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Feasibility of Management of a Green Campus Photovoltaic Solar Power Plant National Institute of Technology Malang: Literature Review

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Abstract

The research aims to analyze the feasibility of managing a green campus photovoltaic solar power plant at the National Institute of Technology Malang. The method used is a literature review study. This method involves searching, selecting, and analyzing articles, books, journals, and other literature sources relevant to this research topic. The research results show that the National Institute of Technology (ITN-Malang) photovoltaic solar power plant (Pembangkit Listrik Tenaga Surya /PLTS) has fulfilled the energy efficiency aspect, an indicator of a green campus. Apart from that, the research results reveal that the feasibility of managing the National Institute of Technology (ITN-Malang) photovoltaic solar power plant (PLTS) from a green campus perspective considers environmental, economic, and social aspects. These three aspects have met the standards for the feasibility of managing a solar photovoltaic power plant at a university that meets green building criteria, including energy conservation, energy efficiency, and renewable energy. However, further studies are still needed related to environmental aspects, especially the use of land in the solar photovoltaic power plant area and the handling, development, and management of solar panel waste.

Keywords: green campus, feasibility, management, solar power plant

INTRODUCTION

Energy plays a crucial role in human activities, contributing to environmental pressures and economic issues. Despite the increasing development of renewable energy technologies, oil-based energy sources remain dominant. Renewable energy sources may compete with oil-based fuels in a country's electricity network in the coming years and potentially become the main source of national energy production. Indonesia faces a discrepancy between renewable energy targets and policy reforms. Currently, Indonesia's energy system heavily relies on state control. In 2014, the government announced an ambitious plan to increase the share of renewable energy sources in Indonesia's energy mix. However, past reforms have proven to be less successful [1]. The Indonesian government has been striving to reform the Foreign Fuel Policy (FFP) for over 20 years but has often failed to achieve targets and cannot break free from dependence on fossil fuels. This dependence poses a major challenge, dominating 69% of the total energy needs until 2050. It creates an energy deficit, threatens the government's climate change program, and slows the transition to renewable energy sources [2].

Meanwhile, in Article 8 of Government Regulation No. 79 of 2014 concerning the National Energy Policy (Kebijakan Energi Nasional/KEN), the goals for providing and utilizing primary and final energy are mentioned. With the increasing growth of regional energy consumption, the aim is to drive economic growth and development in the region as part of the national economy and development. Therefore, energy management and provision in the region must still refer to the reduction in fossil energy utilization and gradual transition to renewable energy (EBT) with a target of 23% EBT by 2025 from a total primary energy of 400 Million Tonnes of Oil Equivalent (MTOE), and 31% by 2050 from a total primary energy of 1,000 MTOE [3]. In this context, using renewable energy sources such as Photovoltaic Solar Power Plants (PLTS) on green campuses can help achieve these targets and contribute to sustainable development in Indonesia.

Developing renewable energy power plants, including photovoltaic solar power plants (PLTS), can help achieve these targets and contribute to sustainable development in Indonesia. According to research [4], solar energy is expected to be a pioneer and driving force in this context. The target for solar energy development for power

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generation is projected to be 6.5 GW by 2025 and 45 GW by 2050, equivalent to 22% of the solar energy potential of 207.9 GW. The projection for PLTS development is optimistic, considering the investment trends and declining prices of global solar power plants due to technological advancements. According to another source [5], the share of solar energy-based power generation is rapidly growing. This is supported by advanced solar technology developments, making solar power plants cheaper every year [6].

However, the development target initially projected at 6.5 GW has decreased to only 3.6 GW by 2025. This results from a decrease in the target the Ministry of Energy and Mineral Resources (ESDM) set. The 3.6 GW target for 2025 will be difficult to achieve, considering that the achievement in 2022 only reached 450 MW, with only 62 MW installed in July. Furthermore, in 2021, the implementation of rooftop solar power plants (PLTS) only reached 48.8 MW [7]. This indicates that the achievement is still far from the set target, especially with the postponement of the PLTS development program in 2022. Despite various efforts made in 2022, such as offering incentives to the community involved in the development program and involving various stakeholders, including universities.

Since achieving the energy target for solar power plants (solar cells) has not been optimal, it is very important to analyze the feasibility of managing photovoltaic solar power plants because this indicates a serious problem of ineffective and inefficient management. According to [8], it is too difficult. It will be difficult for the government to achieve a road map for 3.6 GW Solar Power Plants in 2025, especially as the State Electricity Company (PT. Perusahaan Listrik Negara/PLN) is still in an oversupply condition, coupled with people's mindset whether they will switch to using Solar Power Plants. According to [9], several problems in developing Solar Power Plants are 1) The cost of generating electricity with Solar Power Plants is expensive; 2) Solar Power Plants will require a very large area, where generating 100Wp will require around 1 M^2; 3) Development of Solar Power Plants requires operation, maintenance, repair, and provision of spare parts. Development of Solar Power Plants on a large scale will require standards or product quality standards, installation methods, maintenance methods, and monitoring.

Achieving the goal of developing renewable energy as an alternative to dealing with the impact of fossil energy use requires commitment and support from various lines. So, in implementing the achievement of the National Energy Policy (KEN) targets outlined in the National Energy General Plan (Rencana Umum Energi Nasional/ RUEN), various groups or stakeholders are involved, namely the Ministry of Environment and Forestry, the Ministry of Industry, the Ministry of Transportation, the Ministry of National Development Planning, the Ministry of Agriculture, the Ministry of Finance, and the Ministry of Research, Technology, and Higher Education. The role of the Ministry of Research, Technology, and Higher Education is a strategic step to educate, develop, and align development with the development of science and technology.

The central role of the campus or university then received attention by being outlined in the attachment to Presidential Decree No. 22 of 2017 concerning RUEN, which states that the results of research on the development and mastery of national science and technology (Pengembangan dan Penguasaan Ilmu Pengetahuan dan Teknologi/P3IPTEK) have not been able to contribute optimally to supporting national energy independence. This impacts hampering efforts to create new technology, independent transfer of technology, cooperation and participation of researchers and engineers in industry, and obtaining patents. By involving researchers and engineers, as well as encouraging industrial cooperation and participation, campuses can play a role in creating new technologies, encouraging independent technology transfer, and increasing the acquisition of patents in the field of solar energy. In this way, the campus can become a driving force in overcoming existing obstacles and increasing the contribution of solar energy to achieving national energy independence.

According to a study [10], higher education institutions with extensive open areas can be crucial in reducing conventional energy consumption and carbon footprints. The research findings indicate that by implementing solar campus performance, the campus can generate approximately 8000 MWh of electricity per year, sufficient to meet 100% of the campus's energy needs. Furthermore, the study also demonstrates that this implementation can lead to a reduction of 73,318.0 tons of carbon footprint annually. The research results reveal that developing and

promoting sustainable green concepts will transform academic campuses into energy-efficient and environmentally friendly communities. In line with the opinions of [11] and [12], the use of new, renewable energy (photovoltaics) is one step in the effort toward a green campus.

Because of this, a green campus is an alternative to solving this problem. The Green Campus concept explains that universities or colleges that have tried to preserve the environment include waste collection, energy efficiency, promoting bicycle use, and creating comfortable conditions for studying and working. On the other hand, there is the idea of implementing sustainable development, which is a joint effort of the entire university academic community [13], [14], [15]. By applying the Green Campus concept and implementing sustainable development, universities can positively contribute to the environment and surrounding communities and create a healthier and more comfortable learning environment.

Concerning green campuses, technology also plays an important role in creating a sustainable environment. it is an efficient cause of many environmental problems, is often promoted as part of the solution to those problems, and often mediates interactions, relationships, and experiences of human nature. As a result, environmental ethicists are often involved in the ethical analysis and evaluation of emerging technologies, an interest that has grown significantly in recent years. For example, in the fields of synthetic biology, artificial intelligence, genetic modification, nanotechnology, agricultural technology, and geoengineering [16], In the context of a green campus, implementing sustainable technology and considering aspects of environmental ethics can help create a greener and more environmentally friendly campus environment.

In the context of a green campus, implementing sustainable technology and considering environmental ethics can help create a greener and more environmentally friendly campus environment. As one of the campuses in East Java and the best private campus in 2020, the National Institute of Technology Malang is committed to supporting the creation of sustainable energy. The National Institute of Technology Malang also has a moral responsibility to serve as an example in implementing a green campus at the institutional level. Therefore, the National Institute of Technology Malang uses solar cells to implement a green campus. This is primarily because the National Institute of Technology Malang does not yet have sufficient backup electrical energy sources to meet its energy needs. This action also aligns with one of the indicators of a green campus: the availability of renewable alternative energy.

From the above description, it can be concluded that a green campus plays a vital role in the development of science and technology, including the management of photovoltaic solar power plants (PLTS). Although the purpose of managing photovoltaic solar power plants is to provide renewable alternative energy, the potential impacts must be minimized. Therefore, this research will discuss the feasibility of managing photovoltaic solar power plants at the National Institute of Technology Malang (ITN-Malang). This study will consider environmental, economic, and social aspects. The management of photovoltaic solar power plants on a green campus has the potential to provide significant benefits to the environment and the surrounding community while contributing to sustainable development in Indonesia.

Data Collection

The method used in writing this article is conducting a literature review, which involves gathering and reading research findings published in journals and national proceedings. The literature review includes collecting data from the literature, reading and taking note of relevant information, and managing the acquired research materials [17]. Therefore, this study focuses on analyzing the feasibility of managing photovoltaic solar power generation on the green campus of the National Institute of Technology Malang.

There are several important reasons why a literature review is used in this research. Firstly, a literature review helps researchers understand previous research in the same or related field. Secondly, a literature review aids in building a strong theoretical framework for this research. Thirdly, a literature review assists in gathering evidence and information that support or question previous research findings. A literature review can help establish a solid research foundation, comprehend previous studies, and develop knowledge in analyzing the feasibility of managing photovoltaic solar power generation on a green campus. The following are the steps taken in the literature study method:

- Determine the research topic.

The researcher determined the research topic to be studied, namely the feasibility of managing photovoltaic solar power plants (PLTS) in higher education from a green campus perspective.

- Search for literary sources

Researchers searched for literature sources relevant to the research topic. The literature sources searched include articles, books, journals, and other literature sources related to the research topic.

- Selection of literary sources

Researchers select literature sources that are relevant to the research topic. The selected literature sources must be high quality and relevant to the research topic.

- Analysis of literary sources

The researcher carried out an analysis of the selected literature sources. The analysis evaluated the feasibility of managing photovoltaic solar PV at universities from a green campus perspective.

- Conclude.

Researchers draw conclusions based on the results of the literature source analysis that has been carried out. These conclusions evaluate the feasibility of managing photovoltaic PLTS in higher education from a green campus perspective.

In the literature study method, researchers do not collect primary data but instead use data that has been previously published. This method suits research involving broad topics or when primary data is difficult to obtain. The literature study method can also help researchers understand the research topic in more depth and gain a broader understanding of it.

RESULT AND DISCUSSION

Description of Research Objects

The photovoltaic solar power plant (Pembangkit Listrik Tenaga Surya/PLTS) was built in collaboration with the National Institute of Technology (ITN-Malang) and PT Wijaya Karya (Persero) and PT Surya Utama Nuansa Energy. The investment amount is IDR 7 billion, the largest PLTS in Java for campus-scale in the private university category and the largest in Indonesia [18]. The ITN Malang photovoltaic solar power plant (Pembangkit Listrik Tenaga Surya/PLTS) in its management uses an import-export system in collaboration with the State Electricity Company (PT. Perusahaan Listrik Negara/PLN), and if there is a shortage, ITN will take electricity from PLN; at least 65 percent of the electricity is exported to PLN [19].

The location of installation of the 500,850 kW solar power plant is located at Campus 2 at the National Institute of Technology (ITN-Malang), Tasikmadu, Malang City, more precisely, in an empty area. Hence, it uses a ground-mount model photovoltaic solar power plant installation. The land area required is around 5000 m2. At the installation location, the land does not have tall trees, which could cause shading of the solar modules.

The Campus 2 On-Grid Solar Power Plant with the National Institute of Technology (ITN-Malang) uses JA Solar 1113 mono-crystalline PV modules with a capacity of 450 Wp. Four inverters convert DC to AC, with a DC/AC ratio 1.25. The inverter will be divided into two parts for distribution, with three outputs for Campus 2 at the National Institute of Technology (ITN-Malang) with a maximum load of 0.3 MW and another for the Rusunawa Building with a maximum load of 0.83 MW. Apart from that, the photovoltaic solar power plant (Pembangkit Listrik Tenaga Surya/PLTS) system also has protection devices, monitoring systems, and protection devices.

Thus, the existence of a photovoltaic solar power plant (Pembangkit Listrik Tenaga Surya/PLTS) at the National Institute of Technology (ITN-Malang) has fulfilled the energy efficiency aspect, which is an indicator of a green campus. The management of the photovoltaic solar power plant is in line with the vision of the National Institute of Technology (ITN-Malang), namely excellence in the development of human resources and applied technology. Apart from that, the orientation of scientific activities focuses on green and sustainable technology, which consists of the following fields: (1) new and renewable energy, (2) energy efficiency, and (3) carbon footprint. This means the photovoltaic solar power plant (PLTS) is relevant to academic vision and orientation [20].

Feasibility of Managing Solar Photovoltaic Power Plants from a Green Campus Perspective

The concept of a sustainable or green campus pays attention to three aspects, namely economic, social, and environmental [21], [22]. UI Green Metric and UNEP translated this concept into indicator criteria to achieve a green campus. Establishing these criteria is an effort to increase awareness and real action among academic citizens to adapt to changes and face global challenges. This is important to pay

attention to, develop, and achieve. According to [23], university campuses are very suitable for implementing photovoltaic solar power plants because they provide access to data on a community scale and serve as case study environments for urban experiments. The International Sustainable Campus Network (ISCN) supports universities in building green and low-carbon campuses.

In the context of this research, the UI Green Metric criteria as an assessment of a green campus are related to energy and climate change [24]. The green campus criteria constructed by [25] relate to energy conservation, energy efficiency, and renewable and alternative energy. Using renewable energy at a university can determine whether energy conservation and energy efficiency are met [26]. In this context, ITN Malang is one of the private campuses with renewable energy capacity for solar power plants. Hence, analyzing environmental, economic, and social impacts is very important. Apart from that, its contribution to achieving green buildings from environmental, economic, and social aspects can be known from the feasibility of managing solar power plants.

Feasibility of Managing Photovoltaic Solar Power Plants In the green campus perspective at the National Institute of Technology (ITN-Malang), based on the results of a study conducted by [27], it was found that:

a) Environmental Aspects

The condition of the land is relatively flat, with a height of around 500 to 503 meters above sea level, a total land area of 5000 m2, and a land area of 3400 m2. This land is an open area without any trees or green areas. Apart from that, no large objects around the land could potentially block sunlight from reaching the solar module or shading. So, there is no need to cut down trees in the surrounding area that could block lighting. Thus, the ITN Malang photovoltaic solar power plant (PLTS) was placed on open land without trees or green areas. This is important because no obstruction to solar lighting can reduce the solar module's efficiency. Thus, the construction of the ITN Malang photovoltaic solar power plant (PLTS) does not damage the surrounding environmental ecosystem.

However, from this environmental aspect, further analysis is still needed regarding the use of the area around the solar power plant. A waste management system is also needed for solar panels. Because it is known that, in some instances, solar panels can be damaged before they reach their useful life. Managing post-life waste from solar panels certainly requires special handling in large quantities of solar power plants, considering the potential for negative chemicals in solar panels (solar photovoltaics) [28].

b) Economic Aspects

The installation of the National Institute of Technology (ITN-Malang) photovoltaic solar power plant (PLTS) uses a flexible/renting investment scheme, which allows developers to act as investors and make agreements with customers regarding the financing, installation, and operation of rooftop and ground-mounted solar power plants. This enables broader participation, reduces financial risks, accelerates project development, offers attractive financial returns, and contributes to a cleaner and more sustainable energy future [29].

Let's look at the net present value (NPV) and total investment in the photovoltaic solar power plant (PLTS) at Campus 2 of the National Institute of Technology (ITN-Malang) of IDR 7,789,395,602. It shows that the higher the NPV indicates a large project, the lower the NPV indicates a small project. PBP (payback period) is 8.55 years, equivalent to 8 and 6 months. The PBP value obtained is shorter than the life of the device, so from the perspective of PLTS Campus 2 ITN Malang, it is feasible. ITN IRR for the Malang Campus 2 Solar Power Plant is 13.08%, higher than CIMB Niaga's interest rate of 8%. The ITN Malang Campus 2 Solar Power Plant is feasible with this IRR value. In this case, this project is considered economically feasible based on criteria such as net present value (NPV), total PLTS investment, payback period (PBP), and internal rate of return (IRR).

c) Social Aspects

Socially, the photovoltaic solar power plant (PLTS) of the National Institute of Technology (ITN-Malang) functions to supply electricity for 24 hours to support academic activities. This generator is an alternative for optimizing the electricity at ITN Malang Campus 2 and the Rusunawa Campus and Building. Not only does it fulfill the internal electrical energy needs of the ITN campus, but the electricity is distributed to the community through a collaboration program with PLN. This shows that the photovoltaic solar power plant (PLTS) of the National Institute of Technology (ITN-Malang) provides broad social benefits for the surrounding community, not only on internal campuses or universities.

Considering these environmental, economic, and social aspects, it can be assumed that

managing the solar photovoltaic power plant on the green campus at ITN Malang is highly feasible and to the green campus concept. A similar study that corroborates the findings of this research, especially in terms of photovoltaic solar power plants, is the study by [30] conducted by the results show that optimal photovoltaic power that maximizes emission savings guarantees the best economic benefits and coincides with the maximum solar potential on campus, namely about 3.3 MW. Around 77% of photovoltaic electricity production at the campus level will be consumed locally, which means it covers around 40% of total electricity consumption. Emission savings can reach 30%, and in-depth economic analysis shows the project is highly profitable.

Then, in a study that examines the economic, environmental, and social aspects of implementing the feasibility of managing solar power plants, [31] study found that replacing conventional electricity with electricity produced by solar power plants will increase the effectiveness of investment projects and reduce carbon dioxide emissions into the atmosphere. Apart from providing economic and environmental benefits, the implementation of solar energy projects also positively impacts the university's image at national and international levels.

By adopting renewable energy and becoming an example of sustainable resource management, the National Institute of Technology (ITN-Malang) can improve its reputation as an educational institution that cares about the environment and is committed to sustainable development. Thus, this research reveals that the implementation of solar power plants provides economic and environmental benefits and positively impacts the image of the National Institute of Technology (ITN-Malang) at the national and international levels.

The findings in the green campus context align with the opinion of [32] that the green campus concept can transform academic campuses into energy-efficient and environmentally friendly communities. A relevant study by [33] at the University of Campinas (UNICAMP) has launched the "Sustainable Campus" project, with a focus on renewable energy sources, one of which is photovoltaic. The results show that photovoltaic generation meets the university's energy consumption. It is hoped that the study will encourage other universities to adopt renewable energy sources, contributing to sustainable development In line with the study [34], which suggests promoting renewable energy in educational institutions to enhance renewable energy growth and achieve the IRENA's net-zero emissions goal by 2050,

One specific and relevant study in the context of this research was conducted by [35], which found that green campus initiatives can reduce the carbon footprint of universities and enhance resilience to disasters. The solar photovoltaic system is designed with financial costs and greenhouse gas emissions in mind. This system can achieve 31% electricity self-sufficiency, reduce annual emissions by 27%, and have a payback period of 12.9 years. It can also serve as an emergency power source for the surrounding population and smart city residents, encouraging stakeholders to participate. A study [36] also recommends educational institutions promote solar energy use and initiate pilot projects. The study emphasizes the significant financial and technical benefits of solar energy. Therefore, educational institutions are expected to be crucial in implementing solar energy and green campus concepts.

The concept of a green campus has been explained by [37] and [38]. A green campus is a higher education community that aims to increase energy efficiency, save resources, and improve environmental quality by educating sustainability and creating a better living and learning environment. Healthy. This definition is in line with [38]. A green campus is defined as one that is environmentally friendly, namely, one that integrates environmental science into higher education policies, management, and tri-dharma activities. This aligns with the green campus concept, applied to managing photovoltaic solar power plants (PLTS) in universities. Therefore, it is hoped that this study can encourage other colleges and universities to adopt renewable energy sources and contribute to sustainable development by implementing the green campus concept.

Thus, the benefits of a photovoltaic Solar Power Plant (PLTS) in a green campus are diverse. Firstly, PLTS can reduce the usage of non-renewable fossil energy sources and contribute to sustainable development. Photovoltaic PLTS is a cost-effective energy source that reduces campus operational expenses. Furthermore, photovoltaic PLTS enhances the campus's image as an institution that cares for the environment and contributes to sustainable development. All of these align with the concept of a green campus, which aims

to improve energy efficiency, conserve resources, and enhance the quality of the environment. Therefore, with photovoltaic PLTS, the campus can promote sustainability and create a healthier living and learning environment.

CONCLUSION

Based on the conducted study, it is concluded that managing the green campus photovoltaic solar power plant (PLTS) at ITN Malang is feasible. The environmental aspect indicates that developing PLTS does not harm the surrounding ecosystem. The economic aspect shows that the project is economically viable based on criteria such as net present value (NPV), payback period (PBP), and internal rate of return (IRR). The social aspect shows that PLTS at ITN Malang provides broad social benefits to the surrounding community, not just within the campus or university. Considering these environmental, economic, and social aspects, it can be concluded that the management of the photovoltaic solar power plant in the green campus at ITN Malang is highly feasible and in line with the concept of a green campus. This finding aligns with opinions and studies on the green campus concept at other universities, demonstrating that using renewable energy sources such as photovoltaic contributes to sustainable development.

Based on the study's conclusions, it can be recommended that other universities adopt renewable energy sources such as photovoltaic solar power plants (PLTS) from a green campus perspective. This can significantly benefit the environment and surrounding communities and contribute to sustainable development in Indonesia. Besides that, universities can also consider the environmental, economic, and social aspects of managing photovoltaic PLTS to ensure project feasibility and benefit society broadly. By adopting renewable energy and becoming an example of sustainable resource management, universities can improve their reputation as educational institutions that care about the environment and are committed to sustainable development.

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REFERENCES

[1]. Şevik, S. (2022). Techno-economic evaluation of a grid-connected PV-trigeneration-hydrogen production hybrid system on a university campus. International Journal of Hydrogen Energy, 47(57), 23935-23956.

[2]. Sumarsono, N., Kasali, R., & Balqiah, T. E. (2023). Circular business model, technology innovation and performance: A strategic-based theoretical framework in the Indonesian energy transition. Renewable Energy Focus, 45, 259-270.

[3]. Usman E., Bambang P,. Dedi I., Afri N., Arie P., Artody N. J., Prima A. P.S., Silvia Puspita, S., Inna, K., Eka, S., Widya A. D.S., dan Febrina D. R., (2020). Bauran Energi Nasional 2020. Jakarta; Dewan Energi Nasional.

[4]. Şevik, S. (2022). Techno-economic evaluation of a grid-connected PV-trigeneration-hydrogen production hybrid system on a university campus. International Journal of Hydrogen Energy, 47(57), 23935-23956

[5]. Newell, R., Raimi, D., Villanueva, S., & Prest, B. (2020). Global Energy Outlook 2020: energy transition or energy addition. Resources for the Future.

[6]. Sadoogi, Nasser, Ali Rostami, Behdad Faridpak, and Meisam Farrokhifar. "Performance analysis of organic solar cells: Opto-electrical modeling and simulation." Engineering Science and Technology, an International Journal 24, no. 1 (2021): 229-235.

[7]. EBTKE. (2022) Dorong Stakeholder Lakukan Pemasangan PLTS Atap Secara Masif, Pemerintah Tawarkan Insentif. Accessed Via (Online) https://ebtke.esdm.go.id/post/2022/02/22/3093/dorong.stakeholder.lakukan.pemasangan.plts.atap.secara.masif.pemerintah.tawarkan.insentif [23/10/2023]

[8]. Setiawan, V.N. (202). Jadi Andalan Bauran EBT, Tapi Target PLTS Atap Sulit Tercapai. CNBC Indonesia. Accessed Via (Online) https://www.cnbcindonesia.com/news/20220509162854-4-337539/jadi-andalan-bauran-ebt-tapi-target-plts-atap-sulit-tercapai[23/10/2023]

[9]. Boedoyo, M. S. (2013). Potensi dan peranan plts sebagai energi alternatif masa depan di indonesia. Jurnal Sains dan Teknologi Indonesia, 14(2), 146-152.

[10]. Baitule, A. S., & Sudhakar, K. (2017). Solar powered green campus: a simulation study. International Journal of Low-Carbon Technologies, 12(4), 400-410.
[11]. Suheri, S., Febri, S. P., Arif, Z., & Amir, F. (2019). Kajian Penggunaan Pembangkit Listrik Photovoltaik Atap Sebagai Upaya Implementasi Green Campus. JURUTERA-Jurnal Umum Teknik Terapan, 6(02), 14-18.
[12]. Paudel, B., Regmi, N., Phuyal, P., Neupane, D., Hussain, M. I., Kim, D. H., & Kafle, S. (2021). Techno-economic and environmental assessment of utilizing campus building rooftops for solar PV power generation. International Journal of Green Energy, 18(14), 1469-1481.
[13]. Rumiati, A. T., Tucuan, K. P., & Azmi, D. A. (2018). Implementasi Program Campus Social Responsibility (CSR) ITS pada Masyarakat Di Sekitar Kampus ITS Surabaya. IPTEK Journal of Proceedings Series, (2).
[14]. Kisworo, B., & Muarifuddin, M. (2015). Analisis Implementasi 7 Pilar Konservasi Universitas Negeri Semarang di Fakultas Ilmu Pendidikan. Journal of Nonformal Education, 1(1).
[15]. Suheri, S., Febri, S. P., Arif, Z., & Amir, F. (2019). Kajian Penggunaan Pembangkit Listrik Photovoltaik Atap Sebagai Upaya Implementasi Green Campus. JURUTERA-Jurnal Umum Teknik Terapan, 6(02), 14-18.
[16]. Palmer, C., McShane, K., & Sandler, R. (2014). Environmental ethics. Annual Review of Environment and Resources, 39, 419-442.
[17]. Pilendia, D. (2020). Pemanfaatan Adobe Flash Sebagai Dasar Pengembangan Bahan Ajar Fisika: Studi Literatur. Jurnal Tunas Pendidikan, 2(2), 1-10.
[18]. Werdiono. D. (2022). ITN Malang Punya PLTS Berkapasitas 500 kWp. kompas.id. Accessed Via (Online) https://www.kompas.id/baca/ilmu-pengetahuan-teknologi/2022/03/23/itn-malang-punya-plts-berkapasitas-500-kwp [23/10/2023]
[19]. ITN.ac.id (2021) Kolaborasi: 1. Rektor ITN Malang Prof Dr Eng Ir Abraham Lomi MSEE, 2. Ketua P2PUTN Ir Kartiko Ardi Widodo, MT, 3. PT WIKA (Persero) Harum Akhmad Zuhdi dan 4. Perwakilan Direksi PT SUN Energy Reynaldi Wijaya. Melalui (online) https://itn.ac.id/seputar-kampus/berita/investasi-7-miliar-itn-malang-perguruan-tinggi-swasta-pertama-miliki-05-mwp-plts-terbesar-di-indonesia/[23/10/2023]
[20]. Widodo, N. S. A. (2022). Studi Kelayakan Implementasi Sistem Pembangkit Listrik Tenaga Surya Berkapasitas 500 Kwp Di Kampus Itn Malang. Skirpsi. Departemen Teknik Nuklir Dan Teknik Fisika Fakultas Teknik Universitas Gadjah Mada Yogyakarta
[21]. Tahir, M. (2015). Developing a sustainable campus landscape criteria: an evaluation Universiti Pendidikan Sultan Idris as a Green Campus. Advances in environmental biology, 9(4), 201-204.
[22]. Mukaromah, H. (2020). Strategi Menuju Kampus Berkelanjutan (Studi Kasus: Fakultas Teknik, Universitas Sebelas Maret). Sumber, 2, 4.
[23]. Olivieri, L., Caamaño-Martín, E., Sassenou, L. N., & Olivieri, F. (2020). Contribution of photovoltaic distributed generation to the transition towards an emission-free supply to university campus: technical, economic feasibility and carbon emission reduction at the Universidad Politécnica de Madrid. Renewable Energy, 162, 1703-1714.
[24]. UI Green Metric. (2019). "Petunjuk UI GreenMetric World University Rankings,"
[25]. Sisriany, S., & Fatimah, I. S. (2017, October). Green campus study by using 10 UNEP's Green University toolkit criteria in IPB dramaga campus. In IOP Conference Series: Earth and Environmental Science (Vol. 91, No. 1, p. 012037). IOP Publishing.
[26]. Leal Filho, W., Salvia, A. L., Do Paco, A., Anholon, R., Quelhas, O. L. G., Rampasso, I. S., ... & Brandli, L. L. (2019). A comparative study of approaches towards energy efficiency and renewable energy use at higher education institutions. Journal of cleaner production, 237, 117728.
[27]. Widodo, N. S. A. (2022). Studi Kelayakan Implementasi Sistem Pembangkit Listrik Tenaga Surya Berkapasitas 500 Kwp Di Kampus Itn Malang. Skirpsi. Departemen Teknik Nuklir Dan Teknik Fisika Fakultas Teknik Universitas Gadjah Mada Yogyakarta.
[28]. Qi, L., & Zhang, Y. (2017). Effects of solar photovoltaic technology on the environment in China. Environmental Science and Pollution Research, 24, 22133-22142.
[29]. Jenkins, J. D., Zhou, Z., Ponciroli, R., Vilim, R. B., Ganda, F., de Sisternes, F., & Botterud, A. (2018). The benefits of nuclear flexibility in

power system operations with renewable energy. Applied energy, 222, 872-884.
[30]. Olivieri, L., Caamaño-Martín, E., Sassenou, L. N., & Olivieri, F. (2020). Contribution of photovoltaic distributed generation to the transition towards an emission-free supply to university campus: technical, economic feasibility and carbon emission reduction at the Universidad Politécnica de Madrid. Renewable Energy, 162, 1703-1714.
[31]. Kurbatova, T., Lysenko, D., Trypolska, G., Prokopenko, O., Järvis, M., & Skibina, T. (2022). Solar energy for green university: estimation of economic, environmental and image benefits. International Journal of Global Environmental Issues, 21(2-4), 198-216
[32]. Baitule, A. S., & Sudhakar, K. (2017). Solar powered green campus: a simulation study. International Journal of Low-Carbon Technologies, 12(4), 400-410
[33]. de Souza Silva, J. L., de Melo, K. B., dos Santos, K. V., Sakô, E. Y., da Silva, M. K., Moreira, H. S., ... & Villalva, M. G. (2022). Case study of photovoltaic power plants in a model of sustainable university in Brazil. Renewable Energy, 196, 247-260
[34]. Tseng, K. H., Chung, M. Y., Chen, L. H., & Wei, M. Y. (2022). Applying an Integrated System of Cloud Management and Wireless Sensing Network to Green Smart Environments—Green Energy Monitoring on Campus. Sensors, 22(17), 6521
[35]. Teah, H. S., Yang, Q., Onuki, M., & Teah, H. Y. (2019). Incorporating external effects into project sustainability assessments: The case of a green campus initiative based on a solar PV system. Sustainability, 11(20), 5786.
[36]. Alfaoyzan, F. A., & Almasri, R. A. (2023). Utilizing solar photovoltaic systems in educational facilities to achieve a zero bill campus: The Sulaiman Al-Rajhi University case. Energy Exploration & Exploitation, 01445987231174767
[37]. Humblet, E. M., Owens, R., Roy, L. P., McIntyre, D., Meehan, P., & Sharp, L. (2010). Roadmap to a green campus. Washington, DC: US Green Building Council.
[38]. Setyowati, M., Kusumawanto, A., & Prasetya, A. (2018, May). Study of waste management towards sustainable green campus in Universitas Gadjah Mada. In Journal of Physics: Conference Series (Vol. 1022, No. 1, p. 012041). IOP Publishing.
[39]. Buana, R. P., Wimala, M., & Evelina, R. (2018). Pengembangan indikator peran serta pihak manajemen perguruan tinggi dalam penerapan konsep green campus. RekaRacana: Jurnal Teknil Sipil, 4(2), 82.