# Perspectives of solar food processing in India

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## 1. Abstract

One of the options to tackle food security and undernourishment amidst increased population in third world countries could be through solar drying of food products. It also adds up to the employment generation of large rural youth in these countries in addition to reduction of green house gases emanating from large quantity of fossil fuels, used in agro processing and other processing industries. Planters Energy Network(PEN) , a NGO has introduced roof mounted solar hot air technology, either as preheating or full energy units depending on the temperature requirement, for processing large quantities of food products. This article describes the technology adopted and its applications in the processing of various food products like tea, spices, fish, fruits & vegetables, pulses & grains, salt, etc. Sustainability of these units are proven as 15 years old units are functioning still. Apart from larger solar air heating units in a hybrid mode with fossil fuel, PEN has demonstrated smaller flat plate collector coupled with SPV operated driers successfully for drying fruits in Ladakh and fish in coastal regions of India. Concessions and incentives from Govt.of India make the solar units to have a low pay back period and so it has a greater potentials in the country.

## 2. Introduction

The phenomenal growth in world population, concentrated especially Africa, Asia and South America, in the next 20 years to 3 billion will seriously worsen the existing population-food imbalance. The overall undernourished people in the world has risen from 923 million in 2007 to 963 million in 2008, with a possibility of more people into hunger and poverty in the coming year, is of major concern to all nations (1). Apart from steps to increase food production, concerted efforts for reducing the food losses, that take place during food production, harvest, post-harvest and marketing, are needed. Traditional sun drying followed in the developing countries lead to reduction in the product quality due to insect infestation, enzymatic reaction, and microorganism growth and mycotoxin development. Absence of proper post harvest facilities, fish, cereal, grains, pulses, fruits and vegetables undergo a major losses. The fossil fuel based technology used in the industrialized countries could never be an economical viable solution to these countries. Though much research and development works have been done, there is still a lack of knowledge on the processing of fruits, vegetables and fish in such a way to avoid spoilage and to obtain good quality and clean products. More over a large number of youth in the rural areas of the developing countries are looking for employment to sustain themselves. Adapting a methodology to solve the above two problems could lie in solar drying of food products.

Moreover as there is a popular demand to use environment friendly energy sources, solar hot air technology could play a major role as an alternative fuel for industry and also agro processing applications especially food processing. Planters Energy

Network – PEN, a NGO as an interactive forum formed between the planters and energy scientists in India have done considerable work in the field of solar hot air technology mainly for dehydration of a wide spectrum of products like tea leaves drying, spices drying, leather drying, fruits & vegetables drying, latex rubber drying, pulses& paddy drying, salt drying, ceramic drying, fish drying, etc. This paper presents a brief outline of work done by PEN especially for food processing.

## 3. Background

### 3.1 PROCESS HEAT

Production of process heat/hot air using fossil fuel like electricity, diesel, furnace oil, LPG, coal, firewood and other forms is a common production method in almost all food processing. Moreover all processing industries adopt either drying or process heat as one of its manufacturing step. Solar hot air could be used either as partial energy supply (preheating) or full energy supply depending on the temperature of the process.

### 3.2 TECHNOLOGY FOLLOWED

PEN uses flat plate solar collector having a blackened solar heat absorber that has a 4 mm thick tempered glass as transparent cover and is well insulated on its lower side with mineral wool insulation (2). Air is forced into the space between the cover and the absorber, where it is heated. PEN solar collector is installed on existing buildings. Whereas in early models factory roofs were converted into absorbers(3), in the later ones collectors are constructed on the south – facing roofs of factories, keeping the roof as a base for the collector. Wherever roof is not ideally oriented, collectors are installed on ground. A centrifugal blower with a suitable capacity then draws hot air from the panel into an insulated duct, from which it is distributed to the points of use.

Special features of the PEN collector include: Solar collectors that are designed to allow maintenance staff to walk over them. For higher efficiency and when dust is a problem, use of selective special sheets or v corrugated aluminium as absorbers in a system that heats air from below the absorber, are being used. In addition arrangement of baffles in the collector air flow path increases its efficiency considerably. As a result of this careful design and development process, PEN collector has the following innovative features and characteristics:

- ✓ They can be fitted easily into existing conventional fossil fuel systems;
- ✓ They perform consistently and efficiently;
- ✓ They have a long life of 15 to 20 years with periodical maintenance;
- ✓ They substantially reduce fossil fuel consumption;
- ✓ They are economically viable, paying for their own installation costs within three years through reduced fuel consumption and expenditure; and
- ✓ They ensure cleaner processing, a healthier environment and more hygienic, better-quality end products.

PEN has installed nearly 9000 $m^2$ solar collector for more than 45 projects covering drying of a wide spectrum of products both in agro industry and also in other processing industries.

## 4. Project

### 4.1 PRE HEATING FOR TEA PROCESSING

PEN has installed solar collector for pre-heating the hot air requirement in tea industries, in 9 tea factories having a total collector area of 2,420$m^2$. Tea processing involves the conversion of the harvested tea leaves containing 80% moisture content into the blackened tea of moisture content 2 to 3%(4). The harvested leaves are first dehydrated using ambient or slightly heated air to remove the moisture in a gradual way (withering) spending 7 to 14 hours period using specially designed troughs with axial fans which handle a large volume of air. The withered leaf under goes many process steps and finally fed into a conventional/fluid fed drier in which hot air of temperature 100 to 150 degree C is blown, generated from a heat exchanger in which either solid/liquid fuel is combusted. Solar hot air, drawn from roof mounted collector (Fig.1) is transmitted through insulated duct at the fresh air inlet point of the hot air oven. Solar hot air may also be directed to withering troughs when not used in the drier. These projects, initiated 10 years before, used roof as an absorber (fig. 1). These types of air overflow absorber collectors have an efficiency of around 30%. They were able to save 20 to 30% of fuel consumed for tea processing and have a pay back period of around 3 years. The PEN solar collectors in tea factories have given a savings of 6,055.7 tones of fire wood equivalent fuel and 11,021 tones reduction in carbon emission (2). Even after 15 years those units periodically maintained are working still.

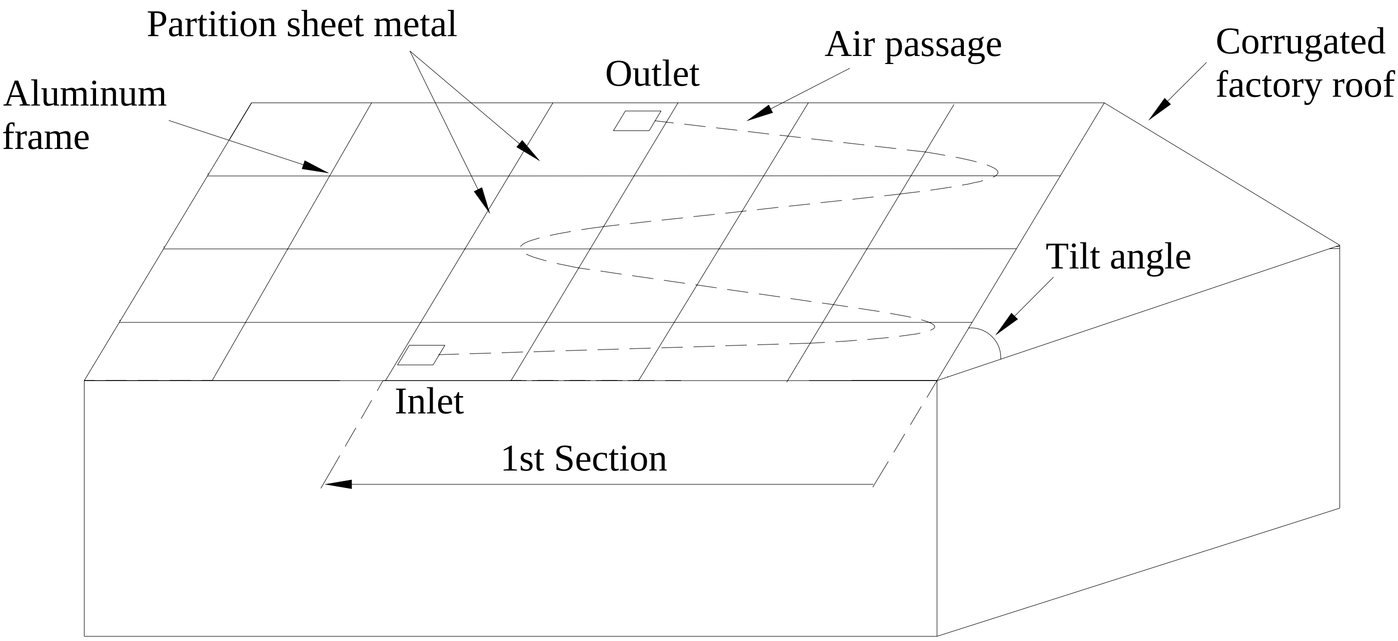


*FIG 1*

Golden Hills 212 m² Installed In 1992

Unit after 15 years with repainting – 2007 December

PARKSIDE TEA ESTATE, COONOOR

### 4.2 SPICES DRYING

Spices powder making factories use fossil fuel for drying the spices to low moisture content so as to obtain good quality grounded powder with good color. PEN has installed solar drying facilities for two leading spices powder manufacturing companies in south India namely M/s.Eastern Condiments (P) Ltd., Theni (collector area 500 + 167m$^2$) and M/s.Sakthi Masala (P) Ltd., Erode (collector area 1040m$^2$). The 500 m$^2$ solar collector at M/s.Eastern Condiments saved 406 t/y fuel wood (5). The technology is so satisfactory to M/s.Eastern Condiments (P) Ltd., it has adopted this technology in 1994 and again in 2002. All these units are retrofitted with conventional heating units so that productions in the factories are uninterrupted. There is good potential to adopt similar solar drying units for drying of other spices like green and black pepper, small and large cardamom, cashew nuts, ginger, turmeric, etc. Presently PEN is working with National Research and Development Corporation to introduce solar drying of organically grown turmeric in drought hit Mizoram state in India's north east.

*CHILLIES DRIER AT EASTERN CONDIMENTS, THENI*

*SAKTHI MASALA (P) LTD, ERODE*

### 04.3 FISH DRYING

India is blessed with an 8041 km long coastline and an exploitable marine fish reserve of 4.57 million tons in country's Exclusive Economic Zone (EEZ) (6). Even though technological leaps have enhanced the fish production, due to the perishable nature of fish, an estimated 21 % of the harvest is lost due to lack of post harvest processing (6). This results in fishermen losing considerable portion of their profit apart from the loss of considerable nutritional food to the common man. Fish is a highly perishable food product and can be stored only by refrigeration or drying. But the problem affecting the quality of the dried fish is the unhygienic way in which fish is prepared and dried. The open beach drying, results in insects laying egg inside the fish, that renders the product non-consumable. In the first project at Visazakpattinam, Andhra Pradesh, India PEN successfully demonstrated a 500 kg batch capacity hygienic processing of fish so as to obtain better market price for the fish. A similar but smaller unit of capacity 150 kg of fish per batch is successfully working near Poompukar, Chidambaram in Tamilnadu, India. These units has a roof mounted solar collector, a recirculation drier and a back up heating unit like bio mass hot air generator. Electrically operated solar hot air blower and circulating fans are used in the unit and it also needs a building (Fig2).

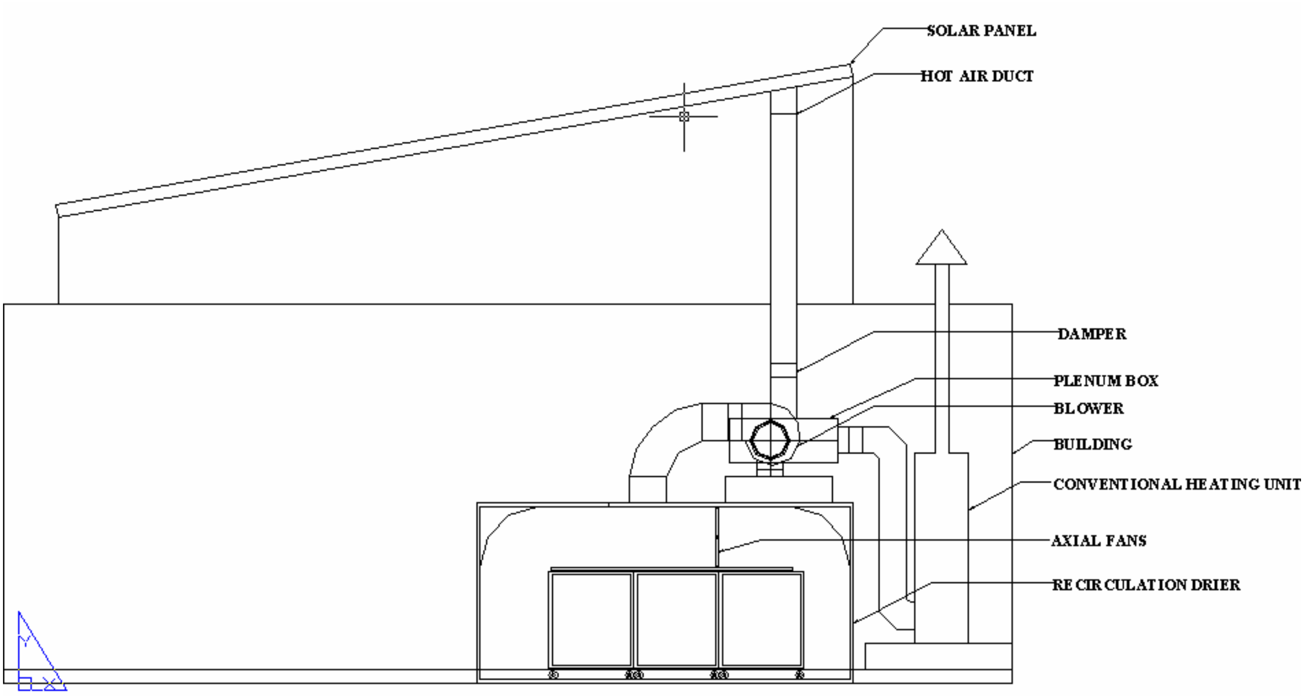


*Fig.2*

SOLDRY- FISH PROCESSING FACILITY PLANT, AT DFYWA, VISAKHAPATNAM

FISH DRIER AT M/S DFYWA, VISAG

SOLAR FISH PROCESSIN PLANT AT POOMBUHAR, TAMILNADU

FISH DRIER AT POOMBUHAR, TAMILNADU

To cater to individual fisher women and small groups PEN launched an 11.5 to 5.9$m^2$ area solar air heating panels which will run by six to four numbers of DC fans, operated by SPV panels – 40 to 20 W and it could process around 70 to 50 kg of product per batch. Nearly 50 units are installed in the coastal belt of Tamilnadu, Orissa and Andrapradesh. Each unit produces around 6000 kg of quality fish per annum creating around 600 job days.

HERBAL DRYING USING SOLAR AT CHENGALPATTU

Among many options, solar drying of salted or non-salted fish offers a tremendous potential in creating multiple job for women in coastal region. UNDP of Orissa ( a state in India) has installed three commercial projects to demonstrate hygienic solar fish drying for fisher men and fisher women in the coastal belt of Orissa. Three solar drier each with 11.5 $m^2$ solar heating collector area and of 70kg capacity were installed at three sites of Orissa state in India. These units are furnished with improvements basing up on earlier feedbacks. To avoid rusting of the unit all nuts and bolts are stainless steel and more over aluminium is used in the interior and exterior of the drier. The working of the three units were reported excellent with a quality product (7).


DRYING OF FISH USING SOLAR FISH DRIER

### 4.4 FRUITS AND VEGETABLES DEHYDRATION

PEN air heaters coupled with PEN's re-circulation drier could be used to dry many fruits and two such units were installed for drying organically grown fruits like mango, pineapple, banana, etc for export near Batlagundu in Tamilnadu. Many of the hilly regions of India suffer from lack of infrastructure facilities for processing its agro products like fruits, vegetables, etc., This leads to a huge wastage in vegetable fruits chain as well as other fruit products and it ultimately affect the farmers income. Horticulture crop is one of the important agricultural activities in most of the hilly regions of India. For example the economy of Ladakh is very much dependent on horticulture and agriculture. Ladakh (presently called as Leh District) is located between $75^0$50'E to $80^0$15'E and $32^0$17'N to $36^0$30'N and elevation between 3000 to 5000 m. The region has low precipitation. Annually around 2600 ton of fresh apricot, 3500 ton of apples and other fruits and 8500 tons of vegetable are grown( 8). Similar to other parts of the country, fruits and vegetables suffer a huge wastage due to the lack of proper processing facility. Dehydration or drying is very critical factor for these products mainly for avoiding spoilage as well as in bringing remuneration prices for the farmers. The absence of biomass fuel and availability of abundant sun's energy (ie) around 5400 Wh/$m^2$day on horizontal plain makes it attractive to adopt solar energy for drying in these regions (9). PEN has installed 8 large solar drying units in Ladakh and Kargil region. The roof of the processing house has 55 to 90 $m^2$ solar collector and the hot air is passed to the re-circulation drier placed inside the room. Many numbers of small drier of 70 kg capacity with SPV panel have been also installed in Ladakh. The solar dried apricot fruits fetches 100 % higher price in the market than the conventional open dried.

The harvesting season for many fruits are of short duration resulting in non-viability (economically) of solar dehydration/drying projects of the fruits. Fruit bar or fruit jelly is one of the by-product which has a shelf life of more than 9 months. The mango fruit concentrate/pulp, if properly prepared and sealed in cans, could be stored at ambient temperature with a life span of more than 12 to 16 months. Recently PEN has installed a solar drying facility at Eluru near Vijayawada, Andhra Pradesh. A $55m^2$ area solar collector generated sufficient hot air to dehydrate in 8 hours around 120 kg of mango concentrate. This unit has a back up heating with bio- mass fuel. This project will handle a minimum of 30 tones of fruit concentrate per annum and create employment of 1500 man-days per year. These kinds of unit could be replicated throughout the country mainly on the mango and other fruits growing areas.

M/S. ESWARI SRINIVASA FOOD PRODUCTS, ELURU, AP

**4.5 ECONOMIC ANALYSIS AND GOVT. CONSESSIONS**

For solar air heating system where conventional fuel like electrical coil, LDO, diesel or gas are used, analysis through a pay-back flow chart taking into account the investment cost, interest for investment, parasitic cost (electrical for blower& maintenance), tax concessions, Government subsidy and savings in fuel show a pay-back period for a profit making company between 2 to 3 years. As the main components are aluminum frame and toughened glass, the expected life span of the system is more than 15 years. The parasitic and maintenance costs are around 3 – 5 % of accrued annual savings. Government of India through its Ministry of New and Renewable Energy (MNRE ) to popularize solar air heating technology offers the following two concessions:

1. An 80% accelerated depreciation leading to a savings of 26 % of project cost through tax saving.
2. 35% on solar installation cost is also available as capital subsidy.

Hence a company investing in solar air heating system will spend only around 40% of the project cost and balance through subsidy and tax savings. Government of India Ministry also offers assistance to state nodal agencies and other organizations in the promotion of the solar air heating technology through many ways including seminar, training program, etc. PEN is operating a project of technology dissemination to industries in 6 states of India funded by MNRE.

## 5. Conclusion

Thus PEN has demonstrated the concept of cost effective (pay-back period is less than 3 years) solar hot air system for food processing as a retrofit in the existing environment to safeguard optimum efficiency. Solar air heating could also be considered as energy saving measure since it reduces fossil fuel consumption. Moreover PEN has shown the working of many large level solar hot air generations using the existing roof of agro/industrial houses and to make the system reliable with longer life. The technology developed by PEN is able to provide a low cost non-fossil fuel operated methodology for processing large quantity of fruits, vegetables, spices, grains, other cash crops and other industrial and chemical products.

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