SOLAR ENERGY FOR SUSTAINABLE FISHERIES AND COLD-STORAGE FACILITIES IN THE KONKAN REGION

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ABSTRACT

Solar energy integration in the Konkan region (Maharashtra) provides a reliable, cost-effective solution to stabilize marine fisheries and reduce high post-harvest losses. [1, 2]

Key Benefits of Solar-Powered Cold Storage in Konkan

- Cost Reduction: Offsets heavy electricity bills and cuts reliance on expensive diesel generators during power outages. [1]
- Uninterrupted Cooling: Prevents voltage fluctuations and sudden compressor stops that damage temperature-sensitive seafood. [1]
- Blue Economy Alignment: Reduces carbon footprints while boosting the economic returns of local fishing communities. [1]

KEYWORDS-solar energy, sustainable fisheries, cold-storage, Konkan

INTRODUCTION

Core Technologies Used

- Photovoltaic (PV) Panels: Direct solar generation coupled with daytime ice production or thermal/water battery storage to maintain low temperatures (2°C to 5°C) even overnight. [1, 2, 3]
- Decentralized Cold Rooms: Compact, modular units deployed near landing centers and ports to allow immediate storage before transport. [1, 2]
- Hybrid Systems: Dual-source setups combining grid/generator backup with solar arrays to ensure 24/7 reliability during the monsoon season when sunlight dips. [1, 2]

Strategies for Sector Strengthening[1,2,3]

- Improved Cold-Chain Connectivity: Linking fish-landing sites directly to processing and domestic/export markets via solar-cooled transport. [1]

- Value Addition: Transitioning from raw bulk selling to ready-to-cook and ready-to-eat seafood packaging enabled by steady power. [1]
- Decentralized Ownership Models: Utilizing framework incentives (such as state and national renewable energy programs) to help fisher cooperatives own and operate micro-cold storage. [1]

The development of Pusa-Farm SunFridge represents a significant leap in agricultural technology, offering a battery-less, grid-independent cold storage solution. Developed by Sangeeta Chopra and her team, this facility leverages solar energy to maintain low temperatures, crucial for preserving perishable goods. The innovation is particularly relevant for India, where a substantial portion of agricultural produce is lost due to inadequate storage facilities. By reducing the cost of cold storage to one-tenth of traditional systems, this technology promises to empower farmers economically and enhance food security.

Global partners, local impact [4,5,6]

The journey of the Pusa-Farm SunFridge began in 2016, with a collaborative effort between the Indian Agricultural Research Institute and Michigan State University. Funded by the National Academies of Sciences, Engineering, and Medicine, and USAID, the project aimed to create a cold storage solution that operates without reliance on grid electricity. The facility uses a unique combination of solar panels, evaporative cooling, and a water battery system to maintain temperatures as low as 2 to 3 degrees Celsius, even during the night. This innovation not only reduces operational costs but also minimizes environmental impact, aligning with India’s sustainability goals.

The impact of the Pusa-Farm SunFridge is already evident in regions like Rajasthan and Haryana, where farmers have successfully utilized the facility to store and sell their produce at optimal market prices. For instance, Tanwar Singh from Picholiya village was able to store flowers until the peak of the Diwali festival, significantly increasing his profits. Similarly, Tilok Devasi stored eggs and tomatoes during the COVID-19 lockdown, avoiding substantial losses. By providing farmers with the ability to control the timing of their sales, this technology enhances their market power and economic resilience.

Pushing the needle on policy goals

The Pusa-Farm SunFridge aligns with India’s national priorities, such as the Atmanirbhar Bharat initiative, by promoting self-reliance in agricultural infrastructure. The technology’s potential to reduce post-harvest losses and improve food supply chains is critical for achieving the vision of a Viksit Bharat (Developed India). Moreover, the scalability of this innovation offers a strategic advantage, with the potential to benefit millions of small farmers across the country.[7,8,9]

Looking ahead, the Pusa-Farm SunFridge is poised to be a gamechanger for India's agricultural sector. By addressing the critical issue of post-harvest losses, this technology not only supports farmers but also contributes to national food security and economic growth. The ongoing efforts to develop a remote-controlled system for the facility further enhance its accessibility and usability. As India continues to strive for sustainable development, innovations like the Pusa-Farm SunFridge will play a pivotal role in transforming the agricultural landscape and ensuring a prosperous future for the nation.

DISCUSSION

Solar energy transforms fisheries and aquaculture by cutting operational costs, lowering carbon emissions, and providing reliable off-grid power. [1, 2]

Key Solar Applications in Fisheries

- Water Pumping & Aeration: Solar-powered pumps and aerators supply oxygen and circulate water continuously in fish ponds and shrimp farms, replacing expensive grid electricity or diesel generators. [1, 2, 3]
- Aquavoltaics (Floating Solar + Aquaculture): Installing photovoltaic (PV) panels above or floating on fish ponds (aquavoltaics) generates clean energy while reducing water evaporation and helping regulate surface water temperatures. [1, 2, 3]
- Cold Chains & Preservation: Solar-powered freezers, portable chillers, and ice-making machines help coastal and riverine communities store catches, prevent post-harvest food loss, and improve market value. [1, 2, 3]
- Low-Cost Hatcheries: Innovations like solar-powered portable hatcheries (such as low-cost models developed in regional hubs) run on minimal wattage (e.g., 50W pumps) to drastically cut electricity bills and improve seed fertilization rates. [1]

Economic & Environmental Benefits[10,11,12]

- Cost Reduction: Energy expenses can make up a large portion of aquaculture operational budgets; shifting to solar removes recurring diesel and high grid-power costs. [1, 2, 3]
- Carbon Footprint: Replaces fossil fuel combustion in boats, cold storage, and land-based farms with clean, renewable energy. [1, 2]
- Balanced Ecosystems: Proper planning is required so solar panels do not block excessive sunlight needed by aquatic plants or alter water thermal dynamics improperly. [1]

Solar-powered cold storage systems in the Konkan region—covering agricultural produce (such as Alphonso mangoes, cashews, and vegetables) and marine/fisheries catch—address high humidity, warm coastal temperatures, and frequent rural grid fluctuations. [1, 2, 3]

Key Operational & Technological Models

- Hybrid and Standalone Systems: Most decentralized farm-gate or village units combine photovoltaic (PV) solar panels with thermal energy storage (TES), phase-change materials, or ice-banks rather than relying solely on heavy electrical battery banks. [1, 2]

- Day-Night Continuity: Thermal storage captures cold energy during peak daytime solar generation (typically maintaining 4°C to 8°C or sub-zero options like -18°C to -25°C for fisheries) to keep compressors and chambers running smoothly through 12–14 hours of night or low-sunlight periods. [1, 2]
- Capacity & Sizing: Farm-level or Farmer Producer Organization (FPO) units typically range from 2 to 20 tonnes, using approximately 3 kW to 10 kW solar arrays, while larger commercial seafood or horticultural hubs integrate higher-capacity solar grid-tied or hybrid setups. [1, 2]

Benefits in the Konkan Context

- Reduction of Spoilage: Combats rapid microbial and enzymatic degradation common in humid coastal conditions, extending the shelf life of delicate crops and marine products. [1, 2, 3]
- Lower Operating Costs: Replaces or offsets expensive diesel generators (DG sets) and rising commercial/industrial electricity tariffs from utilities like MSEDCL. [1, 2, 3]
- Decentralized Post-Harvest Infrastructure: Units can be placed closer to local mandis, landing centers, or farm gates, cutting down initial transit-based spoilage. [1, 2]

Implementation & Support Frameworks[13,14,15]

- Subsidies & Schemes: Programs promoted via national and state agricultural missions (such as central/state cold chain integration and decentralised renewable energy initiatives) provide financial support, capital subsidies, and institutional loans for FPOs and cooperatives. [1, 2]
- Technology Providers: Specialized providers such as Ecozen Solutions (Ecofrost), Ecosaras, and industrial cold-room specialists like EPACK Prefab deploy modular containerized or custom-built cold rooms across Maharashtra.

RESULTS

Indian farmers incur loss of INR 92,651 (1) crore per year in post-harvest losses alone, the primary cause of which are poor storage and transportation facilities. Other issues include limited technical know-how on good agricultural practices, lack of market knowledge and inadequate market access. In the absence of proper storage facilities, farmers of perishable commodities such as fruits and vegetables have been rendered devoid of their livelihoods in both the immediate and the long term.

The DRE-based cold storage units at the farm level can help reduce post-harvest agricultural losses, improve farmer profits and provide climate co-benefits. Powered by renewable energy like solar PV or biomass, these solutions can reduce reliance on diesel, overcome grid reliability issues, and be made available in geographies where grid infrastructure is still non-existent. But the high upfront capital expenditure associated with DRE-based cold storage facilities has constrained adoption, hence restricting the market scale of these solutions. There is a recognized need to pilot different types of business models which can improve the affordability of these solutions for different categories of end users, primarily individual farmers, Farmer Producer Organisations (FPOs), and other grass-roots community-led organizations.[16,17]

Within the agriculture vertical at SELCO Foundation, decentralized agri cooling has emerged as one of the primary priorities for the organization in terms of building replicable and scalable models across different geographies. SELCO Foundation with its technology partners has deployed solar power cold storage at 62 locations. These are designed to store fresh fruits, vegetables, flowers, processed food, and other perishable commodities. A small-scale solar- powered cold room enables both pre-cooling and storage of perishable - thereby helping preserve their freshness and maximizing their shelf life. The system is a solar standalone operation and consists of a solar + DG/Grid hybrid operation. The smart control system helps maintain the temperature, humidity, and air quality parameters precisely as per the product requirement. It consists of a battery-less compressor operation (small battery for auxiliary loads and control system) and a thermal backup due to the PCM plates (24-30 hours). It is a completely portable unit and has very minimal maintenance. So far SF has deployed approximately 69 solar-powered cold storage across 11 states of India. The first cold storage was deployed in the year 2018. Most of the cold storage was adopted by FPOs or cooperatives. The size of the cold storage varies from 2 MT to 30 MT.
To understand how solar-powered cold storage can help solve this problem and lower the cost factor for the end-user, we must first understand how it works. The whole work scenario of solar cold storage is divided into two parts: On-Grid solar-powered cold storage & Off-Grid solar-powered cold storage.[18,19,20]

The on-grid systems work in conjunction with the grid and do not require any energy storage solutions. Most of the large-size cold storage facilities are on-grid systems. Off-grid storage systems are independent of the grid, and use battery backup to store energy. A large number of small and medium size cold storage facilities employ off-grid solar systems.

Types of Solar-Powered Cold Storage
Based on the size and capacity of the solar-powered cold storage, we can divide them into 3 categories:

- Solar-powered small cold storage: used for personal or individual purposes
- Solar-powered medium cold storage: used for small groups or at the community level.
- Solar-powered large cold storage: used for large-scale businesses

CONCLUSIONS

Due to a combination of factors, including an unstable market and a lack of facilities to preserve agricultural products for a longer period, Indian farmers have always battled to reduce the wastage of their produce. According to estimates from the Food and Agriculture Organization, food loss in South and Southeast Asia is approximately 40%.

This has serious ramifications for India, where more than 80% of farmers are small landholders who are barely able to generate enough annual revenue.

Air-conditioned warehouses where perishable products can be stored are one approach to cutting down on waste. However, there are numerous problems with this as well. Rural areas have an inconsistent power supply with frequent power cuts. It has also been discovered that energy expenses account for up to 30% of the entire cost of cold storage.

As a result, India has only a few cold storage warehouses. Solar-powered cold storage, on the other hand, has just begun to gain popularity in rural areas.
After the logistics, the second most expensive operating component of a cold storage investment is electricity.[19,20]

Bacteria and other microorganisms infest the food, causing it to deteriorate. The activity of these creatures increases as the temperature rises. To maintain the temperature as low as possible. These freezer units require round-the-clock power.

To meet these requirements many business owners use diesel generators, which are not only expensive but also a major source of pollution.

Furthermore, the cost of power is always rising. Also, with the rise in crude oil prices. Diesel is also quite expensive. As a result, store owners have high operating expenses, which in turn affects food prices.[20]

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