HYBRID ELECTRIC CATAMARAN FOR INTER-ISLAND SEA ACTIVITIES

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Abstract

The weight of a catamaran boat floats on two hulls. This allows each hull to be slimmer and shallower in cross-section than the single hull of an equivalent mono-hull, so it has less weight, small draught, less water resistance, much more deck area for passengers or marine activities, stable and less power usage. Especially, if it powered by hybrid energy (diesel and solar), then it could be more economical because of relentless rise in oil prices in the world. The increasing of fossil's fuel oil prices urges people to try to complement a part of it with alternative energy such as solar energy using photovoltaic (PV) cells which could power the electric motors (E-motor) as the prime mover of the boat. Powering boats by hybrid energy in tropical countries like Indonesia where solar energy is freely available on average for six to eight hours a day could reduce operational cost and at the same time reduce the carbon emission. In addition, the low noise generated by the E-motor is more suited to passengers and less likely to frighten fishes during the catching operation. The major drawback of this technology is that it needs more investment because of high cost of PV system, but it could be beneficial over a long period. In term of operation the boat can be powered by solar energy directly and during night time the power can be supplemented from batteries charged during the day by solar energy. The hybrid technology using for powering catamaran boats would be future potential especially for daily inter-island sea activities.

1. Introduction

A typical scenario for this study is based on sea activities in Maluku province which is located at the eastern part of Indonesia so called the "Thousand island's Province". The area consists of 90% seas and 10% land. Figure1 shows the Maluku province which consist of small and medium islands. Sea transportation between islands and fishing activities within the region are major activities using diesel powered catamarans.

Figure 1. The map of Maluku province

These activities requiring outboard or inboard motors generate exhaust gasses and cause immeasurable negative effects on the environment. The engine cooling system and waste water pumped out into the sea contained oil and fuel residue causing marine pollution especially when a large number of boats are operating in the region.

Moreover, due to the economic growth at the region the number of boats will increase rapidly consuming more fossil fuel and therefore causing more pollution. So by progressively switching from fossil fuel to alternative energy sources it could reduce pollution and operational cost. Tropical region such as Indonesia having a 12-hour free solar energy can utilize to achieve this transformation [1]. Hybrid solar and gasoline/diesel fuel system for powering the boats may initiate interest to boat operators due to the benefits they provide.

2. Technical Description

2.1. Hybrid Power System

Solar energy is transformed into electricity through photovoltaic (PV) system. This could run electric motor as prime mover on small catamaran fishing boats or for other purposes. Figure 2 and 3 show typical fishing boats and catamaran ferry for transportation between closed islands, respectively [2]. For these boats, daytime they can use solar energy and night time they could run on batteries. Diesel generator could be provided on standby to complement when alternative energy is not available. This system can save fuel between 20-30% compared with the same capacity mono-hull using diesel/gasoline engines [3].

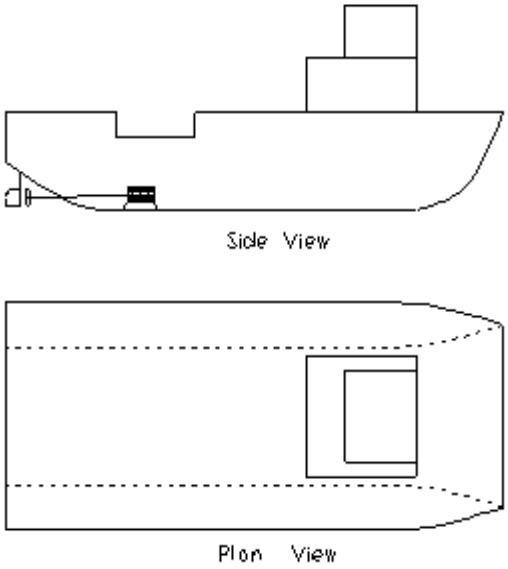

Figure 2. Small catamaran fishing boat

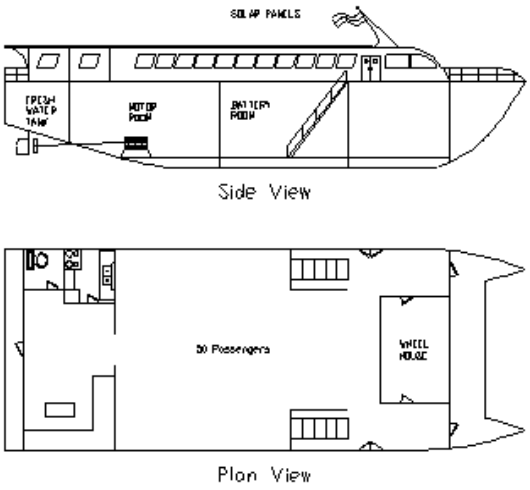

Figure 3. Catamaran ferry for transportation between islands [2]

2.2. Electrical Catamaran Boat

The catamarans presently in operation within the cluster of closed islands in the Maluku province are generally small in tonnage (5-10 GT) ferrying between30-50 passengers and/or operating small gillnets. The characteristics of these boats and operations are suitable for the installation of hybrid energy system. The propose power system components for these boats is shown in Figure 4. By this system, the DC current produced by the solar panels through the controller will run the motor before being channeled to the propeller. Part of the current is going to charge the batteries for running the boat during shortage of solar energy. In particular during the night when the capacity of batteries is low then the generator will perform its duty.

The advantages of a hybrid system are: low operational cost and low maintenance/repair cost. Generally, solar panel has an operation life of 20 years while E-motor has efficiency over 90 % [4]. Under this arrangement, the propulsion system does not require thrust

bearings as the electromotor delivers the propeller thrust directly to the hull which only requires a simple type of gear transmission. Electric motors maintain high efficiency over a wide range of loads and speed. At 60 volts it will generate power up to 10 KW (≈ 13 HP) [4]. At low shaft speed and high torque they are capable of using a simple, cheap and efficient transmission system in most applications. These motors enable us to get the best possible performance from the batteries or directly from the panels. High efficiency gives longer running time and less frequent battery replacement.

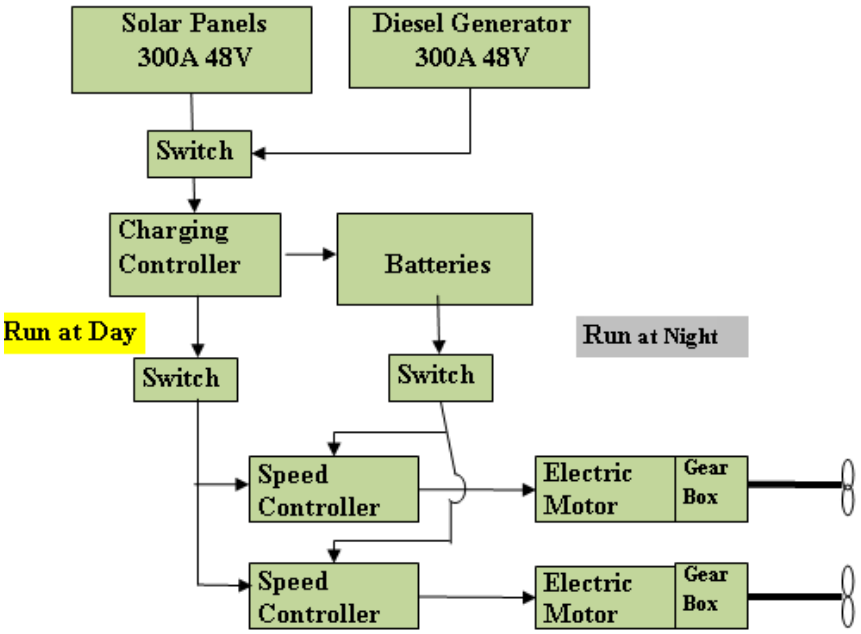

Figure 4. Hybrid solar-diesel propulsion system

2.3. Investment

The system requires some initial investment consisting of [5]:

- New system design cost
- Cost of hull and structural modifications
- Electric motor/diesel engines-propeller system and installation cost.
- Solar power/electricity and installations cost
- Batteries and installation cost

Investment for mono hull gillnet 10 GT or ferry 30 passengers is about Rp. 205,000,000 and for catamaran with new design of same capacity is Rp. 405,000,000. Additional costs include all components to make a complete alternative energy system including installation. The investment of catamaran is more than twice as of the mono-hull boat investment.

3. Result and Discussion

This study the focus is on implementing the alternative energy for powering small fishing boats as they are available in large number thus utilizing large quantities of fossil fuel.

According to Muzathik et al. [6], the daily average sun shines hours are about 7 hours for the study area. In addition these vessels mainly operate during the day thus can benefit from solar energy for propulsion. Normally these vessels operate around 12 hours in a day, out of this 6 hours power requirement should be derived using generator. With this mode of operation the hybrid system could save about 50% fuel usage (Figure 5). This also reduces the maintenance cost related to diesel engine and generator.

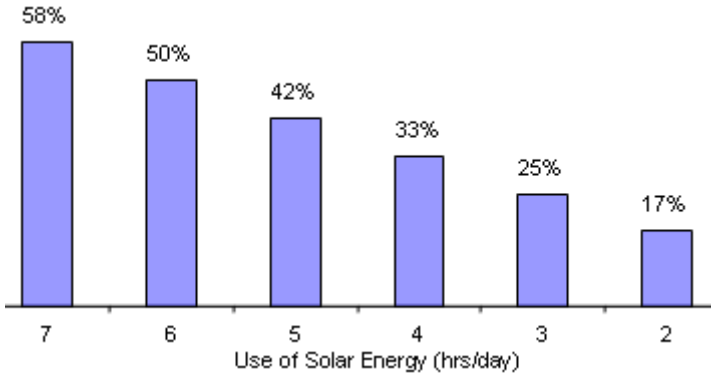

Figure 5. Fuel and the maintenance cost saving percentage

3.1. Income

The income of fishing vessels depends on the amount of average daily catch in one year, the amount of total catching days in one year and the amount of daily operating hours. Based on given data it is assumed that the boat will operate in 12 hours a day. The total catching days per year are 100, 150, 200 and the amount of average daily catch is 100 kg, 120 kg, 140 kg, 180 kg are considered in this analysis. Based on these data the projected income is as shown in Figure 6.

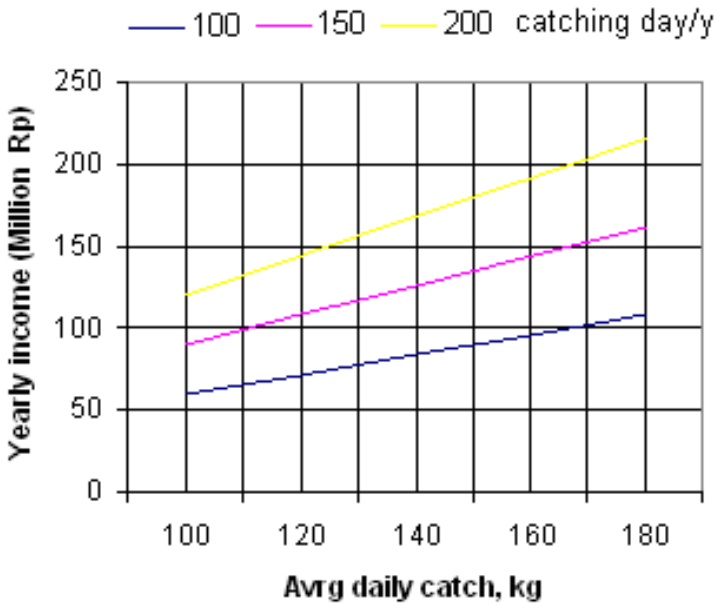

Figure 6. Yearly incomes of typical fishing boat

3.2. Operational Cost

Yearly operational cost of the hybrid catamaran and the mono-hull boat depends on the amount of operational days of the boats in a year. But for the hybrid catamaran the operational cost is also depends on the amount of hours when the boat is powered by solar energy [7]. The results are shown in Figure 7 based on solar energy availability in a day.

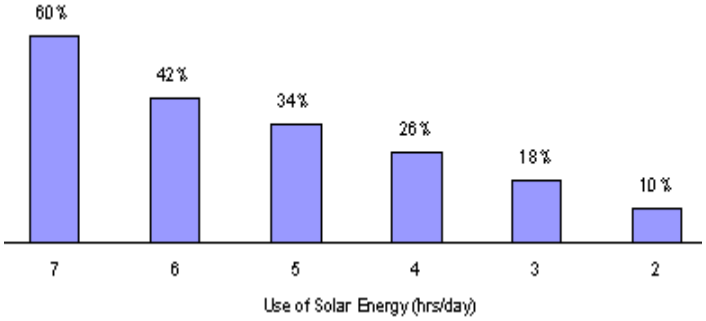

Figure 7. Operational cost saving by using hybrid system

3.3. Maintenance cost

Using the normal system the average maintenance cost per year is around 20-30%. Maintenance cost consists of maintenance cost related to hull, engines, fishing equipments etc. For the new system, the estimated cost of maintenance during the first year is about 5-10% of the price of the boat plus equipments. Each year the maintenance cost is rising at a rate of 1.5%. This will increase gradually over the following years.

3.3. Payback period

Based on Payback period the investment can be recovered within less than five years if operate the vessel more than 130 day per year. It can be seen clearly from Figure 8 for mono hull and catamaran.

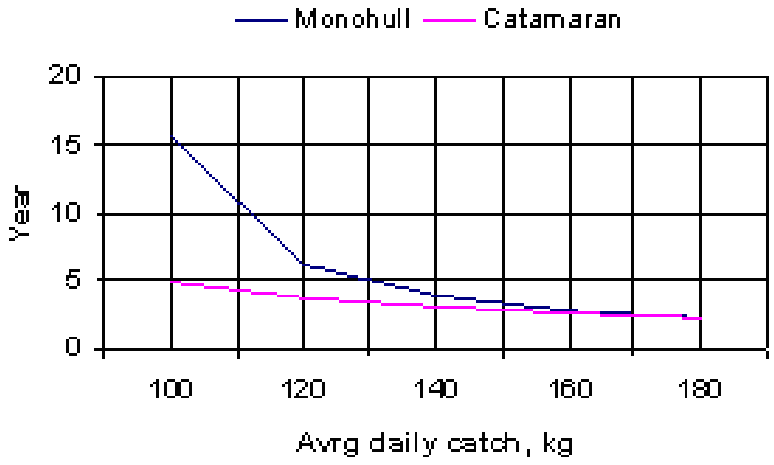

Figure 8. Payback period of mono-hull and catamaran

4. Conclusions

Based on the study:

- The hybrid vessels may operate around 6 hours per day from the solar panels and it could save about 50% of fuel coast and 42% of operational cost.
- The E-motor as the prime mover gives no sounds. So, the fishes will not be frighten to come near to fishing boat [8], and catamaran ferry passengers will not be disturbed by the engine sound.
- The payback period of hybrid system is about three and a half years for 140 kg average daily catch with 200 operational days in a year.

As a conclusion, using solar energy beside fossil fuel for small and medium fishing boats and catamaran ferries is encouraging based on operation and maintenance coasts and environmental issues**.**

References

1. Zekai, S., (2008), Solar energy fundamentals and modeling techniques: atmosphere, environment, climate change and renewable energy, Springer.
2. Comstock, J.P., (1967), Principle of Naval Architecture, SNAME.
3. Harry Benford, (1984), "Ships' Capital Costs: The Approaches of Economists, Naval Architects and Business Managers," Ships' Costs Conference, Cardiff, Wales.
4. Kevin Jeffery, (2006), Independent Energy Guide-electric Power for Home, Boat & RV.
5. Harry Benford, (1991), A Naval Architect's Guide to Practical Economics," Report No. 319, Department of Naval Architecture and Marine Engineering, University of Michigan.
6. Muzathik A.M., Wan Nik W.B., Samo K.B.and Ibrahim M.Z, (2010), Global solar radiation hourly estimate on horizontal plane, Journal of Physical Science, 21(2), pp. 51-66.
7. Kumar R. and Umanand, L., (2005), Estimation of global radiation using clearness index model for sizing photovoltaic system, Renewable Energy, 30 (15), pp. 2221-2233.
8. H. Suzuki, E. Hamada, K. Saito, Y. Maniwa and Y. Shirai, (1980), The Influence of Underwater Sound on Marine Organisms. Journal of Navigation, 33:pp. 291-295.