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Understanding Solar Types

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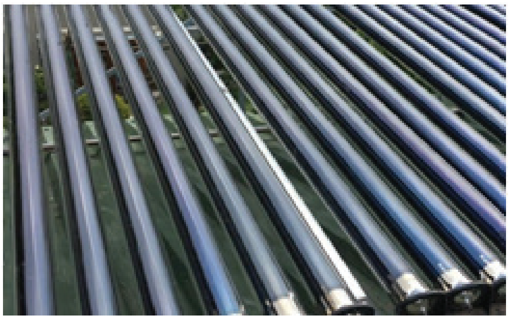
Understanding Solar Water Heating Technologies, Advantages, Disadvantages, Types and Our Opinions

1 Initial Steps to Understand

There are 2 main components; the solar collector and the tank.

The solar collector is the ‘engine’ of the system, collecting solar irradiation (see below) and converting it into hot water, stored in the tank or geyser.

In our systems, we use evacuated tubes because of their lower cost and higher efficiency.



Evacuated Tubes

High Pressure Geyser

The larger, or rather the more powerful, the ‘engine’, the more hot water, and the more kWh saved.

The tank is the battery, or more accurately, the storage of the hot water that has been generated by the solar collector.

Matching a solar collector to the tank size enables electrical savings ranging from 60% to 100% and in much the same way determines the amount of hot water available from the geyser and at the tap.

Ubersolar fits the solar collector on the roof, not the tanks.

2 Solar Water Heaters Types and Designs

While solar system manufacturers or their suppliers may claim that one design type is better than another, when comparing all the different types without prejudice or self-interest, there are some basic fundamentals.

All solar water heaters have the same aim, to heat water using solar irradiation (see below).

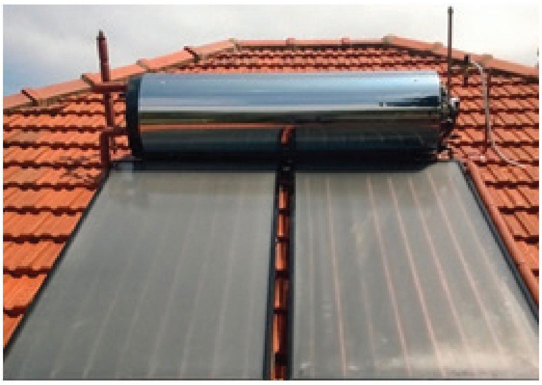
There are numerous different design types as described below.

3 Integrated Systems

a) Integrated systems where the solar collector is inserted into the tank, means that the tank has to be on the roof.
b) The width of the tank limits the number of evacuated tubes (normally 58mm in diameter) that can be insert ed. Consequently, the amount of energy that can be put into the water is limited.
c) The tubes normally use heat pipe risers, with the bulb (at the top of the riser) either inserted directly into the potable water or into a dual jacket type tank, or use a heat exchanger design.
d) Maximum temperature control (in the tank) is difficult, as the EVT's cannot be stopped from heating the water.

4 Close Coupled, Thermo-syphon, Direct or Indirect, Evacuated Tube with heat pipe risers, or Flat Plate

Close coupled, direct, thermosyphon, HP with tank



Close coupled,indirect,flat plate, thermosyphon, HP tank

a) Normally seen with the tanks on the roof, but tanks can be located inside the roof void, as long as the solar collector is below. This requires the tanks to be elevated on stands within the roof void.
b) Uses the principle that heat rises, with the potable water (in the tank) being heated directly, (the potable water is heated) or indirect where a heat exchanger is used.
c) The solar collector may be either a flat plate type or evacuated tubes using a heat pipe riser.
d) Flat plate types need to be filled with glycol (antifreeze) in freeze areas. Such systems require maintenance with glycol being replaced every couple of years, (an additional maintenance expense).
e) Temperature control in the tank is difficult (as with integrated types) as the thermos-syphon process is not controlled.

5 Split /Indirect/ Forced Circulation Types

30 EVT Solar Collector for 150l litres

60 EVT solar collector (30+30) for 300 litres (2 tanks)

a) The tank is separate to the solar collector.
b) The solar collector maybe either evacuated tubes using heat pipe risers, or water, or a flat plate type.
c) A forced circulation from the solar collector using a pump, powered either by mains electricity or solar PV panel, transfers the heat from the solar collector to the tank, using a heat exchanger either in the tank or in the solar manifold.
d) Tanks can be located almost anywhere, with solar collectors some distance away.
e) The size of the solar collector is not limited, as with integrated types and are frequently installed in series.
f) Temperature control in the tank is possible by turning 'off' the pump, when a tank temperature setting has been reached.
g) Flat plate types, as with close coupled thermo-syphon types, require glycol antifreeze in freeze areas, and regular maintenance including glycol replacement every couple of years.
h) Heat transfer to the potable water always employs some form of heat exchanger. This may be into a dual jacket type geyser, or a heat exchanger within the tank, or in the solar manifolds.
i) The split system enables retrofits of existing geysers, where the solar collector is connected to the potable water, using an indirect process employing a heat exchanger.
j) Providing more flexibility than either integrated types or close coupled types, shortcomings include containing the maximum temperature in the solar manifolds or flat plates when in stagnation, or when no hot potable water is being extracted from the tank. (Ubersolar systems are the one exception).

6 Tanks, Solar Geysers, Electric Geysers, etc

a) Tanks are at their simplest, a container that stores high pressure water.
b) They will have a number or ports, normally an inlet port for the cold water mains, which frequently also incor porates a drain cock (to enable the tank to be emptied), a hot water outlet for hot water to be taken to the home, and a port for the Temperature Pressure Safety valve (TP Valve).
c) Solar ready tanks generally incorporate a 4th port which can be used for connection to a solar system or heat pump, in conjunction with the inlet port for cold water into the geyser.
d) Solar tanks may have 5 ports, the 2 extra ports being dedicated for the connection of the solar collector or heat pump.
e) Larger tanks may have multiple ports for connection to hot water, and heating (radiators or underfloor).
f) Solar tanks may also include a dual jacket type, where the potable high pressure water tank, is surrounded by another tank containing solar heated water, or glycol, normally under a lower pressure.
g) Other types include piping within the tank through which the solar heated water is pumped.

Note: a 5 kW element is normally used for 300l as otherwise it would take too long

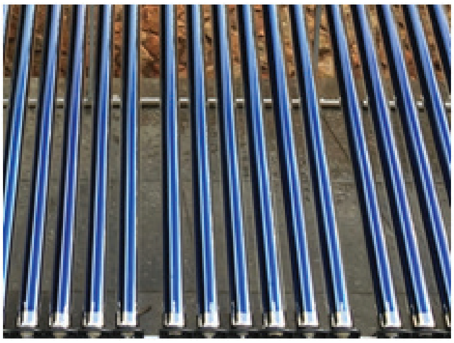
h) The enemy of all high pressure water tanks is corrosion. Corrosion is caused directly or indirectly by impurities in the water and chlorites. In turn, corrosion will limit the life expectancy of the tank.
i) To combat corrosion tanks are made of different materials. Mild steel tanks are coated with a glass enamel that is baked on during manufacturing. Polyethylene plastic liners are sometimes used but are subject to potential shrinking of the liner through repeated high and low temperatures. Fibreglass tanks are also an option. Stainless steel (304, 316, 444) is also used, and is likely to enjoy a longer life than mild steel but at considerably higher manufacturing cost.
j) All tanks need to be insulated to reduce the exposure to heat loss through exposure to the ambient air tem peratures. The more insulation or the higher the quality of insulation, the lower the heat loss.
k) Cost is the final consideration. Very large volume manufacturers enjoy the benefits of economy of scale, established distribution channels, and plumber familiarity.

7 Solar Collectors

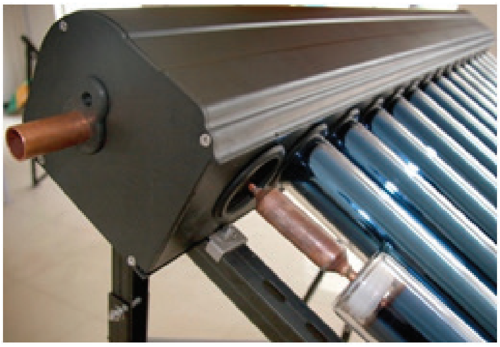
There are 3 main types of solar collectors for hot water heating.
a) Evacuated tubes
b) Flat Plate
c) Unglazed plastic collectors (normally for swimming pools)

Evacuated Tubes

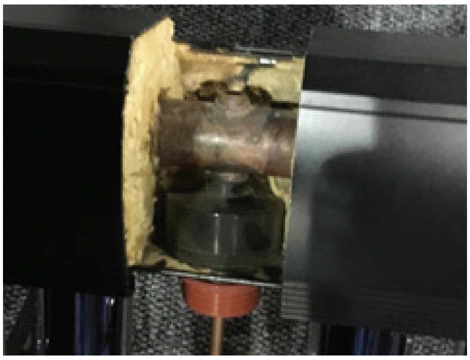
Evacuated Tubes – water filled and with heat pipe risers



Evacuated tubes (water filled)



Evacuated tubes with heat pipe risers



Heat pipe riser into heat exchange

Evacuated tubes account for around 88% of the world’s solar thermal collectors.

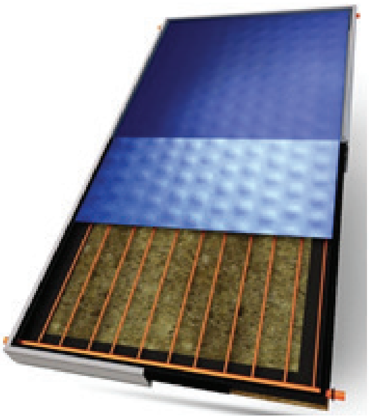
Solar irradiation is collected through the outer glass and absorbed by an inner tube coated with a selective coating for maximum absorption. Between the two glass tubes the air is evacuated, which results in very low heat loss out of the tube, using a principle very similar to a thermos flask (heat or cold cannot travel through a vacuum). Consequently, they are very efficient.

Inside the inner tube, either water or a heat pipe riser sitting within an aluminium sleeve is used to transfer heat. In low pressure solar water heaters and dual jacket tanks (high pressure solar systems) water is used. Water may also be used where a heat exchanger sits inside the solar manifold.

In high other high pressure systems, the heat pipe riser is inserted into a heat exchanger, through which high pressure water from the tank is passed.

Flat Plate Collectors

Serpentine Configuration



Vertical risers attached to footer and header pipes

Flat plate collectors are older technology than evacuated tubes.

Either water or glycol (vegetable antifreeze) is circulated through the bottom pipe up through the copper risers to the header pipe, and from there either directly into the tank (direct systems) or into a heat exchanger (indirect systems) and from the heat exchanger into the tank.

To increase efficiency the heat pipe risers are normally brazed onto a metal plate, which absorbs the heat. A selective coating maybe applied. The whole unit is encased in a frame with insulation and covered with glass.

A major disadvantage in inland areas which are subject to freezing, is that the glycol needs to be replaced every 1-2 years. This is a regular maintenance expense, and in the event is not carried out the solar system will stop working as the glycol will evapourate over time.

Solar Radiation (MJ) and Solar Efficiency

Solar water heating uses solar irradiation for heating water.

The average solar irradiation in South Africa is 20 Mega Joules (MJ) per m2. This works out at 5,56 kWh of energy hitting each square metre of ground per day.

Solar irradiation varies across the country and according to the season.

In Uppington, where many of the solar PV farms are located, the figure increases to 24MJ (6,67 kWh p/d).

At the coast, for example Richards Bay the irradiation is lower at 18MJ (5 kWh p/d) due to coastal cloud.

In areas such as Cape Town the figures change from winter to summer as a result of the weather in winter (cloud and rain) at around 16MJ (4,44 kWh p/d) and summer at around 23MJ (6,39 kWh p/d).

Solar thermal collectors are 30%-50% efficient in converting the energy hitting the solar collector.

8 Factors and Overall Energy Output

With solar water heaters, the heat that the tank reaches from cold at 16 C on an average day of 20MJ, is used to determine the output of the system in MJ.

When testing at the SABS using the SANS 6211 tests the output of the system is expressed as a 'Q' factor, which when divided by 3,6 (at 20MJ p/d) gives the power output in kWh.

As an example, a 200l tank and solar collector with a 'Q' factor of 38,6 at 20MJ p/d would be the equivalent of 10,72 kWh (38.6 / 3.6 = 10,72 kWh)

To heat 200l from cold at 16degC to 60degC with an electrical resistance element would require 10,23 kWh of energy. (Volume 200 litres X temperature differential 44degC / 860= 10,23 kWh's).

With a 200l solar system that is giving out 10,72 kWh the system is over 100% efficient in replacing the electricity that would be used by the electrical element. The temperature in the tank would reach 62degC.

9 What we at Ubersolar Think Matters

In the preceding section, we have described various solar water heating technologies.

What we believe really matters is not how the technology works, but how it performs and this means both hot water and financial performance, or put another way what you get for your investment.

The output of the solar water heating system in kWh's enables all of the information you need to make an informed educated decision. Without it you will be investing in solar technology on salesperson promises and may well end up disappointed.

To recap the (deemed) solar output in kWh will give you approximately 36 litres per kWh at 40 C at the tap. This enables you to decide on the size of system you need, not based on the tank size, but on the performance of the solar system.

The deemed kWh output enables you to calculate the expected daily savings in Rands, by taking the cost per kWh and multiplying it by the solar output. This in turn enables you to calculate the payback period, (the number of months it will take you to get your money back).

The same basis enables you to estimate your financial savings over any period.

Additional considerations are maintenance costs. Evacuated tube types will generally require minimal maintenance other than the occasional washing down of the tubes.

Flat plate collectors also require occasional washing down, but inland will also require annual or biannual glycol replacement (typical cost R1,500 per external service visit).

Aesthetics are also a major consideration particularly in housing complexes where tanks are not allowed to be put on roofs. In these cases, split indirect systems are the best option.

Reliability is also a consideration. Overheating is one of the big enemies of solar thermal technologies, and with integrated and thermosiphon type systems is difficult to control. Protracted periods of 'wet stagnation', where no hot water is being used can result in component failures and voiding of warranties.

10 Conclusion

Solar water heating while simple in concept, like everything else, is more complicated when one starts researching the subject.

The guidelines above (hopefully) provide you with the information to avoid mistakes.

At Ubersolar our approach is to provide you all the information you need.

Offering both retrofits, where the existing electric geyser is used, as well as complete systems, our general advice is to always go for the most powerful systems as they will provide more hot water and better financial returns.

Being 'plug and play' solar systems can be added to at any time to provide more hot water and greater electricity savings.

With the price of electricity going up, and it will for many years to come, solar water heating will prove to be one of the best investments you will ever make.

James Green,
CEO Ubersolar