INTEK Jurnal Penelitian
Vol. 9, No. 2, pp. 89-92, October 2022

PVSYST-Based Solar Power Plant Planning

Muhammad Alif Anrizal Akbar[1,*,a], A. M. Shiddiq Yunus[1,b], Jumadi Tangko[1,c]
[1]Mechanical Eng. Department, State Polytechnic of Ujung Pandang, Jalan Perintis Kemerdekaan KM. 10 Makassar
[*,a] Alifanrizal.aa@gmail.com (Corresponding Author),
[b] shiddiq@poliupg.ac.id
[c] jumaditangko@poliupg.ac.id

***Abstract*—This research uses the PVSyst software which can plan an off-grid SPP system and find out how much electricity is generated in the Auditorium Building Campus 2, Ujung Pandang State Polytechnic. PVSyst is a software package that is used for the learning process, sizing, and data analysis of the PV mini-grid system. PVSyst is divided into grid connected systems, standalone systems, pumping systems. PVSyst is also equipped with a database from a wide and diverse range of meteorological data sources, as well as data on PV mini-grid components. In planning a PVSyst-based solar power plant, it can be used to find out how much electrical energy is generated to meet the electricity needs of the Campus 2 Auditorium Building, Ujung Pandang State Polytechnic. In this study using the PVSyst software according to the proposed load requires an average energy of 482 kWh/day, therefore, the panel module used is the polycrystalline type model CS3W-410P-HE manufacturer Canadian Solar Inc, where each panel unit used has a nominal power of 410 WP requires 422 modules, 2 modules in series and 211 modules in parallel. The battery used is a lead acid type with a 12-CS-11PS model manufactured from Rolls. The batteries used are 195 batteries, of which 3 batteries are installed in series and 64 batteries are installed in parallel. The controllers needed in this design are 50 units with the FLEXmax 80-36V model manufactured from Outback. The technology of this controller is an MPPT converter. In planning Solar Power Plant using PVSyst in the Auditorium Building Campus 2 of Ujung Pandang State Polytechnic, it produces electricity of 227,122 kWh per year.**

***Keywords*—PVSyst, Module, Solar Power Plant, Auditorium.**

I. Introduction

Nowadays, the main support for energy needs still rely on petroleum. Meanwhile, it is unavoidable that petroleum is increasingly scarce and expensive. Reserves of fossil energy sources worldwide since 2002 are 40 years for oil, 60 years for natural gas, and 200 years for coal [1]. With the depletion of these fossil energy sources, in today's world there is a shift from the use of non-renewable energy sources to renewable energy sources. Renewable energy potential, such as: biomass, geothermal, solar energy, water energy, wind energy, ocean energy, hydro power has not been widely utilized, even though the potential for renewable energy is very large, especially in Indonesia [2]. From aforementioned renewable energy sources above, the use of energy through solar cells is the most potential alternative to be implemented in Indonesia [3].

Indonesia has the potential to make solar cells one of the future energy sources where Indonesia's coordinates are on the equator where sunlight can be optimally received in almost all parts of Indonesia throughout the year [4]. In peak conditions or the sun's position is perpendicular, the sunlight that falls on the surface of one square meter of solar panels in Indonesia will be able to reach 900 to 1000 Watts [5]. In fact, the total irradiation intensity per day in Indonesia can reach 4500 watt hour per square meter which makes Indonesia classified as a rich source of solar energy. With its location on the equator, the sun in Indonesia can shine up to 2,000 hours per year [6].

At the stage of the construction process at Campus 2 of the State Polytechnic of Ujung Pandang and seeing the potential for solar energy, the location has great potential for developing a Solar Power Plant (SPP) in the Auditorium Building of Campus 2 of the State Polytechnic of Ujung Pandang. Where the construction of SPP will be a solution when fossil energy is running low and as a form of effort to assist the government in expanding the use of renewable energy. Therefore the authors conducted research at that location using the PVSyst software simulation approach. The PVSyst

DOI : http://dx.doi.org/10.31963/intek. v9i1.3789

software is an application to find out the potential of SPP in an area [7]. Therefore, in this paper, solar power plant system planning using PVSyst is implemented to the case study of of Auditorium of the State Polytechnic of Ujung Pandang (SPUP).

II. Research Methodology

A. Research Variables

The variables of this study are the dependent variable and the independent variable. The dependent variable is a variable that is influenced by other independent variables. The independent variable is the sun. The sun will affect the dependent variables such as temperature, humidity [8].

B. Research Instruments

The software used in this study is PVSyst 7.0 software [7].

C. Research Stages

Research stages can be seen in Figure 1.

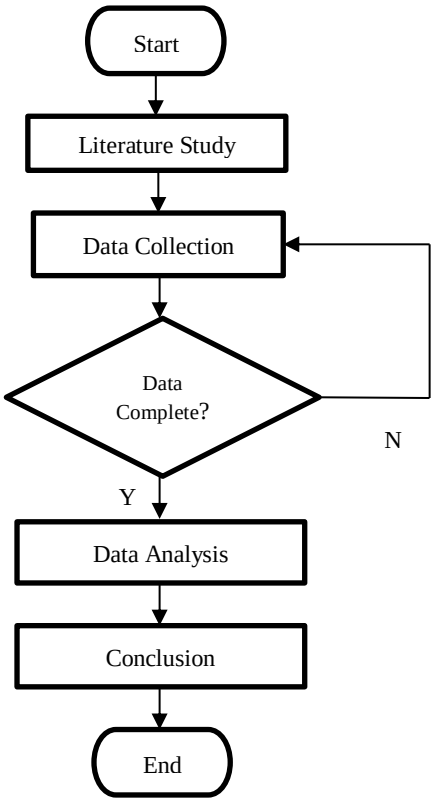

Figure 1. Research Stages

The State Polytechnic of Ujung Pandang Auditorium Building is a multipurpose building located on campus 2 of the Ujung Pandang State Polytechnic which is at coordinates 5.1439, 119.5239.

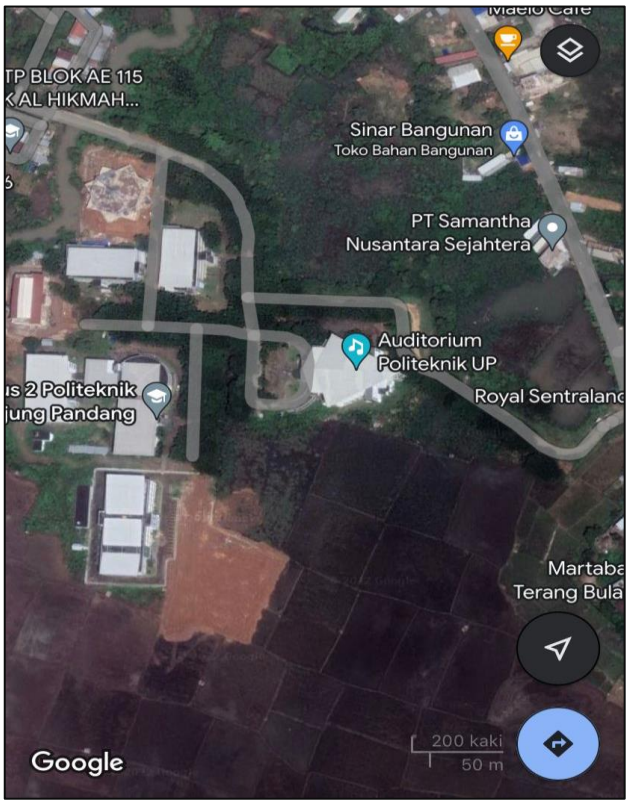

Figure 2. Auditorium of the State Polytechnic of Ujung Pandang Location looked from Google Map [8].

Figure 3. Auditorium of the State Polytechnic of Ujung Pandang.

DOI : http://dx.doi.org/10.31963/intek. v9i1.3789

III. Results and Discussion

Based on Figure 4.3 in the PVSyst software, it shows that the average solar irradiation on Campus 2 SPUP is 1,836.7 kWh per year with an annual temperature of 27,100.

Site: Kampus 2 PNUP (Indonesia)
Data source: Meteonorm 7.3 (1989-2005), Sat=100%

	Global horizontal irradiation kWh/m²/mth	Horizontal diffuse irradiation kWh/m²/mth	Temperature °C	Wind Velocity m/s	Linke turbidity [-]	Relative humidity %
January	144.8	65.9	26.6	2.40	3.491	85.1
February	139.8	69.6	26.7	2.30	3.524	84.1
March	177.2	84.8	27.2	2.19	3.421	82.7
April	170.1	74.2	27.4	1.80	3.384	84.3
May	159.8	74.9	27.9	1.70	3.190	83.1
June	141.5	69.4	27.1	1.59	3.277	84.4
July	150.5	73.3	27.4	1.59	3.325	81.8
August	151.1	73.7	27.5	1.80	3.726	81.5
September	151.8	73.6	27.0	1.70	3.689	84.0
October	157.4	85.7	27.2	1.71	3.843	84.4
November	150.3	67.6	26.8	1.70	3.278	87.1
December	142.4	72.7	26.7	2.09	3.271	86.3
Year	**1836.7**	**885.4**	**27.1**	**1.9**	**3.452**	**84.1**
	Paste	Paste	Paste	Paste		

Global horizontal irradiation year-to-year variability 9.3%

Figure 3. Solar Irradiation Data at Campus 2 of the State Polytechnic Ujung Pandang.

The report below is the result of the SPP simulation on PVSyst with the parameters that have been entered. The simulation results will be explained in the figure 4.

Simulation date 11/09/22 16h48

Simulation parameters	System type	**Stand alone system with batteries**		
Collector Plane Orientation	Tilt	7°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
User's needs :	Daily household consumers	Constant over the year		
	average	482 kWh/Day		
PV Array Characteristics				
PV module	Si-poly	Model	**CS3W-410P HE**	
Original PVsyst database		Manufacturer	Canadian Solar Inc.	
Number of PV modules		In series	2 modules	In parallel 211 strings
Total number of PV modules		nb. modules	422	Unit Nom. Power 410 Wp
Array global power		Nominal (STC)	**173 kWp**	At operating cond. 173 kWp (25°C)
Array operating characteristics (50°C)		U mpp	78 V	I mpp 2211 A
Total area		Module area	**932 m²**	Cell area 837 m²
System Parameter	System type	**Stand alone system**		
Battery		Model	**12-CS-11PS**	
		Manufacturer	Rolls	
Battery Pack Characteristics		Nb. of units	3 in series x 65 in parallel	
		Voltage	36 V	Nominal Capacity 19240 Ah
		Discharging min. SOC	20.0%	Stored energy 554.1 kWh
		Temperature	Fixed (28°C)	
Controller		Model	FLEXmax 80 - 36V	
		Manufacturer	Outback	Nb. units 50
		Technology	MPPT converter	Temp coeff. -5.0 mV/°C/Elem.
Converter	Maxi and EURO efficiencies		97.5 / 96.0%	
Battery Management control	Threshold commands as		Battery voltage	
		Charging	42.5 / 37.6 V	Corresp. SOC 0.92 / 0.75
		Discharging	34.0 / 36.6 V	Corresp. SOC 0.13 / 0.45

Figure 4. PVSyst Results for Auditorium of the State Polytechnic Ujung Pandang.

Figure 4 is a report on the simulation results for this plan according to the proposed load requiring an average energy of 482 kWh/day, therefore the panel module used is the Polycrystalline type model CS3W-410P-HE from Canadian Solar Inc., [9] where each panel unit used has a nominal power of 410Wp requires 422 modules, 2 modules installed in series and 211 modules installed in parallel which will produce a power of 173 kWp, an array voltage of 78V and a current of 2,211A using a standalone system. This SPP can produce 227,122 kWh of electrical energy per year and the energy used by consumers is 164,713 kWh per year. The solar module is placed at an inclination of 70 and an azimuth point of 00. The Auditorium Building of the Ujung Pandang State Polytechnic is located at latitude and longitude 5.1439, 119.5239 using MeteoNorm 7.2 data. The area required for module installation is 932 m^2.

Stand alone system: Detailed User's needs

Project : **Alif Project Skripsi**
Simulation variant : **Skripsi alif**

Main system parameters	System type	**Stand alone system with batteries**			
PV Field Orientation	tilt	7°	azimuth	0°	
PV modules	Model	CS3W-410P HE	Pnom	410 Wp	
PV Array	Nb. of modules	422	Pnom total	**173 kWp**	
Battery	Model	12-CS-11PS	Technology	Lead-acid, sealed, plates	
Battery pack	Nb. of units	195	Voltage / Capacity	**36 V / 19240 Ah**	
User's needs	Daily household consumers	Constant over the year	Global	176 MWh/year	

Daily household consumers, Constant over the year, average = 482 kWh/day

Annual values

	Number	Power	Use	Energy
Lamps 25W	484	25W/lamp	6H/day	72600Wh/day
Lamps 70W	78	70W/app	6H/day	32760Wh/day
AC 1 PK	4	800W/app	6H/day	19200Wh/day
Pompa Air	1		1Wh/day	125Wh/day
AC Standing	11	5275W tot	6H/day	348150Wh/day
Lampu Sorot LED	32	100W tot	3H/day	9600Wh/day
Stand-by consumers			24H/day	24Wh/day
Total daily energy				482459Wh/day

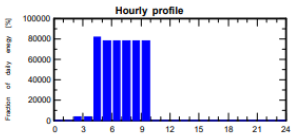

Figure 5. Detail user loads of the Auditorium of State Polytechnic Ujung Pandang.

Figure 5 SPUP Auditorium building based on the type, quantity, and usage time of the components used in the building. Where the average load usage is 482 kWh/day.

Figure 6 is a graph of normalized production which is energy production every day. The total unused energy when the battery is fully charged is 0.69 kWh per day. Solar panel energy losses are 0.72 kWh/kWp per day. System losses and losses when charging the battery is 0.42 kWh/kWp per day. The energy supplied to consumers is 2.61 kWh/kWp per day.

DOI : http://dx.doi.org/10.31963/intek. v9i1.3789

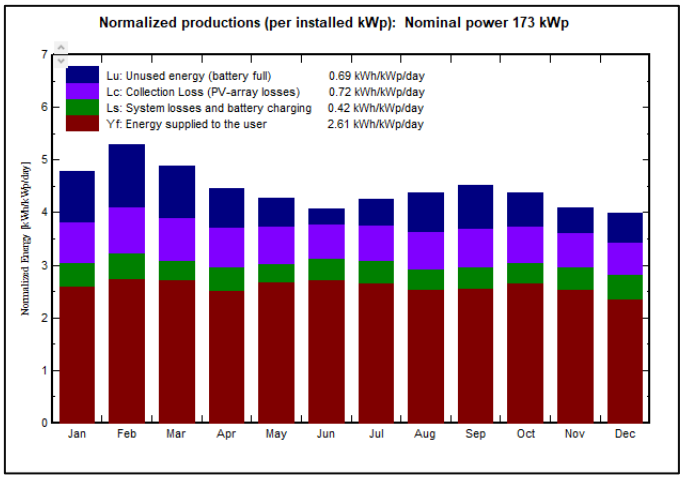

Figure 6. Normalized Production Graph

Stand alone system: Cost of the system

Project : Alif Project Skripsi
Simulation variant : Skripsi alif

Main system parameters	System type	**Stand alone system with batteries**		
PV Field Orientation	tilt	7°	azimuth	0°
PV modules	Model	CS3W-410P HE	Pnom	410 Wp
PV Array	Nb. of modules	422	Pnom total	**173 kWp**
Battery	Model	12-CS-11PS	Technology	Lead-acid, sealed, plates
Battery pack	Nb. of units	195	Voltage / Capacity	**36 V / 19240 Ah**
User's needs	Daily household consumers	Constant over the year	Global	176 MWh/year

Installation costs			
PV modules			
CS3W-410P HE	422 units	2'000'000.00 IDR/unit	844'000'000.00 IDR
Batteries	195 units	31'813'696.00 IDR/unit	6'203'670'720.00 IDR
Controllers	50 units	4'183'938.00 IDR/unit	209'196'900.00 IDR
Studies and analysis			
Engineering	2 units	5'000'000.00 IDR/unit	10'000'000.00 IDR
Environmental studies	2 units	3'000'000.00 IDR/unit	6'000'000.00 IDR
Economic analysis	2 units	3'000'000.00 IDR/unit	6'000'000.00 IDR
Installation			
Transport			2'000'000.00 IDR
Wiring			20'000'000.00 IDR
Settings			7'000'000.00 IDR
		Total	**7'307'867'620.00 IDR**
		Depreciable asset	7'256'867'620.00 IDR

Operating costs		
Maintenance		
Cleaning		5'000'000.00 IDR/year
Provision for battery replacement		620'367'072.00 IDR/year
	Total (OPEX)	**625'367'072.00 IDR/year**
	Including inflation (1.50%)	**752'017'001.95 IDR/year**

Figure 7. Cost of the System

The cost of this PLTS system is shown in Figure 7. In accordance with the price of these components, it can be estimated that the initial investment in this study is IDR 7,307,867,620. The cost of operating the system is IDR 625,367,072.

Figure 8 shows the financial analysis of this simulation. The project lifetime is 25 years starting from 2023. The source of funds obtained is assumed to be self-funded (the Ujung Pandang State Polytechnic campus), which amounts to IDR 5,000,000,000. Subsidies from the government Rp. 2,000,000,000. and a loan of IDR 307,867,620. The payback period is 7.9 years, the Net Present Value (NPV) is IDR 15,436,632,749.

Stand alone system: Financial analysis

Project : Alif Project Skripsi
Simulation variant : Skripsi alif

Main system parameters	System type	**Stand alone system with batteries**		
PV Field Orientation	tilt	7°	azimuth	0°
PV modules	Model	CS3W-410P HE	Pnom	410 Wp
PV Array	Nb. of modules	422	Pnom total	**173 kWp**
Battery	Model	12-CS-11PS	Technology	Lead-acid, sealed, plates
Battery pack	Nb. of units	195	Voltage / Capacity	**36 V / 19240 Ah**
User's needs	Daily household consumers	Constant over the year	Global	176 MWh/year

Financial parameters

Simulation period
Project lifetime 25 years Start year 2023

Income variation over time
Inflation 1.50 %/year
Production variation 0.00 %/year
Discount rate 1.00 %/year

Financing
Own funds 5'000'000'000.00 IDR
Subsidies 2'000'000'000.00 IDR
Loan 307'867'620.00 IDR

Figure 8. Financial Analysis.

IV. Conclusion

Planning for SPP in the Auditorium Building Campus 2 Ujung Pandang State Polytechnic based on using the PVSyst software is as follows:

1. One way to use solar energy is to build an off-grid PLTS in the Auditorium Building Campus 2 of State Polytechnic Ujung Pandang. In this plan using the PVSyst software according to the proposed load requires an average energy of 482 kWh/day, so the panel module used is the polycrystalline type model CS3W-410P-HE manufacturer Canadian Solar Inc, where each panel unit used has a nominal power of 410 WP requires 422 modules, 2 modules in series and 211 modules in parallel. The battery required for this design is a lead acid type with a 12-CS-11PS model manufactured from Rolls. The batteries used are 195 batteries, of which 3 batteries are installed in series and 64 batteries are installed in parallel. The controllers needed in this design are 50 units with the FLEXmax 80-36V model manufactured from Outback. The technology of this controller is an MPPT converter.

DOI : http://dx.doi.org/10.31963/intek. v9i1.3789

2. In planning PLTS using the PVSyst software in the Auditorium Building Campus 2, Ujung Pandang State Polytechnic can generate 227,122 kWh of electrical energy per year.

Some Suggestions regarding the further research:

1. It is necessary to carry out further studies regarding the use of SPP as a renewable energy source to meet the demand for electrical energy. So that the cost of PLTS can be cheaper so that people are interested in developing and utilizing electricity that comes from the sun (SPP).
2. Further research in order to determine the shading in the installation of solar panels so that energy is absorbed better.

Acknowledgement

Authors would like to thank The State Polytechnic of Ujung Pandang asset management who has assist the data collection particularly regarding the Auditorium Data.

References

[1] https://ourworldindata.org/fossil-fuels

[2] N. A. Handayani, and D. Ariyanti, "Potency of Solar Energy Applications in Indonesia," International Journal of Renewable Energy Development, Vol. 1, No. 2, pp. 33-38, Jul. 2012. https://doi.org/10.14710/ijred.1.2.33-38

[3] Widayana, Gede. "Pemanfaatan energi surya". (Utilization of solar energy). Jurnal pendidikan teknologi dan kejuruan, Vol. 9, No. 1, Januari 2012 : 37 – 46.

[4] Kementerian ESDM. "Matahari Untuk PLTS di Indonesia". (Sun for SPP in Indonesia). (Online). (http:// https://www.esdm.go.id/id/media-center/arsip-berita/matahari-untuk-plts-di-indonesia). (Accessed: 30 Januari 2022).

[5] Kurniawan, Izef Aulia. "Analisa Potensi Pembangkit Listrik Tenaga Surya (PLTS) Sebagai Pemanfaatan Lahan Pembangkit Listrik Tenaga Uap (PLTU) Paiton. (Analysis of the Potential of Solar Power Plants as Utilization of Paiton Steam Power Plant Land). Skripsi. Surabaya: Jurusan Teknik Fisika Institut Teknologi Sepuluh Nopember.

[6] https://iesr.or.id/agenda-iesr/indonesia-solar-potential-report

[7] https://www.pvsyst.com/

[8] A. Ansori, I. H. Siregar, S.I., Haryuda, "Renewable Energy Conversion with hybrid Solar Cell and Fuel Cell", Proceeding The 1st IBSC: Towards The Extended Use of Basic Science For Enhancing Health, Environment, Energy And Biotechnology. 26-27 September 2016.

[9] Canadian Solar. 2022. Canadian Solar Datasheet HiKu CS3W. (Online).(https://www.canadiansolar.com/wp-content/Uploads/ /2019/12/Canadian Solar-Datasheet-HiKu_CS3W-P_EN.pdf). (Accessed: 20 April 2022).

DOI : http://dx.doi.org/10.31963/intek. v9i1.3789