SOLAR COOKERS

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Solar Cooking

Solar cooker is one of the early devices developed in the country. The ministry of Non Conventional Energy Sources, India has been promoting the box type solar cooker in the country since 1982-83 in view of its advantages over other designs. A box type solar cooker consisted of an insulated box with a glass cover and a top lid, which has a mirror on its inner side to reflect sunlight into the box when the lid is kept open. The inner part of the box is painted black usually four black painted vessels are placed inside the box along with the material to be cooked .The cooking time is about 1 ½ hrs. to 3 hrs. depending upon the items being cooked and the intensity of solar radiation. Since the cooking inside the cooker is slow , the food cooked retains the nutrients better than that cooked in the conventional devices. Besides cooking the meals, the solar cooker can be used to prepare simple cakes, to roast groundnut, cashew nuts and papads, dry grapes, etc. It , however cannot be used for preparing chapatties or for frying purposes. A normal box cooker of 0.6m x 0.6m size having a weight of around 12 kg is capable of cooking 2kg of food and can save 3 to 4 LPG Cylinder a year if used regularly. To promote the use of solar cooking in community kitchens, solar cookers are being installed. Various types of solar cooker, such as dish solar cookers for preparing food for 10 to 15 people outside the kitchen , indoor type solar cooker for cooking food for around 50 people and solar steam cooking systems for cooking food for 1000 of people , are being installed in community kitchens such as road side dhabas , ashrams, boarding schools, religious places, under specific projects.

A community cooker and a dish solar cooker, when used regularly can save 35 & 10 LPG cylinders per year in community kitchens and small establishments. Based on the performance of the worlds largest solar Steam cooking system at Taleti, Mt. Abu, installed during 1999 –2000 for 10,000 people , a solar steam cooking system on similar technology for 3000, people was sanctioned during the year 2001 at the Shirdi Sai Baba Sansthan.

What is Solar Cooker ?

It is similar to what you use in your kitchen to cook food, but it does not require any cooking gas, kerosene, coal , wood or electricity as fuel. It works only on Solar Energy which gives no smoke, no shoot spoils your cooking utensils. It keeps you free from nauseating smell & keeps our environment clean. Above all it conserves the precious energy resources of country and saves money.

Principles of Solar Cooker

Solar Cookers can be broadly divided into two categories:

1. Cookers utilizing Solar heat with little or no concentration of rays. It may be termed as a “hot box”
2. Cookers which deflect solar energy from a large surface to a smaller area to produce high temperatures.

The first kind of solar cooker, commonly known as a “hot box” consist of a well insulated box, the inside of which is painted dull black and is covered by one or more transparent covers. The purpose of these transparent covers is to trap heat inside the solar cooker. These covers allow the radiation from sun to come inside but do not allow the heat from the hot black absorbing plate to come out of the box. Because of this the temperature of the blackened plate inside the box increases and can heat up the space inside to temperature upto 140 Deg. C. which are adequate for cooking.

The second type of solar cooker uses a lens or a reflector suitably designed to concentrate the solar radiation over a small area. This cooker is able to provide higher temperatures on its absorbing surface when suitably designed.

Advantages of Solar Cooker

The Solar cooker has a number of advantages over the traditional cooking devices. These are :

1. It cooks upto four items at a time
2. It preserves the nutrition value of the food (because the cooking is done at low temperature).
3. It does not require constant attention.
4. It saves time for the housewife.
5. It is pollution free.
6. It is safe & simple
7. It saves money & fuel.
8. It helps in preserving our environment.
9. It keeps the food hot for a long time.

The process of cooking

In normal cooking, heat from the open fire is transferred to the cooking vessel. In this process, a large amount of heat is wasted from the fire to the environment. Another source of heat loss is in the form of steam which comes out from the cooking medium carrying 540 calories heat (which is the latest heat of vaporization) per gram. Though these facts are well known, it is surprising

that we still allow large amount of heat loss in cooking from our electric heaters or gas stoves or wood burn stoves.

In rural areas, wood burn stoves or open chullahs are used. The efficiency of these stoves or chullahs is extremely low. As a result, a huge amount of fuel is required for cooking. Use of Solar Cooker can help in cutting down the use of fuel wood which is playing havoc with our forests.

Sunshine provides hot meals for up to 1000 devotees per day- an experience

The Mount Abu Academy also benefits from a Community Solar Cooker.

Eco Centre ICNEER has installed a community Solar Cooker in the premises of the World Renewal Spiritual Trust at Mount Abu in Rajasthan. Twenty four parabolic dishes in two parallel rows with the dishes facing each other, focus the Sun's rays onto water bearing pipes to produce 600kg of steam at 200 deg. C. at 16-20 bar. This steam passes through the kitchen where it is used to cook between 160 to 2000 meals each day. The parabolic dishes are controlled by a mechanical concentrating device to make sure they face the sun at all times.

Solar Cooking in India is not new. The ministry of Non-Conventional Energy Sources (MNES), Government of India, launched a Solar Cooking Subsidy Scheme in the early 80s to promote the use of solar cooker throughout the country. In 1994, MNES withdrew the subsidy on Solar Cooker but is still continuing to provide grants to the state Renewable Energy Agencies to cover the cost of education and publicity. Till date, a total of about 5,41,,000 nos. of box solar cookers, 630 concentrating solar cookers & 6 solar steam cooking systems have been sold/installed.

There are around 60 manufacturers of box type solar cookers in India and the cookers are being sold through 375 sales outlets in 13 states. Over 400,000 box type solar cookers have already been sold in India. The Mount Abu project is unique and features the first design capable of cooking meals for 1000 people. The overall cost of the cooker was US $ 30,000. Similar Concentrating-type solar cookers are being used in the state of Gujarat to cook meals for school children under the Mid-Day Meal Scheme implemented by the Government of Gujarat.

Agencies from where one can buy solar cooker

In the Union Territory, The solar Cookers are sold by the Super Bazar, Mehrauli Farmer's Service Cooperative Society Ltd. , Delhi Small Industries development Corporation, In the state of Utter Pradesh, They are sold through Naya Bazar,

Lucknow, IERT, Allahabad, and through a network of corporative Stores under the auspices of NEDA (Non conventional Energy Development Agency, Lucknow). Similarly in other states there are nodal agencies selling solar cookers at subsidized rates. Statewise list of nodal agencies is given below :

AIWC experience

AIWC has been propagating the use of solar cookers since 1984- In fact a National level orientation cum training programme of solar cooking was one of the first programme conducted by AIWC at Chennai in collaboration with Alagappa Polytechnic which is famous for rural technology dissemination.

Around 100 persons, both men and women from the state Government and various branches of AIWC from the South took part. In early eighties Solar Cooking was not well known and the participants were quite impressed to see that all kinds of food could be cooked just with the sun rays. Since we conducted this programme in the Polytechnic premises where there were a number of open terraces ,we placed two or three box type cookers for each group of five trainees, and provided the raw materials to them. After understanding the basic method of using the solar cooker, each group produced their own dishes, including rice, pulav, Kheer(sweet Dish), vegetables, curries etc and they were so enthusiastic and interested that they produced mouth watering dishes by the afternoon and also gave quite a few tips on improving the taste, shape etc of the dishes Ever since there has been steady demand for solar cookers in Tamilnadu and later a community cooker was installed at the working women's hostel run by Women's Indian Association- the Tamilnadu central branch of AIWC with around eighty sub branches at Chennai alone. Those who were trained in the workshop continues to give demonstration programmes at different venues as well as awareness programmes on the Radio and some through the Television.

The only draw back was that solar cookers were not readily available in Chennai since the local manufactures had stopped production of Solar Cookers.

While AIWC continues to spread awareness programmes on the use of various thermal devices and had conducted these programmes in most of the states, a couple of programmes were worth mentioning. - One was at Andaman Islands where some of us personally conducted solar cooking training in collaboration with the local branch of the Food Council , where apart from the members and other NGOs all the cooks and bearers of the Government Guest house. The lawns were used for

the demonstration came on their own and were amazed to see that without electricity, fire or kerosene many dishes including coffee and tea could be prepared by these cookers.

The other memorable ones, which we conducted, were in a cluster of nine islands, at the Lakshadeep Islands at the Southern corner of India. We had to carry two cookers all the way from Delhi to Cochin to the Port where we boarded the small ship to reach our destination. We had to get down far away from the shore into small motor boats, when we had to jump down from a high step. While transferring the solar cookers the glass of one of the cookers cracked! We were quite worried since we had to cater to at least hundred persons at each place and one cooker would not be sufficient. Suddenly getting a bright idea we went straight to the local hospital and borrowed their tapes which they use for bandage and with that we could fix the solar cooker which came to our rescue.! In those days there were no public transport available there except a contraption like a Jhonga, drawn by diesel motor with a open trailer owned by the Army and we traveled only on these at every island No sooner than we got down and set up the solar cookers suddenly there were nearly one hundred women and children who came from different directions and also some men. When we showed them how to produce various dishes by the solar cookers they just could not believe their eyes and they examined to see whether there was any fire or electric connection at the bottom! They specially enjoyed the tea and coffee made during demonstration. All these Muslim women were practicing a wonderful way of community living. Since almost all the men were sea farers working for various shipping agencies, these women had all the modern devices like washing machine, radio, sewing machines etc and at their community hall they prepared the morning tea and breakfast at a central place and these were carried on their head in a big tray and distributed to each house. Instead of wasting their time in preparing individual meals, they all assemble each day at the centre and prepare coconut balls which has shelf life of six months and a special pickle by using the residues of the fish after sending the good ones to the market which has also a great demand even in the mainland. For this they use the coconut tree barks and dried leaves in their open wood stoves since that is the only local fuel available to them and every thing else had to be brought from Mainland through the sea. They were very keen to use the solar cookers not only for their cooking but also for the preparation of these two products for export We had similar interesting experiences in the other eight islands also .We mentioned all these points in our report to the Ministry In this way propagation of solar cookers has been a learning process for us since

we came into close contact with the women from various background and culture from whom we could always learn some very useful messages. Another thing which we came to realize was that both the Jawans and their families of the three services. Army, navy and airfoce, are always open and quick to adopt the use of solar cookers apart from a number of members of AIWC who use them regularly in their houses, always producing interesting dishes .

Industries / Manufacturers engaged in the development / manufacture of Solar Cooker

1. Rajasthan State Agro Industries Corpn. Ltd. , 01, Subhash Nagar, Jhotawara Road, Jaipur – 6
2. Gujarat Energy Development Agency, B.N. Chambers 3rd Floor, R.C. Dutt Road, Vadodara – 390005
3. Karnatak Implements & Machineries Co. Ltd., Mysore Road, Bangalore – 560026
4. Hayrana State Small Industries & Export Corporation Ltd. Sec- 17 D, Chandigarh, 160017
5. Madhya Pradesh Agro Industries Development Corporation, Bhopal.
6. Institute of Engineering & Rural Technology , 26, Chaitham Lines, Allahabad.
7. Punjab state Industrial Development Corp. Ltd. Set-17 –A, Chandigarh – 160017
8. Agro Pumpsets & Implements Ltd. 10-2-317/3 , Vijayanagar Colony, Hyderabad-500457.
9. Bharat Solar Energy Z-34, Okhla Industrial Area Ph-II New Delhi –110020
10. Govt. Implements factory, Satya Nagar, Bhubaneshwar, Orissa

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- Laymen's Guide to Solar Cookers
- Website of MNES

SOLAR DRYERS

AIWC

Solar Air Heating

One of the traditional applications of solar energy has been for drying of agricultural products. The drying process removes the moisture and help in the preservation of the product. Traditionally, drying of agricultural products is done on the open ground directly under the sun. This leads to losses due to uncontrolled drying, besides causing contamination of the product. In order to provide controlled drying under hygienic conditions, various kinds of solar dryers have been developed in the country. These include cabinet type solar dryer suitable for small scale use, roof integrated solar heating systems and solar dryer based on flat plate collectors. Solar heated air can suitably be used for space heating during winter in cold regions and can meet process heat requirement in industries

Installation of solar drying systems is being promoted through the Soft Loan Programme being implemented by IREDA under the Interest Subsidy Scheme of ministry. So far, air heating systems comprising of around 4500 sq. m. collector area have been installed under the erstwhile Subsidy Scheme and through soft loans provided by IREDA under the Interest Subsidy Scheme of the Ministry. Solar air heaters are also being used for space heating in some of the buildings in Himachal Pradesh.. During the year a technical survey of industries in and around Delhi engaged in drying of industrial products was conducted in order to explore the prospects of minimizing their energy consumption by installing solar dryers. The survey was conducted by Mahatma Gandhi Institute of Integrated Rural Energy Planning & Development, Bakoli under a project sponsored by the Ministry. Around 50 industries, which are drying pulses, soap, rice, biscuits, wheat, textile, bread etc. were surveyed. It was noted that the most of them were using diesel furnace oil for drying their products, while some were using electric heaters. A few industries even dry their product under the sun in the open ground. The furnace oil consumption varies from 100 to 200 litres per day depending on the size and operating hours of the plant. The electricity consumption is also reported to be high because of the poor efficiency of electrical resistance being used by them. Solar assisted drying has been recommended to them as an appropriate measure for energy efficiency in these industries. Efforts are now being made to recommend suitable designs for air heating. Soft loan packages from IREDA would also be offered.

Need for Solar Drying

Drying of fruits and vegetables is a well-known practice in India. It is one of the chief means of preserving the wide variety of seasonal fruits that India abounds in. Among the many techniques of drying, sun drying is widely practiced.

In India, hardly 2% of the countries horticultural produce i.e. fruits and vegetables are processed whereas countries like Thailand, Philippines, USA process more than 70% of their produce. The fruits and vegetables processed in the form of fruit pulp constitute 50% and dehydrated products only 2.22 % i.e. 33,000 tons per annum.

The cottage industry in urban, semi urban and rural area undertake the processing of dehydrated vegetables and fruits many times more than the government data indicates. Of course this being done in traditional practice of sun drying which is unclean and unhygienic from any standards of safe food. It is needless to say that open sun drying has no quality control and collects contaminants like filth from birds and rodents, dusts, dirt, and dead insects etc.

Solar Drying Technology offers an alternative with zero energy cost and processes the vegetables and fruits in a clean, hygienic and sanitary conditions of national and international standards. Solar Dryer Technology can be utilized in small-scale food processing industries for producing hygienic quality food products. At the same time the act will promote renewable energy sources in income-generating unit. Solar drying also enables to store farm produces and o sell them during off season which fetch better prices in the market.

Climatic Conditions

On an average India receives sun for 250 days in plains. At higher altitude intensity of sun is higher though the number of sunny days are lesser. The above-mentioned climatic conditions reflect that Solar drying can be a suitable venture in Himalayan region and in other parts of India also.

Basics of Solar Drying

The solar Dryer is essentially a solar hot box, which can be used to dehydrate fruits, vegetables, fish, and other products to prolong storage life. This is made of cheap and indigenous materials. The solar dryer is designed and tailored to generate more profit for farmers and fishermen who are presently involved in food processing. The operation of the solar dryer is simple and needs little attention. The transparent plastic cover wraps radiation and also keeps the insects out. The ventilation holes at the bottom and on two sides allow cold air to enter to carry out moisture from the fish or vegetables by the heat of the sun. The access door panel enables the materials to be placed on the drying tray and to be removed when drying is completed. The black painted bottom surface keeps heat in and extend drying time.

Special Demonstration and Pilot Projects.

The Ministry has been implementing a scheme of “Special Demonstration & Pilot Projects” to demonstrate various solar thermal technologies, including solar water heating systems, for the purpose of evaluating the performance of new

technologies and innovative designs and establishing their techno-economic viability for specific applications.

Advantages of Solar Dryer

Solar air heating is being promoted for drying farm produce under hygienic conditions. The devices covered under this programme include cabinet type solar dryer suited for small scale use, roof integrated plate collectors. So far, air heating systems comprising of around 4500 sq.m. collector area have been installed under the erstwhile subsidy scheme and the current soft loan scheme. In some of the buildings in Himachal Pradesh air heaters are being used for space heating. During the year a technical survey of industries engaged in drying of various products in and around Delhi was made to explore the prospects of development of solar dryers to minimize energy consumption. Use of solar dryers in such industries can save furnace oil and electricity consumption to a significant extent.

In nutshell the advantages of solar dryers can be listed as:

1. Zero Energy Cost
2. Moisture Control
3. Export Quality
4. Income Generation
5. Self Employment
6. Sizes for small farmers to commercial production.

Types of Solar Dryers

Many types of Solar Dryers are available in the market. But very few commercial manufactures are into the venture. Most of the solar dryers are developed by research organizations promoting rural technologies. Solar Dryers are of portable type and are some supports high quantity drying suitable for cottage industries or in the farms. The values ranges with quality and sizes, starting from 1000.00 Rs. to1,50,000.00 Rs.. To discuss with two types of Solar Dryers will be considered. On an average the basic principles for all the dryers is similar.

1. SOLARWALL Crop Drying

SOLARWALL® roof integrated panels are being used to dry numerous crops around the world. Commercial drying operations can displace fossil fuels used in most driers by adding SOLARWALL® panels as a preheater or primary heater. Solar heat for drying air will not burn or harm many delicate foods, which may happen with steam heated or fossil-fuel heated air.

New Construction : Drying chambers can incorporate solar heating by covering the entire roof and walls of the chambers and productions buildings with SOLARWALL® metal panels. Each square metre of SOLARWALL® panel is roughly equivalent to a 500-watt heater.

Retrofit : Existing crop drying operations can be easily converted to solar heat by the installation of SOLARWALL® solar heating panels on nearby roofs or walls and connecting the panels to the intake of drier fans. Existing burners can be turned off entirely, or used to augment nighttime heating. The SOLARWALL® system utilizes existing fans to save even more energy.
Applications : dries all types of produce ,

- excellent for tea, coffee, fruit, spices, rubber, cocoa beans, rice, timber, nuts, manure
- wall or roof mount
- works with tunnel, trough, conveyor and other types of driers

2. Portable farm solar dryer

Developed by Panjab Agricultural University, Ludhiana Centre)
Function : Natural circulation low cost solar dryer for drying of different farm products
Salient Features : High efficiency, light weight & portable, easy to assemble/dismental, convenience in loading / unloading of the product, option to dry the product under the shade, uniform drying, drying temperature in desirable range and suitable for rural / remote locations.
Important specification : Aperture area 3.34 sq m Glazing UV stabilized Plastic sheet, Inclination 45^o Loading tray area $1.35m^3$, 7 perforated trays arranged in 7 levels Loading per batch 15 – 50 kg (depending on product) Drying time 3-5 days (depending on product) Inclination of the dryer 45^o for north India, 30^o for south India
Performance: Stagnation temperature of 75^oC for solar radiation of 750 W/m^2 & ambient temperature of 30^oC in North India, up to 100% more efficiency than the cabinet dryer, around 20-30 kg of red chillies dried to a moisture content of around 5-7% in 3-4 sunny days in batch mode operation, market price of the product about 70% higher than open sun dried product, pay back period 60 days of operation.
Present Status: Commercially available at a cost of around Rs.5,500/- (US $ 121) from M/s Vishwa Karma Solar Energy Corporation (Regd.), Phillaur - 144 410 (Punjab) India.

3. Solar Drying machine (SDM)

SDM is developed by Society for Energy and Environment Development, Hyderabad.
Principle of Dryer: The solar radiation passes through the transparent glass window located on top of the cabinet, which is oriented to south with a tilt equal to latitude to collect maximum solar radiation. The ambient air enters from the bottom of the cabinet and gets heated up with Solar radiation incident from the top window. The heat energy is trapped in the cabinet and heats up the air. The hot air passes through the trays, carries the moisture from the product through the space below the glass, then it is exhausted by solar PV fans. It has capacity

to evaporated 50 kgs of water in a day from the food to be evaporated and has the maximum loading capacity of 50 kgs of wet products.

Solar Dryer as an income-generating unit

To help our women overcome the poverty using the available resources like farm produce and the zero cost energy sources. As horticultural produce is perishable in nature and the markets are flooded with seasonal produce, for which farmer women do not get proper prices, the process of Solar Drying enables them to get a better price of the dehydrated products for selling during off season. Thus, value addition can ensured for practically all categories of farm produce. The end products are hygienic and retain its original color and taste. The product fetches handsome prices through proper marketing. At the end, the entire process will help the poor women to generate income through a renewable energy source.

AIWC experiences:

AIWC initiated the project "Income generation for poor women through solar dryers in Andhra Pradesh, Kerala, Tamil Nadu and Delhi" with support from Asian Development Bank, New Delhi as part of small grants program.

For this particular project SDM 50 Solar Dryer was identified developed by SEED (Society for Energy and Environment Development. Products were identified on the basis farm produces available in the local market. The details of each product were recorded systematically in the cost analysis data sheet prepared specially for the project. The analysis helped to come out with a strategic planning on promotion, management, product combination and marketing of the solar dried products. Self help groups and individual women could be encouraged to take up the enterprise after proper training. The yearlong action research project proved that Solar Dryer can help the poor women to come out of poverty by selling value added products.

As a follow up of this program and to utilize these unique experiences on Solar Drying to empower our women, AIWC strarted the project on "Enhancing energy security and rural entrepreneurship through energy interventions: Capacity building of rural women on solar dryers". The project is supported by Winrock International (USAID funded) SARI/E Round III. It is jointly implemented by Centre for Rural Technology, Nepal and AIWC, India. The project focuses on capacity building of women in India and Nepal. The experiences of the ADB AIWC Solar Dryer projects was utilized in preparation of training manual on solar drying. The manual was translated to three local languages-Hindi, Malayalam and Tamil.

Awareness programs were conducted in three places with the objective to provide exposure about different renewable energy technology to women. Altogether seven awareness camps were conducted with 140 participants. 50 participants were shortlisted for the 5 days intensive training on Solar Drying at Delhi, Kerala and Chennai. Most of the trainees were members of SHGs. We had a trainee group representing a wide range of socio economic spectrum. The intensive training was focused on practical training on product preparation, quality control, accounts keeping, managerial ability, marketing, product procurement and packaging.

We were happy to receive enthusiastic feedback from the trainees. They have now formed a number of groups among themselves and are keen to start up Solar Dryer enterprise. In Kerala, many members of the SHG wanted to procure the dryer especially for drying rubber sheet.

The project had popularized Solar Dryers in all the 4 states where it was implemented. MNES had offered 33% subsidy in Solar Dryers to a limited number of beneficiaries to promote the technology, which is now becoming more popular.

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Manual on Commercial Model Solar Dryer Published by SEED - Hyderabad

SOLAR THERMAL SYSTEM

Mrs. Lalita Balakrishnan (Member incharge),By AIWC

INTRODUCTION

The Energy scenario in India is complex and facing many problems. Every state is passing through energy crisis at some point of time in every year. The demand for energy is increasing day to day with the increase in population. It is anticipated that the deficit between demand and supply of energy is going to be 10% - 15% in the next 10 year period. This is also indicated by the low per capita consumption of electricity which is around 250 kWh.

If we have to achieve even 500 kWh per capita consumption in the next 10 years period, we have to double our installed capacity of power generation. With the present installed capacity of 81,000 mw, and If we have to add 8000 MW every year, the present energy resources and the finances are not sufficient to meet the demand. Various strategies have been adopted to meet the situation such as energy conservation, achieving highest efficiency in power generation and utilization, use and application or renewable energy technologies, etc. One of the ways of bridging this gap is the use and application of renewable energy source/technologies especially producing power through bio methanation using the huge quantities of biomass and bio degradable garbage which are piling up throughout the country and making the best use of sun's energy through thermal route .

RENEWABLE ENERGY SOURCES

To-day's renewable energy sources include wind, water, oceans, solar radiation(thermal and photovoltaic), wood , cogeneration, biogas and biomass.

Many of these new sources are already commercialized in the world market and the Indian Market is also catching up.

Efficiency of solar water heaters

There are many losses during the collector is in operation and all these losses determine the efficiency of the collector. The efficiency of a collector is referred to the quantity of energy extracted by the circulating water expressed as a fraction of the total amount of solar energy falling on the glass cover of the collector. For example, if the collector has received 5 kWh of solar energy in a day and contributed 2.5 kWh for heating the water in shortage tank, then the efficiency of the collector is 5%.

BASIC REQUIREMENTS FOR INSTALLATION OF SOLAR HOT WATER SYSTEMS

The basic requisites are :

a) Plenty of sunshine in terms of radiation and number of sunny days in a year,
b) The availability of space-either terrace of the building or roof top or ground space without shadowing.
c) The quality of water – hard water or soft water.
d) The location and nature of supply of cold water overhead tanks, city supply line etc.

Space

The space availability for domestic systems may not pose a problem in most of the residential houses or commercial buildings to meet the needs of bathing, kitchen, canteen, etc. Open terraces of the buildings will meet the requirements in most cases.

Industrial systems need plenty of space, depending on the load requirements. This needs close examination of the space availability and proximity to the process in each case.

In the domestic sector, SHW Systems are generally installed on the flat terrace of one storey or multistory buildings, unlike on sloped roofs of the buildings in Western Countries. It is customary to install thermosyphon SHW Systems for residential buildings. Most of the commercially available domestic systems are integral in nature as the collector and the hot water storage tank are made to be compact in one framework. The criterion of keeping the bottom of the hot water storage tank at a minimum height of about 50 cms above the outlet of the collector is taken care of in designing the position of collector and tank by the manufacturers.

In commercial or institutional buildings such as hotels, hospital and hostels, the SHW Systems are located on the top most terrace and the solar hot water delivery systems is interfaced with the already existing centralized distribution system in the building . The overhead cold water tanks are usually located at higher levels on the terrace in such buildings. This facilities the refilling of water from the overhead tank under gravity to the solar hot water storage tank.

Industrial solar hot water systems are employed to economize the process heat generated from furnace oil fired or coal fired boilers. In retrofit systems, the choice of site location or size is usually beyond the control of solar system installers or designers. The space availability may be on the ground, or sloped top roof of on the terrace of a multistory factory building. This results in fragmentation of collector field in different rows or banks resulting sometimes in heavy thermal & pipe losses for large capacity systems. In industry, if the solar hot water system is planned concurrently with the installation of the main factory, one could design an efficient

systems with minimal thermal losses. The project cost will also be low as efficient system engineering would economize the plant configuration and operational costs.

Quality of water

The quality of water is important. The water should be soft and be preferably treated water. For large or small systems, this is a must. Water soluble salts and minerals in hard water are responsible for corrosion, formation of scales or deposits in collectors, pipes and shortage tank. Large systems should employ treated water only. This of course adds to the cost of the systems.

Water supply tank location

In thermosyphon systems, the cold water supply tank should be atleast a foot above the top of solar hot water tank to facilitate gravity flow to the system. In pumped systems, the cold water supply tank can be anywhere but should preferably be near to the installation

Orientation

In addition to the above pre-requisites, the placement of the solar collector system with proper orientation and tilt is necessary for optimum solar energy utilization. The collector should be so connected that they face DUE SOUTH. However, a variation of fifteen degrees either way from due south results in little or no difference in the performance of the system.

Shading

Selecting the site in this aspect should be carefully considered, and a site free from shade all the year round should be chosen. However, small shading before 9 am. Or after 4 pm will be of no great consequences to the system's performance.

Minimum distance between rows of collectors

The minimum distance D is given by the formula : $D = L \sin \varnothing$

$$\frac{\quad}{\text{Tan } (66.5 - \text{latitude})}$$

Where $\varnothing$ = collector Tilt, L = collector length

DESCRIPTION OF SOLAR HOT WATER SYSTEMS

A. Residential Buildings – Domestic Systems

The domestic solar hot water systems will substitute or supplement electrical geysers in bathrooms and kitchens for bathing and washing purpose. The system should deliver hot water at 60 Deg. C. The capacity of shortage and collector area vary depending on the consumption of hot water in the families. A family of four members consumes on an average 100 litres of hot water a day at 60 Deg. C. . A flat plate collector area of 2 sq. m. will collect solar radiation of 6 kWh (units) on a good sunny day to deliver 100 liters of hot water by evening or next morning. For 8 family members, the storage capacity should be doubled and the collector area will also be double.

The thermosyphon system

The thermosyphon system consists of collector, insulated hot water storage tank and pipelines suitably arrange for free flow of water in the collector loop. As the water flowing in the collector heats up and becomes lighter in weight due to the decrease in density, the heated water circulates into the tank and cold water flows from the tank into collector.

B. Institutional/Commercial SHW Systems

This market segment for solar hot water consists of hotels, hostels, hospitals, holiday resorts and pilgrim centers for supply of hot water for bathing and washing purposes. Conventional electrical geysers and furnace oil or coal boilers are the main sources of supply of hot water in these institutions until now.

The fossil fuel costs are subject to continuous inflation and the electrical energy tariffs are also on a continuous upward trend. Past experience has proved that solar hot water systems are economically viable in these institutions. Besides, these systems are reliable sources of supply of energy for atleast 300 sunny days in a year. Most of the institutional systems are large scale hot water plants ranging from 1,000 to 10,000 liters storage capacity. The systems are forced circulation ones with electrical pumps to aid the circulation. These active solar systems can, in turn, be classified as open loop and closed loop systems.

The open loop system is the one where the water in the forced circulating system is exposed to the atmosphere through air space above water in the hot water tank or other point. The water in the storage tanks is circulated and recirculated through collectors until maximum temperature is attained in a day. This works out well as long as treated water is used in the solar hot water system.

When the water is hard, then one has to adopt heat exchangers in the collector-storage loop and the storage-load loop. This is defined as closed loop system.

C. Industrial Systems

The solar hot water systems find many applications in industrial process plant. Boilers supply low pressure steam ranging from 110-150Deg. C. for industrial process heat. The source of energy in the conventional boilers is furnace oil or coal. In the case of furnace oil, it is an imported commodity and is expensive. As an energy conservation measure, solar hot water systems can be used for pre-heating boiler feed water to meet the energy requirement partly. Flat plate collectors can provide hot water at about 80 Deg. C. on sunny days at locations having favorable climatic conditions. The solar hot water system capacities range from 20,000 liters to 100,000 liters. Two types of collector system designs and configurations are adopted for these systems.

CASE HISTORIES

A. COMMERCIAL APPLICATIONS

Application : Solar Hot Water System In Hotel Industry.
Location : Hotel Jaya International (P) Ltd., Hyderabad, Andhra Pradesh.
Description : Hotel Jaya International, with accommodation of 75 rooms, is located in the heart of Hyderabad City. The rooms were supplied with hot water from a 3000 litre capacity oil fired boiler. The supply to the rooms was limited to 4-5 hours in a day. The furnace oil consumption per month was 1,600 litres.
System : A solar hot water system of 6000 litres per day at 60 Deg. C. was installed in 1990. It consist of 48 flat plate collectors with areas of 2 sq. m. each, arranged in thermosyphon and forced circulation modes and 2 tanks each of 3000 litres capacity were arranged for storage of hot water from the collectors. The system has parallel series configuration.

B. INDUSTRIAL APPLICATIONS

Application : Solar Tobacoo Drying Plant
Location : Agricultural Research Centre, Nippani, Karnataka
Description : The solar hot air system was designed to produce hot air to cure 300kg of native tobacco per batch from a moisture content of 70% to 11% continuously in 16 hrs. It was installed in 1994. The inlet air temperature to the barn is 45 Deg. C. and outlet temperature is 38 Deg. C. The average rate of evaporation is 11.25 kg of water per hour.
System : A flat plate collector system with a total area of 38 Sq. m. was installed. It consists of 2 M.S. tanks of 2000 litre capacity for shortage of hot water for continuous drying process. The hot water was circulated through a water to air heat exchanger having heat exchanger area of 2 sq. m. The hot air was blown into the drying chamber of 20 cubic metres. The tobacco leaves were hung inside the barn and the hot air was blown from the bottom of the chamber carrying moisture to the atmosphere through exhaust pipes.

C. SOLAR HOT WATER SYSTEM AT AIWC HEADQUARTERS IN DELHI

AIWC had installed the solar hot water system of 1000lts capacity nearly 15 years ago and the system is working very well even today. The unit was installed by government owned PSU Bharat Heavy Electricals with the panels produced in their own unit through their contractors.

These systems provides hot water for the AIWC Mess which caters to around 300 working women every day providing breakfast, lunch, tea, dinner etc. and the personnel working in the kitchen use this hot water for washing utensils. During summer the temperature inside the water heater goes above 60 degree centigrade. During last summer steam started coming out from the water heater. He experts from BHEL instructed to cover the panels during hot summer days.

ESTIMATION OF COSTS AND BENEFITS OF SOLAR HOT WATER SYSTEMS.

The use of Solar Hot Water System depend on its cost effectiveness. The increase in the prices of conventional fuels is an important point to be considered while examining the viability of Solar Systems. In financial terms, an investment is made towards the costs of a solar system to reduce the recurring expenditure on energy bills. The return on investment will, therefore, depend on the savings in energy bills and the higher cost of conventional fuels.

The economics of a solar system can be looked at in different angles.

a. In the present context of increasing costs of energy and energy shortages, the other alternative, apart from energy conservation, is the application of renewable energy sources like solar energy, wind energy and bio energy, while operating costs are very little or nil.
b. Solar Systems do not pollute the environment, as no fuels are burned in such a system. This is very important, in the light of the present high levels of atmospheric pollution.

In the following sections, the costs associated with Solar Hot Water Systems, the ways to reduce them and the tools for assessing the economic impact of solar energy use are discussed.

Total Cost

The total cost of the system will consist of :

* The cost of solar hot water system including sub-systems if any;
* The value of the invested capital itself. The Indian renewable energy development agency limited (IREDA), extends term loan up to an extent of 75% of the system cost, subject to a prescribed minimum 25% as promoter's contribution. The interest on investment made has to be taken into account while making the cost-benefit analysis.
* Annual allowance made for maintenance should be added to the cost of the system.

* Incentives allowed on investments should be taken into account calculating costs and benefits.

In the cost benefit analysis for domestic, institutional and industrial applications that follow, the above factors are taken into consideration and a cost of Rs. 125-150 per litres per day of solar hot water systems is adopted.

Costs & Benefits

The economic benefit of a solar hot water system is obviously the money saved each month on energy bills (fuel and /or electricity). The value of energy furnished by a solar system depends upon the fuel it is replacing and the efficiency at which it is replacing the boiler heat. It is important to realize that the actual savings will be lower, if the delivered heat is not used. This will apply for instance, if you take long vacations away from home.

Domestic solar hot water systems will be viable if the existing systems are electrically operated (geysers). It will also depend on the electricity tariff and the domestic power tariff varies from Rs. 1.00 to 2.50 per unit.

Limit for Cost Effectiveness

The simplest way of determining whether or not a solar system would be an economically worth while investment is to check that the total return exceeds its total cost. The total return is a summation of the fuel bill savings for every year that the system functions.

Total Return = (working life of the system) x (Annual Saving)

Payback Period

Pay back period (Yrs.) = Total Cost/Annual Savings. The concept of pay back period emphasizes the need to install systems to such a standard, that they will have a long life, say 15 years at least-long enough not only to repay the investment made on them, but to provide a reasonable return on the investment made.

Economic Worksheets

The pay back period or the economic viability depends on

a. Type of the solar system installed (Forced/Thermosyphon).
b. Type and cost of the energy used (coal, furnace oil or electricity)
c. Mode of payment, (self financing or term loan through intermediaries or IREDA)
d. Interest payable on investments made and loan availed.
e. Tax benefits.

Reference : Manual for Solar Thermal Systems IREDA –New Delhi

SOLAR PUMPS

Rural Energy Department, AIWC

A solar photovoltaic water pumping system consists of a photovoltaic array mounted on a stand, and one of the following motor-pump sets compatible with the photovoltaic array. The photovoltaic array converts the solar energy into electricity, which is used for running the motor pump set. The pumping system draws water from the open well, bore well, stream, pond, canal etc.

The system components of solar photovoltaic water pumping system are: photovoltaic array, motor pump set, interface electronics, connecting cables & switches, support structure & tracking system, pipes, etc.

The SPV water pumping system is used in agriculture, horticulture, animal husbandry, poultry farming, high value crops, orchards, silviculture, fish culture, salt farming, drinking water etc.

The water pumping systems are available in different types to meet various needs and applications:

- **SURFACE PUMPS:** These pumps are suitable for lifting and pumping water from a maximum depth of 20 meters (Total head).
- **SUBMERSIBLE PUMPS:** These pumps can be used in areas where water is available at a greater depth and where open wells are not available. The maximum recommended depth these systems can pump is 50 meters.
- **SOLAR HAND PUMPS:** These pumps are exclusively designed by **Balaji Industrial and Agricultural Castings** to meet both the requirements of Surface and Submersible pumps. It has a manual operation mode where the system can be used manually when sufficient sunshine is not available to drive the pump.

Applications:

These pumps are used in village water supply, livestock watering, remote homes, micro-irrigation, homes, dispensaries & Community Centers, etc.

Capacity of SPV water pumping system

Sources: - http://www.balajicastings.com/solarpumps-en.shtml and http://www.iredaltd.com

A SPV water pumping system is available with a photovoltaic array of capacity in the range of 200 watts to 3000 watts. (Capacity of motor pump set is from 0.5 hp to 2 hp). The system is expected to deliver a minimum of 65,000 liters per day for a 900 watts panel and 135,000 liters per day for a 1800 watts panel from a suction head of 7 meters and/or a total head of 10 meters on a clear sunny day. In case of deep well submersible pumps, the water output shall be a minimum of 45000 liters from 1200 wp.

The SPV water pumping system may command an area of irrigation 0.5-6 hectares at a total head of 10 meters depending on water table, type of soil and water management.

The table indicates critical irrigation command area for different crops with the type of method used:

S. No.	Crops	Critical command area in ha.	Irrigation method
1.	Year round vegetables cultivation	1.00	Surface
2.	Chillies/ sorghum/ groundnut	1.41	Surface
3.	Paddy nursery	0.70	Surface
4.	Garlic	2.08	Micro sprinkler
5.	Cucumber	1.82	Drip
6.	Groundnut	1.97	Micro sprinkler
7.	Grapes	2.14	Drip
8.	Lime	4.89	Drip
9.	Banana	2.36	Drip
10.	Pomegranate	7.32	Drip

Cost

The subsidized cost of installation and commissioning of a SPV water pumping system will vary between rs. 1,90,000 to rs.2,70,000 depending upon the supplier and model. Subsidy is available @ rs.110 per wp subject to a maximum of rs. 2,50,000 per pump set.

Life span of the system

Solar PV modules have a long-lasting life of more than 20 years and are absolutely maintenance free according to **Balaji Industrial and Agricultural Castings,** who is one of the manufacturers.

For more information consult websites: - http://www.balajicastings.com/solarpumps-en.shtml and http://www.iredaltd.com

Sources: - http://www.balajicastings.com/solarpumps-en.shtml and http://www.iredaltd.com

The manufacturers and suppliers of SPV water pumping systems as mentioned by IREDA website are:

1.	M/s. Photon Energy Systems 1/482, Avanashi Road, Neelambur, Coimbatore – 641 014 Phone: 0422 – 2627545, 2627003 Fax: 0422 - 2628504
2.	M/s. Udhaya Semiconductors Ltd. Plot No. 775 – K, Road No. 45, Jublee Hills, Hyderabad – 560 033 Phone: 040 – 23231685, 23231545 Fax: 040 – 23546152, 23544839
3.	M/s. Central Electronics Ltd. 4, Industrial Area, Sahibabad – 201010, Uttar Pradesh Phone: 0120 – 2895166, 2895165 Fax: 0120 – 2895147, 2895148
4.	M/s. Surya Jyothi Devices Pvt. Ltd. E-3, Lajpat nagar – II, New Delhi - 110 024 Ph: 91-11-29814822, 29814129. Fax: 91-11-29819444
5.	M/s Tata BP Solar India Ltd. Plot No. 78, Electronic City Hosur Road, Bangalore - 561 229 Ph: 080-8520082/3, 8520973/4 Fax: 080-8520972/116 And M/s Tata BP Solar India Ltd. 70-73 UGF, World Trade Centre Barakhamba Lane, New Delhi - 110 001 Ph: 011-23411537, 23411538 Fax: 011-23411539
6.	M/s. Rajasthan Electronics & Instruments Ltd. 2, Kanakpura Industrial Area Sirsi Road, Jaipur 302 012 Rajasthan Ph: 0141-352271, 354362, 63 Fax: 0141-351926, 352841, 358808
7.	M/s. Titan Consultants & Services Ltd. 16, Aruna Enclave, Trimulgherry Secunderabad - 500 015 , Andhra Pradesh Ph : 040-7742085 , Fax: 040-7795629
8.	M/s Premier Solar Systems (P) Ltd. 41 S V Co-op Indl. Estate, Balanagar, Hyderabad - 500 037 Ph: 040 – 23777521, 23777522 Fax: 040 – 3771879
9.	M/s. Bharat Heavy Electricals Ltd. P. B. No. 2626, Mysore Road, Bangalore – 560 026 Ph: 080 – 6744283, Fax: 080 - 6740137

Sources: - http://www.balajicastings.com/solarpumps-en.shtml and http://www.iredaltd.com