Design of full solar electric push boat for scenic spots

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Abstract. In view of the current situation that the scenic cruise ship is still dominated by diesel power, the solar photovoltaic technology is applied to small and medium-sized cruise ships, and solar power generation and ship electric propulsion technology are combined to carry out ship design and optimization, component design and matching, and reasonable. The solar panels on the ship and the dock are arranged to design an all-solar power cruise ship, which realizes zero discharge of the operation process without affecting the sightseeing conditions, and achieves the effect of energy saving and emission reduction.

1.Introduction
With the development of the tourism industry, the number of water upstream play projects across the country is increasing, and the number of tour boats is increasing. At present, cruise ships usually use fossil fuels, and the pollution of water bodies in tourist areas cannot be ignored [1].

Solar energy is inexhaustible and inexhaustible. In today's energy shortage, solar energy will become one of the main natural energy sources [2]. In the marine sector, the application of photovoltaic technology is not a blank. Compared with foreign countries, domestic research in this field has only just started due to the lag of development. Although the application of photovoltaic power generation technology on ships is mainly concentrated on small ships, there have been some attempts on full-power ships and large-scale ocean-going ships, and there are some possibilities for commercial operation. [3]

At present, there are many beautiful scenic spots still using traditional diesel-powered cruise ships. The gas pollution and noise pollution generated during operation are not compatible with the tourist attractions [4]. Therefore, this paper designs a solar power generation system for a typical cruise ship, which provides power for the ship electric propulsion system, without the need for a diesel engine and its supporting system, which takes up less space, has less noise and the backup battery pollution. At the same time, it avoids the consumption of non-renewable energy such as petroleum, as well as the emission of pollutants such as CO₂, and has certain economic and social benefits.

2.design goal
In a typical design inland lake resort boat tour as a reference, the required speed, the main dimensions, comfort, environmental, and other aspects of daily operating time has its particularity, which has the following features

(1) The speed of the ship required by the tourist boat is not high.
(2) The tour boat sails on the inland rivers and lakes, subject to restrictions on drafting, etc., and the main scale is generally small.
(3) Passengers visiting the city have high requirements for the comfort of the ship, especially noise and roll.
(4) The environmental protection requirements of the water bodies in the scenic spots make the tour vessels strict in environmental protection.

Sightseeing is generally done during the day, the day of the tour boat is deducted from the waiting time, usually 6-8 hours, the daily running time is shorter.

Therefore, the main requirements of the design are:

1. Design speed can reach the maximum 12km/h, the number of guests in the design is 33+1 people.
2. The entire ship energy source relies entirely on solar photovoltaic cells to generate electricity.
3. The ship's daily running time is at least 6 hours, full capacity battery life is at least 3 hours.
4. The annual running time is full year.

3. Overall design

As shown in Figure 1, the design of the all-solar cruise ship is divided into two parts. One part is to build a solar photovoltaic system on the ship, and drive the ship forward through electric propulsion; part of it builds a solar photovoltaic system on the shore and stores the electric energy in the onshore power station.

![Figure 1 design overall idea](image1.png)

3.1 Design process

As shown in Figure 2, the basic components of a photovoltaic system are: photovoltaic arrays, controllers, converters, batteries (groups), loads [5]. The photovoltaic system in the solar tour vessel is also composed of the above parts. In the design, the load power consumption, the power of the photovoltaic array and the capacity of the battery are mainly determined, and the controller and the converter are selected according to the technical parameters.

![Figure 2 Photovoltaic system main component parameter matching diagram](image2.png)

![Figure 3 Schematic diagram of solar power boat power plant design](image3.png)
In the design of photovoltaic system for solar tour vessels, the load of the ship is first calculated and determined. The load mainly includes propulsion motor and lighting equipment. The propulsion motor is the key, and it is usually the main component of electric energy consumption.

After determining the daily power consumption of the ship load, the photovoltaic array power is calculated and determined according to the power consumption, the solar radiation resources in the navigation area, and the power generation characteristics of the photovoltaic array.

The capacity of the battery is determined according to the power of the photovoltaic array, the solar radiation resources in the navigation area, and the rainy weather conditions.

According to the imbalance of solar radiation in the navigation area, battery discharge depth, battery life and investment economy, the PV array power and battery capacity are optimized and matched, and the power of the PV array and the capacity of the battery are finally determined [6].

Finally, according to the above design calculations, system characteristics, technical requirements, etc., equipment selection. Possible equipments include: propulsion motors, solar panels, control cabinets (controllers), inverters, chargers, DC-DC converters, displays, power distribution cabinets, etc.

3.2 Onboard photovoltaic power generation system

The working principle of the all-solar cruise ship can be summarized as the use of solar photovoltaic power generation technology to convert solar energy into electrical energy, and the solar energy charging controller adjusts and controls the solar energy. On the one hand, the adjusted electric energy is sent to the inverter system to drive various loads on the ship. On the other hand, the excess power is sent to the battery to automatically charge the battery. When the solar energy is not enough to meet the load demand, the controller sends the battery power to the inverter system to drive various loads on the ship. The propulsion of part of the electric propulsion drives the propeller to advance the hull, thus designing a pollution-free, noise-free all-solar cruise ship. The whole set consists of two parts: solar power system and electric propulsion system. Among them, the solar power generation system is composed of a solar battery pack, a solar controller, and a solar battery (group). The electric propulsion system consists of an electric motor, a gear box and a propeller. The system composition is shown in Figure 3.

3.3 Onshore photovoltaic power generation system

The onshore photovoltaic power generation system is mainly composed of a solar battery pack, a solar controller, and a solar battery pack. Its main function is to store the electricity generated by the solar panels. When the cruise ship is docked at the dock, the battery on the ship is charged to ensure that the cruise ship can operate normally at night, on a rainy day or when the solar PV array on board does not have enough power.

In order to have enough area on the ship to arrange solar panels, the ship type chooses a catamaran, which not only has a large deck area, but also has good stability; solar panels are laid on the top of the ship, and manual slides are designed to increase the solar cells. The board area, as shown in Figure 4; the propulsion mode selects the double-machine twinblade double rudder; to reduce the weight of the hull, the battery selects the lithium battery.

The main dimensions and elements of the design cruise ship are as follows:

- Total length 14 m
- Water line length: 12 m
- Total width 4.5 m, single width Deep: 1.7 m
- Draught 0.8 m
- Displacement 8.31 t
- Designed continuous speed 9 km/h
- Maximum speed 12 km/h
- Propulsion motor 2 × 7.5 kW
- Square factor $C_b = 0.611$
- Solar panel area 44.24 m²
- Expanded area 64 m²
3.4 propulsion system
The main part of the design power includes a solar panel power generation module and the AC load module arrangement structures and devices are shown in Figure 5:

3.5 battery pack design
There are three kinds of battery packs of different capacity on the ship, one is the main battery pack, which is mainly responsible for supplying power to the propulsion motor, and the capacity is the largest; one is the spare battery pack, which is mainly used in series with the main battery when the motor starts or the ship needs to accelerate. The capacity is small; the other is the load battery pack. In normal times, the amount of electricity generated by the solar photovoltaic array is stored after the ship is navigating, and is supplied to the load for use as The backup battery No. 2 supplies power to the main battery in an emergency. The connection mode of each battery pack is as shown in Figure 6.

This design also has a shore-based battery pack. When designing the shore-based battery capacity, its capacity needs to be considered to meet the power supply requirements of the ship in continuous rainy weather (when solar photovoltaic power generation is small or unable to generate electricity). Can meet the normal sailing of the ship 24 hours [7]. The shore-based battery pack design capacity is:

\[
B_{\text{shore}} = \left( E_{\text{ship}} + E_{\text{shore}} \right) \cdot N_d / (\eta_{\text{out}} \cdot \text{DOD max}) = 4.1 \text{ kW} \cdot 24 / (0.8 \cdot 0.9) \\
= 136.67 \text{ kW} \cdot h \approx 137.28 \text{ kW} \cdot h
\]

Where: \(B_{\text{shore}}\) is the main battery design capacity;

Figure 4 Design cruise ship renderings

Figure 5 equipment layout diagram

Figure 6 Distribution diagram of the battery pack on board
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\[ N_d \text{ guarantees the sailing time of the ship when it is rainy and cloudy; } \]
\[ DOD_{\text{max}} \text{ To design the maximum depth of discharge of the battery; } \]
\[ \eta_{\text{out}} = 0.8 \text{ (loss rate of AC circuit such as inverter).} \]

4. benefit analysis

Compare the diesel engine power generation and solar photovoltaic power generation of the ship, and compare the two power supply schemes of the ship's daily navigation and navigation power.

Solution powered by solar photovoltaic systems

Large industrial iron-lithium battery of 48 V /65 W·h 11 solar panels with 24 V / 180 W 50 pieces, 48 V charge and discharge control

Controller 1, 10 kA lightning 2, 48 V / 380 V inverters 1 single, 48 V / 24 V inverter 1 item, several accessories and cables.

Diesel engine power generation propulsion system

Output Power 8 kW diesel generator 2 sets, rated output power 7.5 kW motor 2 sets, several attachments.

Specific examples are shown in Table 1.

| Comparison project                        | Solar photovoltaic power generation system | Diesel engine power generation propulsion system |
|-------------------------------------------|-------------------------------------------|-------------------------------------------------|
| Technical indicators                      |                                            |                                                 |
| Power supply reliability                  | Basically meet the requirements           | fulfil requirements                              |
| Quality of navigation                     | fulfil requirements                        | fulfil requirements                              |
| Economic Indicators                       |                                            |                                                 |
| One-time input costs and daily            | 48 V /65 W·h iron lithium battery 11 pieces, unit price is 8,000 yuan, its comprehensive investment is 11×8000=88000 yuan | 8 kW diesel generator 2 sets, 46,000 yuan |
| consumption costs                         | 24 V / 180 W solar panels 50 pieces, unit price is 2160 yuan, its comprehensive investment is 50×2160=108,000 yuan | The total diesel consumption cost is 257,763 yuan (see note 1) The total oil consumption cost is 11680 yuan (see note 2) |
|                                           | 2 sets of rated output power 7.5 kW motor, unit price 15,000 yuan, a total of 30000 yuan | Rated output power 7.5 kW motor 2 sets, unit price 15,000 yuan, a total of 30000 yuan |
|                                           | 10 kA lightning protection 2, the unit price is 300 yuan, its comprehensive investment is 2 ×300 = 600 yuan 380 V /48 V controller 2,000 yuan, 1×48V/380V inverter 800 yuan, 1×48V/24V inverter 800 yuan | 10 kA lightning protection 2, the unit price is 300 yuan, its Comprehensive Combined cost Capitl for 2×300 = 600 yuan |
|                                           | Accessory, cable 300 yuan                  | Attachment, etc. 300 yuan                       |
| Update, maintenance costs                 | Use solar photovoltaic system 10 years, iron lithium battery every Replace it in 5 years, need 88,000 yuan | Every run 1.5 years maintenance, the cost is 500 yuan, use 10 years, maintenance:The number of times is 6 times, the total cost is 500 × 6 = 3000 yuan |
|                                           |                                            |                                                 |
| Total cost                                | The total cost is 318,500 yuan             | The total cost is 349,343 yuan                  |

Total diesel consumption cost calculation:

Rated output power 8 kW diesel generator set At 9km/h, the diesel engine output is 5.5 kW, fuel consumption rate 250 g / kW · h, the two diesel generators work hourly fuel consumption with diesel generator sets, working on average every day 6 hours, every 1000g.

For the calculation of 8.56 yuan, the daily consumption of diesel fuel is 5.5×250/1000×8.56×6=70.62 yuan.

Used in diesel generator sets In 10 years, the total diesel consumption cost is...
70.62 × 365 10 = 257,763 yuan.

The total engine oil consumption is:

With diesel generator sets and every run 100 hours, you need to change the oil once, the cost is 20 yuan. Use 10 years need to consumed

8×365×10/100×2=584 times,

the total cost is

584 × 20 = 11680 yuan.

It is available from the above two different forms of power generation. In the current view, when the price of oil is in every kilogram At about 8.56 yuan, the two forms of power generation drive the motor. From the initial investment, the solar photovoltaic system has higher cost, and the diesel engine has lower power generation cost. However, the diesel engine continuously consumes diesel oil over time, and under normal circumstances, solar photovoltaic power generation does not. Cost to In the 10-year cycle, we found that the total cost of solar photovoltaic power generation is slightly lower than that of diesel engines, and with the continuous improvement and improvement of solar energy technology, the production cost of solar modules continues to decrease, and the non-renewable energy sources such as fossil fuels are depleted day by day. The cost will increase year by year, and solar power generation will be more competitive with fossil fuel power generation in the future.

5. Conclusion
At present, there are many beautiful scenic spots still using traditional diesel-powered cruise ships. The gas pollution and noise pollution generated during operation are not in harmony with the tourist attractions, and all-solar electric power driven ships can be selected. At the same time, all-solar cruise ships can satisfy people's pursuit of environmental protection and low carbon, and raise people's awareness of energy saving and emission reduction.

According to the national "Twelfth Five-Year Plan Implementation Outline" in the guide of energy saving policies, our country will increase the development and utilization of renewable energy, building a resource-saving and environment-friendly society. Based on the demand for energy conservation and emission reduction, this work has realized the development and utilization of new energy and eased the crisis of depletion of non-renewable energy consumption.

The power source of the cruise ship comes from solar energy. The power provided by the solar panels and the terminal solar cells on the ship itself can guarantee the normal operation of the ship, which not only reduces the loss of non-renewable energy, but also reduces the greenhouse gases such as carbon dioxide. Emissions, with good promotion value and great market potential.

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