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Energy efficiency analysis of inland ship photovoltaic system based on PVsyst

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Abstract. With the current energy crisis and environmental pollution increasing, expanding the use of solar energy is an important trend in the field of energy applications, and the development of photovoltaic systems in the ship field is also very rapid. This paper analyzes the photovoltaic power generation application of inland small ships, designs a photovoltaic power generation system suitable for passenger ships, simulates and optimizes the system with PVsyst software, predicts the power generation and loss of the system, and verifies its value.

1. Introduction

With the rapid development of the world's industrial level, the demand for energy is increasing, and the speed of mining and consumption of traditional fossil fuels is rapidly increasing. While using a large amount of traditional fuels, it also causes serious environmental pollution. The phenomenon of haze, photochemical smog, and greenhouse effect is becoming more and more serious. How to avoid the negative impact on the environment while using energy is becoming an important factor in today's society. As a rich, clean, safe and convenient new energy source, solar energy is a kind of renewable energy that has been extensively explored and developed to some extent, and has attracted the attention and research of many countries [1]. At the same time, the application of solar energy on ships has also attracted the attention of ship scientific research personnel. From small cruise ships to large ocean-going transport ships, the application of solar photovoltaic systems on ships has broad and far-reaching significance. According to the survey data, solar photovoltaic power generation technology is relatively used in small sightseeing cruise ships and yachts, and there are few applications in inland river civil ships [2]. In this paper, PVsyst software is used to analyze and summarize the energy efficiency of photovoltaic system application in inland ship.

2. Simulation system overall design

There are various types of inland ship, including general cargo ship, bulk ship, sand transport ship and passenger ship. This paper selects the steel flat-top passenger ship that is widely used in the Yangtze River basin and is most suitable for laying solar panels. The three-story steel passenger ship with a length of 39 meters and a width of 8 meters is selected for simulation analysis. The environmental parameters such as solar radiation intensity, illumination time and temperature were selected as the reference for the meteorological information of the Yangtze River Basin in Nanjing. The hull photovoltaic system is mainly composed of solar panels, solar controllers, inverters, battery packs and loads [3]. These components will be designed and simulated in turn during the research process.

This paper uses PVsyst software to carry out the main simulation analysis. PVsyst software is a computer-aided design software dedicated to the design of photovoltaic system. The software can be used for parameter design of PV module type, inverter type, system installed capacity and installation mode. The photovoltaic power generation system can also be used for power generation simulation calculation and shadow analysis [4].

3. System parameter setting

3.1 Environmental parameter settings

The latitude and longitude of Nanjing City, Jiangsu Province is located at 31°14’ to 32°37’ north latitude and 118°22’ to 119°14’ east longitude. The meteorological environment information of the region can be obtained by using the meteorological data acquisition software Meteonorm. The information obtained is shown in Table 1. As shown, the analysis shows that the total annual solar radiation in the basin reaches 1218.7 kWh, and the solar radiation per month in the year is above 60 kWh/m^2. From April to October, the solar radiation is 90 kWh/m^2. Above the meter, solar energy resources are very rich, suitable for photovoltaic power generation [5].

Table 1. Monthly Meteorological Data of the Yangtze River Basin in Nanjing, Jiangsu Province

Month	Solar radiation kWh/m^2	Temperature °C	Wind speed m/s
January	61.1	3.0	2.39
February	75.3	5.5	2.80
March	87.0	10.6	3.00
April	116.6	16.1	2.91
May	139.9	21.5	2.70
June	123.2	25.1	2.70
July	144.8	28.7	2.70
August	133.6	27.5	2.69
September	113.5	23.2	2.60
October	93.9	18.2	2.19
November	69.3	10.8	2.10
December	60.5	5.2	2.29
Annual	1218.7	16.3	2.6

3.2 Battery board layout and installed capacity

Taking into account the ship's mobility and travel resistance and other factors, it is proposed to design the panel layout as horizontal without gaps, while ensuring higher power generation efficiency without affecting the normal navigation of the ship. Based on the total amount of electrical load on the small passenger ship, the installed capacity of the system is set to 30 kW [6]. The solar module's slope is subject to a solar radiation and horizontal radiation (Transposition Factor FT) of 1.00, a relative optimized loss ratio (Loss by respect to optimum) of 5.3%, and a PV module's maximum solar on collector plane (Global on collector plane). Up to 1219kWh/m2, the system setting is shown in Figure 1.

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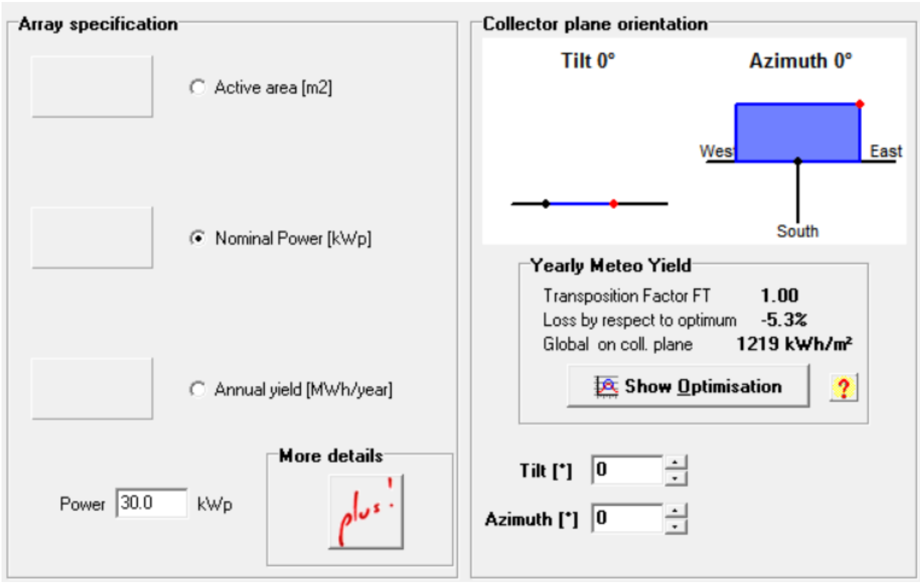

Figure 1. Solar panel layout and installed capacity

3.3 PV components and inverter selection

The solar panel used in the design of this system is the 260Wp27V polysilicon solar photovoltaic module of KS-260 series, and the total installed capacity of the system is 30kW. According to the functional requirements of this project design, the inverter is its core component, which plays an important role in the stable operation of the whole system. Only after inverter can realize the safe connection of AC power [7]. The capacity of the inverter used in this system is selected according to the principle that the total installed capacity of the PV array is the same, the rated capacity cannot be less than the total installed capacity, and the rated capacity should be greater than the installed capacity to ensure safe and stable operation [8]. After analysis and comparison, the inverter model selected is the Fronius_IG390.OND inverter manufactured by Fronius International. The specific parameters are shown in Table 2.

Table 2. Grid-connected inverter parameters

parameter name	Parameter value
Maximum input power	43kW
Maximum input current	164A
Maximum input voltage	530V
MMP voltage range	210- 420 V
rated power	30 kW

4. Analysis of simulation results based on PVsyst

After the design is completed, the system performs simulation analysis and outputs a design report, as shown in the following picture.

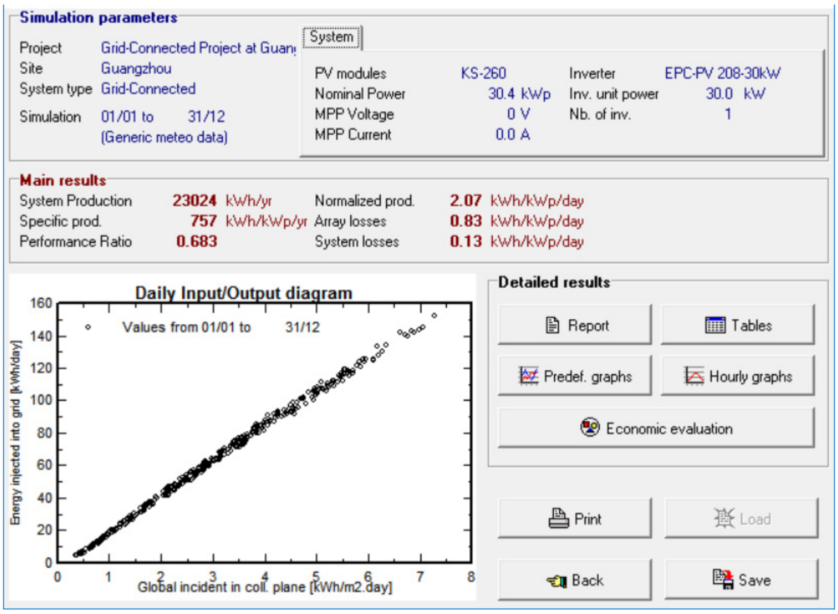

Figure 2. System design simulation report

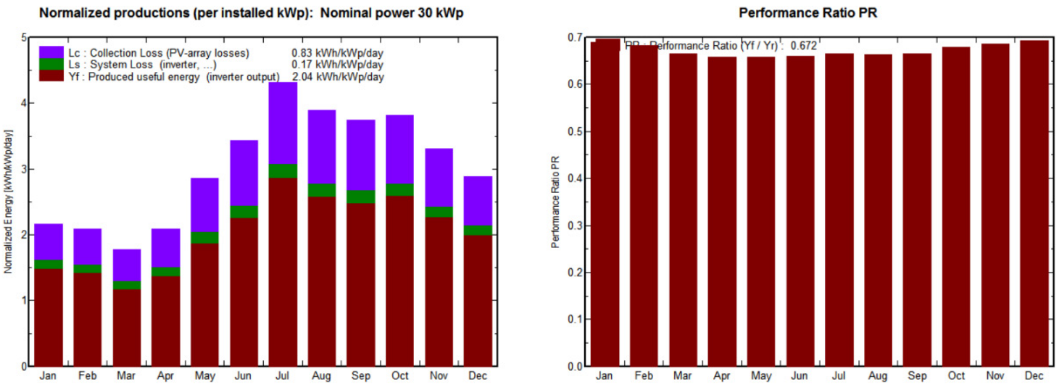

Figure 3. System design simulation report

New simulation variant

Balances and main results

	GlobHor kWh/m2	T Amb oC	GlobInc kWh/m2	GlobEff kWh/m2	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	67.0	13.30	67.0	63.8	1531	1405	12.07	11.08
February	58.5	14.30	58.5	55.9	1326	1214	11.97	10.95
March	55.1	17.70	55.1	52.6	1232	1114	11.80	10.67
April	62.6	21.90	62.6	59.9	1379	1253	11.63	10.57
May	88.5	25.60	88.5	84.8	1929	1772	11.51	10.57
June	103.0	27.30	103.0	99.0	2239	2070	11.48	10.61
July	133.9	28.50	133.9	128.7	2911	2709	11.48	10.68
August	120.5	28.30	120.5	115.7	2621	2434	11.48	10.67
September	112.3	27.10	112.3	108.1	2447	2274	11.51	10.69
October	118.3	24.00	118.3	113.5	2623	2446	11.71	10.91
November	99.4	19.40	99.4	94.9	2227	2072	11.83	11.00
December	89.3	15.00	89.3	84.9	2029	1881	11.99	11.12
Year	1108.4	21.91	1108.4	1061.8	24494	22644	11.67	10.79

Legends:				
	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

Figure 4. System design simulation report

According to the data in the simulation report, the annual output of the system is 23024 kWh, and the system energy utilization rate is 68.3%. During the period from January to April, the electricity production is lower due to the shortening of light intensity and time. During the period from June to October, the electricity production is high, and the monthly average exceeds 100kWh/m2. By analyzing the simulation report, we can get the conclusion that the photovoltaic power generation system has better application benefits for small inland river ships, and the generated electricity can be supplied to the daily use of the ship, which is of great significance and practical value for energy conservation and emission reduction.

5. Conclusion

Based on the geographical design and meteorological data generated by software, the design process of PVSYST can quickly calculate the parameters of each part of the system for simulation [9]. The system designed in this paper simulates the application of the inland river small passenger ship photovoltaic system and analyzed the energy efficiency of the system. It is concluded that the photovoltaic power generation system is suitable for inland small ships and has practical conclusions. In the future of vigorously promoting the development and utilization of new energy, photovoltaic systems applied to inland small ships will be more common. The method proposed in this paper is also applicable to the design of similar independent photovoltaic power generation systems in other regions, which has certain engineering practical significance.

Acknowledgments

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