7 Cleaner, safer food: India

GENERAL INFORMATION

- **Implementing institution**
  Planters Energy Network (PEN)

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- **Implementation period**
  1989 to December 2002 (nearly 27 private industrial projects with government incentives, three international conferences, seminars and business meetings).

- **Costs**
  US$420,000

Summary

India is an agrarian country that has achieved good levels of agricultural production. The challenge it now faces is to find ways of improving post-harvest processing to boost the quality and shelf life of its agricultural products.

Traditionally, sun-drying in the open air was the main way of processing crops after harvest, and this is still practised by small-scale producers. More recently, however, conventional fossil fuels have replaced the sun as a source of energy for the drying of crops and produce, particularly among industrial-scale producers.

Both methods have drawbacks: either they are not particularly hygienic or healthy or they consume energy inefficiently and uneconomically, causing environmental pollution, which, among its other negative effects, reduces the quality of the final products.

Solar thermal energy has the potential to replace fossil fuels in both industry and agriculture and represents a cleaner alternative that is more economical, more environmentally friendly and sustainable and that produces higher-quality end-products.

With this goal in view, a group of Indian planters and energy scientists came together to create an interactive forum called the Planters Energy Network (PEN). One of the first objectives of PEN was to improve solar air heating technology for industrial and agricultural uses. It did this by developing the solar hot air roof (SHARO), which is based on a simple device that is economical to install because it uses existing rooftops as solar collectors.

SHAROs use two main types of system: the partial energy delivery (PED) system for tea processing and the full energy delivery (FED) system for processing spices and fish and preserving vegetables. In all of these industries, the use of SHAROs has reduced energy consumption and expenditure to such an extent that the initial costs of installing the system can be recuperated within two to three years. Nine tea factories are saving a total of US$17,500 a year in fuel costs, while the potential exists to cut fuel consumption for the processing of spices, fruit and coffee by between 70 and 90 per cent. Vegetable-drying units and tanneries are also consuming far less non-renewable energy.

Overall, the use of SHAROs is cutting the fuel bills of these industries by almost US$44,000 per year and reducing environment-damaging emissions of carbon dioxide by almost 21,990 tonnes, thereby helping to arrest the deforestation that threatens the entire world, particularly developing countries.

Background and justification

Nearly 70 per cent of the population of India is engaged in agriculture and related activities. Many of these activities involve the drying of such crops as tea,

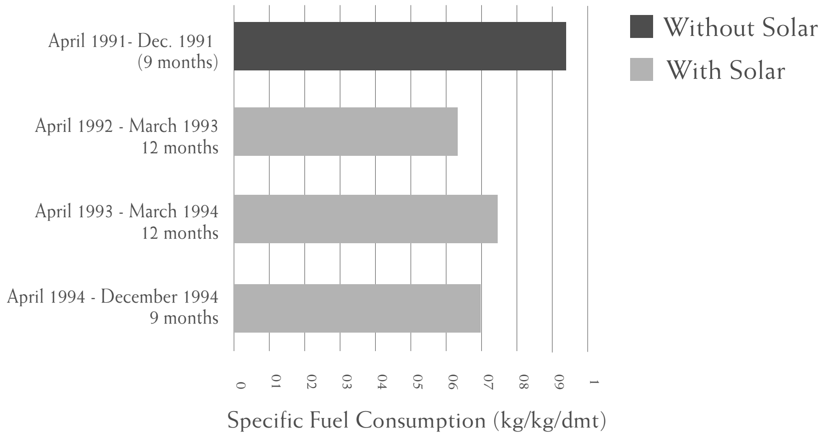

Figure 1 | Fuel consumption comparison with and without solar heating at a tea factory

coffee, cardamom, spices and pulses, which usually involves systems that are powered by burning wood or fossil fuel. At present, the processing of pulses consumes an estimated 5 million litres of diesel fuel a year, while tea and cardamom processing need 400,000 tonnes and 50,000 tonnes of fuel wood, respectively. This puts great pressure not only on the country's forests but also on its capacity to earn foreign exchange.

In addition, nearly 25 per cent of the fruit and vegetable production of India (the second largest in the world) is left to perish because it costs too much to process. Moreover, as long as fish continues to be dried and salted through traditional unhygienic open-air sun-drying techniques, the country will not be able to exploit to the full its potential 5.24 million tonnes of this low-cost protein source, which is available from its 7,500 kilometres of coastline.

India has an excellent supply of solar energy. It lies between latitudes 8° and 36° north and between longitudes 6° and 95° east and has 250 to 300 days of sunshine a year, providing 5.4 to 5.8 kilowatts per square metre of power every day. Solar heating of both air and water therefore represents an excellent alternative to the use of fossil fuels and wood.

The main aims of the PEN project were to conserve energy, improve product quality and promote cleaner, healthier production by developing:

- large-scale solar hot-air generation systems that are reliable and durable, using the roofs of homes and factories as a source;
- a cost-effective solar hot-air system for agricultural and industrial processing that is environmentally friendly and efficient and that can be fitted into existing fossil fuel-driven systems;

- a low-cost methodology that does not use fossil fuel and that can be used in developing countries with suitable solar resources to process large quantities of fruits, vegetables, spices and other cash crops;
- a hygienic processing method that uses solar heating to dry and salt fish to provide a low-cost, nutritious food for poor populations; and
- a sustainable, efficient and durable substitute for fossil fuel that can be used in industrial processing through preheating or full energy delivery.

Description

A SHARO is a blackened solar heat absorber that has a transparent cover and is well insulated on its lower side. Air is forced into the space between the cover and the absorber, where it is heated. SHARO systems are installed on existing buildings. Whereas early models converted factory roofs into absorbers, later ones constructed collectors on the south-facing roofs of factories.

In these systems, the absorber is created by insulating the surface of the roof with 65-millimetre rock wool and covering this with a sheet of corrugated aluminium that has been painted matt black. Aluminium frames are used to support a four millimetre-thick tempered glass cover, whose edges are made air tight by two layers of aluminium sheet. Each 212-square metre collector is divided into four units of 53 square metres each. A centrifugal blower with a 3.75-kilowatt capacity then draws hot air from the panel into an insulated duct, from which it is distributed to the point of use.

The first step in the project was to collect as much data as possible on the airflow requirements of SHARO systems and the dynamics of conventional heating systems. Special features of the SHARO include: solar collectors that are designed to allow maintenance staff to walk over them and, where dust is a problem, use of copper-coated sheets as absorbers in a system that heats air from below the absorber. In addition, a new arrangement of baffles in the collector overflow partitions is increasing the efficiency of the system by up to 50 per cent. Improvements have also been made by developing a special paint to replace the original matt black paint.

As a result of this careful design and development process, SHARO systems have 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;
- 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.

Patenting and commercialization

A patent for a roof-integrated solar heater for tea processing was granted in 1998. Patent applications have also been submitted for a modified solar air heater and a chilli drier.

Although an unusually depressed tea market in south India has meant that fewer tea producers are adopting innovative technologies, most tea factories in this area are already using SHARO technology, and efforts are under way to spread its uptake into northeastern areas as well. A successful system at a spice-drying factory is encouraging other local factories and industries to adopt SHAROs and, to date, two other systems have been installed and others are likely to follow in the near future. Similar examples of the dissemination of this technology have also occurred in facilities for drying pulses and leather, including some in Sri Lanka.

Partnerships

Development of the SHARO has involved many partnerships with public and private organizations, including the Ladakh Autonomous Development Council, the Ministry of Food Processing Industries, the Ministry of Non-Conventional Energy Sources (MNES), Tamilnadu Energy Development Agency and more than 27 private industrial companies.

International partnerships include: the International Centre for Theoretical Physics, Trieste (Italy); the Technical

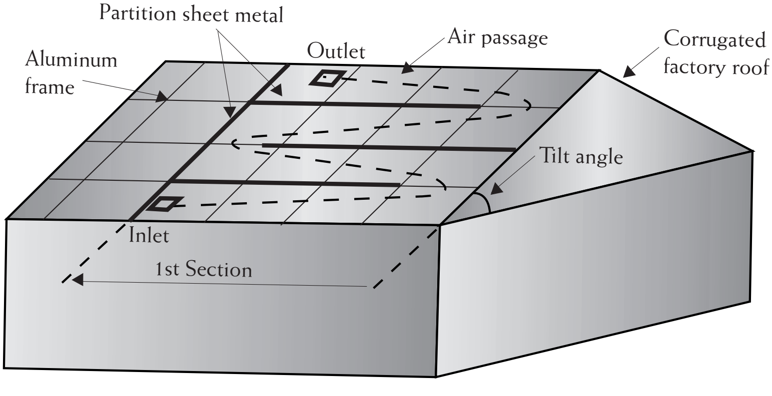

Figure 2 | SHARO roof collector airflow direction

University of Munich (Germany), which sent 11 junior scientists for periods of three to four months to test the performance of SHARO systems; and Walker and Sons (Sri Lanka), which has a five-year agreement to promote SHARO technology in Sri Lanka. Similar partnerships for technology promotion and diffusion have been made with the Asian and Pacific Centre for Transfer Technology and the National Research and Development Centre of India.

REPLICABILITY

Many other developing countries experience the same situation and problems as India, and many have similar agricultural production systems that require post-harvest drying and processing. Most of these countries have acute shortages of fossil fuels and lack the financial resources to import large quantities. At the same time, most of them — including many island countries — have a ready supply of solar energy. So far, however, Thailand is the only other country that has carried out significant research and development into the agricultural and industrial uses of solar energy, which it is beginning to apply to banana drying.

As with many other renewable energy systems, the SHARO requires high initial capital investments for its installation but has low replacement and maintenance costs. Policies that could help to increase the uptake of the technology include financial incentives, visits to demonstration sites and successful projects, tax benefits and the granting of long-term soft loans. Financial support is particularly important because, at present, there are hidden subsidies for fossil fuel-based technologies, which disguise the true environmental and economic costs of fossil-fuel use.

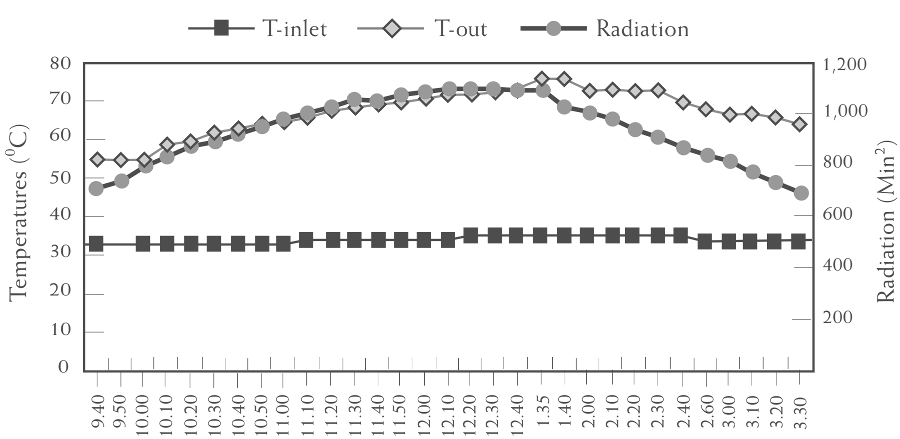

Figure 3 | Daily performance of a 212 m² SHARO for Vegetable dehydration

LESSONS LEARNED

In its early stages, the design and development of SHARO technology had to address several problems:

- The efficiency of the overflow absorber system was a very low 30 per cent. In-house R&D and selection of new materials increased efficiency to 50 per cent.
- As box-type arrangements on existing roofs, the collectors were experiencing a substantial leakage of cold air. Improved sealing materials, such as silicon, are helping to rectify this situation.
- The blowers were consuming large quantities of electricity, resulting in lower net savings from the overall systems. Use of an improved aerodynamic design has cut blower electricity consumption by 30 per cent.
- At midday, temperatures within the systems were exceeding the maximums that some products can support, so many systems were being switched off in the middle of the day. Temperature-regulated actuator controls, which open or close the cold air outlet, are now keeping the temperature of the sun-heated air within the necessary limits.

There was also a certain amount of public reticence with respect to the project, and many people were put off by the high installation costs. Demonstrations of SHARO success and cost-efficiency have helped to change this situation. For example, one town's successful use of SHARO for spice-drying over a six-year period encouraged other agroprocessors, such as pulse driers, to adopt the technology. Ongoing PEN programmes, such as national seminars and international conferences, are continuing to help to convince potential users of the benefits of SHAROs.

PEN has also lobbied vigorously to obtain institutional recognition and financial support. In 1992, after MNES recognized solar water heaters as a successful thermal device, PEN pushed to have solar air heating included in the subsidy scheme of the Ministry (which offers 25 per cent capital subsidies) and demonstration units and, by 1997, nearly 13 SHARO systems had received subsidies. MNES has now identified solar air drying as an area of national focus and plans to support PEN in its current five-year programme. PEN has also encouraged the Indian Renewable Energy Development Agency (IREDA) to include the SHARO in its soft loan programme and is now a business development associate of IREDA. Again, in recognition of the success of PEN, the State government of Tamilnadu now provides capital subsidies of 23 per cent as an incentive to the uptake of SHARO technology.

Impact

Successful operation of SHAROs for the past six years has given agro-industries confidence in the reliability of renewable energy technologies. In many sectors, improved product quality has been noticed: tea has been found to dry better in solar-than in fossil fuel-generated hot air; pulses maintain a better colour; fish that has been dried in SHARO systems is of far better quality than that dried in the open air, which is often contaminated by dust and dirt; spice driers report a higher drying rate, improved powdering and subsequent better profits; and organic fruits that have been dried in solar hot air are now well placed in European export markets.

By replacing fossil fuels, solar power can reduce greenhouse gas emissions and industrial pollution, thereby promoting sustainable development. PEN teams of experienced expert technicians can install SHARO systems for any industry very quickly (for example, a recent installation for the leather industry took five weeks to complete). All the materials used are available locally and the technology has been developed so that it is easy to maintain, is sustainable and continues to operate at optimum performance levels for at least 10 years.

Future plans

To date, the PEN SHARO project has realized only a small part of its potential. Several million square metres of SHARO systems could be installed in India alone through training entrepreneurs, designing marketing strategies and developing infrastructure. Similar results could be achieved in other developing countries. At present, experiments are being conducted in low-cost matrix collectors, which need less pumping power than the existing system and which can achieve higher temperatures from a single glass cover, owing to their higher heat transfer coefficient.

Publications

In addition to the following list of publications, the project has generated some 35 documents and articles, including contributions to local and international journals and national and international conferences.

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Palaniappan, C. and Subramanian, S.V. (1998a). A note on economic aspects of a solar air heater for preheating air in a south Indian tea factory. *Solar Energy Journal*, 64(1).

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