Journal of Urban Development and Management
https://www.acadlore.com/journals/JUDM

Techno-Economic Assessment of Solar Power Plants on River Land in Indonesia Using HOMER Pro

Singgih Dwi Prasetyo[1,2*], Bintang Bangkit Putra Pranata[2], Muhammad Salman Alfaridzi[2], Zainal Arifin[2], Catur Harsito[3,4], Mochamad Subchan Mauludin[5], Arya Kusumawardana[1]

[1] Power Plant Engineering Technology, Faculty of Vocational Studies, Universitas Negeri Malang, 65145 Malang, Indonesia
[2] Department of Mechanical Engineering, Faculty of Engineering, Universitas Sebelas Maret, 57126 Surakarta, Indonesia
[3] Department of Mechanical Engineering, Faculty of Vocational, Universitas Sebelas Maret, 57126 Surakarta, Indonesia
[4] Department of Mechanical Computer Industrial and Management Engineering, Kangwoon National University, 25913 Chuncheon, Republic of Korea
[5] Department of Informatics Engineering, Faculty of Engineering, Universitas Wahid Hasyim, 50236 Semarang, Indonesia

[*] Correspondence: Singgih Dwi Prasetyo (singgih.prasetyo.fv@um.ac.id)

Received: 05-21-2024 **Revised:** 07-02-2024 **Accepted:** 07-15-2024

Citation: S. D. Prasetyo, B. B. P. Pranata, M. S. Alfaridzi, Z. Arifin, C. Harsito, M. S. Mauludin, A. Kusumawardana, "Techno-economic assessment of solar power plants on river land in Indonesia using HOMER Pro," *J. Urban Dev. Manag.*, vol. 3, no. 3, pp. 164–175, 2024. https://doi.org/10.56578/judm030302.

Abstract: The increasing urgency of climate change mitigation necessitates the adoption of renewable energy sources to meet the growing demand for clean energy. Solar energy, in particular, presents a viable solution, contingent on the availability of sufficient land to optimize power generation. River land offers an alternative location for solar power plants, potentially conserving valuable land resources while providing a natural cooling medium for solar panels to enhance efficiency. This study evaluates the techno-economic feasibility of establishing a solar power plant system (PLTS) on river land in Surakarta City, Indonesia, using simulations conducted with the Hybrid Optimization Model for Electric Renewables (HOMER) software. The simulation considers both on-grid and off-grid systems, with a daily energy demand of 2,947.236 kWh projected over a 25-year period at the Tirtonadi Dam site. The On-Grid system demonstrated a total annual energy production of 885,358 kWh, significantly outperforming the off-grid system, which produced 34,400 kWh annually. The Net Present Cost (NPC) for the on-grid system was calculated to be USD 1,805,634.01, while the off-grid system's NPC was substantially lower at USD 1,970.18. The Levelized Cost of Energy (COE) for the on-grid system was found to be USD 0.09 per kWh, compared to USD 0.10 per kWh for the off-grid system, indicating favourable investment potential. The breakeven point (BEP) for the On-Grid system was achieved in the 0.54th year. The initial capital expenditure required to implement the on-grid PLTS at Tirtonadi Dam was estimated at approximately USD 47,782.10, while the off-grid system's initial cost was around USD 1,923.77. These findings suggest that the deployment of solar power plants on river land, particularly with an on-grid configuration, is a technically viable and economically advantageous approach to enhancing renewable energy capacity in Indonesia.

Keywords: Renewable energy; Solar power; Hybrid Optimization Model for Electric Renewables (HOMER); Techno-economic analysis; On-grid system; Off-grid system; Investment feasibility

1 Introduction

The need for clean energy in the 21st century is increasing [1]. This is brought on by the usage of fossil fuels, which contribute to global climate change [2]. The solution to the issue of the need for clean energy is to shift our reliance on fossil fuels to renewable energy sources [3]. Renewable energy has the characteristic that it is environmentally friendly because it produces almost zero pollutants, so this gets more attention from the public [4]. Several countries in Asia, Australia, and Europe have set a target: by 2040, renewable energy sources must contribute more than 50% to meet total electricity needs [5]. Renewable energy is available on earth and is still being developed to produce electricity, namely wind, solar, water, geothermal, biomass, and marine energy [6].

One renewable energy source that is widely available on Earth and may be used without restriction is solar energy [7]. The sun emits rays with an amount of energy of 3.8×1023 kW, and that which is intercepted by the earth is 1.8×1014 kW [8]. Solar energy potential is enormous for tropical regions that receive constant sunshine. Indonesia can use 4.5–4.8 kWh/m^2/day of solar energy [9]. With the potential that Indonesia has, of course, this will be an advantage in meeting electricity needs in Indonesia.

Solar energy used to supply electricity requires a conversion tool in the form of a solar panel, which will later convert solar radiation into electricity [10]. However, due to the low efficiency of solar panels, a large enough land area is needed to meet electricity needs [11]. Therefore, this is usually overcome by building on the roof of a building or open land for use on a larger scale [11, 12]. According to data from the Geospatial Information Agency, Indonesia's land area is 1,905 million km^2, where rivers are a characteristic part of the land in Indonesia [13]. This river area has the potential to be used as land for generating solar electricity by floating solar panels on the river, commonly known as floating PLTS. There are several advantages to be gained from implementing floating solar power plants, namely optimizing the water area so that water can be used to cool the panels so that efficiency is maintained [14]. Then another advantage of implementing floating PLTS is that it can reduce water evaporation so that if it is applied to water areas such as reservoirs, it will be helpful, especially when experiencing drought situations [15]. However, like technological innovation, the implementation of floating PLTS cannot be separated from several challenges ranging from technical aspects such as design to sustainability aspects and environmental impacts, especially on aquatic ecosystems, so studies are needed to minimize the effects of implementing floating PLTS.

The purpose of this study was to model the use of river land at Solo's Tirtonadi Dam as a solar power plant. The techno-economic analysis of the PLTS system—which examines the variables influencing cost-effectiveness—was conducted through simulation to ascertain if investing in the project is feasible. The HOMER program was used for the techno-economic study. Both off-grid and on-grid studies are performed by connecting the system to the PLN electricity network and the system to the PLN electricity network, respectively.

2 Methodology

2.1 Research Flow Chart

The research began with a literature study, data collection, simulation, and analysis of results. Simulation of river land use for on-grid and off-grid PLTS using HOMER software to determine the ideal solar power plant configuration, as shown in Figure 1.

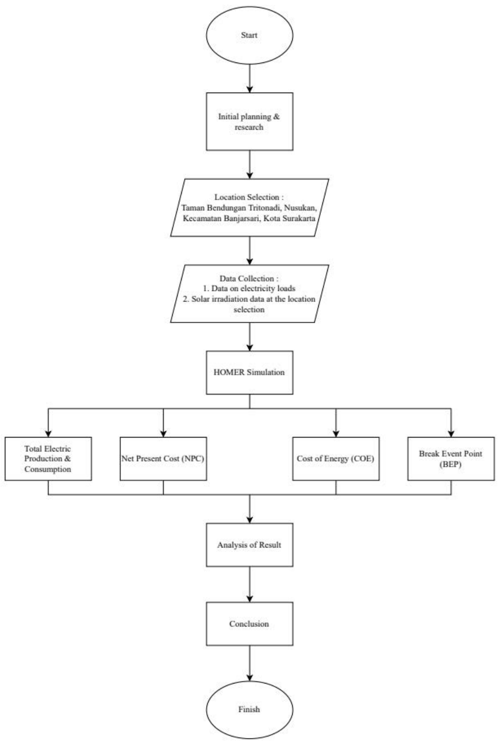

Figure 1. Flowchart of PLTS system design simulation

2.2 Description of the PLTS System Design Model

HOMER software can simulate small-scale generating system models (micropower) in on-grid and off-grid networks. This software makes it possible to compare different design options based on technical requirements and economic benefits [16]. The process in HOMER Pro begins with inputting data related to the energy system to be analyzed, such as the type of energy sources, energy load, and location characteristics. Users then define system design options, including the type and size of components such as solar panels, wind turbines, batteries, and diesel generators. Afterward, HOMER Pro performs simulations to evaluate various system configurations, considering technical and economic aspects to determine the most efficient configuration. The software generates reports that include graphs, tables, and summaries of the analysis results, helping users understand system performance and make better decisions. Economic analysis assesses investment costs, operational costs, and return on investment (ROI), providing a clear picture of the financial feasibility of different design options. By simulating this device, the results will be used to determine a feasible configuration to meet electricity needs with estimated installation and operating costs during the project [17]. NPC is the basis for selecting the economic factors used to find the optimal configuration. The total of all component costs (capital costs), component replacement costs, fuel expenses, operating and maintenance costs, and component residual costs is known as the NPC [18]. The PLTS system design scheme in this research can be completed using two methods, namely the on-grid and off-grid systems.

a. On-grid System

Solar panels and the PLN electrical network are the two energy sources of the on-grid PLTS paradigm. Since the PLTS system at the research location only provides electricity for 14 hours a day, an implementation design like this is expected to reduce energy use from the PLN network by increasing the amount of energy used. Solar panels and PLTS connected to the electricity network provide electricity for households for 24 hours. Figure 2 shows how the on-grid PLTS system is modeled using this approach.

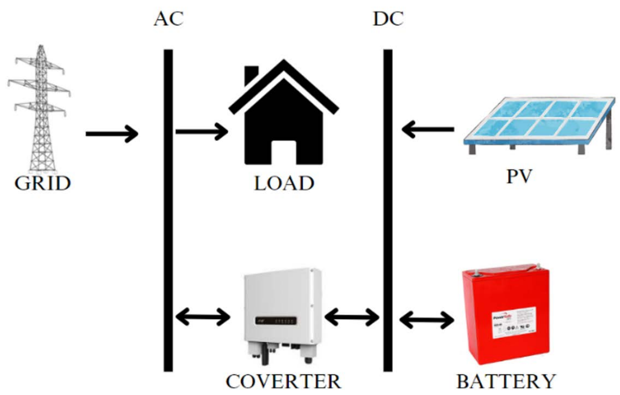

Figure 2. On-grid PLTS system design scheme

b. Off-grid System

Off-grid solar Power Generation Systems (PLTS), known as stand-alone PV, use solar energy as the primary source. A series of photovoltaic modules are used to generate electricity for households. Areas that do not have a PLN electricity supply usually use this system. The model of the off-grid PLTS system can be seen in Figure 3.

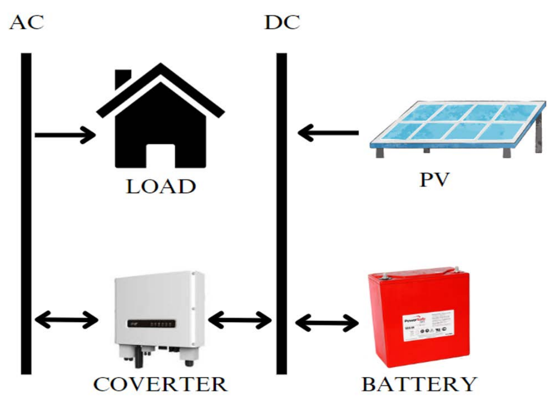

Figure 3. Off-grid PLTS system design scheme

The PLTS architecture shown in the above image relies on a generating system linked to the PLN electrical network and a producing system not to supply the demands for electricity. Meanwhile, Figure 4 and Figure 5 show the loads or electrical requirements that must be supported in this PLTS system.

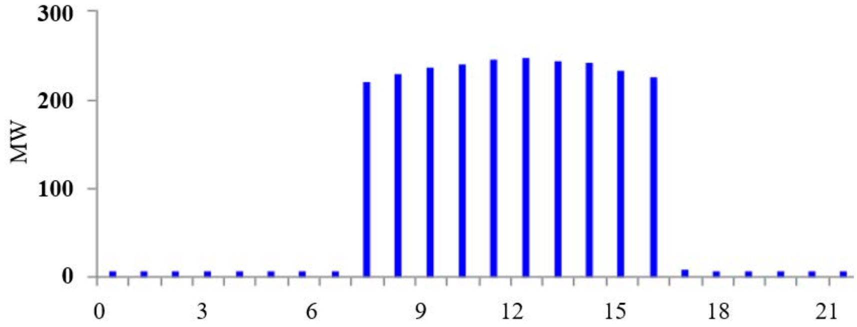

Figure 4. PLTS electrical load profile

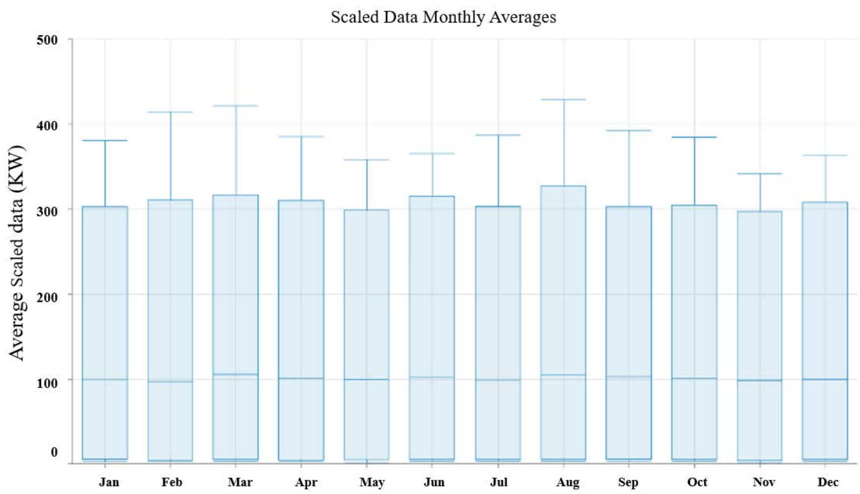

Figure 5. PLTS electricity load profile every month

The required electrical components are determined after the electrical load requirements have been determined. The elements that must be resolved include solar panels, inverters, and batteries. Table 1 shows the components used in the simulation and economic data on each element.

Table 1. PLTS system components

Parameter	Schneider Conext CL25000 E with Generic PV	KEHUA France KF-BCS 630K-B	EnerSys PowerSafe SBS 970
Capital Costs	USD 1,601.02	USD 324.02	USD 745.87
Replacement Cost	-	USD 648.03	USD 745.87
O&M Costs	USD 160.10	USD 32.40	USD 74.59
Lifetime	25 years	10 years	15 years

2.3 Description of PLTS Design Location

The location for the PLTS system design was carried out on the Bengawan Solo River, Tirtonadi Dam Park, Nusukan, Banjarsari District, Surakarta City, as shown in Figure 6. This aims to utilize river land for solar power plants in Surakarta. In urban planning, implementing solar PV in riverine areas can improve land use efficiency and support renewable energy development in urban areas. It can also promote greener transport policies by reducing dependence on fossil fuels. In addition, the involvement of community stakeholders in the project is essential to ensuring social acceptance and long-term sustainability. The government and relevant parties need to integrate the results of this study into broader development policies and programs.

Figure 6. PLTS system design location [19]

2.4 Potential Use of Solar Energy

The distribution of solar radiation and the sun's intensity in an area. Influences the process of converting electrical energy from solar energy [7]. The higher the solar intensity value, the more electricity produced [20]. Direct Normalized Irradiance data in Surakarta is shown in Figure 7 and Table 2.

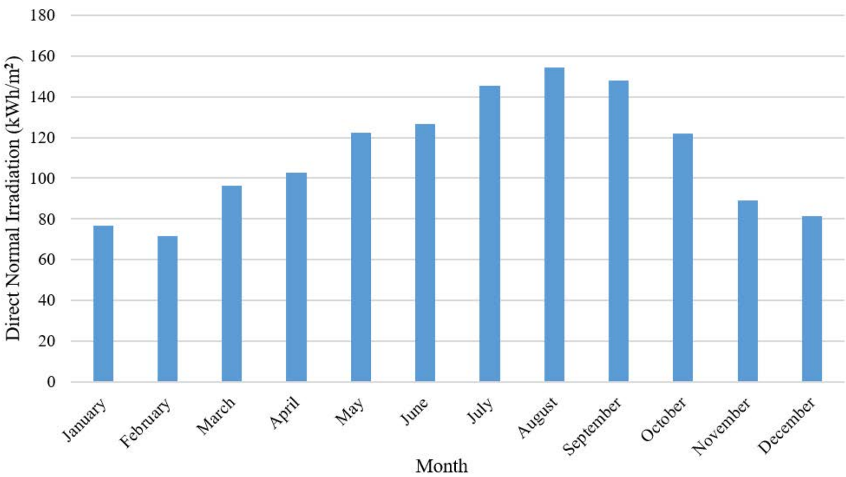

Figure 7. Direct normal irradiation [19]

Table 2. Direct normal irradiation data in Surakarta [21]

Month	Direct Normal Irradiation (kWh/m^2)
January	76.8
February	71.4
March	96.5
April	102.8
May	122.2
June	126.6
July	145.3
August	154.4
September	148.1
October	121.8
November	89.3
December	81.4
Annual	1336.6

2.5 Main Components of the System

2.5.1 Total Expense

Daily Load Data applied to the system analysis is shown in Figure 8 and Table 3.

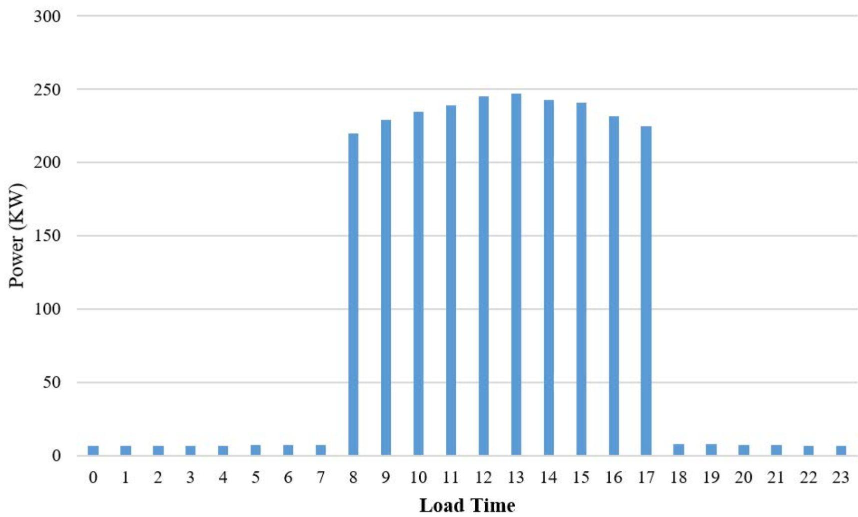

Figure 8. Daily load graph [19]

Table 3. Daily load data [19]

Afternoon (07.00 – 17.00)		Evening (17.00-07.00)	
O'clock	**Load (kW)**	**O'clock**	**Load (kW)**
7	7.4	18	8.1
8	220	19	7.93
9	229	20	7.6
10	235	21	7.4
11	239	22	6.8
12	245	23	6.5
13	247	0	6.7
14	243	1	6.7
15	241	2	6.8
16	232	3	6.85
17	225	4	6.9
		5	7.15
		6	7.2
Total (kW)	2363.4		92.63
Increase the load by 20%, so the total power (kW)	2836.08		111.156
Total load per day (kW)		2947.236	

2.5.2 Solar Panels

Solar panels are a tool used to convert solar energy into electrical energy [22]. Solar panels capture solar radiation with a semiconductor material, which causes electrons in the semiconductor to move, thereby generating an electric current. In this simulation, a Schneider Conext CL25000 E with a generic PV solar panel is used with the specifications shown in Table 4.

2.5.3 Inverters

An inverter is a device used to convert DC (Direct Current) current into AC (Alternating Current) current [23]. This device converts the DC electricity generated by solar panels into AC electricity. This conversion is necessary because most electrical devices used in daily life operate on AC power. In this PLTS design simulation, the type of inverter used is KEHUA France KF-BCS 630K-B, whose specifications can be seen in Table 4.

2.5.4 Battery

The battery functions as a place to store electrical energy [24]. In this PLTS system, batteries are used to store electricity that solar panels have produced during the generation process. The higher battery capacity is better because the electricity generated by the solar panels requires storage space for use at specific times. The battery used is EnerSys PowerSafe SBS 970, with the specifications in Table 4.

Table 4. Main component specifications for river PLTS systems

Components	Parameter	Value
PV	Maximum power (Pmax)	25000 Wp
	Maximum voltage (Vmp)	1000 V
	Maximum current (Imp)	37 A
	Open circuit voltage (Voc)	480 V
	Short circuit current (Isc)	36 A
	Module efficiency	98%
	Module efficiency	85%
Inverters	Maximum power	1400 kW
	Output power	700 kW
	Output frequency	50-60 Hz
	Input dc voltage	48 V
	Efficiency	94%
Battery	Maximum capacity	1.07E+03 Ah
	Nominal capacity	12.8 kWh
	Nominal voltage	12 V
	Maximum charging current	970 A
	Efficiency	97%

2.6 Economy

2.6.1 NPC

NPC is the cost that must be incurred both during installation and during the project. In the HOMER simulation, NPC values are sorted from the lowest value. NPC costs include component costs, component replacement costs, operation and maintenance costs, fuel costs minus the cost of remaining components at the end of the project period, and annual interest rates. The NPC value calculation can be done with the following equation [25].

$$NPC = \frac{C_{\text{ann, tot}}}{CRF, i.R_{\text{proi}}}$$

where,
NPC : Net Present Cost
Cann, tot : Total annual fee (Rp/year)
CRF : Capital recovery factor
i : interest rate
Rproj : life of use (years)

2.6.2 COE

Energy costs are calculated by comparing the total annual costs of the system divided by the energy produced during the same period. The COE value can be calculated using the following equation [26].

$$\text{COE} = \frac{C_{\text{ann, tot}}}{L_{\text{prim},AC} + L_{\text{prim},DC}}$$

where,
COE: Cost of energy
Lprim, AC: AC loads per year (kWh/year)
Lprim, AC: AC loads per year (kWh/year)

3 Results and Discussion

3.1 Homer Simulation Result

The simulation procedure was executed using the HOMER software optimization technique, enabling the optimal configuration for the created system. With HOMER, configuration is done on a machine that is both connected to PLN (on-grid) and disconnected from PLN (off-grid) [27]. The study was conducted by Kumar et al. on the development of river solar power plants in India using on-grid and off-grid scenarios. The results showed that the on-grid system is more economical in the long run, with a higher ROI. In contrast, the off-grid system is more suitable for remote areas not covered by the electricity grid. The data shows that the energy conversion efficiency of the on-grid system reaches 17.8%, while that of the off-grid system is around 15.6% [28]. Homer's simulation for this system can be seen in Figure 9. The following summarizes the simulation results of two categories and two systems designed using HOMER, shown in Table 5.

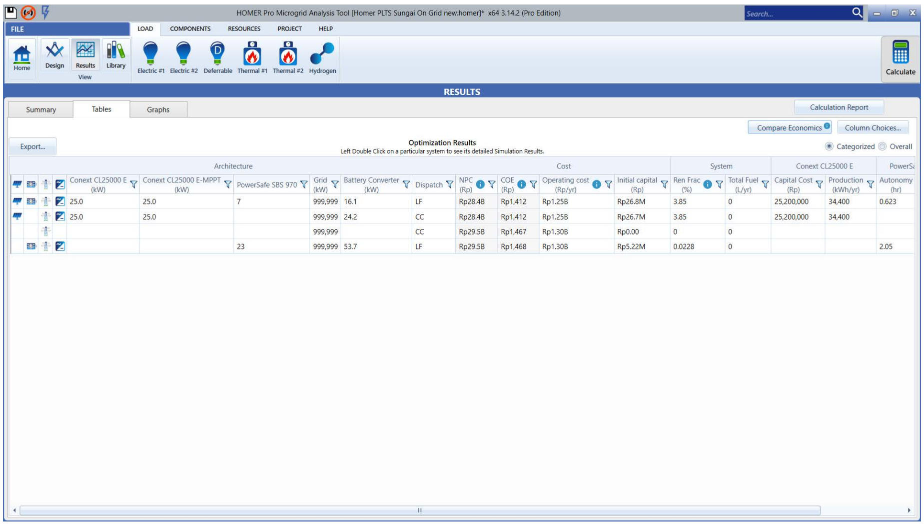

Figure 9. Homer simulation results

Table 5. Economic comparison of on-grid systems and off-grid

Parameter	On-grid	Off-grid
Total Production (kWh)	885,358	34,400
Grid Production (kWh)	850,959	-
Renewable Energy Production (kWh)	34,400	34,400
Primary Load AC	884,852	909
Sales Grid	200	-
Energy Consumption (kWh/year)	885,052	909

The overall electrical power generation of the on-grid system is 887,798 kWh/year, and the Off Grid system is 2,153 kWh/year, according to simulation data in Table 5.

3.2 Economy

Calculating the River PLTS system with NPC efficiently utilizes solar panels to produce electrical energy. For the economics of PLTS Sungai, the leading indicator used to measure the financial efficiency of the project is the COE. The concept of BEP is also relevant in determining how long it will take for a river PLTS investment to reach the BEP, where the income generated is equivalent to the initial investment cost. The results of PLTS economic calculations can be seen in Table 6.

Table 6. River PLTS economics

Parameter	On-grid	Off-grid
NPC	USD 1,805,634.01	USD 1,970.18
COE	USD 0.09	USD 0.10
BEP	0.54	-

a. NPC

The quantity of NPC determines the best possible system setup outcomes. All project-related expenses, including component costs, replacement costs, maintenance costs, fuel costs, and financing rates, are included in the overall NPC cost. Homer ranks the optimization results based on the lowest NPC since NPC is the total cost of the system over a certain amount of time [29]. Based on the simulation, the NPC value shows that the On-Grid system has an NPC value of 1,805,634.01 USD and the off-grid system of 1,970.18 USD.

b. COE

The average cost per kWh of electrical energy produced by the system may be used to calculate the energy cost. The yearly cost of producing electrical energy is divided by the entire amount of electrical power utilized by the system to get COE. Since kWh is the COE unit used in the Homer simulation, we can determine the electricity rate and revenue from energy sales by knowing the COE [3]. Based on the data in Table 5, it is found that the on-grid system has a COE value of 0.09 USD, and the off-grid system is 0.10 USD.

c. BEP

When income and investment value reach point 0, or when there is neither a profit nor a loss, this is referred to as a BEP [30]. The BEP value is employed in economic operations to ascertain the system's potential level. A lower BEP value indicates a higher system potential value. Table 5 data suggests that the BEP value for the on-grid system is 0.54 years.

3.3 Proposed System

The optimal configuration is ascertained from the results of the HOMER simulation, which uses two systems: on-grid and off-grid. The simulation was conducted at the Tirtonadi Solo Dam on the Bengawan Solo River. A comparison of many criteria, including total electrical energy generated, total electrical energy used, NPC value, COE value, and BEP value, is the outcome of optimization using HOMER software. Figure 10 displays the monthly power generation based on the system setup. Figure 11 and Table 7 below demonstrate the cash flow in the suggested model from the HOMER simulation using these two systems.

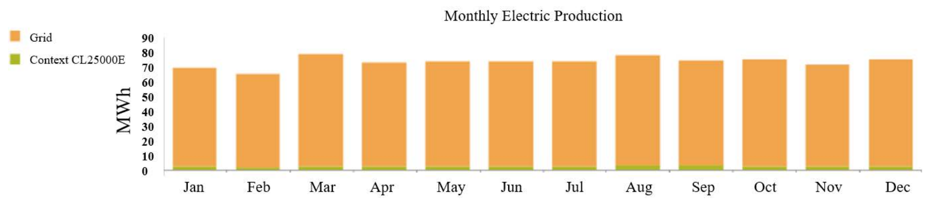

Figure 10. Monthly electricity production using the proposed on-grid system model

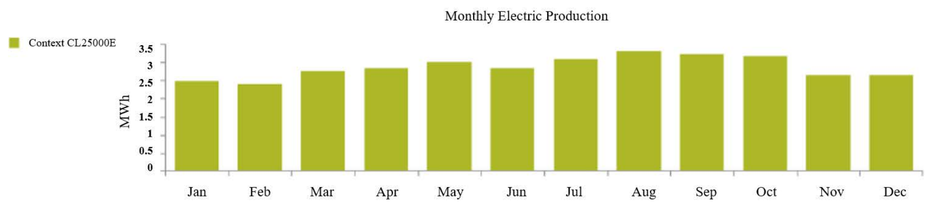

Figure 11. Monthly electricity production using the proposed off-grid system model

Table 7. Cash flow in the proposed on-grid system

Components	Capital	Replacement	O&M	Salvage	Total
KEHUA France KF-BCS 630K-B	USD 65.21	USD 233.58	USD 148.27	USD 54.19	USD 392.87
EnerSys PowerSafe SBS 970	USD 34.81	USD 31.15	USD 79.15	USD 9.64	USD 135.46
PLN	-	-	USD 1,803,140.84	-	USD 1,803,140.84
Schneider Conext CL25000 E with generic PV	USD 1,601.02	-	USD 364.05	-	USD 1,965.06
System	USD 1,699.13	USD 264.73	USD 1,803,732.31	USD 63.83	USD 1,805,634.23

After carrying out a simulation using the HOMER application, a comparison of the electricity production results of the on-grid and off-grid systems can be seen in Figure 12 below.

The total electricity production output using the on-grid system tends to be higher than that of the off-grid system because it can utilize more extensive and continuous resources from the PLN electricity network. Meanwhile, the total electricity production output with an off-grid system depends on local resources such as solar panels, wind turbines, or power generators. The production capacity of off-gird systems is also more limited and influenced by fluctuations in weather or environmental conditions.

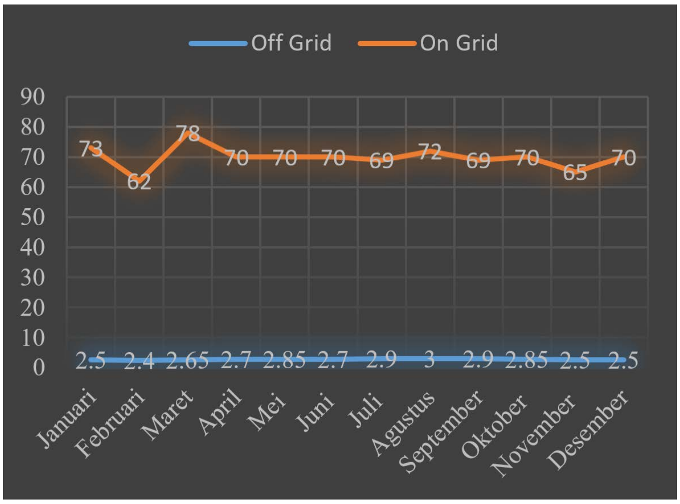

Figure 12. Comparison chart of total electricity production for on-grid and off-grid systems

4 Conclusion

This study created two PLTS systems, the on-grid, and off-grid systems, particularly for the Bengawan Solo riverfront region near Tirtonadi Dam in Surakarta. Optimizing the integration of renewable resources, such as solar panels, in power-producing systems was the goal of the research. This research provides insight into how river PLTS can improve energy efficiency in urban and rural areas. Using this method, the researchers examined several scenarios of resource allocations and energy storage systems to reduce operating and capital expenses while maintaining the stability of the electrical supply. The total amount of energy produced and consumed, the NPC value, the COE value, and the BEP value are critical variables used to evaluate the possibility of creating this system. The system project is planned to last for 25 years. The on-grid system produces 885,358 kWh/year, while the total electricity consumption is 887,798 kWh/year. Apart from that, the NPC value is USD 1,805,634.01, and the COE value is USD 0.09, with a BEP in the year of 0.54. The initial cost to build an on-grid PLTS at Tirtonadi Dam is estimated at around USD 47,782.10. Meanwhile, the off-grid system produces 34,400 kWh/year, while the total electricity consumption is 2,153 kWh/year. Apart from that, the NPC value is USD 1,970.18, and the COE value is USD 0.10. The initial cost to build a grid PLTS at Tirtonadi Dam is around USD 1,923.77. This research introduces a hybrid model of river PLTS in the Tirtonadi Dam area, Solo, which can be integrated into both on-grid and off-grid electricity systems. The results of this research are expected to provide technical and economic guidance for implementing solar power plants in similar locations while offering a more environmentally friendly and sustainable option for urban areas with similar potential.

Data Available

The data used to support the research findings are available from the corresponding author upon request.

Acknowledgments

This research is required to determine Permanent Non-State Civil Apparatus Lecturers at the State University of Malang. Furthermore, the results of this work can be used as a condition for promotion to functional or structural positions.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] M. K. G. Deshmukh, M. Sameeroddin, D. Abdul, and M. Abdul Sattar, "Renewable energy in the 21st century: A review," *Mater. Today Proc.*, vol. 80, pp. 1756–1759, 2023. https://doi.org/10.1016/j.matpr.2021.05.501

[2] M. Höök and X. Tang, "Depletion of fossil fuels and anthropogenic climate change - A review," *Energy Policy*, vol. 52, pp. 797–809, 2013. https://doi.org/10.1016/j.enpol.2012.10.046

[3] A. Kalair, N. Abas, M. S. Saleem, A. R. Kalair, and N. Khan, "Role of energy storage systems in energy transition from fossil fuels to renewables," *Energy Storage*, vol. 3, no. 1, 2021. https://doi.org/10.1002/est2.135

[4] F. Dellano-Paz, A. Calvo-Silvosa, S. I. Antelo, and I. Soares, "The European low-carbon mix for 2030: The role of renewable energy sources in an environmentally and socially efficient approach," *Renew. Sustain. Energy Rev.*, vol. 48, pp. 49–61, 2015. https://doi.org/10.1016/j.rser.2015.03.032

[5] M. N. Uddin, M. M. Biswas, and S. Nuruddin, "Techno-economic impacts of floating PV power generation for remote coastal regions," *Sustain. Energy Technol. Assessments*, vol. 51, no. December 2021, p. 101930, 2022. https://doi.org/10.1016/j.seta.2021.101930

[6] I. B. Fridleifsson, "Geothermal energy for the benefit of the people," *Renew. Sustain. Energy Rev.*, vol. 5, no. 3, pp. 299–312, 2001. https://doi.org/10.1016/S1364-0321(01)00002-8

[7] N. Kannan and D. Vakeesan, "Solar energy for future world: A review," *Renew. Sustain. Energy Rev.*, vol. 62, pp. 1092–1105, 2016. https://doi.org/10.1016/j.rser.2016.05.022

[8] N. L. Panwar, S. C. Kaushik, and S. Kothari, "Role of renewable energy sources in environmental protection: A review," *Renew. Sustain. Energy Rev.*, vol. 15, no. 3, pp. 1513–1524, 2011. https://doi.org/10.1016/j.rser.2010.11.037

[9] I. Desti, "Literature review: Upaya energi bersih dan terjangkau," *J. Sains Edukatika Indones.*, vol. 4, no. 1, pp. 8–11, 2022. https://jurnal.uns.ac.id/jsei/article/viewFile/70928/39315

[10] M. H. Ahmadi, M. Sadeghzadeh, M. Ghazvini, A. Nazari, R. Kumar, A. Naeimi, and T. Z. Ming, "Solar power technology for electricity generation: A critical review," *Energy Sci. Eng.*, vol. 6, no. 5, pp. 340–361, 2018. https://doi.org/10.1002/ese3.239

[11] J. Yadav, "A review paper on solar tree," *Int. J. Eng. Res. Technol.*, vol. 5, no. 23, pp. 66–70, 2018.

[12] H. F. Ummah, R. Setiati, Y. B. V. Dadi, M. N. Ariq, and M. T. Malinda, "Solar energy as natural resource utilization in urban areas: Solar energy efficiency literature review," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 780, no. 1, p. 012007, 2021. https://doi.org/10.1088/1755-1315/780/1/012007

[13] F. T. Hasanah, "Karakteristik wilayah daratan dan perairan Indonesia," *J. Geogr.*, vol. 20, no. 13, pp. 1–6, 2020. https://www.researchgate.net/publication/345803603

[14] A. Sahu, N. Yadav, and K. Sudhakar, "Floating photovoltaic power plant: A review," *Renew. Sustain. Energy Rev.*, vol. 66, pp. 815–824, 2016. https://doi.org/10.1016/j.rser.2016.08.051

[15] R. S. Yuniar and F. U. Najicha, "The bio-rights scheme in the use of the sun as a renewable new energy promotes the availability of sustainable electricity energy sources skema bio-rights dalam pemanfaatan matahari sebagai energi baru terbarukaan penunjang ketersediaan sumber energi list," *IPMHI Law J.*, vol. 4, no. 1, pp. 65–81, 2024. https://doi.org/10.15294/ipmhi.v4i1.77908

[16] A. B. Prawira, B. Winardi, and A. Nugroho, "Optimasi pengunaan sumber energi listtrik di Departemen Teknik Elektro Universitas Diponegoro dengan menggunakan perangkat lunak homer," *Transient*, vol. 7, no. 4, p. 904, 2019. https://doi.org/10.14710/transient.7.4.904-910

[17] T. Lambert, P. Gilman, and P. Lilienthal, "Micropower system modeling with homer," *Integr. Altern. Sources Energy*, pp. 379–418, 2006. https://doi.org/10.1002/0471755621.ch15

[18] G. Alvianingsih and J. C. H. Simanjuntak, "Analisis tekno-ekonomi hibrid sistem pltd plts di pulau gersik, belitung menggunakan perangkat lunak homer," *Sutet*, vol. 11, no. 1, pp. 1–12, 2021. https://doi.org/10.33322/sutet.v11i1.1372

[19] "Homer research apps," 2024. https://homerenergy.com/

[20] C. Y. Park, S. H. Hong, S. C. Lim, B. S. Song, S. W. Park, J. H. Huh, and J. C. Kim, "Inverter efficiency analysis model based on solar power estimation using solar radiation," *Processes*, vol. 8, no. 10, pp. 1–19, 2020. https://doi.org/10.3390/pr8101225

[21] "Global solar atlas," 2024. https://globalsolaratlas.info/map

[22] M. B. Hayat, D. Ali, K. C. Monyake, L. Alagha, and N. Ahmed, "Solar energy - A look into power generation, challenges, and a solar-powered future," *Int. J. Energy Res.*, vol. 43, no. 3, pp. 1049–1067, 2019. https://doi.org/10.1002/er.4252

[23] W. U. Tareen, S. Mekhilef, M. Seyedmahmoudian, and B. Horan, "Active power filter (APF) for mitigation of power quality issues in grid integration of wind and photovoltaic energy conversion system," *Renew. Sustain. Energy Rev.*, vol. 70, pp. 635–655, 2017. https://doi.org/10.1016/j.rser.2016.11.091

[24] P. Setiyawan, S. B. Utomo, and A. A. Nugroho, "Analisa optimasi photovoltaic (PV) 100 w menggunakan mppt dengan alogaritma perturb dan observe," *Elektrika*, vol. 13, no. 1, p. 1, 2021. https://doi.org/10.26623/elektrika.v13i1.2984

[25] Z. Arifin, Suyitno, D. Tjahjana, M. Muqoffa, S. Prasetyo, N. Alfaiz, and A. Sanusi, "Grid-connected hybrid PV-wind system simulation in urban java," *J. Eur. des Syst. Autom.*, vol. 55, no. 4, pp. 477–483, 2022. https://doi.org/10.18280/jesa.550406

[26] K. A. D. Sari, , F. D. Wijaya, and H. R. Ali, "Optimization of hybrid power plant system in Enggano Island," *J. Nas. Tek. Elektro Dan Teknol. Inf.*, vol. 11, no. 2, pp. 154–160, 2022. https://doi.org/10.22146/jnteti.v11i2.3849

[27] I. K. Bachtiar, "Rancangan implementasi pembangkit listrik tenaga surya (PLTS) skala rumah tangga menggunakan software HOMER," *J. Sustain. J. Has. Penelit. dan Ind. Terap.*, vol. 5, no. 2, pp. 17–25, 2016. https://www.academia.edu/114317293

[28] M. R. Heidari, G. Heravi, and A. M. Esmaeeli, "Integrating life-cycle assessment and life-cycle cost analysis to select sustainable pavement: A probabilistic model using managerial flexibilities," *J. Cleaner Prod.*, vol. 254, p. 120046, 2020. https://doi.org/10.1016/j.jclepro.2020.120046

[29] M. Z. Zulni and Sepannur, "Planning on solar power plant 900 va power grid using micropower homer household application perencanaan pembangkit listrik tenaga surya ongrid daya 900 va menggunakan homer dayamikro aplikasi rumah tangga," *Indones. J. Electr. Eng. Renew. Energy*, vol. 3, no. 1, pp. 29–35, 2023. https://journal.irpi.or.id/index.php/ijeere/article/view/475

[30] J. Windarta, E. W. Sinuraya, A. Z. Abidin, A. E. Setyawan, and Angghika, "Perancangan pembangkit listrik tenaga surya (PLTS) berbasis homer di sma negeri 6 surakarta sebagai sekolah hemat energi dan ramah lingkungan jaka," *Pros. Semin. Nas. MIPA 2019 Univ. Tidar*, vol. 2, no. 1, pp. 21–36, 2019. https://proceeding.unnes.ac.id/SNMIPA/article/view/430/279