Estimation of energy efficiency of CIFT solar hybrid dryers

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ICAR-Central Institute of Fisheries Technology, Kochi has developed energy-efficient, low-cost and eco-friendly solar hybrid dryers for hygienic and uniform drying of fish and fishery products (Fasludeen et al., 2018). A solar hybrid dryer can generate higher air temperatures followed by lower relative humidity, which favors improved drying rates and lower moisture content of the final dried products. Global solar energy generation was estimated to reach a rate of 8.9% annually between 2012 and 2040, creating a way for faster energy generation for various applications (Kumar and Singh, 2020). Thus, solar hybrid drying technology can be an ultimate solution to achieve energy-efficient drying as drying of agricultural products consumes around 3.62% of the world's total energy consumption (Mohana et al., 2020). This article discusses the details of eco-friendly, cost-effective, and hygienic solar driers developed by CIFT.

The solar electrical hybrid dryer of 20 kg capacity comprised of solar flat plate collectors with an area of 10 m^2 for harnessing solar energy to heat the air (Fig.1). The hot air was circulated into the drying chamber for drying the product (Alfiya et al., 2018). In the absence of solar radiation during cloudy/rainy days to heat the air for circulation, alternative electrical backup system will be automatically activated. Drying was carried out under controlled temperature and humidity conditions.

Solar electrical cabinet dryer with 40 kg capacity consisted of thirty-six trays, nine each in four chambers inside the dryer (Fig.2). A through-flow drying pattern was accomplished inside the drying chamber by the perforated trays placed at a distance of 10 cm vertically. Solar flat plate collectors harnessed solar energy and transferred it to the air flowing through the collector which was then transmitted to the drying chamber (Murali et al., 2019). During rainy or cloudy days, when desired temperatures were not attained in the drying chamber, electrical backup will be automatically activated.

Solar LPG hybrid dryer is a solar drying system for the hygienic production of dry fish by using environment-friendly, abundantly, freely available and renewable solar energy. Continuous drying of fish is possible in this system with the help of LPG backup, where the fish can be dried in unfavorable weather conditions without spoilage and maintaining its nutritional value. The hot water from the calorifier tank was collected through the solar collectors using a pump. Axial flow fans were provided in the drying chamber for hot air circulation across stainless steel trays loaded with fish for drying. The circulating air was heated by hot water passing through the heat exchangers (Murali et al., 2020; Murali et al., 2021). LPG backup heating system supplemented the heat requirement for drying during rainy or cloudy days to heat the water for circulation (Fig. 3). The complete process parameters of fish drying could be controlled by a PLC system.

Fig. 1 *Solar-electrical dryer - 20 kg*

Fig. 2 *Solar-electrical cabinet dryer - 40 kg*

Fig. 3 *Solar-LPG-electrical dryer - 50 kg*

Table 1. *Energy consumption charges for CIFT developed solar hybrid dryers*

Sl. No.	Type and capacity of the dryer	Cost of the dryer (in Rs.)	Operational cost of dryer Rs./kg fish)	Drying time (h)*	Manpower requirement for handling	Electricity/ LPG charges for one year (in Rs.)**	LPG charges for 1 year (in Rs.)**
1	Solar-electrical hybrid dryer - 20 kg	1,50,000 + 18% GST	2.9	6-10	1	14,361	Nil
2	Solar-electrical hybrid dryer - 40 kg	2,80,000 + 18% GST	2.15	6-10	2	20,688.3	Nil
3	Solar -LPG-electrical hybrid dryer - 60 kg	4,20,000 + 18% GST	3.65	6-10	2	41,823.7	10,800
4	Solar-LPG - electrical hybrid dryer - 250 kg	13,75,000 + 18% GST	2.11	6-10	4	83,647.4	43,200

** vary depending on the type and thickness of fish*
*** Considering 8 months of operation @ 1 batch per day (1 batch approximately equivalent to 8 hours) and unit cost of electricity as Rs. 8/- Assuming 30% of energy supply through heating coils/LPG and 70% by solar collectors during daytime*

The energy consumption chart of CIFT developed solar hybrid dryers is depicted in Table.1, and a comparison chart among solar hybrid and electrical/LPG dryers is given in Table.2. It is evident from the table that the solar hybrid dryers are energy efficient with a reduction in energy expenses to the tune of 40-60 %.

Table 2. *Comparison of energy consumption of solar hybrid, electrical and LPG dryers*

Type of the dryer and capacity	Total energy consumption (KWh) for 1 year (240 days)	Approximate electricity and LPG charge for 1 year (in INR)	Percentage reduction in energy	Percentage reduction in cost
Solar Electrical Hybrid - 20 kg	1795.20	14, 361	59.95	59.95
Electrical - 20 kg	4483.2	35,865.60		
Solar Electrical Hybrid - 40 kg	2586.04	20,688.38	60.92	60.92
Electrical - 40 kg	6618.64	52,949.12		
Solar LPG Hybrid - 60 kg	5227.96	52,623.70	42.34	51.5
LPG - 60 kg	9067.96	1,08,543.74		
Solar LPG Hybrid – 250 kg	10,455.93	1,26,847.48	42.34	56.12
LPG dryer - 250	18,135.93	2,89,087.44		

It was found that all CIFT developed solar-based hybrid drying systems were energy-efficient and promote conserving electricity or fossil fuels. The solar dryers work on minimal operating expenses and provide better quality hygienic products.

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