The Application of PVSyst for Design of Solar Photovoltaic Power Generation at School Building

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Abstract. The need of electrical power at the school building may be partly fulfilled by solar PV power generation. The panels are installed on the rooftop of the building. For the purpose of optimal design of the generation system, PVSyst is employed for this task. This paper proposes the design of solar PV generation using PVSyst. The design result is then confirmed with the real system. Some adjustments will be carried out to align the design with the real system. For the design, the data of electric load is recorded. The capacity of solar intensity and other parameters were also recorded. With the data in hand, the design of solar PV generation may be carried out using PVSyst. With the design results, the real system may be implemented referring the document of design. Since the capacity of the available panels is limited some application may not be completely implemented. Besides the contribution in the form of load sharing, the system may be used by the students to learn how the electricity can be generated using the resources that are freely available

1 Introduction

Electrical energy will be one of the most prospective energies in the coming decade. There are some reasons behind this prediction. The electrical energy can be easily generated using different technique utilizing diverse resources. This energy may also be delivered achieving long distance with minimum losses. The possibility of using this energy by numerous equipment for different purpose further supports this expectation. Considering this picture, the demand for electricity will certainly be high in the future. For the particular case in Indonesia, the increase of electricity demand is due to the economic development, which is combined with urbanization and industrialization [1]. It was observed that the peak of electricity demand in Indonesia may triple between 2010 and 2030 in a business-as-usual case, to 77.3 GW. This is due mainly to the massive use of air conditioning while lighting and refrigerator also give significant contribution to this addition.

Another motivation to extensively use electrical energy is the sustain increase of oil price [2]. The intensive use of fossil fuels will cause the resources to last quickly. The accelerated exploration of the mineral will certainly reduce the resource faster. Further

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including the factor of population growth in this prediction may lead to the faster reduction of the mineral. If this condition persists, then it may lead to the situation where there is no fossil fuel left for future generation. Currently, some countries still depend heavily on fossil fuels. Due to this reason it is estimated that by 2050 it will only remain approximately 14% of oil proven reserves, 72% of coal proven reserves and 18% of gas proven reserves [3]. If the real use of the resources is more intensive then the these will fast disappear.

Capturing the abovementioned picture, there is a massive movement to use electrical energy replacing fossil fuels. Some sectors previously used fossil fuel are currently moving to use electricity. The rapid development and massive production of transportation system powered by electric motor is one of the strategies responding the skyrocket oil price [4]. The intensive use of fossil fuel that causes some negative environmental impacts has also strongly motivated to leave fossil fuels and use more environmentally friendly resources. One of the impacts of using fossil fuels is air pollution that causes health problems. More generally, environment problem also indirectly causes negative effects on social and economic aspect. On the other hand, it was reported that urban road transport is the main source of air pollution contributing 75% - 85% of pollutant emission [5]. A number of efforts are made in the worldwide level for the purpose of avoiding global warming.

Considering the aforementioned situations, the need for escalation of power generation may not be avoided. When the generation of electricity still uses fossil fuels, the increase of electricity demand leads to the increase use of the fuels. Hence, there is no significant benefit of replacing fossil fuel with electricity. It is therefore necessary to generate electricity with resources other than fossil fuel. There are many resources that may be used to generate electricity that are extensively available. On the other hand, energy-efficiency improvement may reduce the electricity demand at the country level. Utilizing energy efficiency to lower peak electricity demand may reduce the risk of economically damaging power shortages while freeing up the funds that would otherwise be used for construction of new power plants. It may also be noted that efficiency improvement of appliance and lighting enables holding the increase of peak load.

Renewable energy generation is widely considered as the answer to long-term energy supply since it is either unlimited or non-polluting. There is a global trend toward gradually incorporating renewable energy sources to meet countries' electricity demands. Given the present rate of growth in renewable energy generation, it is believed that the objective of replacing fossil-fuel based power generation with renewable energy generation will be fulfilled soon. There is some empirical data showing that the combination of various renewable energy sources for electricity generation will reach 100%, effectively eliminating the use of fossil fuels for electricity generation [6].

According to REN21 2022's report, renewables achieved their greatest achievement in the power sector in 2021. A record 315 GW of additional renewable energy capacity was added. Solar photovoltaic and wind power account for 90% of all new renewable energy installations. According to reports, 135 countries have renewable energy goals, while 156 have regulatory renewable energy policies. The levelized costs of onshore wind power and solar photovoltaic (PV) are currently less expensive than fossil fuels [7].

According to BP Energy Outlook, the structure of energy demand has shifted, with the dominance of fossil fuels progressively being replaced by a growing proportion of renewable energy and increasing electrification. Rapid expansion of renewable energy compensates for the waning importance of fossil fuels. The proportion of renewable energy in the world's primary energy supply rises from approximately 10% in 2019 to between 35% and 65% in 2050. Wind and solar power are anticipated to account for approximately 70% of the world's power generation [8] at this time.

According to REN21 2022 data, another interesting information emerges about the shift toward renewable energy. In addition to being crucial for decarbonizing the environment and reducing global climate change, hydropower, solar PV, and wind generation may get more than 50% of climate mitigation money [9]. As a result of decarbonization, funds formerly spent on environmental compensation can be redirected to the research and development of alternative energy sources. This will hasten the development of renewable energy sources at the same time that environmental quality is enhanced.

Due to the ease of energy conversion and the durability of the device, solar photovoltaic is a promising technology for future applications in energy generation. These advantages have led to the widespread adoption of solar photovoltaic technology, whether in the form of a stand-alone or grid-connected system. Ground-mounted, rooftop, building-integrated, and roof-jack mounting systems are all viable options for solar photovoltaic installations. Solar photovoltaic efficacy is largely reliant on conversion efficiency, which is determined by the factors of material, construction, and spectrum.

Design and planning of solar PV generation requires simulation of power generation and connection into the existing electric utility. To assist the design, a software package is employed. This paper presents the application of PVSyst to design the solar PV Panels for school building. The software provides features and facilities including database of available resources for PV generation at specific location, simulation of panel orientation, simulation of used devices, and simulation on power sharing to the existing system.

In this paper, the data of available resources are generated by the software. However, real measurements were also carried out for comparison purpose. The design was initially carried out for the ideal system, where the required number of solar PV panel is sufficient to provide the demand. Some excessive power may be supplied to the grid. Since the project established smaller number of panel, the design was also carried out for the real system. In this case, the generated power is insufficient for fulfilling the demand and the scheme of load sharing is then applied.

The real generation system is installed at the roof of Islamic Senior High School Daarul Echsan Muhammadiyah Sragen (Madrasah Aliyah Muhammadiyah DIMSA). The electric capacity of the school's installed 23 kVA three-phase system is provided by the Government Utility Company. The electrical load of the building consists of lighting, the air conditioning system, computers, and a few educational devices such as LCD Data Projectors. Some photovoltaic panels are installed on the roof to distribute the load. The system has a capacity of 8 x 545 Wp. The output of the solar panels is connected to a 15 kW inverter, whose output is synchronized with the electricity grid. The ideal system's capacity is 38 panels x 545 Wp, which allows it to produce 32,710 kWh of energy per year. With the daylight use of 5,970 kWh, the system may export the energy to grid of 26,740 kWh. If the night use is 7.350 kWh, the annual net selling to the grid is 19,390 kWh. However, since the real system is 8 panels x 545 Wp, the annual energy production is only 6,770 kWh. The remaining energy supplied to the grid is 2,070 kWh but the night energy use of 8,620 kWh. Therefore, the net electricity bill must still be paid for 6,550 kWh.

2 Project description

The solar PV generation system has been completely installed at the building. Solar PV panels, inverters, line and connection, and embedded measurement equipment are all included. It should be noted that the school building is still under construction, and so the generation system is not yet operational. On the other hand, authorisation from the Government Utility Company is required to establish the synchronous link to the utility grid. This is owing to the prospect of exporting power to the grid, which the government should carefully investigate from both technical and economic standpoint [6]. There is policy from the Government of Indonesia regarding the Rooftop Photovoltaic Solar System issued at 2018 that should be followed [7]. However, the proposal has been submitted and the Government Utility Company staff has conducted a field survey. It is in the phase of awaiting approval. In the interim, experiments and measurements are conducted while the proposal is being evaluated.

The Islamic Senior High School Daarul Ehsan Muhammadiyah Sragen is one of two institutions affiliated with the Daarul Echsan Muhammdiyah Sragen foundation. Islamic Secondary School Daarul Ehsan Muhammadiyah Sragen is another school. These two schools are located adjacent to one another and are governed by the same top manager, although each school has its own principal. The institutions are located in separate buildings with separate electrical connections.

The secondary school is managed by a principal, who is assisted by 55 teachers and staffs for the educational process and administrative duties. Additionally, the school employs personnel for cleaning service, catering service, canteen, and security. The school's educational model is residential school, and the institution must provide housing for 440 students. From the perspective of electricity demand, the government utility's power capacity is 85,6 kVA. The electricity is utilized to meet the requirements of everyone in the school. The intensive use of electricity results in an average monthly energy consumption of 70 kWh and a bill of 15 million IDR.

The high school is basically the new school. The school has only one first-year student enrolled. Their student number is 37. However, because it is well-managed, this school is likely to be good, and it is predicted that in the future, this school will be highly appealing to potential students. This school, like the secondary school, is a boarding school where students are provided with living accommodations and meals. The school is directed by a principal, who is assisted in administering the learning process by 15 academic and administrative staff members. The boarding supervisor also supervises activities outside of school hours. This is intended to attain an integrated learning goal encompassing everything from academics to Islamic behaviour. The Government Utility Company provides 23 kVA of electricity for these purposes. This maximum installed capacity is very sufficient for the time being. As the number of students grows, so will the demand for electricity. At the moment, the school's average power consumption is 10 kW, and its average monthly energy consumption is 60 kWh. The average monthly electricity expense for the school is IDR 1.8 million for this use.

For the purpose of solar PV generation, the design using PVSyst was carried out [8]. There are some features provided by PVSyst for designing the grid-connected solar PV generation [9]. The selection of this software is due to the advance of the software compared with its counterpart, like PV GIS and Homer [10]. For the project in hand, the software was used to design the ideal and the real system. The so-called real system is the system of solar PV generation, which is currently established. For this case, the simulation is used to predict the system performance and the expected energy generation to contribute sharing the load.

3 Generation system design using PVSyst

PVsyst is a modeling application that can be used to design PV generation system as a standalone or grid-connected system. This application can be used to design and determine how much solar energy may be produced in a particular location. There are various features that can be used in this application including to determine the module, inverter, location under study and to entry the module and inverter manually. In this design, shadow factor is not considered for the purpose of finding the optimum value that can be produced as well as the performance of the solar power plant.

The developed generation system is in the form of grid-connected system as shown in **Fig. 1**. It may be described from the figure that the solar panels generate DC power, which

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supplies the inverter. The inverter is employed to simultaneously convert into AC power and synchronize it into the power of utility grid. Combination of the two power sources enables satisfying the load.

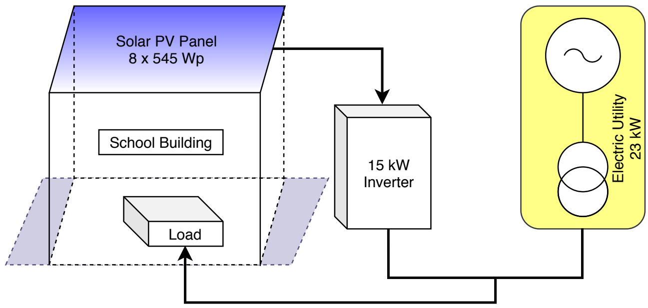

Fig. 1. The system of solar photovoltaic for DIMSA School

The first step of system design is measurement of the load. The installed capacity of the building is 23 kVA, while the power of all connected load is 13.614 kW. Therefore, it is still enough power in case additional loads are connected to the system. For the purpose of designing the generation system, the type and size of the panel need to be determined. The specification of the PV panel is given in **Table 1**, showing 2 alternatives of PV panel.

Table 1. The Modul of Solar PV used in this study

Parameter	**Specification**	**Specification**
Model	JAM72S30-545/MR	LR4-66HPH-400M
Maximum Power (Pmax)	545	400
Tolerance	0~+5%	0~+3%
Voltage at Maximum Power (Vmp)	41,80	37,60
Current at Maximum Power (Imp)	13,04	10,64
Open Circuit Voltage (Voc)	49,75	44,80
Short Circuit Current (Isc)	13,93	11,42
Maximum System Voltage	1000V/1500V DC	1500V DC
Maximum Series Fuse Rating	25A	25A
Operational Temperature	-40°C~+85°C	-40°C~+85°C
Safety Class	Class II	Class II
Cell Technology	Mono-si	Mono-si
Weight	28,6kg	22kg
Dimensions (mm)	2279*1134*35	1924*1038*35

The next step is generating the data of resources from the sunlight at the place where the system is established. The data is provided by PVSyst after the specific location is given. In this study, the location of the system is at Pringan, Karang Tengah, Sragen with the coordinate of -7.4144 South Latitude and 111.023 East Longitude. The display of the PVSyst for the specific area is given by **Fig. 2**. From the given location, the data of resources for generating the power is given in **Fig. 3**. It may be seen that the resources is sufficient for power generation to fulfil the electricity demand at DIMSA School.

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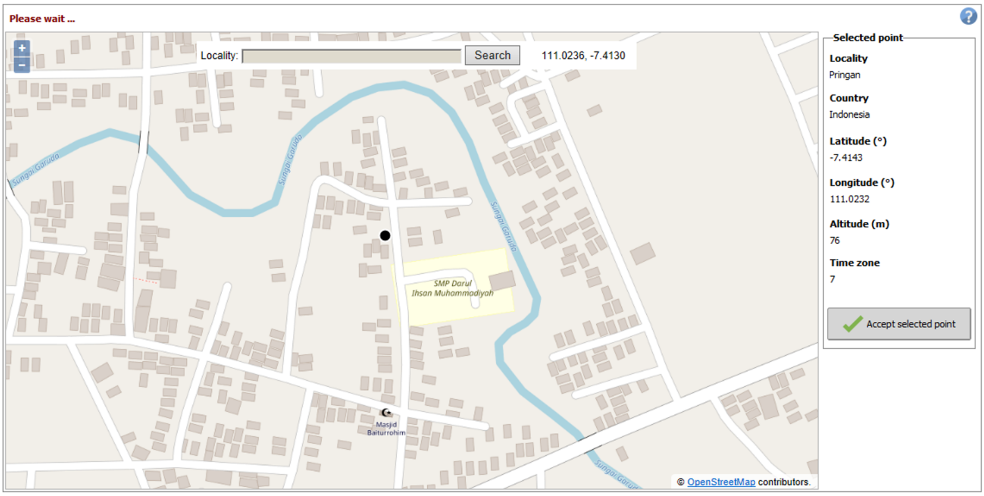
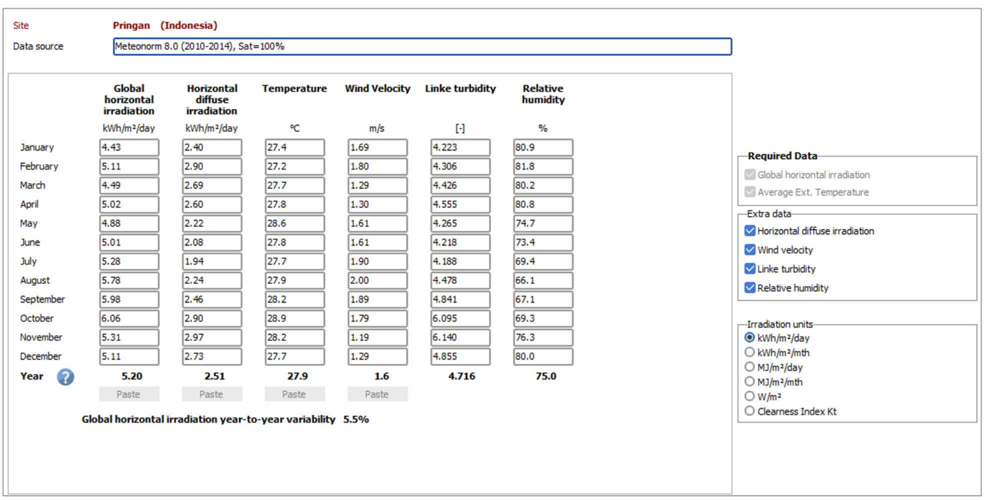


Fig. 2. The location of solar photovoltaic generation at DIMSA School


Site: Pringan (Indonesia)
Data source: Meteonorm 8.0 (2010-2014), Sat=100%

	Global horizontal irradiation	Horizontal diffuse irradiation	Temperature	Wind Velocity	Linke turbidity	Relative humidity
	kWh/m²/day	kWh/m²/day	°C	m/s	[-]	%
January	4.43	2.40	27.4	1.69	4.223	80.9
February	5.11	2.90	27.2	1.80	4.306	81.8
March	4.49	2.69	27.7	1.29	4.426	80.2
April	5.02	2.60	27.8	1.30	4.555	80.8
May	4.88	2.22	28.6	1.61	4.265	74.7
June	5.01	2.08	27.8	1.61	4.218	73.4
July	5.28	1.94	27.7	1.90	4.188	69.4
August	5.78	2.24	27.9	2.00	4.478	66.1
September	5.98	2.46	28.2	1.89	4.841	67.1
October	6.06	2.90	28.9	1.79	6.095	69.3
November	5.31	2.97	28.2	1.19	6.140	76.3
December	5.11	2.73	27.7	1.29	4.855	80.0
Year	**5.20**	**2.51**	**27.9**	**1.6**	**4.716**	**75.0**

Global horizontal irradiation year-to-year variability 5.5%

Fig. 3. The resources for solar photovoltaic generation

The next step is determining the system and panel orientation. The system specifications have been entered to the software. The type of panel is JA Solar or LONGI Solar. For the inverter, there are 2 choices: one unit of 15 kW with the brand of KLNE or two units, 10 kW each, with the brand of Growatt. The result of system is given in **Fig. 4**, and the result of panel orientation is given in **Fig. 5**. Form the orientation, it may be given here that the panel is placed with the tilt of 29o meaning that the elevation of panel is 29o toward the north direction.

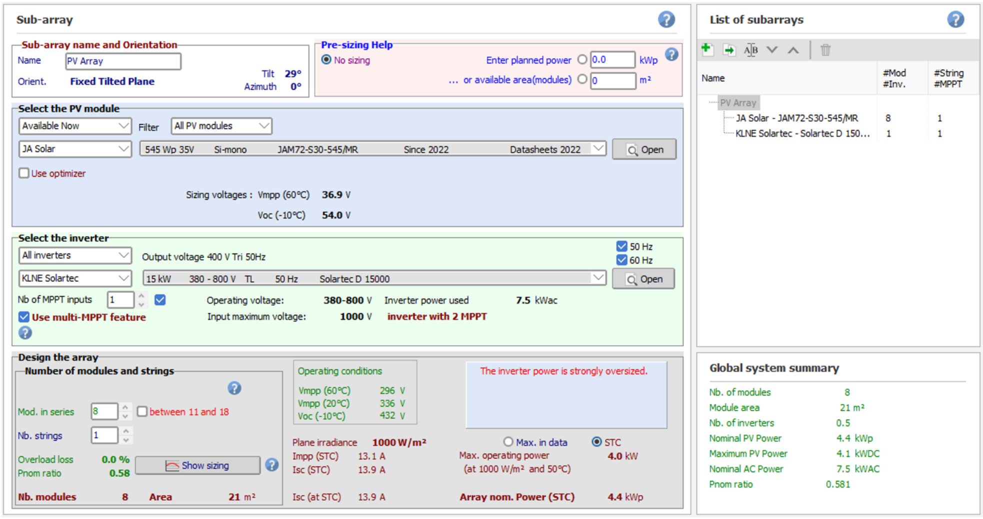


Fig. 4. The data of solar PV for power generation

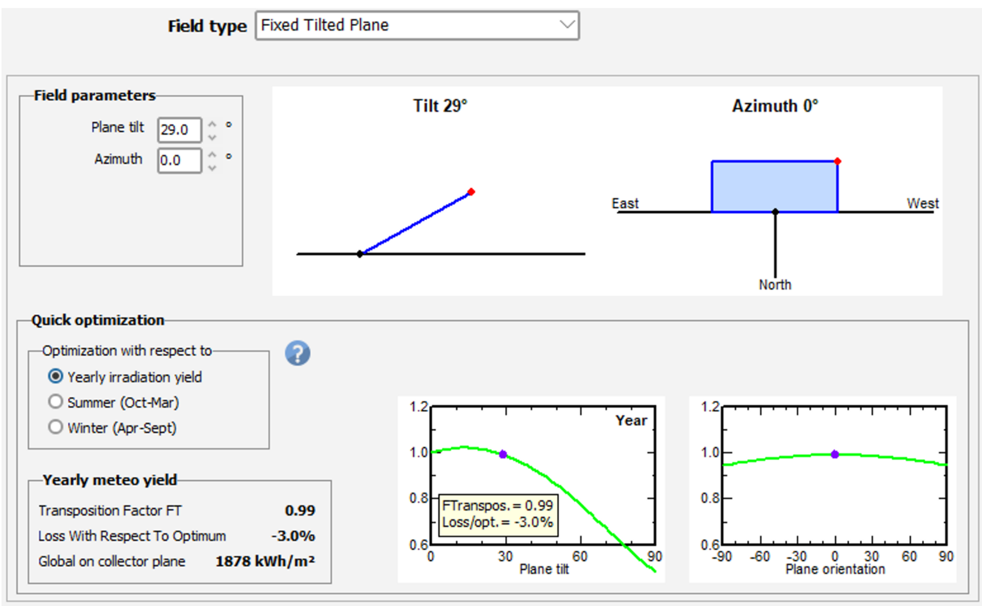


Fig. 5. The orientation of solar PV for power generation.

4 Result and Discussion

Upon completion of data entry for the system and determination of resources for generation, the system is now ready for simulation. For the real system, the number of panel is 8 with the capacity of 545 Wp each, the display for the generation summary is given by **Fig. 6**. The detail of the power generation is given by **Fig. 7**. For the 8 panels, the energy that can be provided is 6770 kWh per-year. Since the use of electricity at daylight is 4710 kWh, there is still energy surplus of 2070 kWh. However during night, the use of electricity from the grid is 8620 kWh and there is a margin of 6550 kWh that the school still needs to pay.

System summary

Grid-Connected System | **No 3D scene defined, no shadings**

PV Field Orientation
Fixed plane
Tilt/Azimuth 29 / 0 °

Near Shadings
No Shadings

User's needs
Fixed constant load
1521 W
Global
13.32 MWh/Year

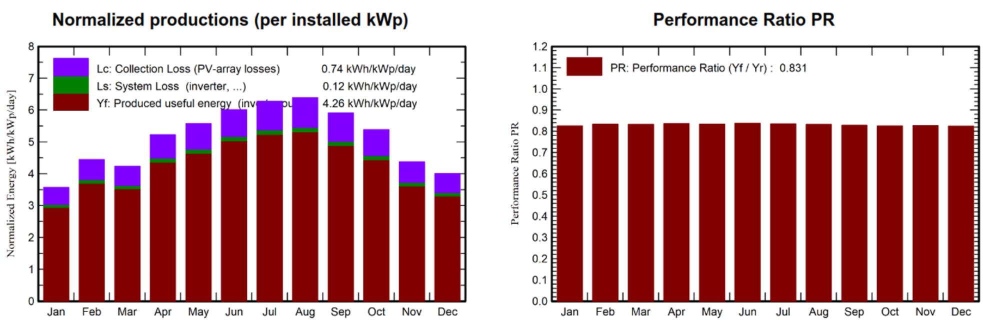
System information

PV Array		**Inverters**	
Nb. of modules	8 units	Nb. of units	1 Unit
Pnom total	4360 Wp	Pnom total	5.00 kWac
		Pnom ratio	0.872

Results summary

Produced Energy	6.77 MWh/year	Specific production	1554 kWh/kWp/year	Perf. Ratio PR	83.14 %
				Solar Fraction SF	35.33 %

Fig. 6. The summary of power generation of 8 panels solar PV



	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_User MWh	E_Solar MWh	E_Grid MWh	EFrGrid MWh
January	137.4	74.38	27.37	110.6	105.3	0.412	1.132	0.318	0.080	0.813
February	143.1	81.14	27.23	124.4	119.7	0.466	1.022	0.342	0.110	0.680
March	139.1	83.47	27.68	131.5	127.3	0.493	1.132	0.356	0.122	0.776
April	150.7	78.09	27.80	156.8	152.8	0.588	1.095	0.391	0.180	0.704
May	151.3	68.77	28.60	172.7	169.0	0.645	1.132	0.419	0.208	0.712
June	150.2	62.42	27.84	180.3	176.9	0.677	1.095	0.422	0.237	0.673
July	163.8	60.00	27.72	194.7	190.9	0.728	1.132	0.446	0.262	0.685
August	179.2	69.28	27.93	198.2	194.1	0.739	1.132	0.447	0.272	0.684
September	179.4	73.76	28.16	177.3	172.6	0.658	1.095	0.415	0.225	0.680
October	187.8	89.98	28.88	166.9	161.1	0.618	1.132	0.421	0.180	0.711
November	159.4	89.18	28.20	131.3	125.4	0.488	1.095	0.369	0.105	0.726
December	158.4	84.52	27.74	124.2	117.8	0.461	1.132	0.359	0.087	0.772
Year	1900.0	914.99	27.93	1868.8	1813.0	6.972	13.323	4.706	2.068	8.617

Fig. 7. The detail energy production

The design is further carried out for the ideal system. For the ideal generation system, the number of panel is 52 with the capacity of 545 Wp. The combination of the series and parallel are conducted assuring that the system complies with the load. The total capacity is 208,000 Wp and the system is grid-connected. Therefore, the system contributes sharing the load. For the period of one year, the total production is 32,710 kWh. Since the use at daylight is 5,970 kWh, the exported energy to grid is 26,740 kWh. The night use is 7.350 kWh, and the net energy sold to the utility is 19,390 kWh. The summary of the system simulation is given by **Fig. 8**. The detail of power generation is given by **Fig. 9**.

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System summary

Grid-Connected System | **No 3D scene defined, no shadings**

PV Field Orientation		**Near Shadings**	**User's needs**
Fixed plane		No Shadings	Fixed constant load
Tilt/Azimuth	29 / 0 °		1521 W
			Global
			13.32 MWh/Year

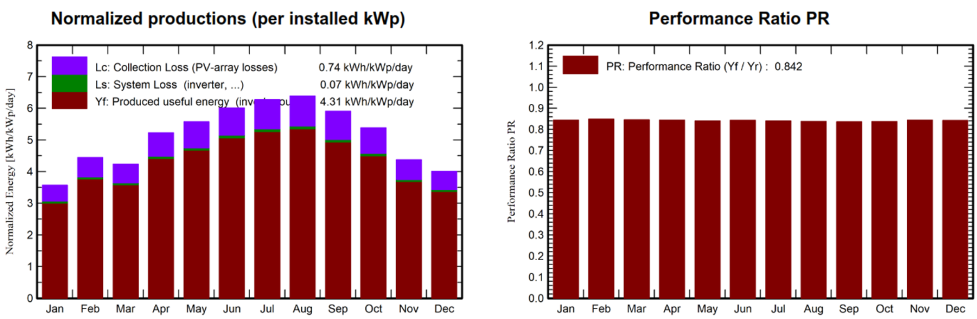
System information

PV Array		**Inverters**	
Nb. of modules	52 units	Nb. of units	2 units
Pnom total	20.80 kWp	Pnom total	20.00 kWac
		Pnom ratio	1.040

Results summary

Produced Energy	32.72 MWh/year	Specific production	1573 kWh/kWp/year	Perf. Ratio PR	84.16 %
				Solar Fraction SF	44.84 %

Fig. 8. The summary of power generation of 52 panels solar PV



	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_User MWh	E_Solar MWh	E_Grid MWh	EFrGrid MWh
January	137.4	74.38	27.37	110.6	107.0	1.981	1.132	0.493	1.451	0.639
February	143.1	81.14	27.23	124.4	121.2	2.236	1.022	0.451	1.745	0.571
March	139.1	83.47	27.68	131.5	128.7	2.354	1.132	0.485	1.827	0.646
April	150.7	78.09	27.80	156.8	154.2	2.801	1.095	0.490	2.265	0.605
May	151.3	68.77	28.60	172.7	170.3	3.068	1.132	0.509	2.509	0.623
June	150.2	62.42	27.84	180.3	178.1	3.216	1.095	0.497	2.669	0.599
July	163.8	60.00	27.72	194.7	192.2	3.456	1.132	0.513	2.888	0.618
August	179.2	69.28	27.93	198.2	195.5	3.509	1.132	0.517	2.936	0.615
September	179.4	73.76	28.16	177.3	174.2	3.133	1.095	0.497	2.586	0.598
October	187.8	89.98	28.88	166.9	163.0	2.955	1.132	0.520	2.385	0.612
November	159.4	89.18	28.20	131.3	127.3	2.346	1.095	0.493	1.811	0.602
December	158.4	84.52	27.74	124.2	119.7	2.219	1.132	0.510	1.668	0.622
Year	1900.0	914.99	27.93	1868.8	1831.4	33.275	13.324	5.975	26.739	7.349

Fig. 9. The detail energy production

5 Conclusion

The design of solar PV generation for the school building is presented in this paper and the task of design was carried out using PVSyst. The real system is actually established on the rooftop of the school building. The data of resources for electricity generation is provided by the software as long as the specific location is provided. The system specifications were also entered into the system. With the existing system 8 panel, 545 Wp each the negative margin of energy may still need to be paid for 6550 kWh. With the ideal system, the generation should include the panel of 52 with the capacity of 545 Wp each resulting ini total capacity of 208,000 Wp. With this condition, the system experiences energy surplus and may be sold to electric utility. For the ideal system the expected revenue from 19,390 kWh may be received to the school.

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References

1. McNeil, M.A.; Karali, N.; Letschert, V. Forecasting Indonesia's Electricity Load through 2030 and Peak Demand Reductions from Appliance and Lighting Efficiency. *Energy for Sustainable Development* 2019, *49*, 65–77, doi:10.1016/J.ESD.2019.01.001.
2. Shrivastava, A.; Sharma, R.; Kumar Saxena, M.; Shanmugasundaram, V.; Lal Rinawa, M.; Ankit Solar Energy Capacity Assessment and Performance Evaluation of a Standalone PV System Using PVSYST. In Proceedings of the Materials Today: Proceedings; Elsevier, July 24 2021.
3. Martins, F.; Felgueiras, C.; Smitkova, M.; Caetano, N. Analysis of Fossil Fuel Energy Consumption and Environmental Impacts in European Countries. *Energies 2019, Vol. 12, Page 964* 2019, *12*, 964, doi:10.3390/EN12060964.
4. Shah, K.J.; Pan, S.-Y.; Lee, I.; Kim, H.; You, Z.; Zheng, J.-M.; Chiang, P.-C. Green Transportation for Sustainability: Review of Current Barriers, Strategies, and Innovative Technologies. *J Clean Prod* 2021, *326*, 129392, doi:10.1016/J.JCLEPRO.2021.129392.
5. Leroutier, M.; Quirion, P. Air Pollution and CO2 from Daily Mobility: Who Emits and Why? Evidence from Paris. *Energy Econ* 2022, *109*, 105941, doi:10.1016/j.eneco.2022.105941.
6. Akpolat, A.N.; Dursun, E.; Kuzucuoğlu, A.E.; Yang, Y.; Blaabjerg, F.; Baba, A.F. Performance Analysis of a Grid-Connected Rooftop Solar Photovoltaic System. *Electronics 2019, Vol. 8, Page 905* 2019, *8*, 905, doi:10.3390/ELECTRONICS8080905.
7. Setyawati, D. Analysis of Perceptions towards the Rooftop Photovoltaic Solar System Policy in Indonesia. *Energy Policy* 2020, *144*, 111569, doi:10.1016/J.ENPOL.2020.111569.
8. Baqir, M.; Channi, H.K. Analysis and Design of Solar PV System Using Pvsyst Software. *Mater Today Proc* 2022, *48*, 1332–1338, doi:10.1016/J.MATPR.2021.09.029.
9. Sulas-Kern, D.B.; Owen-Bellini, M.; -, A.; Nakamura, T.; Fukumochi, S.; Mohamed, N.; Sulaiman, S.; Rahim, S. Design of Ground-Mounted Grid-Connected Photovoltaic System with Bifacial Modules Using PVsyst Software. *J Phys Conf Ser* 2022, *2312*, 012058, doi:10.1088/1742-6596/2312/1/012058.
10. Ahmad, S.; Mohammadi, D.; Gezegin, C.; Articlehistory, A.I. Design and Simulation of Grid-Connected Solar PV System Using PVSYST, PVGIS and HOMER Software. *International Journal of Pioneering Technology and Engineering* 2022, *1*, 36–41, doi:10.56158/JPTE.2022.24.1.01.