

INTEGRATION OF SOLAR ENERGY IN FISHING VESSELS IN INDIA

Abstract

This book chapter investigates the use of solar energy as a sustainable and viable power source in Indian fishing vessels. India stands to profit from solar energy solutions in its fishing industry as a country with a huge coastline and a significant reliance on traditional fishing practices. This chapter analyses the technical features, benefits, and challenges connected with integrating solar energy systems in fishing vessels, focusing on the Indian fishing industry.

Keywords: Solar energy, Sustainable energy, Fishing vessels

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I. INTRODUCTION

The globe is currently dealing with a tremendous challenge primarily because of reduction of fossil fuel resources. To ensure a sustainable future for ourselves and future generations, immediate action is required to reduce energy use and greenhouse gas emissions, notably carbon dioxide. For a long time, fossil fuels have been the dominant energy source, but their availability on Earth is finite, and they are consumed much quicker than they are being produced. These supplies will eventually be depleted. To manage the above problem, the emphasis has switched to clean and environmentally friendly renewable energy options. Renewable energy sources emit few to no pollutants and are a safer alternative to typical fossil fuels, which also have safety and waste disposal issues [1].

The fishing sector requires alternative energy technology, goods, and services to lessen its reliance on fossil fuels, resulting in significant energy and water savings and carbon emissions reductions. Fishing is widely acknowledged to be the most energy-intensive method of food production. Many large and medium-sized fishing vessels in India, including trawlers, seiners, liners, and gillnetters, rely mainly on diesel or kerosene as their primary fuel source. The procedures involved in fishing's pre-harvest and post-harvest operations consume significant energy and water. Using solar energy in fishing vessels can overcome problems related to this primary fuel source and make the fishing industry more sustainable [2].

In the long run, the cost advantage of using solar energy would be superior to other sources of electricity. Solar energy is seen as a potential source of energy cause of its limitless nature, comprehensiveness, and inherent benevolence. The initially developed solar cell converted sunlight with four per cent efficiency, whereas modern solar cells can only do a quarter of that. Building-integrated PV (BIPV) is a revolutionary breakthrough in PV cells. BIPV is preferable to PV since its construction costs less than silicon PV cells. Renewable energy source such as solar energy can be making use in distributed energy systems (DESS) [3].

II. PHOTOVOLTAIC (PV) SYSTEMS

The sun is the source of solar energy, and the surface of the earth receives considerable solar radiation, allowing the self-powered PV applications. As a widely dispersed renewable energy source, solar energy has long been employed in various applications; consist of solar power generation, photochemical reactions, solar thermal utilization and photobiological uses. The expenditure of PV generation is reducing rapidly due to ongoing technological advancement. PV self-powered equipment have emerged alongside the rise of PV generating. The PV panel generates electricity from received solar radiation; the controller and inverter process the generated electricity, and the processed electricity is then reserved in the electricity storage device via the filtering circuit to distribute power to applications [4].

III. SOLAR ENERGY RESOURCES IN INDIA

India has a considerable for solar power potential, which is predicted to be many times the country's annual energy requirement of 5000 trillion kWh. The incident solar radiation over India is 4-7 kWh per square meter per day, having a yearly radiation range of

1200-2300 kWh per square meter. It has 250-300 bright sunny days per year and 2300-3200 hours of sunlight. India's energy needs may be supplied on a total surface area of 3000 km², which is equivalent to 0.1% of the country's entire land area [5, 6, 7].

IV. BENEFITS OF USING SOLAR ENERGY IN INDIAN FISHING VESSELS

Solar energy has many advantages. For starters, solar energy is almost free after the primary capital commitment. Unlike traditional energy sources, which require ongoing fuel expenditures such as oil, coal, or gas, solar energy does not. This makes it particularly tempting for industries such as fishing, particularly in light of current oil prices.

Second, unlike fossil fuels, which have a limited supply and will eventually run out, solar energy is a source renewable energy source. Solar energy will always be available if the sun remains, making it a sustainable and dependable energy source.

Third, solar energy is less harmful to the environment than fossil energy. As we all know, fossil energy harms the environment and contributes significantly to the greenhouse effect. On the other hand, solar energy is a type of "zero emission" energy, which means it pollutes the fragile environment less [8].

V. APPLICATIONS OF SOLAR ENERGY IN INDIAN FISHING VESSELS

Solar PV boat includes components such as PV array, DC-DC converter, electric propulsion, MPPT, and battery management system. The hybrid system of PV-diesel comprises many components: a PV module, a DC-DC converter, an MPPT, a battery and its charging and discharging controllers, a diesel generator, a coupler and an inverter. Another boat which is solar-powered relies entirely on solar PV output energy as the only source to meet the ship's load needs. This structure was created for the small-scale vessels, such as tiny fishing boats and entertainment ships. Water craft only need power to drive their electric engine for momentum and a small load, like lighting. PV alone is sufficient to satisfy all purposes on a modest scale in these boats.

The use of a diesel-powered engine in hybrid system is the only variation between the topologies. The rest of the parts for both boats are same, although there is a small variance in component ratings because this boat fulfils a modest load requirement. The average 30-foot boat requires 300-350 watts of power, determined primarily by energy consumption and boat size [21].

The components include the solar array, DC-AC converter, DC-DC converter, MPPT, management control, diesel generator set, charge/discharge control, main switchboard, and the electric motor propulsion.

- 1. PV Array:** The biggest challenge with solar boats is the restricted space available for installing solar PV cells. PV modules require room and must be positioned to catch maximum sunshine. Creating such an arrangement is a challenging endeavor. A PV array, often known as a solar array, is a grouping of various solar modules. The greater the amount of sunlight absorbed by the photovoltaic (PV) system; the greater energy output made by the PV array [16].

Implementing solar PV in a boat creates a stability issue because the load of the Photovoltaic module, battery and other gear increases the load of the vessel. Solar PV provides the most significant technological advantages, including no energy production costs, versatile installation, energy production that corresponds with peak demand and economic savings. Sun-directed energy falls at 120 petawatts per second on the surface of Earth. This means that the energy derived from sunlight in a single day may meet the world's energy requirement for over 20 years. Spagnolo et al. proposed a tourist boat with solar-electric power system. They employed solar PV arrays, a 45Ah battery, a 14m long and 5.50m wide catamaran boat, an MPPT controller, a DC-DC boost converter, an inverter, a charge controller, and a controller for power management.

- 2. DC-DC Converter:** A power conditioner is a required component that improves system efficiency. It regulates the photovoltaic system's output and, if linked to an MPPT, boosts its production. DC-DC converter is the power conditioner used in PV systems. Three kinds of DC converters are commonly used with PV systems. There are three types of converters: buck, boost, and buck-boost. Boost converters are widely utilized due to their high output. The yield voltage from a buck converter can be less than the input voltage, but the yield voltage of a boost converter is more than its input voltage. The yield voltage in a buck-boost converter can be greater or less than the voltage at the input. In their study, Kumar et al. used a Cuk converter on the place of the buck, boost, and buck-boost on the Photovoltaic grid-connected system. The key advantage of the Cuk converter is that the output voltage of the Cuk converter does not reverse. Cuk has higher efficiency and smaller ripple voltage than the buck-boost converter, according to the results. A photovoltaic generator (PVG) can be effective if it converts the maximum available of solar power equally throughout, also in adverse weather conditions. Buck converters can harvest energy from a PV source to fulfill load demand [18].
- 3. PV MPPT:** Maximum power point tracking (MPPT) assists in increasing the PV array's output in any weather condition. PV arrays' full power varies with sun irradiance and meteorological conditions. MPPT approaches are classified as artificial intelligence (AI) or non-AI. The non-AI-based techniques are Perturb and observe, incremental conductance and fractional open circuit, whereas the AI-based methods are fuzzy logic [9] and neural networks. Different algorithms for MPPT are employed to control the duty cycle of a DC-DC converter [25]. MPPT techniques are essential in increasing power output from solar cells [23]. Chakraborty et al. [22] presented a unique MPPT-based solar-powered system for fishing trawlers to minimize fuel uses. However, the article provides no cost details or investment payback duration statistics. Chao et al. [19] proposed design of a solar-powered boat that uses the most recent patented distributed PV power system having MPPT technology, a power optimizer, and a PV power controller. The quadratic maximization (QM) method is utilized in this design for MPPT, which is particularly efficient for rapidly changing temperature and sun insolation.

Furthermore, the sole drawback in this layout is the higher expense caused by the Li-ion battery, which is at least three times the price of the absorbed glass mat (AGM) lead acid battery. Mirza et al. [12] introduced a novel bio-inspired technique for solar systems under various climatic situations that employ Salp Swarm Optimisation (SSO) for effective MPPT. It uses the salps feature to trail the highest available power,

especially under partial shade (PS), which limits output power [12]. The MPPT studies discussed above focused on increasing output through various strategies.

- 4. Electric Propulsion:** In a PV-powered boat, the electric motor serves as propulsion. PV provides the energy required by the electric motor. There are two types of electric motors: DC electric motors and AC electric motors. Before improvements, only DC motors were employed since they are easier to operate than AC motors. With developments in power electronics, controlling the speed of an AC machine became easier than maintaining a DC machine. Nowadays, AC motors are preferred over DC motors because they are less in weight, less expensive, and smaller in size [10]. Many studies have concentrated on improving the efficiency of solar vessel electric propulsion. Simonetti et al. [20] proposed a fuzzy logic-based controller solution for a solar-powered boat powered by an indirect vector-controlled induction motor. Soeiro et al. [21] suggested a fuzzy logic-based indirect vector controller to improve the efficiency of a PV boat. The preceding studies need more information on solar energy utilization, performance of induction motor and impact.

VI. BATTERY MANAGEMENT SYSTEM IN THE SOLAR VESSEL

The battery is a component of the solar vessel. Because solar electricity cannot fulfil the demand at night or in cloudy or wet conditions. Solar panels produce more energy on bright days. It will be challenging if electric propulsion fails during a journey due to solar PVs not receiving enough sunlight to create power. In such instances, the battery serves as a backup. A good battery management system is essential to improve battery efficiency and lifespan. Lithium-ion batteries are the most popular for their longlife, high energy density, and eco-friendliness [13,14]. A battery management system (BMS) monitors and manages internal working parameters such as current, temperature, and voltage while charging and discharging. It calculates the state of charge (SOC) and state of health (SOH) to optimize safety and performance [17]. It keeps a charge limit between maximum and minimum to prevent overcharging and abrupt explosions. Duan et al. [15] described a safe BMS for electric vehicles with a high energy density and reliability. The researchers listed many techniques for monitoring and regulating BMS, including spectrum analysis, the fibre Bragg grating sensor, gas sensor, and microscopy.

VII. CHALLENGES AND BARRIERS TO USING SOLAR ENERGY IN INDIAN FISHING VESSELS

While solar energy integration in Indian fishing vessels has significant advantages, there are some problems and impediments that must be overcome to ensure its successful implementation:

- 1. High Initial Cost:** Installing solar panels and accompanying equipment might be prohibitively expensive for many fishing vessel owners, mainly small-scale fishermen with limited financial means.
- 2. Limited Awareness and Knowledge:** Many fishermen may need to be aware of solar energy's possible benefits. A need for more technical knowledge and experience to build, operate, and maintain solar systems may also exist.

- 3. Space Restrictions:** Because fishing vessels frequently have limited space for mounting solar panels, the size and capacity of the solar power system may be constrained.
- 4. Intermittent Power Generation:** Solar energy generation is affected by weather and daylight availability. Power generation may need to be improved on overcast days or at night, making it difficult to rely only on solar energy for all energy needs.
- 5. Infrastructure and Support Services:** In some areas, the availability of infrastructure for solar power maintenance and repair, as well as support services for fishing communities, may be restricted.
- 6. Regulatory and Policy Barriers:** Ambiguous or restrictive regulations may impede solar energy use in fisheries. Delays in acquiring permits or certifications may put off potential investors.

VIII. GOVERNMENT INITIATIVES AND INCENTIVES TO SUPPORT SOLAR INTEGRATION

- 1. Pradhan Mantri Matsya Sampada Yojana (PMMSY; FY21–FY25):** The PMMSY aims to close gaps in fish productivity, quality, post-harvest infrastructure and management technology, modernization and strengthening of boats and other assets, traceability and safety through improved telematics, the establishment of a strong fisheries management framework, and fisherfolk welfare. Under the Atmanirbhar Bharat package. The initiative is expected to cost INR 20,050 crore. Although the PMMSY sufficiently meets the need for craft modernization, encouraging the adoption of clean technologies could assist in reducing emissions and increase savings for fishermen.
- 2. Fisheries and Aquaculture Infrastructure Development Fund (FY19–FY23):** The Indian government promotes private enterprises and fish growers to create fisheries infrastructure. The Fisheries and Aquaculture Infrastructure Development Fund was established with an expected capital outlay of INR 7522.48 crore to produce 20 million tonnes of fish by 2022-2023. Solar-assisted e-boats can play an essential role in meeting this goal.
- 3. Kisan Credit Card Scheme (ongoing from FY20):** The Kisan Credit Card scheme was expanded to fishermen in 2019. Fishermen can use this scheme to get help with their short-term working cash needs. The credit ceiling is INR 2 lakh, and the interest subvention is provided at 2% per year, with an additional 3% subvention available as a prompt repayment incentive. The government can expand the credit plan to support greener technology by raising the credit ceiling for buying e-boats.

IX. FUTURE PERSPECTIVES AND OUTLOOK

The energy density and relatively low energy conversion efficiency of a PV plant will provide power ranging from a few hundred watts to a few kilowatts. As a result of this property in small-scale vessels, solar energy is often employed as the major power source, while in large-scale vessels, it is used as an auxiliary power source. On the other hand, a storage system or battery is required for high power requirements and long working times.

Medium and small-scale vessels that use solar PV for propulsion need a power system layout that includes batteries for energy storage. The vessel's area is known to be limited for the placement of a significant number of solar panels; hence, the energy obtained is limited. If the density of solar panels can be enhanced to generate more electrical energy, solar energy can power larger ships in the future. Solar energy can also be blended with green energies such as wind or waves [5].

X. CONCLUSION

Given the crucial relevance of reducing fuel use, increasing sustainability, and lowering costs, programmes to substitute carbon-based fuels with renewable alternatives are urgently needed. Community-led efforts to reduce operating expenses and reliance on fossil fuels are critical to lowering carbon emissions. Solar energy is a highly successful strategy that saves gasoline, money, and time while drastically reducing carbon emissions, an essential factor contributing to global warming. Using solar energy in the fishing vessel can launch a blue revolution, encouraging more ecologically friendly and sustainable fishing practices.

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