3rd International Conference on Recent Innovations in Science Engineering and Management
Sri Venkateswara College of Engineering and Technology,Srikakulam,Andhra Pradesh (ICRISEM-16)
27 February 2016, www.conferenceworld.in ISBN: 978-81-932074-1-3

A DETAIL PROJECT REPORT ON INSTALLATION PROCESS FOR SOLAR WATER HEATER

Er . Amit Tiwari [1], Er .Deepak Chand Solanki [2], Er . Mugishullah Shekh[3]

[1, 2, 3] Assistant Professor, Mechanical Engineering Department, DCET, Dungarpur (Rajasthan)

ABSTRACT

Solar water heating systems use solar collectors and a liquid handling unit to transfer heat to the load, generally via a storage tank. The liquid handling unit includes the pump(s) (used to circulate the working fluid from the collectors to the storage tank) and control and safety equipment. When properly designed, solar water heaters can work when the outside temperature is well below freezing and they are also protected from overheating on hot, sunny days. Our project work is to given a idea if somebody want to installed the plant the how the procedure for it.

The various parameters considered to project installation

Keywords: Introduction, Salient Features, Equipments Details, Economic Benefits, Installation Process, Cost Analysis and its Applications.

I. INTRODUCTION

1.1 What is solar water heater?

Solar water heater the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating system comprises various technologies that are used worldwide increasing. In a "close-coupled SWH system the Storage Tank is horizontally mounted immediately above the solar collectors on the roof. No pumping is required as the hot water naturally rises into the tank thought thermo siphon flow. In a "pump-circulated" system the storage tank is ground – or floor – mounted and is below the level of the collectors; a circulating pump moves water or heat transfer fluid between the tank and the collector

A Solar Water Heater is a device which provides hot water for bathing, washing, cleaning, etc. using solar energy. It is generally installed at the terrace or where sunlight is available and heats water during day time which is stored in an insulated storage tank for use when required including morning. We are blessed with Solar Energy in abundance at no cost. The solar radiation incident on the surface of the earth can be conveniently utilized for the benefit of human society. One of the popular devices that harness the solar energy is solar hot water system (SHWS). A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the hat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and is delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80 C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system. Broadly, the solar water heating systems are of two categories. They are: closed loop system and open loop system. In the first one, heat exchangers are installed to protect the system from hard water obtained from bore wells or from freezing temperatures in the cold regions.

 ISBN: 978-81-932074-1-3

In the other type, either thermosyphon or forced circulation system, the water in the system is open to the atmosphere at one point or other. The thermosyphon systems are simple and relatively inexpensive. They are suitable for domestic and small institutional systems, provided the water is treated and potable in quality. The forced circulation systems employ electrical pumps to circulate the water through collectors and storage tanks. The choice of system depends on heat requirement, weather conditions, heat transfer fluid quality, space availability, annual solar radiation, etc. The SHW systems are economical, pollution free and easy for operation in warm countries like India.

1.2 Why should go for a Solar Water Heater?

A 100 liter per day capacity system suitable for 3-4 people can save up to 1500 units of electricity in a year, depending on hot water used. It can also save around 140 liters of diesel in an establishment using oil fired boiler besides reducing green house gas emissions in the atmosphere. Higher capacity systems will save higher amount of electricity/fuel oil besides reducing higher amount of GHG emissions. Electricity is expensive and is not available due to power cuts in many areas when required for heating water. Solar Water Heater, since it stores hot water in an insulated tank, provides water all the time when required. Fuel oil is also expensive and creates pollution. Storing the fuel oil for long term use in commercial establishments is another problem.

The table below gives approximate likely electricity and money savings for a typical 100 liters per day system located in different parts of the country.

Table 1

	Northern Region	Eastern Region	Southern Region	Western Region
Expected no. of days of use of hot water per year	200 Days	200 Days	300 days	250 Days
Expected yearly electricity saving on full use of solar hot water (units of electricity	1000	1000	1500	1250
Monetary savings at different prices of electricity, Rs/year				
Rs. 4/kwh	4000	4000	6000	5000
Rs. 5/kwh	5000	5000	7500	6250
Rs. 6/kwh	6000	6000	9000	7500

1.3 Salient Features of Solar Water Heating System

Solar Hot Water System turns cold water into hot water with the help of sun's rays.

- Around 60 deg. – 80 deg. C temperature can be attained depending on solar
- Radiation, weather conditions and solar collector system efficiency
- Hot water for homes ,hostels, hotels, hospitals, restaurants, dairies, industries etc.
- Can be installed on roof-tops, building terrace and open ground where there is no

 ISBN: 978-81-932074-1-3

- Shading, south orientation of collectors and over-head tank above SWH system
- SWH system generates hot water on clear sunny days (maximum), partially
- Clouded (moderate) but not in rainy or heavy overcast day
- Only soft and potable water can be used
- Stainless Steel is used for small tanks whereas Mild Steel tanks with anticorrosion
- Coating inside are used for large tanks
- Solar water heaters (SWHs) of 100-300 litres capacity are suited for domestic application
- Larger systems can be used in restaurants, guest houses, hotels, hospitals, industries etc.

1.4 Service Hot Water

There are a number of service hot water applications. The most common application is the use of domestic hot water systems (DHWS), generally sold as "off-the-shelf" or standard Kits as depicted in Other common uses include providing process hot water for commercial and institutional applications, including multi-unit houses and apartment buildings, housing developments, and in schools, health centres, hospitals, office buildings, restaurants and hotels. Small commercial and industrial applications such as car washes, laundries and fish farms are other typical examples of service hot water. solar water heating system at the Rosewall Creek Salmon Hatchery in British Columbia, Canada. 260 m² unglazed solar collectors heat make-up water and help increase fingerlings production at the aquaculture facility. Storage tanks help regulate temperature of make-up water. This particular project had a five-year simple payback period. Solar water heating systems can also be used for large industrial loads and for providing energy to district heating networks.

Solar Domestic Hot Water (Thermo siphon) System

II. LITERATURE REVIEW

2.1 Man and Energy

Man has needed and used energy at an increasing rate its sustenance and well-being ever since he came on the earth a few million years ago. Primitive man required energy primarily as the form of food. He derived this by eating plants or animals, which be hunted. Subsequently be discovered fire and his energy need for increasing as be started to make use of wood and other bio mass to supply the energy needed for cooking as well as agriculture. He added a new dimension to the use of energy by domesticating and training animals to work for him. With further demand for energy , man began to use the wind for soiling ship and for driving. And the force of failing water to turn water wheels. Till time, it would not be wrong to say that the sun was supplying all the energy needs of man either directly or indirectly and that man was using only renewable source of energy.

The industrial revolution, which began with the discovery of the steam engine, brought about great many change. For the first time, man began to use a new source of energy in large quantities. A little later, the internal combustion engine was invented and the other fossil fuels, oil and natural combustion engine extensively. The fossil era of using non-renewable source has began and energy was now available in a concentrated form. The invention of heat engine and then use of fossil fuels made energy portable and introduced the much needed flexibility in mans movements. For the first time man could get the power of a machine where he required it and was not restricted it and was not restricted to a specific site like a fast-running stream for running a water wheel or a windy hill for operating a windmill. This flexibility was enhanced with the discovery of electricity the development of central power generating stations using either fossil fuels or waterpower. A new source of energy-nuclear energy-came on the scene after the second world war the first large nuclear power station was commissioned about 40 years ago, and already, nuclear energy is providing a small but significantly amount of the energy requirements of many countries. Thus today, every country draws its energy needs from a variety of source. We can broadly categorize these source as commercial and noncommercial. The commercial source include the fossil fuels, hydroelectric power and nuclear power, while the non-commercial source include wood, animal wastes, geothermal and agricultural wastea. In an industrialized country like USA, most of the energy requirements are meant from commercial souece, while in an industrially less development country like India, the use of commercial and non-commercial source is about equal. In the past few years, is has become obvious that fossil fuel resources are fast depleting end that the fossil fuel era is gradually to an end. This is particularly true for oil and natural gas first examine the rates of consumption of the different source of energy and to give some indication of the reserves available this study will be done for the world as a whole and then for India in particular with the help of these figures it will be possible to form estimates of the time periods for which the existing source will be available. The need for alternative energy optional will thus be established and these options will then be briefly described. Before passing on to these topics, it is worth nothing that while man's large-scale use commercial energy has led to a better quality of life it has also created many problems. Perhaps the most serious of these is the harmful effect on the environment. The combustion of the fossil fuel has caused serious air pollution problems in many areas because of the localized release global warming. This is now a matter of great concern. Similarly the phenomenon of waste heat from power plants has caused thermal pollution in lakes and rivers leading to destruction of many forms of plants and animal life. In the case of nuclear power plants there is also concern over the possibility of radio action being released into the atmosphere in the event of an accident and over the long term problem of disposal of radioactive wastes from these plants. The gravity of most of these environment problems had not really been foreseen. Now however, as man embarks on the search alternative source of energy.

2.2 Factors Effecting Human Comfort

The important factors while designing any system of comfort are

- Effective Temperature
- Heat production & regulation in human body
- Heat and moisture losses from body
- Moisture content of air
- Quality and quantity of air

ISBN: 978-81-932074-1-3

- Air motion
- Air stratification

III. SOLAR WATER HEATERS

3.1 Types of Solar Water Heaters

Solar water heaters can be either active or passive. An active system uses an electric pump to circulate the heat-transfer fluid; a passive system has no pump. The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, proper installation, and the tilt angle and orientation of the collectors. Solar water heaters are also characterized as open loop (also called "direct") or closed loop (also called "indirect"). An open-loop system circulates household (potable) water through the collector. A closed-loop system uses a heat-transfer fluid (water or diluted antifreeze, for example) to collect heat and a heat exchanger to transfer the heat to household water.

3.1.2 Active Systems

Active systems use electric pumps, valves, and controllers to circulate water or other heat-transfer fluids through the collectors. They are usually more expensive than passive systems but are also more efficient. Active systems are usually easier to retrofit than passive systems because their storage tanks do not need to be installed above or close to the collectors. But because they use electricity, they will not function in a power outage. Active systems range in price from about $2,000 to $4,000 installed.

3.1.2.1 Open-Loop Active Systems

Open-loop active systems use pumps to circulate household water through the collectors. This design is efficient and lowers operating costs but is not appropriate if your water is hard or acidic because scale and corrosion quickly disable the system. These open-loop systems are popular in nonfreezing climates such as Hawaii. They should never be installed in climates that experience freezing temperatures for sustained periods. You can install them in mild but occasionally freezing climates, but you must consider freeze protection. Recirculation systems are a specific type of open-loop system that provide freeze protection. They use the system pump to circulate warm water from storage tanks through collectors and exposed piping when temperatures approach freezing. Consider recirculation systems *only* where mild freezes occur once or twice a year at most. Activating the freeze protection more frequently wastes electricity and stored heat. Of course, when the power is out, the pump will not work and the system will freeze. To guard against this, a freeze valve can be installed to provide additional protection in the event the pump doesn't operate. In freezing weather, the valve dribbles warmer water through the collector to prevent freezing.

3.1.2.2 Closed-Loop Active Systems

These systems pump heat-transfer fluids (usually a glycol-water antifreeze mixture) through collectors. Heat exchangers transfer the heat from the fluid to the household water stored in the tanks. Double-walled heat exchangers prevent contamination of household water. Some codes require double walls when the heat transfer fluid is anything other than household water. Closed-loop glycol systems are popular in areas subject to extended freezing temperatures

because they offer good freeze protection. However, glycol antifreeze systems are a bit more expensive to buy and install, and the glycol must be checked each year and changed every 3 to 10 years, depending on glycol quality and system temperatures. Drain back systems use water as the heat transfer fluid in the collector loop. A

ISBN: 978-81-932074-1-3

pump circulates the water through the collectors. The water drains by gravity to the storage tank and heat exchanger; there are no valves to fail. When the pumps are off, the collectors are empty, which assures freeze protection and also allows the system to turn off if the water in the storage tank becomes too hot.

3.1.3 Passive Systems

Passive systems move household water or a heat-transfer fluid through the system without pumps. Passive systems have no electric components to break. This makes them generally more reliable, easier to maintain, and possibly longer lasting than active systems. Passive systems can be less expensive than active systems, but they can also be less efficient. Installed costs for passive systems range from about $1,000 to $3,000, depending on whether it is a simple batch heater or a sophisticated thermo siphon system.

IV. PRINCIPLE OF HEATING WATER THRO SOLAR

4.1 Black Body Absorption

It is a well known fact that a black body absorbs heat which can be used to heat water.

1. The Sun's rays heats the black powder coated copper fins (larger surface area) which in turn heats the cold water in the copper tubes. The heated water slowly rises in the copper pipes thro thermo-siphon action and eventually
2. Gets stored in the hot water storage tank.
3. This principle ensures that no electricity is used in the entire system.

4.2 Thumb Rules

1. Surface area of each collector: **2m x 1m**
2. Flat / roof area required per collector: **3.5 sqm**

V. EQUIPMENT FOR ENERGY EFFICIENCY IMPROVEMENTS

5.1 Solar water heating system (SWHS)

5.1.1 Description of technology/equipment

The Solar Hot Water Systems consists of two main parts:

- Solar collector
- Storage tank

The collector used in such SWHS is of flat-plate type. The solar radiation directly falls on the collector surface and the solar energy is converted into thermal energy. Water is circulated in tube and gets heated by solar energy. Heated water is then stored in the storage tank for use in the process. However, the existing conventional system is sometimes also maintained to provide the thermal heat required during inclement weather conditions. Solar water heating systems can be either active or passive. However, the present DPR is prepared for passive solar water system which is most commonly used

5.1.1.1 Solar collectors

Solar collectors are the key component of SWHS. Solar collectors gather the sun's energy, transform its radiation into heat, and then transfer that heat to water. There are several types of solar collectors viz flat-plate collector, evacuated-tube collector and integer collector storage system. However, flat –plate collectors are generally used.

ISBN: 978-81-932074-1-3

5.1.1.2 Flat-plate collectors

Flat-plate collectors are the most common solar collector for SWHS. A typical flat-plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark colored absorber plate. These Collectors, heat liquid or air at temperatures less than 80°C. Liquid flat-plate collector's heat liquid as it flows through tubes in or adjacent to the absorber plate. The simplest liquid systems use potable water, which is heated as it passes directly through the collector and then flows to the process line. Comparison of conventional chulhas with SWHS is shown in Table below:

Srno	Details	Chulhas	SWHS
1	Wood consumption	High	No fuel required
2	Environment pollution	High	Pollution free
3	Safety of workers	Poor	Good
4	Maintenance 5	High	Low
5	Operational cost	High	Low
6	Availability of local service providers	Yes	Yes / limited
7	Hot water generation	Continuous	Intermittent
8	Fuel cost	High	Nil
9	Man power	Required	No required

5.1.2 Equipment specification

Equipment specification of SWHS along with terms of sales, performance guarantee and after sales services details are furnished in Annexure 8.

5.1.3 Suitability with existing process

The proposed new equipment is used for hot water generation which was earlier generated by conventional chulhas. Hence proposed equipment is suitable with existing process.

5.1.4 Availability of equipment / technology

Based on the detailed energy use and technology audits conducted in various textile Industries in Solapur textile cluster, it is suggested to install solar hot water system of 1000 LPD capacity for dyeing and soaping process. The company representatives of various solar equipment suppliers are locally available in Solapur and these companies will also provide necessary guidance for documentation required for getting loan and financial incentives available for installing SWHS.

5.1.5 Technical specifications of equipment

ISBN: 978-81-932074-1-3

Table: Technical specifications

Table Terms & conditions of sale for energy efficient SWHS

Particular	Condition
Price	Transportation, Loading - Unloading & Handling Charges at actual
Insurance	0.45%
Taxes	CST 4% and exempted from excise duty
Delivery	7 weeks from the date of order with advance
Inspection	Inspection of equipment prior dispatch, at your own cost
Commissioning	Included in total cost
Inspection	At our works prior to dispatch

Details	Units	Value
Name of equipment	NA	Solar water heating system
Model	NA	VIJRA
Capacity	LPD	1000
Temperature of hot water	oC	60
Ambient temperature	oC	25
Transitivity	%age	85

5.1.6 Process down time during Implementation

There is no process down time, as the proposed equipment is additional equipment.

5.2 Life cycle of equipment

The life expectancy of SWHS is 8-12 year depending upon its maintenance, cleaning and uses

5.3 Suitable unit for Implementation of proposed equipment

Large quantities of hot water is required in the dyeing process and the proposed system will give an output of 1000 LPD, which replaces about 1000 LPD hot water generation in conventional chulha systems

VI. ECONOMIC BENEFITS OF SWHS

6.1 Technical Benefit

6.1.1 Fuel saving

The wood savings due to installation of SWHS in a typical unit having 1000 LPD hot water generation capacity is estimated at 60 tonnes per annum. The wood savings is estimated based on the present Chulhas efficiency of 6.25 %.

6.1.2 Electricity saving

Project implementation will not save electricity consumption ***directly and indirectly***.

6.1.3 Improvement in product quality

Product quality achieved would be same as the present quality. It does not have any impact in improving the quality of the product.

ISBN: 978-81-932074-1-3

6.1.4 Increase in production

The proposed equipment does not contribute to any increase in production.

6.1.5 Reduction in raw material consumption

Raw material consumption is same even after the implementation of proposed technology.

6.2 Monetary benefits

Annual monetary savings due to implementation of SWHS in place of the conventional chulhas is ` 1.50 lakh per annum. Energy & monetary benefit analysis of energy efficient boiler is presented in

Table: Energy and cost benefit analysis of energy efficient SWHS

S No	Parameter	Unit	Value
1	Wood consumption in existing chulhas	Tonnes/annum	60
2	Operational hours	Hours	8
3	Operational days per annum	Days	240
4	Wood consumption in proposed equipment	Tonnes/annum	Nil
5	Wood saving	Tonnes/annum	60
6	Cost of wood	`/Tonne	2500
7	Total monetary benefit	in lakh	1.50

6.3 Social Benefits

6.3.1 Improvement in working environment in the plant

The replacement of inefficient chulhas with SWHS will reduce the wood consumption and will improve the work condition and environment.

6.3.2 Improvement in skill set of workers

The technology implemented will create awareness among the workforce towards clean and renewable energy systems.

6.3.3 Impact on wages/emoluments

No significant impact on wages and emoluments of the workers.

6.3.4 Reduction in GHG emission such as CO2, NOx

Implementation of this project will lead to reduction in CO2 emissions due to reduction in overall fuel consumption. Implementation of this project will result in saving of 60 tonnes of wood per year thereby; reducing 84 tonnes of CO2 emissions per year from one unit. Similarly, there are many similar type of unit in Solapur, and if all units will implement this project then significant amount of CO2 emission reduction possible per year. This will also help in getting the carbon credit benefit through Clean Development Mechanism (CDM) project. *Taking CO2 emission factor as 1.4 tCO2 per tonnes of wood consumption*

6.3.5 Reduction in other emissions like SOx

As wood doesn't contain sulphur and hence there is no impact on SOx emissions.

ISBN: 978-81-932074-1-3

6.4. Reduction of deforestation

Proposed SWHS will reduce wood consumption in unit thus automatically reduce the deforestation.

VII. INSTALLATION OF NEW ENERGY EFFICIENT EQUIPMENT

7.1 Cost of Project

7.1.1 Cost of Equipment

The total cost of equipment and machinery is estimated ` 1.55 lakh, , the total cost includes for solar collectors, insulated hot water tanks of SS make, mounting stands for hot water tank & collectors besides the installation & commissioning cost.

7.1.2 Other Costs

Other cost includes erection & commissioning cost which is ` 0.03 lakh, and Construction cost which is ` 0.16 lakh. The total cost of implementation of the SWHS is estimated at ` 1.74 lakh and furnished in Table below:

Table: Details of project cost

S.no	Details	Cost (` in lakh)
1	Equipment and machinery	1.55
2	Erection & Commissioning	0.03
3	Contingency cost	0.16
	Total	1.74

VIII. APPLICATION OF SOLAR WATER HEATER

- Flat , Bungalows And apartment
- Hotel, Hospitals, Hostels And Dormitories.
- Process industries, preheating boiler feed water.
- In domestics sector, hot water is used for bathing, washing of clothes & utensils etc.
- The requirement may, however, vary with the season of the year & number of family members.
- Pre-feed for boilers for steam generation for various industrial applications.
- Milk dairies for applications such as pasteurization, condensation & cleaning.
- Leather processing industry for drying and tanning.
- Metal finishing industry for degreasing and phosphating.
- Resin emulsification in polymer industry.
- Drying & related processes in pharmaceutical industry.
- Solar drying thro air-heating is an area of growing interest.

ISBN: 978-81-932074-1-3

REFRENCES

[1]. ASHRAE, Applications Handbook, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA, 30329, USA, 1991.

[2]. ASHRAE, Applications Handbook (SI) - Service Water Heating, American Society of Heating,Refrigerating, and Air- Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA, 30329, USA, 1995.

[3]. ASHRAE, Handbook - Fundamentals, SI Edition, American Society of Heating, Refrigeratingand Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA, 30329, USA, 1997.

[4]. Carpenter, S. and Kokko, J., Estimating Hot Water Use in Existing Commercial Buildings, ASHRAE Transactions, Summer Meeting 1988, Ottawa, ON, Canada, 1988.

[5]. Smith, C. C., Löf, G. and Jones, R., Measurement and Analysis of Evaporation from an Inactive Outdoor Swimming Pool, Solar Energy 53, 1, pp. 3-7, 1994.

[6]. Soltau, H., Testing the Thermal Performance of Uncovered Solar Collectors, Solar Energy49, 4, pp. 263-272, 1992.

[7]. Swinbank, W. C., Long-Wave Radiation from Clear Skies, Quarterly J. Royal MeteorologicalSoc., 89 (1963) pp. 339-348, 1963.

[8]. University of Waterloo, WATSUN Computer Program, Version 13.2, University of Waterloo, Waterloo, ON, Canada, N2L 3G1, 1994.