Solar Water Heating

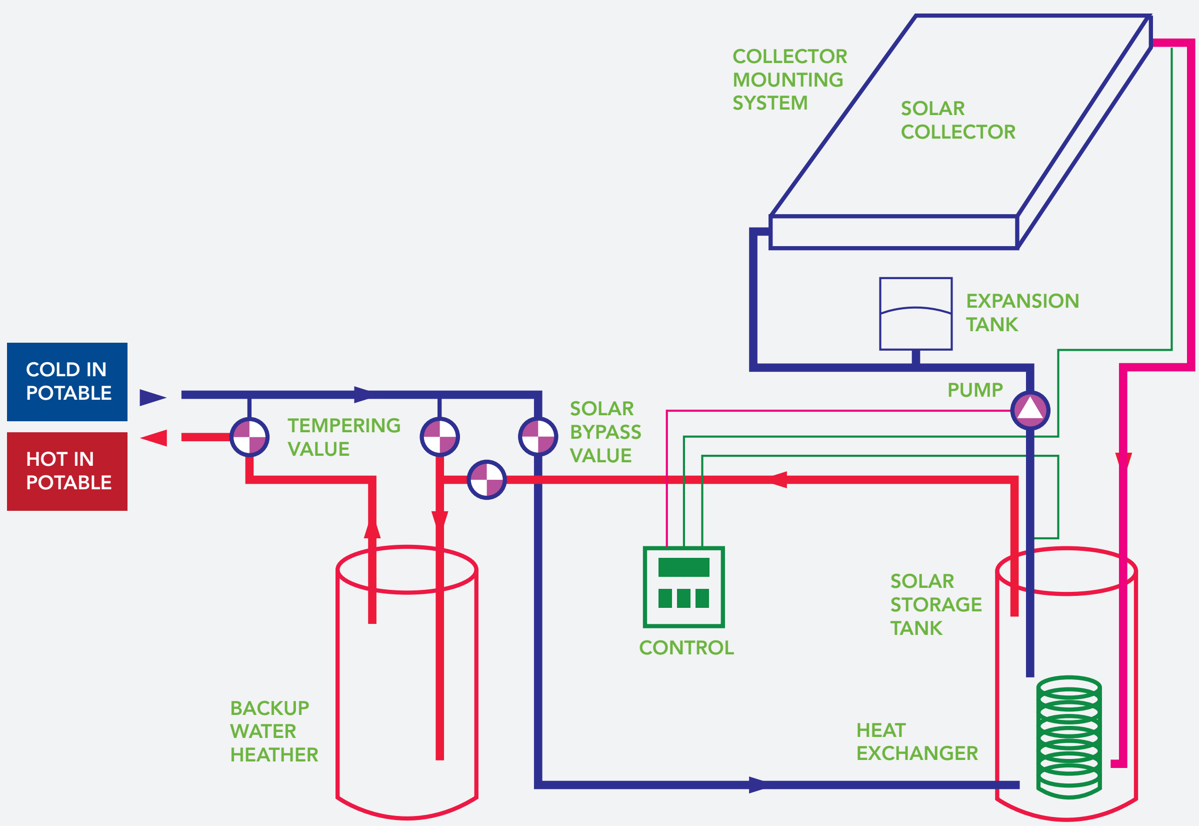
OVERVIEW

Solar water heating systems harness the sun's radiant energy to heat water and reduce the amount of purchased energy. Solar hot water systems typically are used to pre-heat domestic cold water before the temperature is boosted in a conventional water heating system. Other applications for solar water heating include heating swimming pools, specialized cleaning processes, and space heating.

In most cases, solar water heating systems result in lower greenhouse gas emissions.

TECHNICAL SPECIFICATION

Schematic of a typical solar domestic hot water system



Solar water heating systems typically consist of the following components:

- Solar collectors (unglazed, glazed, or evacuated tube);
- Solar fluid and storage tank; and
- Pumps, piping, and heat exchangers to integrate the system with existing water heating systems (along with controls).

SOLAR COLLECTORS

Solar Collectors gather the sun's energy and therefore should be oriented to the south, and as a rule of thumb should be tilted at an angle equal to the latitude angle of the installed location. There are three types of collectors, which offer different advantages and disadvantages as outlined in the following table.

COLLECTOR TYPE	ADVANTAGES	DISADVANTAGES
UNGLAZED	• Low cost • Simple installation • Durable	Usable energy produced only in the summer months
GLAZED	• Can produce energy all year and in cold climates • Durable • Can shed snow which may accumulate	Heavy/large footprint compared to evacuated tubes
EVACUATED TUBE	• Can produce energy all year and in cold climates • Can produce the highest temperature hot water • Individual tubes can be replaced if needed	• Highest cost • Tubes can break or lose their vacuum • Snow may ice up on collectors in cold climates

SOLAR FLUID AND STORAGE TANKS

Typically the solar fluid is a separate fluid from that of the fluid being heated. For domestic hot water applications, some jurisdictions such as BC require a double walled heat exchanger between the solar fluid and the water piping. The solar fluid can be water; however these systems will require a complete drain-down under freezing conditions. A water-propylene glycol mixture can be used for use in freezing climates; however the glycol reduces the heat transfer efficiency.

A storage tank is typically required to store the solar energy. Without an adequately sized solar fluid storage tank, the system can over-heat, which may cause the system to shut down. Typical rules of thumb state that the storage capacity should be 50 L/m2 collector area (source: RETScreen), however this should be evaluated on a case by case basis. Sometimes non-pressurized collapsible tanks are used and are erected in the field because it is often difficult to move a large water tank into an existing mechanical room. TPR (temperature pressure relief) valves or a heat dissipater are also used to prevent dangerous pressure build up should the system overheat.

To eliminate the risk of Legionnaires disease (a water borne bacteria that thrives at mild temperatures), it is critical that the final hot water storage tank is maintained at a temperature of no lower than 60°C.

HEAT EXCHANGERS, PUMPS AND PIPES

Heat exchangers can be of many varieties including copper or stainless steel coils in the solar fluid tank, shell and tube, brazed flat plate or plate and frame. Pumps are typically operated based on temperature differential between the tank and the collectors, and pumps distributing heat transfer fluid from the solar storage tank to the collectors can even be operated based on photovoltaic solar panels, meaning that the pumps will operate only when solar energy can be harnessed. Most drainback systems use AC powered pumps as the DC/PV powered pumps do not often have enough lift to operate.

APPLICATIONS

The most typical application for solar water systems is pre-heating domestic cold water. Indoor and outdoor pools are also good candidates. Unglazed collectors are very effective for outdoor pool applications. Chlorinated pool water can be pumped directly through unglazed collectors, avoiding the cost and complexity of installing heat exchangers. For indoor pools, any of the collectors can be used, and glazed/evacuated tube systems can be used to heat the pool water year-round. A pool is a steady load, and some systems can be installed with little or no solar storage capacity, if space in the mechanical room is an issue.

Lastly, solar water heating systems can be integrated with a hydronic heating system to provide space heat. These systems have more complex piping loops, and require more sophisticated controls. In BC's climate, the only method of providing complete space heating through the sun's energy is to over-size the system so that the system rejects excess heat in the summer. Other methods include seasonal storage, where heat is stored in the ground, requiring the installation of a geothermal field.

MAINTENANCE

A solar water heating system typically requires little maintenance. Collectors should be kept free of dirt and debris, because a shaded solar collector will harness little of the sun's energy. The solar fluid should be checked periodically, as the heat will eventually degrade the glycol in a glycol-water mixture. In areas with hard water, the system may need to be de-scaled. The controls should be checked and verified on a regular basis: a failed temperature sensor can shut down the system, or cause it to overheat and vent.

CASE STUDY

In 2010, a solar thermal water heating system was installed at Summerland Health Centre (SHC), a community health centre located in Summerland, BC, approximately 18 km north of Penticton.

SHC was identified by Interior Health's Energy Manager as a good candidate as:

- The climate at Summerland is good for collecting solar energy as it gets an average 2,085 sunshine hours a year;
- SHC's domestic hot water system was due for an overhaul, therefore two projects were merged.

The solar thermal components were fully installed and integrated with the existing building water heating system by the end of December 2010. The system started providing solar heated water to the building at the end of April 2011. The direct digital control (DDC) system was used to obtain solar energy gain between April 28th and July 15th 2011 for monitoring and verification (M&V).

During the M&V period, the solar system provided 57 GJ of heating energy. Prorating this for a full year, the annual solar energy that could be delivered to the domestic hot water system is calculated to be 140 GJ. If this heating energy was to be generated by a natural gas heater with an AFUE of 70 percent, 200 GJ of gas would be required. At the current natural gas rate (including the carbon tax and GHG credit) of $9.20/GJ, the total annual cost avoidance is $1,850.

Although the savings did not justify the capital investment, the installation was sponsored as a demonstration project by the BC Government under PSECA [1], NRCan [2] and Terasen Gas (now Fortis BC).

This case study was prepared by **Prism Engineering Ltd** for **The Climate Action Secretariat, BC Ministry of the Environment** with support from **Solar BC**, **Fortis BC** and **BC Hydro**.

[1] Public Sector Energy Conservation Agreement

[2] Natural Resources Canada