AN EFFICIENT WAY TO STORE AND PERENNIALLY USE SOLAR THERMAL ENERGY BY COUPLING WITH HIGH TEMPERATURE HEAT PUMP

Summary

The paper investigates an innovative idea of using solar thermal energy for supply of district heating water 24x7 throughout the year. It arrives at a cost-effective design that is universally applicable at almost any location without any major changes in the design. Due to its fluctuating irradiance, it is considered to receive solar energy, whenever it is available, and store it for later use on demand. Using ASHP, solar thermal energy is stored at a higher temperature in pipes carrying a suitable liquid and located underground. The stored liquid exchanges heat with the water stream and is supplied to the user. Thus, the sources of stored energy are mainly Solar and Energy from Air. Electrical energy is required to operate ASHPs, part of which also contributes in heating the refrigerant. This innovative approach ensures uninterrupted supply of district heating water at a competitive cost. A large space filled with hot air is available within the Thermal Envelope that is proposed to be used for drying of fruits and vegetables.

Keywords: Solar thermal, Energy Storage, Air Source Heat Pump (ASHP), Solar water heating, Solar drying
Field of application for the findings: District Heating Network
Addressed audience: Persons engaged in Science and Technology of Solar Energy and Heat Pump

1. Introduction

The document explores the possibility of perennial use of solar thermal energy for various applications, which are economical, easy to operate and maintain. Solar power is categorized as a variable renewable energy source, due to its output fluctuating based on predictable factors like the time of day and season, as well as unpredictable weather conditions like cloud cover. So it is necessary to think of storage for its perennial use. Analogous to photovoltaic systems, there are thermal batteries in a solar thermal system (Caldera, 2026). Usually they are versatile units that receive and store energy from any thermal source including solar energy. In this presentation, it is proposed to receive solar energy without concentration and store it for later use, making it a reliable source addressing solar's intermittency.

2. Challenges and Innovation

There are several challenges of conceiving a solar thermal storage system. It is proposed to innovatively link up solar energy as directly received and absorbed in the system, with high efficiency heat pumps, to make a storage system that can supply thermal energy at the required temperature on demand. The system is perceived to have several new features and merits outlined below:

The innovative aspects include its robust design concept for supplying hot water 24 x 7 throughout the year, utilising inexpensive solar energy, whenever available and storing at a high temperature with the help of ASHP. Another important aspect is the prospect to utilise the hot space inside the system for drying of fruits and vegetables. This can happen simultaneously with the supply of hot water. It would certainly consume energy but a good part of it would have been lost if this approach was not incorporated. Other features worth mentioning is its universal application irrespective of location, high reliability, low operating and maintenance costs and good efficiency. Further, the technology development in high temperature heat pumps can be directly coupled to this system which would open new areas of application.

3. Details of Proposed System

In the proposed system, thermal energy is stored in pipes carrying suitable liquid and located underground. The maximum temperature of the liquid is around 90 degrees Celsius, only to make the overall system economical and yet good enough for supplying hot water at around 60 degrees C. Simultaneously, it provides space for drying of food items between 30 to 40 degrees C. This arrangement makes good use of thermal energy available within the system.

The input to the system is via three sources:

- Solar energy
- Energy from air routed through suitable ASHPs located within the system but admitting ambient air
- Electrical energy that is required to operate such ASHPs

The percentage contribution of each varies mainly upon local conditions. However, average values can be worked out for continuous operation throughout the year for any location. This innovative approach ensures availability of district heating water all the time at relatively low cost.

In this paper, the major features of thermal storage are presented in the form of a schematic diagram which is self-explaining. However, for more clarity it is described below in brief:

- **Thermal Envelope:** It is precisely a hemispherical dome made of transparent material like glass or thick plastic sheet supported on metal or fibreglass structure. The simple geometrical shape allows easy and maximum possible admission of sunlight at any location.
- **Floor:** The circular floor is dug to about 2 meters to accommodate two separate circular pipe coils, carrying the primary heat storing liquid and the heating water to be supplied to the district heating network. The larger storage pipe is typically about 20 cm in diameter and the water supply pipe is much smaller in diameter. Both circular coils are placed one above the other, the coil carrying the higher temperature liquid is placed below the smaller water supply coil. The circular cavity below the ground is covered with suitable insulation mats. The floor at the ground level is actually in the form of a network of iron rails to transport the trolleys carrying the food items to be dried. The rails can be moved to allow easy access to the underground storage pipes.
- **ASHPs:** It is one of the most important subsystems that is proposed to be located all around the periphery. It admits ambient air to the evaporator and also rejects the cold air back to ambient. As conceived, it is the heat pump that builds up the temperature of the storage liquid by taking up heat from the compressed refrigerant, which in turn exchanges heat with water and ensures its supply at the required temperature.
- **Heat exchangers(HX):** These are located within the dome, however for better understanding of the flow loops, it is shown outside the dome in the accompanying diagram. The district heating water takes up heat from the stored liquid in this unit.
- **Energy balance:** This is shown in the diagram. The values mentioned are only indicative and may vary to a good extent depending primarily on the prevailing conditions at the location and also on the nature and type of dome structure. To give an example, a double layer transparent dome with air gap can potentially reduce the thermal loss without compromising the admitted sunlight significantly.

4. Conclusion

In conclusion, we have conceived a thermal storage system that makes use of sunlight as directly received in association with high temperature heat pumps, already known for its efficiency and reliability. The space available within the system may easily be employed for drying of food items, which are placed on retractable trolleys.

5. Reference

1. caldera.co.uk March 2026

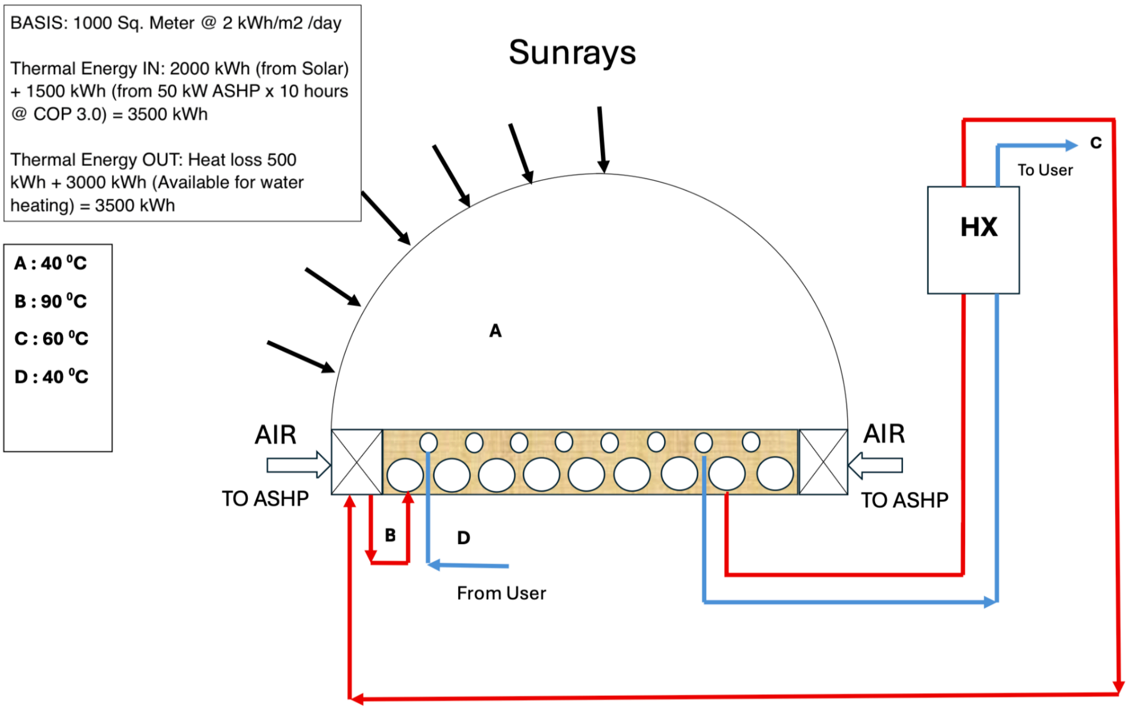

Figure 1. Schematics of the System