CREATE!

Center for Renewable Energy and Appropriate Technology for the Environment

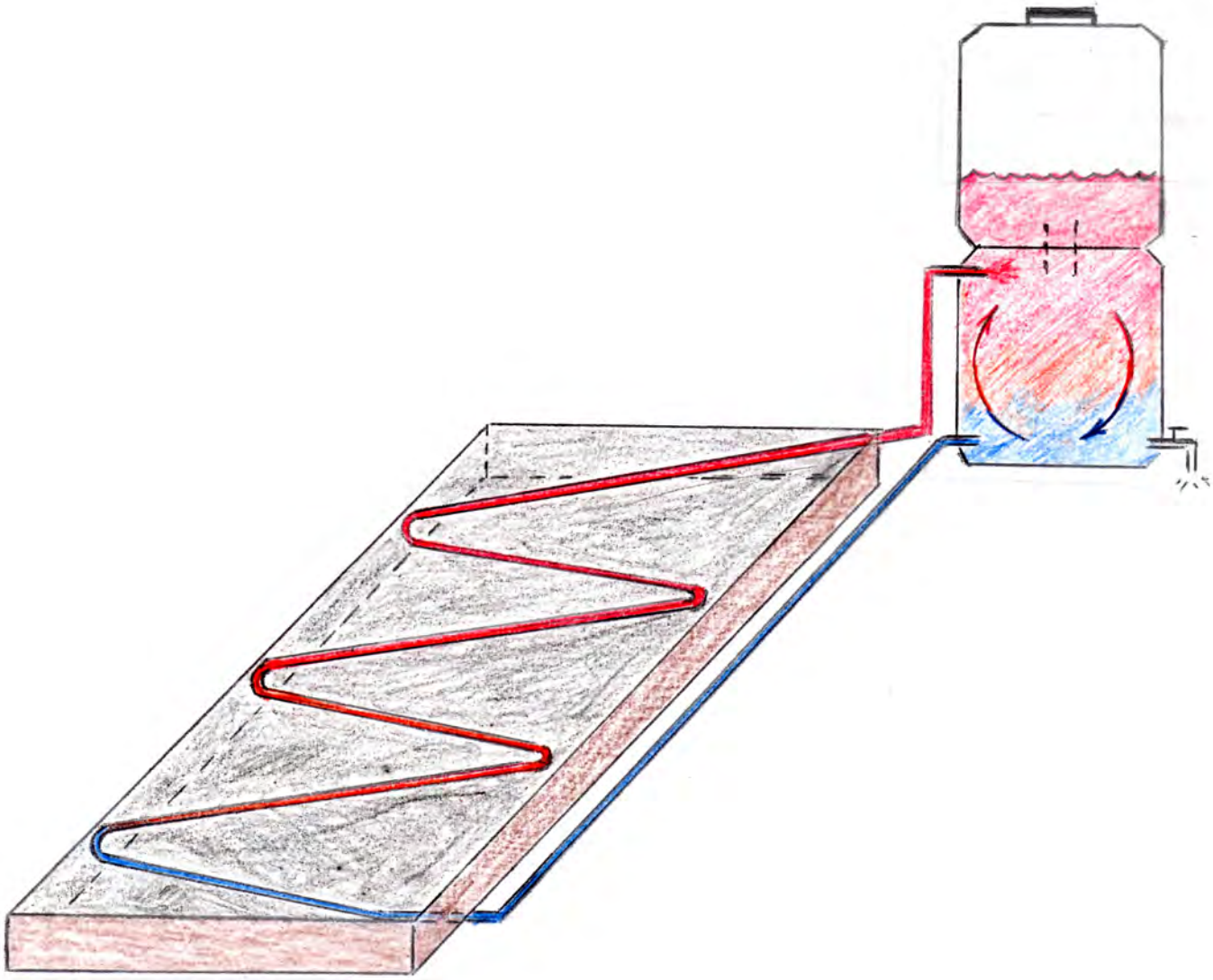
www.createaction.org

Eugene, Oregon
U.S.A.

Gossas, Senegal
WEST AFRICA

Passive Solar Thermosiphon Hot Water System

A Low-Cost Village Appropriate Technology



Overview: The *CREATE!* passive solar water heater is a low-cost, easily accessible solution for producing hot water for daily use in health posts and maternity wards in non-electrified villages in rural Senegal. The small-scale *CREATE!* solar hot water system is easy to understand; easy to build and replicate; and uses only locally available tools and materials in its construction. It operates using no solar PV panels; no electricity; no pumps; no moving parts; and no fuel other than renewable energy from the sun. Once built, it can last for many years, serving rural villagers and improving their lives and the lives of their children.

How Does It Work? The passive (no electricity) solar water heater works by converting sunlight (solar radiation) directly into heat in a solar collector; transferring the stored heat to copper tubing through which water is heated and circulated; and rises by natural convection the length of the solar collector box and into an adjacent storage barrel. The hot water storage barrel is elevated slightly higher than the top of the solar collector, which is oriented towards the arc of the sun (either north or south, depending on the latitude) and tilted at an angle greater than 15 degrees to facilitate the natural rising of hot water by convection. The hot water continues to circulate to, and through, the storage barrel until all the water in the barrel is the same temperature as the water in the solar collector.

The Parts: The essential component parts of the system include:

1. ***A solar collector:*** This is essentially a rectangular box (e.g. 2 m. x 1 m. x 15 cm. high) made from wood, metal, cement or adobe bricks. This box becomes a solar collector when:
    - The bottom of the box is filled with 10 cm. of locally available insulation (e.g. sawdust, wood chips, cotton, or kapok).
    - A piece of sheet metal or sheet aluminum, the same size as the box, is placed on top of the 10 cm. of insulation; this is called an absorber plate.
    - Flexible copper tubing (approximately 1.5 cm. in diameter) is affixed to the absorber plate in a serpentine configuration, from the bottom of the absorber plate to the top, exiting at the top of the box.
    - The absorber plate and the copper tubing are painted **black**.
    - A pane of safety glass, the same size as the collector box, is secured and sealed on top of the solar collector box, enclosing it, preventing any hot air leaks.

2. ***A Storage Barrel:*** The barrel is insulated with a black wool blanket, with a conduit pipe (same diameter as the copper tubing) exiting the bottom of the barrel and connected to the copper tubing at the bottom of the solar collector box; likewise, the conduit pip connects the copper tubing exiting the top of the solar collector to the top of the barrel.

3. ***A Fill Barrel:*** This barrel, the same size as the storage barrel, is placed on top of, and is connected to, the storage barrel with a short PVC pipe (approximately 6 cm. in diameter) to allow water from the fill barrel to fill the storage barrel. When filled, partially or fully, this ensures that the water in the storage barrel is **always**

higher than the hot water "in" pipe at the top of the storage barrel coming from the hot water "out" pipe exiting the top of the solar collector. This protects the "thermosipon" effect (defined as "an arrangement of siphon tubes that enables water in a heating apparatus to circulate by means of convection"), which ensures the continual circulation of water from the bottom of the storage barrel, into and through the solar collector, heating the water as it rises, to the top of, and into, the storage barrel.

4. ***Plumbing Fittings:*** Brass or copper T's, elbows, and conduit piping to connect the storage barrel to the copper tubing in the solar collector.

5. ***A Small Faucet:*** The faucet draws hot water from the storage barrel, when needed.

The Principles: These must be understood and **respected** for the solar thermosiphon hot water system to function properly and efficiently:

1. Sunlight (light energy, short wave radiation) is highly energetic and passes easily through glass;

2. Heat (long wave radiation) gets trapped in the glass enclosed solar collector and can't penetrate or escape through the glass;

3. A black body absorbs light;

4. Light energy is absorbed in the black solar collector and converted to heat by striking metal, a good conductor; copper is an excellent conductor of heat, especially when painted black;

5. Hot water (or air) rises naturally by convection. Colder, more dense water (or air) falls;

6. Insulation is critical in keeping heat, once collected, from escaping – either from the solar collector or the water storage barrel;

7. The solar collector must be oriented towards the arc of the sun at solar noon (north or south, depending on the latitude of the location. In villages where *CREATE!* works, for example, the villages are located at approximately 14 degrees N. latitude; therefore, for approximately 8.5 months of the year, the arc of the sun is in the south [mid-August to early May]; for approximately 3.5 months of the year, the arc of the sun is in the north [early May to mid-August]). The solar collector must also be tilted at a tilt angle that: a) maximizes light transmission through the glass; b) minimizes reflection; c) maximizes light absorption by the black body (solar collector absorber plate, including the affixed black copper tubing); and d) which facilitates the natural rising of hot water by convection;

8. Size the desired hot water capacity in the storage barrel to the appropriate surface area of the solar collector: 40 – 80 liters of hot water/m^2 of collector area.

The Process:

1. Orient the well-constructed and well-insulated black solar collector towards the arc of he sun at a tilt angle of at least 15 degrees. Fix in place.

2. Mount the storage barrel and the fill barrel securely, adjacent to the solar collector and elevated slightly higher than the top of the solar collector.

3. Connect the "cold out" conduit pipe from the bottom of the storage barrel to the copper tubing affixed to the absorber plate at the bottom of the solar collector; connect the "hot out" conduit from the copper tubing at the top of the solar collector to the top (side) of the storage barrel.

4. Install a water faucet at the bottom of the storage barrel, on the side opposite the solar collector.

5. Place and secure the fill barrel on top of the storage barrel, with a short pipe connecting the two barrels, to permit water from the fill barrel to **completely** fill the storage barrel, thus protecting the thermosiphon and ensuring continuous circulation of heated water.

6. Insulate the two barrels with heavy black blankets.

7. Completely fill the storage barrel with water through the top of the fill barrel.

8. The cold water at the bottom of the storage barrel will flow by gravity and water weight into the bottom of the solar collector. Water, seeking its own level, will completely fill the serpentine configured copper tubing in the solar collector and up to the "hot in" conduit pipe at the top of the storage barrel.

9. Continue filling the fill barrel, partially or completely, to ensure that the storage barrel is full.

10. The coldest, densest water will flow from the bottom of the storage barrel to the bottom of the solar collector; the heat generated in the solar collector will heat the water passing through the black copper tubing, causing it to rise naturally by convection to the top of the collector, out the collector, and into the top of the storage barrel.

11. The water will continue to flow and circulate in this way until all the water in the barrel is the same temperature as the water in the solar collector – and then it will stop, having achieved equilibrium.

12. The water temperature achieved by the passive solar thermosiphon hot water system is typically too hot to comfortably touch: greater than 45 degrees C (113 degrees F). Cold water can then be mixed with the hot water to achieve the desired temperature for use in the health clinic and maternity. The size of the storage barrel could also

be increased to both increase the quantity of water stored and available, and to reduce the overall water temperature in the barrel so that the water is not too hot.

13. After drawing hot water from the storage barrel, ensure that cold water is added to the fill barrel to ensure that the storage barrel is again completely full to protect the thermosiphon and allow for continuous circulation.

It works, silently and continuously, fueled only by the renewable energy of the sun!

CREATE!

Center for Renewable Energy and
Appropriate Technology for the Environment

www.createaction.org