Integration of Solar Energy in Fishing Vessels in India

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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 the integration of solar energy systems in fishing vessels, with a focus on the Indian fishing industry.

Keywords: Solar energy, Sustainable energy, Fishing vessels

Introduction

The globe is currently facing a tremendous challenge due to the depletion of fossil fuel stocks. 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 many years, fossil fuels were the dominant energy source, but their availability on Earth is finite, and they are being consumed at a much quicker rate than they are being created. These supplies will eventually run out. To overcome this issue, 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 as well as carbon emissions reductions. Globally, fishing is recognized as the most energy-intensive technique of food production. Many large and medium-sized fishing vessels in India, including trawlers, seiners, liners, and gillnetters, rely largely on diesel or kerosene as their primary fuel source. The procedures involved in fishing's pre-harvest and post-harvest operations consume a significant amount of energy and water. Use of solar energy in fishing vessels can over come 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 than other sources of electricity. Because to its limitless nature stockpile, comprehensiveness, and inherent benevolence, solar energy is seen as a potential source of energy. The first solar cell converted sunlight with a four percent 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. Solar energy is a renewable energy source that can be utilized in distributed energy systems (DESs).(2)

Photovoltaic (PV) Systems

Solar energy is derived from the sun, and the Earth's surface receives a considerable quantity of solar radiation, allowing for PV self-powered applications. As a widely dispersed renewable energy source, solar energy has long been employed in a range of applications, including solar power generation, solar thermal utilization, photochemical reactions, and photobiological uses. The cost of PV generation is rapidly reducing as a result of ongoing technological advancement. PV self-powered applications have emerged alongside the advancement of PV generating. The PV panel generates electricity from received solar radiation; the generated electricity is processed by the controller and inverter; and the processed electricity is then stored in the electricity storage device via the filtering circuit to supply power to applications. (4)

Solar Energy Resources in India

India has a large potential for solar power, which is predicted to be several 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, with an annual 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 [6, 7, 8].

Benefits of Using Solar Energy in Indian Fishing Vessels

Solar energy has a number of advantages. For starters, after the initial capital commitment, solar energy is almost free. Unlike traditional energy sources, which require ongoing expenditures on fuels 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 renewable energy source. Solar energy will always be available as long as 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 has a negative impact on the environment and contributes significantly to the greenhouse effect. Solar energy, on the other hand, is a type of "zero emission" energy, which means it pollutes the fragile environment less.(5)

Applications of Solar Energy in Indian Fishing Vessels

PV array, DC-DC converter, MPPT, electric propulsion, and battery management system are the components of a solar PV boat. The next part discusses a survey of scientific effort connected to solar PV boat components and their function. The PV-diesel hybrid system is made up of several components, including a PV module, a DC-DC converter, an MPPT, a battery and its charging and discharging controllers, a diesel generator, an inverter, and a coupler. Another form of solar-powered boat is one that is entirely reliant on solar PV output energy as the only source to meet the ship's load need. This structure was created for small-scale vessels, such as entertainment ships and tiny fishing boats. Such watercraft only require power to drive their

electric engine for momentum and a small amount of load, such as lighting. PV alone is sufficient to satisfy all purposes on a modest scale in these types of boats.

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

Solar array, dc-dc converter, dc-ac converter, MPPT, management control, charge/discharge control, diesel generator set, main switch board, and electric motor propulsion are the components.

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 such that they catch the maximum amount of sunshine. Creating such an arrangement is a difficult endeavor. A PV array, often known as a solar array, is a grouping of various solar modules [20]. The greater the amount of sunlight absorbed by the photovoltaic (PV) system, the greater the energy output produced by the PV array (22).

The implementation of solar PV in a boat creates a stability issue because the load of the Photovoltaic module, battery, and other gear increases the load on the vessel. Solar PV provides the biggest technological advantages, including zero energy production costs, versatile installation, energy production corresponds with peak demand, and economic savings. Sun-directed energy falls at a rate of 120 petawatts per second on the earth's surface. This means that the energy obtained from sunlight in a single day may meet the whole world's energy requirement for more than 20 years . Spagnolo et al. proposed a solar-electric tourist boat. They employed solar PV arrays, a 45Ah battery, a catamaran boat 14m long and 5.50m wide, an MPPT controller, a DC-DC boost converter, an inverter, a charge controller, and a power management controller to accomplish this.

DC-DC Converter

A power conditioner is a required component that improves system efficiency. The power conditioner regulates the output of the photovoltaic system and, if linked to an MPPT, boosts its output. DC-DC converters are the power conditioners used in PV systems. There are three kinds of dc converters that are commonly used with PV systems. There are three types of converters: buck, boost, and buck-boost. Boost converters are commonly utilized due to their high output. The yield voltage of 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. Kumar et al. [24] used a Cuk converter instead of the buck, boost, and buck-boost on the Photovoltaic grid-connected system in their study. The main advantage of the Cuk converter is that its output voltage does not reverse. When compared to the buck-boost converter, the results show that Cuk has higher efficiency and lower ripple voltage than

the buck-boost. A photovoltaic generator (PVG) can give good efficacy if it converts maximum available solar power equally throughout, even in adverse weather conditions [16].Buck converters can be used to harvest all of the energy from a PV source in order to meet load demand.

PV MPPT

Maximum power point tracking (MPPT) assists in increasing the output of the PV array in any weather condition. PV arrays' maximum 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 & Observe, incremental conductance, and fractional open circuit, whereas the AI based techniques are fuzzy logic [10] and neural networks. Different algorithms for MPPT are employed to control the duty cycle of a DC-DC converter [25]. MPPT techniques are important in increasing the output of power from solar cells [23]. Chakraborty et al. [26] presented a unique MPPT-based solar-powered system for fishing trawlers in order to reduce fuel usage. However, the article provides no statistics on costing details or investment payback duration. Chao et al. [27] proposed a solar-powered boat design that makes use of the most recent patented distributed PV power system, which includes 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. [28] introduced a novel bio-inspired technique for solar systems under various climatic situations that employs Salp Swarm Optimisation (SSO) for effective MPPT. It makes use of the salps feature to trail the highest available power, especially under partial shade (PS), which limits output power[28].The MPPT studies discussed above focused on increasing output through the use of various strategies.

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. Prior to 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 controlling a DC machine. Nowadays, AC motors are preferred over DC motors because they are less in weight, less expensive, and smaller in size[11]. Many studies have concentrated on improving the efficiency of solar vessel electric propulsion. Simonetti et al. [32] proposed a fuzzy logic-based controller solution for a solar-powered vessel powered by an indirect vector-controlled induction motor. Soeiro et al. [33] suggested a fuzzy logic-based indirect vector controller to improve the efficiency of a PV boat. The preceding studies lack sufficient information on solar energy utilization, induction motor performance, and impact.

Battery Management system in 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. TIt will be a very difficult situation if electric propulsion fails in the middle of a journey due to solar PVs not receiving enough sunlight to create power. In such instances, the battery serves as a backup. To improve battery efficiency and lifespan, a good battery management system is essential. Lithium-Ion batteries are the most popular batteries nowadays due to their long life, high energy density, and eco-friendliness [29,30]. 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) in order to optimize safety and performance [34].It keeps a charge limit between maximum and minimum to prevent overcharging and abrupt explosions. Duan et al. [31] described a BMS for electric vehicles that is safe, has a high energy density, and is reliable. For monitoring and regulating BMS, the researchers listed many techniques including spectrum analysis, the fibre Bragg grating sensor, gas sensor, and microscopy.

Challenges and Barriers in 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:

High Initial Cost: Installing solar panels and accompanying equipment might be prohibitively expensive for many fishing vessel owners, particularly small-scale fishermen with limited financial means.

Limited Awareness and Knowledge: Many fishermen may be unaware of the possible benefits of solar energy. A dearth of technical knowledge and experience required to build, operate, and maintain solar systems may also exist.

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.

Intermittent Power Generation: Solar energy generation is affected by weather and daylight availability. Power generation may be insufficient on overcast days or at night, making it difficult to rely only on solar energy for all energy needs.

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.

Regulatory and Policy Barriers: Ambiguous or restrictive regulations may impede solar energy use in the fisheries sector. Potential investors may be put off by delays in acquiring permits or certifications.

Government Initiatives and Incentives to Support for Solar Integration

Pradhan Mantri Matsya Sampada Yojana (PMMSY; FY21–FY25)

The PMMSY aims to close gaps in fish productivity, quality, technology post-harvest infrastructure and management, 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 (39), 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 reduce emissions and increase savings for fishermen.

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 with the goal of producing 20 million tonnes of fish by 2022-2023. Solar-assisted e-boats can play an important role in meeting this goal (38).

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 in the form of a prompt repayment incentive (39). The government can expand the credit plan to support greener technology by raising the credit ceiling for buying of e-boats.

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, solar energy is typically used as the primary power source in small-scale vessels and as an auxiliary power source in largescale vessels. A storage system or battery, on the other hand, is required for high power requirements and long working times. Medium and small-scale vessels that use solar PV for propulsion require 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 be used to power larger ships in the future. Solar energy can also be blended with other green energies such as wind or wave. (5)

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 important factor contributing to global warming. Using solar energy in the fishing vessel can launch a blue revolution, encouraging more ecologically friendly and sustainable fishing practises.

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