio instruction finishes or the visual instruction disappears.

B. Mapping Symptoms in DSM5 with Variables

Below is the mapping of the 18 symptoms contained in DSM5 with the variables (if any) used in the game application.

Symptom 1
1.1 Data is stored in variables 1 and 2.
1.2 Data is stored in variables 3 and 4.
1.3 Data is stored in variable 5.

Symptom 2
2.1 There is no measurable data in VR application.
2.2 Data is stored in variable 3.
2.3 Data is stored in variables 6 and 7.
2.4 Data is stored in variable 5.

Symptom 3
3.1 Data is stored in variable 3.
3.2 Data is stored in variable 5.

Symptom 4
4.1 Data is stored in variable 3.
4.2 There is no measurable data in VR application.
4.3 Data is stored in variable 8.

Symptom 5
5.1 Data is stored in variables 4 and 9.
5.2 Data is stored in variables 1 and 2.

Symptom 6
6.1 Data is stored in variables 1 and 2.
6.2 Data is stored in variables 2 and 8.
6.3 Data is stored in variables 4 and 9.

Symptom 7
There is no measurable data in VR game application.

Symptom 8
8.1 Data is stored in variables 1 and 2.
8.2 Data is stored in variables 10 and 11.
8.2 Data is stored in variable 12.

Symptom 9
9.1 Data is stored in variables 1 and 2.
9.2 Data is stored in variable 3.

Symptom 10
10.1 to. 10.3 no data can be measured in VR apps.
10.4 Data is stored in variable 6.

Symptom 11
There is no measurable data in VR application.

Symptom 12
12.1 to. 12.3 no data can be measured in VR apps.
12.4 Data is stored in variables 6, 12 and 13.

Symptom 13
There is no measurable data in VR application.

Symptom 14
14.1 to. 14.2 no data can be measured in VR apps.
14.3 Data is stored in variables 1 and 8.

Symptom 15
15.1 Data is stored in variable 6.

Symptom 16
16.1 Data is stored in variables 1, 3 and 14.
16.2 Data is stored in variable 6.

Symptom 17
There is no measurable data in VR game application.

Symptom 18
18.1 Data is stored in variables 1, 3 and 14.
18.2 Data is stored in variable 6.
18.3 Data is stored in variables 7 and 12.

So, four symptoms (7, 11, 13 and 17) can not be measured in this VR game application because of some limitations with the tools that have been used.

VI. Conclusions and Recommendations

This research showed that not all 18 symptoms in DSM 5 could be use is VR game application to detect children with ADHD tendency. The tool that will be used is Oculus with several limitations, such as could not detect face recognition, no heat map, no feature to count steps, etc. Using 14 variables is still possible to create a VR game application. The game itself has already been tested several times. Now need to be tested with many children.

For future works, if possible, it could combine heat map, step motion and face recognition in this VR game application to get more accurate result.

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Teaching Challenges Influencing Undergraduate Students' Engagement

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***Abstract*—In this paper, the complexity of student engagement in higher education and its influence on teaching quality is examined. Student engagement involves active and reciprocal interactions, covering instructional requirements, curriculum decision-making, and grade determination. It denotes the quality of effort and involvement in both formal and informal learning activities. Insights from Educational Psychology highlight behavioral, cognitive, and affective indicators, stressing resource allocation and time investment. This study also investigates the evolving concept of online engagement. Understanding these dynamics is essential as challenges in remote learning affect student participation, offering valuable insights for educators and institutions.**

Keywords—student engagement, e-learning engagement, higher education, community of inquiry

I. INTRODUCTION

The function of student engagement marks an active and reciprocal interaction between students and teaching quality. Overall, the term "engagement" has been conceptualized in various ways across the literature, reflecting its association to instructional requirements, curriculum decision-making, and the determination of students' grades [1-3]. In educational settings the term engagement is commonly used to describe constructs such as the quality of effort and involvement in all aspects of learning activities, both within and beyond the classroom setting [4], comprising both student-formal and student-informal activities [5]. In the context of this study, student engagement is comprehensively defined, encompassing a variety of activities and practices. Faculty interactions, participation in student clubs, and the implementation of educational curricula collectively function as 'mechanisms,' offering diverse opportunities for student engagement. These opportunities, in turn, contribute to multifaceted learning experiences, facilitating increased knowledge acquisition and the development of various skills [6]. Noteworthy, students who actively participate in educational activities exhibit a higher likelihood of persisting through to graduation, as opposed to their less-engaged peers [7]. In alignment with these considerations, educational institutions aspire to mitigate dropout rates by prioritizing the improvement of students' educational experiences—an acknowledged benchmark for assessing teaching quality. This emphasis becomes especially pertinent for marginalized cohorts, including low-income and underrepresented groups, necessitating strategic efforts to identify and ameliorate the determinants that bolster the efficacy of engagement [8]. More specifically, higher education institutions make efforts to design approachable curricula that strengthen student engagement, thereby increasing the chances of students attaining their educational objectives [9]. Nevertheless, to fully grasp the link between student engagement and the factors influencing it, it is essential first to examine the term 'engagement' across different period of times and explore its components [10].

In the context of Educational Psychology, the function of engagement provides insights into the factors that influence students' learning processes which are related to academic outcomes [11-12]. In this line, [13] suggests that student engagement is a comprehensive concept that encompasses various factors that aid in the enhancement of the student experience and academic achievements which 'can be observed through a range of behavioral, cognitive, or affective indicators as a spectrum'. These factors include the allocation of resources, exertion of effort, and investment of time by students, educators, and educational institutions [14-15]. Moreover, [16] elaborate on the new concept of online (e-learning) engagement and suggest that it comprises a set of multifaceted components, including the sense of convenience, autonomy, active and collaborative learning, interaction with educators, tutors and peers, involvement in technological educational experiences, and overall, a sense of support. Behavioral engagement, whether via distance learning or on-campus, refers to student's active participation in lectures, diligent effort in academic tasks, focused attention on assignments, and fulfilment to instructions [17-19]. Emotional engagement refers to positive emotions that manifest as enthusiasm about the university, a positive attitude and enjoyment toward learning, interest, and satisfaction in participating in lectures [20-21]. Cognitive engagement concerns the student's psychological investment in learning, affective strategic study approaches, and effortful cognitive processes [22]. More broadly, undergraduate student engagement has increasingly become a matter of increased attention during the Coronavirus-19 (COVID-19) global pandemic due to the reported challenges that negatively impact students' engagement in e-learning [23-27]. For instance, researchers support that the absence of direct, face-to-face interaction between students and educators in distant e-learning environments create challenges for students to participate effectively in lectures [28].

II. Theoretical Foundation of Online Learning

The Community of Inquiry (CoI) framework was introduced by [29] based on the idea of a community of learners who share the same experience of learning online and, according to [30], CoI is the most used framework in online education research. The CoI framework is based on social constructivist principles of learning and, based on these principles, [31] described the three elements that construct the student's learning experience. The first element is the social presence which is defined as the students' ability to project their personal characteristics into the community, thereby presenting themselves to the other participants as 'real people' [29]. The second element is the cognitive presence which is defined as 'the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry' [32]. The third element is the teaching presence which is defined as 'the design, facilitation and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes' [33]. The CoI framework is used not only as a design tool for online courses but also as a tool to assess their effectiveness and provides teaching stuff with actual practical guidelines and help with how to develop strategies to create effective and engaging course designs.

The CoI framework was used in [34] both as a design and a research tool to redesign an English for Academic Purposes Pathway Program for online learning and assess its effectiveness and satisfaction based on the three "presences" of the CoI framework. The module was, overall, deemed satisfactory by the students. The most interesting finding of this research was the following: both the students and the instructors recognized that social presence could not be easily attained but students and instructors perceived teaching presence and cognitive presence differently (positive for students but less positive for instructors). Regarding social presence, students reported that it was the least satisfactory presence as they could not form relationships with their classmates. However, the positive interactions they had with the instructors could have made up for the difficulty in forming relationships with their classmates. Regarding teaching presence, from the instructors' point of view, instructors reported that they did not have the same knowledge of the students' academic development as face-to-face teaching and had to rely more on graded assessments. However, students were content with the teaching presence, something that suggests that instructors may have had higher expectations of themselves compared to those that the students had of them [34]. Lastly, regarding cognitive presence, instructors described the lessons as more streamlined and didactic while the students did not share the same experience and, overall, found the design of the module and the teaching satisfactory.

In [35] a phenomenological study on 15 educators' experiences of online teaching during Covid-19 was conducted using the CoI framework as a guide. The authors found that teacher presence could be easily attained by the educators. However, cognitive and social presence could not be easily attained mainly due to challenges from student's perspectives and participation. These finding suggests that teaching presence may not lead to accomplishing cognitive and social presence. In a study conducted by [36], an investigation into whether teaching, social, and cognitive presence could vary across different disciplines was undertaken. The findings revealed that students enrolled in 'applied' disciplines consistently rated the three presences higher compared to those in 'pure' disciplines. This suggests that the CoI framework may be more pertinent and applicable to applied disciplines as opposed to pure ones.

In response to the COVID-19 pandemic, [37] transitioned a nursing course to an online format. Throughout the conversion process, they employed strategies aligned with the three 'presences' outlined in the CoI framework. Specifically, regarding teaching presence, they employed discussion forums, interactive learning sessions, and synchronous laboratory consultation sessions. Regarding social presence, the students were encouraged to work in pairs and were able to communicate with each other using an asynchronous online chat on the learning platform. Lastly, regarding cognitive presence, online video-recorded lectures, quizzes and active learning laboratory assignments were employed. The authors of [37] identified noteworthy correlations between student engagement and perceived learning satisfaction. This finding supports the assertion made by [38] that perceived learning satisfaction has the potential to influence engagement.

According to [39], there are some common elements in the literature that are reported to improve student engagement. Those are interaction, exploration, relevancy, multimedia, instruction, and authentic assessment. More specifically, interaction refers to the respectful relationships and interactions, exploration refers to the problem and inquiry-based exploratory classroom practices, relevancy refers to the application of learning to real-life scenarios, multimedia refers to the use of multimedia and technology, instruction refers to the engaging and challenging instruction and, lastly, authentic assessment refers to the Assessment for Learning which calls for the use of formative assessment in the classroom in order to learn for further development [39]. Based on the research reported above, as well as its philosophy, the CoI framework can potentially improve student engagement and make the experience of online learning better.

In a systematic review, [40] synthesized the 'Seven Principles of Good Practice for Undergraduate Education' adapted from [41] and based on the CoI framework in order to create a document of instructional strategies for educators. This document contains a plethora of strategies and activities regarding student-teacher contact, cooperation among students, active learning, prompt feedback, time on task, communication of high expectations, respecting diverse ways of learning and, lastly, how these principles can be applied within the dimensions of the CoI. According to [40], these activities and strategies could guide online practitioners in creating effective, meaningful, and engaging course designs and making the process of online teaching/learning easier.

In order to gain a more comprehensive understanding of the factors influencing student engagement in online and traditional learning environments this article reviews the three different periods of time before the COVID-19 pandemic [42], during COVID-19 [43], and after [44], in order to understand how these factors have changed over time. Additionally, reviewing these factors may offer insights into which specific factors positively impact learning engagement despite the challenges.

III. Impact of COVID-19

A. Challenges

In 2020, the global COVID-19 pandemic and subsequent unexpected lockdowns [45-46] precipitated widespread transformations across various facets of individuals' lives, resulting in substantial disruptions to global education systems [47]. This upheaval necessitated an abrupt transition from traditional face-to-face teaching and learning modalities to a virtual environment, characterized by online learning, activities, and technologies [48-54]. This rapid shift, occurring within a few days, compelled educational institutions to adopt emergency remote online teaching approaches [55].

This emergency online learning environment created challenges in the way education was delivered and received, with potential implications for both university students and tutors [43, 56]. More specifically the rapid spread of the SARS-CoV-2 coronavirus infection [57] led to the unplanned closure of universities and educational institutions, which according to empirical evidence is strongly associated with distress and mental health problems because of the highly stressful condition for both university students [58-61] and educational administrators who were left with limited options [62]. Even though these studies suggest an increase in mental and physical health-related problems, it is worth noting that the consequences of the discontinuation of face-to-face educational activities remain largely unknown and need more research to be elucidated. For example, the authors of [63] observed that tutors noted a lack of behavioral engagement among students once they entered the breakout rooms. The study's results indicate that engagement dimensions could be influenced in a separate way and by different factors. Furthermore, this global unexpected transition into an online learning environment posed a variety of technical and pedagogical challenges for both educators and university students, necessitating a complete re-orientation to face and adapt to the new learning environment [62, 64]. For example, digital educational environments could be more challenging for tutors to comprehend how their students engage and learn within the teaching-learning process. This lack of insight into students' learning methods makes it even more difficult for tutors to understand students' behavior and learning in the higher educational system [65].

Several initial quantitative research studies exploring online learning and engagement among undergraduate students during the global pandemic have been published, revealing a complex and diverse range of outcomes and findings [66-69]. However, the effectiveness of quantitative research is constrained when conducted in confined situations or environments, posing a high risk of generating inaccurate or biased measurements. Factors such as changes in participants' economic situations and the psychological impact of the virus-induced high mortality rates, which were not measured, may influence the current methodology. On the other hand, during the pandemic, qualitative research could provide more insights into the unique challenges and opportunities presented by the unexpected emergency remote online teaching, as well as the impact of academic and sociocultural factors which influence undergraduate student engagement.

B. Research Limitations during COVID-19

The examination of students' experiences and engagement during the pandemic exposes a notable limitation that could adversely influence reported engagement levels. A key constraint is the insufficient knowledge among tutors regarding online education, encompassing both synchronous and asynchronous modes. This knowledge gap, stemming from the unforeseen nature of the pandemic, has left a considerable number of educators unequipped with the necessary skills and training for effective online course delivery. Consequently, students may have grappled with challenges in fully participating in online learning, leading to a potential misalignment with their prior learning experiences.

This convergence of mismatched prior experiences and educators' inadequate familiarity with online education constitutes a significant limitation, likely contributing to a diminished self-reported engagement among students. Conversely, first-year students embarking on their university journey during the pandemic might offer a more impartial perspective, lacking a comparative benchmark for traditional learning environments. This group could potentially report higher engagement levels, despite navigating an online learning landscape unfamiliar to many of their tutors.

It is crucial to highlight that first-year students reporting heightened engagement might be influenced by self-assessment bias or attribute it to a profound sense of belonging during their transition from high school to university. To conduct a more comprehensive assessment of student engagement during the pandemic, particularly in the context of online learning, it becomes imperative to address this limitation by equipping tutors with comprehensive training or familiarization with technical procedures.

IV. Factors Influencing Students' Engagement Before and After COVID-19

However, many scholars indicate different factors that shape student engagement. For example, according to recent studies, there is a significant correlation between students' engagement in university and their perceived social integration and sense of academic belonging [70-71]. These findings corroborate earlier studies that found a positive association between participation in university groups or certain activities (e.g., cultural groups, sports, social organizations) and the level of academic belonging, along with a negative association with loneliness and social anxiety in university students [72].

A recent meta-analysis conducted by [73] investigated the various factors that affect student engagement across different contexts. Their findings support that cognitive, emotional, and behavioral integration of learning performance impacts student engagement. More specifically, they find several factors such as personal resources, financial profile, gamification, and teacher support influencing student engagement. Additionally, this meta-analysis also highlights two dimensions of student engagement, campus and class engagement. Moreover, this study underscores a range of internal and external factors, including students' abilities, behavior, and personality characteristics, tutor-student relationship, learning resources, and environmental support that significantly contribute to shaping student engagement.

Scholars argue that social support is the most important factor in shaping undergraduate students' engagement over time in the context of online education [42, 74-76]. For example, [75] indicate the tutor's presence along with the student's interaction with tutors and peers and the participation in online and offline activities as significant factors that contribute to engagement in online learning environments. Therefore, social support could be encompassed by various sources, including the interaction between teacher and learner, interactions among learners and the interactions between the learner and their family [43]. In a systematic review conducted by [77], a variety of factors that influence undergraduate students' engagement in online education learning was explored. Specifically, they found that both tutor support and learners' academic self-efficacy were positively associated with engagement in online education. Thus, the study's results indicate that tutors provide support to students' autonomous learning attitudes. On the other hand, engagement in online learning could be challenging. These challenges include issues related to low self-efficacy, poor time management skills, the lack of motivation, and difficulties in forming relationships with tutors and peers [78]. For example, students have cited concerns with respect to their lack of privacy in their house or vision and attention difficulties that potentially decrease their engagement [79-82]. Another factor is students' difficulty in regard to communication. For example, [83] found that online students often struggle to communicate their desire to participate in class or answer questions, leading to disengagement. Also, in [84] it was found that online students tend to feel disconnected from their universities, something that emphasizes the need to establish a sense of connection between online students, their tutors, and peers. However, it is worth noting that these studies were conducted before the pandemic.

Online educational contexts take into consideration the multifaceted nature of students' profiles (recognizing their diverse personal and professional obligations, including work and family commitments) [85-86]. In the past, students' academic duties were often given more importance, while other aspects of their lives were neglected. However, over time it has been recognized that students have complex and multidimensional lives that encompass family, work, and personal commitments that significantly influence their engagement in learning process. Modern forms of education should consider these aspects of students' lives to ensure that their educational needs are met in a more comprehensive manner. This entails recognizing that academic duties are not the only obligation that students have and acknowledging that accommodating their other commitments is essential in promoting their academic success and overall well-being.

Based on this, it could be interesting to discuss the concept of "virtual environment confidence," which differs from "online learning preference." Online learning preference relates to a student's inclination towards learning through digital platforms, whereas virtual environment confidence refers to a student's perceived ability or skills to feel comfortable or even more secure while utilizing digital or virtual environments for learning, more so than in traditional face-to-face settings that may generate more stress. Students who possess high levels of digital environment confidence may also feel more resourceful while engaged in online learning. Therefore, it is essential to consider all these issues when designing virtual or traditional classes. Additionally, an important challenge of the current educational systems could be the simultaneous engagement of both online students and those who join on campus.

V. FUTURE RECOMMENDATIONS AND CONCLUSION

Identifying research gaps concerning the role/aspects of various intelligent technologies such as Artificial Intelligence (AI) and natural language processing applications could be of particular importance, as they potentially may enhance students' learning experiences and engagement in both online and traditional learning environments. A critical question that arises in this context is whether these new technological aspects influence student engagement in a biased manner. In other words, quantitative research needs to examine whether the use of AI technologies in educational settings actively promote engagement in learning processes, or, contrariwise, leads to student disengagement. To further explore these thoughts, future research should also consider whether the prolonged use of such technologies could potentially reduce the stimuli essential for nurturing critical thinking, possibly leading students to engage in less cognitively demanding processing of information. Furthermore, it is worth noting that the negative impact of AI technologies might not be immediately apparent and this could result in skewed or biased outcomes. Therefore, a comprehensive understanding of the implications of AI on student learning and engagement is essential.

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Digitalization of the Supply Chain System for Moringa Leaves in East Nusa Tenggara-Indonesia

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Abstract— **This paper discusses the design of digitalization for supply chain system of moringa leaves using mobile and web-based technology. Through a methodological approach involving surveys, observations and requirements analysis, the blueprint of the digitizing system was successfully designed. This design aims to integrate all elements in the supply chain, from farmers to Small Medium Enterprise (SME) in East Nusa Tenggara-Indonesia, especially to maximize transparency and efficiency. While having high potentially, this digitizing design presents challenges, especially in terms of fulfilling the needs of all actors, infrastructure limitation, and user adaptation. However, this design is expected to be a strong foundation and references for developing Moringa leaves supply chain system, and other similar supply chain scenario in the future.**

Keywords— Digitalization, Supply Chain, Moringa, System Design, East Nusa Tenggara

I. Introduction

East Nusa Tenggara (it known by *Nusa Tenggara Timur* short by “NTT”) is a province in Eastern Indonesia with 566 islands, including 10 large islands such as Flores and Sumba. Kupang is the capital city. NTT covers 2.49% of Indonesia's area with land of 47,349 km2 and sea of around 200,000 km2. It borders Timor Leste to the East, West Nusa Tenggara to the West, the Flores Sea to the North, and the Indian Ocean to the South [1].

The huge potential that NTT Province has in terms of topology has been successfully utilized by the community to carry out supervision in the agricultural and livestock sectors. This is reflected in the number of agricultural households that use agriculture as their main source of business. Data in 2018 revealed that around 818,853 people chose to work in the agricultural sector. NTT as a province with a dry climate has quite promising non-rice field agricultural land potential, namely around 3.8 million hectares[2] .

People in the East Flores Regency area of East Nusa Tenggara Province have known about the Moringa plant since ancient times. They use it as a regular food source, such as vegetables and other processed food products. As information about the potential benefits of Moringa for health, namely as a therapy for treating degenerative diseases and as a food ingredient, has become increasingly widespread, this has encouraged the NTT provincial government to make the Moringa cultivation business sector one of its mainstay programs. Apart from that, the Moringa plant is also known to have great economic opportunities for cultivation because it has a very promising export market potential, especially for countries in the Middle East region. The quality of NTT Moringa is also known to be very good, even one of the best in the world [3], [4].

As information continues to spread regarding the benefits of the Moringa plant, especially its leaves which have high nutritional content, this has encouraged the East Nusa Tenggara (NTT) provincial government to make the Moringa cultivation business sector one of the priority programs to increase people's income[5]. Apart from that, the Moringa cultivation sector is also expected to improve the health of the people of NTT through a stunting prevention program. The road map for developing Moringa cultivation as a superior commodity in the NTT province was launched by the Governor of NTT, Viktor Laiskodat in 2019, carrying the concept of collaboration [6].

As a follow-up to the plan to develop the moringa industry in NTT, the Regional National Crafts Council (Dekranasda) chaired by Julie Sutrisno Laiskodat is starting to build a moringa business ecosystem in the NTT region. Where in the moringa business ecosystem involves all components of society, both individuals and organizations. Since 2021, the results of Dekranasda's hard work have begun to bear fruit, and a moringa business ecosystem has begun to form. The moringa business ecosystem, which is a network of organizations from suppliers, producers to downstream, namely sellers or retailers, is starting to run. This ecosystem involves individual communities, government institutions and also Micro, Small and Medium Enterprises (also in Bahasa known as UMKM) [7].

In the upstream section, the supply of fresh Moringa leaves as raw material is carried out by individual members of the community, while the collectors and also processing of raw materials into raw materials are carried out by government agencies and also the community. Furthermore, the sector that produces raw materials into finished products is carried out by MSMEs. In the downstream part of the moringa business ecosystem, it is driven by UMKM and also government agencies that help commercialize processed moringa products produced by UMKM. All components in the moringa business ecosystem involve the community and local NTT organizations.

CV. Xyz is one of the UMKM in Kupang City which specializes in cultivating Moringa plants starting from garden processing, production processing to marketing. Featured Products from CV. Xyz are Moringa Tea in the form of tea bags and brewed tea, Moringa coffee and Moringa chocolate. With the increasing demand for products and the expansion of the market, then the need for a consistent supply of large quantities of raw materials becomes an unavoidable necessity. Meanwhile, in terms of the supply chain of the main raw material, namely the supply of Moringa leaves, there are still many obstacles. Some of the obstacles that have been identified are that potential sources of raw materials in the NTT area are spread across 14 locations on three different

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islands, namely, 7 locations on Timor Island, 2 locations on Sumba Island and 5 locations on Flores Island. Where all of them have also become plasma farmers from CV. Xyz. The following image is a map of the distribution of Moringa cultivation in the NTT islands.

Meanwhile, the Moringa supply chain starts from farmers to CV production warehouses. Xyz is also very long. Before Moringa can be sent to CV. Xyz, these raw materials must go through several processing stages such as harvesting from the garden, drying in the center/plasma, and shipping between islands in NTT, which aims to maintain the quality and freshness of the raw materials. This is because the freshness of the harvested Moringa leaves is very short, so this process must be carried out immediately. After that, the raw materials, which are in the form of dry leaves or flour, can be sent from production centers to the CV.Xyz warehouse uses various modes of transportation, both land and sea, which of course have many obstacles and constraints.

The length and complexity of supply chain causes the raw material supply system to be unable to be managed properly. It is challenging for CV. Xyz to obtain information about the number of raw materials that can be sent from each moringa production center and also the schedule for the arrival of raw materials at the warehouse. This of course has an impact on production planning is currently getting higher. Production quantities cannot be planned with certainty, which ultimately greatly disrupts product supply on the market.

In 2021-2022, a program of activities has been carried out to identify and create supply chain mapping from CV.Xyz. Supply chain mapping is the documentation, both video and written, of the process of material flow from upstream (farmers) to downstream (consumers). Apart from that, the supply chain process map also contains information about the parties involved in the supply chain, both individuals and organizations. The supply chain map document will also provide information regarding the resources needed and also the problems and obstacles that must be faced in the supply chain route . Apart from that, this activity also has the potential to produce a blueprint, which illustrates the potential for digitalization in supply chain process.

This paper aims to describe the digitalization design process which is the basis for building a blueprint which in the future can be developed into an integrated mobile and web-based raw material supply recording and monitoring application system that can be accessed by all components involved in the supply chain of Moringa leaves.

II. Methodology

A. Research Actiivities

The program begins with brainstorming to identify a list of problems, followed by a literature review and field observations of the raw material supply chain. During this phase, a materials supply chain inventory is conducted to identify the roles and constraints of each supply chain. The material supply chain observed covers the entire supply chain from upstream (farmers) to downstream (CV.Xyz), and observational data collection was conducted through interviews, focus group discussions, and field surveys. Further detail can be seen in Fig. 1.

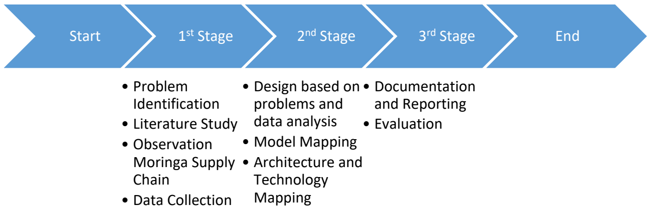

Fig. 1. Research Activities

After all the information and data is collected and analyzed, the next step is to map and draft a process map in the form of an information system architecture. Furthermore, in this second step, model-to-function mapping of the system and supply chain maps are determined, which can be seen in the form of simulated modeling diagrams.

In stage three, once the architecture, functions and models are completed, the process map and supply chain design are documented and raw materials are monitored from upstream to downstream. The process of creating this documentation follows the partner validation process so that it can be used as a resource for future application development. This third stage is the re-iterative process, using the feedback and feedback received during the validation phase to improve the document. This process continues until the creation of a design that meets existing problems and the needs of partners as end users.

B. Data Collection Method

To be able to get a clear picture of the supply chain of CV.Xyz, the data used in this mapping process is primary data. Several data collection methods such as Focus Group Discussion (FGD), interviews and field observations have been conducted to explore the information needed. In total, FGD has been carried out twice to gather information from plasma or leaf collectors and also from centers or collectors. In addition, interviews were also conducted with six actors involved in the supply chain, namely two people from CV.Xyz is the CEO and marketing staff, two people from the transportation process, namely the Crew (called "ABK") who are responsible for the goods on board and port personnel who are in charge of picking up goods and sending them to the CV.Xyz warehouse. While the other two people are representatives of MSMEs who work on making tea bags for CV.Xyz and central representatives from Larantuka, East Flores.

In the FGD activity with the center held in Kupang, nine people attended face-to-face. These nine people are representatives of nine centers out of a total of 36 centers spread throughout NTT. Meanwhile, one person attended using the online method. Of the nine people who attended face-to-face, eight people represented centers located in Kupang and surrounding areas and one person represented centers from Larantuka, east Flores. Meanwhile, representatives of the center who attended online, represented the center from Maumere. For the FGD conducted with plasma parties, 15 people attended face-to-face, all of which were plasma located in Kupang city and surrounding areas.

Meanwhile, in observation activities carried out to see firsthand the activities in the supply chain, the first thing to do is to review the CV.Xyz office to see the process of making moringa tea. In addition, observations were also made to see the cleaning process of Moringa leaves carried out by plasma before the leaves were sent to the center and see the process of transportation and loading and unloading of Moringa products at the Port of Bolok, Kupang which was sent by sea by various centers in NTT. Then the last is to review the downstream part of CV.Xyz supply chain, namely Dekranasda, where various processed moringa products from CV. Xyz is marketed in Dekranasda's Gallery.

All audio recordings from FGDs and interviews are then put into writing and then analyzed and studied to understand CV.Xyz supply chain and the problems it faces.

The location of this study was carried out on CV. Xyz is located in Klp. Lima, Kec. Klp. Lima, Kupang City, East Nusa Tenggara Province. Meanwhile, the research time when conducting initial observations in September 2021 to December 2022 by visiting UMKM partners and seeing the UMKM-scale production process in cultivating moringa in NTT.

III. Results and Discussion

Supply Chain Map CV. Xyz is a visual form that represents the process or activity of actors involved in the Moringa leaf supply chain starting from upstream, namely collectors or plasma to end users. The upstream part of the supply chain is the stage where the actors involved work to process raw materials into raw materials, while the downstream part is the stage where the actors distribute processed finished products to the end users.

The production process of Moringa leaves from raw materials to the final product in the form of Moringa tea with various flavors and also several other Moringa processed beverage products, is a long process consisting of several stages. The stages of the process include the process of taking raw materials, pre-production processes, production, distribution and sales to end users. Each stage also involves different actors interacting with each other. Detail Process can be seen in Fig. 2:

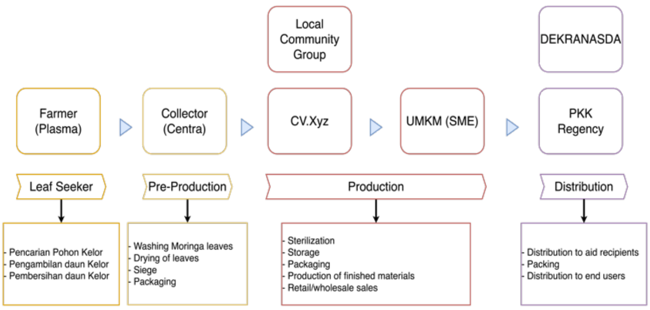

Fig. 2. Activity Map of Chain Actor in CV.Xyz

In the first stage, the process of taking raw materials in the form of Moringa leaves from the tree, involving community members as the main actor. It can be seen from the activity chain mapping that CV. Xyz does not involve moringa farmers in its production chain. This is done with the main consideration for achieving the company's goal, which is to improve the welfare of the people of NTT. The various individuals involved in this process are called plasma. Moringa leaves are usually obtained from Moringa trees that grow in their own yards. In addition, they usually also take leaves from Moringa trees that grow around their residence. Moringa trees grow wild in the NTT area, so Moringa leaf collectors until now have no difficulty in getting them.

The collectors then send the leaves that have been cleaned and packed in several bags to the center. After the fresh leaves are delivered to the center, the leaf cleaner will receive a reward for every kilogram of leaves he has successfully cleaned.

Wet leaves received from the collector, then processed into dry leaves or moringa flour. Each center has at least 3 drying machines operated by 2 or 3 people. The center produces 7 days a week to produce dried leaves and moringa flour. Each center has an area of operation that has been determined by CV. Xyz. In total in all NTT provinces there are 36 centers spread across various regions in NTT.

Moringa powder produced from the siege process in the center, then packed in bags and sent to CV. Xyz. For some centers located on the island of Timor, deliveries are made using pick-up vehicles. But for centers located on the island of Flores and other islands, the delivery is carried out using a ferry.

In the shipping process, the perpetrators involved are officers at the port of departure, crew members and officers at the port of Kupang. ABK is an employee of the ferry company that owns the ferry. ABK is tasked with receiving moringa flour sent from Centra and handing it over to officers at port. It is the crew who is responsible for the shipment package while on the way to Kupang until it is handed over to the officer there. While officers are in charge of receiving shipments of goods from all centers that use ferry. The shipment package is then taken to the warehouse.

Meanwhile, Moringa flour shipped from centers is stored in warehouses, while some other Moringa flour will be produced into finished products, after a sterilization process is carried out first. The sterilization process is necessary considering that the resulting product will be consumed by the end user, so the hygiene of the product needs to be maintained properly.

Moringa-based finished products that have been produced will then be sent to PKK groups in various regency that have been determined by Dekranasda as the recipient districts. In this PKK group several products from CV. Xyz will be combined with other products into a government assistance package for improving community nutrition which will then be sent directly to various beneficiary individuals who have been listed in the list of beneficiaries. The visualization of supply chain process can be seen in Fig 3.

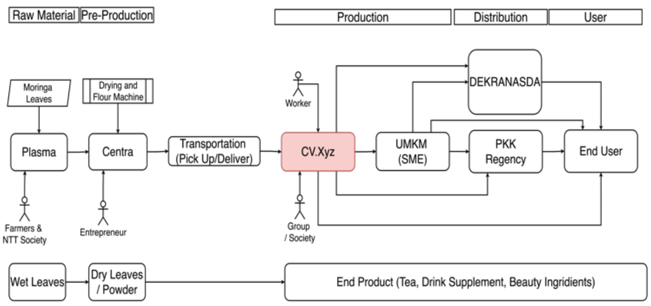

Fig. 3. Supply Chain of CV.Xyz

Part of the finished product CV.Xyz is also sent to Dekranasda which has special outlets that sell various MSME products from all over NTT Province. End users can purchase products CV.Xyz through this Dekranasda outlet.

From the supply chain results, the next step is to identify problems and potential solutions that can later be used in identifying any processes in the supply chain that can be digitized.

From problem identification, supported by observations and interviews during our visit to CV.Xyz and Partners (Centra) in NTT, It was founded several problems related to the Moringa leaf Supply Chain process, such as: (1) Manual recording using books in each Center, especially regarding the number and dating of wet leaves, dry leaves and flour produced per day; (2) There is no recording of shipment information which makes the delivery process difficult to trace; (3) there is no integrated information about the number and date that becomes important information in the production process in CV.Xyz, (4) The number and location of the centers are many and scattered in many places in the NTT islands.

From the problems we have identified, the Supply Chain process in the Moringa Leaf industry can be improved by building a system that helps the recording process from each Center to CV.Xyz. We can briefly describe the supply chain process in the form of an "Activity Diagram" in Fig 4.

From the "*Activity* diagram" in Fig.4 , it illustrates the core process of the Moringa leaf supply chain that occurs from Plasma (Farmer) to CV. Xyz. From these processes, processes have been identified that can later be built and developed into an application system that can help the supply chain process become more optimal. The green color of the *Activity* diagram illustrates the processes that can be digitized. That can then be continued in developing a *Use Case* diagram. Fig. 5 is an overview of actors and systems that can be digitized.

Furthermore, the design of the Activity and Use Case diagrams must be able to represent the needs according to the available infrastructure. Because the target application users are mostly farmers (plasma) and collectors (centers), an application that is more free and can be accessed anytime and anywhere is needed, therefore a mobile-based design is needed to support this scenario. For the monitoring process carried out by CV. Xyz, needed a computer device that could be accessed in their office and could be used by more than one person. Therefore, the system to be built must also support the use of using a PC. To facilitate data integration and communication, Web-based systems are the most optimal choice that can be implemented. Fig.6 is a design of the solution in the form of a system based on the needs of the available infrastructure:

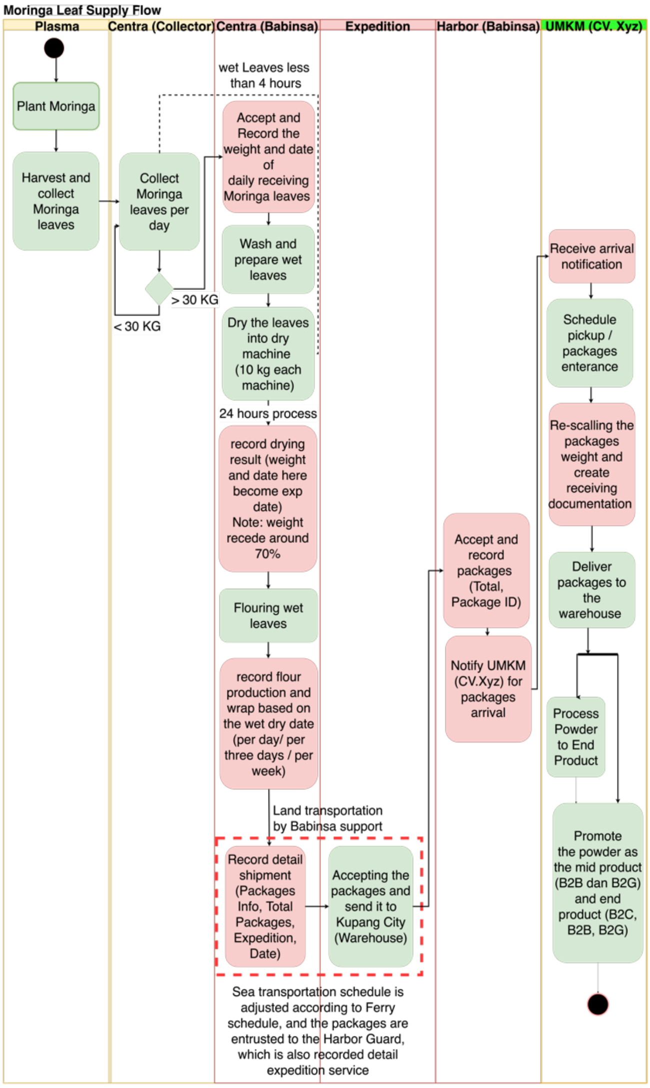

Fig. 4. Activity Diagram and the Potential Digtalization Identification Process

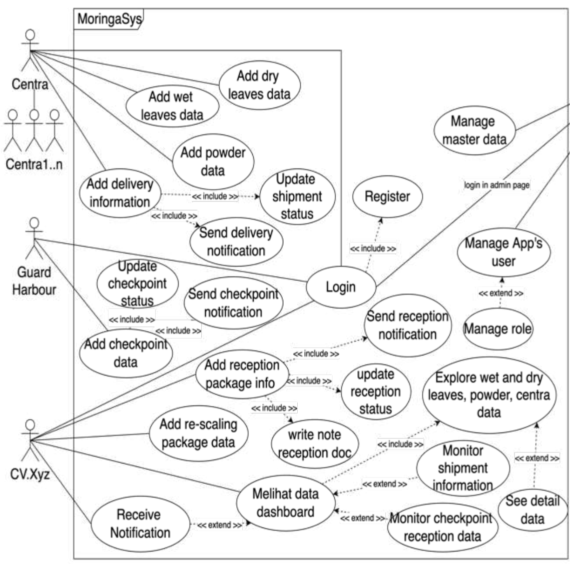

Fig. 5. Use Case Diagram of the propose system (MoringaSys)

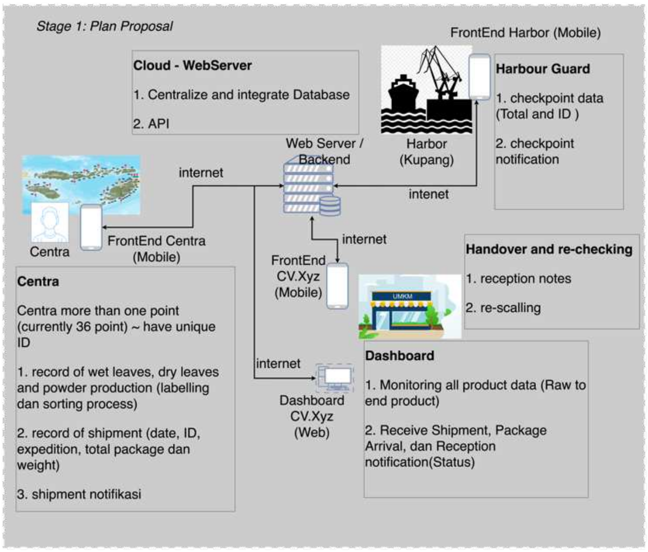

Fig. 6. Infrastructur Design Plan

To support the digitization design process, mobile and web-based interfaces are needed. The following is an example interface design in the form of a mockup of a mobile application that illustrates the recording and monitoring function above called MoringaSys:

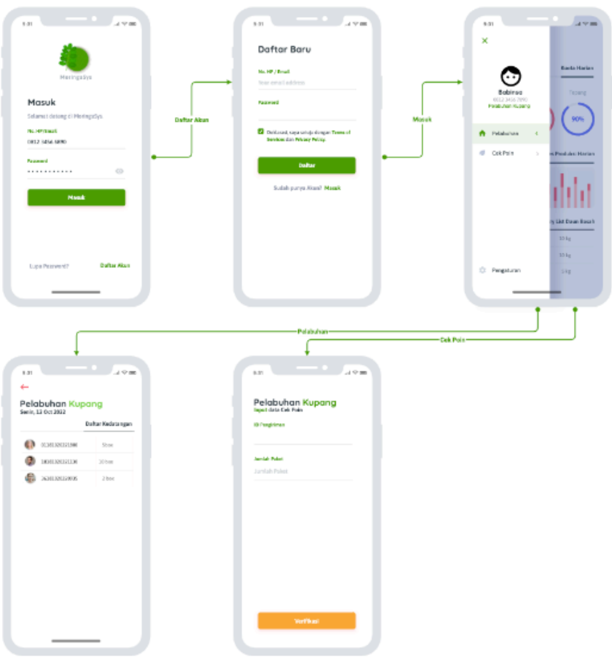

Fig. 7. Mobile Version Example Mockup for MoringaSys App on CV. Xyz using Moqups [8]

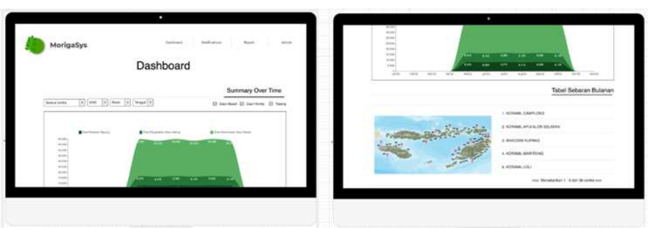

Fig. 8. Desktop Version Example Mockup for MoringaSys Application for Monitoring on CV. Xyz using Moqups [8]

IV. Conclusion

Moringa plants, which are one of the leading commodities of NTT province, are still being pursued to be able to contribute to the economic growth of NTT province. The market for moringa-based products is still very wide open both in national and international markets. Hence, this must be supported by the ability to be able to provide a stable supply. In addition, in order to be able to contribute more to regional economic growth, it is necessary to have the ability to innovate that is able to create a variety of moringa-based products. But all of that of course requires considerable effort to achieve. In addition, there needs to be a lot of development of basic community capabilities both in terms of management technology and in terms of operational management.

With the study of supply chain maps from CV. Xyz, which is one of the pioneers of the moringa business and also one of the largest in NTT, is expected to help improve performance and can support the achievement of the dream to make moringa a commodity that is able to support high regional economic growth.

In terms of raw material management, which has been using a manual recording system, this often creates differences in information between actors. Some information from the center, such as the date of processing and flour weight is sometimes not recorded accurately which ultimately causes difficulties from CV. Xyz in handling its products.

In terms of monitoring the flow of material from the collector / plasma to the center until finally arriving at CV. Xyz, there are several crucial problems which include: Recording the number and date of wet leaves, dry leaves and flour produced per day which is still done manually using books; There is no logging for shipping information which makes the shipment process difficult to track; There is no integrated information about the number and date which is important information in the production process in CV. Xyz, As well as the number and location of many centers and scattered in various places in the NTT islands.

Therefore, the need to be able to digitize several processes that occur in the Moringa leaf supply chain process is very important to be done immediately. Problems that arise in the recording process that have been successfully identified can be solved by building a system that helps the recording process from each center to CV. Xyz. Although potentially revolutionary, this digitization design presents challenges, especially in terms of data security and user adaptation, which he hopes to do as a focus for further study in the future. However, this design is expected to be a strong foundation for Moringa raw material supply management innovations in the future that can also be adopted by other supply chain systems in other regions in Indonesia.

Acknowledgment

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Development of Automatic Transfer Switch on Photovoltaic System 5.2kWp Grid-Connected Rooftop

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***Abstract*—The goal of this study is to create an Automatic Transfer Switch (ATS) for a 5.2kWp Grid-Connected Rooftop Photovoltaic system. The developed ATS may alternate between automatic and manual load delivery modes. This ATS also incorporates a Smart Home feature, which improves the efficiency and comfort of electricity use. Magnetic contactors, 4 channel relays, 8 channel relays, MK2p relays, ESP 32, mini circuit breakers (MCB), timer delay relays (TDR), and DHT 11 sensors were employed in this study. The findings of this study show that the Smart Control and Smart Home algorithms that were developed may operate in accordance with the simulations that were performed. Furthermore, the average voltage difference between Solar Home System (SHS) and State Electrical Company (SEC) power supplies is only around 0.16 Volts, and the average latency in switching from SHS to SEC in automatic mode is about 2695 ms. Furthermore, evaluating the Smart Home system by activating and deactivating the load on the Thinger.io platform yielded an average delay of 882 ms and an average internet speed of roughly 9.02 Mbps. This study's conclusions have a substantial impact on enhancing energy efficiency, particularly in optimising energy use from renewable energy sources like SHS. Furthermore, Smart Home integration enables customers to manage and monitor their electricity consumption more efficiently, boosting comfort and efficiency in everyday electricity use.**

Keywords—Automatic Transfer Switch (ATS), Photovoltaic System, Smart Control Algorithm, Smart Home Integration, Energy Efficiency

I. INTRODUCTION

Energy sustainability and environmental preservation are becoming increasingly important in the current day [1], and renewable energy has emerged as the primary solution to this dilemma [2]. Solar energy [3], which may be transformed into electricity via a photovoltaic system (PV) [4], is one type of renewable energy that is growing in popularity [5]. PV has emerged as a viable ecologically acceptable method for fulfilling the energy needs of households and businesses [6]. However, solar energy implementation is not always straightforward, and the transition between PV energy sources and the traditional power grid known as the State power Company (SEC) presents a number of issues [7]. The efficient regulation of power flow between the 5.2kWp PV system and the main power grid on the roof of the building connected to it was a key concern. An imbalance between PV energy supply and electrical power requirements in homes or businesses can limit renewable energy efficiency and force over-reliance on traditional energy sources. As a result, the importance of this research increases, as it attempts to address the obstacles of power switching in PV systems through the development of intelligent Automatic Transfer Switches (ATS).

Previous research examined many aspects of photovoltaic (PV) and Automatic Transfer Switch (ATS) system development in grid-connected systems. [8] investigated the use of ATS in similar PV systems with an emphasis on power flow efficiency and load management. According to the research, using ATS can optimise power transfer between PV energy sources and the grid network, reducing reliance on nonrenewable energy by 20%. [9], on the other hand, focused on Smart Home integration possibilities in PV systems. According to the findings of this study, Smart Home can boost the efficiency of customers' electricity consumption by 15% while also providing greater convenience in controlling the system. While previous studies provide useful insight into the usage of ATS and Smart Homes in a PV environment, they do not cover PV systems with capacities as large as 5.2kWp, which is the case in our study. As a result, the purpose of this project is to address a research gap by creating an ATS on a 5.2kWp PV system and combining it with Smart Home features to assess its influence on energy efficiency and user comfort in a bigger scenario. Thus, this research expands previous understanding and presents a deeper contribution to the sustainable and smart use of PV technology. This research aims to develop an ATS that can optimize the power flow between a 5.2kWp PV system and the SEC network in an efficient way. This ATS is also equipped with a Smart Home feature which allows users to manage and monitor their electricity consumption more efficiently, increasing comfort and efficient use of electricity in everyday life. With a deep understanding of the background and urgency of this research, it is hoped that the solutions offered by the development of this ATS can make a positive contribution in increasing energy efficiency and supporting the wider application of environmentally friendly solar energy technology. As a result, our study adds to past knowledge and makes a more substantial contribution to the sustainable and intelligent use of PV technology.

The goal of this study is to create an ATS that can efficiently optimise the power flow between a 5.2kWp PV system and the SEC network. This ATS also includes a Smart Home feature, which lets customers to better manage and monitor their electricity consumption, boosting comfort and efficiency in everyday living [10]. With a thorough knowledge of the context and importance of this research, it is envisaged that the answers supplied by the development of this ATS would contribute to increased energy efficiency and the wider deployment of ecologically friendly solar energy technology. This discovery may also have an impact on lowering our reliance on nonrenewable energy sources and ensuring the long-term sustainability of our environment.

II. METHODS

The ATS's design is dependent on the unique requirements of the SHS system under consideration. In accordance with the design criteria, we carefully chose components for implementation, including magnetic contactors, relays, micro circuit breakers (MCB), temporal delay relays (TDR), and DHT 11 sensors. Following that, the assembly of the ATS prototype began in accordance with specified design criteria. To ensure compliance with these criteria, the components were carefully integrated and electrically coupled. Following the completion of the assembly, a complete battery of tests was carried out to ensure the appropriate operation of the ATS prototype.

After that, the ATS system was installed and rigorously tested on the Photovoltaic System 5.2kWp Grid-Connected Rooftop. This included assessing the principal power sources, which included solar panels and, if available, the State Electricity Company (SEC), as well as analysing the functioning of the Smart Control Mode in both manual and automatic modes. The system testing results were meticulously analysed, with a special emphasis on voltage quality, resource switching, and response time. The analytical methods were carried out in accordance with the protocols outlined in Figure 1, which depicts the research processes.

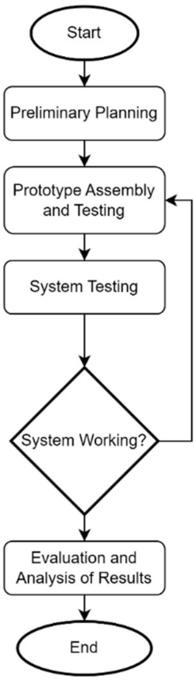

Fig. 1. Flowchart research

We made essential changes to the ATS prototype based on the assessment results, with the goal of ensuring its smooth and dependable operation. The Smart Home control, which monitors and regulates room temperature and humidity using the DHT 11 sensor, was another feature we included in the ATS. Following the refinement phase, the improved ATS system was installed in the Photovoltaic System 5.2kWp Grid-Connected Rooftop. On-site field testing were undertaken to validate the system's performance in real-world circumstances [11]. The data collected from these field testing was thoroughly analysed to validate that the ATS system met the specified parameters. Our investigations were meticulously documented. This research methodology was meticulously designed with the goal of producing an ATS system distinguished by efficiency [12], dependability [13], and the potential to promote the use of renewable energy [14], particularly in residential applications incorporating a Photovoltaic System 5.2kWp Grid-Connected Rooftop.

A. *System Planning*

The suggested system intends to create an Automatic Transfer Switch (ATS) for the 5.2kWp Grid-Connected Rooftop Photovoltaic System. This ATS has an automated mode for continuous power delivery as well as a manual mode for troubleshooting. This system also includes manual load supply control using the Thinger io platform, with the ESP 32 used to relay user input data. The Thinger io platform [15], often known as Smart Home, allows users to control the electrical supply and manage various home loads. The schematic depiction below depicts the block diagram for constructing this ATS system, which has been adapted to fulfil the Smart Home needs within the Solar Home System, as shown in Figure 2:

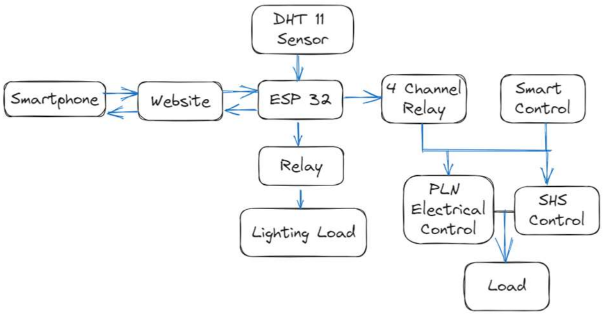

Fig. 2. Block diagram of the system

This diagram depicts the flow of power and communication among various system units. The DHT 11 Sensor is in charge of monitoring temperature and humidity, while the smartphone/website interface allows for user management and monitoring. The ESP 32 acts as an intermediate between the user interface and the 4 Channel Relay & Smart Control, which manages power distribution to various loads, including the Lighting Load. The PLN Electrical Control - SHS Control, a critical component, manages power transfer between the PLN and the SHS system, allowing for automatic switching during PLN outages or disturbances. This complete system is an essential component of the ATS development strategy for the SHS system, which includes a Photovoltaic System 5.2kWp Grid-Connected Rooftop capacity, guaranteeing a dependable and efficient flow of electricity between PLN resources and solar power.

B. Method for Installing the Smart Control Panel

The installation of the Smart Control panel is critical to the proper execution of this advanced technology. As shown in Figure 3, the Smart Control panel is strategically placed to act as a vital junction between the power supply emanating from the Solar Power Plant (PLTS) and the power supplied from the SEC energy network. This panel functions as the primary control hub, integrating these two independent power sources before efficiently distributing electricity to the various loads that rely on it. To ensure the Smart Control system's flawless and effective operation [16], the installation process must be carried out with precise accuracy [17]. A correctly fitted Smart Control panel enables accurate regulation of power distribution to varied loads, allowing both automatic and manual modes as needed. This versatility allows for the most efficient use of power from both PLTS and the SEC network, improving overall energy efficiency and increasing the availability of electrical power for residential loads [18]. As a result, the Smart Control panel installation emerges as a critical milestone in assuring the successful deployment of this new system, where streamlined power distribution and resource allocation are fundamental concepts in attaining sustainable and resilient energy management.

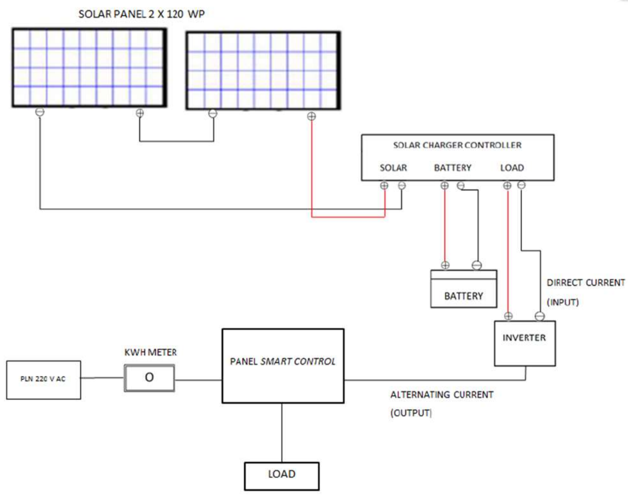

Fig. 3. Smart Control panel installation diagram

The Solar Charge Controller, which in this case uses a DC (Direct Current) technology, will regulate two sources in the solar power generation system, as illustrated in figure 4 below.

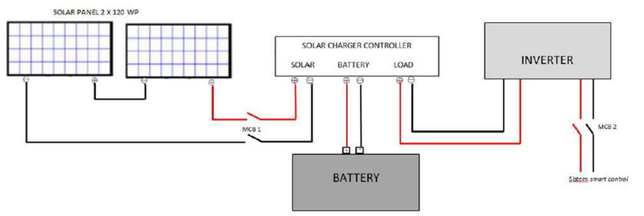

Fig. 4. Control circuit in DC system

The Solar Charge Controller regulates the link between charging and supply from the battery to the solar panel, ensuring that no errors occur either charging from the solar panel to the battery or directly supplying from the solar panel to the load. The Smart Control system series is comprised of automatic switches, specifically relays and magnetic contactors.

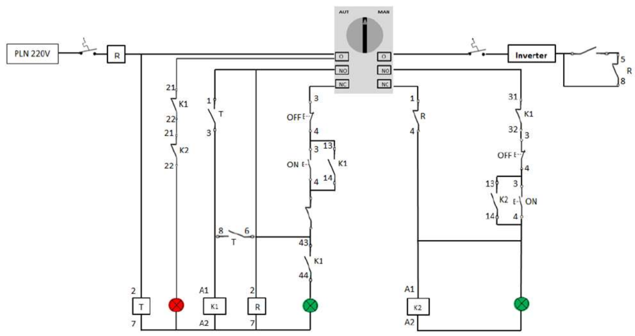

Fig. 5. Control circuit in AC system

Figure 5 displays the working system of the developed circuit. This circuit uses an interlock circuit mechanism to ensure that when one power source is switched on, the other cannot be turned on. When in automated mode, the directly linked power source is SEC, and if the SEC electricity source fails or has issues, the electricity source will automatically switch to PLTS. When the SEC power source is stable, the power source will automatically switch back to SEC after a time delay set on the timer. This circuit also includes a four-channel relay installed at the power source's output, which will subsequently be connected to the Thinger io platform and controlled via the Thinger io platform.

III. Research Result

A. System Design Result

A front-view prototype of the Load Supply Smart Control System panel box is shown in Figure 6 (a). This panel's front features three LCD screens that act as monitors for power output from various sources, including SEC, Solar Home System (SHS) Resources, output from solar panels, and batteries. This panel also has a selector switch for selecting the load's power supply mode. Aside from that, three indicator pilot lamps are used as signals, with the green light indicating the active power supply from SEC, the second green light indicating the active power supply from SHS, and the red light indicating that the system is completely turned off.

Fig. 6. (a) Smart Control Box Panel External View, (b) Inside View of Smart Control Box Panel

Figure 6 (b) displays an inside view of the box panel that has been constructed in such a way that it can function properly.

B. Loads testing of the Smart Home System on the Thinger.io Platform

In this test, a Smart Home system was used to determine the latency when executing a load over the Thinger io platform.

Table 1. Use of Relays for Smart home and Smart Control

Relay	Use
Relay 1	Porch Lights
Relay 2	Living Room Lamp
Relay 3	Room Light 1
Relay 4	Room 2 lights
Relay 5	Kitchen Lights
Relay 6	Electric socket
Relay 11	PLN Electricity Safety
Relay 12	SHS Security

Table 1 shows the use of relays, where each relay has been connected to a load and power source so that it can be controlled via the Thinger io platform.

Table 2. Smart home test results using the Thinger io platform

Testing	**Relay**	**Use**	**Initial Conditions**	**Final Conditions**	**Delay (ms)**	**Internet Speed (ms)**
1	Relay 1	Porch lights	OFF	ON	820	27,3
	Relay 2	Central Room Lamp	OFF	ON	830	
	Relay 3	Room lamp	OFF	ON	850	
	Relay 4	Room 2 lights	OFF	ON	860	
	Relay 5	Kitchen lights	OFF	ON	700	
	Relay 6	Electric socket	OFF	ON	850	
2	Relay 1	Porch lights	OFF	ON	820	18,5
	Relay 2	Central Room Lamp	OFF	ON	830	
	Relay 3	Room lamp	OFF	ON	850	
	Relay 4	Room 2 lights	OFF	ON	860	
	Relay 5	Kitchen lights	OFF	ON	700	
	Relay 6	Electric socket	OFF	ON	810	
3	Relay 1	Porch lights	OFF	ON	1110	3
	Relay 2	Central Room Lamp	OFF	ON	1050	
	Relay 3	Room lamp	OFF	ON	850	
	Relay 4	Room 2 lights	OFF	ON	1300	
	Relay 5	Kitchen lights	OFF	ON	780	
	Relay 6	Electric socket	OFF	ON	910	
4	Relay 1	Porch lights	OFF	ON	690	5,55
	Relay 2	Central Room Lamp	OFF	ON	1450	
	Relay 3	Room lamp	OFF	ON	1060	

	Relay 4	Room 2 lights	OFF	ON	780	
	Relay 5	Kitchen lights	OFF	ON	660	
	Relay 6	Electric socket	OFF	ON	880	
5	Relay 1	Porch lights	OFF	ON	1160	4,31
	Relay 2	Central Room Lamp	OFF	ON	1180	
	Relay 3	Room lamp	OFF	ON	620	
	Relay 4	Room 2 lights	OFF	ON	700	
	Relay 5	Kitchen lights	OFF	ON	620	
	Relay 6	Electric socket	OFF	ON	890	
Average					882	9,02

Testing was carried out in this study by deactivating and activating the electrical load coupled with the 8 Channel relay. The results of testing the Smart home system by activating and disabling the load on the Thinger io platform are shown in Table 2. The findings showed an average delay of 882 milliseconds and an average internet speed of 9.02 Mbps.

C. *Testing the Smart Control System in Automated Mode*

The test is carried out automatically by activating the MCB from the SEC and PLTS. When testing the transfer from SEC to PLTS, the SEC's MCB will be depressed [19], cutting off the SEC's power supply [20]. When testing PLTS to SEC, the MCB from SEC will be reset [21].

Table 3. Automativ Mode Smart Control System Test Results

No	Condition Testing 1	Delay Connected to load (ms)	Condition Testing 2	Delay Connected to load (ms)
1	SEC-SHS	2420	SHS-SEC	2050
2	SEC-SHS	2250	SHS-SEC	3150
3	SEC-SHS	1750	SHS-SEC	3000
4	SEC-SHS	1750	SHS-SEC	3150
5	SEC-SHS	630	SHS-SEC	3100
6	SEC-SHS	2450	SHS-SEC	2620
7	SEC-SHS	2550	SHS-SEC	2280
8	SEC-SHS	1430	SHS-SEC	3120
9	SEC-SHS	1800	SHS-SEC	2230
10	SEC-SHS	1320	SHS-SEC	2245
Average		1835	Average	2695

Table 3 displays the results of ten tests, with an average delay of 1835 ms on the transfer of the electricity source from SEC to SHS caused by starting the inverter to supply electricity [22], and an average delay of 2695 ms on the transfer of SHS to SEC caused by the settings. A graph of delay versus number of tests is shown in Figure 4.9. Figure 7 shows that the delay with the highest value in the SEC-SHS graph is in the 7th trial with a value of 2550ms, whereas the delay with the highest value in the SHS-SEC graph is in the 2nd experiment with a value of 3150ms.

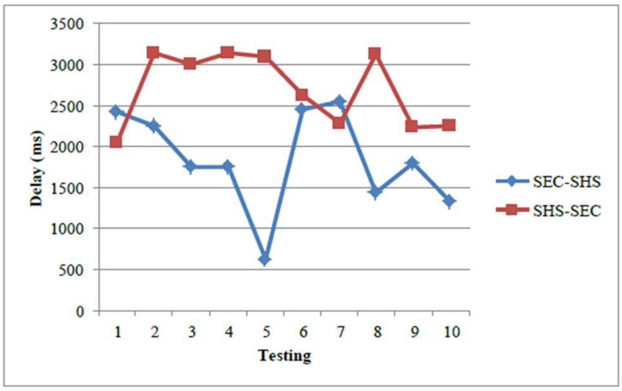

Fig. 7. Delay graph for automatic mode smart control system testing

D. *Testing the Smart Control System in Manual Mode*

Manual testing on the Smart Control system was undertaken in this study, and the following data was obtained:

Table 4. Manual Mode Smart Control System Test Results

No	Supply Electricity To Selected Load	LED		Push Button		Load Conditions
		Red	Green	PLTS	SEC	
1	PLTS	-	√	ON	OFF	Operate
2	SEC	-	√	OFF	ON	Operate
3	O	-	-	OFF	OFF	Not Operating

Table 4 explains the Smart Control test results; the load supply operates as designed; the table shows that when the SEC is turned on, the load condition is operational, and similarly, when the PLTS is turned on, the load condition can still operate, because the interlock circuit system has been implemented [23], so that when one of the power sources is turned on, other power sources cannot be turned on. There are three rows of data in this table that describe varied operational situations. When the PLTS (Solar Power Plant) is turned on and there is no mention of the SEC (Reserve Energy Source), the load operates in ON and OFF modes. This demonstrates that PLTS can provide adequate power to selected loads under operational conditions.

When the SEC is turned on and the PLTS is turned off, we find that the load also operates with ON and OFF conditions in the second line. This demonstrates that SEC can substitute PLTS in supplying power to chosen loads, which might be critical in emergency situations or when PLTS fails. However, when the SEC and PLTS are switched off in the third line, we observe that the load is not running at all. This signifies that the load cannot work without an external power source. The table findings show that the intelligent control system tested can correctly switch the power supply between PLTS and SEC. The installed interlock system is a critical aspect in guaranteeing that only one power source is active at any given moment, avoiding conflicts or equipment damage, and assuring the successful continuity of operational loads. This is a nice approach for optimising energy use while maintaining power supply.

E. Circuit Voltage Testing

The incoming and outgoing voltages in the circuit are monitored in this test to determine if there are any losses in the circuit or the components. This test is carried out using a multimeter.

Table 5. Testing The Incoming and Ooutgoing Voltage of the Electricity Source at tge SEC Power Source

No	Voltage Source	Vin	Vout	Difference
1	SEC	224	223.5	0.4
2	SEC	225.4	225.2	0.2
3	SEC	229.7	228.9	0.8
4	SEC	228.1	227.7	0.4
5	SEC	228.4	228	0.4

Samples were collected five times from each power source in this test. The results are shown in Tables 3 and 4, with negligible differences between the incoming and outgoing voltages within the circuit supplying the load. These findings confirm that the intended device functions properly and meets component and load criteria. Tables 5 and 6 show the results of voltage measurements from two different power sources, SEC (Reserve Energy Source) and SHS (Solar Energy Source). This measuring procedure was done five times for each source to guarantee the uniformity and stability of the results. The range between input voltage (Vin) and output voltage (Vout) is extremely tiny, ranging from 0.2 to 0.8 volts, according to Table 3, which shows data at SEC. These results demonstrate the SEC's capacity to maintain a remarkably constant voltage level during load supply, highlighting the device's quality and reliability.

Table 6. Testing The Incoming and Ooutgoing Voltage of the Electricity Source at tge SEC Power Source

No	Voltage Source	Vin	Vout	Difference
1	SHS	221.1	221.1	0
2	SHS	223	222.8	0.2
3	SHS	222	221.5	0.5
4	SHS	221.1	222	0,1
5	SHS	221	221	0

Table 6, on the other hand, details measurements on SHS, a solar-powered resource. The difference between Vin and Vout in this case is modest, ranging from 0.2 to 0.5 volts. This demonstrates SHS's capacity to maintain a constant voltage level while powering the load. Despite the inherent fluctuation of solar energy, the constant measurements demonstrate a high level of efficiency in turning solar energy into stable electrical power. The repeat of sampling from each source improves the representativeness of the results. Finally, these data confirm that the planned device functions properly and adheres to stated component and load standards. The voltage stability found in these tests emphasises the quality and reliability of such devices, which are critical in preserving the uninterrupted operation of systems that rely on a consistent power supply.

IV. CONCLUSION

According to the findings of this inquiry, the creation of the Automatic Transfer Switch (ATS) for the Photovoltaic System 5.2kWp Grid-Connected Rooftop Solar Home System (SHS) was a resounding success. In accordance with the designed algorithm, the Smart Control system effectively provides power to the load in both automated and manual modes. The results of the tests confirm to the remarkable performance of the proposed Smart Control and Smart Home algorithms, as proved by simulation and hardware testing. During the automatic mode testing, a minor voltage discrepancy of 0.16 Volts was found in the SHS power source, which was accompanied by an average transfer latency of approximately 2695 ms from the SHS Power Supply to the SEC. The ATS system's smooth integration of magnetic contactors, 4-channel relays, 8-channel relays, MK2p relays, mini circuit breakers (MCB), and timer delay relays (TDR) has given users with a convenient and efficient means of regulating energy supply. This study has important implications for the development of renewable energy. The use of electricity resources from both SEC and SHS can be adjusted to meet individual requirements with the adoption of an effective ATS system, resulting in significant energy conservation and lower power prices. Furthermore, this system contributes significantly to the growth of smart homes by improving household comfort and energy efficiency. In the broader context of renewable energy, this study contributes to the development of more advanced and efficient ATS technology, which has the potential to be applied across varied SHS systems. As a result, the research has a positive impact by encouraging the use of renewable energy and the advancement of smart home technologies in the coming period.

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A GAN-BERT Model For Semi Supervised Classification : Quality Attributes Prediction in Software Requirements Text

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***Abstract*—The field of automatic detection of quality attributes from software requirements text stands as one of the most pioneering realms within software requirements research. Such automatic quality attributes aim to aid stakeholders in establishing the system architecture and preemptively circumventing faults. A considerable number of classifier models have been put forward, many of which show encouraging results. However, our analysis has identified substantial gaps in these studies, including: a) a limited dataset volume, b) the absence of an evaluation study for cross-domain test sets, c) the problem of real-time prediction scenarios where a vast amount of unlabeled data floods the system each second, and d) a dearth of comparative studies scrutinizing diverse software requirements datasets and multiple machine learning models, with particular emphasis on in-domain and cross-domain testing. Hence, there is a pressing need to construct an alternative framework to enhance classifier performance under such conditions. Our research is primarily centered on developing a semi-supervised methodology that hinges on GAN-BERT, introducing two datasets for the requirements engineering community, and delivering comparative studies that consider a variety of classifiers and two labeling paradigms: binary and multi. Remarkably, even with fewer data in a multi-classification scenario, our model outperforms other classifiers when assessing data from both identical and different domains.**

***Index Terms*—Semi Supervised, GAN, BERT, Software Requirements, Quality Attributes**

I. Introduction

Regarded as a critical phase in the software or product development cycle, Requirements Engineering plays an instrumental role. The fundamental purpose of software requirements lies in providing stakeholders with a comprehensive understanding of their needs and the requisite actions to address these. Further, the quality attributes embedded within software requirements exert a considerable impact on both software design and the overall development process, serving as a guiding compass for the trajectory of the project. [1].

Consider, for example, a statement like "the product must remain operational at all times, providing 24/7 accessibility." This requirement underscores the need for a thorough examination of the system's availability. To accomplish this goal, stakeholders must meticulously scrutinize both technological and operational controls. Understanding the quality attributes inherent in each requirement is a vital step towards ensuring the project's successful outcome. In order to construct architectures that satisfy constraints related to availability, performance, and recovery capabilities, it is incumbent upon system architects to fully grasp these limitations. Similarly, system integrator, tasked with the implementation of large-scale software systems, need a keen awareness of non-functional requirements (NFR). This awareness enables them to situate systems in environments that meet NFRs such as capacity, security, and operational restrictions. In the eyes of customers, the ideal application is one that offers immediate utility, necessitates minimal training, and boasts a user interface designed to minimize errors. Such features are not merely convenient; they are crucial to user engagement and satisfaction [2].

Nonetheless, the process of identifying quality attributes presents a considerable challenge due to its time-consuming nature. This is largely because it necessitates a mutual agreement between customers and requirements engineers on the system's expected performance. Furthermore, manual labeling or classification of each requirement to determine its appropriate category constitutes an arduous task. It calls for the specialized expertise of professionals from various sectors, thereby escalating the associated costs significantly. Such a process, while necessary, underscores the complexity and resource-intensive nature of implementing effective requirements engineering [3].

Despite these challenges, the advent of Artificial Intelligence (AI) has opened new horizons in numerous fields, including but not limited to customer service, customer support, and software development. In the realm of software development, an array of applications has been designed to assist developers in their coding endeavors. Examples of these tools include automated testing for new features [4], automated database generators [5], automated push and deploys code for continuous integration [6], etc. Aside from that, various research have been conducted to build automated tools to aid developers during the examination of textual software requirements. Approximately 79% of software requirements are stated in plain language, making this method feasible [7].

Traditional approaches and deep learning are the two primary types of research used to construct quality attributes classification models from text. Both approaches provide encouraging results, particularly for deep learning, where the reported F1-score may exceed 90% [8], [9]. However, we discovered significant shortcomings in those studies:

1) Under the conditions of a restricted datasets and a small number of labels, no comparable research can ensure accurate measurement.
2) The majority of related works only use PROMISE dataset [10] and are tested in the same domain. According to our prior research, numerous models that perform well in the same area cannot ensure success in other domains [11].
3) It is difficult to adapt Supervised Learning to the online context, because training must be conducted in real time and the prediction model must be constantly updated. In a realistic application, labeling in real time is difficult to do. Especially when large quantities of data are input every second.
4) Regarding in-domain and cross-domain testing, there is a lack of comparative research comparing distinct software requirements datasets and machine learning models.

In this paper, we implement approach in the form of a semi-supervised model, which employs a custom-tailored GAN-BERT technique. This technique is a fresh perspective in the realm of semi-supervised learning, an expansive branch of machine learning. This approach uniquely combines labeled data, utilized in making predictive decisions, with unlabeled data, employed to decipher the hidden structure within the broader data distribution. The beauty of this method is that it can yield noteworthy results with just a fraction of the labeled data, optimizing resource expenditure and saving precious time.

The data sources we used for this study are diverse, specifically WordPress official documentation sources and also some online open-source project documents. These sources were chosen to encompass a wide range of requirement texts. It's worth noting that the majority of these texts do not adhere to a rigid language pattern or ISO standardization. Instead, they predominantly exhibit an informal, conversational language style.

Each requirement text is meticulously classified as either a Non-Functional Requirement (NFR) or a Functional Requirement (FR). However, five unique types of NFRs - performance, availability, operational, usability, and security - are treated as distinct categories due to their specific attributes and differential impact on the system. The labeled data, which explicitly tags these classifications, will provide the benchmark against which our semi-supervised model's performance is measured.

During the model's training phase, our aim is to generate accurate prediction outcomes. To achieve this, we fuse a modest volume of labeled data, categorized as either FR, NFR, or one of the five unique NFR types, with a substantially larger pool of unlabeled data. Our current understanding indicates that this is a pioneering application of semi-supervised learning to the GAN-BERT technique, particularly in the context of software requirements classification.

1) We offer a detailed analysis of published research on software requirements classification, employing both Machine Learning and Deep Learning approaches. The categories we focus on include the distinction between FR and NFR, as well as the five specific NFR aspects - security, availability, performance, operational, and usability.
2) We introduce a new semi-supervised learning methodology for categorizing FR, NFR, and the five distinct NFR categories, drawing upon our custom-tailored GAN-Bert model.
3) We create two additional datasets using online resources, specifically WordPress official documentation sources and open-source project documents. These datasets, which can supplement existing data for further research, are available upon author request.

This paper is organized into ten sections for clarity and ease of navigation. Section I serve as an introduction, setting the stage for the discussions to follow. Section II outlines the problem formulation, offering a clear understanding of the challenges addressed. Section III elaborates on the research methodology adopted in this study. Section IV presents our results and analysis, showcasing the outcomes of our work. Section V engages in discussion, dissecting the implications of our findings. Section VI identifies potential validity threats, ensuring the integrity of our work. Finally, the last section encapsulates the conclusions derived from this study.

II. CROSS-DOMAIN PROBLEM FORMULATION

Predicting quality attributes from software requirements text is a key task within the realm of machine learning, specifically under text classification. The process begins with a requirement text, symbolized as 'r', sourced from a set 'X' of a document. This set 'X' is a high-dimensional feature space, wherein each dimension corresponds to a unique semantic feature extracted from 'r'. Such semantic features may include term frequency, sentiment, syntax patterns, or part-of-speech tags, all of which are selected for their ability to capture valuable semantic and structural information from the requirements text, making them highly relevant for predicting software quality attributes.

We define a set of quality attributes 'Q' as {q1, q2, ..., qj}, where each 'qj' represents a distinct software quality attribute, such as reliability or maintainability. These attributes are then transformed into one-hot vectors in R^j, where 'qj' maps to 'ej'. This one-hot encoding process presents each attribute as a unique binary pattern within a vector space. For example, in a space with three attributes, each attribute would be represented as a separate dimension in this three-dimensional vector space. This method aids machine learning models by providing a clear differentiation between attributes, enhancing the model's capability to learn these attributes.

Software experts, usually experienced software engineers or analysts, provide the labels, which are the quality attributes. They assign labels based on their knowledge, experience, industry standards, and specific criteria, such as how much a particular requirement text aligns with a certain quality attribute. Our training set 'D' consists of pairs of labeled required text (hr, qi), where 'hr' denotes a specific requirements text, and 'qi' signifies its corresponding quality attribute. This pair (hr, qi) belongs to a product space X × C, with 'C' being the set of all potential quality attributes.

We envision the test set as a dataset 'E', which shares a semantic relationship with 'D'. This relationship is measured using similarity metrics such as cosine similarity. In this context, cosine similarity calculates the cosine of the angle between the high-dimensional vectors representing documents in 'D' and 'E'. This calculation provides a quantitative measure of their semantic correlation. Despite this semantic similarity, the high-dimensional space that encapsulates 'r's semantic feature in 'E' and 'D' might not perfectly align, indicating different feature distributions.

We utilize a classification function 'γ', which maps documents to quality attributes (γ: X $\rightarrow$ C). This function is derived using a specific learning method denoted as 'τ'. In this scenario, τ(D) = γ implies that the learning method 'τ' uses the training set 'D' to create the classification function 'γ', which then produces a predicted label value for a given document.

A significant challenge, the cross-domain problem, occurs when the classification function 'γ', trained on 'E', cannot yield a comparable value to predict 'D'. This issue typically originates from differences in feature distributions between the training and test sets. To counteract this, we inspect and adjust the function 'γ' and the feature space 'X'. This adjustment might involve domain adaptation techniques, where we fine-tune the model's parameters to perform well on a new but related domain, or transfer learning, where knowledge obtained from one problem is applied to a different but related problem. An example would be utilizing a model trained on a similar text classification task and then fine-tuning it to predict software quality attributes specifically.

This work primarily concentrates on examining and resolving the cross-domain problem in predicting software quality attributes from software requirements texts. These predictions serve as a guiding beacon for the software development process. In practical terms, these predicted quality attributes act as benchmarks during the development phase. These benchmarks provide a comparative measure, enabling software developers

The prediction of quality attributes from software requirements text is a text classification problem. In which we are given requirements text $r \in X$ of a document, where X is a high-dimensional space corresponding to a semantic feature of r; and a fixed set of quality attributes can be defined as $Q = \{q_1, q_2, ..., q_j\}$ where q_j can be encoded as one-hot encoding form, in $\mathbb{R}^j$, $q_j \rightarrow e_j$. The labels that are determined by software experts are the quality attributes. Then, a *training set* D containing labeled required text $\langle r, q \rangle$ is provided, where $\langle r, q \rangle \in X \times C$, we can think the test set as a dataset E with the semantic relation $D \approx E$ in human cognitive terms. As a result, $E \in r$ and $D \in r$ share a domain context. However, the high dimensional space that represents the semantic feature of r in E and D may not have any similarities.

A classifier or classification function γ that maps documents to quality attributes $\gamma : X \rightarrow C$ will be used with a specific learning method. τ denotes the classifier method, and $\tau(D) = \gamma$ is the classification function that return a predicted label value. The learning method τ takes the training set D as input and return the prediction model or learned classification function $\underline{\gamma}$.

The cross-domain problem occurs when the learned classification function $\underline{\gamma}$ from E cannot give a similar value to predict D. In order to solve the problem, the function $\underline{\gamma}$ and X should be investigated and adjusted using some techniques and this work is conducted to explore the problem in terms of quality attributes predictions from software requirements texts.

III. Research Method

A. Overview

In this paper, we provide a sequence explanation for assessing the performance of GAN-BERT and other variations of deep learning. Evaluating and measuring across domains is one of the most focused. There are three processes inside the structure. These processes are explained in Sections 3.2, 3.3, and 3.4 as Requirements Collection, Modeling, and Analysis, respectively.

We cover the technique for selecting dataset, as well as labeling and data preparation, when gathering requirements. In addition, the subsequent step is to create a prediction model based on four dataset, including PROMISE, PROMISE EXP, Wordpress, and Project Document. In the last phase, analyzing, there are three sub-phases: in-domain and cross-domain evaluation, comparison, and summary.

B. Requirements Gathering

The requirements text consists of four dataset, the first of which is the PROMISE repository [10]. It includes twelve kinds of software requirements, including eleven sets of non-functional requirements and one set of functional requirements (NFR and FR). The dataset were generated from the fifteen master's student projects. There are a totals of 625 rows of data, and the validation size in each epoch comprises 20% of the overall datasets.

We employ two assessment scenarios: binary and multi. In the binary-classification, five quality attributes are relabeled as Non-Functional Requirements Label. Consequently, there are only two labels remaining for the training and prediction models. Second, we only apply five labels to our non-functional requirements: security, availability, performance, operational, and usability. The selection of these five labels is based on their prevalence in other dataset and the proportionate distribution of data for each class.

The second piece of data is PROMISE EXP, which is an extension of PROMISE [12], instead of use all quality attributes, we only pick five NFR: security, availability, performance, operational, usability and functionality labels. WordPress and online project documentation are the third and fourth dataset. Both are collected and classified manually from February 20th, 2022 to September 5th, 2022, using internet sources such as blog, search engine, documentation, community forum and change log.

Since it is one of the most popular open source website technologies, Wordpress is selected. In light of this, it may be seen as a representation of website needs as it comprises a wealth of website technological expertise. We personally categorized it as security, availability, performance, operational, and usability. If there are any prerequisites that are not included, we will not conduct the experiment. The collected data include 939 software requirements texts, the majority of which do not adhere to ISO standards.

The final data collection is compiled from 33 online project papers as well as IoT community requirements such as smart home, smart agriculture, smart office, etc. This data collection contains a mixture of unstructured and organized transcription requirements. Similar to others, we solely examine functional and five quality factors when evaluating labels. The gathered data consist of 5292 requirements text. In order to assure the labeling quality, we also invite three annotators who are software engineers who work on IoT, Website Development, and Information system. During a three-hour online conference, the first author, a software analyst, provided a briefing on quality attributes.

The author administered a quiz to ensure that the developers understood the annotation procedure, and then the author and developers conducted a cross-checking procedure to re-annotate the requirements text with six labels. To guarantee the validity of the annotations, the interpreter agreement is determined using Cohen's Kappa, yielding k = 0.85, which indicates a nearly perfect agreement. The following qualitative metrics are related with the different ranges of Cohen's Kappa: $k \leq 0$, no agreement; $0 \leq k \leq 0.20$, mild agreement; $0.21 \leq k \leq 0.40$, reasonable agreement; $0.41 \leq k \leq 0.60$, moderate agreement; $0.61 \leq k \leq 0.80$, significant agreement; and $0.81 \leq k \leq 1$, nearly perfect agreement.

All datasets have the same amount of categories, and this technique will assist us in analyzing cross-domain results; the differences are in terms of quantity and style of natural language. In the [10] and [12] dataset, the natural language pattern gravitates towards the IEEE standard 830-1998, but our gathered data are not just organized since developers express the requirements freely so long as the requirements can be comprehended in informal natural language. This approach will increase the difficulty of each model in order to prevent noise and capture the requirements' original intent.

C. Modeling

We employ three classifiers: LSTM, BERT, and GAN-BERT, and for each classifier we use four training datasets. Therefore, twelve models have been produced. 80% of the training data and 20% of the test data were utilized to construct each model. Then, each model will be applied to a set of cross-domain test data for prediction. For instance, the LSTM model trained on wordpress will be used to predict the wordpress test dataset, which we refer to as in-domain. In addition, the test project document, PROMISE, and PROMISE EXP data will be utilized. Due to the imbalanced number of categories in the test dataset, we only evaluate Macro Average F1-score, accuracy, and recall to ensure a fair comparison.

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive} \tag{5}$$

$$Recall = \frac{True\ Positive}{True\ Positive + False\ Negative} \tag{6}$$

$$F1 = 2 \times \frac{Precision \times Recall}{Precision + Recall} \tag{7}$$

Using this method, the computation is unweighted and all classes are treated equally. The sections 3.3.1, 3.3.2, and 3.3.3 provide specifics regarding our classifiers' architecture.

1) LSTM: We employ Section 3's notations to provide a more detailed explanation of the model utilized in this experiment. As indicated earlier, the LSTM approach (τ) is utilized to obtain the classification function (γ). The text of the requirements (q) is tokenized and preprocessed into a 300-dimensional vector. Using the vector embedding process, we obtain the collection of high-dimensional space X, which represents a collection characteristic of the required text.

Each of these spaces' outputs will then be lowered using the max pooling function before being concatenated into a single tensor. In the final layer, the nonlinear softmax activation function will be used to determine the label, where (q) will be encoded by a one-hot encoder and each label space will include the probability of prediction value between 0 and 1.

2) BERT: BERT is an encoder stack for Transformers that has been trained. In addition to the encoder-decoder structure, the self-attention layers of BERT allow for a stronger emphasis on significant words. Using the Transformers library, we constructed a classifier on top of the BERT model. Two classifiers were developed: binary and multi classification. Using the sklearn toolbox, the data is divided into training sets for each classification model, which account for 80% of the training data, and test sets, which account for 20% of the validation data, we use random state value '42'. The training set is picked at random prior to division. During Fine-Tuning, the classifier is predominantly trained using the BERT model with minimal adjustments. Pytorch "distilbert-uncased" was used in our technique. Before tokenization, the "uncased" method of text input normalization converts words to lowercase. The distilbert-uncased model generates the hidden layer's output tensor size.

After combining the output of BERT into a single vector, it was sent through the Dropout layer, the Average Pooling layer, and two further Dense layers to estimate the probability of each category. Using Adam optimization, the classifier has been trained. Adam optimization is a gradient descent method that has been evaluated at different learning rates. The optimal hyperparameter is "1e-5" for the learning rate. During each training session, the Adam optimizer repeatedly adjusts network weights based on the random state library-generated training set. The loss function used during training is sparse categorical cross entropy. The BERT classifier model was trained with a batch size of 16 across 30 training epochs. We increased the batch size since a small batch size increases the processing time.

3) GAN-BERT: In comparison, we provide the refined performance of the BERT-base model on the supplied training data. BERT-base also served as the foundation for training our approach. GAN-BERT is implemented in PyTorch by extending the BERT implementation. G is designed as an MLP with one hidden layer that is activated by a leaky-relu function.

G inputs consist of N noise vectors with a normal distribution (0, 1). The MLP is applied to the noise vectors, resulting in 768-dimensional vectors that are used in our design as examples. D is also an MLP with one hidden layer activated by a leaky-relu function and a softmax layer for final prediction. After the hidden layer, we used dropout=0.1 for both G and D. To test the performance of each model, we repeated its training using a rising number of annotated data (L), starting with sampling just 0.01% or 1% of the training set. Beginning with a limited number of examples with annotations (about 50-70 occurrences). GAN-BERT is also provided with a collection of UNKNOWN (U) examples U derived from unannotated data for each sample from the training set.

D. Analyzing

The experiment purpose is to investigate the prediction performance on software requirements classification problem using GAN-BERT in cross-domain condition, in which mentioned in the section three. We classify unseen data from different domain dataset, the classification performance is evaluated on multi-classification problem containing five quality attributes including security, performance, usability, availability and operational as target classes and binary-classification (FR vs NFR). The conclusion is gathered by analyzing the weighted average F1-score of model to predict quality attributes in inner and outer domain.

IV. Results and Analysis

This section discusses the classification results achieved for binary and multi classification issues utilizing GAN-BERT, LSTM, and BERT. When a trained model is used to analyze in-domain and cross-domain datasets, the results are presented in tables with macro precision, recall, and F1-score in each column. We present the optimal results of each model with the most effective fine-tuning parameter; we do not provide all results in different fine-tuning parameters because the offered study findings solely address our research objectives, namely comprehending the advantages of GAN-BERT and its influence across domains.

A. Binary Classification

In sections 4.1.1, 4.1.2, 4.1.3, and 4.1.4, the results of binary-classification for the WordPress, PROMISE, PROMISE EXP, and project document datasets are reported, respectively. These subsections are denoted by training datasets belonging to the domain specified in the subsection's heading. In the binary-classification findings, the BERT technique beats others significantly in the WordPress trained domain (in three out of four instances) and the PROMISE domain (beating others in two cases over four as total). In the PROMISE EXP and Project Documents sector, however, both GAN-BERT and BERT provide similarly impressive results.

1) Wordpress Trained Domain: Using the WordPress dataset to construct a classifier model. The proposed models were evaluated using binary-classification. The classification results are shown in Tables 1, 2, and 3 for LSTM, BERT, and GAN-BERT, respectively. By analyzing the macro average F1-score, LSTM and GAN-BERT models surpass others while evaluating the WordPress test set (in-domain) with a score of 0.49, which is more than BERT's 0.48. In contrast, for the cross-domain challenge including three different datasets, GAN-BERT outperforms the competition by an increase of 0.12 to 0.28 F1-score.

2) PROMISE Trained Domain: The PROMISE dataset are used to construct a classifier model. The proposed models were evaluated using binary-classification. The classification results are shown in Tables 4, 5, and 6 for LSTM, BERT, and GAN-BERT, respectively. By monitoring the macro average F1-score, LSTM surpasses BERT and GAN-BERT in assessing the PROMISE test set with a value of 0.48, an increase of between 0.12 and 0.18 in comparison to BERT and BERT.

Even while BERT performs poorly when predicting PROMISE as an in-domain dataset, it demonstrates exceptional performance in two cross-domain datasets: wordpress

TABLE I
LSTM

Testing Domain	Precision	Recall	F1-Score
Wordpress (In-Domain)	0.47	0.50	**0.49**
PROMISE	0.13	0.50	0.20
PROMISE EXP	0.27	0.50	0.35
Project Document	0.20	0.50	0.28

TABLE II
BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress (In-Domain)	0.472	0.5	0.48
PROMISE	0.634	0.634	**0.48**
PROMISE EXP	0.55	0.519	**0.44**
Project Document	0.631	0.575	**0.4**

TABLE III
GAN-BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress (In-Domain)	0.47	0.5	**0.49**
PROMISE	0.54	0.53	0.34
PROMISE EXP	0.27	0.5	0.35
Project Document	0.49	0.50	0.30

and PROMISE EXP, with F1-score of 0.65 and 0.88, respectively, which significantly outperforms other models. GAN-BERT model beats others only when evaluating a project document test set with a 0.50 F1-score value and an increase between 0.03 and 0.04 over other models.

3) PROMISE EXP Trained Domain: The PROMISE EXP dataset are used to construct a classification model. The proposed models were evaluated using binary-classification. The classification results are shown in Tables 7, 8, and 9 for LSTM, BERT, and GAN-BERT, respectively. By monitoring the macro average F1-score, LSTM and GAN-BERT perform better than BERT in assessing the PROMISE test set, with a score of 0.51 compared to BERT's 0.39.

Even while BERT performs poorly when predicting in-domain problems, its performance in two cross-domain datasets, wordpress and project document, is considerably superior to other models, with F1-score of 0.5 and 0.56, respectively. GAN-BERT model surpasses others significantly while evaluating PROMISE EXP test set with an F1-score value of 0.55 and an increase between 0.07 and 0.12 in comparison to other models.

4) Project Document Trained Domain: The Project Document dataset are used to develop a classification model. The proposed models were evaluated using binary-classification. The classification results are shown in Tables 10, 11, and 12 for LSTM, BERT, and GAN-BERT, respectively. By examining the macro average F1-score, LSTM surpasses BERT and GAN-BERT in assessing the PROMISE EXP test set, with 0.44 vs 0.34 and 0.38, respectively.

When categorizing the Project Document test set (in-domain issue), we see that BERT and GAN-BERT perform equally well with an F1-score of 0.77. In cross-domain problems, such as WordPress and PROMISE, both models are superior. In WordPress, BERT surpasses others with an F1-score of 0.77, but GAN-BERT outperforms others with an F1-score of 0.46. Both BERT and GAN-BERT surprisingly outperform LSTM in the WordPress domain, with incremental values between 0.42 and 0.48.

B. Multi Classification

The results of multi-classification for the WordPress, PROMISE, PROMISE EXP, and project document datasets are provided in sections 4.2.1, 4.2.2, 4.2.3, and 4.2.4, respectively. These subsections are designated by training datasets from the domain given in the headline. In the multi-classification results, the GAN-BERT method outperforms the competition greatly in the PROMISE EXP trained domains (in four out of four instances). In three out of four instances, the GAN-BERT technique outperforms competitors, including as the Wordpress, PROMISE and Project Document sectors. Therefore, 13 out of 16 examples (81.25%) are outperformed by GAN-BERT in this instance.

1) Wordpress Trained Domain: Using five quality attributes: usability, security, performance, operational and availability in wordpress dataset, the suggested models were assessed. Tables 13, 14, and 15 provide the classification results for LSTM, BERT, and GAN-BERT, respectively. By examining the macro average F1-Score, GAN-BERT models outperform others when evaluating the WordPress test set (in-domain), PROMISE, and Project Document with scores of 0.30, 0.21, and 0.28, respectively. However, in PROMISE EXP test sets, BERT outperforms others with a difference 0.01 greater than GAN-BERT and 0.14 greater than LSTM.

2) PROMISE Trained Domain: Using five quality attributes: usability, security, performance, operational and availability in PROMISE dataset, the suggested models were

TABLE IV
LSTM

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.51	0.55	0.39
PROMISE (In-Domain)	0.52	0.53	**0.48**
PROMISE EXP	0.55	0.55	0.55
Project Document	0.47	0.47	0.47

TABLE V
BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.977	0.600	**0.65**
PROMISE (In-Domain)	0.561	0.527	0.30
PROMISE EXP	0.886	0.889	**0.88**
Project Document	0.474	0.473	0.46

TABLE VI
GAN-BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.58	0.79	0.58
PROMISE (In-Domain)	0.45	0.47	0.28
PROMISE EXP	0.57	0.55	0.49
Project Document	0.61	0.58	**0.50**

TABLE VII
LSTM

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.49	0.45	0.37
PROMISE	0.53	0.54	**0.51**
PROMISE EXP (In-Domain)	0.43	0.43	0.43
Project Document	0.50	0.51	0.50

TABLE VIII
BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.601	0.582	**0.5**
PROMISE	0.430	0.407	0.39
PROMISE EXP (In-Domain)	0.576	0.537	0.48
Project Document	0.669	0.63	**0.56**

TABLE IX
GAN-BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.47	0.48	0.48
PROMISE	0.59	0.61	**0.51**
PROMISE EXP (In-Domain)	0.55	0.55	**0.55**
Project Document	0.60	0.58	0.51

TABLE X
LSTM

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.45	0.29	0.29
PROMISE	0.46	0.45	0.45
PROMISE EXP	0.45	0.45	**0.44**
Project Document (In-Domain)	0.50	0.50	0.50

TABLE XI
BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.70	0.95	**0.77**
PROMISE	0.37	0.50	0.42
PROMISE EXP	0.60	0.50	0.34
Project Document (In-Domain)	0.77	0.78	**0.77**

TABLE XII
GAN-BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.67	0.94	0.72
PROMISE	0.50	0.50	**0.46**
PROMISE EXP	0.68	0.53	0.38
Project Document (In-Domain)	0.76	0.77	**0.77**

TABLE XIII
LSTM

Testing Domain	Precision	Recall	F1-Score
Wordpress (In-Domain)	0.2	0.2	0.17
PROMISE	0.05	0.2	0.08
PROMISE EXP	0.04	0.19	0.07
Project Document	0.12	0.20	0.15

TABLE XIV
BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress (In-Domain)	0.26	0.27	0.26
PROMISE	0.15	0.28	0.19
PROMISE EXP	0.16	0.34	**0.21**
Project Document	0.24	0.32	0.26

TABLE XV
GAN-BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress (In-Domain)	0.33	0.29	**0.30**
PROMISE	0.21	0.24	**0.21**
PROMISE EXP	0.29	0.25	0.20
Project Document	045	0.49	**0.28**

assessed. Tables 16, 17, and 18 provide the classification results for LSTM, BERT, and GAN-BERT, respectively. By examining the macro average F1-Score, GAN-BERT models outperform others when evaluating the WordPress test set, PROMISE (in-domain), and Project Document with scores of 0.20, 0.96, and 0.36, respectively. However, in PROMISE EXP test sets, BERT outperforms others with a difference 0.02 greater than GAN-BERT and 0.71 greater than LSTM.

3) PROMISE EXP Trained Domain: The proposed models were evaluated using five quality attributes, including usability, security, performance, operational, and availability, from PROMISE EXP dataset. The classification outcomes for LSTM, BERT, and GAN-BERT are presented in Tables 19, 20, and 21, respectively. Examining the macro average F1-score, GAN-BERT models surpass others while analyzing all test sets, including WordPress, PROMISE, PROMISE EXP (in-domain), and Project Document, with corresponding scores of 0.28, 0.92, 0.93, and 0.37. Compared to the LSTM model, all F1-score show considerable improvement. In this scenario, our proposed model provides just a marginal improvement over BERT, with a 0.01 incremental value.

4) Project Document Trained Domain: The proposed models were evaluated using five quality attributes, including usability, security, performance, operational, and availability, from Project Document dataset. The classification outcomes for LSTM, BERT, and GAN-BERT are presented in Tables 22, 23, and 24, respectively. Examining the macro average F1-score, GAN-BERT models surpass others while analyzing cross-domain test sets, including WordPress, PROMISE, PROMISE EXP, with corresponding scores of 0.24, 0.33, 0.29. Compared to the LSTM model, all F1-score show considerable improvement. In this scenario, BERT outperforms our proposed model in Project document test sets (in-domain) with a difference value of 0.07 greater than GAN-BERT.

TABLE XVI
LSTM

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.23	0.28	0.20
PROMISE (In-Domain)	0.36	0.38	0.35
PROMISE EXP	0.21	0.23	0.22
Project Document	0.19	0.33	0.16

TABLE XVII
BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.35	0.20	0.18
PROMISE (In-Domain)	0.97	0.95	0.95
PROMISE EXP	0.93	0.92	**0.93**
Project Document	0.30	0.29	0.30

TABLE XVIII
GAN-BERT

Testing Domain	Precision	Recall	F1-Score
Wordpress	0.21	0.25	**0.20**
PROMISE (In-Domain)	0.97	0.95	**0.96**
PROMISE EXP	0.92	0.90	0.91
Project Document	0.38	0.38	**0.36**

TABLE XIX
LSTM

Methods	Precision	Recall	F1-Score
Wordpress	0.2	0.22	0.17
PROMISE	0.23	0.19	0.18
PROMISE EXP (In-Domain)	0.16	0.19	0.17
Project Document	0.19	0.15	0.16

TABLE XX
BERT

Methods	Precision	Recall	F1-Score
Wordpress	0.13	0.2	0.16
PROMISE	0.91	0.91	0.91
PROMISE EXP (In-Domain)	0.85	0.83	0.81
Project Document	0.38	0.28	0.28

TABLE XXI
GAN-BERT

Methods	Precision	Recall	F1-Score
Wordpress	0.32	0.28	**0.28**
PROMISE	0.92	0.92	**0.92**
PROMISE EXP (In-Domain)	0.93	0.93	**0.93**
Project Document	0.39	0.36	**0.37**

TABLE XXII
LSTM

Methods	Precision	Recall	F1-Score
Wordpress	0.14	0.16	0.15
PROMISE	0.04	0.12	0.05
PROMISE EXP	0.10	0.23	0.12
Project Document (In-Domain)	0.17	0.20	0.18

TABLE XXIII
BERT

Methods	Precision	Recall	F1-Score
Wordpress	0.21	0.23	0.20
PROMISE	0.25	0.43	0.28
PROMISE EXP	0.23	0.33	0.25
Project Document (In-Domain)	0.62	0.37	**0.39**

TABLE XXIV
GAN-BERT

Methods	Precision	Recall	F1-Score
Wordpress	0.41	0.26	**0.24**
PROMISE	0.29	0.43	**0.33**
PROMISE EXP	0.45	0.34	**0.29**
Project Document (In-Domain)	0.43	0.30	0.32

V. DISCUSSIONS

In order to give more clarification on the study outcomes, we provide the answers to the presented research questions (RQ).

RQ1. Are the performance patterns of each model for binary and multi-classification comparable?

LSTM, BERT, and GAN-BERT have the highest value in their respective domains for binary-classification utilizing WordPress dataset; the same is true for multi-classification. Unlike binary-classification utilizing PROMISE dataset, multi-classification does not follow the same trend. In multi-classification, the F1-score of each model's in-domain is greater than its cross-domain score. Due to the similarity of the text patterns between PROMISE dataset and PROMISE EXP dataset, the difference between their F1-score is minimal. In the case of binary-classification, the maximum F1-score is not derived from the in-domain model, but rather from one of the cross-domains. In the case of LSTM and GAN-BERT, which had the greatest F1-score relative to the others, this score was accurately derived from the PROMISE EXP test set assessment findings. This occurs because PROMISE as training dataset and PROMISE EXP as a test set have a similar text pattern. Examining the GAN-BERT model, which yields the top score when evaluating the WordPress test set, is of interest. This implies that the produced phony data is quite comparable to the WordPress domain distribution.

In the instance of the PROMISE EXP domain, an additional singular occurrence occurs. In this instance, the GAN-BERT model, both in binary and multi, performs well for the In-Domain pattern and the cross-domain pattern that is most similar to it. So that the model test conducted with PROMISE and PROMISE EXP yields a higher F1-score than the rest. In the binary-classification scenario, BERT exhibits an anomaly in which the greatest F1-score is in the Project Document cross-domain and the second highest score is in the wordpress cross-domain, with corresponding values of 0.56 and 0.5. Due to these two values, BERT excels in this test section's two cross-domains. This is inversely related to the performance of BERT on multi-classification situations in which both domain values are much lower than PROMISE and PROMISE EXP. In addition, BERT on multi-class yields much superior results than PROMISE EXP in cross-domain PROMISE testing.

In the case of the Project Document domain, both BERT and LSTM produce the highest F1-score in the in-domain, whereas in GAN-BERT, the highest scores in the in-domain are only found in the binary-classification problem. However, in the multi-classification problem, the difference in value increase for PROMISE as the highest score is only 0.01 points. Both BERT and GAN-BERT have a similar trend in the binary-classification where the F1-score in the WordPress cross-domain is greater than in other circumstances. In the multi-classification scenario, the PROMISE test set evaluation yields the greatest cross-domain value, while in the LSTM binary classification case, PROMISE yields the highest cross-domain value, and in the multi-classification case, PROMISE yields the lowest value.

RQ2. How does the F1-score compare in binary-classification against multi-classification, is it more or less?

Comparing tables 1, 2, 3, and 13, 14, and 15, it is evident that binary-classification utilizing a Wordpress-trained domain has a greater value than multi-classification. This is not the apparent, however, in the PROMISE domain as a whole, particularly for the BERT and GAN-BERT models. Only the cross-domain binary-classification values in the Wordpress and Project domains show a significant difference, with this value being greater than the value in the multiple instances. Meanwhile, in the case of the domains PROMISE and PROMISE EXP (which is most comparable to PROMISE), multi-classification results in a large rise. This demonstrates that both BERT and GAN-BERT are adaptable in areas with comparable distribution data. Additionally, the more aggressive the data membership characteristic of a class, the simpler it is for the model to learn. What we find difficult to explain is how the BERT phenomena finds a PROMISE EXP binary-classification whose domain is identical to that of PROMISE (in-domain). In this instance, the produced amount is much more than in-domain, even in WordPress, but it is not as large as PROMISE EXP. In the case of promise domains, multi-classification LSTMs are often less valuable than binary-classification LSTMs.

Similar results are observed in the PROMISE EXP domain, where it is evident that the WordPress and project document scores are lower in the case of multi-classification. However, similar to the PROMISE EXP, there is a significant increase in the F1-score in the case of multi-classification for the PROMISE domain and PROMISE EXP, where the values in GAN-BERT are 0.92 and 0.93 compared to 0.51 and 0.55 in the case of binary-classification. In contrast, the BERT values are 0.81 and 0.91, although the binary-classification values are just 0.39 and 0.48. LSTM has a greater value for binary-classification than for multi-classification in general.

In the project document domain, all multi-classification models have a lower value than the binary-classification. Despite the similarity between this pattern and the WordPress domain, the F1-score obtained in the binary case for in-domain issues utilizing BERT and GAN-BERT is substantially higher than in the other cases, where the F1-score approaches 0.77. This shows that the semantics that may be acquired by the model in the case of binary-classification can be represented more accurately than in the case of multi-classification. In the case of binary-classification, BERT and GAN-BERT are able to capture a more stable data distribution.

RQ3. In this experiment, which model provides the most in-domain testing value?

The highest in-domain scores in the case of binary-classification occur in BERT & GAN-BERT (Project Document), GAN-BERT(PROMISE EXP), LSTM(Wordpress), LSTM(PROMISE) with F1-score levels of 0.77, 0.55, 0.49, 0.48 respectively, whereas in the case of multi-classification occurs in GAN-BERT (PROMISE), GAN-BERT(PROMISE EXP), BERT(Project Document) and GAN-BERT (Wordpress) with F1-Score levels are 0.96, 0.93. 0.39 and 0.30 respectively. Therefore, GAN-BERT has the greatest performance in in-domain testing.

RQ4. Which model provides the most cross-domain testing value for both identical and non-identical cross-domains?

To answer this research question we use the MODEL_NAME(TRAINED DOMAIN — TESTING DOMAIN) notation. The highest cross-domain value in the binary-classification case actually occurs in the non-identical cross-domain case where BERT (Project Document — Wordpress) and GAN-BERT (Project Document — Wordpress) with F1-score are 0.77, 0.72 respectively. And in the case of identical cross-domains BERT (PROMISE — PROMISE EXP) gives a significant value where the value is 0.88 and even this value has a value difference of 0.53 points higher compared to the in-domain value.

Meanwhile, the highest multi-classification result occurs in BERT (PROMISE — PROMISE EXP) with a score of 0.93, followed by GAN-BERT (PROMISE EXP — PROMISE) with a score less than 0.92. However, for cases where the cross-domains are not identical, the highest score is achieved by GAN-BERT (PROMISE EXP — Project Document) with F1-score levels of 0.77, 0.55, 0.49, 0.48 respectively, whereas in the case of multi-classification it occurs in GAN- BERT (PROMISE), GAN-BERT(PROMISE EXP), BERT(Project Document) and GAN-BERT (Wordpress) with F1-Score are 0.96, 0.93. 0.39 and 0.30 respectively.

As a result, we can infer that in the case of binary-classification, the BERT model has superior transfer learning skills compared to other models, but it also has the potential to produce a much greater performance value when evaluated on other cross-domains. This is because the BERT-studied pre-trained domain has a data distribution that is more comparable to the cross-domain test set, which is more similar to the training domain. In contrast, when it comes to multi-classification, GAN-BERT performs better than other models, particularly when the domains are not similar.

RQ5. Exists a classification anomaly? Why did that occur?

In this paper, we define classification anomaly as a situation in which the in-domain value that should be greater than the cross-domain value is instead lower than the cross-domain test value. This is evident in the case of binary-classification: BERT (PROMISE — to other cross domain), LSTM (PROMISE — PROMISE EXP), GAN-BERT (PROMISE — to other cross domain), LSTM (PROMISE EXP — PROMISE & Project Document), BERT (PROMISE EXP — Wordpress & Project Document), LSTM (PROMISE EXP — PROMISE & Project Document) (Project Document — PROMISE). In binary- classification, the most significant anomaly value occurs in BERT (PROMISE — PROMISE EXP) with a value of only 0.3 in the in-domain, whereas the cross-domain value is 0.88 in PROMISE EXP. In multi-classification, the most significant anomaly value occurs in BERT (PROMISE EXP — PROMISE) with a value of 0.91, whereas the in-domain value is only 0.81. Due to the black-box nature of the algorithm, we cannot say much about the cause of this issue. However, this is really a benefit for BERT, since the transfer learning process might appear to be operating quite well.

VI. Threats to validity

Due to the fact that our research is open to several challenges to its validity, we utilize a range of mitigating measures. This section elaborates on the hazards and countermeasures.

Construct Validity: Lack of reporting and evaluation standards in published research projects impedes performance comparison and analysis especially in cross-domain problems as we proposed in the section three. To combat this, we conducted several trials comparing the performance of categories with varying numbers. In addition, we used four performance measures that provide light on the performance of classifiers. To increase the repeatability of research, the seed of all random number generators was adjusted to 42 for all studies. In addition, we partition training and test sets into distinct files to ensure that each model is trained and evaluated using the identical training and test sets. We also only consider to use distilbert-uncased for BERT and GAN-BERT model.

External Validity: The student-created PROMISE and PROMISE EXP projects are not representative of all projects, especially industry efforts. We selected the PROMISE dataset since it is the most often mentioned dataset in the literature, enabling us to compare it to other approaches. Additionally, the PROMISE dataset is labelled by a single author, and thirty out of seven hundred ninety-two needed words were validated by other persons with an inter-rater agreement of 0.50. A grade of 0.71 indicates moderate agreement among raters. Additionally, we employed the Wordpress dataset, and the Project Document dataset to construct other domain. However, despite the fact that, we obtained a nearly perfect agreement on Cohen's kappa (k=0.85), we recommend that researchers recheck our labeling work, as a single software requirements text may contain a number of quality attribute identifications, and the interpretation of each system analyst may vary based on their level of expertise. In this work, we restrict ourselves to a maximum of one phrase per quality characteristic and also does not limit a sentence style, grammar and pattern.

Conclusion Validity: The uneven dataset may have an impact on our results, notably in the NFR subcategories with varying sample sizes. Due to the small size of the dataset, undersampling is not a viable method. By doing several trials with diverse NFR subcategories, the problem of a limited number of samples from a certain subcategory may be alleviated. Additionally, we used stratified 10-fold cross-validation, which maintains the same number of samples for each category throughout each cycle.

VII. Conclusion

Based on our observation, each predicted model is highly dependent on the text semantic dataset between training and testing. Furthermore, the experiment demonstrates that the prediction model cannot provide precise classification decision areas for unanticipated variations, such as disparate domains. On the basis of our findings, semi supervised GAN-BERT can improve the performance compared to others although has limited number of trained dataset and unlabeled trained inputs. In addition, we also found that our proposed model has potential to provide more accurate result when evaluation cross-domain test set with a highly not identical domain compared to others.

We recommend three issues of awareness to other researchers in related fields. First, adding more dataset may facilitate the development of a practical software model, however, the collecting and augmenting work itself should consider a domain carefully, secondly, collecting a broader domain may improve performance, as the number of unique tokens and semantics may capture more robust text features than when relying on a single dataset, and, lastly, we believe that the existing evaluation measurement of this field is still a long way to go into practical technology since a highly cross-domain software requirements text that should be handled by quality attributes prediction model and the unpredictable test data that always appear in practical use. In this paper, we only propose two additional datasets and using GAN-BERT as semi-supervised learning, in our perspective is still infant.

We will investigate the combination of several praprocessing method and GAN-BERT performance in online learning behavior in future studies. An innovative praprocessing approach could solve the prediction problem with limited dataset and software domain in training data by adopting specific rules and weight optimization for semantic embedding. Also, in order to support more reliable real-time prediction systems, online learning should be considered in order to manage massive text datasets with unanticipated cross-domains and natural language styles.

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Analysis of Hybrid Power Generation (PV & WTG) at Base Transceiver Stations (BTS) in Saobi

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Abstract—The solution to global warming effects lies in reducing the use of fossil fuel energy and transitioning to alternative (renewable energy) sources. The provision of electricity for Base Transceiver Station (BTS) operations, sourced from environmentally friendly green energy solutions such as Solar Power Generation (PLTS), Wind Power Generation (SKEA), and Hybrid Power Generation (integration of PLTS with SKEA), can replace conventional fossil fuel-based electricity.In this paper, solar panels supply 72.8% or 122.122 kWh of the total BTS power consumption of 167.75 kWh/day, with 78 panels, while wind turbines supply 27.2% or 43 kWh/day, consisting of 4 wind turbine units x 565 Wp x 19 hours = 42,940 Wh/day. This also leads to a reduction in CO2 emissions, with a coefficient of 0.719 kg/kWh x 152.5 = 120.612 kg/day.

Keywords—Renewable Energy ,Solar Cells, Wind Turbine, BTS.

1. INTRODUCTION

Indonesia has many islands, including the Saobi Islands with coordinates 6°59'22"S 115°27'3"E which ranges as far as 30 nautical mills or as far as 48,340 meters with the Sumenep Regency government center, and as far as 60 sea mills or 111,120 meters with the East Java Province government center. The distance limited by the sea has an impact on the difficulty of obtaining PT. PLN in the archipelago, this encourages several providers to develop the use of alternative energy for Base Transceiver Stations (BTS) in addition to conventional energy, namely diesel power plants (generators). The use of generators requires high costs, sometimes constrained by fuel delivery, in the rainy season, and causes global warming which results in greenhouse gas effects [1]. This has received serious attention by the government and the private sector to synergize to find solutions, such as efficient use of electrical energy, the use of renewable energy (Renewable energy) around which is environmentally friendly (green energy) for the supply of electrical energy sources [2]. According to the results of the JICA survey, the largest potential for renewable energy in Indonesia is hydropower, which is 76.4 GW, biomass/biogas is 49.8 GW, and geothermal is 29 GW. Although solar energy is very abundant, which is around 4.8 kWh / m2 / day, but the efficiency of solar cell technology still ranges from 6-16%. For wind power potential in Indonesia ranges from 3-6 m / sec. This value is still below the average wind required by turbines to produce electricity optimally which is 12 m / s [3].

The paper explains the Analysis of a Hybrid Power Plant consisting of solar panels (PV) and wind turbine Generator (WTG) that can be used to supply electrical power (electricpower supply station) at BTS (Base Transceiver Station) based on the potential of environmentally friendly renewable energy at the Saobi island location with a solar radiation intensity of 5.23 kWh / m2 / day and an average wind speed of 1 year reaching 4.48 m / second. The goal is to combine the advantages of each plant while covering the weaknesses of each plant for certain conditions and achieve optimum supply reliability, so that the overall system can operate more economically and efficiently [4].

2. RENEWABLE ENERGI POTENTIAL

Saobi Islands with coordinates 6°59'22"S 115°27'3"E, has the potential for renewable energy, sea breeze speed, abundant solar heat. The average sea breeze speed in the Saobi islands per year is at an altitude of 20 meters.

TABLE I. TYPE STYLES CLEARNESS INDEX & DAILY RADIATION EVERY MONTH

Month	Clearness Index	Daily Radiation (kWh/m^2/day)	Average Wind Speed (m/s)
Jan	0.397	4.220	4.310
Feb	0.435	4.670	4.360
Mar	0.503	5.290	3.170
Apr	0.529	5.210	3.320
May	0.574	5.200	4.770
Jun	0.590	5.090	5.550
Jul	0.622	5.490	6.340
Aug	0.650	6.190	6.250
Sep	0.644	6.590	5.080
Oct	0.565	5.990	3.820
Nov	0.454	4.810	3.310
Dec	0.382	4.030	3.420

From 2010 to 2014 it reached 4.50 m/s, making it suitable for small-scale turbines up to 10 kW. The intensity of solar radiation reaches 5.23 kWh / m2 / day per day, especially in the dry season around April-October each year, the total heat of optimal sunlight in 1 day shines for 4.5 hours based on data from the National Renewable Energy Laboratory (NREL), can be considered in table 1.

2.1 HOMER Software

HOMER *(Hybrid Optimization Model for Energy Renewables)* is a simulation model software that simulates a viable system for all possible combinations of equipment considered to be considered. Homer works based on 3 things, namely simulation, optimization, and sensitivity analysis. These three things work in a row and have their respective functions, so that optimal results are obtained [5].

3. BTS System Capacity

The power requirements for BTS (Base Transceiver Station) operations vary widely depending on the type and function of the BTS. Typically, it ranges from 1 to 7 kW. Table 2.2 shows the typical power consumption of BTS.

TABLE II. BTS POWER CONSUMPTION

BTS Type	Power Consumption (Watt)
GSM Base station 2/2/2	70 – 2000
GSM Base station 4/4/4	800 – 2000
UMTS Node B Macro/Fiber 2/2/2	820 – 1100
Macro/Fiber - 4/4/4	1200 – 1800

Telecommunication operators aim to minimize TCO (Total Cost of Ownership), which consists of operational costs (OPEX) and capital costs (CAPEX). One of the significant operational costs is electricity consumption [6]. A BTS requires continuous electrical power of approximately 3000 watts. The air conditioning (AC) system requires 900 watts of electrical power to maintain a room temperature of 18-22°C. Below is the load data for one of the BTS units over a 24-hour period. [7].

TABLE III. BTS Daily Load Data

No	Hours	Load (kW)	Energy/hr (kWh)
1	00:00 - 01:00	4	4
2	01:00 - 02:00	4.5	4.5
3	02:00 - 03:00	4	4
4	03:00 - 04:00	4	4
5	04:00 - 05:00	4.5	4.5
6	05:00 - 06:00	5	5
7	06:00 - 07:00	5.5	5.5
8	07:00 - 08:00	6	6
9	08:00 - 09:00	6.5	6.5
10	09:00 - 10:00	7	7
11	10:00 - 11:00	7	7
12	11:00 - 12:00	7.5	7.5
13	12:00 - 13:00	7.5	7.5
14	13:00 - 14:00	7.5	7.5
15	14:00 - 15:00	7	7
16	15:00 - 16:00	7	7
17	16:00 - 17:00	7.5	7.5
18	17:00 - 18:00	7.5	7.5
19	18:00 - 19:00	7	7
20	19:00 - 20:00	7	7
21	20:00 - 21:00	7.5	7.5
22	21:00 - 22:00	7.5	7.5
23	22:00 - 23:00	7	7
24	23:00 - 24:00	7	7
Total kWh in 24 Hours			152.5 kWh

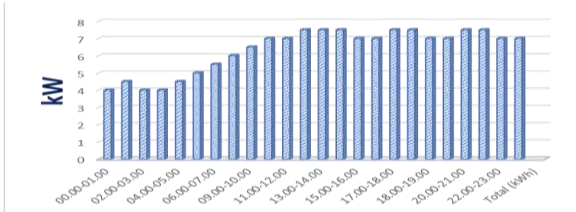


FIG.1. BTS Daily load

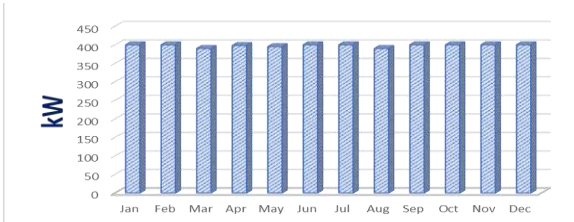


FIG.2. MONTHLY BTS LOAD GRAPH

From the graph, it is evident that the electrical power consumption of the BTS load over 24 hours is 152.5 kWh/day, with a 10% safety margin. Therefore, the total requirement is 167.75 kWh/day. This allows us to calculate the electrical power capacity that needs to be supplied by Solar Photovoltaic Power Generators and Wind Turbine Power Generators [8].

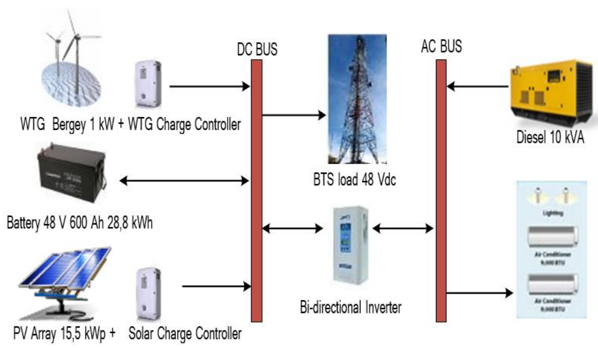


FIG.3. SYSTEM CONFIGURATION

3.1. Solar Power plant (PV)

Photovoltaic (PV) is technology converts energy from the sun (photons) into electrical energy in the form of direct current. Following that, electrical energy in the form of direct current is converted into alternating current in accordance with the voltage and frequency system in place. A Solar Power Center (PLTS) is made up of numerous major components, including PV panels, inverters, and batteries [9]. Photovoltaic capacity is calculated using the formula based on daily load parameters and a 70% energy contribution from photovoltaics [10].

$$CPV = \frac{EPV}{Q \times \frac{1}{A} X K}$$

Details :
CPV = Photovoltaic Capacity (kWp)
EPV = Photovoltaic Energy Output Per Day (kWh)
Q = Solar Insulation Average (kWh/m2/day)
A = Solar Radiation Standard (1 kW/m2)
K = Losses Compensation (loses)
Temperature Losses and Installation for PV array = 0,9

If solar panels provide 80% of BTS's total power demand (80% x 167.75 kWh/day = 134.2 kWh). If the solar cell contributes 70% of the energy, the EPV is 0.70 x 134.2 kWh = 93.94 kWh / day. Average sunlight intensity in Saobi (Q=5.23kWh/m2/day).

$$CPV = \frac{0.70 \times 134.2}{5.23 \times \frac{1}{1} \times 0.9} = 20.35 \text{ kWp}$$

Maximum power (Pmp) 222.4 Wpeak/module when using the PV sharp ND-224UC1. Model Advisor software (SAM 2016.3.14)

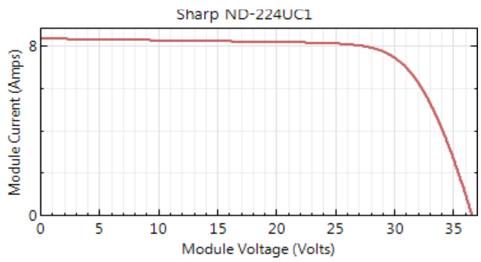


FIG.3. SOFTWARE ADVISOR MODEL RESULTS

TABLE IV. PV PANEL REQUIREMENT DATA

No	Details	Value	Unit
1	PV Maximum Output Power	224	Watt Peak
2	PV irradiation duration	4,5	Hours
3	Derating factor	0,9	
4	Number of panels required	60	Panel
5	Modules per string	12	Panel
6	String in Parallel	5	Panel
7	Total module area	94,4	m^2
8	Output Power PV/panel/day	907,2	kWh
9	String Voc	439.2	V
10	String Vmp	351.6	V
Total Capacity		15.50 kW	

3.2. BATTERY

Batteries are one of the components used in solar cell systems and WTG that could store electrical energy as a backup [11]. The main function of batteries is to store direct current electrical energy generated by solar panels and WTG. The energy stored in the battery serves as a backup source to keep the BTS electrical energy running. In addition, the use of batteries assists in maintaining the system's energy output stability [12].

The formula below can be used to calculate battery capacity[11] :

$$C\ Bat = \frac{EL \times Atonomous\ Day}{Vn \times \eta \text{ Bat x DoD}}$$

Details:

C Bat = Battery Capacity (Ah)
EL = Energy Load (kWh)
A = Atonomous day
DoD = (Depth of discharge) = 60%
Eff Bat = 85 %
Nominal voltage
Vn = 48 Vdc for Hybrid
A = 3 days (72 hours)

The technology used is a hybrid system, which means:

$$C\ Bat = \frac{152.5\ kWh \times 3}{48 \times 0.85 \times 0.60} = 18688.7\ Ah$$

If the battery is a Valve Regulated Lead Acid type GIANT Power (48 Volt 600 Ah).

$$= \frac{18688.7\ Ah}{600\ Ah} = 31.15\ unit$$

3.3. BI-DIRECTIONAL INVERTER

Bidirectional inverter A bi-directional inverter is a power electronics device that converts DC input voltage to AC output voltage and vice versa in both directions. As a result, this inverter may convert AC input voltage to DC output voltage or vice versa from DC to AC [13].

A bi-directional inverter functions as both a rectifier (charger) and an inverter. During the day, when the power provided by the PV module exceeds the load, the bidirectional inverter converts the AC voltage from the inverter output on grid to the DC voltage of the battery. The inverter converts DC electricity stored in the battery into alternating current (AC current) for power supply air conditioning (AC) loads, BTS illumination lights, and other loads that require current alternation. The inverter's capacity is determined on the peak power requirements that occur at the load shown on the 24-hour daily load chart. PV and WTG output DC voltage of 48 Volts, function for battery charging and power supply load of 48 VDC BTS, and Inverter input voltage[14].

3.4 WIND POWER PLANT

Wind turbine Generator = WTG, also known as the Wind Energy Conversion System (SKEA) in Indonesia, converts wind energy into electrical energy. The principle of operation of the mill rotates the rotor on the generator to produce electrical energy; however, because the wind speed is not constant (fluctuating), the electrical energy produced is first stored in the battery before it is able to be used [15]. The formula can be used to convert kinetic energy into electrical energy:

$$P = 0{,}5x(\rho)\ (A)\ (V)^3$$

Details :
ρ = Air density 1,225 kg/m^3
A = Windmill blade turning area = $\pi D^2/4\ m^2$
D = Diameter swept area (m)
V = Wind speed (m/s)

As a result, the electrical energy obtained from the wind is

$$P = 1/2\,\rho\,(\pi D^2/4)\,v^3$$

TABLE V. WIND SPEED CONDITION

WIND CLASS	WIND SPEED (m/s)	WIDN SPEED (km/h)	WIND SPEED (knot/h)
1	0.3 - 1.5	1 - 5.4	0.58 - 2.92
2	1.6 - 3.3	5.5 - 11.9	3.11 - 6.42
3	3.4 - 5.4	12.0 - 19.5	6.61 - 10.5
4	5.5 - 7.9	19.6 - 28.5	10.7 - 15.4
5	8.0 -10.7	28.6 - 38.5	15.6 - 20.8
6	10.8 - 13.8	38.6 - 49.7	21 - 26.8
7	13.9 - 17.1	49.8 - 61.5	27 -33.3
8	17.2 - 20.7	61.6 - 74.5	33.5 - 40.3
9	20.8 - 24.4	74.6 - 87.9	40.4 - 47.5
10	24.5 - 28.4	88.0 - 102.3	47.7 - 55.3
11	28.5 - 32.6	102.4 - 117.0	55.4 - 63.4
12	>32.6	>118	>63.4

The minimum restriction is class 3 wind, while the maximum limit is class 8 wind. More than the eighth grade is an injurious wind.

TABLE VI. AVERAGE WIND SPEED 2010-2014

NO	Month	Wind Speed (m/s)
1	Jan	6.88
2	Feb	4.86
3	Mar	4.44
4	Apr	3.17
5	May	3.89
6	Jun	4.69
7	Jul	5.15
8	Aug	5.36
9	Sep	4.36
10	Oct	3.70
11	Nov	2.58
12	Dec	4.92
Average wind speed		4.50

Based on data from Table VI Based on statistics from 2010 to 2014, the average sea breeze speed on the Saobi islands per year at an altitude of 20 meters reached 4.50 m / s, making it ideal for small-scale turbines up to 10 kW. Bergey BWC XL 1 is the model of the simulated windmill (WTG).

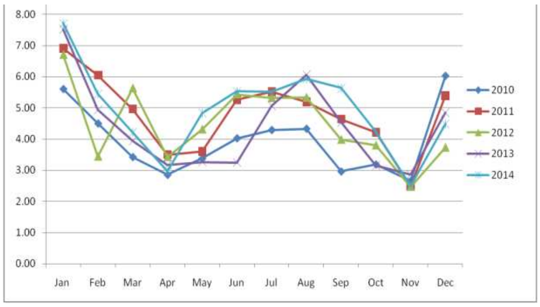


FIG.4. AVERAGE WIND SPEED GRAPH 2010-2014

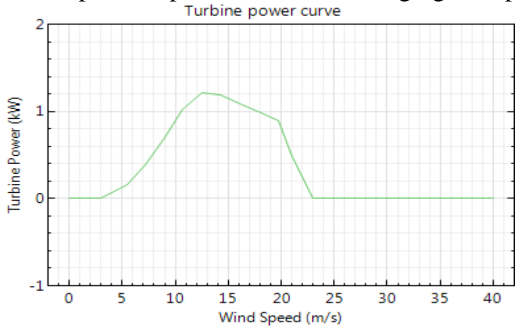
TABLE VII. WIND TURBINE SPECIFICATIONS

No	Details	Value	Unit
1	Output Power	1	kW
2	Rotor diameter	2,5	m
3	Hub Height	80	m
4	Shear Coefficient	0,14	

FIG.5. TURBINE POWER GRAPH

4. DISCUSSION AND RESULT

1. Hybrid Power Generation, which sources power for BTS from renewable energy such as wind turbines and solar panels (PV), may seem complex, expensive, and challenging to operate



when compared to conventional Diesel Engine Generators (Gensets) or using grid electricity from PLN (Indonesia's state-owned electricity company).
2. Solar panels supply 72.8% or 122.122 kWh of the total BTS power consumption of 167.75 kWh/day. Using PV panels with a rating of 240 Wpeak/array, to generate a power output of 18.69 kWpeak, approximately 78 solar panels or arrays are required (18.69 kWp / 240 Wp = 77.86).
3. The total wind blowing time in coastal areas is 19 hours (sea winds blow from 08:00 to 16:00 and from 19:00 to 06:00). A 1.5 kW wind turbine can produce 565 watts at a wind speed of 4.5 m/s. The daily production of wind turbines is 4 units x 565 Wp x 19 hours = 42,94 Wh/day (43 kWh/day) or 26%.

4. The Hybrid BTS Solar Power Plant is capable of reducing CO_2 emissions, with a CO_2 emission coefficient of 0.719 kg/kWh x 152.5 = 120.612 kg/day.

5. SUGGESTIONS

1. It is necessary to conduct an economical technical study, for comparison of the use of power supply derived from PLN electricity and fuel generators that are substituted with the use of alternative energy (PV, Wind turbine).
2. Use of Homer software simulation to determine energy management.
3. The use of Matlab / Simulink to determine the simulation of loading characteristics with the use of alternative energy.

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Achievement Use Photovoltaic Power System In Indonesia 2023

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Abstract: *The direction of development of rural electricity and smart grids is expanding access to electricity in remote and scattered areas. The rural electricity program's objective is to achieve a 100% electrification ratio and increase the number of villages with electricity to 100% by 2024. Considering that Indonesia is a tropical region where almost all corners of Indonesia receive sunlight, one solution to increase the electrification ratio can be to use solar energy plant (Pembangkit Listrik Tenaga Surya – PLTS). Currently, PLTS technology is increasingly improving and developing. By taking into account the roadmap target for the development of PLTS in the world and the projection of PLTS utilization until 2023 in the General National Electricity Plan 2023-2060, this scientific work will formulate strategies in an effort to increase the electrification ratio and achieve PLTS utilization capacity in accordance with those predicted.*

Keywords: *Solar Energy Plant (Pembangkit Listrik Tenaga Surya – PLTS), General National Electricity Plan, Electrician ratio.*

INTRODUCTION

According to the 2022 Electricity and Energy Statistics, with the growth of 2022 statistics on the number of household customers from 75,726,553**) customers at the end of 2021 to 78,327,897**) customers at the end of 2022, the electrification ratio will be 97.63%. Compared to 2021, it increased by 1,273,599 subscribers or 3.27%. Of the total number of customers, the household group is the largest number of customers at 37,099,830 customers or 92.4% [1]. When compared with statistics from 2021 the growth in the number of household customers from 72,606,681**) customers at the end of 2020 to 75,701,985**) customers at the end of 2021, the electrification ratio is 97.26%. In other words, within one year there has been an increase in the electrification ratio by 5.23% [2]. Therefore, the Ministry of Energy and Mineral Resources of the Republic of Indonesia has a target of 100% electrification ratio by 2024 [3].

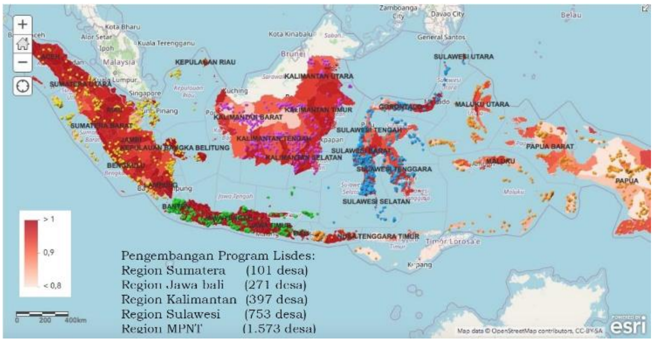
Indonesia which is located in the tropics has the gift of sunshine / sun. Almost in every corner of Indonesia, solar shines throughout the morning until evening where the solar potential is abundant with an average daily radiation of 4.8kWh / m2 [4]. Although Indonesia is an archipelagic country located in a tropical country, the utilization of solar energy sources has not been maximized as well as possible to increase the electrification ratio and the ratio of electrified villages. In fact, when viewed in terms of availability, this Solar Power Plants is very practical compared to other energy sources. So that the use of solar energy can also accelerate the electrification ratio, especially in areas that are difficult to reach by the electric power grid. In addition, the trend of increasingly frequent use of distributed generation has a positive influence on the wider use of this PLTS.

RESEARCH METHODS

The data collection methods used are literature study, observation, and consultation methods. In the method of literature study and observation, the author takes and collects data that can be used as a reference from electrical engineering journals, especially in the field of renewable energy as a reference. Meanwhile, with the consultation method, the author conducts consultation and guidance activities with supervisors who are competent in their fields intensively.

In the data analysis method, the author uses a qualitative analysis method where the author analyzes the strength, weakness, opportunities, threats (SWOT) of the use of Solar Power Plants (PLTS = Pembangkit Listrik Tenaga Surya) as a solution to increase the electrification ratio and the ratio of electrified villages..

The Ministry of Energy and Mineral Resources also held an APDAL program for villages that have not been electrified, and in 2017-2019 a Pre-electrification program using Energy Saving Solar Lights (LTSHE = Lampu Tenaga Surya Hemat Energi) was also implemented for villages which in the next two to three years are still very difficult to electrify. This program is a bridging program from the Ministry of Energy and Mineral Resources in areas that are very difficult to reach by PLN, before later being electrified by PLN. In 2020 and above, villages that have expired their LTHSE warranty period (ex-LTHSE) will be electrified by PLN.

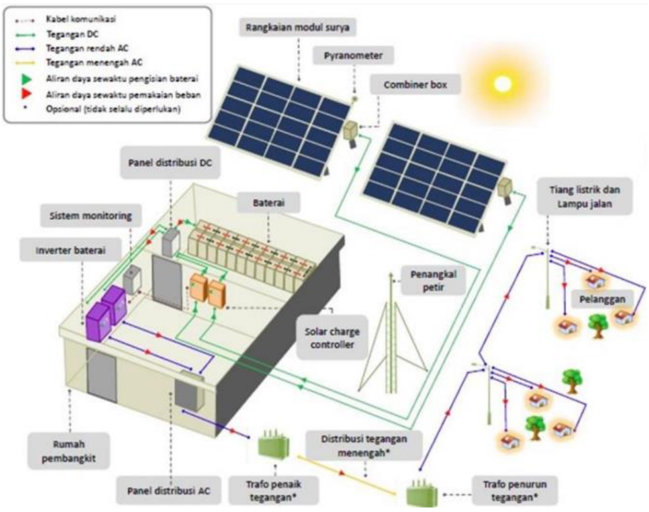


Gambar 1. Map of PLN Village Roadmap Distribution Location 2021

In addition to the 2021 target, PT PLN (Persero) also has made a roadmap for Rural Electricity until 2030. This effort is intended to provide direction for the company to always be committed in an effort to provide electricity to all corners of the country with sufficient energy and qualified constraints [3].

RESULT AND DISCUSSION

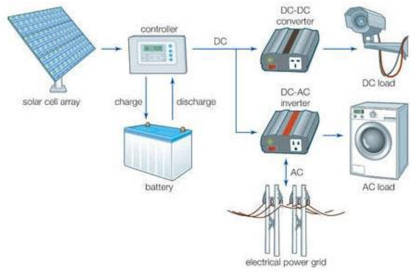
The most abundant energy source on earth is the solar energy source. (The solar energy that reaches the Earth's surface in one hour is equivalent to the amount of energy consumed by all human activities in a year.) Its low energy density and intermittency make solar energy quite expensive to be exploited on a large scale [5].



Gambar 2. Solar Power Plant Circuit

The concept of Solar Power Plant (PLTS) is to convert sunlight into electrical energy. Sunlight is one form of energy from natural resources. This solar natural resource is already widely used to supply electrical power in communication satellites through solar cells. These solar cells can produce unlimited amounts of electrical energy directly taken from the sun, without any rotating parts and no need for fuel. So that solar cell systems are often said to be clean and environmentally friendly.

Solar Power Plant Systems (PLTS) will be more in demand because they can be used for any purpose and anywhere both in large buildings, factories, housing, and others. In addition to its unlimited supply, solar power has almost no adverse impact on the environment compared to other fuels. In advanced industrial countries such as the United States, Japan, China and several countries in Europe with the help of subsidies from the government have been launched programs to popularize solar electricity. Not only that, in developing countries such as India, the promotion of the use of renewable energy sources continues to be carried out.



Gambar 3. Solar Power Plant Component

The components of Solar Power Plant are:

1. Solar Panel / Module, serves to capture sunlight and stream it to the Battery / Accumulator (battery).
2. Battery / Accumulator (battery), serves for stores the electric current generated by solar panels before being utilized for their application and construction. Based on the application, batteries are distinguished for automotive, marine and deep cycle. Deep cycle includes batteries commonly used for PV (Photo Voltaic) and back up power. While in construction, the battery is divided into wet, gel and AGM (Absorbed Glass Mat) types. AGM type batteries are usually also known as VRLA (Valve Regulated Lead Acid).
3. Controller/Regulator that functions as electric traffic controller from the panel to the load.
4. Inverter that functions to change the current DC becomes AC.
5. Converter that works for flow controllers

DC required

6. Load (AC and DC) in the form of lamps lighting or other electrical equipment, like TV.

Basically, the PLTS system is divided into two system fixations. The first is PLTS with a connected grid system connected to the kWh meter electricity network from PLN. This system allows the use of PLTS which is able to be a backup source of electricity when there is a disruption or outage in the PLN electricity network. The second is stand-alone PLTS or commonly referred to as stand-alone PLTS. This PLTS system is designed to operate independently without any relationship between system configuration and PLN's electricity network [6].

In the National Energy Policy as stipulated in Government Regulation Number 79 of 2014 and the National Medium-Term Development Plan (RPJMN = Rencana Pembangunan Jangka Menengah Nasional) 2020-2024 stipulated through Presidential Regulation Number 18 of 2020, the national electrification ratio is targeted at 100% starting in 2020. However, until the end of 2022, it was recorded that the electrification ratio had only reached 99.63%, this figure was below the target stated in the RPJMN of around 0.37%. The government continues to accelerate the increase in the electrification ratio to pursue the 100% target by preparing access to electricity through distribution network expansion, minigrid construction, and the Electric Energy Charging Station (SPEL = Stasiun Pengisian Energi Listrik) program along with Electric Power Distribution Equipment (APDAL = Alat Penyalur Daya Listrik). For people who have access to electricity but are unable to connect as customers of PT PLN (Persero), the government has prepared a New Install Electricity Assistance (BPBL = Bantuan Pasang Baru Listrik) program. Through these programs, it is expected that by 2024 the national electrification ratio will have reached 100%. To achieve an increase in the electrification ratio to around 100% by 2024, it is necessary to add around 0.29 million electrified households. Meanwhile, to maintain the electrification ratio at 100%, it is necessary to add an average of around 0.38 million electrified households per year from 2024 to 2060. The addition of electrified households can be in the form of electricity connections from PT PLN (Persero) and non-PT PLN (Persero). The electrification ratio target can be achieved provided that sufficient funding for electricity supply infrastructure development and obstacles in electricity supply infrastructure development can be overcome. If the budget of PT PLN (Persero) is insufficient to add electricity households, other funding sources are needed, such as funding from the State Budget (APBN = Anggaran Pendapatan dan Belanja Negara).

Solar potential renewal is carried out by taking into account the potential land area and radiation intensity filtering. Based on the results of the update, the total solar potential in Indonesia reached 3,294 GW. The region with the largest solar potential is the Sumatra Region with the potential to reach 36% of the total national solar potential. The potential is spread throughout Sumatra with the largest potential located in Riau Province amounting to 25% of the total solar potential in the Sumatra Region and South Sumatra Province with a total potential of 24% of the total solar potential in the Sumatra Region. The province with the largest solar potential is East Nusa Tenggara with a total potential of 94% of the total solar potential in the Nusa Tenggara Region or 11% of the total national solar potential. The province with the lowest solar potential is Gorontalo Province with solar potential only 3% of the total solar potential in the Sulawesi Region or 0.2% of the total national solar potential [7].

COVER

Conclusion

1. The concept of Solar Power Plant (PLTS = Pembangkit Listrik Tenaga Surya) is to convert sunlight into electrical energy. Sunlight is one form of energy from natural resources. This solar natural resource is already widely used to supply electrical power in communication satellites through solar cells.
2. The province with the largest solar potential is East Nusa Tenggara with a total potential of 94% of the total solar potential in the Nusa Tenggara Region or 11% of the total national solar potential. The province with the lowest solar potential is Gorontalo Province with - 124 - solar potential only amounting to 3% of the total solar potential in the Sulawesi Region or 0.2% of the total national solar potential.

Suggestion

1. The development of the concept of Solar Power Plant (PLTS = Solar Power Plant) it is expected that in the future it will be easier to develop in a cost-efficient manner and in the right place. So that PLTS will be

more optimal in its utilization and use.

2. Indonesia which is located in the tropics has the gift of sunshine / sun. Almost in every corner of Indonesia. It is hoped that underdeveloped areas can implement PLTS with the potential that Indonesia has with the right calculations and planning.

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Optimizing Wind Turbine Plants by Referring to Average Wind Speed in Indonesia

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***Abstract*— Wind turbine plant is increasing year-on-year globally because of the technological development that makes wind turbine more efficient and powerful. It is required to have proper analysis and field study about the location and environment. This paper explains the design aspects of a wind turbine, like wind speed, wind resources, turbine rotor size, wind power, and estimated output power to calculate the potential wind turbine capacity in Indonesia.**

Keywords*— *wind speed, wind resources, turbine rotor size, wind power output, estimated output power capacity.

I. Introduction

Energy plays an essential role in all aspects of our life. Our dependence on fossil energy must be reduced because it's dwindling [1]. Wind turbine plants are one of the most promising renewable energies [2] [3]. in the world, occupying the 2nd largest total power capacity with 845 GW after Solar Panel with 942 GW [4]. The Indonesian government, through PLN, is targeting wind energy utilization (PLTB) in 2026, which is 597 MW of 60.6 GW of total wind energy potential that can be produced [5] [6]. This is due to improved efficiency and support from technology development. The dimensions of turbines (e.g., capacity, rotor diameter, hub height) were expanded to enhance both cost-efficiency and performance. In 2021, the typical turbine size introduced to the market exceeded the 3.5 MW benchmark, marking a 27% increase from the 2.81 MW size observed in 2020. Additionally, new onshore turbines with power ratings varying from 6 MW to over 7 MW were introduced [7]. Concurrently, multiple European and Asian manufacturers unveiled plans for fresh offshore turbines ranging from 11 to 16 MW in capacity [8] [9].

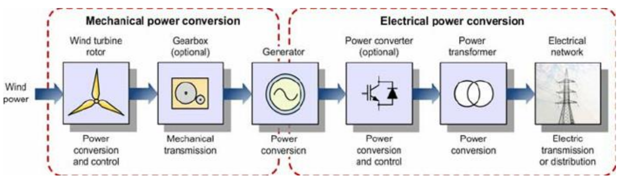


Fig. 1. Example of a figure caption. (*figure caption*)

This wind turbine is a tool for changing the kinetic energy of the wind [10] (e.g., propeller rotor, gearbox) into electrical energy [11] [12] [13] (e.g., generator, power transformer, electrical transmission). A power curve defines the connection between wind speed and power and depends on the turbine types and site location.

- Wind speed: most wind turbines will be started to produce power at wind speeds of approximately four m/s and achieve the optimal rated power at about 13 m/s [14].

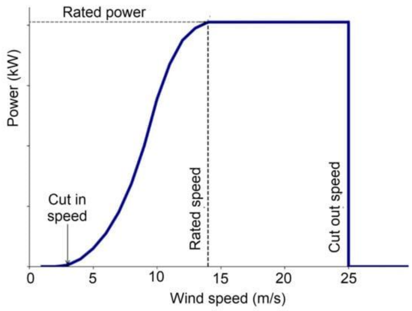


Fig. 2. Power Curve Wind Generator

- Site location for onshore or offshore and types of the turbine, such as the turbine size and maximum power that can be produced.

Fig. 3. Wind Turbine Onshore

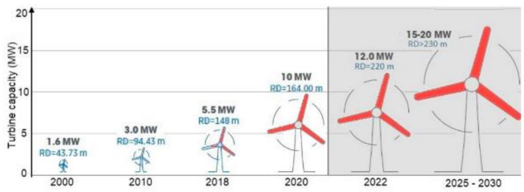


Fig. 4. Wind Turbine Offshore

Many methodologies can be used to calculate the maximum power capacity produced within a single wind turbine. The easy way to understand is to remember this fundamental condition [15].

- Power capacity generated is proportional to the area of coverage of the rotor; the more comprehensive the coverage area, the greater the power produced.
- The amount of power produced varies with wind speed.

II. Optimizing Wind Turbin Plan

A. Wind Energy Utilization

Wind, as an available natural resource, can be utilized as one of the sources of electrical energy. This energy source is inexhaustible, so using wind energy conversion systems will positively impact the environment. Wind is one form of natural energy that can be harnessed by converting from kinetic energy to electrical power. Wind energy can significantly contribute to reducing emissions as it does not produce CO2 emissions during the electricity generation process by wind turbines.

Wind power represents Indonesia's most substantial energy potential, as evident from the data presented in Table I.

TABLE I. RENEWABLE POTENTIAL ENERGY IN INDONESIA

No	Type of Energy	Potential Energy	Installed Capacity	Utilization
1	Geothermal	29.5 GW	1.4 GW	4.9 %
2	Hydro	75.1 GW	4.8 GW	6.5 %
3	Mini-micro Hydro	19.3 GW	197 GW	1.0 %
4	Bioenergy	32.6 GW	1.6 GW	5.1 %
5	Solar	207.8 GW	78.5 MW	0.04 %
6	Wind	60.6 GW	3.1 MW	0.01 %
7	Ocean	17.9 GW	0.3 MW	0.002%

According to data from the National Electricity Company's Electricity Supply Business Plan (RUPTL PLN 2021-2030), wind energy has the highest potential to generate electrical energy, amounting to 60.1 GW, with wind speeds above four m/s in Indonesia. However, the installed capacity of wind energy power plants in Indonesia is only 3.1 MW, significantly lower than other energy sources such as geothermal, hydro, mini-micro hydro, bioenergy, and solar [6]. Wind measurements are also necessary to determine regions with wind speed potential and the required turbine power characteristics. Wind data collected by the Meteorology Climatology Geophysics Agency (BMKG) and the National Institute of Aeronautics and Space (LAPAN) cover 166 locations across Indonesia.

TABLE II. LOCATION POTENTIAL

Wind Potential	Wind speed at 50 m (m/s)	Wind Power Density at 50 m (W/m2)	Total Location	Province
Less	3.0 – 4.0	<75	84	Maluku, Papua, Sumba, Mentawai, Bengkulu, Jambi, East &West Nusa Tenggara, North & South Sulawesi, North Sumatera, Central Java, Yogyakarta, Lampung, and Borneo
Medium	4.0 – 5.0	75 – 150	34	East & Central Java, Yogyakarta, Bali, Bengkulu, East &West Nusa Tenggara, North & South Sulawesi, North Sumatera,
Good	>5.0	>150	35	Banten, Jakarta, West & Central Java, Yogyakarta, East &West Nusa Tenggara, North & South Sulawesi, North Sumatera, and Maluku

B. Define The Wind Turbine Characteristics and Wind Turbine Design Requirement

There are a few crucial questions the developer must respond to before selecting to construct a wind turbine on a specific site [16] [17]:

1. Analyze the average wind speed in the region each year.
2. Analyze the potential damage by wind gusts in the chosen location within the next 50 years.
3. Analyze the inconsistent wind speed in the region.

The wind type of a wind turbine is determined by three critical variables: wind speed, strong gusts, and turbulence. The following essential criteria will be used to choose the type of wind turbine, according to International Standards IEC 61400 and ISO 19900:

- Average wind speed,
- Extreme 50 years gusts– Wind speed,
- Potential Turbulence

IEC Classification of Wind Turbines
Ref.: (IEC61400-1: 2005): Appendix II
Rayleigh distribution is assumed, i.e., k = 2

TABLE III. WIND TURBIN TYPE – WIND SPEED

Wind Turbine Type	I	II	III
$V_{ave}(m/s)$	10	8.5	7.5
$V_{ref}(m/s)$	50	42.5	37.5
$V_{50,gust}(m/s)$	70	59.5	52.5
$I_{ref}\ A$	0.16		
$I_{ref}\ B$	0.14		
$I_{ref}\ C$	0.12		

Where:
V_{ave} = Annual average wind speed
V_{ref} = Extreme wind speed over 10 minutes (50-year)
$V_{50,\ gust.}$ = Extreme gust over 3 seconds (50-year)

I_{re} = mean turbulence intensity at 15 m/s.
A, B, and C = categories of higher, medium, and lower turbulence intensity characteristics, respectively

TABLE IV. WIND TURBIN TYPE – EXTREME WIN SPEED 50 YEARS

Wind Type Category (Turbulence)	Wind Average Speed (m/s)	In 50 years gust in m/s (miles/hours)
1. High wind - higher turbulence 18%	10	70(156)
2. High wind - lower turbulence 16%	10	70(156)
3. Medium wind - higher turbulence 18%	8.5	59.5(133)
4. Medium wind - lower turbulence 16%	8.5	59.5(133)
5. Low wind - higher turbulence 18%	7.5	52.5(117)
6. Low wind - lower turbulence 16%	7.5	52.5(117)

Based on the 3 m/s average wind speed, the maximum or severe wind speeds are calculated. When the wind speed reaches 15 m/s, there is turbulence. This is the definition in IEC 61400-1 edition 2.
Wind Turbine type impact on blade design.

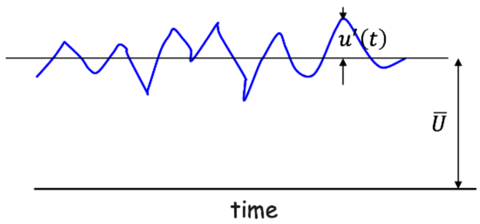
- Type 1 wind turbines are used at locations with high wind speed (average wind speed above 8.5 m/s). Typically, these turbines have small rotors (short bars) located on short towers to minimize structural loads.
- Type 2 wind turbines are used in moderate conditions (locations with an average wind speed of up to 8.5 m/s). This turbine is the most widely used.
- Type 3 wind turbines are used in locations with a low wind speed (average wind speed less than 7.5m/s), and these turbines usually use huge rotors to capture low wind energy.

Turbulence intensity
Turbulence intensity measures how much the wind is changing. (within 10 minutes).

$\mathcal{U}(t) = \overline{\mathcal{U}} + u'(t)$

$$rms = \sqrt{\sum (u')^2}$$

$$TI = \frac{rms}{\overline{\mathcal{U}}}$$



Understanding how turbulent the site is is important since turbulence primarily contributes to the fatigue stresses of several components in a wind turbine.

TABLE V. WIND TURBIN TYPE – TURBULENCE INTENSITY (HIGH, MEDIUM, LOW, RESPECTIVELY)

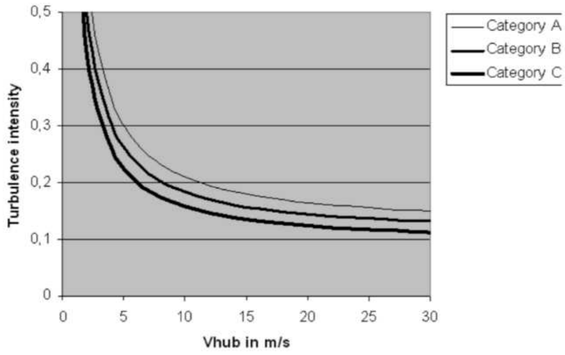


Fig. 5. Turbulence Intensity

Wind Turbine Design Requirement

Design requirements
IEC 61400-1 Edition. 3.0 b: 2005
Part 1: The design requirements outline critical specifications necessary to uphold the structural integrity of wind turbines, offering suitable safeguards against potential damage from various risks throughout their anticipated operational lifespan. This encompasses all the components and subsystems within wind turbines, including control and safety mechanisms, internal electrical systems, mechanical components, and supporting structures. These specifications apply to wind turbines of various sizes.

Small wind turbines
IEC 61400-2 Edition. 3.0 b: 2013
Windmills, other words from wind turbines; part 2 Small wind turbines define safety criteria for SWTs and address safety principles, quality control, and engineering integrity. These requirements encompass the design, installation, maintenance, and operation of SWTs in specific environmental conditions. This standard ensures the necessary safeguards against potential hazards throughout their intended lifespan. Although this standard shares similarities with IEC 61400-1, it has been modified to suit the unique needs of small wind turbines, simplifying and incorporating significant changes to their application.

Design requirements for offshore wind turbines
IEC 61400-3 Edition. 1.0 b: 2009
Part 3: The design criterion for offshore wind turbines lays down critical design requirements to ensure the structural integrity of offshore wind turbines and provides supplemental prerequisites for evaluating the environmental conditions at an offshore wind turbine location. Its main goal is to provide adequate protection against potential harm caused by numerous hazards for the required operational lifespan duration. It also includes internal electrical and mechanical systems and subsystems, such as control and protection mechanisms. The applicable IEC and ISO standards, particularly IEC 61400-1, should be used with this publication.

Some design requirements for making wind turbine gearboxes

IEC 61400-4 Edition. 1.0 en: 2012 (Cont.)

Wind turbines - Part 4: Wind turbine gearboxes design

- Used in enclosed gearboxes for boosting speed drivetrains of Wind turbines with a horizontal axis having a power rating of more than 500 kW.
- Both onshore and offshore wind turbines must adhere to the standard.
- The standard covers spur, helical, or double helical gears and their combinations in parallel and epicyclic arrangements in the main power channel. It provides guidelines for wind turbine stress analysis about the design of the gear and gearbox elements.
- The standard was created utilizing rolling element-bearing gearbox designs.
- There is also guidance on how to engineer shafts, shaft hub connections, bearings, and the gear case structure to build a fully integrated design that meets the stringent working criteria.
- Transmission lubrication, as well as prototype and production testing, are discussed. The final part of the instructions covers how to use and maintain a gearbox.

Acoustic noise measurement techniques

IEC 61400-11 Edition. 3.0 en: 2012

Wind turbines - Part 11: Acoustic noise measurement techniques present measurement procedures that characterize a wind turbine's noise emissions. Noise emission assessment measurement methods have been used close to the machine to limit errors due to sound propagation but far enough away to account for the finite source size involved. They are designed to make it easier to characterize wind turbine noise about different wind speeds and directions. Comparisons between wind turbines will be made more accessible by measuring standard operating practices. This updated edition is a technical modification, adding new guidelines for data reduction techniques.

Measurement of mechanical loads

IEC 61400-13 Edition. 1.0 b: 2015

Wind turbines - Part 13: IEC 61400-13:2015(B), Measurement of Mechanical Loads, outlines the measurement of essential structural loads on wind turbines for the load simulation model validation. The standard requires site selection, signal selection, data acquisition, calibration, data verification, measurement load cases, capture matrix, post-processing, uncertainty determination, and reporting. Additionally, helpful annexes are included to enhance comprehension of testing procedures. The technical shift and transition from a technical specification to an international standard supersedes IEC TS 61400-13, released in 2001.

C. *Determine The Root Cause*

Wind power generation is a new and renewable energy that has great potential to be developed in Indonesia. Further study is required to define and develop suitable Wind Energy design and planning to fulfill total Energy Demand for the next 10-25 years. This study will focus on supporting environment (wind speed), selection, and efficient wind turbine selection.

III. Tip Speed Ratio (TSR)

The TSR (Tip Speed Ratio) is an essential factor in producing the optimal power output of wind turbines. TSR measurement refers to the proportion between the wind speed and the speed of the tips of the wind turbine blades with the basic equation below [18]:

$$TSR\ (\lambda) = \frac{Tip\ Speed\ of\ Blade}{Wind\ Speed}$$

$$TSR\ (\lambda) = \frac{\omega . r}{v}$$

$Whare,$

$\omega = Rotational\ speed\ in\ radians/sec$

$r = Rotor\ radius\ in\ m$

$\mathrm{v} = Wind\ speed\ in\ m/s$

Understanding the tip speed ratio will provide data for maximizing wind turbines' power output and efficiency. If the wind turbine rotor moves slowly, most of the wind will pass through the gap between the blades. Therefore, the turbine will not produce any power. But if the rotor moves fast, the edges will blur and act like a solid wall to the wind. The rotor speed will be halved when the radius is doubled with the tip speed ratio held constant. In general, rotor speed will be inversely proportional to the radius.

TABLE VI. Optimum Tip Speed Ratio

The Tip Speed Ratio	Number of Blades
6	2
4 to 5	3
3	5
2	6

IV. Coefficient of Power (C_P)

The coefficient of power (C_p) of a wind turbine is to measure the efficiency of the wind turbine to convert the energy in the wind into electricity. To find the coefficient of power given to wind speed can be done by dividing the electricity produced by the total energy available in the wind at that speed [10] [11].

$$C_p = \frac{Rotor\ power}{Power\ in\ the\ wind} = \frac{P_{rotor}}{{}^{1}/_{2}\, A\rho v^3}$$

$Whare,$

$\rho = density\ of\ the\ wind\ \ kg/m^3$

$A = blade\ swept\ area\ (\pi r^2)$

$v = velocity\ of\ the\ wind\ m/s$

$P_{rotor} = rotor\ power$

The highest attainable value of the power coefficient is identified as the Betz Limit (C_p) is 16/27 or 0.593. A maximum of 59.3% of the available wind power can be converted to output power at ideal conditions and this gives C_p between 0.4 and 0.5 [10] [19]

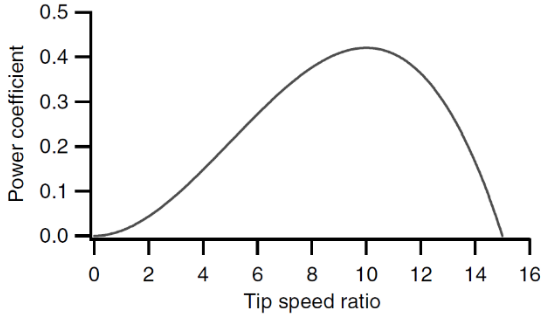


Fig. 6. Coefficient of Power-TSR curve

V. Wind Turbine Generated

The variable output power made by a wind turbine is captured as the estimated power produced using the statistical approach given by:

$$P = \frac{1}{2} \times \rho \times \pi \times r^2 \times C_p \times v^3$$

$P = power\ generated\ in\ Watts$
$v = velocity\ of\ the\ wind\ m/s$
$\rho = density\ of\ the\ wind\ \ kg/m^3$
$\pi r^2 = sweap\ area, where\ r = blade\ length\ in\ m$
$C_P =$ power coefficient

TABLE VII. Power Output (R=32,H=50m,Cp 0.2)

Power (MW)	Rotor Blade Length 32, Height 50 m Cp 0,2	
	ρ (Kg/m3)	*v (m/s)*
0,05	1,22	4,00
0,17	1,22	6,00
0,40	1,22	8,00
0,78	1,22	10,00
1,36	1,22	12,00
2,15	1,22	14,00
3,21	1,22	16,00
4,58	1,22	18,00
6,28	1,22	20,00
8,36	1,22	22,00

TABLE VIII. Power Output (R=32,H=50m,Cp 0.4)

Power (MW)	Rotor Blade Length 32, Height 50 m Cp 0,4	
	ρ (Kg/m3)	*v (m/s)*
0,05	1,22	4,00
0,17	1,22	6,00
0,40	1,22	8,00
0,78	1,22	10,00
1,36	1,22	12,00
2,15	1,22	14,00
3,21	1,22	16,00
4,58	1,22	18,00
6,28	1,22	20,00
8,36	1,22	22,00

TABLE IX. Power Output (R=52,H=50m,Cp 0.2)

Power (MW)	Rotor Blade Length 52, Height 50 m Cp 0,2	
	ρ (Kg/m3)	*v (m/s)*
0,07	1,22	4,00
0,22	1,22	6,00
0,53	1,22	8,00
1,04	1,22	10,00
1,79	1,22	12,00
2,84	1,22	14,00
4,24	1,22	16,00
6,04	1,22	18,00
8,29	1,22	20,00
11,03	1,22	22,00

TABLE X. Power Output (R=52,H=50m,Cp 0.4)

Power (MW)	Rotor Blade Length 52, Height 50 m Cp 0,4	
	ρ (Kg/m3)	*v (m/s)*
0,13	1,22	4,00
0,45	1,22	6,00
1,06	1,22	8,00
2,07	1,22	10,00
3,58	1,22	12,00
5,69	1,22	14,00
8,49	1,22	16,00
12,08	1,22	18,00
16,58	1,22	20,00
22,06	1,22	22,00

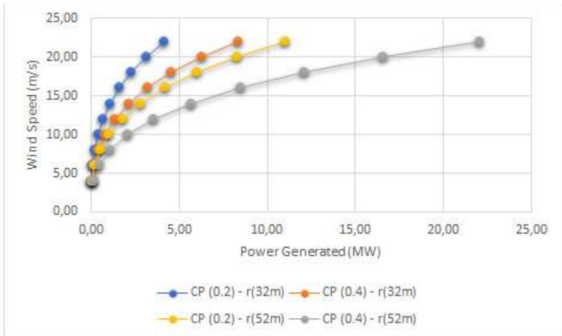


Fig. 7. Power Output Comparison

Three factors determine the wind turbine's maximum efficiency. The three factors are:

1. The size of the turbines, the longer rotor blade produces additional power output.
2. The speed of winds through the rotor, the faster wind speed produced additional power output.
3. The power coefficient, the more efficient the power output reduces the loss of power output.

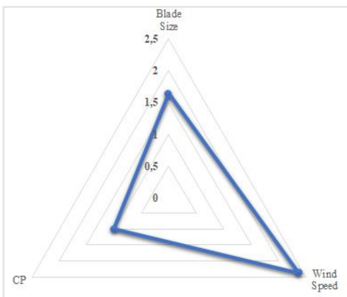


Fig. 8. Power Output Factor

VI. POTENTIAL CAPACITY WIND TURBINE IN INDONESIA

Fig. 9. Wind Speed Mapping

Figure 7 Wind Speed Mapping [20] shows the distribution of wind speed mapping in Indonesia. Onshore, along the southern coasts of Java, Maluku, South Sulawesi, and NTT, the wind blows at 6 to 8 m/s. Offshore Banten, Pulau Wetar, Sukabumi, Kupang, Jeneponto District, and Tanimbar Islands District all had wind speeds greater than eight m/s. The Australian monsoon season runs from June through August (JJA), when wind speeds are at their highest, to March through April and March (MAM), when the Asian monsoon changes to the Australian monsoon.

The total estimated power output can be simulated by combining the information between wind speed distribution and the power output equation. With the assumption of wind speed, an average of 6-8 m/s, rotor length of 52 m, and Cp 0.4, the maximum power produced in a single wind turbine is 1.2 MW.

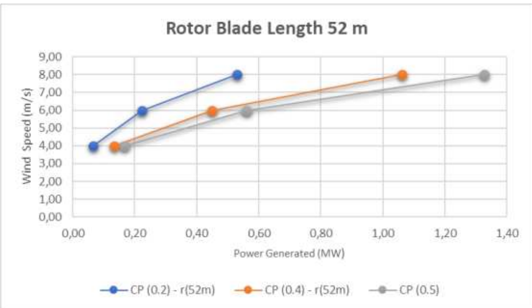


Fig. 10. Estimated Wind Turbine Power Output

The following is a calculation of wind energy capacity in Indonesia, where the East Nusa Tenggara area has the most potential for developing wind power plants [21].

TABLE XI. THE POTENTIAL OF WIND ENERGY IN INDONESIA

Province	Potential Power (MW)
East Nusa Tenggara	10.188
East Java	7.907
West Java	7.036
Central Java	5.213
South Sulawesi	4.193
Maluku	3.188
West Nusa Tenggara	2.505
Bangka belitung	1.787
Banten	1.753
Bangkulu	1.513
Southeast Sulawesi	1.414
Papua	1.411
North Sulawesi	1.214
Lampung	1.137
DI Yogyakarta	1.079
Bali	1.019
South Kalimantan	1.006
Riau Island	922
Central Sulawesi	908
Aceh	894
Central Kalimantan	681
West Kalimantan	554
West Sulawesi	514
North Maluku	504
West Papua	437
West Sumatera	428
North Sumatera	356
South Sumatera	301
East Kalimantan	73
Gorontalo	137
North Kalimantan	73
Jambi	37
Riau	22
DKI Jakarta	4
Total	**60.647**

Source: Attachment to Presidential Regulation No. 22 of 2017

SUMMARY

Indonesia has not optimized the potential of wind energy as a renewable source for developing and constructing wind power plants. The successful realization of efficient wind power plants hinges on two crucial factors: selecting suitable locations and adopting cutting-edge wind turbine technologies. When tapping into the potential of wind energy, initial calculations suggest that wind speeds ranging from 6 to 8 meters per second, combined with rotor blades measuring 52 meters in length, can produce an output of 1.2 MW per turbine.

Initial analysis and research using wind energy potential maps reveal that several regions display favorable wind conditions. For instance, East Nusa Tenggara province boasts a potential of 10,188 MW. As a result, the overall potential power capacity generated from wind power plants amounts to 60,647 MW, distributed across multiple regions in Indonesia.

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Correlation between regular motorbike oil changes and energy efficiency: user perspectives

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***Abstract*—Oil changes are recognized as a key factor influencing the energy efficiency of motorcycles. However, it is important to ascertain whether motorcycle riders are aware of this correlation and whether the level of motorcyclist understanding influences routine oil change behavior. This study aims to investigate the perceptions of motorcycle riders concerning the impact of routine oil changes on the energy efficiency of their motorcycles and how these perceptions influence their oil change behavior. Given the presence of variables lacking an interval scale, the Spearman correlation test is employed to assess the associations between these variables. A significant finding is that respondents exhibit a relatively strong comprehension of the significance of oil changes, but their belief in the positive impact of regular oil changes on energy efficiency remains somewhat limited. Consequently, while there are significant positive correlations between routine oil change behavior and nearly all efficiency variables, a substantial portion of drivers still do not adhere to regular oil changes. This research underscores that understanding of the importance of regular oil changes does not consistently translate into actual compliance. Further investigations are recommended to explore additional factors that may influence this behavior.**

Keywords— Energy efficiency, motor rider, oil changes, Spearman Correlation, user behavior

I. INTRODUCTION

Motor transportation is currently in great demand by the public. Motorbikes are a very popular means of transportation in Indonesia. In 2021, the number of motorcycle ownership in Indonesia reached 120, 042, 298 units [1]. A study states that the mobility of motor transportation contributes to increased air pollution [2]. The transportation industry is the main contributor to CO2 emissions. Fossil fuels, which provide the majority of its energy, are responsible for around 22% of the world's CO2 emissions [3].

Almost all motorized vehicles use oil as a lubricating fluid. By placing a material coating between rubbing surfaces, advanced lubricants have been developed to reduce wear and friction of the tribological components of an engine. An engine oil does more than just lubricate; it also cools and cleans the engine, prevents corrosion, and enhances sealing. The primary components of the lubricant are a base oil and chemical additives, which are combined based on grade and intended use. Wear and maintenance requirements can be decreased when a device is optimized for its duty, resulting in higher cost savings and less air pollution [4].

Due to the fierce market competition and strict emission regulations, lubricants are receiving more attention from motorcycle manufacturers as a potential tool to enhance engine performance while lowering exhaust emissions and fuel consumption. However, application of very effective low viscosity oils to modern motorcycles necessitates careful formulation technique and exhaustive testing method due to very unique hardware limits [5].

Motor vehicle energy conservation is facilitated by timely and routine oil changes, especially as engine efficiency rises. After a certain amount of time, the lubricating function of all lubricants dramatically degrades, necessitating a replacement. If this adjustment is delayed, the machine could malfunction or suffer from excessive wear and tear on its components [6]. One method of keeping a motorcycle engine durable is to change the oil. It is the same as damaging the motorcycle engine to be late or not change the oil. We have to spend a lot of money on repairs as a result [7]. Changing the engine oil on an automobile entails replacing the old oil with a fresh one up to the manufacturer's maximum mileage. The outcomes of applying the methodology for certain car types provide a simple process of monitoring and verification. The result showed that an accurate findings for the evaluation of energy savings following the change of the vehicle's engine oil [8].

The relationship between users' routines for changing their oil and their perceptions of the use value of oil in relation to energy savings will be investigated in this study. The research focuses on how consumers believe oil changing behavior can conserve or waste energy. By investigating the correlation between users' opinions concerning oil change practices and their actual oil change habits, we aim to enhance our understanding of how awareness of the importance of routine oil changes relates to actual oil change behavior.

II. ENGINE-RELATED FACTORS TO ENERGY EFFICIENCY

In this study, factors that affect energy savings include engine performance and fuel consumption. gasoline consumption is the measure of how much gasoline a car or engine uses to move a certain amount of weight or cover a specific distance. The engine performance of cars also has a significant impact on how much fuel they use. Driving technology and speed are the two main elements that directly affect fuel consumption. The lubricant's quality has an impact on how well the engine performs [9]. Reducing fuel usage translates into less money spent on fuel, which can save people a lot of money.

Regular oil changes influence engine performance, which is the engine's efficiency in converting fuel into mechanical power. Enhanced engine performance leads to more efficient energy utilization. By converting a higher proportion of the fuel's energy into useful mechanical effort, a more efficient engine minimizes energy loss as heat or exhaust gases. Analysis of the machine's performance can be done using [10]:

1. Vibration

Excessive friction and wear on moving parts can either produce or worsen vibration in a machine. Fresh oil offers superior lubrication, lowering wear and friction. Engine vibration can be decreased by reducing these causes through routine oil changes. The effectiveness of the machine can be impacted by vibration. Increased friction and mechanical losses brought on by excessive vibration can lower engine efficiency. To maintain the same level of performance, this could lead to a higher energy consumption. A motorcycle's aerodynamics can be impacted by vibration. Airflow around the bike may be disrupted by vibrations, which could lead to an increase in drag and a decrease in fuel efficiency. Designing with aerodynamics in mind is crucial for reducing this impact. For your motorcycle to perform effectively, regular maintenance is crucial. Component wear can be accelerated by vibration. Failure to solve vibration-related problems as soon as they arise may lead to decreased performance and increased energy usage.

2. Heat

Heat is a byproduct of engine operation that must be appropriately handled. By transporting heat away from engine components and into the oil cooler or radiator, fresh oil aids in the effective dissipation of heat. Regular oil changes preserve the oil's capacity to absorb and dissipate heat at its peak, avert overheating, and maintain a stable engine temperature. Motorcycles have a cooling system (such as an air- or liquid-cooled system) to control and dissipate extra heat produced by the engine. There may be a reduction in overall efficiency and an increase in energy use if the cooling system is not functioning properly or if the engine generates excessive heat.

Engines work best between a specified range of temperatures. Too-cold operation of the engine can lead to poor combustion and decreased efficiency. On the other hand, if the process is excessively hot, overheating, and poor performance may result. To maximize energy use, temperature management must be done properly.

3. Sound

Engine parts with adequate lubrication make less mechanical noise. Oil may not offer enough lubrication as it ages and becomes polluted, increasing friction and mechanical noise. The engine can become quieter by reducing this noise and using fresh oil. Motorcycle design, construction, and operation-related variables have a significant impact on the link between engine noise and energy use. Poorly built exhaust systems may limit the flow of exhaust gases, increasing back pressure, lowering engine performance, and perhaps increasing energy consumption. A well-designed exhaust system, on the other hand, can improve exhaust gas flow, boost engine economy, and reduce noise. Motorcycle parts, including as the engine and drivetrain, can be properly maintained to minimize mechanical noise and guarantee top performance. Due to mechanical inefficiencies, neglecting maintenance can result in increased energy use and noise

III. METHODS

The participants in the study were the residents of the BSD area who used two-wheeled motorcycle for their daily activities. The rider being the subject of the study is essentially older than 17 years old because that is the minimum age specified by the government in law number 22 of 2009 article 81, which governs the eligibility of individuals to operate motor vehicles. The separation surrounding driving age restrictions is meant to expose the legitimacy of drivers who are the subject of giving researchers' input and information, who will then draw conclusions based on the details given by the resource person [11].

A. Instrument

A questionnaire is the tool used to gather feedback from motorbike riders on their routine oil usage and its impact on energy conservation. There are ten inquiries made (Table 1). The first query concerns regular replacement practices. The second query asked for comments on the value of routine oil changes for energy conservation. The next section asks a question about the connection between oil changes and engine performance and fuel efficiency. Vibration, heat, engine sound, and engine efficiency are the four criteria used to quantify engine performance. The question is whether regular oil changes have an impact on performance enhancement for each of these parameters. On the other hand, is it possible for erratic oil changes to impair engine performance? This section contains a total of 8 questions because there are two questions for each aspect.

TABLE I. VARIABLES IN QUESTIONNAIRE

Var	Statements
Importance	Regular oil changes are important
Efficiency	
Fuel Consumption	
Fuel_reg	Regular oil changes reduce fuel consumption
Fuel_irreg	rregular oil changes increase fuel consumption
Performance	
Vibration	
Vibration_reg	Regular oil changes reduce engine vibration
Vibration_irreg	rregular oil changes increase engine vibration
Heat	
Heat_reg	⌇Routine oil changes reduce the possibility of engine overheating
Heat_irreg	rregular oil changes increase the possibility of engine overheating
Noise	
Noise_reg	Regular oil changes reduce engine noise
Noise_irreg	irregular oil changes increase engine noise

B. Data Analysis

We employ the measured mean and standard deviation values to describe the distribution of variables related to importance and efficiency, assuming that these variables exhibit interval characteristics with equivalent ranges. On the other hand, data regarding oil change routine behavior has ordinal properties rather than interval characteristics. Therefore, we use frequency per scale 1 – 5 to analyze the data

Due to the nature of an ordinal scale, we assess the strength of the relationship using the Spearman correlation, a non-parametric statistical technique designed for measuring associations between ordinal or nominal variables. Spearman correlation operates by transforming the data into rankings for each variable, which are then ordered from smallest to largest. It quantifies the connection between these rankings rather than the actual data values. This approach proves particularly useful in mitigating issues related to non-normality, asymmetry, or non-linearity within the data distribution.

In this study, we employ Spearman correlation to explore the extent and nature of the relationship between the variables "Routines" and "Importance" in relation to user perspectives on fuel consumption, performance, and individual performance attributes. It's important to note that a high correlation between two variables does not inherently imply a causal relationship. Determining causality typically necessitates further in-depth research and experimentation.

IV. RESULT

A total of 100 participants completed a questionnaire concerning motorbike riders' perceptions of the impact of regular oil changes on enhancing motorbike efficiency. The results, based on the calculation of mean and standard deviation, reveal that, on average, participants strongly endorse the importance of regular oil changes (mean = 3.99, SD = 1.18) (Table 2).

TABLE II. AVERAGE AND STANDARD DEVIATION OF ASSESSED VARIABLES

Var	Avg.	SD
Importance	3.99	1.18
Efficiency	**2.93**	
Fuel Consumption	**2.93**	
Fuel_reg	2.9	1.25
Fuel_irreg	2.96	1.25
Performance	**2.94**	
Vibration	**3.04**	
	3.01	1.21
	3.06	1.34
Heat	**2.91**	
Heat_reg	2.96	1.22
Heat_irreg	2.85	1.29
Noise	**2.87**	
Noise_reg	2.79	1.33
Noise_irreg	2.94	1.34

However, when it comes to the belief that changing oil can significantly boost engine efficiency, the level of agreement is notably lower, as reflected in mean scores of 2.93 for both fuel consumption and engine performance. Specifically, participants seem to have more confidence in the notion that routine oil changes will reduce engine vibration (mean = 2.94) within the context of the performance variable. In contrast, there is a relatively lower level of agreement when it comes to the perceived effects of oil changes in reducing overheating and engine noise.

Approximately 39% of respondents demonstrate a tendency to change their oil regularly, indicated by the substantial proportion of respondents who selected the upper end of the scale (4 and 5) (Table 3). Around 27% of respondents reported that they nearly always adhere to the recommended oil change intervals. However, a mere 12% of respondents claimed to consistently change their oil regularly in accordance with the recommendations.

Conversely, in a similar percentage range of 39%, respondents appear to be inclined not to change their oil regularly, as evidenced by their selection of the lower scale values (1 and 2). In fact, roughly 8% of respondents explicitly stated that they never change their oil on a regular basis.

These statistics suggest that while respondents may have knowledge about the importance of regular oil changes, this knowledge does not necessarily translate into consistent oil change behavior.

TABLE III. FREQUENCY OF RESPONDENTS'S ANSWER FOR SCALE 1-5

Var.	Frequency of answer (in %)				
	1	2	3	4	5
Routine	8	31	22	27	12

*only for interval scales variables

The Spearman correlation analysis revealed significant positive relationships among various variables, both within groups of variables (as shown in Table 4) and across individual questions (as presented in Table 5). Notably, a positive association was observed between oil change routine behavior (variable "routines") and the agreement regarding the importance of oil change routines (variable "Importance"). This implies that as the level of agreement increases, there is a corresponding tendency to adhere to regular oil changes. Moreover, these two variables exhibited positive correlations with several energy efficiency variables, specifically fuel consumption and engine performance attributes such as vibration, heat, and noise. This positive correlation extends across both groups of variables (Table 3) and the detailed variables (Table 4).

Table 4 further illustrates that respondents tend to hold the belief that regular oil changes can enhance the performance of these variables. Conversely, there is a corresponding belief that irregular oil changes could have a detrimental impact on these performance aspects.

TABLE IV. SPEARMAN CORRELATION AMONG VARIABLES

Variables	Routine	Impt.	Fuel_cons	Vibration	Heat
Importanc	0.418**				
Fuel_cons	0.618**	0.877**			
Vibration	0.69**	0.829**	0.971**		
Heat	-0.069	0.741**	0.631**	0.551**	
Noise	0.36**	0.884**	0.889**	0.838**	0.83**

TABLE V. SPEARMAN CORRELATION AMONG SUB-VARIABLES

	Routine	Importance	Fuel_reg	Fuel_irreg	Vibr._reg	Vibr_Irreg	Heat_reg	Heat_irreg	Noise_reg
Importance	0.418**								
Fuel_reg	0.568**	0.893**							
Fuel_irreg	0.426**	0.899**	0.937**						
Vibration_reg	0.763**	0.769**	0.904**	0.825**					
Vibration_Irreg	0.584**	0.836**	0.914**	0.899**	0.877**				
Heat_reg	-0.105	0.704**	0.63**	0.75**	0.391**	0.612**			
Heat_irreg	-0.044	0.742**	0.668**	0.776**	0.442**	0.620**	0.934**		
Noise_reg	0.154	0.804**	0.757**	0.841**	0.570**	0.725**	0.868**	0.863**	
Noise_irreg	0.522**	0.852**	0.928**	0.922**	0.853**	0.892**	0.662**	0.691**	0.778**

In Table 5, the Spearman test reveals a significant connection between regular oil changes and the fuel consumption. This relationship shows a positive correlation, meaning that regular oil changes are associated with improved fuel consumption performance. This positive correlation is particularly strong for vehicles with routine oil changes, leading to significant performance improvements. Conversely, irregular oil changes also show a positive relationship, but the effect on engine performance is more moderate in comparison. It is also evident that routine oil changes are perceived linked to machine vibrations. Specifically, regular oil changes are strongly associated with a reduction in machine vibrations. Along with this result, irregular oil changes are correlated with an increase in machine vibrations, also classified within the strong positive category.

An anomaly occurs in the relationship between routine oil changes and the perception that routine oil changes will reduce the possibility of engine overheating (Table 4). The relationship that occurs tends to be negative, although the value is not significant. It could be interpreted that increasing routine oil change behavior does not cause an increase in positive perceptions of its impact on reducing overheating. An insignificant value is also shown by the relationship between regular oil changes and the sound generated by the vehicle. Routine oil changes do not show any association with a perception on the decrease in engine sound. However, they are positively linked to an increase in vehicle sound when oil changes are not performed regularly, and this relationship falls within the strong positive category.

V. DISCUSSION

Based on the findings of the Spearman tests conducted, the research results demonstrate that routine oil changes significantly related to user's perception of fuel consumption and engine performance. Regarding engine performance, it is evident that regular oil changes lead to enhanced motorbike fuel consumption, while infrequent oil changes result in worsening one. This aspect of efficiency is particularly important to many drivers since fuel consumption directly affects to daily financial cost. Therefore, regular oil changes play a crucial role in maintaining optimal engine performance, and failure to perform these changes regularly can lead to reduced performance and potential damage to the vehicle.

Engine vibration during operation plays a pivotal role in shaping the engine performance and energy efficiency. Excessive vibration may lead to increased friction and mechanical losses, which can reduce the overall efficiency of the engine. This, in turn, can result in higher energy consumption to achieve the same level of performance. Vibration can influence the aerodynamics of the motorcycle. Vibrations can disrupt airflow around the bike, potentially increasing drag and reducing fuel efficiency. Aerodynamic design plays a significant role in minimizing this effect. Regular maintenance is essential to keep a motorcycle running efficiently. Vibration can accelerate wear and tear on components. Failing to address issues related to vibration promptly can result in increased energy consumption due to degraded performance.

The Spearman test revealed that routine oil changes were not associated with the comfort aspect related to the vehicle's heat output. This absence of correlation is primarily attributed to the common use of scooter-type motorbikes, often referred to as mopeds, by most motorized vehicle users in their daily routines. Scooter motorbikes are characterized by engines located beneath the motorbike seat, distant from the rider's position. Consequently, the heat generated by the engine remains isolated from the rider and does not influence the rider's comfort during the journey.

Regular oil changes exhibit a positive correlation with most efficiency-related variables, yet the conviction that changing oil yields improvements in fuel consumption and engine performance remains relatively lower. This discrepancy may contribute to the observed deviation from the expected regularity of oil changes. Despite respondents expressing a favorable attitude towards the significance of routine oil changes, a considerable number still fail to adhere to such a regimen.

These findings suggest the possibility that additional factors play a role in influencing routine oil change behavior. Subsequent interviews with respondents unveiled various reasons, including concerns about oil prices, forgetfulness, and busy schedules, which often hinder regular oil change practices. To investigate these claims, further research is advisable to delve into the factors that shape oil purchasing behavior.

Motorcycle users may not consistently grasp or implement the advantages of regular oil changes to enhance energy efficiency. Compliance with recommendations for routine oil replacement is often inconsistent due to a range of factors. These factors encompass financial constraints, scheduling conflicts, forgetfulness, and various other considerations. Perceptions about the energy conservation achieved through timely oil changes and the energy wastage resulting from neglecting such maintenance may contribute to these behavioral patterns.

VI. CONCLUSION

From the research findings, several conclusions can be drawn regarding users' perspectives on the impact of routine vehicle oil changes on vehicle efficiency. Firstly, it is evident that regular oil changes are associated with improved fuel consumption and enhanced engine performance. Engine performance, in this context, encompasses factors like vehicle vibration and engine sound. There is a widespread belief that vibrations and engine noise tend to decrease when oil changes are performed regularly and increase when oil changes are infrequent. However, it is important to note that there is no significant correlation between engine heat and the frequency of oil changes. In other words, changing the oil regularly does not appear to have a substantial impact on engine heat, as per the research results.

Despite drivers' awareness of the significance of oil changes in enhancing energy efficiency, many still neglect routine maintenance. Hence, there is a need to intensify efforts aimed at raising motorists' awareness and deepening their understanding of the crucial role oil changes play in optimizing energy efficiency. It is anticipated that such endeavors will empower drivers to fully leverage vehicle efficiency by maintaining the ideal oil conditions.

For future research, it is imperative to delve deeper into the factors contributing to the low frequency of routine oil changes among drivers, even when they are cognizant of the importance of these changes. A comprehensive exploration of these factors will provide valuable insights for designing more effective interventions and strategies to promote better oil change practices among drivers.

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Solar Energy Electrification for a Brighter Papua

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***Abstract*—Technology and electrification are crucial aspects of a region's or province's development that cannot be separated. However, when it comes to the island, with its demanding natural environment and disproportionate proportion of the inhabitants compared to the size of the area, regional development will be a significant challenge. Papua's electrification is critical; thus, when fossil energy is running low, the government and the industrial community are left with no options but to explore renewable energy options for Papua's electrification. For Papua, which has high solar insolation typical of tropical conditions, solar energy is the ideal choice. This article addresses the design, installation, and analysis of solar energy potential in Papua by constructing 16 PV systems in diverse places throughout the territory. The PV systems were installed in conjunction with PT Surya Utama Putra. Data was collected using a monitoring system from the commencement of PV system operations to the end of September 2023 to examine the potential for future PV system development. Data demonstrate that Papua has enormous solar energy potential, so the currently installed PV system still has a surplus energy supply and may still increase the burden on housing. Hence, it is expected that it can continue to improve the Papuan people's quality of life.**

Keywords—Electrification, Papua, PV System, Solar Energy, Solar Insolation.

I. Introduction

Technology installation in an area requires a reliable and sufficient power source, which is a necessary part of developing a region. The industrial sector, home appliances, and education are basic human needs that depend on energy. Electricity thus guarantees the introduction of technology in a certain location. Situations like this are common in places with challenging environmental features, such as mountainous regions with small populations compared to the area, which causes the electrical system to slow down. As a result, if rural areas are to be developed, they must have access to power, such as the case in Guatemala and Puerto Rico presented by Sperry et al. in 2023, and Sadik-Zada et al. discuss the renewable energy electrification for Eastern Pamir in 2023 [1]-[3]. People's lives will be improved by electrical facilities, which will allow them to receive technological information and install the essential technologies to develop the area; as presented by Palit in 2013, energy is needed for sustainable development [4]-[6].

Papua fits the above criteria since it is Indonesia's largest island, accounting for 21.9% of the total land area, with 421,981 km2 ranging from west to east (Sorong-Jayapura) for 1,200 km and from north to south (Jayapura-Merauke) for 736 km. Papua also boasts a slew of islands dotting its coastline. The islands of Biak, Numfor, Yapen, and Mapia are located on the north coast. Salawati, Batanta, Gag, Waigeo, and Yefman are the islands to the west. The islands of Kalepon, Komoran, Adi, Dolak, and Panjang are located on the south coast, while Papua New Guinea is located to the east. Papua Province has a land area of 312,224.37 km^2.

Papua's geography ranges from marshy lowlands to highlands with tropical rainforests, grasslands, and reedy valleys. A 650-kilometer-long string of high mountains runs across the center. The Jayawijaya mountains are famous for having the three highest peaks that, despite being close to the equator, are always covered in snow: Jayawijaya (5,030 m/15,090 ft), Trikora (5,160 m/15,480 ft) and Yamin (5,100 m/15,300 ft) [5]-[8].

Renewable energy is a feasible choice for electrifying Papua due to its complex nature, extensive territory compared to population, and diminishing quantity of conventional energy sources. Papua's location in a tropical zone with intense solar insolation is an advantage that must be capitalized. Hence, this study shows that two goals can be achieved: improving Papua and introducing technology to Papua by advancing renewable energy. The Ministry of Energy and Mineral Resources indicated that Papua has tremendous new renewable energy potential, totaling 381 gigatons. The government also intends to expand renewable energy in Papua, focusing on solar and hydropower for green manufacturing [9][10]. Papua has a renewable energy potential of around 381 GW, primarily solar and hydro, which can be used to fund the development of a green sector based on renewable energy. In Morowali, government utilities are constructing a 5,000 MW Renewable Energy power plant. According to Ministry of Energy and Mineral Resources data, Papua's total solar energy potential is 327.2 GW. West Papua has a solar energy potential of 66.9 GW, while Papua has a potential of 253.3 GW.

Wind energy [11][12] and solar energy have significant promise in Indonesia [13]-[21]. This potential can be expanded to attain 100% electrification in Indonesia, particularly in places that are difficult to access by government utilities. Various technological advancements in solar energy can improve the efficiency with which this energy is used. This paper discusses the installation and implementation of PV systems in 16 locations in Papua and presents the prospect, design, and analysis of On-Grid PV systems in Papua.

II. METHODS

PV system installation should be based on the demographics of the area where it will be installed. This paper explores the utilization of solar energy for Papua electrification to improve the quality of life for the people of Papua. Fig. 1 depicts the solar energy potential in Indonesia, which can be used as a guideline for PV system implementation. Fig. 1 also shows that solar insolation can reach up to 1500 W/m^2 in some regions, which is more than enough for high electricity output.

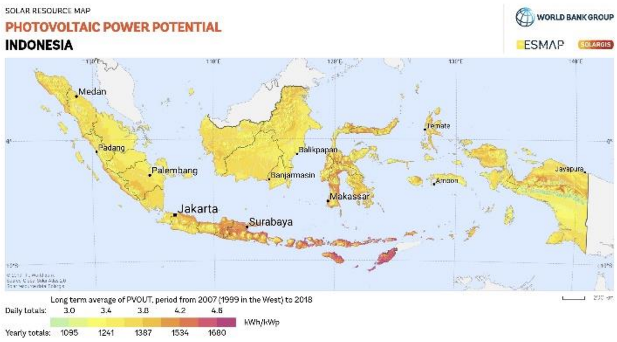

Fig. 1. PV power potential in Papua, Indonesia [22]

The amount of daily solar insolation received by PV panels affects the energy generation as given by [23]:

$$J_L = Q\int_0^W \left[H_0\alpha(\lambda)e^{-\alpha(\lambda)x}d\lambda\right] CP(x)dx \quad (1)$$

where J_L is the generated current density (), H_0 is the number of photons in solar insolation, Q is the electric charge, W is the solar cell thickness, $\alpha(\lambda)$ is the absorption equation related to solar insolation wavelength (λ), and $CP(x)$ is the collective probability of excited electrons and holes combination.

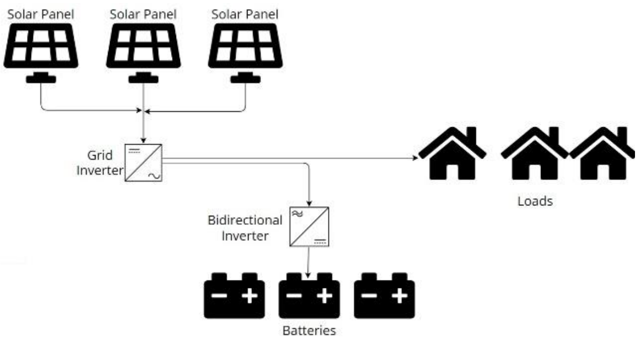

Fig. 2. Schematics diagram of installed PV systems

Fig. 2 shows the simplified schematic diagram of installed PV systems in 16 sub-districts of Papua, where the PV system capacities are varied from 10 kWh to 120 kWh depending on the power required by the loads (residential population of the areas). Table 1 lists the complete installed PV systems and their capacity in Papua, where the highest capacity is in Wambi, Merauke, and the lowest in Audam, Raja Ampat.

TABLE I. LIST OF INSTALLED PV SYSTEMS IN PAPUA

No	Location	District	Lat.	Long.	Capacity (kWp)
1	Audam	Raja Ampat	1,681	130,337	10
2	Renis	Mare Selatan	6,388	139,824	20
3	Suswa	Mare	6,326	139,815	20
4	Solal	North Misool	1,118	132,339	20
5	Biga	Raja Ampat	0,932	132,280	20
6	Kabilol	Raja Ampat	0,150	130,627	20
7	Waifoi	Raja Ampat	0,114	130,641	20
8	Warimak	Raja Ampat	0,098	130,714	20
9	Aramay	Raja Ampat	0,145	130,737	20
10	Yare/Afu	Boven Digeol	1,774	129,964	20
11	Yare/Suwo	Boven Digeol	5,867	138,455	20
12	Ambisu	Asmat	8,110	139,646	20
13	Iwol	Merauke	2,020	130,268	30
14	Mutus	Raja Ampat	0,347	130,344	40
15	Amamapare	Mimika	4,821	136,852	50
16	Wambi	Merauke	8,155	139,55	120

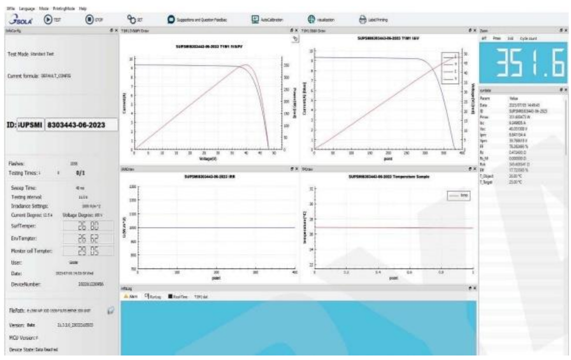

Fig. 3. IV-curve characteristic of installed PV panels in this study

Table 2 lists the installed components of the installed PV system, where the PV module capacity is 350 Wp each produced by PT Surya Utama Putra, which has good quality and longer live time. Fig. 3 shows the IV-curve test of PV modules implemented in this study, where I is the generated current related to Eq. 1 and V is the generated voltage given by

$$V = \frac{nkT}{Q}\ln\left(\frac{I_L - I}{I_0}\right) \quad (2)$$

where n is the number of intrinsic carrier concentrations, k is the Boltzmann constant, and T is the temperature (K). Hence, the IV curve shows the maximum power that might be generated by a PV panel, which is generated during a no-load testing environment, as presented in Fig. 3.

TABLE II. LIST OF COMPONENTS INSTALLED ON PV SYSTEM

No	Items	10 kW	20 kW	30 kW	40 kW	50 kW	120 kW
	PV System						
1	**Solar Modul 350Wp, IEC**	37	73	109	145	181	433
2	**Array Wiring Kit**						
	PV Connector	3.7	7.3	10.9	14.5	18.1	43.3
	PV Cable - HV (PV Cable)	200	200	600	600	600	1500
3	**AC Cable**						
	NYFGbY 4 x 10mm2				50	50	125
	NYFGbY 4 x 6mm2		50	50			
	NYFGbY 4 x 4mm2	50					
4	**Array Combiner box - High Voltage**	2	2	2	2	2	5
5	**Grounding protection kit**						
	BC Cable Underground	38	76	114	152	190	456

No	Items	10 kW	20 kW	30 kW	40 kW	50 kW	120 kW
	BCC Cable from base to BC	3	6	9	12	15	36
	BCC Cable from the combiner to BC	4	4	4	4	4	10
	Rod	2	4	6	8	10	24
	Battery						
1	**Battery VRLA, OPzV 48 kWh - 0.85m3 (1.8t) (kWh)**	48	96	192	192	288	720
2	**Battery Bank**	1	2	4	4	6	5
	Controller						
1	**Solar Inverter**						
	Sunny Tri power 25kW					2	5
	Sunny Tri power 20kW				2		
	Sunny Tri power 15kW			2			
	Sunny Tri power 10kW		2				
	Sunny Tri power 5kW	2					
	Distribution Panel GRID	1	1	1	1	1	1
2	**Battery Inverter (continue 25derC)**	13, 2	18	36	48	54	120
	Inverter 6kW, Sunny Island (master)				2		5
	Inverter 6kW, Sunny Island (slave)				4		10
	Inverter 4.6kW, Sunny Island (master)		1	2		3	
	Inverter 4.6kW, Sunny Island (slave)		2	4		6	
	Inverter 3.6kW, Sunny Island (master)	1					
	Inverter 3.6kW, Sunny Island (slave)	2					
	Synchronizer - Combiner Output Inverter						
	MC Box - 6 Inverter			1			
	MC Box - 12 Inverter	0	0	0	1	1	
	MC Box - 36 Inverter						1

III. Results and Discussion

West Papua, or Western New Guinea, is the part of New Guinea that belongs to Indonesia. The 412,214.61 km^2 of land with challenging topography urgently needs to be electrified to improve Papua residents' life quality. This paper discusses the implementation of 16 PV systems installed in various regions of Papua, as shown in the map in Fig. 4.

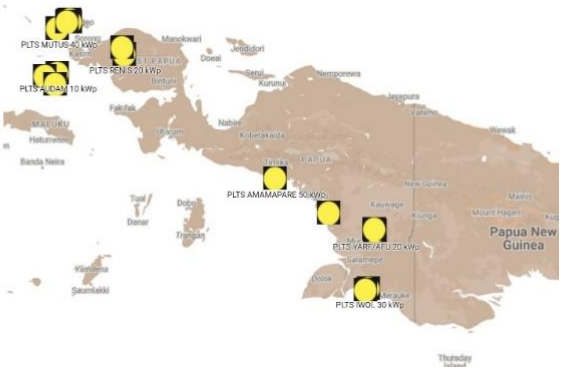

Fig. 4. Location of PV system installment in Papua, Indonesia

Figure 5 depicts the process of delivering the PV panels to the installation location at every point depicted in Figure 4. The problematic topography compelled the team to carry it by various modes of water transportation and air. This condition demonstrates how difficult it is to electrify Papua, despite the fact that it is critically needed to secure Papua's development by installing vital technology for education, health, and other purposes.

Fig. 5. Transporting material for PV systems installation in Papua

Table 2 shows the complete list of installed PV systems and their locations. However, due to identical capacity, the discussion will be limited to 6 PV system locations. Figs. 6-11 show the PV systems in those locations, in which the left side is the PV systems, and the right side of the fig is the components such as batteries, inverters, and combiner boxes

Fig. 6. 10 kWh Audam PV System

The first is an Audam PV system with a capacity of 10 kWh, as shown in Fig 6. Audam village/sub-district is located in Raja Ampat Regency, South West Papua, in District East Misool.

Fig. 7. 20 kWh Renis PV System

Figure 7 depicts a Renis PV system in the Ayau District of Raja Ampat Regency in Southwest Papua. Renis PV system has a 20 kWh capacity. Figure 8 depicts the Mutus PV system, which is located in the village of Mutus. Mutus PV system has a 40 kWh capacity. Mutus is also a sub-district in Raja Ampat regency. Mutus PV system is installed by the side of Papua's stunning ocean, depicted in Fig. 8. Raja Ampat Regency is known for its tourist attractions, with a population of 66,793 people and a land area of 7,442.31 km^2. This electrification will boost tourism in this beautiful area.

Fig. 8. 40 kWh Mutus PV System

Figure 9 depicts the 30 kWh capacity Iwol PV system, and Figure 10 depicts the 120 kWh Wambi PV system, both of which are located in District Okaba, Merauke Regency, South Papua Province. Iwol and Wambi are the names of the Sub-districts of Merauke Regency, which have a total population of 233,621 people living in a 45,013.35 km^2 area. Merauke is also Indonesia's largest regency, with the majority of its territory covered in forest and home to the Wasur National Park.

Fig. 9. 30 kWh Iwol PV System

Fig. 10. 120 kWh Wambi PV System

The 50 kWh Amamapare PV system in Mimika Regency, Central Papua Province, is seen in Fig. 11. Amamapare is a port town and a major industrial center for copper and gold mining. Amamapare has a tropical rainforest climate with intense solar insolation all year, implying a high-power output. Mimika Regency has 312,255 residents and covers an area of 18,295.95 km2.

Fig. 11. 50 kWh Amamapare PV System

Figure 12 depicts the power generated by the 20 kWh PV systems indicated in Table 1. The data recorded from the time the PV system began operating and the supply loads displayed in Fig 13; thus, the initial recording data varies amongst PV systems. The power produced by Fig 12 is higher than the demand to be supplied in Fig 13; however, to provide a clearer perspective,

Fig 14 uses data from the Araway PV system, which clearly shows that the generated power is greater than the load to be supplied. The electricity given directly to the load without charging the battery is referred to as direct consumption.

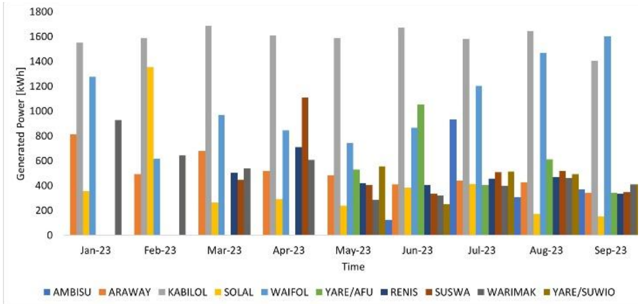

Fig. 12. The power generated by 20 kWh PV Systems listed in Table 1

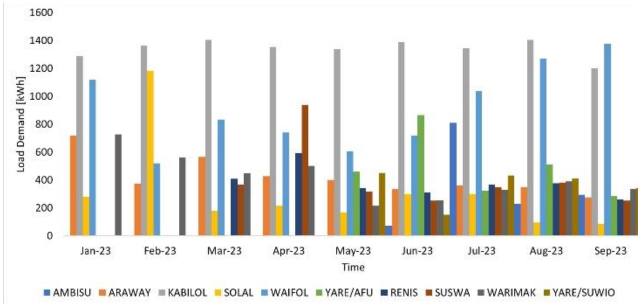

Fig. 13. The load supplied by 20 kWh PV Systems in Fig 12.

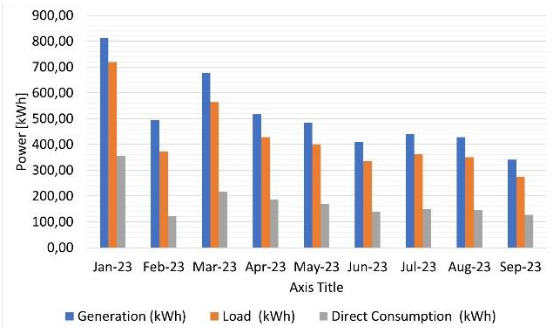

Fig. 14. The power generated and supplied comparison in the Araway PV System.

Fig 15 shows the comparison of the generated and supply power of the Wambi PV system, where the generated power keeps on higher than the supply demand.

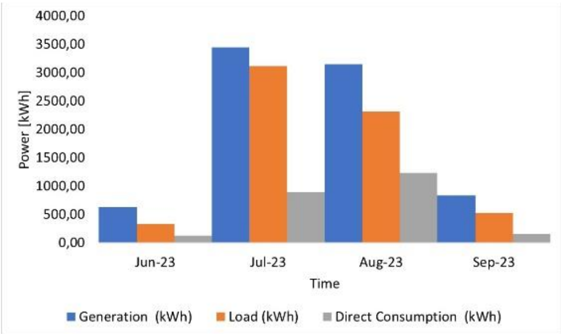

Fig. 15. The generated power and supplied electricity in the Wambi PV system.

Eq. 1 indicates that the weather in a particular location has a significant impact on power output. Figure 12 depicts the solar insolation, humidity, and ambient temperature in Mutus Village, where a Mutus PV system is established. Data in Fig. 12 are digitally recorded for 7 days using the Monitoring system listed in Table 2. Mutus' average temperature is 29.14 ^{o}C, with a maximum of 34.70 ^{o}C and a minimum of 25.30 ^{o}C, which is typical for a tropical island. The ambient temperature is not excessive, and it does not have a significant impact on power generation, as shown in Eq. 2. Mutus has a maximum humidity of 92.23%, an average humidity of 79.68%, and a lowest humidity of 60.92%.

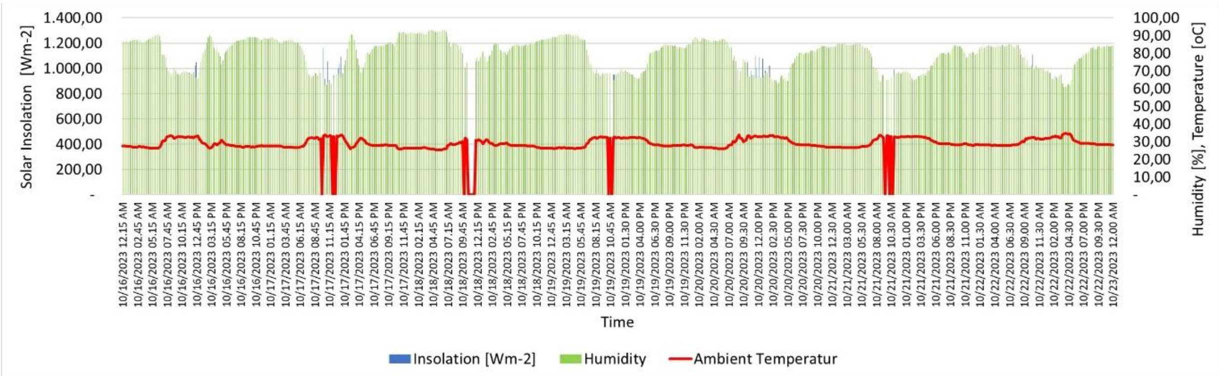

Fig. 16. Weather condition of Mutus PV System

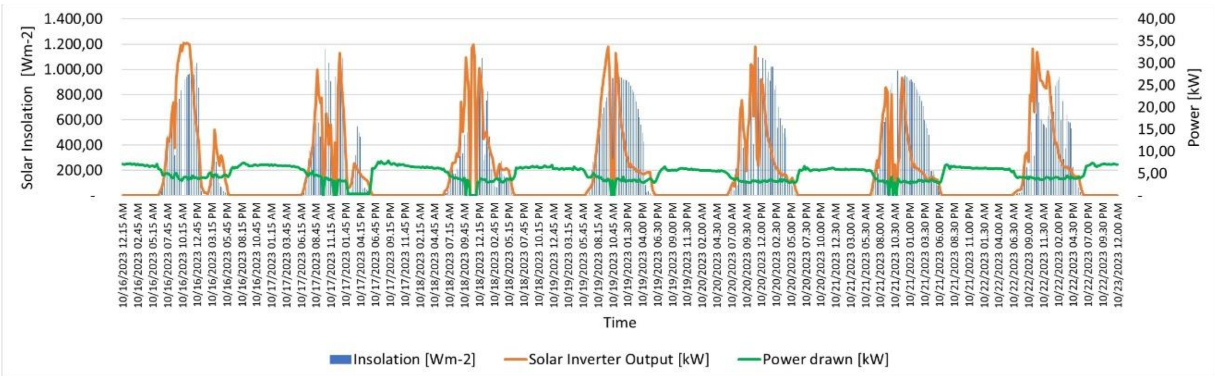

Fig. 17. Generated power compared to load (Power Drawn) in Mutus PV System relative to solar insolation.

The most noticeable weather aspect in the vicinity of the installed PV system is solar insolation. Figures 12 and 13 demonstrate that the maximum irradiation in Mutus is 1,161 W/m^2, sufficient to generate enough electricity to power the prescribed load. According to Fig. 13, the maximum power generated is 34.51 kWh, and the average power generated is 10.77 kWh. The highest load for the Mutus PV system is 7.86 kWh, and the average load is 5 kWh; therefore, the PV system has more than enough power to serve the load. As a result, the load increase that might occur in 5 years would still be adequately covered.

IV. CONCLUSIONS

The electrification process in Indonesia, particularly in Papua, needs to be accelerated, which was accomplished by building 16 PV systems in various areas around Papua, including the districts of Raja Ampat, Merauke, Timika, and Misool. The installed PV systems range from 10 kWh capacity to 120 kWh, depending on the load that needs to be supplied in those areas. This study addresses the potential, design, installation, and analysis of the results of solar energy generation in Papua. Data is collected from the PV system's monitoring system, showing much room for growth because the electrical energy produced is still more significant than the demand, such as the Araway PV system having an 18% surplus of power generation compared to demand.

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Manage Services Solar Cell Case : Rooftop Installation

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Abstract—As usual, managing service into solar cell that based on material photovoltaic required preventive and corrective action in particular part of operation management. Operations management is a discipline that originated to solve management problems in a factory environment, but since the mid-twentieth century researchers, lecturers and practitioners have begun to adapt the knowledge of the field to also support service operations [1].Some cases in term of installation, there are two primary ways to benefit from solar energy which is installing a solar panel system on property or participating in a communal solar cell project. If installing solar cells at home or business, most likely install a rooftop solar panel system, using that otherwise empty space above a head to produce electricity. If not good fit for solar cells, though, communal solar cell allows us to access the benefits of solar by offering the opportunity to subscribe to, or even purchase a part of, a larger solar panel project at those areas. They are often used to generate electricity for homes and businesses. Communal space refers to areas that are shared by a group of people, such as a park or a community center. Rooftops are the tops of buildings. There are many ways in which solar cells, communal space, and rooftops can be related. For example, solar cells can be installed on rooftops to generate electricity for the building below. The two main types of solar PV power systems are roof-mounted, on-grid and off-grid. The term 'grid' refers to the electrical or utility grid feeding domestic and commercial buildings. An on-grid solar system is directly connected to the electrical grid through an inverter and metering equipment. It cannot supply power at night. An off-grid system does not connect to the grid and charges batteries for night-time use.

Keywords—Manage Service, Operational Management, Solar Cell, Implementation Rooftop.

1. INTRODUCTION

Indonesia had target to transform of energy usage from conventional into renewable energy with targeting 23% (6500 MW) until 2025. Demand for energy itself being primary needs. Increasement in power energy for industrial, commercial, domestic, farming and transportation used. Minister Regulation from Directorate General of Mineral and Coal No. 49/2018 [2]. This regulation utilizes rooftop solar cells for customer electrical national company (PLN). Based on this regulation, it is possible for customers to reduce electrical cost consumption even more to export the excess wattages as deposit energy to use. After the customer finish installation, demands standard operation and maintenance, to keep and maintain PLTS system from customers.

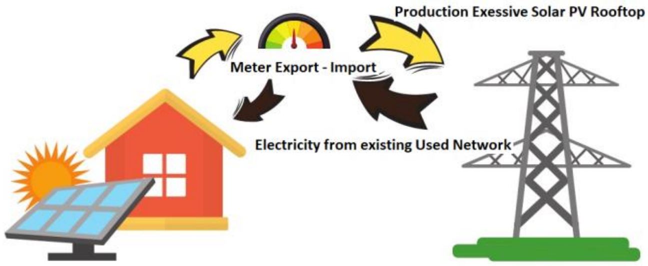

Fig.1. Illustrations on-grid metering system

2. RENEWABLE ENERGI POTENTIAL

Accelerations target renewable energy implementations, and the deployment of solar PV rooftop power plant is one of government concerns. Otherwise, the ministry directorate general of mineral and coal setting the target capacity installed on Solar plant on 3.6 Giga Watt (GW) in 2025 [3].

TABLE I. POTENTIAL DEPLOYMENT SOLAR PV ROOFTOP

No.	Customer Group	Development Solar PV Rooftop (kWp)				
		2021	2022	2023	2024	2025
1	Society	166	2.073	4.146	8.291	16.652
2	Housing	15.188	189.854	379.709	759.418	1.524.213
3	Commercial	7.257	90.709	181.418	362.836	728.679
4	Industry	13.017	162.714	325.428	650.855	1.303.103
5	Government	372	4.650	9.300	18.600	37.353
	TOTAL (kWp)	36.000	450.000	900.000	1.800.000	3.610.000

Target development for Solar PV rooftop needs to be balanced with the quality of planning. Therefore, it is necessary to evaluate the performance and quality of solar PV to ensure that the solar PV system is in accordance with standards and planning so that the quality of solar energy development and utilization in Indonesia is sustainable.

3. SOLAR PV ROOFTOP PERFORMANCE ON-GRID SYSTEM

One of the important parameters to ensure reliability of solar PV rooftop is based on Performance Ratio (PR) [4]. On this system, PR is calculated based on data instantaneous solar irradiation from sensor irradiation and data energy cumulative result from solar PV from energy meter.

PR daily calculated with formula below:

$$PR_{daily} = \frac{E^{PV}_{daily}}{\frac{\sum_0^T Ir_t}{G_{STC} \times N} \times P^{PV}_{nom}} \times 100\%$$

PR_{daily} is daily performance ratio (%)

E^{PV}_{daily} is total energy (AC) result from solar PV in one day read from inverter solar PV

Ir_t is solar irradiation from minutes to $-t$ (W/m²)

This formula has been generated by a sunny portal system. Visualization graphical daily show below:

TABLE II. GENERATING PERFORMANCE SOLAR PV ROOFTOP ONE DAY

SUNNY PORTAL powered by ennexOS

Version	4
Language	en-US
Local export date	13.10.2023 23:33:01
Export UTC date	2023-10-13T16:33:01.274Z
Time zone	Asia/Jakarta
User name	smpnjakbar190@gmail.com
Level	System
System ID	2576004
System name	SMPN 190 JAKBAR

Day Period	Time period	Power [kW]
9/22/2023	05.45 AM	0
9/22/2023	06.00 AM	0.05
9/22/2023	06.15 AM	0.27
9/22/2023	06.30 AM	0.5
9/22/2023	06.45 AM	0.72
9/22/2023	07.00 AM	0.9
9/22/2023	07.15 AM	1.05
9/22/2023	07.30 AM	1.29
9/22/2023	07.45 AM	1.65
9/22/2023	08.00 AM	2.15
9/22/2023	08.15 AM	2.77
9/22/2023	08.30 AM	3.49
9/22/2023	08.45 AM	4.09
9/22/2023	09.00 AM	4.82
9/22/2023	09.15 AM	5.61
9/22/2023	09.30 AM	6.26
9/22/2023	09.45 AM	6.88
9/22/2023	10.00 AM	7.55

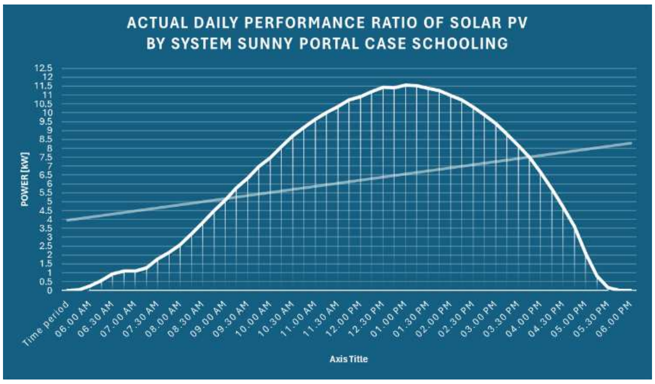

Fig.2. Curve of generating performance

4. OPERATION AND MAINTENANCE

Maximizing the performance of any PV system is one of the priorities of owners and integrators. This can be done with routine maintenance to ensure optimal operation conditions. Since PV systems can be owned by individuals, organizations, or utilities, there must be a set of practical guidelines to operate and maintain these systems to minimize downtimes and maximize the return on investment. The maintenance requirements vary depending on the system size, installation type, and locations. For example, stand-alone systems require more maintenance consideration due to the addition of batteries. Furthermore, manufacturers may provide maintenance guidance or procedure for components.

Maintenance Approaches

There are several major O&M approaches that exist in the market today, and each comes with tradeoffs. In simple words, each approach aims to achieve the three key goals of an effective O&M:

1. Reduce costs.
2. Improve availability.
3. Increase productivity.

There are three main strategies for maintenance: Preventative Maintenance, Corrective or Reactive Maintenance, and Condition-based Maintenance.

4.1 Preventive Maintenance (PM)

This strategy includes routine inspection and servicing of equipment to prevent breakdowns and unnecessary production losses. PM strategies can lower the probability of unplanned PV system downtime. However, the upfront costs associated with PM programs are moderate and require more labor time, and the increased inspection and maintenance activity contributes to site wear and tear and perversely expedite system malfunctions.

4.2 Corrective or Preventive maintenance

This strategy addresses equipment breakdowns after their occurrence to mitigate unplanned downtime. This strategy allows for low upfront costs, but it brings with it a higher risk of component failure and higher costs at the back end (negotiating warranty terms). A certain amount of reactive maintenance will be necessary over the system lifetime, but this strategy can be minimized if more proactive PM and condition-based maintenance (CBM) strategies are adopted.

4.3 Condition-based maintenance (CBM)

This strategy uses real-time data to prioritize and optimize maintenance and resources and can be done through third party integrators and turnkey providers. Different CBM regimes have been developed by third parties to offer greater O&M efficiency. However, this comes with a high upfront cost due to communication and monitoring software and hardware requirements.

4.4 Routine maintenance Considerations

In general, most PV systems share basic maintenance elements such as modules, inverters, charge controllers, and batteries.

4.5 PV module

A thorough inspection of PV modules can be done visually by the owner or installers. Main signs to look for when inspecting a PV system include:

- Physical damage to frame and glass
- Delaminating or change in color of the module's outer layer due to separation of bonds between glass and frame that allow moisture or corrosion to seep into the modules
- Burned connections inside module (hot spots)
- Grounding corrosion of wires or frame
- Array mount weakness or corrosion

Shading control

As we learned in lesson 2, shading can significantly reduce the electrical output of PV array. Even after a careful site evaluation is performed before installing the system, routine maintenance is recommended to avoid:

- Soiling
- Tree growing
- Leaves and debris accumulation

Battery maintenance

Batteries are considered one of the most maintenance intensive components in the PV system. We discussed in lesson 4 that lead-acid batteries are still widely used in PV systems and special maintenance attention is needed. A careful consideration and review of the manufacturer's maintenance recommendations is important to ensure safety on the site.

4.6 Electrical Equipment Maintenance

Besides visual inspections of inverters, chargers, transformers, and all other electrical equipment; there are other industry tools that can be used to find the weak points of the system. An infrared (IR) thermometer can be used to find the points where higher temperatures occur, such as circuit breakers, terminals, wires, and others.

4.7 Maintenance plan

A checklist of all required maintenance tasks and their recommended intervals to ensure the best economic scheduling is referred to as a maintenance plan. The intervals can vary according to the site condition and system type. For example, a PV array installed in the desert requires more frequent scheduled cleaning of modules due to dust and soil accumulation.

5. Conclusion

There are various factors that can impact the solar PV rooftop Performance Ratio. Some of these factors are outside the control of the plant operator (e.g., weather), while others are possible to impact by the operator's actions (e.g., dirty problems). Several factors that influence the Performance Ratio can be influenced at least through decisions taken in the solar PV rooftop design stage.

Factors over which there is little or no control:

1. Total incident sunlight
2. Spectral intensity of sunlight
3. Angle of incidence of light
4. Module temperature
5. Degradation of module efficiency
6. Degradation of module efficiency
7. Wiring losses

Factors over which we have some control:

1. Shadow (Shading)
2. Soiling
3. Damaged or defective module
4. Damaged or defective inverter
5. Wiring errors and minor component failures

To gain sustainability solar PV rooftop we should cover operation and maintenance due to the factors above.

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STANDALONE PV SYSTEM STUDY AND DESIGN FOR BINTUANG ISLAND, INDONESIA

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***Abstract*—This research designs a standalone photovoltaic system to meet the energy needs of Bintuang Island, Indonesia. Through economic and technical analysis using HOMER Pro and PVsyst software, it was found that the investment in this system has a positive economic value, with a Total Net Present Cost (NPC) of approximately IDR 1,709,623,000.00 and a Levelized Cost of Energy (COE) of about IDR 14,790.46. The system design includes 15.75 kWp solar panels, 92.3 kWh batteries, and 15 kW inverters. Implementing this design is expected to help Bintuang Island achieve energy independence, reduce its dependence on fossil fuels, and improve the quality of life for its residents. This research makes a significant contribution to the development of renewable energy in remote areas, providing long-term benefits to local communities and the environment.**

Keywords—Standalone PV System, Economic Analysis, Technical Analysis, HOMER Pro, PVsyst

I. INTRODUCTION

Indonesia is an archipelagic nation, holding the distinction of having one of the highest numbers of islands in the world, totaling 16,771 islands spanning from the Indian Ocean to the Pacific. This geographical diversity endows Indonesia with abundant natural resources, including significant potential for renewable energy, particularly in the form of solar energy. Despite its rich natural resources, a substantial challenge arises when discussing the provision of equitable and sustainable energy access across the nation. Remote islands in Indonesia often encounter difficulties in accessing the national electricity grid (PLN), resulting in a high dependence on expensive and high-risk fossil fuels.

The challenge of energy access is a complex and pressing issue. It not only affects the quality of life for local populations but also has substantial implications for economic growth and social opportunities in these regions [1]. Thus, meeting energy needs stands as a national priority in Indonesia.

A noteworthy fact is that electrification ratios in Indonesia remain uneven. While most areas in Indonesia have access to electricity, there are still regions falling below the 90% electrification threshold [2]. This situation creates disparities in access to energy resources, which, in turn, can constrain economic growth, quality of life, and opportunities for the residents in these areas.

To address these inequalities, the Indonesian government has taken serious initiatives to accelerate electricity supply to underdeveloped areas. This is reflected in Ministerial Regulation No. 38 of 2016, which governs the acceleration of electrification in underdeveloped rural areas, rural regions, border areas, and sparsely populated small islands[3]–[5]. Under this regulatory framework, the government is committed to providing broader and more affordable electricity access to all citizens without exception[6].

Despite advancements in this regard, the challenge of energy supply becomes more intricate when looking at remote islands like Bintuang Island. The limitations of infrastructure and access to conventional fossil fuels make sustainable solutions increasingly urgent. Standalone photovoltaic (PV) systems based on solar energy emerge as a promising alternative. These systems have the potential to enhance access to electricity, reduce environmental impacts, and create development opportunities in these remote islands[7], [8].

This research aims to assess the potential of standalone photovoltaic systems as a solution to meet the energy needs of Bintuang Island. Understanding the crucial role of sustainable energy in achieving national goals, this research seeks to provide insights and recommendations that can support government initiatives to expand electricity access in remote regions. By harnessing the potential of solar energy, it is hoped that Bintuang Island can achieve energy self-sufficiency and improve the quality of life for its residents.

II. METHODOLOGY

In the context of this research, the methodology comprises several key steps, including the evaluation of energy needs on Bintuang Island, the design of a standalone photovoltaic system, system performance simulation, and economic analysis. This research is grounded in the design of a solar power generation system based on two primary factors: the level of electricity demand at the location and the potential solar energy resources available. The estimation of electricity demand can be calculated based on the number of buildings and primary needs in the area, using survey data sourced from the South Nias Regency Central Statistics Agency and interviews with the local community[9]. Meanwhile, information about the potential solar energy resources is obtained from NASA and the Solar Global Atlas data. All relevant data will be collected through PVsyst and HOMER Pro software. PVsyst is used for designing the PV system, and HOMER Pro will be the application used to calculate financial metrics such as Net Present Cost (NPC), Levelized Cost of

Energy (LCOE), and Renewable Fraction (RF) of the proposed system[10].

A. Location Description

The research location is Bintuang Island, located in the western part of Indonesia. The island covers an area of 0.86 km^2 and has a population of 244 people, according to the 2023 data from the South Nias Regency Central Statistics Agency. The community settlements are divided into two centralized locations, with a distance of approximately 153 meters between them. In other words, residents living in these two settlement centers have relatively easy access to each other due to the short distance.

TABLE I. LOCATION DESCRIPTION DATA

Parameter	Value
Island Area	0.86 km^2
Geographic Coordinates	-00°06’12"S, 098°13’35"N
Population	244 people (Year 2023)
Elevation Above Sea Level	7 meters
Number of Residential Buildings	66
Number of Elementary Schools	1
Number of Churches	2

Fig. 1. Bintuang Island

B. Energy Needs Assessment

In this context, we conducted field surveys to identify energy needs in household, school, and church sectors. Primary needs such as lighting, water pumps, and information facilities will be the priorities. Energy consumption data were collected on a daily basis, with projections of energy demand growth. Additionally, data from the Ministry of Energy and Mineral Resources of the Republic of Indonesia were used as a reference. Based on the survey results, each type of load has an energy usage limitation of around 350 Wh per day.

TABLE II. DAILY ENERGY NEEDS DATA

Jenis Beban	Jumlah Pengguna	Energi (Wh)	Total (Wh)
Rumah Tangga	66	350	23100
Gereja	2	450	900
Sekolah Dasar	1	500	500
Total energi yang dapat digunakan			24500

C. Solar Energy Resources

Solar energy is a primary determinant in assessing the extent to which PV modules can generate sufficient electricity. One of the most critical parameters is the availability of solar energy in the research area. Data on average annual solar radiation on Bintuang Island can be obtained from databases provided by NASA.

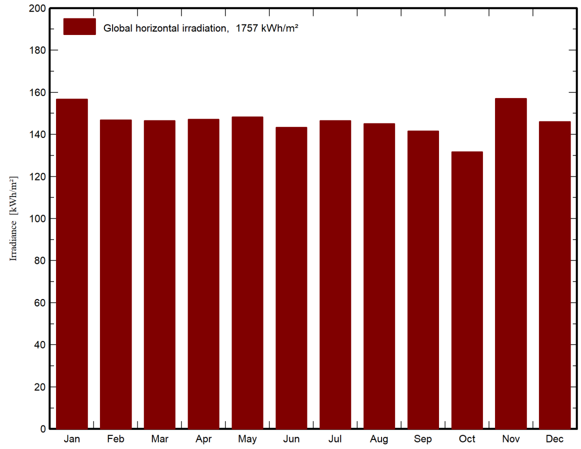

Fig. 2. Average Annual Solar Radiation Data on Bintuang Island

III. SYSTEM AND COMPONENTS

The standalone photovoltaic system designed for Bintuang Island consists of several key components that play a vital role in electricity generation, storage, and distribution. Here is a brief description of the main components used in the system:

- ***Photovoltaic Panels (PV)***: Photovoltaic panels are the primary components of the system. These panels are responsible for converting sunlight into electrical energy. PV panels will be strategically placed in locations with optimal levels of solar radiation.
- ***Batteries***: Batteries are used for energy storage. When the PV panels generate more energy than is needed, the excess energy is stored in batteries. This enables the use of solar energy when sunlight is not available, such as during the night or in adverse weather conditions.
- *Inverter*: The inverter is a component that converts the electrical current from DC (Direct Current) produced by the PV panels and batteries into AC (Alternating Current), which is used by various electrical loads on Bintuang Island.
- ***System Loads***: System loads include the daily energy needs on Bintuang Island, such as lighting, water pumps, school facilities, and churches. These daily energy requirements are derived from surveys and estimated in watt-hours (Wh).

In the double-bus system architecture, these components will be connected to the DC bus and AC bus. The DC bus is responsible for electricity generation and storage from the PV panels and batteries, while the AC bus manages the distribution of energy to various loads, including the system loads and backup generator if required.

This system is designed to provide sustainable and reliable access to electricity for the residents of Bintuang Island, with solar energy as the primary source, while also providing a backup option through a generator. Therefore, the system is expected to enhance the quality of life and support the development of the region.

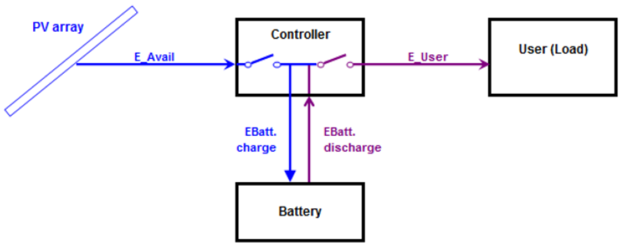

Fig. 3. System Architectural Design

In this standalone PV system design, several key components are involved to create a sustainable energy supply solution on Bintuang Island, Indonesia. The main components of the system include a 350 Wp Solar Panel, a 1.2 kWh capacity Battery, and a Bidirectional 5000VA Inverter. For detailed specifications, please refer to Table 3 to Table 5.

TABLE III. SOLAR MODULE SPECIFICATIONS

SUPSM - 350M672 MONOCRYSTALLINE	
Rated Power	350 kW
Vmpp	38.97 V
Impp	9.310 A
Voc	47.30
Isc	9.800 A
Power Tolerance	3%
Number of Churches	2

TABLE IV. BATTERY SPECIFICATIONS

Volta 6SB100	
Capacity at C10	100 Ah
Nominal Voltage	12 V
Lifetime	10 years
Stored energy at DoD	80%
Efficiency	97%
Technology	Lead Acid, sealed, Tubular
Temperature reference	20°C
Financial	
Capital Cost	Rp. 4,605,000
Replacement Cost	Rp. 4,605,000
O&M Cost	Rp. 184,200/year

TABLE V. INVERTER SPECIFICATIONS

Studer Xtender XTH 6000-48	
Rated Power	5000VA
Nominal Voltage	48 V
Efficiency	96%
Maximum charging current	100 A
Financial	
Capital Cost	Rp. 78,010,000
Replacement Cost	Rp. 78,010,000
O&M Cost	Rp. 3,120,000/year

IV. RESULTS AND ANALYSIS

After obtaining the dimensions of each system component, various scenarios were run through two different software applications. First, to identify the most economical scenario, HOMER Pro was used as the analysis tool. Subsequently, the technical aspects of the selected scenarios in each region were verified using PVSyst software. By combining these two software applications, this research allows for a deeper understanding of the economic and technical aspects of implementing a standalone photovoltaic system on Bintuang Island.

A. System Design Identification

In identifying various system design scenarios, the HOMER Pro application, developed by the National Renewable Energy Laboratory (NREL) for optimizing and analyzing the feasibility of the most economical system, was used. HOMER has the unique ability to search for the optimum combination of various system components, including wind turbines, solar panels (PV), hydro energy sources, and distributed generators.

To design a standalone photovoltaic system based on the conditions on Bintuang Island, a number of relevant daily load data parameters were input into HOMER. In this process, the latitude and longitude coordinates of the Bintuang Island area were also set to match the research location. The results of the design with HOMER include the average monthly electricity production and global horizontal radiation data, which are crucial for evaluating system performance. These data will be used to support system analysis and the selection of optimal scenarios.

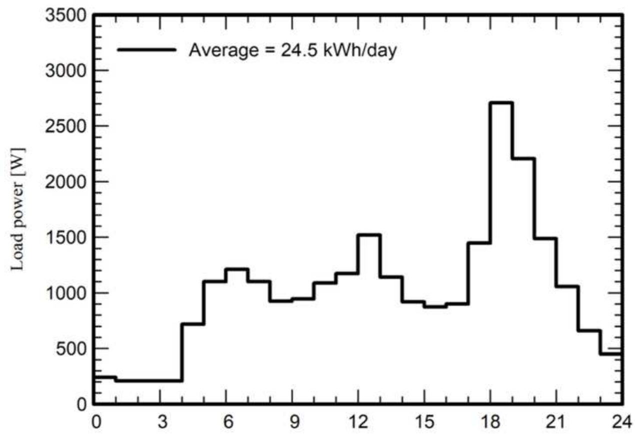

Fig. 4. Daily Load Data

In Figure 5, a schematic diagram of a 37.1 kW standalone photovoltaic system can be seen after adjusting the geographic coordinates. HOMER also provides information about the average monthly electricity production and hourly electricity production, which serve as references for evaluating system performance. All this data will form the basis for determining the best scenarios and further analysis related to the economic and technical implementation of a standalone photovoltaic system on Bintuang Island.

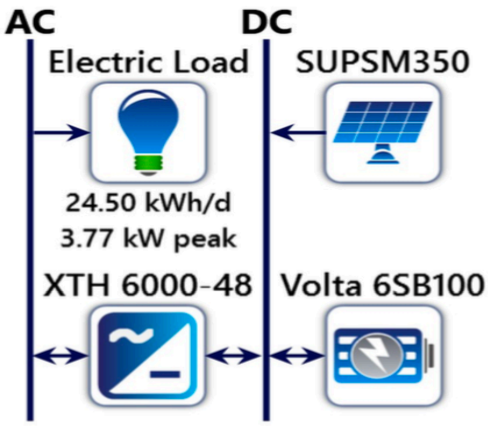

Fig. 5. Schematic Diagram of the Standalone System

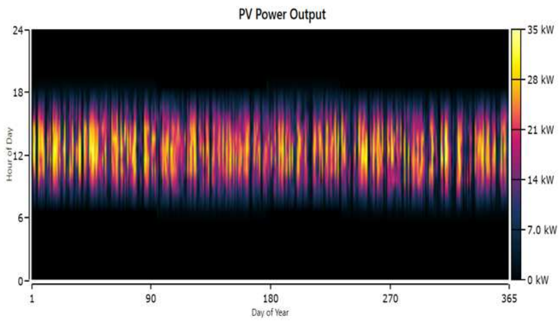

Fig. 6. PV Output

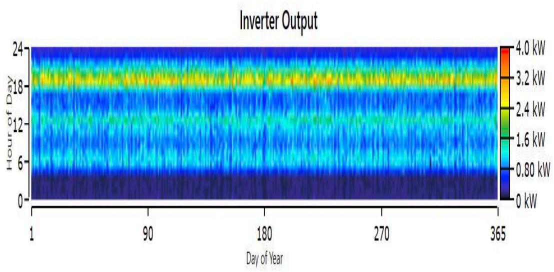

Fig. 7. Inverter Output

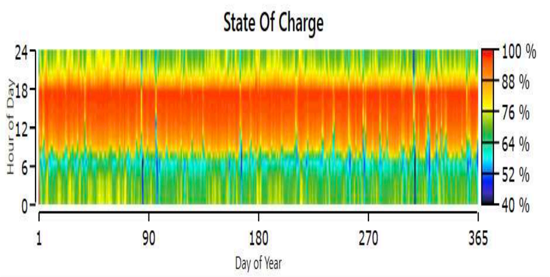

Fig. 8. Battery State of Charge

In addition to graphical data, HOMER also provides advanced data about the designed system as shown in Table 6.

TABLE VI. HOMER ANALYSIS RESULTS

Parameter	Value
PV Mean Output	143 kWh/day
The capacity factor of PV	16 %
Total Production of PV	52,071 kWh/year
Nominal Capacity of Battery	37 kWh
Battery Autonomy	21.8 hours
Lifetime Throughput of Battery	29600 kWh
Inverter mean Output	1.02 kW
Capacity factor of Inverter	27.8 %
Financial	
Total NPC	IDR 1,587,631,917.43
Levelized COE	IDR 13,783.07
Operating Cost	IDR 63,317,380

B. System Design Verification

After identifying the best scheme through HOMER Pro simulations, the next step is to verify the technical aspects of the design using PVsyst software. PVsyst allows for a more detailed technical analysis, considering various factors such as far shading, near shading/partial shading, losses, and other technical aspects. The goal of using PVsyst is to ensure that the system design meets all the required technical specifications.

PVsyst excels in meticulously considering component specifications. Additionally, the software simulates the system, considering various types of losses, including optical losses, losses in solar panels, losses in batteries, Maximum Power Point Tracking (MPPT) losses, losses in converters, and overall battery losses. All these losses are calculated based on primary energy source data in each region.

By using appropriate location data, optimal tilt angles, and parameters from Table 7, PVsyst can generate outputs, as shown in Table 6. Various outputs include loss diagrams, monthly normalized energy, daily input and output diagrams, and hourly electricity production profiles.

TABLE VII. ANALYSIS ADDITIONAL PARAMETERS

Parameter	Value
Azimuth	0°
Plane Tilt	13°
Technical specification	
PV Capacity	37.1 kW
Battery Capacity	37 kWh
Inverter Capacity	3.67 kW

After entering the specified parameters into the PVsyst system, there was a failure in implementing the design from HOMER. This was due to the very small inverter capacity in the HOMER design to handle the capacity of the solar modules. Figure 9 shows the failure in implementing the HOMER design.

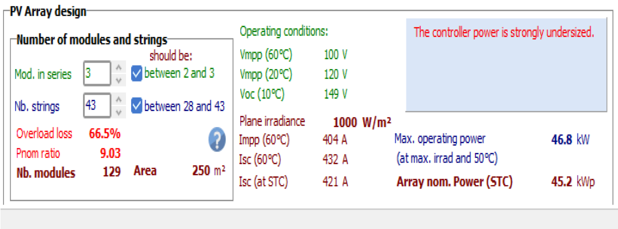

Fig. 9. Battery State of Charge

From this failure, design improvements were made by adjusting the capacity of each PV component. Some steps taken to address the design failure are as follows:

- Recalculating the capacity of each component.
- Ensuring that the new capacity estimates can run on both PVsyst and HOMER.
- After obtaining several feasible designs, technical and financial optimization is performed on each design.

C. *Final System Design*

After going through the technical verification stage, we found the optimal system design for implementation on Bintuang Island. In the PVsyst simulation, various data were obtained, including technical system parameters, as listed in the table below:

TABLE VIII. OPTIMIZATION RESULTS

Parameter	Value
PV Module	
Nominal Power of PV System	15.8 kWp
Quantity of PV Modules	45 units
PV Modules in Series	3
PV Modules in Parallel	15
Module Area	87.3 m^2
Battery	
Stored Energy	104 kWh
Capacity	2400 Ah
Quantity of Batteries	96 units
Batteries in Series	4
Batteries in Parallel	24
Inverter	
Nominal Power of Inverter	15 kW
Quantity of Inverters	3
System Kind	
System Production (kWh/year)	8942
Specific Production (kWh/kWp/year)	568
Available Solar Energy (kWh/kWp/year)	22472.20
Normalized Production (kWh/kWp/year)	1.56
Array Losses (kWh/kWp/year)	2.91
System Losses (kWh/kWp/year)	0.27
Useful energy from solar (kWh/year)	8,941.40
Available Energy (kWh/year)	22,150.87
Unused Energy	10,568.87
Performance Ratio	32.81 %
Missing Energy (kWh/year)	0

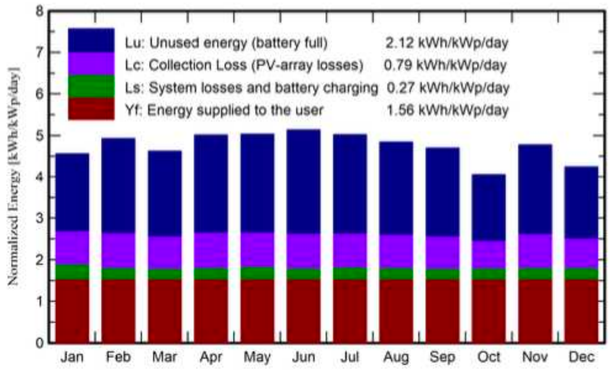

Fig. 10. Normalized Production (Per Installed Kwp)

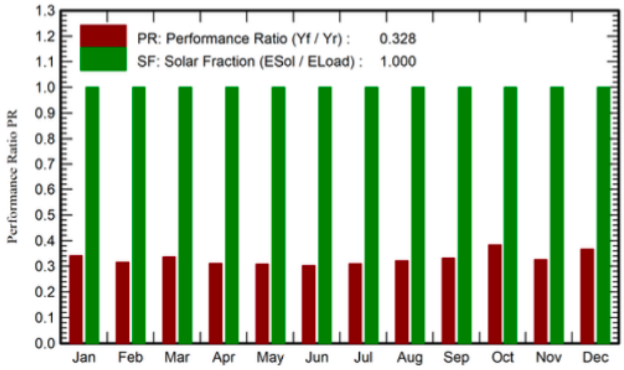

Fig. 11. Performance Ratio

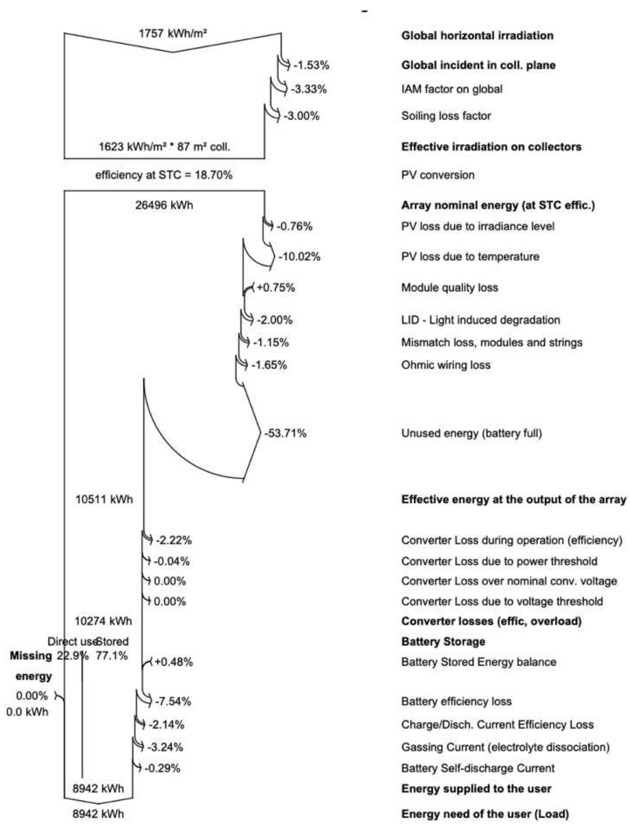

Fig. 12. Loss Diagram

In addition to the technical results generated by PVsyst, there are financial results obtained from HOMER Pro. Some of these parameters can be seen in the following table:

After going through the technical verification stage, we found the optimal system design for implementation on Bintuang Island. In the PVsyst simulation, various data were obtained, including technical system parameters, as listed in the table below:

TABLE IX. FINANCIAL ANALYSIS RESULTS OF SYSTEM DESIGN

Parameter	Value
Total NPC	IDR 1,709,623,000.00
Levelized COE	IDR 14,790.46
Operating Cost	IDR 69,646,030.00
Initial Capital	IDR 809,281,428.00
RF (Renewable Energy Fraction)	100%

V. CONCLUSION

In this research, an optimal standalone photovoltaic system has been identified and designed to meet the energy needs of Bintuang Island, Indonesia. This system involves key components such as solar panels with a capacity of 15.8 kWp, batteries with a capacity of 92.3 kWh, and 15 kW inverters. The economic analysis results indicate that the investment in this system has a positive economic value, with a Total Net Present Cost (NPC) of approximately IDR 1,709,623,000.00 and a Levelized Cost of Energy (COE) of about IDR 14,790.46.

In terms of technical aspects, the use of HOMER Pro and PVsyst software allows for the identification of the best scenarios and a detailed verification of the system design. After overcoming some technical challenges, a system design that meets the required technical specifications was found.

With this optimal standalone photovoltaic system design, it is expected that Bintuang Island can achieve energy independence, reduce dependence on fossil fuels, and improve the quality of life for its residents. Initiatives like this reflect positive steps toward achieving the national goal of providing equitable and sustainable access to electricity across Indonesia.

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Development of a 5.2 kWp Photovoltaic Lab for Renewable Energy Advancement in Indonesia

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***Abstract*— The Photovoltaic Laboratory at Atma Jaya Catholic University of Indonesia (ATM) stands as a pioneering initiative in the realm of renewable energy technology. Situated in a carefully chosen location to optimize solar radiation, this laboratory embodies the potential of photovoltaic (PV) systems in addressing energy challenges. With a capacity of 5.25 kWp spread across 30m², it harnesses approximately 18.9 kWh of solar energy daily, either for immediate use or storage in LiFePO4 batteries totaling 10.2 kWh. The laboratory operates both off-grid and on-grid modes, showcasing versatility in adapting to diverse energy demands. Integrated monitoring systems, both local and remote, enable comprehensive real-time management. Through meticulous testing and experimentation, this research substantiates the laboratory's efficacy across various operational modes. The ATM Photovoltaic Laboratory emerges not only as a research center but also as a beacon for renewable energy innovation, offering practical solutions for sustainable energy generation and paving the way for future energy advancements.**

Keywords—Photovoltaic Laboratory, Renewable Energy, Solar Energy, Monitoring Systems.

I. Introduction

Energy has been the backbone of human development throughout history. However, with the current global dynamics, energy crises and environmental impacts have prompted an urgent need to transition towards more sustainable energy sources. The limitations of non-renewable fossil fuels and their adverse environmental impacts have spurred the quest for alternative solutions [1]. In this context, renewable energy technologies, particularly photovoltaic (PV) systems, have emerged as potential balancers in the global energy equation.

Indonesia, as an archipelagic nation with abundant solar potential, faces similar challenges in meeting increasing energy demands while maintaining environmental balance. In this regard, investing in photovoltaic technology in Indonesia is not only a necessity but also a strategic step supporting global efforts to curb carbon emissions and reduce dependence on fossil fuels. To address this challenge sustainably, the Indonesian government has set an ambitious target to achieve 25% utilization of renewable energy by 2025 [2]. In response to this urgent need, initiatives promoting the adoption and advancement of renewable energy technologies, such as photovoltaic systems, are crucial [3], [4].

Universitas Katolik Atma Jaya Indonesia (ATM) stands as a pioneer in promoting innovation in the field of renewable energy. Their commitment to bringing sustainable solutions is evident in their efforts to construct an advanced photovoltaic laboratory as a facility for education, research, and the development of cutting-edge technology [5]–[7]. With a focus on the development of a 5.2 kWp photovoltaic laboratory at the Bumi Serpong Damai (BSD) campus, ATM positions itself as a trailblazer in introducing this technology within the unique local context of Indonesia.

The subsequent sections of this paper will delve into the description of the proposed system, architecture, and components of the photovoltaic laboratory, operational system, monitoring and communication systems, as well as the results and discussion. The aspiration of this initiative is not only to facilitate academic and research activities but also to serve as a practical example of harnessing solar energy for sustainable electricity generation.

II. Description of the Proposed System

The proposed photovoltaic laboratory is situated within Campus 3 Atma Jaya, Bumi Serpong Damai, strategically designed to optimize available solar radiation. This area is purposefully devoid of tall buildings, allowing photovoltaic (PV) panels to maximize solar radiation absorption, as depicted in Figure 1 based on data from the Global Solar Atlas.

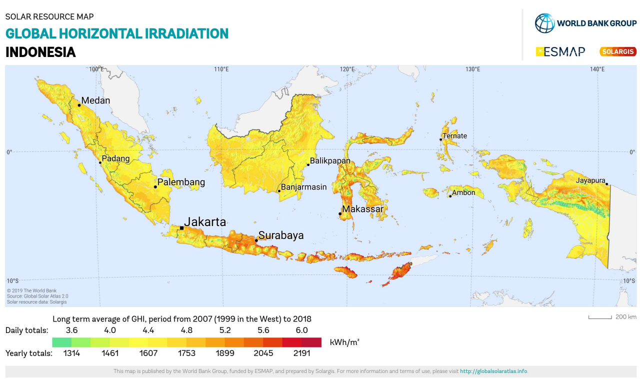

Figure 1. Solar Radiation in Indonesia

The PV system to be installed will have a capacity of 5.25 kWp and will occupy a 30 m2 area carefully chosen to avoid hindrances such as tall trees or buildings. This location is planned as an open space to facilitate maximum solar radiation absorption. It is estimated that the solar energy obtainable daily is around 3.6 kWh with a 1 kWp system. Therefore, with the planned 5.25 kWp system, the anticipated daily energy production is estimated to reach 18.9 kWh. The generated electrical energy can either be utilized immediately or stored in LiFePO4 batteries with a total storage capacity of 10.2 kWh.

The PV system is intended to power several devices such as air conditioning units, water pumps, lighting, and PCs. Presently, the electrical load system is supplied by a low-voltage network and operates independently from the main campus supply. For the time being, the PV system is controlled to prevent energy supply to the network, while the grid is solely used as a reference for voltage and frequency.

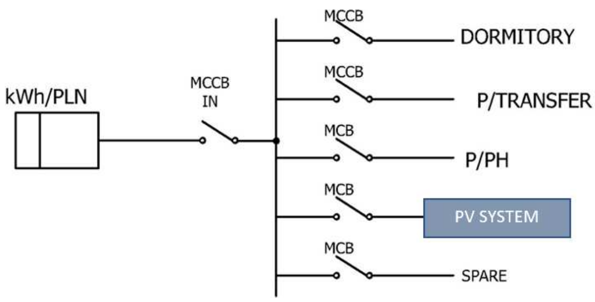

Figure 2. Diagram illustrating the connection scheme to the grid and ATM Dormitory

The proposed system can operate in various modes, including an on-grid PV system connected to the main network through a bidirectional inverter. Furthermore, this system can operate in parallel with other PV systems using solar inverters. This flexibility allows for diverse functionalities and adaptation to the campus's energy needs and various operational scenarios.

III. Architecture and Components of the Photovoltaic Laboratory

The photovoltaic laboratory is constructed on an open area spanning 30 m2, elevated 3 meters above the ground level. The mounting panel structure's orientation comprises an azimuth angle of 7° and a tilt/elevation angle of 10°.

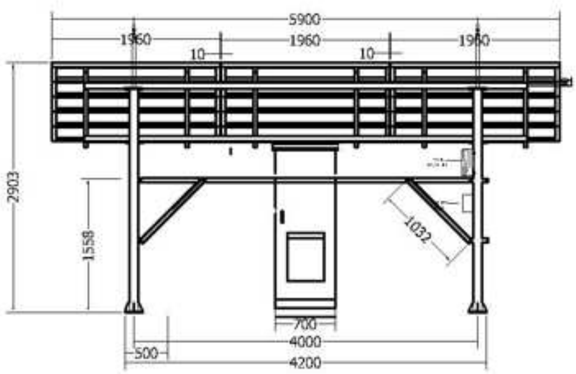

Figure 3. Front View of the Laboratory Structure

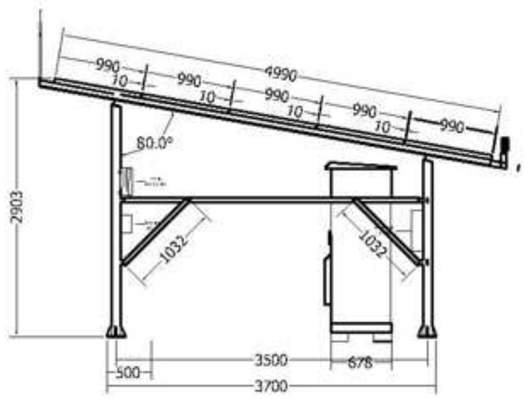

Figure 4. Side View of the Laboratory Structure

Various components supporting the photovoltaic laboratory system include:

1) Photovoltaic Modules: Monocrystalline silicon solar modules with a capacity of 350 Wp and an efficiency of 18% are used. There are 15 modules arranged in two circuits. The first circuit consists of seven series-connected modules for the on-grid system. The second circuit comprises four strings, each composed of two modules.

2) Battery Inverter: This inverter operates in off-grid mode with a total output power of 3500 VA and operates bidirectionally. The inverter output is 220 V, 50 Hz, single-phase, with a pure sine wave form. The input to this inverter is 48 V, while the AC input voltage ranges from 160 V to 250 V with a frequency of 45 Hz to 60 Hz. The inverter is equipped with LED/LCD displays, battery management systems, and power control to optimize system performance.

3) Solar Charge Controller: This component regulates battery charging with a capacity of 4 kWp and utilizes MPPT (Maximum Power Point Tracking) control algorithms. The nominal input voltage is 48 V, and this controller is equipped with protection systems to prevent overloading, reverse polarity, and voltages above and below safe limits.

4) Solar Inverter: This inverter is used in on-grid mode with an output power of 2.5 kW. It generates an output voltage of 230 V in a single phase with a pure sine wave form. Equipped with web-based communication interfaces for remote monitoring to optimize system performance.

5) Battery Bank: For energy storage, LiFePo4 battery banks with an output voltage of 51.2 V and a total storage capacity of 10,000 Wh are employed. These batteries have a charging capacity of up to 2000 times with a usage capacity of up to 90%.

6) Dummy Load: The Photovoltaic Laboratory uses fabricated load components to simulate various load conditions in the photovoltaic system. The dummy load components consist of resistors with resistances of 2 kW and 3 kW, along with 6 lamps of 100 W each. Resistors are used to simulate constant power loads or load variations, while lamps simulate different power consumption in the PV system. This combination allows testing and validation of the PV system's performance in various scenarios without requiring real equipment.

IV. OPERATIONAL SYSTEM

The photovoltaic laboratory can operate in several modes, including as an on-grid PV system, an off-grid PV system, or both simultaneously. In the on-grid PV mode, the system is connected to the main electrical grid through a solar inverter and consists of seven panels connected in series. In this system, there is integration with a pyranometer and weather station, acting as the primary data center for solar radiation and weather conditions.

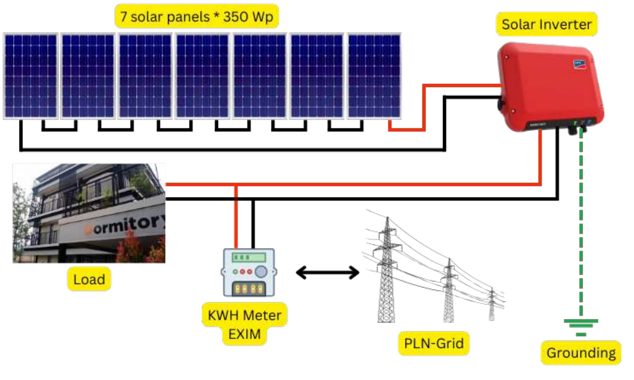

Figure 6. On-grid Mode

In the off-grid PV mode, the system operates independently without connection to the main electrical grid. This system is supported by eight solar panels, each string consisting of two panels connected in series, integrated with a solar charge controller to regulate the battery and a battery inverter to convert DC electricity into AC electricity according to the load requirements. The system has an energy storage capacity of 10 kWh.

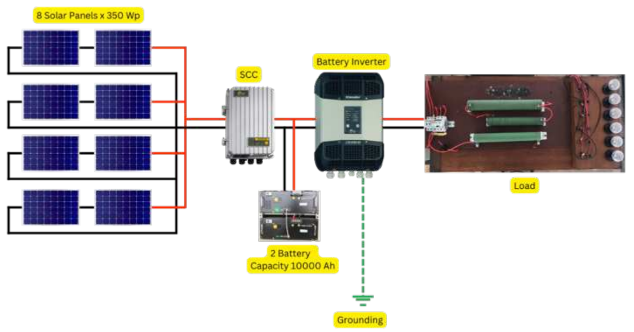

Figure 7. Off-grid Mode

These two modes can interconnect in a hybrid mode, allowing collaborative operation. In the hybrid mode, the battery inverter acts as a battery regulator to control power export-import to and from the battery.

V. MONITORING AND COMMUNICATION SYSTEM

The integrated monitoring and communication system serve as vital elements in the operational framework of the photovoltaic laboratory. This system encompasses two primary aspects: local and remote monitoring to ensure optimal performance and efficient control settings.

1) Local Monitoring: The local monitoring system utilizes the RCC-03 display integrated with various sensors and control devices within the photovoltaic laboratory. This display offers detailed information regarding the system's performance, such as energy production levels, solar panel efficiency, battery status, and device energy consumption. Users have direct access to monitor system operations and control settings, responding to immediate needs directly from the laboratory location.

2) Remote Monitoring: In the off-grid monitoring mode, the system employs Programmable Logic Controller (PLC) technology and Supervisory Control and Data Acquisition (SCADA). The PLC plays a role in automatically controlling various operational aspects of the system. Simultaneously, SCADA acts as a user interface allowing remote monitoring and control via an internet connection. Through SCADA, system administrators can monitor real-time system performance, receive status-related notifications, and make necessary adjustments and configurations.

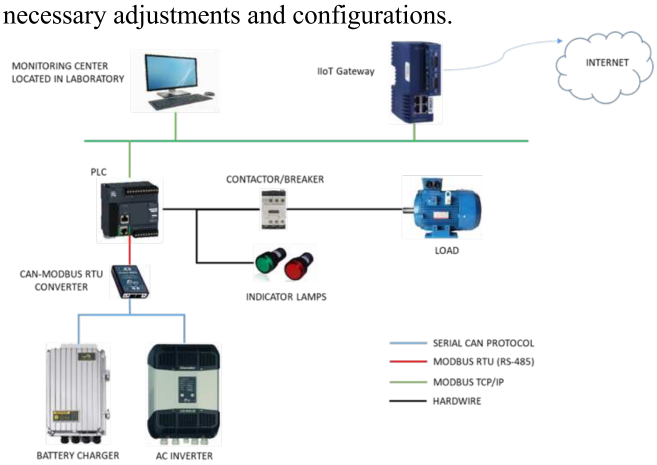

Figure 8. Remote Monitoring Architecture Scheme in Off-Grid Mode

3) Integration with Online System: In the on-grid mode, there exists a web-based monitoring system integrated with a pyranometer (a device measuring solar radiation) and a weather station sensor. This system is accessible through an online platform, enabling system managers to observe actual data regarding solar radiation and weather conditions in real-time. This information provides crucial insights into the surrounding environmental conditions that can influence the performance of the photovoltaic system.

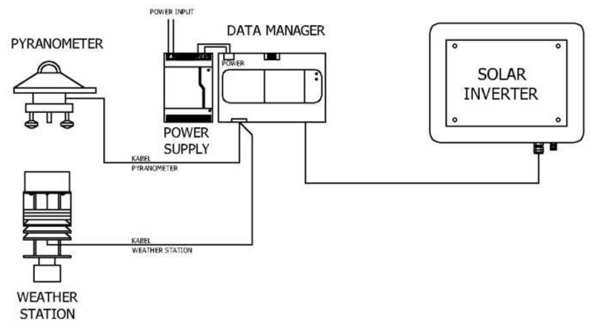

Figure 9. Communication and Monitoring One-Line Diagram in On-Grid Mode

The integration of the local monitoring system, remote control, and online platform allows comprehensive management of the photovoltaic system. This capability empowers users to effectively and efficiently monitor, manage, and optimize system performance, whether from the laboratory location or remotely, according to the operational needs and conditions at hand.

VI. Results and Discussion

Following commissioning and testing, the photovoltaic laboratory has successfully operated in various predetermined modes. Visual representations of the laboratory and indoor equipment are presented. Experiments were conducted to verify the previously conducted analyses. The operational modes were validated through parameter monitoring in both off-grid and on-grid modes.

Laboratory Overview:

Figure 10. Atma Jaya University Photovoltaic Laboratory

Figure 11. Indoor Photovoltaic Laboratory Equipment

Monitoring and Experimental Results:

Figure 12. Local Monitoring Results with RCC-03 in Off-Grid Mode

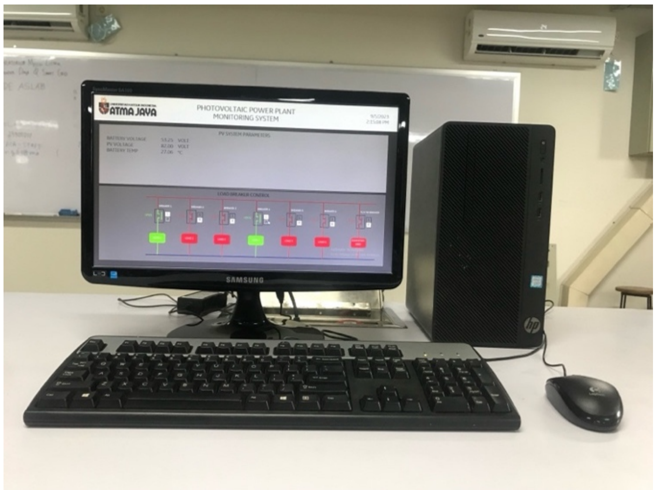

Figure 13. Remote Monitoring Results in Off-Grid Mode

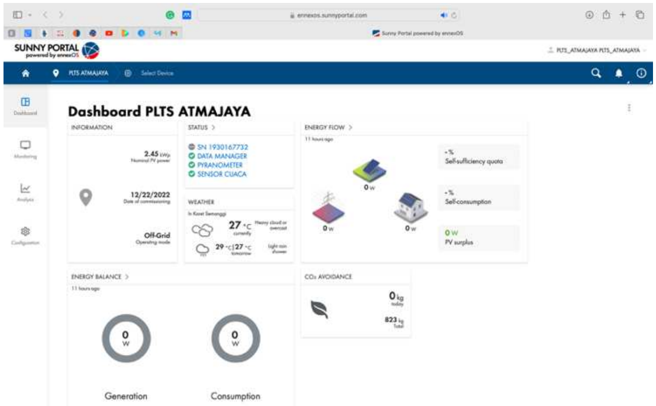

Figure 14. Remote Monitoring Results in On-Grid Mode

From these images and monitoring results, the Atma Jaya University's photovoltaic laboratory has demonstrated its success in operating in various modes. It exhibits detailed parameters and system performance observed comprehensively in both off-grid and on-grid situations.

VII. Conclusion

In exploring renewable energy technology, the photovoltaic laboratory of Atma Jaya Catholic University of Indonesia (ATM) has demonstrated its potential as a facility supporting the development of efficient and sustainable photovoltaic systems. Various operational modes have been tested and validated, showing the laboratory's ability to operate independently in off-grid mode, connect to the grid in on-grid mode, and operate in a hybrid manner.

This investigation provides evidence that the implementation of photovoltaic technology can be effectively adapted in local contexts such as Indonesia, particularly by optimizing abundant solar resources. The laboratory's capability to monitor, control, and provide comprehensive experimental experiences is a significant step in the development of renewable energy technology in Indonesia.

With good infrastructure availability and meticulous monitoring, this laboratory has proven its potential in contributing to research, technological innovation, and education related to renewable energy, particularly in implementing photovoltaic systems. In conclusion, the ATM photovoltaic laboratory is not only a research and development center but also an inspiration for enhancing solar energy utilization towards achieving energy sustainability in the future.

ACKNOWLEDGMENT

This work was supported by the Erasmus+ Programmed of the European Union: Capacity Building within the Field of Higher Education eACCESS (EU-Asia Collaboration for accessible Education in Smart Power Systems) Project number: 610041-EPP-1-2019-1-PL-EPPKA2-CBHE-JP.

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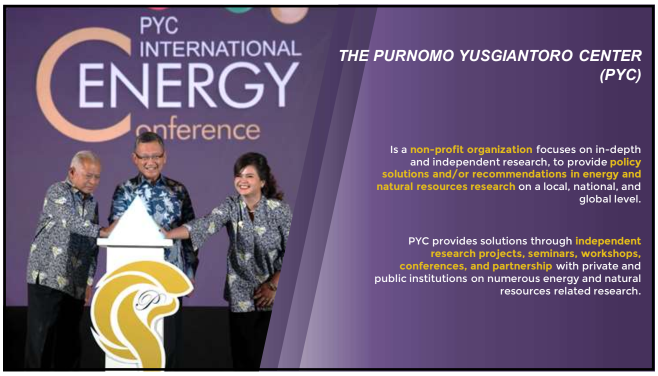
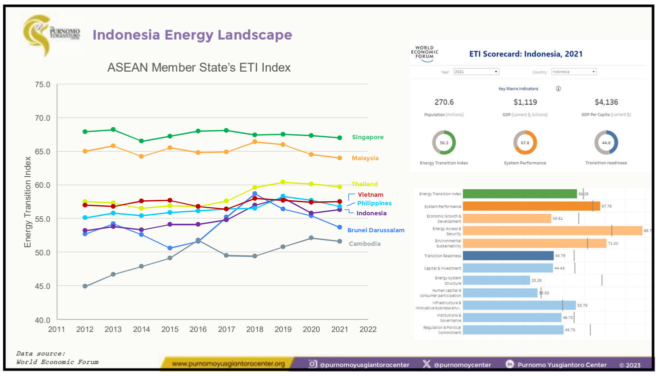
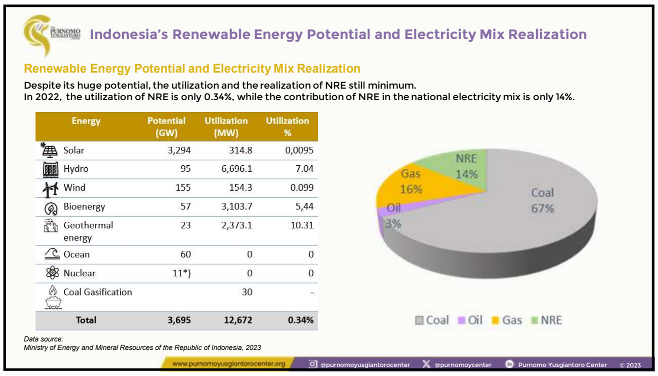
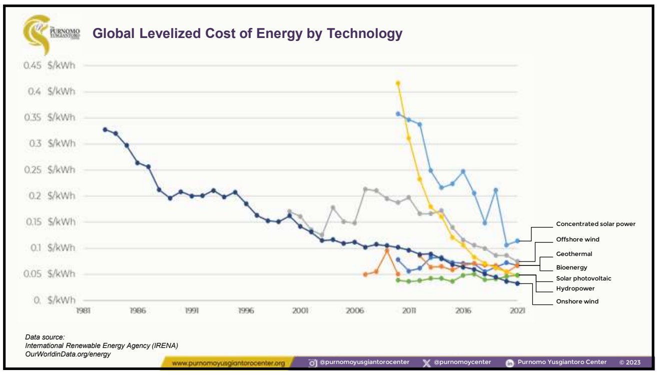
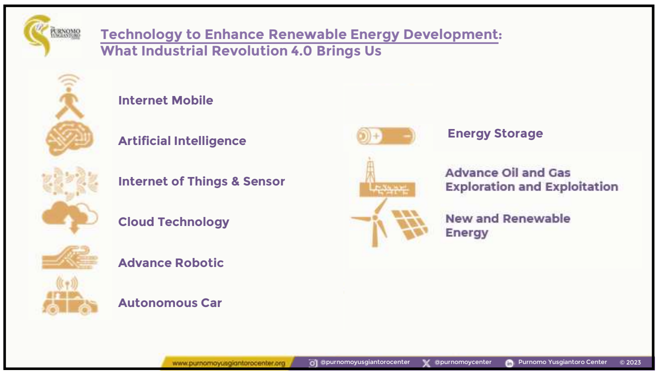


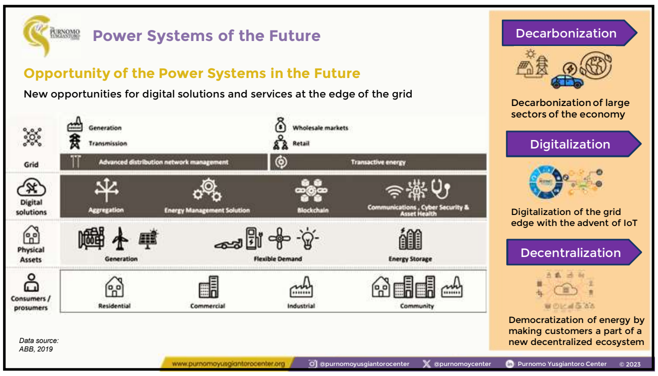




Energy	Potential (GW)	Utilization (MW)	Utilization %
Solar	3,294	314.8	0,0095
Hydro	95	6,696.1	7.04
Wind	155	154.3	0.099
Bioenergy	57	3,103.7	5,44
Geothermal energy	23	2,373.1	10.31
Ocean	60	0	0
Nuclear	11*)	0	0
Coal Gasification		30	-
Total	3,695	12,672	0.34%






Power Systems of the Future
Opportunity of the Power Systems in the Future
New opportunities for digital solutions and services at the edge of the grid
Grid
Generation
Transmission
Wholesale markets
Retail
Advanced distribution network management
Transactive energy
Digital solutions
Aggregation
Energy Management Solution
Blockchain
Communications , Cyber Security & Asset Health
Physical Assets
Generation
Flexible Demand
Energy Storage
Consumers / prosumers
Residential
Commercial
Industrial
Community
Decarbonization
Decarbonization of large sectors of the economy
Digitalization
Digitalization of the grid edge with the advent of IoT
Decentralization
Democratization of energy by making customers a part of a new decentralized ecosystem
Data source: ABB, 2019
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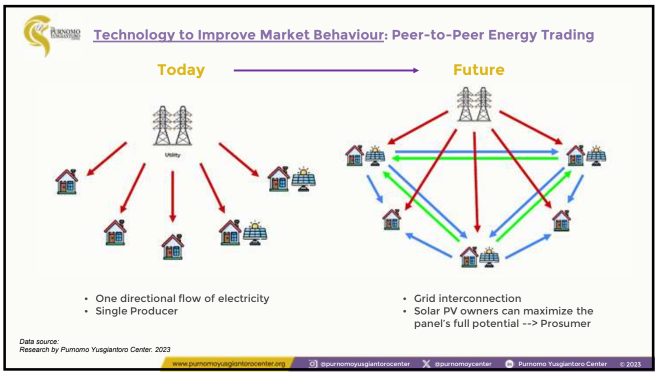
Technology to Improve Market Behaviour: Peer-to-Peer Energy Trading
Today
Future
Utility
One directional flow of electricity
Single Producer
Grid interconnection
Solar PV owners can maximize the panel's full potential --> Prosumer
Data source: Research by Purnomo Yusgiantoro Center. 2023
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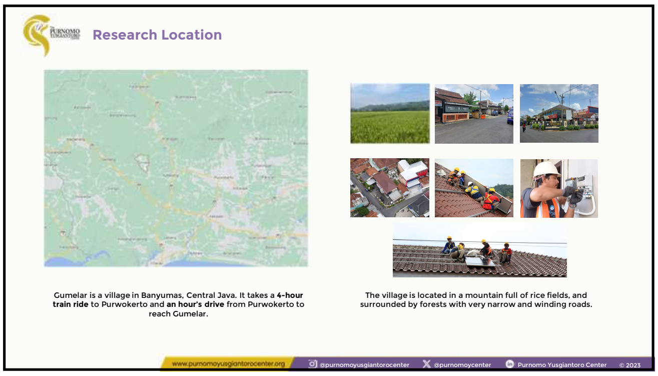
Research Location
Gumelar is a village in Banyumas, Central Java. It takes a 4-hour train ride to Purwokerto and an hour's drive from Purwokerto to reach Gumelar.
The village is located in a mountain full of rice fields, and surrounded by forests with very narrow and winding roads.
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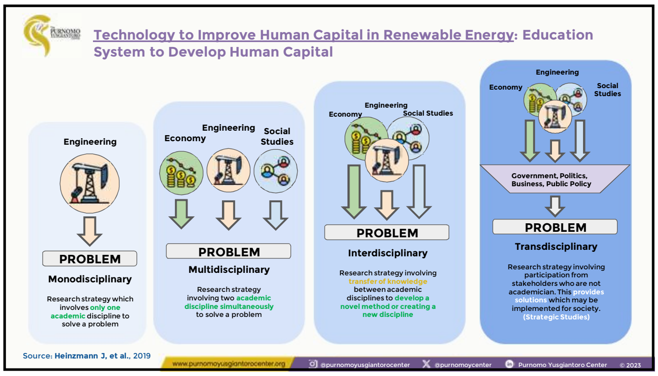
Technology to Improve Human Capital in Renewable Energy: Education System to Develop Human Capital
Engineering
PROBLEM
Monodisciplinary
Research strategy which involves only one academic discipline to solve a problem
Economy
Engineering
Social Studies
PROBLEM
Multidisciplinary
Research strategy involving two academic discipline simultaneously to solve a problem
Economy
Engineering
Social Studies
PROBLEM
Interdisciplinary
Research strategy involving transfer of knowledge between academic disciplines to develop a novel method or creating a new discipline
Economy
Engineering
Social Studies
Government, Politics, Business, Public Policy
PROBLEM
Transdisciplinary
Research strategy involving participation from stakeholders who are not academician. This provides solutions which may be implemented for society. (Strategic Studies)
Source: Heinzmann J, et al., 2019
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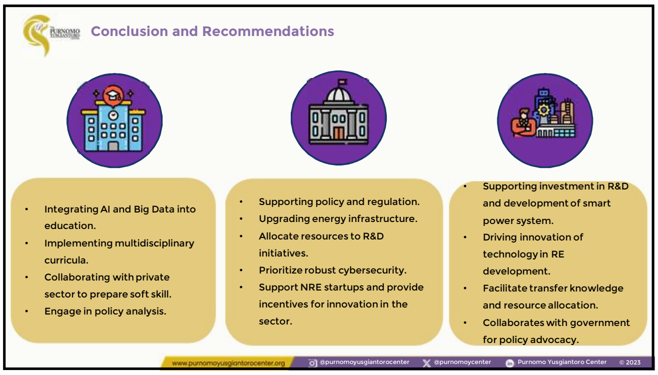
Conclusion and Recommendations
Integrating AI and Big Data into education.
Implementing multidisciplinary curricula.
Collaborating with private sector to prepare soft skill.
Engage in policy analysis.
Supporting policy and regulation.
Upgrading energy infrastructure.
Allocate resources to R&D initiatives.
Prioritize robust cybersecurity.
Support NRE startups and provide incentives for innovation in the sector.
Supporting investment in R&D and development of smart power system.
Driving innovation of technology in RE development.
Facilitate transfer knowledge and resource allocation.
Collaborates with government for policy advocacy.
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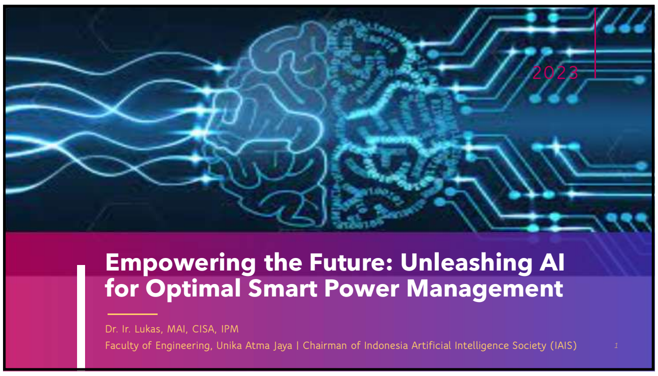
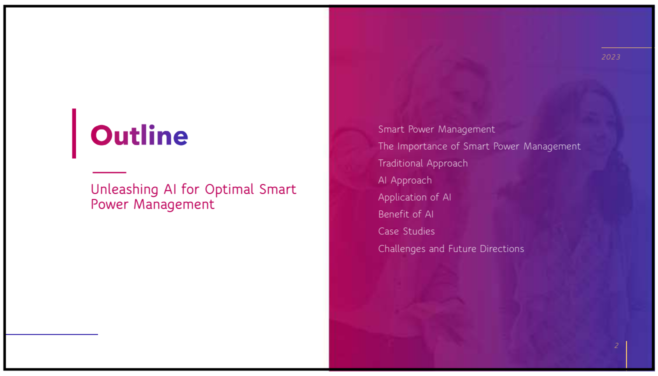
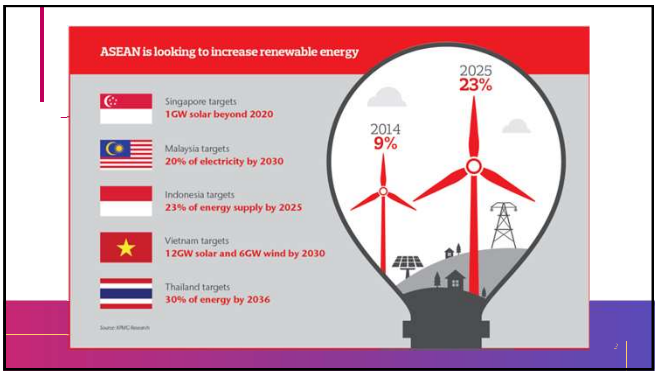
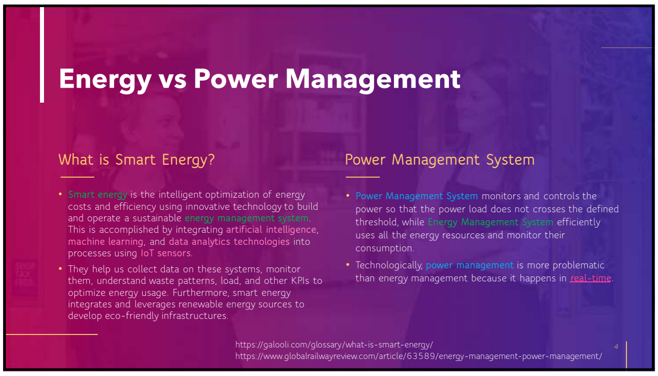
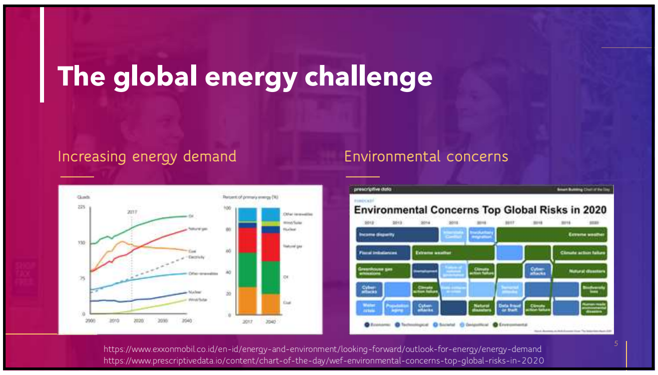
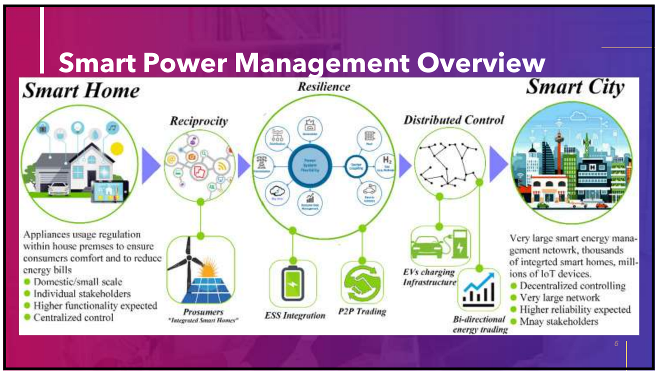

2023
Empowering the Future: Unleashing AI for Optimal Smart Power Management
Dr. Ir. Lukas, MAI, CISA, IPM
Faculty of Engineering, Unika Atma Jaya | Chairman of Indonesia Artificial Intelligence Society (IAIS)
1


Outline
Unleashing AI for Optimal Smart Power Management
2023
Smart Power Management
The Importance of Smart Power Management
Traditional Approach
AI Approach
Application of AI
Benefit of AI
Case Studies
Challenges and Future Directions
2


ASEAN is looking to increase renewable energy
Singapore targets
1GW solar beyond 2020
Malaysia targets
20% of electricity by 2030
Indonesia targets
23% of energy supply by 2025
Vietnam targets
12GW solar and 6GW wind by 2030
Thailand targets
30% of energy by 2036
2014
9%
2025
23%
3

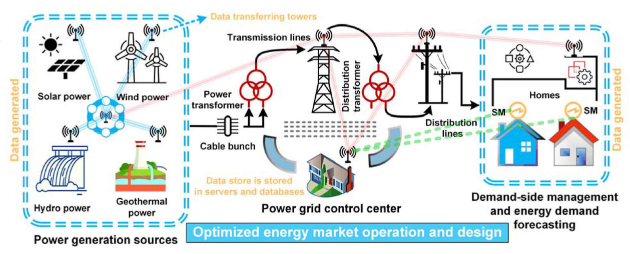

Energy vs Power Management
What is Smart Energy?
Smart energy is the intelligent optimization of energy costs and efficiency using innovative technology to build and operate a sustainable energy management system. This is accomplished by integrating artificial intelligence, machine learning, and data analytics technologies into processes using IoT sensors.
They help us collect data on these systems, monitor them, understand waste patterns, load, and other KPIs to optimize energy usage. Furthermore, smart energy integrates and leverages renewable energy sources to develop eco-friendly infrastructures.
Power Management System
Power Management System monitors and controls the power so that the power load does not crosses the defined threshold, while Energy Management System efficiently uses all the energy resources and monitor their consumption.
Technologically, power management is more problematic than energy management because it happens in real-time.
https://galooli.com/glossary/what-is-smart-energy/
https://www.globalrailwayreview.com/article/63589/energy-management-power-management/
4


The global energy challenge
Increasing energy demand
Environmental concerns
Environmental Concerns Top Global Risks in 2020
https://www.exxonmobil.co.id/en-id/energy-and-environment/looking-forward/outlook-for-energy/energy-demand
https://www.prescriptivedata.io/content/chart-of-the-day/wef-environmental-concerns-top-global-risks-in-2020
5


Smart Power Management Overview
Smart Home
Reciprocity
Resilience
Distributed Control
Smart City
Appliances usage regulation within house premses to ensure consumers comfort and to reduce energy bills
Domestic/small scale
Individual stakeholders
Higher functionality expected
Centralized control
Prosumers
"Integrated Smart Homes"
ESS Integration
P2P Trading
EVs charging Infrastructure
Bi-directional energy trading
Very large smart energy management netowrk, thousands of integrted smart homes, millions of IoT devices.
Decentralized controlling
Very large network
Higher reliability expected
Mnay stakeholders
6

What is Smart Power Management?

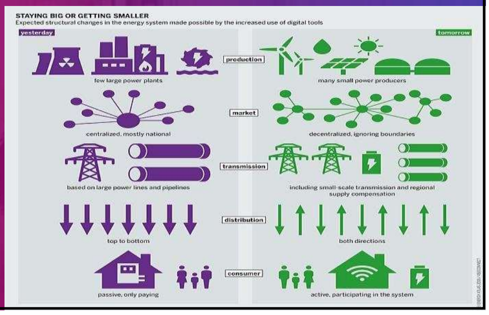
Big data and AI applications.



https://www.sciencedirect.com/science/article/abs/pii/S0959652621000548

Conventional vs Smart Power Grid

Key objectives:
- reliability
- Efficiency
- cost savings



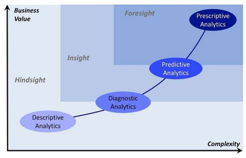
https://www.researchgate.net/figure/Smart-grid-and-conventional-power-system-Wikipedia-2016_fig2_357932910

AI in Smart Power Management

The role of Artificial Intelligence

- Machine Learning for data analysis
- Predictive analytics for demand forecasting
- Decision support systems

The evolutionary model of analytics

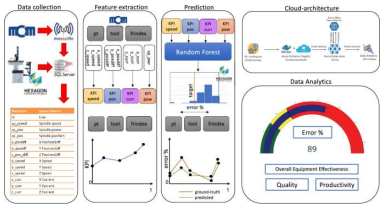


https://tdwi.org/articles/2018/07/24/bi-all-analytics-one-scenario-in-decision-making-support.aspx

Applications of AI in Smart Power Management

Grid Optimization

- Predictive maintenance
- Demand-side management
- Renewable energy integration
- Microgrid control

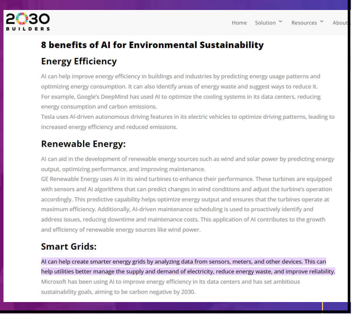


https://link.springer.com/article/10.1007/s10845-022-01960-x

Benefits of AI in Smart Power Management

- **Increased efficiency and reliability**
- **Cost savings**
- **Reduced environmental impact**
- **Enhanced customer experience**

https://2030.builders/8-ways-ai-can-contribute-to-environmental-conservation



2030 BUILDERS — Home Solution Resources About

8 benefits of AI for Environmental Sustainability

Energy Efficiency

AI can help improve energy efficiency in buildings and industries by predicting energy usage patterns and optimizing energy consumption. It can also identify areas of energy waste and suggest ways to reduce it.
For example, Google's DeepMind has used AI to optimize the cooling systems in its data centers, reducing energy consumption and carbon emissions.
Tesla uses AI-driven autonomous driving features in its electric vehicles to optimize driving patterns, leading to increased energy efficiency and reduced emissions.

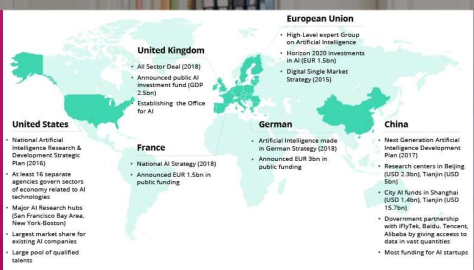
Renewable Energy:

AI can aid in the development of renewable energy sources such as wind and solar power by predicting energy output, optimizing performance, and improving maintenance.
GE Renewable Energy uses AI in its wind turbines to enhance their performance. These turbines are equipped with sensors and AI algorithms that can predict changes in wind conditions and adjust the turbine's operation accordingly. This predictive capability helps optimize energy output and ensures that the turbines operate at maximum efficiency. Additionally, AI-driven maintenance scheduling is used to proactively identify and address issues, reducing downtime and maintenance costs. This application of AI contributes to the growth and efficiency of renewable energy sources like wind power.

Smart Grids:

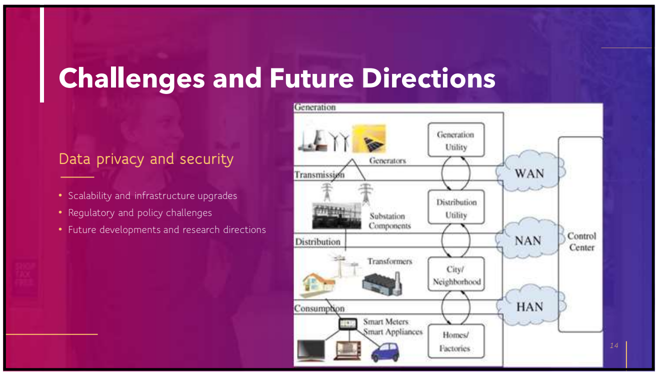
AI can help create smarter energy grids by analyzing data from sensors, meters, and other devices. This can help utilities better manage the supply and demand of electricity, reduce energy waste, and improve reliability.
Microsoft has been using AI to improve energy efficiency in its data centers and has set ambitious sustainability goals, aiming to be carbon negative by 2030.

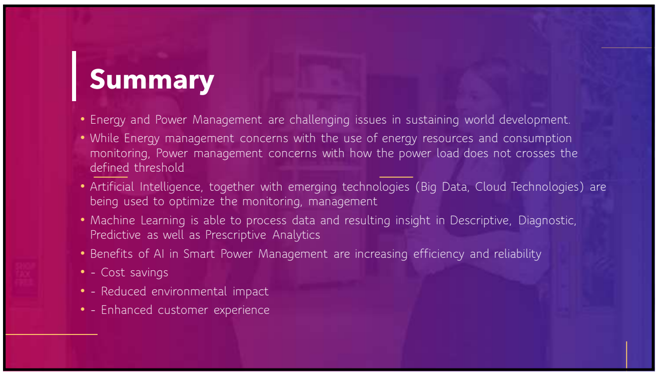
Top uses of AI in the energy sector



https://intellias.com/opportunities-and-challenges-of-artificial-intelligence-in-the-energy-sector/


How AI is used in the Energy Sector


Challenges and Future Directions
Data privacy and security
• Scalability and infrastructure upgrades
• Regulatory and policy challenges
• Future developments and research directions
Generation
Generators
Transmission
Substation Components
Distribution
Transformers
Consumption
Smart Meters Smart Appliances
Generation Utility
Distribution Utility
City/ Neighborhood
Homes/ Factories
WAN
NAN
HAN
Control Center


Summary
• Energy and Power Management are challenging issues in sustaining world development.
• While Energy management concerns with the use of energy resources and consumption monitoring, Power management concerns with how the power load does not crosses the defined threshold
• Artificial Intelligence, together with emerging technologies (Big Data, Cloud Technologies) are being used to optimize the monitoring, management
• Machine Learning is able to process data and resulting insight in Descriptive, Diagnostic, Predictive as well as Prescriptive Analytics
• Benefits of AI in Smart Power Management are increasing efficiency and reliability
• - Cost savings
• - Reduced environmental impact
• - Enhanced customer experience


PATTERN RECOGNITION
ARTIFICIAL INTELLIGENCE
MACHINE LEARNING
AUTOMATION
NEURAL NETWORKS
DATA MINING
ALGORITHM
PROBLEM SOLVING
THANK YOU!
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Comparison of Flipped classroom teaching methods for Power engineering subjects

7 Nov 2023

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eACCESS

EU-Asia Collaboration for aCcessible Education in Smart Power Systems

Contents

eAccess project aim and objectives

- eACCESS project
- "Accessible education" and "the exchange of good practices" in the field of Power and Electrical (PE) Engineering
- Many innovative teaching and assessment methods
- Different ways to implement Flipped classroom

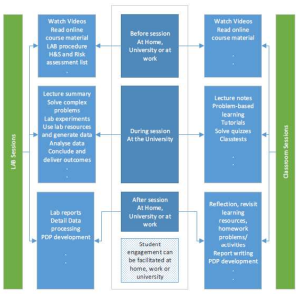


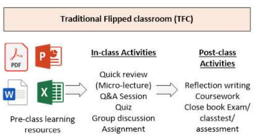
Figure 4.2 Different student engagement scenarios and associated resources/activities

eAccess project aim and objectives

- Objectives:
- Investigate Flipped classroom pedagogical approaches
- Develop teaching and Learning resources
- Implement a methodology
- Run a pilot study and capture students' experience
- Result evaluation and conclusion

Traditional Flipped classroom (TFC)

- The basic principles of a flipped classroom teaching method are to deliver "learning resources" before the scheduled class and to facilitate "active learning" during the classroom session.
- Post class activities: Consolidation and assessment
- Traditional Flipped class-room (TFC) includes: notes/chapters/presentations/work examples
- physical notes,
- Digital reading copies (pdf, docx, ppts etc),

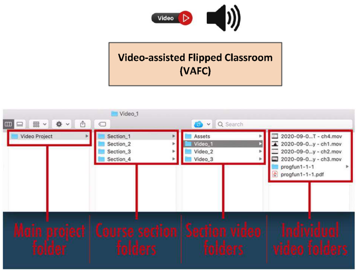


Video assisted pedagogy

- Video assisted learning is exploited in the Flipped class-room. Some findings:
- "*Students felt satisfied when engaged in a video watching due to facilitation of understanding and the convenience of time and venue. A flipped instruction with integrated videos could enhance learning effectiveness*" (Gastardo, 2016).
- "*Video assisted Flipped classroom improvs student in-depth understanding*" (Stelovska et al., 2016).
- "*Flipped class assisted with videos was more engaging and effective than traditional class in terms of learning outcomes*" (Yu, 2019)
- "*Videos in flipped instruction could immerse students in learning, provide a good platform for peer discussions and critical thinking cultivation, engage students by opinion sharing, and help students memorize key knowledge and conceptions*" (Mora, 2016).

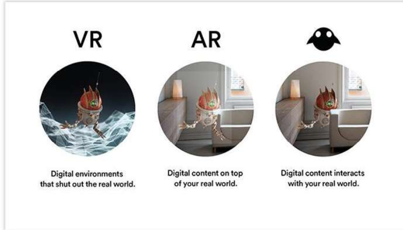
Video assisted Flipped classroom (VFC)

- Online videos limitations
- Multimedia resources (Audio/Video), eg recorded lecture
- Video capture and editing tools can free to use and some of them can be purchased through license.
- Both options are explored during this pilot study.
- It can be regarded as a video production task, which can be time consuming to begin with and requires systematic approach.



XR assisted teaching methods

- Extended reality (XR): Augmented reality (AR) complements real world view by overlaying computer/digital model and information.
- Virtual reality (VR) provides immersive experience by replacing user's view with virtual/digital/computer generated graphical environment.
- Mixed reality (MR) merges the real and virtual environments.



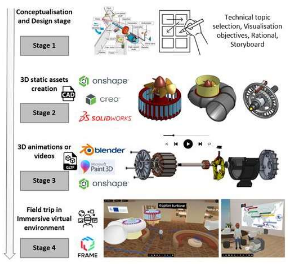
https://www.mobileappdaily.com/2018/09/13/difference-between-ar-mr-and-vr

VR assisted teaching methods

- From the pedagogical point of view, XR lend itself to experiential learning, where students learn from experiencing the subject area (Klob, 2014).
- This involves:
- Using XR to let students go through a series of specialised tasks designed to maximise learning of a specific subject, (pre-class activity)
- While being immersed within a contextual virtual environment that reflects working conditions of real-world industry, (pre-class activity)
- Followed by reflections and group discussion activities, (during class)
- Followed by experiments where students practice what they learned through experience. (post-class)

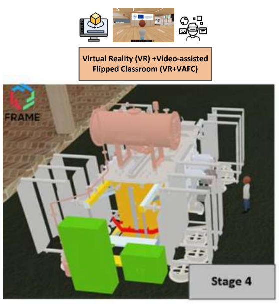
Video assisted Flipped classroom (VFC)

- Step 1: Conceptualisation and Design stage
- Step 2: 3D static assets creation stage, where 3D assets such as 3D models, pictures, videos, animations, and other media assets are produced be used in the VR environment.
- Step 3: Some of the CAD packages can be utilised to produce process simulations. These simulations can be captured in a video format (.avi, .mp4 etc) or in an animation formats (such as .glb, .gltf etc).
- Step 4: Digital documents, video-audio media and animation assets can be inserted into FrameVR's virtual immersive environment.

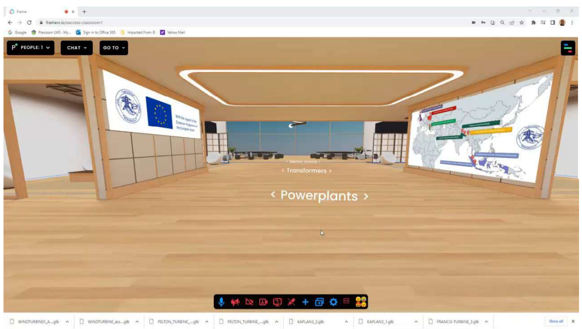


Video assisted Flipped classroom (VFC)

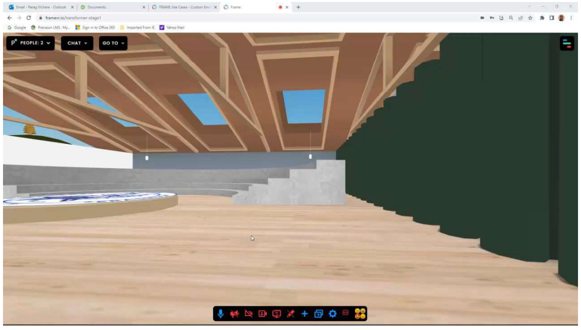
- Prior to implement this method, XR technology feasibility study was undertaken.
- This involved reviewing required resources at KEC for introducing VR assisted teaching approaches.
- Immersive web environment approach was preferred over dedicated VR headset due to cost considerations.
- Hence, FrameVR platform was selected as a part of this case study. FrameVR provides a web based immersive virtual environment for asynchronous pre-class activities.
- It can launch from any browser from desktop, laptop, mobile, tablet or VR headset.



Implementation

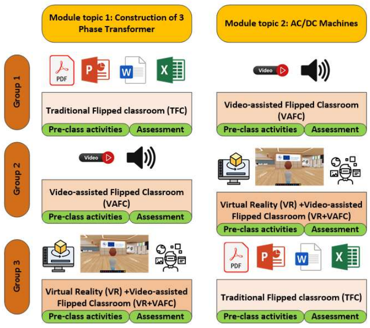


Implementation



Implementation methodology

- 2 Module topics
- 3 Groups of students (total 45 students)
- 3 Flipped classroom methods: TFC, VAFC, VR+VAFC
- Assessment
- 1 Survey



Implementation and analysis

- Please rank (1-3) the following teaching methods in order of preference:

Flipped classroom method	Preference 1 Count	%	Preference 2 Count	%	Preference 3 Count	%
Video-assisted Flipped Classroom (VAFC)	17	37.78%	7	15.91%	9	20.45%
Traditional Flipped Classroom (TFC)	12	26.67%	17	38.64%	9	20.45%
Virtual Reality (VR) +Video-assisted Flipped Classroom (VR+VAFC)	7	15.56%	5	11.36%	6	13.64%
Non-Flipped Classroom (NFC): A conventional Teacher led teaching method	9	20%	15	34.09%	20	45.45%

Conclusions

- VAFC emerged as a preferred method, with many students citing advantages such as personalised pace, flexibility, and the ability to review pre-class learning resources.
- TFC method was well received by students as compared to lecturer led conventional classroom teaching methods.
- VR was generally perceived as an effective tool for visualizing and understanding the internal parts of electrical machines.
- The immersive and interactive nature of VR was appreciated, but technical issues and hardware limitations were noted as potential drawbacks.

SUMMARY

This IC-SPET International Seminar is the main event of the eACCESS program as a forum for eACCES partner universities, energy and energy experts from academia, industry, utilities, electricity, and energy service providers, researchers, and scientists around the world to exchange ideas and experiences regarding new technologies, especially in the field of Power Engineering. IC-SPET 2023 is sponsored by eACCESS Erasmus+ Project EU-Asia Collaboration for accessed Education in Smart Power Systems, with coordinator Lodz Technology University Poland, and supported by The University of the West of Scotland, Aristotle University of Thessaloniki, Kantipur Engineering College, Pokhara University, Royal University of Bhutan, Atma Jaya Catholic University Indonesia, Soegijapranata Catholic University.

The electric power system is currently experiencing rapid and transformational change. Distributed Generation, Nano grids, and Microgrids with and without storage are now emerging as common features of today's complex electric power systems. With modern computers, communication, and information technology, traditional electric power systems will be connected to Smart grids. This conference is an opportunity to exchange views on energy transformation, especially energy development in Asia and Europe. The theme of this conference is **"Smart Power & Emerging Technologies",** where this event was attended by keynote speeches in the field of Energy and Smart Power Systems as well as paper presentations from seminar participants to disseminate knowledge in the field of Energy and Smart Power Systems.

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