Sourojan: A low cost and profitable solar boat for coastal tourist areas

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Abstract. Technology intervention for making our life easier is always a main focus for researchers from different disciplines. In coastal tourism areas, economy largely depends on the boats and fossil fuels such as octane, diesel, used as the main fuel of this boats. So nowadays this fossil fuels have become a great problem due to its increasing price and limited supply. It has become a great threat for the survival for the community of the riverine and coastal regions. We designed a low cost and profitable solar boat so that we can replace the use of fossil fuels like octane diesel with renewable solar energy. In our proposed system photovoltaic arrays and batteries are used to store the solar energy which is used as the main fuel of the boats. It will mitigate the daily fuel cost used in these boats and increase the profit level. This solar boats will help the community of the riverine and coastal regions to improve their economic condition.

Keywords: Solar Energy, Low-cost and Profitable Boat Prototype

1 Introduction

Tourism is one of the greatest factor for a country's economy. There are many countries whose economy largely depends on tourism business. Malta, Croatia, Thailand, Jamaica, Iceland are the five top most countries in the world whose economy largely reliant on tourism [2]. At the same time United States, China, Germany, Japan, United Kingdom are top five countries having the large tourism industries [2]. There are also some countries who are shifting their main economy towards tourism. Abu Dhabi can be the perfect example in this regard.
Sea, river and islands are great resources for coastal tourism. The advent of the availability of new destinations, more adventurous activities and a desire to observe wildlife (birds, whales, corals, etc.) mean that coastal resorts still attract the greatest percentage of tourists every year; 63% of European holidaymakers prefer the coast (EC, 1998). Worldwide the number of international arrivals (i.e. arrivals from outside the country) has shown a steady increase from 25 million in 1950 to over 700 million in 2002, corresponding to an average annual growth rate of 6.6% and it is estimated that by 2020 there will be 350 million tourists visiting the Mediterranean coastal region only (WTO, 2004)[3]. Coastal tourism largely depends on the boats. Tourists visiting coastal areas hire this boats to

explore the natural beauty.
Boats are one of the main source of income for the people near the sea, river and islands. Boats are integral part of their day to day life. They have to carry their necessary commodities from one side to another side of the river or see. Sea foods are famous in this areas as well as all over the world. As a result many people of this area choose fishing as their main profession. They use the boats for fishing.
The main fuel of this boats used in this areas is fossil fuels such as octane and diesel. But the price of octane and diesel is increasing rapidly. But the communities near the sea and river are mostly poor and illiterate people. So increasing the price of this fuel has become a great problem for their survival and daily earnings. It is high time to think about some alternative solution for replacing fossils and fuels and minimize the fuel cost.
The technological search of the alternative energy in shipping was started in the early 2000 to mitigate the use of natural resources and harm of the environment [7]. The invention of solar energy has drawn the researchers' attentions to use this energy in different fields. Researches have discussed many principles for using renewable energy such as solar, photovoltaic etc. as an alternative fuel.On the other hand increasing price [9] and limited supply of the fossil fuels has made it hard to use it as fuel. So now researchers are trying to replace it with renewable energy [5].Many countries are already getting the impacts of the renewable energy over fossils fuels [10]. Researchers are designing and developing models that can replace fossil and fuels with solar energy in vehicles and boats [6].The best possible method to utilize the solar energy in the ship is by using catamaran boat with the flat top structure to provide room for placing solar panel. Furthermore, the solar energy extracted from the panel can be optimized by using quadratic Maximization Maximum Power Point Tracking (MPPT) that executed by KY converter, and converted to AC voltage using a multilevel inverter [4].
In this paper we have proposed a cost effective prototype to replace fossil fuels with renewable energy for the boats. Solar energy is used as the main fuel of this type of boats. In our research we have tried to minimize the construction cost of the boats. We also analyze the day to day cost of our proposed system comparing to the old fossils and fuel system. Our analyze report indicates that it will be profitable for the boatman.
Our idea is to provide real autonomy of navigation and real power from the battery in these boats. In our system, a storage device (battery bank) is used for balancing the mismatch between the available energy by the photovoltaic arrays and power required by motors and boat instruments. Both the powers that flow in and out of the storage device is designed accurately and controlled with global energy management

2 Motivation

Bangladesh is a densely-populated, low-lying, mainly riverine country located in South Asia with a coastline of 580 km (360 miles) on the northern littoral

of the Bay of Bengal. The delta plain of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna Rivers and their tributaries occupy 79 percent of the country. There is also the largest sea beach in the world located in cox's bazar Bangladesh. A huge number of people are living near this river and sea areas. Most of the population in these areas are poor and illiterate. Their livelihood is directly or indirectly connected to the rivers, sea and especially dependent on the boats. They need to use the boats for fulfilling their day to day needs. Boats are used in bringing their daily necessaries from town areas, movement from one side to another and also in fishing. At present they are using boats which is mainly dependent in octane and diesel. But with increasing price and limited supply of octane it has become a difficult situation for their day to day life. Though the day to day lifestyle cost has increased rapidly because of this, their daily income has not increased in proportion of that. Therefore we have designed and developed a low cost and profitable boat in which solar energy is used as main fuel and it can lessen the use of octane. The objective of our design is to replace the use of octane and thus provide the people near the river or sea a low cost boats with more profits than the old boats so that they can lead a good life.

User acceptability of this new technology in river and sea areas is also an important factor for the success of our design. Therefore, we plan to do a survey over the river and sea areas in order to determine whether they need the new system for reconstructing the boats and how the people will accept this. In the following section, we will discuss the survey and the findings of our survey.

3 Survey

We plan to investigate some areas near the rivers and sea to find out the depth of the problem. We have selected Rangamati, Bandar ban and Cox's Bazar in Chittagong region for our survey. Rangamati and Bandar ban are hill tract areas as a result many known and unknown rivers are flowing in this hill areas. On the other hand Cox's Bazar is the longest sea beach in the world so we can find out the actual situation easily in the sea areas. In this areas there are some place named "JELEPOLLI" where the fishermen live. We asked them about the details of their boats they are currently using. According to fishermen the initial cost of this boats is 1, 50,000 BDT. The maximum speed they gained from this boats is 8.33 km/h. This boats can carry a maximum load of 500kg. This boats needs 5 liter octane which costs 110 BDT per liter every day. There are other maintenance cost for this boats. The annual maintained cost with the fuel cost is shown in table 1

At the same time their annual total income is almost fixed. They earn 1000 BDT per day which gives an annual income of 3, 60,000 BDT. So their annual profit from the current boats is (3, 60,000 – 2, 20,000) or 1, 40,000 BDT. But the increasing price and limited supply of octane are decreasing this profit level in a high rate. As a result it has become a hard problem for them to survive in such circumstances. We had then discussed with them about our proposed

Table 1. Monthly Maintenance Cost of the Current boats

Field of Cost Monthly	**Daily Cost Price**	**Annual Cost Price**
Fuel Cost	550 BDT(Daily)	1,98,000 BDT
Maintenance Cost	1000 BDT (Monthly)	12,000 BDT
Square Parts Expenditure		10,000 BDT
Total Annual Cost		**2,20,000 BDT**

system for the boats. Our system may need an installation cost of 2,53,000 BDT which is pretty much high from the current boats. But it will replace the total annual fuel cost as it does not need any fuel like octane. The maintenance cost of our boats is also very low. As a result the annual profit by using our boats is higher than the current boats. On the other hand the speed of the new boats is 10 km/h which is pretty higher than the current boats. It will also help to increase the daily income.
After hearing the facts, they showed interest in such boats and gave a positive response in using the boats instead of the current ones. In case of high installation cost we will be trying with more elements to minimize the cost. But the high installation cost can easily overcome by the high increase in profit level. The fisherman of this areas agreed with us that, the implementation of the proposed solar boats may increase their annual profits and obviously ease their lives.

4 Methodology

4.1 Block Diagram

Here in figure 1 the photovoltaic arrays store the solar energy from the sun. MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called maximum power point (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature. We used MPPT to get the information that the energy from the photovoltaic arrays is enough to drive the boat or we have to use energy from the batteries. We used the charge controller which gets the information by the management control (MPPT) to charge the battery or direct use the power to drive the boat.A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. Charge controller sends the energy that comes from the photovoltaic array, to the fully discharged battery bank. During the charge process, charge controller measures the flow of incoming energy in the battery bank. When the battery bank is completely charged, the energy flow is sent to another fully discharged battery bank. In the eventuality that there are no fully discharged battery banks the energy flow is sent to the loads through

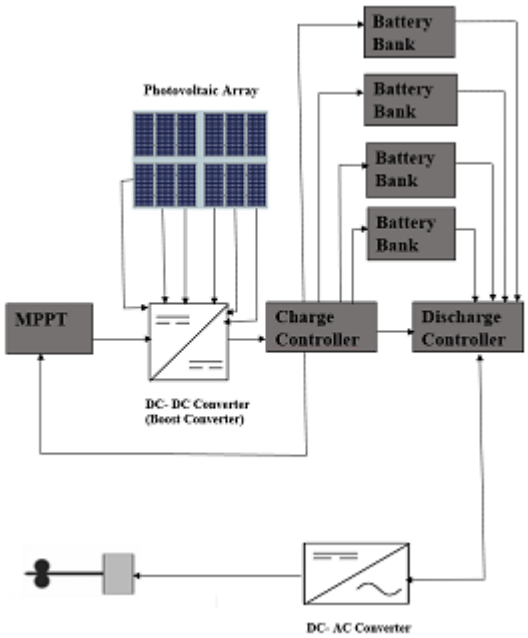

Fig. 1. Block Diagram of the Proposed System

the discharge controller; in alternative, the energy flow is sent to the grid if it is connected. The discharge control carries to discharge fully a single battery bank at a time. During the discharge process the discharge control measures the energy flow and management control compares this with one memorized during the preceding charge. Through this comparison it is possible to establish the aging of the battery and to determine the real storable energy.

4.2 Cost Analysis of the proposed system

There are many research in making the boats with different techniques. In a maritime research mission, an autonomous sailing boat also named "ASV Roboat"[8] was constructed. The whole process of sailing boat navigation is performed by an autonomously acting system of technical devices. In another research small solar boats are designed which can take only two human at a time. Because of the used materials and the solar concept the Solar boat is with a price of about 12000 Euro (13300 USD) relatively expensive compared to boats with similar main dimensions[1].
In our research we have tried to minimize the construction cost of the solar boats by using minimum cost equipment which can also give a good performance. There are some elements which are constant in almost all kinds of boats such as hull, motor and the propeller. The labor cost may vary in different areas.

In table 2 we have listed the equipment we are using in our prototype with their market prices. The total cost of our solar boat will be 2,53,000 BDT which is almost 3000 USD. The most effective thing about this solar boats is that it is a onetime investment. It will replace the big amount of price used in fuel. It also needs a little amount of money for maintenance. On the other hand it can carry at most 5-6 human at a time. It can also carry 550 kg load at a time.

Table 2. Calculation of cost

ITEM NAME	**UNIT**	**MODEL**	**PRICE**
Battery (12v 200Am)	4 pcs.	U27-36XP model.	12000x4=48000/=
Solar panel	500 watt 1pcs.	1.580mm X 798mm X 46mm	100000/=
Hull	1 pcs.	Original wood	70000/=
Motor	1 pcs.	Model-ST335xU	15000/=
Labor Cost	4 Person.	N/A	20000/=
Propeller	1 pcs.	5 Inch	400/=
Total Annual Cost			**2,20,000 BDT**

5 Testing

Fig. 2. Solar Electric Boat

We had tested our prototype in the pool. In figure 2 we can see the image of our proposed solar boats. The boat was working correctly without driver, and manual mode being able to rounding the pool. Since this test run was done on a very good performance. We had observed that the boat could drive for 30 minutes in the pool as shown in figure 3. It was enough to confirm that the solar panel could charge the batteries, however the configured maximum threshold was possibly too high to allow the boat to drive and charge. This was hard to determine, as the battery voltage fluctuates when under variable load.

Fig. 3. Floating successfully in the pool

6 Comparison Current system vs Proposed System

Boats plays very important role in the economy of the coastal tourism areas. Almost all the work in this areas are mainly dependent on the boats. The main fuel of this boats is octane. Not only the increasing price and limited supply of octane are causing problem, but also the burning octane creates CFC gases which Is very harmful for our environment. In our research we find that our proposed solution not only solve the problem of increasing price and limited supply of octane but also it is safe for the environment. In table 3 we have compared the current system boats (octane engine) with our solar boats. After analyzing all the facts we can prove that this solar boats are not only low cost and economically profitable for the coastal tourist areas but also it is good for the environment.

Table 3. Current system vs Proposed System

Comparison Type	**Current system (octane engine)**	**Propose System (solar boat)**
Installation cost	1,50,000/-	2,53,400/-
Annual Fuel cost	1,98,000/=	Free cost
Speed	8.33km/h	10km/h
Energy type	No renewable energy	Renewable power energy
Effect in enivironment	Air, water and release huge amounts of Greenhouse gasses into the atmosphere	CFC Free, so it is green technology

7 Future Plan

The community of the riverine and coastal regions can use this proposed boats so that the use of octane can be mitigated as well as replaced. The economy of

the riverine and coastal regions do not have to depend on the increasing price and limited supply of the fossil fuels. Though our proposed system replace the use of fossil fuel, at present the initial construction cost of this boats is pretty much high comparing to the present boats. We have always tried to make this boats with low price elements. We plan to experiment with lower price elements in our proposed system to minimize the construction cost. We plan to deploy our proposed system to all the riverine and coastal tourist regions. It is yet to be investigated that, how the technology is accepted among low economy riverine and coastal communities.

8 Conclusion

Finding effective solution of different economic problems is one of the main focus of the researchers from disciplines. Providing low cost with profitable economic solutions is the main principle of the technology designer. Moreover, researchers want to find the perception of a community about different scientific solutions in economic problems. In this study, we have designed and developed a low-cost and profitable boats based on renewable solar energy as main fuel for community of the riverine and coastal tourist regions. Boats are one of the fundamental pillars of the economy system of the riverine and coastal tourist regions. According the survey we did, the main fuel of this boats is octane and diesel. But the increasing price of the octane is becoming a great problem people whose livelihood is largely depending on this boats. As the income from this boats is pretty much fixed, the increasing price and limited supply of octane has decreased the profit level from this boats. In our system we have proposed to use renewable solar energy as an alternative use of octane. The solar energy from the sun is stored in the batteries through the photovoltaic arrays. The boat will directly use the energy from the photovoltaic arrays if the energy is sufficient to drive the boats. At the same time the batteries also charge from the photovoltaic arrays. If the energy is insufficient to drive the boat, the boat will use the stored energy from the batteries. Our proposed system will replace the fossil fuels with solar energy in the fuel system of the boats as a result the increasing price and limited supply of the fossil fuels will not affect the economy of the riverine and coastal regions. Moreover the use of the renewable solar energy is also good for the environment comparing to the use of fossil fuels. We plan to start our deployment and minimize the construction cost of this boats so that people of all economic conditions can use this proposed system.

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