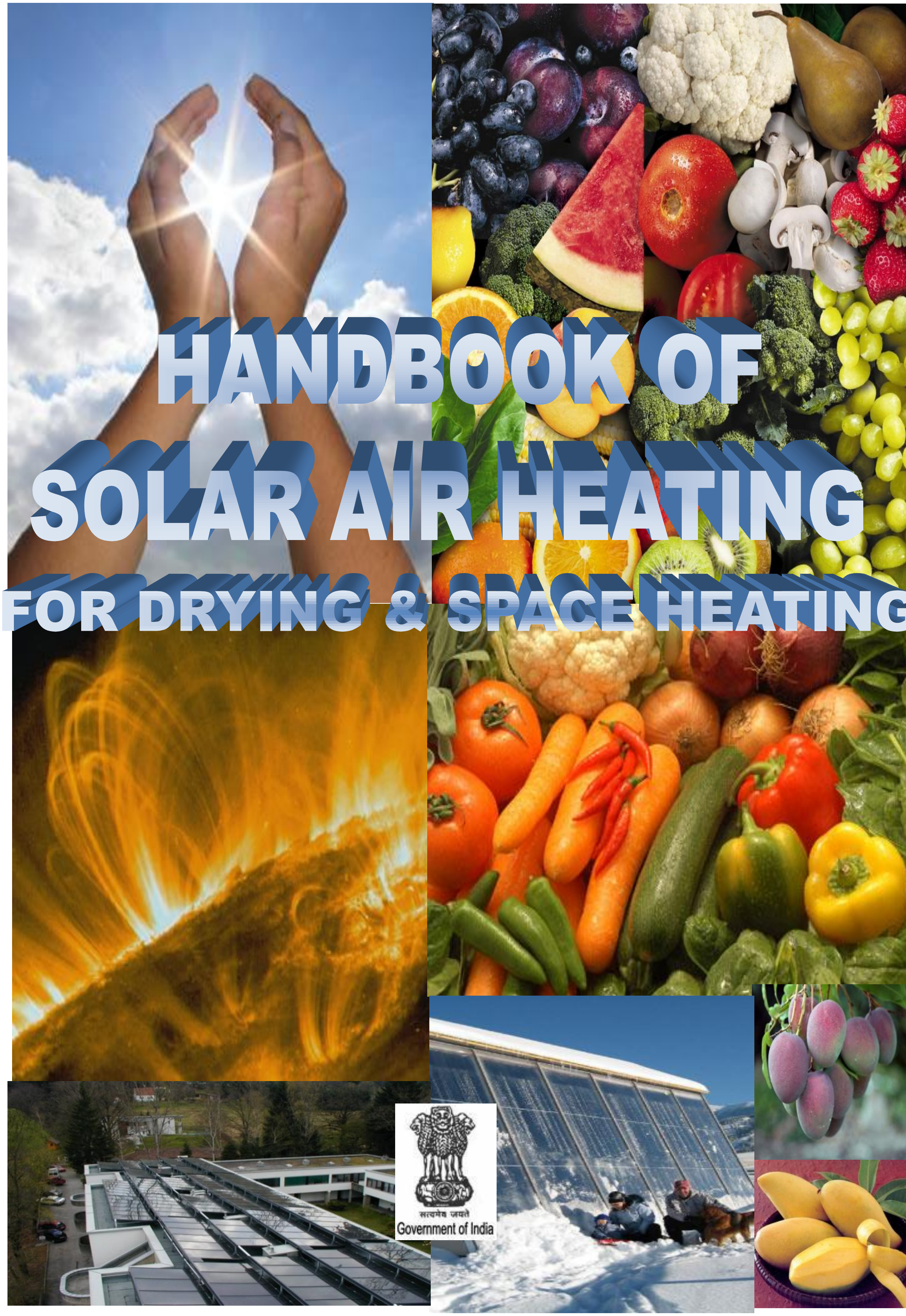
HANDBOOK OF SOLAR AIR HEATING

FOR DRYING & SPACE HEATING



सत्यमेव जयते

Government of India

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Government of India

The Ministry of New & Renewable Energy

Ministry of New and Renewable Energy,
Blok No: 14, C.G.O. Complex, Lodhi Road,
New Delhi- 110 003.

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Preface

Fritjof Capra in his famous book "***The Turning Point***" aptly writes – "From the broad historical perspective of cultural evolution, the fossil-fuel age and the industrial era are but a brief episode, a thin peak around the year 2000 on our graph. Fossil fuels will be exhausted by the year 2300, but the economic and political effects of this decline are already being felt. This decade will be marked by the transition from the fossil fuel age to a solar age, powered by renewable energy from the Sun; a shift that will involve radical changes our economic and political systems." Basing on his predicaments the new millennium has witnessed the emerging of many renewable technologies, as there is a growing demand for environmental friendly energy sources due to fossil fuel crunch and moreover to mitigate global warming. Solar thermal among many renewable has emerged as a viable alternative to fossil fuel reduction/ replacement in the country. Solar hot air technology is one of the emerging sectors in solar thermal division and it could be play a vital role as an alternative fuel for industry and also agro processing applications both in large and small scale. Due to many success stories in India, the technology is matured for adaptation to industries, farmers and agro processing companies. This presentation will help in the promotion of solar drying technology in the country for many new sectors as well as wide applications.

This handbook of Solar Drying is a partial fulfillment of a project given to Planters Energy Network by Ministry of New and Renewable Energy sources. This presentation covers basics of solar drying, its advantages over open drying, success stories and cost economics.

C.Palaniappan
Planters Energy Network
info@pen.net.in;
Web: pen.net.in

NEED FOR SOLAR AIR HEATING

Global warming refers to the increase in average earth and ocean temperatures by the "enhanced greenhouse effect" mostly (more than 50%) due to human made impact in atmospheric greenhouse gases like carbon dioxide, methane, nitrous oxide etc.

From 1905-2005 the global average air temperature has increased approximately 1.33°F. This trend is believed to be caused by the increase in use of greenhouse gasses and will likely continue if steps are not taken to lessen the dependency on fossil fuels and move towards environmentally friendly alternatives like solar energy.

Our world's energy sources are slowly declining as our supply of fossil fuels grows scarce. Oil and gas are running short, and although coal may be available for some more time, it is harmful to the environment. Since fossil fuels are non-renewable, we will have no other source of energy to depend on unless we find another solution. Solar energy is an ideal solution to the current crisis because there is a plentiful supply; it's an all-purpose energy source that's safe for human. By the world-wide research in solar energy, its collection will become more economically feasible for many applications which may reduce our dependence on fossil fuels. But the challenges are solar energy's availability is too variable and too limited to completely replace fossil fuels.

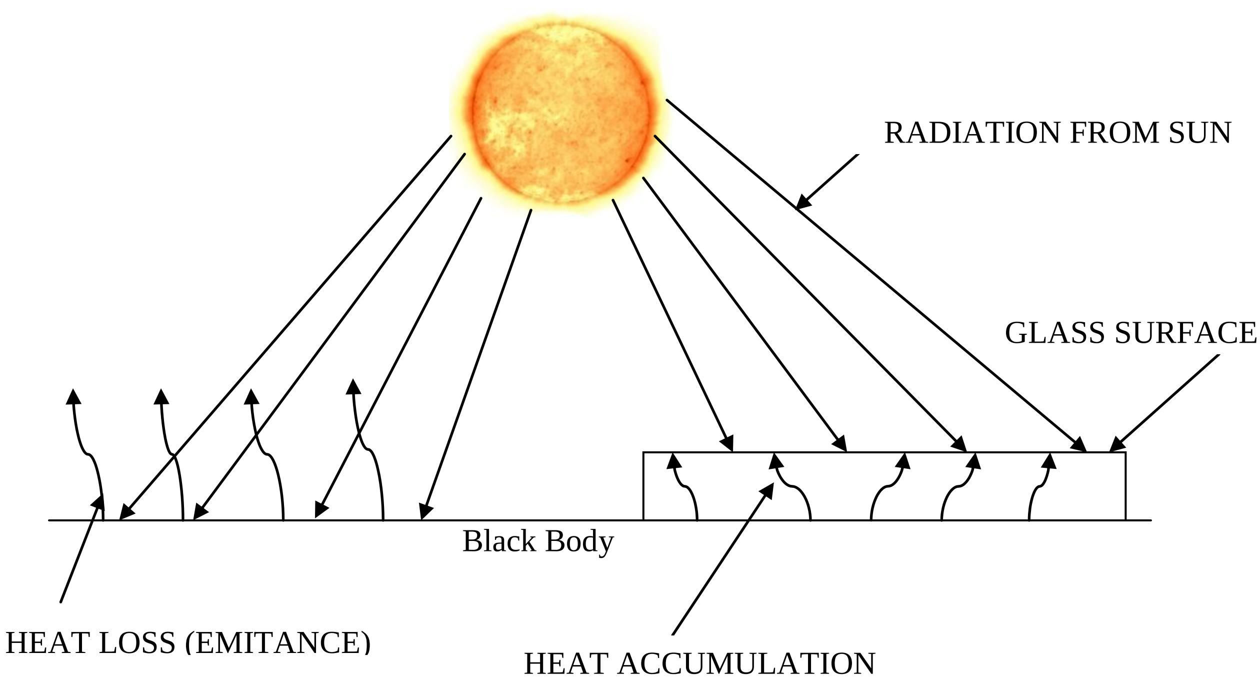
Hence Let us move into the Solar Passage...........

BASICS OF SOLAR AIR HEATING

Black surface absorbs heat

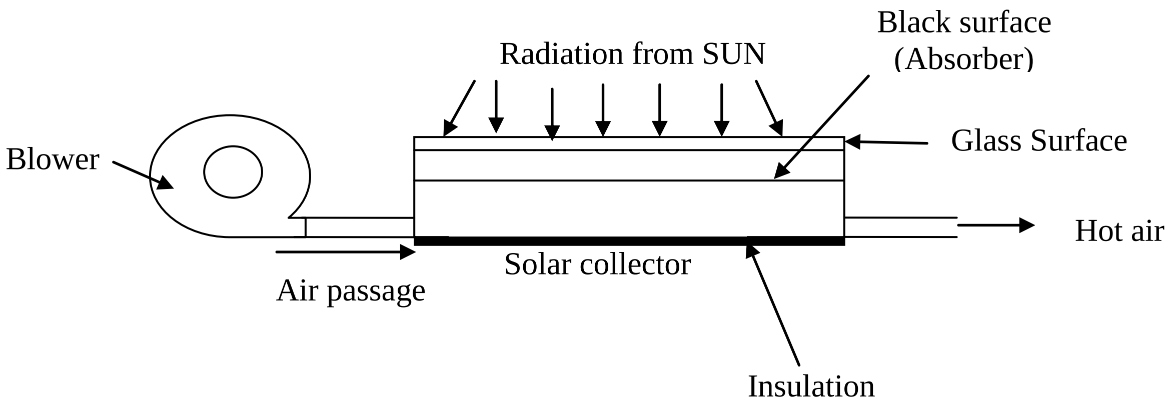
A black surface absorbs heat rapidly rather than a white surface. Even though it absorbs heat, promptly it emits heat to the atmosphere. Hence we would adopt some screen for preventing heat losses. Glass is a material which transmits radiation and traps the heat.

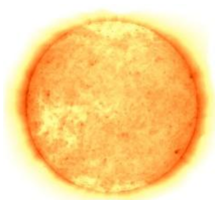
Glass will trap the heat in black absorber.



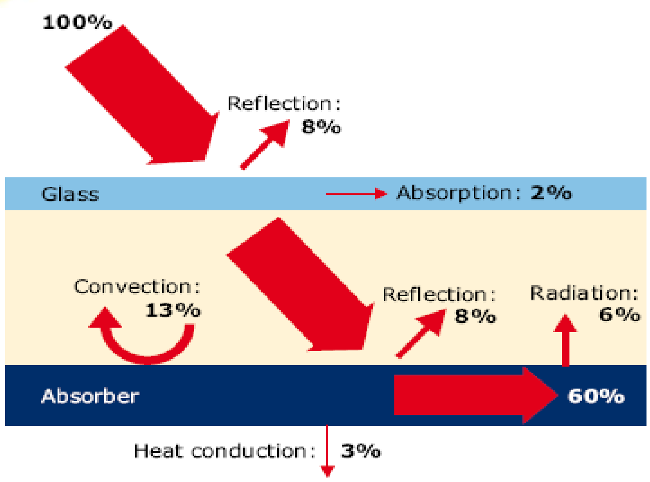
Let us see about how to use the accumulated heat?

To utilize the accumulated heat we need some transferring medium like air. The air is forced through the solar collector. The forced air takes heat and it is delivered to where it is required. The insulation will be added to the lower end as well as the sides of the solar collector to avoid the heat losses.





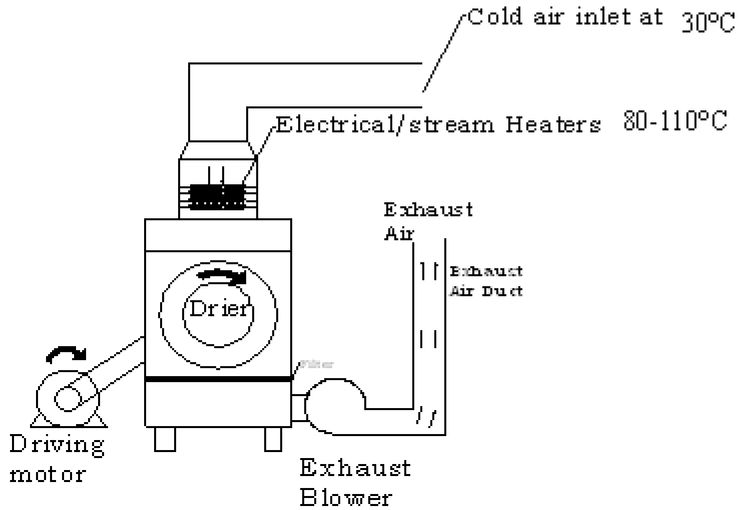
Hence a solar collector is basically to receive the heat from solar radiation through an absorber (black body) and transfers the heat into a fluid by means of a fan/blower.



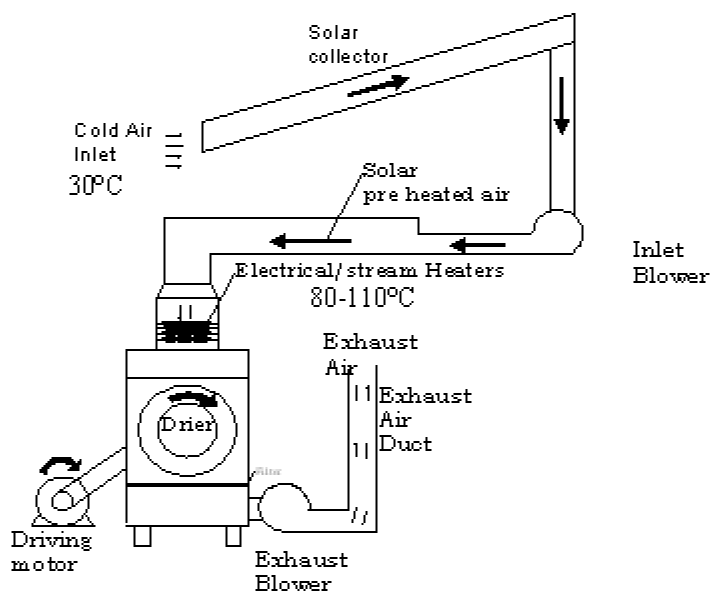
Natural draft model with chimney is found to be not very effective. Thus we can obtain the hot air. Consider the unit receives 100% of sun's radiation. The solar glass reflects 8% back to space and it absorbs 2%. Due to convection 13% and reflection of the absorber 8% loss takes place. By the absorber there is 6% loss in radiation and 3% loss in heat conduction. Finally the unit (called a flat plate collector) converts 60% of incident solar energy into useful energy in the form of hot air. That hot air could be utilized for suitable applications. The following sketch shows one of such application where cold inlet air is heated by the solar collector and the solar heated air is further heated by conventional electrical/steam heater so that the required process air temperature is obtained for drying products (mainly cloth, leather and latex rubber) in a tumble drier.

TUMBLE DRIER

Without solar



With solar preheating



POTENTIAL AREAS OF APPLICATIONS

01. Space heating

02. Large industrial and agro processing

- Pharmaceuticals and chemicals
  - Like gypsum calcining, drying of chemicals like borax, phosphoric acid, potassium chloride and other chemicals and fertilizers.
- Latex rubber and coir mattress
- Food processing industries including Vermicelli, Vegetables, fruits & Papad Companies
- Fish and Marine Drying
- Textiles
- Tea industries
- Leather processing
- Ceramics
- Agro process industries like Spices, Dhal Mill,
- Automobile units (for washed components & painted components drying)
- Laundry drying for Garment manufacturer, Star Hotels and Hospitals
- Mosquito coil manufacturing
- Herbal producing companies – (drying requirements)
- Tobacco industries
- Drying requirement in animal & poultry feeding
- Drying needs in mining
- Salt drying

03. Remote areas solar drier with solar photo voltaic panels to run fans.

01. SOLAR SPACE HEATING

Solar hot water and hot air could be to ideal choices for space heating. In the case of solar hot water, while it has an advantage of storage but freezing 15problem is a major discouragement. In the case of air storage bulkiness of pebble bed could be an issue; anyhow PCM (Phase Change Material) could be an alternate choice for storage.

Fig 1. Solar space heating at Leh, J&K.

For day time heating solar air heating is an ideal solution. It is expected that the room will be maintained at 10 to 15 degree Celsius above the ambient temperature during the winter period. It is also expected an 18m^2 area of solar collector (Fig.1) could be able to save 1500kg of LPG/9000 units of electricity in one winter operation. A large savings in electrical and gas which are being used in space heating could be reduced by adopting this method. Potential areas of application include – parts of J&K including Ladakh, Himachel, Uttranchel and many northern states including Delhi. Without storage solar air heating could be used for space heating in Schools, office buildings and hospitals and with storage could be employed for houses, hotels and other needy places. A large quantity of LPG and diesel which are presently used could be reduced by adopting solar air heating technology.

02. SOLAR AIR HEATING SYSTEM FOR INDUSTRIES AND AGRO PROCESSING

Figure 2

The purpose of solar air heater is to convert atmospheric air into hot air using sun's radiation. This hot air could be used directly if the temperature requirement is within the solar collector range i.e. 60 to 80 deg C. If the process demand higher temperature or consistent output then the hot air to be coupled with existing heating unit to assure the required temperature to the process. For example consider the following example of paint shop drying. The dryer/oven draws cold air and heating the air into 80 to 150 Degree Celsius by burning petroleum products. If pre heated air at 60^0 to 95^0 C (depending upon the solar radiation) is provided to the dryer instead of cold air, the fuel consumption could be reduced. Apart from creating profit, environmental degradation including global warming is reduced by solar path.

In above figure 2, a 297 m^2 area solar air heating system was installed, integrating on the south facing roof of the factory. The hot air obtained is drawn by a low electric power blower. The hot air is transmitted by insulated metal pipes to the fresh air inlet point of the paint shop drier to preheat the air required for oven.

As there is no moving part except blower, which is used to draw the hot air for delivery to the dryer through insulated metal pipes, the system used in industries having continuous production throughout year, will have life time of more than 15 years during which it will save around 261 kl of super kerosene of present market worth Rs.81 lakhs apart from reduction in carbon emission. In a nutshell solar air heaters will payback its investment in 2 years and also result in approximately a minimum of 8 times monetary gain on the investment cost by way of fossil fuel savings.

Benefits of solar drying in food products:

- "Dried foods are tasty, nutritious, lightweight, easy-to-prepare, and easy-to-store and use. The energy input is less than what is needed to freeze or caning, and the storage space is minimal compared with that needed for canning jars and freezer containers.
- "The nutritional value of food is only minimally affected by drying. Vitamin A is retained during drying; however, because vitamin A is light sensitive, food containing it should be stored in dark places. Yellow and dark green vegetables, such as peppers, carrots, winter squash, and sweet potatoes, have high vitamin A content. Vitamin C is destroyed by exposure to heat, although pre-treating foods with lemon, orange, or pineapple juice increases vitamin C content.
- "Dried foods are high in fiber and carbohydrates and low in fat, making them healthy food choices. Dried foods that are not completely dried are susceptible to mold.
- "Microorganisms are effectively killed when the internal temperature of food reaches 70 to 80 degree centigrade."
- **Dennis Scanlin,** an expert in alternative energies and instructor at Appalachian State University, Boone, NC informs, “Food scientists have found that by reducing the moisture content of food to between 10 and 20%, bacteria, yeast, mold and enzymes are all prevented from spoiling it. The flavor and most of the nutritional value is preserved and concentrated. Vegetables, fruits, meat, fish and herbs can all be dried and can be preserved for several years in many cases. They only have 1/3 to 1/6 the bulk of raw, canned or frozen foods and only weigh about 1/6 that of the fresh food product. They don’t require any special storage equipment and are easy to transport."

SUCCESS STORIES

01. SOLAR TOBACCO DRYING

Tobacco industry consumes considerable quantity of thermal energy for processing raw tobacco to final product. Tobacco industries need hot air with variable temperature cycle – 40 deg to 65°C and use chimney effect for air circulation. Large quantity firewood is being used. Apart from emission of green house gases due to burning the fossil fuel, considerable quantity of petroleum products are required to transport fossil fuel to the plantation site.

ITC Rajahmundry has adopted to use solar heat to reduce Firewood. The south facing roof of the factory has been covered by 100 m^2 area solar collector panel. By using solar panel 60 to 65°C hot air of volume 1700 m^3/h is obtained. A SPV operated DC fan is used to deliver the hot air from the solar panel to the point of usage with damper control. Operation cycle is 8 to 10 hrs, based on sunshine for 5 days to obtain the final product from 80 % moisture to 10 %. Instead of 1600 kg of firewood normally used, around 50 to 55% fuel wood is saved by solar heating. A payback period of 3.5 years was reported.

02. SOLAR YARN DRYING

A substantial amount of energy is consumed in drying of yarn and cloth in textile processing unit. In small and medium processing unit steam obtained by fossil fuels is used. A project sponsored by MNRE and supported by a processing mill, a solar yarn drying machine for small processing units were developed. The prototype solar yarn drying machine has a capacity to dry 50kg hank yarn. Total collector area was around 24m^2 and using a blower (of capacity around 1200CFM, 800mm pressure head) air is sucked before the collector and gets heated while passing through the collectors. Through this arrangement air can be pre-heated to a temperature of 60˚C to 80˚C. The drying chamber is specially designed having a volumetric size of around 2m x2m x3m, totally enclosed by transparent acrylic sheets, which absorbs direct solar rays and having insulation properties to maintain inside heat. The hank yarns are hung in a movable trolley provided with number of wooden rods. For effective circulation of hot air uniformly in the drying chamber exhaust fans are provided in the chamber.

03. SOLAR WOOD DRYING (SEASONING)

Green wood needs drying/seasoning, so that it could be used for carpentry as well as for long time storage. Non seasoning of wood will lead to poor quality of wood. There are seasoning method for wood known as kiln seasoning. Wood seasoning is a long term process including costlier fossil fuel. Forest Research Institute, Dehradun have been designed a solar kiln. The super structure consists of a timber or metal frame, with double wall and solar collector integrated at the roof. An electrical operated axial fan is used for air circulation; the hot air from the solar panel is re circulated with a percentage of fresh air inlet and Exhaust.

This kilns functions on the glass house principle. In this way, the temperature inside the kiln rises and this seasons the timber which has been stacked in it. It takes about 15 to 20 days for seasoning timber of average dimensions and moisture content in this kiln. A water spray of the spinning disc types may be provided to give a floating mist of very fine drops of water that does not wet either the timber stack or the floor of the kiln. This is helpful in seasoning refractory hardwoods which may split and crack otherwise.

04. SOLAR TUMBLE DRYING FOR LATEX/ CLOTH

Figure 3

The process of latex rubber drying consists of converting rubber latex into a compound – then converting into a mould liquid using Tip & Dry method. Latex condom is formed from automatic machine using glass moulds. A 38 kW IR lamps are used for drying the molded pieces. These pieces are then washed and part of the moisture is removed by centrifuge motors. Then it is placed in a tumble drier(figure 3) so as to bring down its moisture from 8% to nil by using hot air of temperature of around 80 to 110^0 C obtained through 18 kW electrical coils. The fresh air at the room temperature is taken into the tumble drier through a 20 micron filter and the drier has sensitive controls to regulate the temperature to any required value.


Figure 4

A 55 m^2 area solar hot air panel had been installed to provide preheated air for two tumble driers at TTK – LIG Chennai factory as a pilot project. A fuel saving of 40% was recorded in the factory. Basing on the successes of this project the same company has installed two numbers of 113m^2 Solar collector at Pondicherry for providing preheated air to 8 tumble driers and another project of 113+180 m^2 for preheating the air to 9 tumble driers at Virudhunagar, Tamilnadu (figure 4). Through solar preheating system of total area 461 m^2 the company could reduce around 250,000 electrical units per annum and the company reports a payback period of 1.7 years. Similar concept was used for cloth drying in a tumble drier (figure 5)at Apollo Hospital where a 55m^2 solar collector reduces the electrical consumption for heating air from 30 to 110° C by 50 % and the payback is less than 2 years.

Figure 5

05. TEA DRYING

Tea processing involves the conversion of the harvested tea leaves containing 80% moisture content into the blackened tea of moisture content 2 to 3%. 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 is transmitted through insulated duct at the fresh air inlet point of the hot air over. 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 (figure 6). 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 payback period of around 3 years. Even after 15 years those units periodically maintained are working still

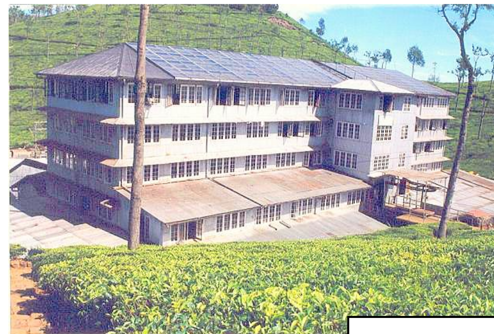


Figure 6

Golden Hills 212 m² Installed In 1992

Unit after 18 years with repainting (2010 Jan.)

06. 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.

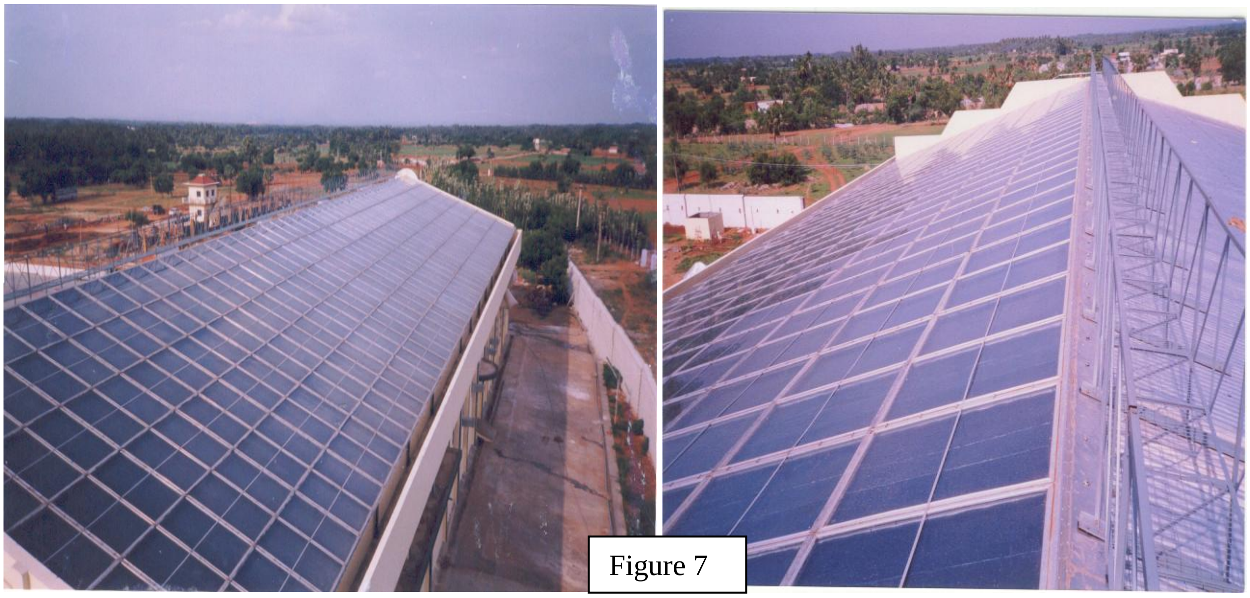


Figure 7

Solar drying facilities for two leading spices powder manufacturing companies in south India namely M/s.Sakthi Masala (P) Ltd., Erode (collector area 1040m^2) (figure 7)

And M/s.Eastern Condiments (P) Ltd., Theni (collector area 500 + 167m^2) (figure 8) were installed successfully. 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.

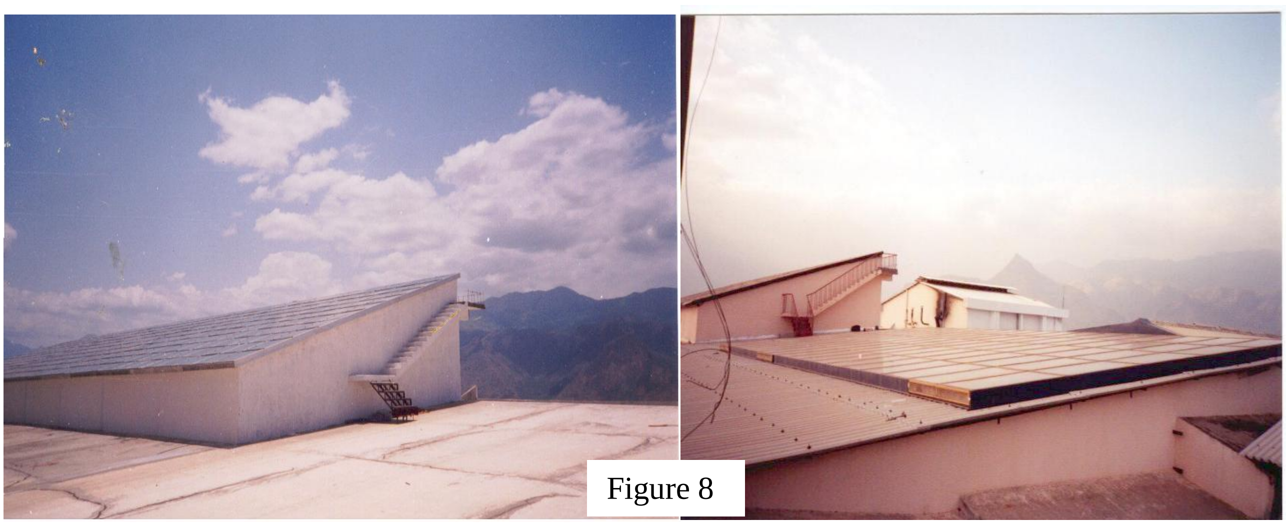


Figure 8

07. Leather Drying

Under facilitation from UNIDO, a $700m^2$ area roof integrated solar hot air system unit (figure 9) has been installed for a leading tannery to dry leather in Ranipet, Tamilnadu, India. The factory uses two imported drier where moving leather are dried by hot air of temperature around 70^0C is produced by heat exchange from steam coils. Solar hot air reduces the usage of steam heating during sunny period. This unit in six months time could save 368.8 tones of firewood fuel and replaces a 1.2 tone steam boiler during its operation.

Figure 9

A similar and smaller unit of a collector area $50m^2$ (figure10)in a tannery at Vaniyambadi, Tamilnadu, India has generated hot air of temperature above 100^0C so as to save around 5 liters of diesel per hour in an auto-spray drying unit. Around 3 years payback is being reported by these projects.

Figure 10

08. Fruits and mango bar drying

CABINET TYPE SOLAR DRIER WITH SPV FANS FOR MANGO BAR

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. Smaller units of various capacities like 25 kg to 100 kg capacity units are promoted by a Hyderabad based NGO. These units are similar to cabinet drier with glass cover and dc fans run by SPV panels. For example a typical model of 50 kg capacity mango bar making unit will have 3 numbers of dc fans run by 2 1 W SPV panels.

Another solar drying facility at Eluru near Vijayawada, Andhra Pradesh was installed to demonstrate larger capacity roof integrated collector concept. A 55m^2 area solar collector in the roof 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 equal to 1500 man-days per year. These kinds of unit could be replicated throughout the country mainly on the mango and other fruits growing areas creating hygienic food products and employment for rural poor.

09. *Solar Salt Drying*

Figure 11

Figure 12

In Salt Refineries, drying is one of the high energy consuming steps. For drying of salt, hot air generated by coal or fossil fuel fired boiler with a heat exchanger (figure 11) is used. The air is heated from ambient to the temperature of around 160 Deg C. This hot air is forced in to a fluidized bed dryer where salt around 4 – 5% moisture is dried to moisture of 0.2%.

By using solar pre heated air at 60^0 to 95^0 C (depending upon the solar radiation) the fuel consumption could be reduced. Introduction of solar heating system having a life span of more than fifteen years with proper maintenance will give an added economical sustainability especially during the fuel escalation periods. This will also provide a cleaner environment to the industries and the surroundings.

A 113 m^2 area solar air heating system was installed at a Salt refinery industry (figure12). The hot air obtained is drawn by an electrical blower. The hot air is transmitted by insulated metal pipes to the fresh air inlet point of the heat exchanger to preheat the air.

SOLAR COIR MATTRESS DRYING AT THODUPUZHA, KERALA

SOLAR DAL PROCESSING AT THENI, TAMILNADU.

Remote areas solar drying applications:

Solar Fish Drying

Drying is the only preservative method for long storage of fish but mechanical drying needs recurring fossil fuel and hence economically not viable. Open sun drying renders fish into unhygienic products including a large wastage. Control drying is needed for longer shelf life and solar drying offers a just solution through low cost hygienic method.

A 500 kg capacity solar fish drying unit was installed in 1999 at Vizagapattinum Andhra Pradesh with the support by Ministry of Food Processing Industries (MFPI), Government of India. A 60 m^2 roof integrated solar collector generates hot air and dries 500 kg of fish charged in a recirculation drier. Good quality dried fish are obtained. Many large capacity fish processing units are installed Capacities like 150 kg, 250 kg, 500 kg & 1000 kg/batch are possible. A suitable building and 1 to 2 kW electrical power are needed to run the unit. Back up heating either through biomass or electrical heaters

to meet heating demand for non sunny period has also been given.

Also to address small fisherman who couldn't afford building and electricity supply, a fully solar dependent drier for fish was designed. The unit has a solar collector for hot air production. A solar photovoltaic panel to run DC fans to push hot air into the drier. A drier with multiple trays and chimney for processing the product was used. Different capacity like 50kg to 250kg small driers is being used. The standard unit is 50 Kg/batch with solar collector of area 5.75 m^2, which yields good quality products leading to value addition to the fish. Other capacity units having collector area 11.5 m^2 and 18 m^2 were successfully used for drying copra, fish and fruits. Collector of area 55m^2 with a recirculation drier has been employed for drying mango bar in Andhra Pradesh successfully.

Solar Apricot Drying

OVERVIEW OF SOLAR AIR HEATING

In India Solar air heating which has equal (or) more potentials than solar water heater is still in the emerging sector though there are many success stories.

Solar air heating application can be categorized in to five areas.

1. The important application as on date is for reducing fossil fuel like diesel, furnace oil and firewood through solar pre heating. This technology has been successfully proven in following industries:
    - Tea industry
    - Spices industry
    - Leather industry
    - Pharmaceutical and chemical industry
    - Automobile industry (painted components drying)
    - Food processing industry
    - Rubber and coir mattress industry

2. Demonstration of large scale drying of fish, fruits & vegetables, copra products and other commodities using solar hot air coupled with biomass/electrical backup heating.

3. Fully solar dependant solar dryers for remote areas applications mainly for employment creation among women folk for value addition, example: small capacity SPV-run solar fish drying unit, herbal dehydration unit etc…

4. Solar hot air could be used for space heating at hilly region in the country – A very limited attempts only made, a large scope exists.

5. Wood seasoning using solar hot air systems. There is a large demand for these kinds of units in almost all the states, since it is essential that the green wood has to be seasoned before fabrication.

Solar air heating is reaching a maturity level by many success stories as listed in the preceded discussion. There is a general need for applications like hilly region space heating. The technology has a tremendous potential and it is still to be explored.

The technology has a advantage over other sister technology like concentrator, due to a low payback (ROI) and more number of operating hours per year, though the operating temperatures are lower than concentrating system. There is a good potential to promote for sector wise application by using the generous Govt. incentives.

COST ECONOMICS

ECONOMIC ANALYSIS ON SOLAR FISH DRIER (50kg Capacity)

1) Capital Expenditure

Cost of Solar drier including installation charges : 1, 66,000/-
Government subsidy 30% : 49,800/-

Total : 1,16,200/-

2) Recurring Expenditure

1. Cost of fish per day 50kgs cost Rs.25/Kg
   (For 200 days 10000 kgs) : 2, 50,000/-
2. Cost of water chemical & salt
   @Rs.1/per kg of fresh fish : 10,000/-
3. Packing charges including cost of packing material
   @Rs.10/kg of dried fish (3000 kg x Rs.10) : 30,000/-
4. Marketing expenses at Rs.3/- per kg of Dried fish : 9000/-
5. Watch & ward : 10,000/-
6. Repair and Maintenance of Machinery
   (@ 10% of the total cost) : 16,600/-
7. Sundries : 2,500/-

Total : 3, 28,100/-

3) Returns

1. Sale of Dried fish (from 30% of 10 tons of fresh fish)
   @Rs.150/kg : 4,50,000/-

4) Net Profit in the 1st year

Total Sale Value + cost of solar drier - Annual Recurring Expenditure
: Rs.4, 50,000 – 4,44,300

=**Rs. 5,700 per annum**

5) Net Profit in the 2nd year

Total Sale Value - Annual Recurring Expenditure
: Rs.4, 50,000 – 3, 28,100

=**Rs. 1,21,900 per annum**

This is in equivalent to creating 1219 jobs day per year (Rs.100/ job day)

Payback period = **Around 2 Years**

The payback period is around 2 years

ECONOMIC ANALYSIS ON SOLAR TUMBLE DRIER (113m^2)

Cost Benefit

No. of working hours per day	-	8 hours
Total no. of working days in a year	-	250 days
113m^2 solar air heater could saver per hour	-	24 units
Cost of one unit of electricity	-	Rs.4.50
Therefore saving per day	-	24 x 4.50 x 8
	-	Rs. 864/-
Savings Per Year	-	Rs. 864/- x 250 days
	-	Rs. 216000/-
Savings for 113m^2 units	-	**Rs. 216000/-**
Total Investment	-	Rs. 9, 47,150/-
Depreciation benefit (Rs. 947150 x 0.8 X 0.33)	-	Rs. 250047/-
Cash out flow without subsidy	-	Rs. 9, 47,150– Rs. 2,50,047
	-	Rs. 6,97,103/-
Government subsidy	-	Rs. 1, 97,750
Cash out flow after deducting		
Government subsidy (Rs.1750/m^2)	-	Rs. 6,97,103 - Rs. 1, 97,750
	-	Rs. 4,99,353/-
Payback period is	-	4,99,353/216000
		Around 2.31 years

The payback period is around **2.31 years** after reducing the IT rebate.

Conclusions

The status of solar air heating for Western countries is mainly focused on space heating only. This need not be a limiting factor to harness this technology for other applications in India and other developing countries.

This presentation it is hoped will reveal the tremendous potentials available for this technology in our country. This technology is relevant for many areas of application-broadly:

Industrial hot air generation,

Space heating for colder regions,

Food processing and Agro processing sectors,

Rural area job creation using fully solar dependant dryers.

There is a need for many entrepreneurs to enter this field which this publication will help to achieve. It is hoped that to reach a target of 1 million m^2 of solar air heating systems in the country within a few years is quite possible.