Interdisciplinary Journal of Advanced Research and Innovation
Volume 2 No. 1 January 2024 E-ISSN xxxx-xxxx
https://ijari.publicascientificsolution.com/index.php/rv

UTILIZING SOLAR POWER PLANTS AS RENEWABLE ENERGY FOR THE FUTURE (Case Study: PLTS Likupang)

Deitje. S. Pongoh[1], Muchdar Daeng Patabo[2], Enzza Sampaleng[3], Benaya Ticoalu[4], Einstein Kondoj[5], Gabriel Rumagit[6], Timothy Mamentu[7], Felove Mirah[8], Mikha Assa[9]
Politeknik Negeri Manado
pongohdeitje@gmail.com[1], patabomuchdar@gmail.com[2], enzzafs5@gmail.com[3], ticoalubenaya@gmail.com[4], einstenkondoy@gmail.com[5], gabrielrumagit5@gmail.com[6], tmthym18@gmail.com[7], willymirah06@gmail.com[8], assamikha3@gmail.com[9]

Abstract:
Solar energy is one of the renewable energy sources that has great potential to replace conventional energy sources that have a negative impact on the environment. Solar power plants (PLTS) are technologies that utilize solar energy to generate electricity by converting sunlight into electric current. PLTS can be divided into two types, namely photovoltaic (PV) and concentration (CSP). PV is a PLTS that uses solar cells to directly convert sunlight into electricity, while CSP is a PLTS that uses mirrors or lenses to focus sunlight to a point and generate heat that is used to drive turbines. Both types of PLTS have their own advantages and disadvantages, depending on factors such as location, climate, cost, and land availability. This study discusses the development, challenges, and prospects of PLTS as a renewable energy source for the future. This study also provides an example of Likupang PLTS in North Sulawesi, which is one of the largest PLTS in Indonesia. It can supply electricity to several regions around it with an installed capacity of 21 MWp. This study shows that PLTS has economic, social, and environmental benefits and can contribute to achieving national and global renewable energy targets.

Keywords: Likupang PLTS, solar power plants, renewable energy

Corresponding: Enzza Sampaleng
E-mail: enzzafs5@gmail.com

INTRODUCTION

Our daily lives are largely dependent on electricity, which is an essential component of almost everything we do. Its removal would surely present a variety of difficulties, upsetting our daily schedules and making numerous tasks laborious. Electricity is the unseen enabler of the modern world, powering everything from our homes and offices to enabling communication and movement. Now enter solar power plants, or PLTS, which capture the infinite energy of sunshine, a naturally occurring renewable resource. These novel plants mark a paradigm shift in our search for renewable energy sources. Their use of solar energy promotes environmental sustainability in addition to providing a dependable way to generate electricity (sunenergy.id, 2021; Rangkuti, 2023). The wonderful aspect of solar energy is its capacity to minimize environmental effects while providing a sustainable solution. By making solar energy our main source of electricity, we not only meet our energy demands but also make major progress in maintaining the fragile ecological balance of our world.

The Likupang PLTS is a transforming addition to North Sulawesi's energy environment, ushering in a new age of sustainable power generation. This innovative plant goes beyond meeting the electricity needs of the immediate area. It provides power to not only North Sulawesi but also Gorontalo and Central Sulawesi, acting as a key source of energy. The Likupang PLTS, with its remarkable installed capacity of 21 Mega Watt Peak (MWp), is an excellent example of the potential for renewable energy.

This solar farm, namely the Likupang 15 MWac Solar Farm, is located in Wineru Village, Likupang Timur, North Minahasa Regency. It represents a concerted effort towards utilizing the sun's endless energy to power communities while being environmentally conscious. Its capacity to disperse up to 15 MW of electricity highlights both its important position in the regional power grid and its sustainability as an environmentally beneficial energy source, providing opportunities for a cleaner, more prosperous energy future throughout these Indonesian countries (Setkab.go.id, 2020; Sianipar, Boedoyo, & Sasongko, 2022).

The project was developed as part of the Eastern Indonesia Renewable Energy Project (Phase 2) and aimed to contribute to the country's renewable energy goals, The facility was designed to generate 15 MWac of electricity, which would be supplied to the national grid. The construction of the Likupang PLTS is a significant step in reducing Indonesia's dependence on fossil fuels and encouraging sustainable energy sources (Agustin, Restikadewi, Trinarningsih, & Hartomo, 2021).

The project from Environmental and Social Impact Assessments (ESIAs) is evolving in relation to hydropower development. The project highlights how crucial ESIAs are as instruments for decision-making when it comes to addressing the negative impacts that hydropower projects have on the environment and society. It goes into the historical background of ESIAs, how they differed from Environmental Impact Assessments (EIAs), and how they are currently used to address the growing need for sustainability and inclusion in hydropower development. It also focuses on the difficulties and negative effects of hydropower development, including the breaking down of river connections, modifications to hydrology and geomorphology, and extensive implications on local inhabitants and biodiversity. The objective of the project is to comprehend how ESIAs have changed over time in the hydropower industry, as well as the actors, social and normative concepts that have shaped this evolution, and how ESIAs respond to the growing need for sustainability and inclusion in the industry (Quigley, 2021).

The current study about solar power plants and the insights gained from ESIAs' project regarding the evolving environmental and social impact assessment processes in the renewable energy industry may prove beneficial. Regarding the advancement of solar power plants in the future, it offers a comparative viewpoint on the advantages and difficulties of various renewable energy sources. An expanded comprehension of the environmental and social factors involved in the development of solar power plants and other renewable energy projects can be achieved by concentrating on the evolution of ESIAs and their function in mitigating the adverse environmental and social effects of hydropower development.

The aim of researching solar power plants is to look for other electricity alternatives because the cost of providing electricity is very high. Therefore, we are researching solar power plants to start implementing them in everyday life. PLTU (Solar Power Plant) North Sulawesi - Likupang is starting to contribute electrical energy in North Sulawesi, especially in the East Likupang area.

METHOD

The research method that will be used is a quantitative research method. Resistance Test: A total of 64,620 solar panels are neatly arranged in Wineru Village, East Likupang District, North Minahasa Regency, North Sulawesi Province. Vena Energy has been using this sun-catching device as a new source of electrical energy since September 5, 2019. The PLTS unit in Likupang, the East Likupang Solar Power Plant (PLTS), distributes up to 15 MW of electricity even though it has an installed capacity of 21 Mega Watt Peak (MWp). Starting at 05.30 in the morning until the hot sun can reach 15 MW, Likupang LTS is the largest PLTS in Indonesia to date and supports the electricity system of the State Electricity Company (PLN) Sulutgo (Sulut-Gorontalo) network of 15 MWp. improved so that energy

sources are needed that are cost-effective but of good quality and safe for the environment. The Likupang PLTS (Solar Power Plant) was constructed starting from the Power Purchase Agreement (PPA) at the end of 2017 and took approximately 1.5 years to complete, with a total investment cost of USD 29.2 million. The power plant consists of 120 array boxes, 24 sets of inverters, and 6 PV boxes. The electricity purchase contract spans 20 years under the Built, Own, Operate, Transfer (BOOT) scheme. During the peak of the construction activities, Likupang Solar Power Plant (PLTS) was able to employ up to 900 local workers. Meanwhile, during its operational phase, 80% of its workforce comprises individuals from the surrounding community. While in operation, this power plant has the capacity to supply electricity to approximately 15,000 households and reduce greenhouse gas emissions by 20,01-kilo tons.

RESULT AND DISCUSSION

1) Destination
   - Solar Power Plant

     A technology known as solar power generation uses sunlight to create electricity that may be employed on a small to large scale for a variety of purposes. With this technology, sunlight is captured and transformed into power using solar cells or solar panels. The PV effect, which is the creation of an electric voltage between two electrodes associated with a solid or liquid system when exposed to light, is how photovoltaic (PV) cells produce electricity. With multi-junction PV cells, the efficiency of PV cells can increase to about 34.1%. With concentrated solar power (CSP) technology, sunlight is directed onto a small area, like a tower or dish, generating high temperatures that can power a turbine to create electricity or produce steam (Hayat, Ali, Monyake, Alagha, & Ahmed, 2019). The working principle of solar power plants is based on the photovoltaic effect, which occurs when sunlight hits semiconductor material, such as silicon, in solar cells. When sunlight hits a solar cell, photons of light move electrons in the semiconductor material, creating an electric current (Eke, 2021).
   - Photovoltaic (PV)

     A crucial field of study devoted to generating solar energy's enormous potential is photovoltaic technology, which effectively transforms radiant sunlight into a usable source of electrical power. Recent developments highlight the importance of solar photovoltaic systems in transforming energy storage applications, as explained in the academic work of Dada & Popoola (2023) utilizing photovoltaic solar panels, which are precisely engineered to capture photons from sunlight and cause an electron release in semiconductor materials like silicon, is how this technology works. The photovoltaic effect catalyzes the creation of a direct electric current (DC). The thorough analysis highlights how crucial these devices are to converting solar energy into a valuable and sustainable source of electricity. Such developments in solar photovoltaic materials and systems not only improve efficiency but also show promise for strengthening energy storage capacities, which is important for promoting a more efficient and sustainable energy environment.
2) Condenser
   - Substrate

     As the structural backbone of the solar panel assembly, the substrate is a fundamental component that not only supports the other components physically but also facilitates their ideal connectivity. Its critical function goes beyond simple structural stability; in order to function as a positive terminal contact in the system, it must possess strong electrical

conductivity. By facilitating the seamless integration and harmonious operation of all connected components, the substrate's dual functionality of providing mechanical support and electrical conductivity highlights its importance in guaranteeing the solar panel's optimal performance and efficient operation and improves the overall efficiency of solar energy conversion (Mohammad & Mahjabeen, 2023).

- Semiconductor Materials

  Semiconductor materials are essential to the operation of solar panels and are crucial in the process of capturing sunlight and converting it into energy that can be used. These materials, which provide an essential portion of the solar panel, are composed of a specific junction or a two-part semiconductor material combination: the p-type semiconductor and its complementary counterpart, which together constitute the important p-n junction (Fronk, 2017). In order to maximize their performance, the semiconductor material's surface is carefully covered with a thin layer of transparent metal, which is then used as the negative contact to facilitate effective electron flow and encourage the solar energy to be converted into electrical power that can be used by the solar panel system (Husain, Hasan, Shafie, Hamidon, & Pandey, 2018).

- Anti-reflection Coating

  Positioned strategically between the semiconductor material and the surrounding air, the anti-reflection coating plays a crucial role as a thin but essential layer. This thin layer, designed to have a high optical refractive index, arranges incident sunlight in a way that purposefully bends light rays toward the semiconductor material. Taking advantage of this optical phenomenon, the anti-reflection coating serves as a crucial tool for reducing reflecting losses, making sure that a significant amount of solar radiation entering the semiconductor surface enters rather than escapes into space. The primary purpose of this coating is to maximize light absorption by the semiconductor, which improves overall energy-collecting capacity and increases the power plant's efficiency by making the most use of solar irradiance for efficient and continuous power generation.

- Solar Charge Controller

  The Solar Charge Controller performs a variety of functions that are all directed toward coordinating the energy's flowing transfer. Serving as an advanced regulator, its main function is to carefully monitor and adjust the electric current flowing to the battery bank. In addition to performing this vital duty, the charge controller also acts as a watchful defender, averting any overcharging situations that can jeopardize battery longevity and efficiency, particularly when the battery is fully charged. Its operational capabilities also include acting as a perceptive central monitoring point, carefully measuring and documenting important parameters such as voltage, current, and the amount of solar energy that the solar modules are able to capture. The extensive data is then carefully directed and sent to the battery, which enhances the energy transfer procedure and guarantees the continuous, effective, and secure use of solar energy in the plant's energy storage system.

- Encapsulation

  In a solar power plant, encapsulation is essential for maintaining the longevity and efficiency of the solar modules. Encapsulation is a crucial barrier that shields the delicate parts of solar panels from external factors, including dust, rain, and debris (Müller et al., 2017; Aghaei et al., 2022). This crucial layer serves as a defensive mechanism, keeping the solar modules' delicate internal components safe from outside influences and maintaining their

functioning and performance. For maximum performance, the various parts of a solar panel must work together harmoniously. This interconnection ensures that the solar panel operates at its best, reliably and efficiently capturing solar energy. As a result, the encapsulation procedure not only protects the panels but also creates an atmosphere that allows every part to develop successfully and support the solar power plant's overall function.

- Baterai

  Batteries are an essential component of solar power plants since they are the basis for effective energy storage (Zhang, Wei, Cao, & Lin, 2018). Their main function is to store the excess electricity produced by solar panels when the sun is shining. These storage devices are used to store surplus power generated by the solar panels during periods of maximum sunlight, which is then converted into electricity. Even on cloudy or nocturnal days, when sunlight is not easily available, this procedure guarantees a steady and dependable energy source. In this instance, the use of batteries makes it possible to create a reservoir for solar energy that can be collected and used as needed. Furthermore, the implementation of batteries into the solar power system provides flexibility and resilience, allowing the plant to effectively control power output and meet fluctuating energy requirements (Polleux, Guerassimoff, Marmorat, Sandoval-Moreno, & Schuhler, 2022). By acting as a vital buffer and ensuring stability and continuity of the power supply, the stored energy improves the overall functionality and dependability of the solar power plant.

- Inverter

  An essential piece of equipment in a solar power plant's infrastructure, the inverter serves as a battery system protector in addition to converting direct current (DC) to alternating current (AC). Its main function is to convert solar-generated DC electricity into AC power appropriate for grid distribution, ensuring compatibility with conventional electrical infrastructure. However, its importance goes beyond this conversion procedure. The inverter is essential for overseeing and controlling the battery charging process as the solar panels continue to produce electricity. The inverter uses protections to keep batteries from being overcharged while they are at maximum capacity. Overcharging may shorten a battery's life and reduce its efficiency. The inverter helps the solar power plant's energy storage system operate longer and perform better by controlling the charging current and rerouting excess energy away from the battery once it reaches capacity. This keeps the battery at the ideal charge level and prevents overcharging damage. The inverter's double function of promoting effective energy conversion and protecting the integrity of the battery system makes a substantial contribution to the overall sustainability and reliability of the solar power infrastructure.

CONCLUSION

Based on the results of this study, we can draw the following conclusions. 1) PLTS in East Likupang is the most significant contributor to solar power generation in Indonesia, distributing 15 MW every day. 2) Because PLTS is environmentally friendly and renewable energy, the environment will not be polluted because it uses sunlight as a source. The advice that can be given is the need to disseminate information to the public that the use of solar power plants for current and future life is very effective so that it can also keep up with current developments.

REFERENCES

Aghaei, M., Fairbrother, A., Gok, A., Ahmad, S., Kazim, S., Lobato, K., Oreski, G., Reinders, A., Schmitz, J., & Theelen, M. (2022). Review of degradation and failure phenomena in photovoltaic modules. Renewable and Sustainable Energy Reviews, 159, 112160.

Agustin, V. S., Restikadewi, A., Trinarningsih, W., & Hartomo, D. D. (2021). Electricity machinery, renewable energy, and green economy. IOP Conference Series: Earth and Environmental Science, 905(1), 12142. IOP Publishing.

Dada, Modupeola, & Popoola, Patricia. (2023). Recent advances in solar photovoltaic materials and systems for energy storage applications: a review. Beni-Suef University Journal of Basic and Applied Sciences, 12(1), 66.

Eke, Mkpamdi N. (2021). Photovoltaic Characteristics and Applications. In Electrode Materials for Energy Storage and Conversion (pp. 351–364). CRC Press.

Fronk, Ryan G. (2017). Dual-side etched microstructured semiconductor neutron detectors. Kansas State University.

Hayat, Muhammad Badar, Ali, Danish, Monyake, Keitumetse Cathrine, Alagha, Lana, & Ahmed, Niaz. (2019). Solar energy—A look into power generation, challenges, and a solar-powered future. International Journal of Energy Research, 43(3), 1049–1067.

Husain, Alaa A. F., Hasan, Wan Zuha W., Shafie, Suhaidi, Hamidon, Mohd N., & Pandey, Shyam Sudhir. (2018). A review of transparent solar photovoltaic technologies. Renewable and Sustainable Energy Reviews, 94, 779–791.

Mohammad, Ashif, & Mahjabeen, Farhana. (2023). Revolutionizing Solar Energy with AI-Driven Enhancements in Photovoltaic Technology. BULLET: Jurnal Multidisiplin Ilmu, 2(4), 1174–1187.

Müller, Kerstin, Bugnicourt, Elodie, Latorre, Marcos, Jorda, Maria, Echegoyen Sanz, Yolanda, Lagaron, José M., Miesbauer, Oliver, Bianchin, Alvise, Hankin, Steve, & Bölz, Uwe. (2017). Review on the processing and properties of polymer nanocomposites and nanocoatings and their applications in the packaging, automotive, and solar energy fields. Nanomaterials, 7(4), 74.

Polleux, Louis, Guerassimoff, Gilles, Marmorat, Jean Paul, Sandoval-Moreno, John, & Schuhler, Thierry. (2022). An overview of the challenges of solar power integration in isolated industrial microgrids with reliability constraints. Renewable and Sustainable Energy Reviews, 155, 111955.

Quigley, Guillaume Thomas. (2021). The evolution of Environmental and Social Impact Assessments in Hydropower. Norwegian University of Life Sciences, Ås.

Rangkuti, M. (2023). Apa Itu Pembangkit Listrik Tenaga Surya? Retrieved from fatek.umsu.ac.id website: https://fatek.umsu.ac.id/2023/07/29/apa-itu-pembangkit-listrik-tenaga-surya/

Setkab.go.id. (2020). PLTS Likupang, Panel Surya Terbesar di Indonesia Salurkan Listrik 15 MW Per Hari. Retrieved from Setkab.go.id website: https://setkab.go.id/plts-likupang-panel-surya-terbesar-di-indonesia-salurkan-listrik-15-mw-per-hari/

Sianipar, Ronald, Boedoyo, M. Sidik, & Sasongko, Nugroho Adi. (2022). Application of LCA (Life Cycle Assessment) to Solar Energy Development in Indonesia. International Journal of Innovative Science and Research Technology, 128–132.

sunenergy.id. (2021). Pembangkit Listrik Tenaga Surya (PLTS) Atap Terbaik di Indonesia. Retrieved from sunenergy.id website: https://sunenergy.id/blog/pembangkit-listrik-tenaga-surya

Zhang, Chao, Wei, Yi Li, Cao, Peng Fei, & Lin, Meng Chang. (2018). Energy storage system: Current studies on batteries and power condition system. Renewable and Sustainable Energy Reviews, 82, 3091–3106.