

WHAT IS SOLAR WATER HEATER?

A solar water heater is a device that utilizes the energy from sunlight to heat water for various domestic or commercial purposes. It consists of solar collectors, a storage tank, and a circulation system.

The solar collectors are typically mounted on the roof or in an area with good sun exposure. They absorb the heat from the sun's rays and transfer it to a fluid, usually a mixture of water and antifreeze or a specialized heat transfer fluid. This fluid carries the captured heat to the storage tank.

The storage tank is insulated to minimize heat loss and stores the heated water until it is needed. In some systems, the tank may have a backup heating element or a secondary heat source to ensure hot water availability during periods of low solar radiation.

The circulation system, which may be passive or active, helps move the fluid between the collectors and the storage tank. In a passive system, natural convection allows the heated fluid to rise and circulate, while in an active system, pumps are used to move the fluid through the system.

Solar water heaters can be used to provide hot water for various applications, including bathing, washing clothes, and heating swimming pools. They are especially effective in regions with abundant sunlight and can significantly reduce the energy consumption and associated costs of heating water using conventional methods.

It's worth noting that there are different types of solar water heaters available, including direct systems, indirect systems, and batch systems, each with its own configuration and functionality.

INTRODUCTION

Limited availability of natural gas and abundant sunshine made solar water heating (SWH) systems an attractive choice for consumers during the end of the 19th and early 20th centuries.

This report focuses on the energy savings and environmental benefits of community-scale solar water heating systems. In this context, “community-scale” describes both the size of the system and an adherence to a set of design principles. Community scale systems occupy an intermediate space between the domestic and utility scales. This report defines community scale systems as those able to meet the hot water demands of tens of residential buildings up to hundreds of residential units with greater than the minimum solar fraction required by law.

The report will specify the following:

1. Solar Collector Technology Type & Thermal Efficiency
2. Energy Storage Time Horizon (i.e. Diurnal vs. Seasonal Storage)
3. Auxiliary or Back-up Heat Source Required
4. Methods for Predicting Solar Fraction and System Performance.

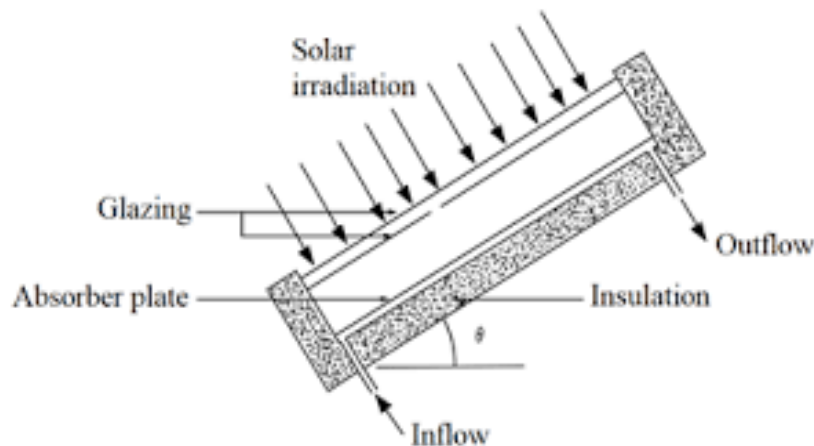
This report will conclude with a basic description of the community scale solar water heating system design for the purposes of this analysis.

Solar Water Heating Components and Systems :-

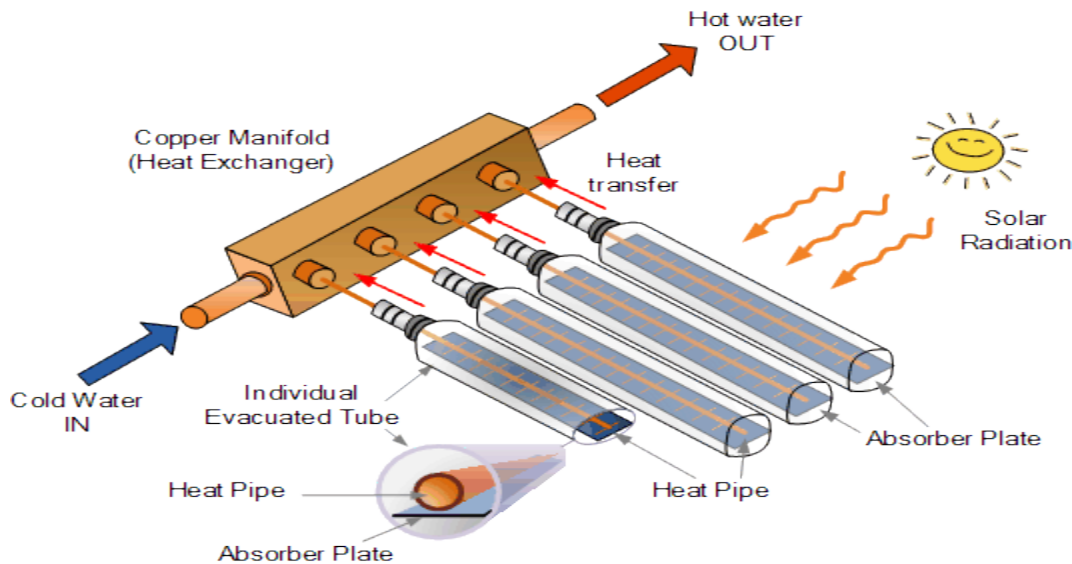
The fundamental elements of solar water heating systems include solar thermal collectors, storage tanks (to store the heated working fluid/ heated water), and piping systems to move heated water and working fluid between collectors, storage tanks, and buildings.

Solar thermal collectors absorb thermal energy from incident solar radiation, and transfer to water or a working fluid. The four most common collector types are:

- **Flat Plate Collectors (FPCs)**

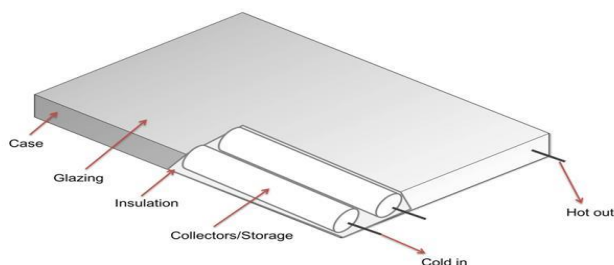


- **Evacuated Tube Collectors (ETCs)** : Evacuated tube collectors consist of an array of evacuated glass tubes, each containing a smaller glass tube within. The inner glass tube houses an absorber plate in thermal contact with a flow tube. A vacuum between the two glass layers serves to thermally insulate the inner tube.



- **Integral Collector-Storage Systems (ICSS)**

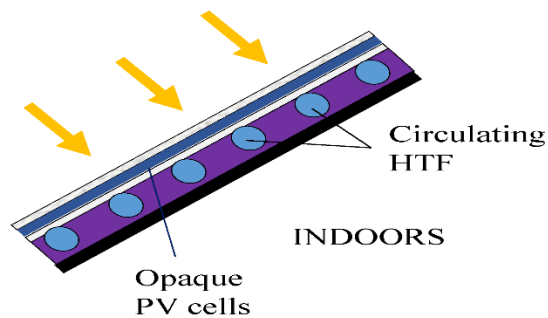
Integral collector storage systems are the oldest and simplest type of solar thermal collector technology. Integral collector storage systems store heated water within the solar thermal collection device, rather than in a separate tank (i.e. a distributed system). A wide variety of designs for integral collector storage systems exist. Integral collector storage systems may employ a flat plate design with storage tanks instead of flow tubes, use a series of evacuated tubes that terminate in a storage tank, or employ reflectors and phase-change materials to maximize heat absorption and minimize thermal losses.



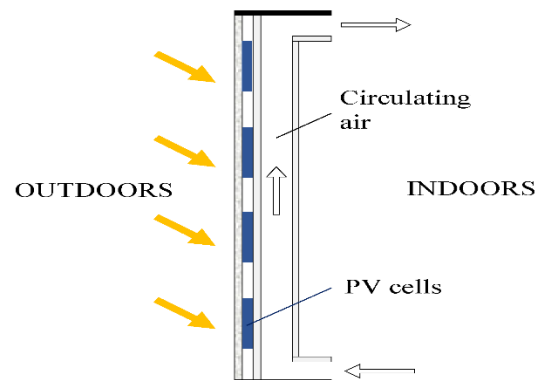
- **Integrated Photovoltaic/ Thermal (PV/T) Collectors** : Integrated PV/T collectors couple the generation of electric current from photovoltaic solar cells with the collection thermal energy for water and space heating. The conversion of solar energy into electric current via the photoelectric effect is a process which is a relatively inefficient process that produces a

large amount of waste heat.

OUTDOORS



(a)



(b)

Storage Tanks : The design and use of storage tanks for water and working fluid has a significant impact on the thermal performance of solar water heating systems. Storage tank insulation and temperature stratification help to minimize thermal losses from solar hot water heating systems. Thermal insulation of tanks helps minimize losses to the ground and air, especially during colder months.

Heat Exchange Fluids and Heat Exchangers : Closed systems with freeze resistant heat exchange fluids are required in climates that experience prolonged freezing temperatures, as most collectors are not designed to withstand such forces. Antifreeze agents are also toxic, requiring a heat exchanger be installed between the collection and storage/ delivery loops.

WORKING OF SOLAR WATER HEATER:

The working principle of a solar water heater involves the following steps:

1. **Solar Collector:** The solar collector, typically mounted on the roof or in an area with good sun exposure, absorbs solar radiation. It consists of a dark-colored, heat-absorbing material such as blackened metal or selective coating on the surface. The collector's design allows for maximum solar energy absorption.
2. **Heat Transfer Fluid:** A heat transfer fluid, which is a mixture of water and antifreeze or a specialized heat transfer fluid, flows through the solar collector. As the fluid passes through the collector, it absorbs heat from the absorbed solar energy.
3. **Circulation:** The heated fluid circulates through the solar water heating system using either a passive or active circulation system.
 - **Passive Circulation:** In a passive system, natural convection and gravity allow the heated fluid to rise and flow into the storage tank while cooler fluid descends to the collector for reheating. This process continues as long as there is a temperature difference between the collector and the tank.
 - **Active Circulation:** An active system employs pumps or other mechanical devices to circulate the fluid between the collector and the storage tank. This ensures a more controlled and efficient flow of the heated fluid.

4. **Storage Tank:** The heated fluid transfers its heat to the water in the storage tank through a heat exchanger. The storage tank is insulated to minimize heat loss and stores the hot water until it is needed.
5. **Backup Heating Element:** To ensure hot water availability during periods of low solar radiation or high demand, solar water heaters often have a backup heating element. This element, typically powered by electricity or gas, can heat the water in the tank when the solar energy is insufficient to meet the required temperature.
6. **Hot Water Distribution:** When hot water is required, it is drawn from the storage tank and distributed for various domestic or commercial purposes.

Throughout this process, the solar collector continuously absorbs solar energy and transfers it to the heat transfer fluid, which in turn heats the water in the storage tank. The circulation system ensures the transfer of heat from the collector to the tank, providing a constant supply of hot water.

It's worth noting that there are different types of solar water heater systems, including direct systems, indirect systems, and batch systems, each with slight variations in the working mechanism. However, the general principle of harnessing solar energy to heat water remains consistent across these systems.

Community Scale Approach to Solar Hot Water:

This report focuses on the energy savings and environmental benefits of community-scale solar water heating systems. In this context, “community-scale” describes both the size of the system and an adherence to a set of design principles. Community scale systems occupy an intermediate space between the domestic and utility scales.

This report defines community scale systems as those able to meet the hot water demands of tens of residential buildings up to hundreds of residential units with greater than the minimum solar fraction required by law. Community scale energy systems are intended to make maximally efficient use of local resources where possible and create a range of options for residents to contribute to its operation. According to the CEC and National Renewable Energy Laboratory (NREL), community scale solar energy projects should include the following considerations.

- **Primary Considerations**
 - Make economically optimum use of local space and resources when and where possible.
 - Develop community scale energy infrastructure in a socioeconomically equitable manner.
- **Secondary Considerations**
 - Improved project siting
 - Exploration of new models for service delivery and project financing. A community scale approach to solar water heating in LA County is consonant with the considerations listed

above. LA County has a mild, Mediterranean climate with abundant sunshine, but land use and development patterns range from densely populated urban areas to near-rural exurbs.

In places where residents cannot afford to install separate domestic systems, or where space for system infrastructure is limited, a community scale approach offers opportunities for all participants to receive the benefits of solar water heating and support their system's operation. Residents may contribute by allowing system infrastructure to be installed on their property, or by contributing financially if they do not own property on which collectors or tanks can be placed. Studies of solar district heating in Northern Europe suggest that there are positive returns to scale for solar water heating systems.

WHY SHOULD WE TOOK IT SERIOUSLY ?

1. **Energy Efficiency:** Solar water heaters are highly energy-efficient as they utilize the sun's energy, which is a free and abundant resource. By converting sunlight into heat, they can provide hot water without relying on traditional energy sources like electricity or gas.
2. **Cost Savings:** Solar water heaters can significantly reduce energy costs for heating water. Once installed, the operation costs are minimal since the primary energy input, sunlight, is free. This can result in substantial long-term savings on utility bills, particularly in areas with high electricity or gas prices.
3. **Environmentally Friendly:** Solar water heaters are environmentally friendly because they harness renewable energy and produce zero greenhouse gas emissions during operation. By reducing the reliance on fossil fuels, they contribute to mitigating climate change and promoting a cleaner and more sustainable future.
4. **Independence from the Grid:** Solar water heaters provide a degree of energy independence. By generating hot water using solar energy, homeowners or businesses can reduce their dependence on external energy providers. This can be particularly advantageous in remote areas or during power outages, ensuring a continuous supply of hot water.
5. **Long Lifespan and Low Maintenance:** Solar water heaters are designed to be durable and require minimal maintenance. With proper installation and regular inspections, they can have a long lifespan, often exceeding 20 years. This reduces the need for frequent replacements and lowers maintenance costs.
6. **Versatility and Adaptability:** Solar water heaters can be integrated into both residential and commercial buildings, ranging from single-family homes to large-scale applications. They can be customized to meet specific hot water demand requirements and can be used for various purposes, including domestic hot water, space heating, and swimming pool heating.
7. **Government Incentives and Rebates:** Many governments and local authorities offer incentives, tax credits, or rebates for installing solar water heaters. These incentives

aim to promote renewable energy adoption, making solar water heating systems more financially attractive and accessible.

8. Increase in Property Value: Installing a solar water heater can increase the value of a property. Potential homebuyers are increasingly interested in energy-efficient and sustainable features, and having a solar water heater in place can make a property more appealing and marketable.

Overall, solar water heaters provide a reliable, cost-effective, and environmentally friendly solution for meeting hot water needs while reducing energy consumption and carbon footprint.

SUMMARY

Reducing greenhouse gas emissions from the residential housing sector is an important part of Worlds attempt to shrink its carbon footprint, and prioritizing the most carbon intensive end-uses is essential to success. Residential water heating in big cities represents a quarter of household energy consumption, and the vast majority of residences use natural gas to heat water. Substantial energy savings can be realized if the share of renewable energy used to heat water were increased. This analysis explores the potential of community scale solar water heating systems to reduce residential natural gas consumption and generate energy savings.

The *Solar Water Heating Report* is the first part of the larger analysis. This report reviews the available solar thermal technologies and system types for community scale solar water heating systems. The resulting community scale system design based on climatic conditions, energy storage requirements, applicable building and energy efficiency codes, and cost. Based on these considerations, community scale systems considered in this analysis will be closed, active systems with flat plate collector arrays. Determination of basic system characteristics is a prerequisite for estimating their potential energy savings.

