The facts about solar water heating. rev 3.0

Do they really work?

Some do and some don't

Whether a solar water heating system will provide any real benefit is purely a function how much energy the volume of water in question requires and how much energy the collector can deliver and when.

The energy required to heat for example, a 200L geyser by 40 degrees Celsius is 9.13kWh.

Systems currently listed on the Eskom web site show products with energy delivery ratings from 3.74kWh to 9.23kWh for 200L systems.

This rating is known as the Q factor. It is produced from SABS test measurements and indicates the heat output from an insolation[1] level of 16MJ or 4.44kWh/m2/day of sunlight energy.

This means that the 3.74kWh product will provide 41% of the energy required whereas the 9.23kWh product will deliver 101% of the energy required to achieve a 40-degree temperature rise in the 200L of water at the 16MJ datum.

Many systems available on the subsidy scheme are, in my opinion, under powered some of which are even S ABS Mark approved. Unfortunately, mark approval in the case of Solar Water Heating equipment does not indicate that the product is fit for purpose.

The minimum output energy rating required for approval being only 2.5kWh regardless of the volume of water into which the energy is being delivered. Typically in a 200l geyser 2.5kWh is just enough to keep the water hot. It will not provide sufficient energy to reheat the water used.

Make sure you select a product with a High Q Factor and compare it to the required to heat the volume of water in question.

See the Sky Power Product Performance Evaluator:
http://www.skypower.co.za/content/calculators/power_demand.asp

When will the energy be delivered?

Part of the time or all of the time

The unwritten expectation of the public is that a solar water heating system will perform all year round. Sadly this is not the case with many products.

In a very obvious statement, "energy output from solar heating systems is directly proportional to input energy from the sun".

Which means that system performance will be variable with season and the weather as well as location i.e. latitude.

At what point in the year then does a solar collector deliver the rated amount of energy equal to the Q factor? Or to put it another way, typically when in the year is the sunlight received equal to the SABS standard day?

[1] Insolation is the measurement of the suns radiation falling on the earth.

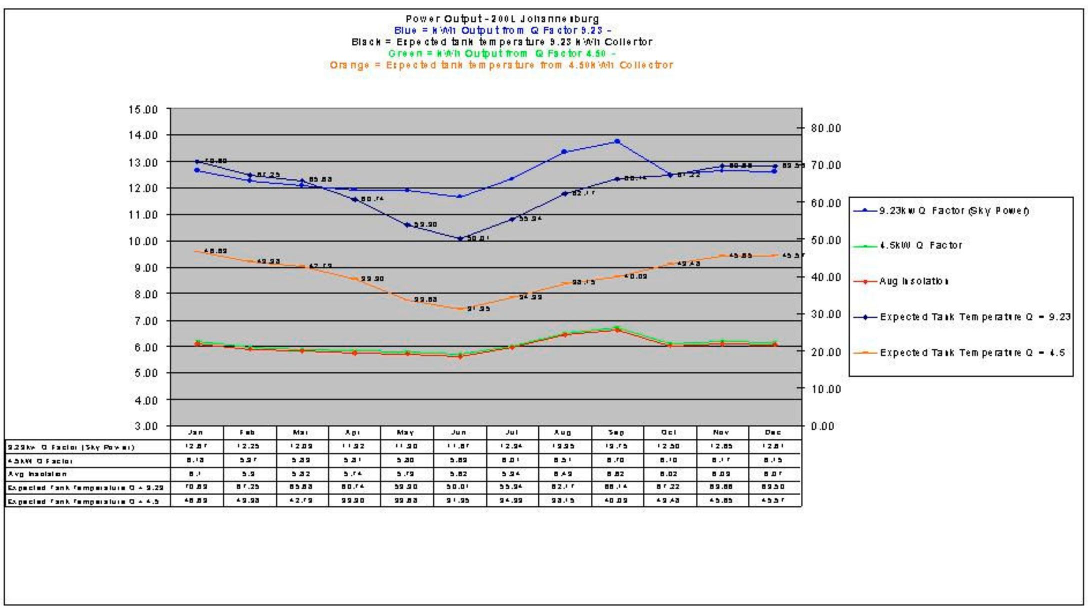
The table below shows insolation data for Johannesburg latitudes on a horizontal surface and inclined surfaces at two different angles of inclination. Since solar radiation absorbed by a collector on an inclined plane is somewhat different to that on a horizontal plane, inclination is important.

Table 1.

Lat -26.08	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lon 27.54													Average
Horizontal	6.76	6.23	5.62	4.9	4.44	4.04	4.38	5.09	6.02	6.18	6.66	6.83	5.59
Tilt 26	6.1	5.9	5.82	5.74	5.73	5.62	5.94	6.43	6.62	6.02	6.09	6.07	6.01
Tilt 41	5.33	5.4	5.57	5.82	6.11	6.14	6.44	6.72	6.5	5.58	5.38	5.26	5.86

Depending upon the angle of the collector; output performance therefore would track this energy with final output being dependent upon both size and efficiency of the collector under test. Its rated Q factor being achieved when insolation is equal to the measurement datum of 4.44Kwh/m2/day. Typically occurring in May in Johannesburg when measured on a horizontal plane.

Given that most systems will lie on an inclined roof however inclination is important as this effects how much energy is available. Fortunately in Johannesburg a very typical roof slow is approx. 26^{o} as it is almost the same as our latitude. It can be seen above that inclination at 26^{o} helps to reduce the summer power level and boost winter performance a little. Sadly however performance at different latitudes, Cape Town and Durban for example, the picture is not so rosy. Requiring much steeper elevations to obtain desirable year round delivery.



Graph 1

The graph above attempts to show how power output from a collector will vary according to season at optimum inclination and tries to forecast expected achievable water temperatures adjusted for cold water input temperature. Two products are shown, one delivering 9.23kWh and the other delivering 4.5kWh . The results should be considered as indicative rather absolute, since there are many variables that come into play that can effect final results.

It can be seen that the higher performing collector will deliver good water temperatures in the region of 50 degrees in winter whereas the lower performing product is only capable of producing water temperature in the order of 23 degrees or so..

The correct inclination also helps limit maximum summer temperature even before temperature limiting control mechanisms are applied. Thus the product is prevented from overheating in summer as is therefore safe, whilst still delivering outstanding winter performance.

What about losses?

What you lose you pay for

Losses from a geyser are affected by a number of factors. Firstly the geyser insulation itself, whether it has an additional blanket and if the pipe work to and from the geyser are insulated.

Standing loss, the natural tendency of a geyser to cool down is a measured parameter in all SABS tested tanks.

The average standing loss of a typical 200L geyser would seem to be in the order of 2.3-2.6 kWh /24hrs.

This means that a typical geyser will cool down by approx. 25% over a 24-hour period.

So a geyser heated to 60 degrees will have cooled to approximately 45 degrees 24 hours later, in theory. An additional geyser blanket can reduce this loss by as much as 25%

Further additional losses, which are more variable and difficult to calculate also come into play. What I call “the spoon in the tea syndrome” Heat loss through attached pipe work.

This can probably account for as much as another 50% if the pipe work is not adequately insulated.

So the best performing system on the Eskom web site will probably be able to deliver enough energy for at least 11-12 months of the year. Requiring some limited additional top up from electrical heating for up to 1 to 2 months of the year. Whilst the worst performing system on the list will probably need constant electrical top up throughout the year.

Retrofit to existing or complete replacement

Solar geysers for which you pay a premium are required to have a better standing loss performance than a standard geyser.

The SABS spec states that a 200L Solar geyser must achieve 2.26 kWh or better. That’s only 0.04kWh better than a popular brand of standard geyser. A good argument in itself to uses a system that will fit to your existing geyser rather than buy a new one.

In terms of losses there is often no significant difference between a solar geyser and a good standard one with adequate insulation. Greater losses come from un-insulated pipe work.

Cost per kilowatt-hour
(for the capital cost of the system)
The true cost of the system.

Again using the Eskom web site as the source of data. Indicated installed pricing varies from R22, 700 down to R14, 900.

The Q factor explained earlier is used by Eskom to determine the value of the subsidy for which the product will be eligible. The subsidy has recently been revised and in no longer applied linearly relative to Q factor.

Nonetheless a products Q factor can be determined from its subsidy value though the calculation is more complicated then before.
Please visit our web site for our product performance evaluator. This allows you to calculate the Q factor and an estimate of how much energy any system will deliver from solar input.

The calculator also provides a "cost per kilowatt hour" comparison to help you select a suitable product by comparing apples with apples.

http://www.skypower.co.za/content/calculators/power_demand.asp

It is imperative that purchasing decisions be made on performance/price rather than just price.

But which is the most cost-effective product to buy? Divide the Q factor by the indicated pricing and you come up with a price per Kilowatt-hour. Figures range from R1874 to R3995 per kWh.

Still be wary however of any very low offerings as this might indicate the supplier is allowing insufficient funds to provide a reliable after sales service.

What about financial payback?
Approximately 5 years

A typical 200L geyser uses an average of approximately 11-13 kWh per day to maintain the temperature at 60 degrees. At the current 39c/kWh this resolves to R4.29 per day or 1565.85 per annum.

With projected Eskom tariff increases of 30% per annum the recovery point for a system delivering 9.23kWh into a 200L tank will be reached between 5 and 6 years based on the installed price of the 9.23kWh product of R17, 300

Anything less powerful than 9.23kWh into 200L will take correspondingly longer to recover.

	kWh Cost	Annual Saving
Year 1	R 0.39	R 1,575.89
Year 2	R 0.51	R 2,048.65
Year 3	R 0.66	R 2,663.25
Year 4	R 0.86	R 3,462.22
Year 5	R 1.12	R 4,500.89
Year 6	R 1.46	R 5,851.16
Total		R 20,102.07

See the Sky Power Payback Calculator: -
http://www.skypower.co.za/content/calculators/power_demand.asp

Any 200L product with a lower Q factor forecasting a shorter payback will be overly optimistic.

<u>What about the Eskom subsidy itself</u>
<u>Is it really worth going for?</u>
You decide

Unfortunately whilst it is a step in the right direction, the Eskom subsidy is very rigid in its structure and as a result is not working very well as its testing requirements favour many of the poorer performing and older flat plate products with integrated tanks.

Only the specific systems tested by the SABS are eligible for subsidy. And therein lies the problem, the definition of the word "system".

SABS testing specs were written many years ago after a number of problems with flat plate type products failing due to their susceptibility to frost damage, amongst other things.
The nature of the construction of these old designs of systems meant that most had an integral tank and were close coupled to a flat plate absorber. The design was fixed.

Specs were written to suit these fixed configuration products as complete systems.

With the advent of vacuum tube technology, solar collectors can now be fitted to almost any standard geyser, either as a retrofit to an existing geyser supplied as part of a new install.

Given that the test specs were only written to test complete systems. The powers that be in the SABS deemed it necessary to test every solar water heater as a complete system, locked together with not only a particular size but also the brand of geyser.

So suppliers of solar collectors suitable for retrofit installations are currently required to test their products in conjunction with many suppliers tanks e.g. Kwikot, Franke, Duratherm etc, not just the volume, each configuration being considered a different product or system. Even though each of these tanks is a separately SABS Mark approved product.

Requests have been make to the SABS to adopt international collector testing standards to test collectors independently of geysers and allow their use in conjunction with any SABS approved geyser but to date the request seems to have fallen into the "too difficult" drawer.

As a result, in order to be able to offer subsidy to any potential customer the collector supplier is required to have an SABS issued test report for each combination of, the size of tank, manufacturer of the tank and the size of collector being used.

This requirement has severely limited the number of systems available for subsidy due to the prohibitive cost of these multiple tests.

In many cases it is less expensive to forgo the subsidy and simply install to your existing geyser.

Calculate the cost per kilowatt-hour for the complete installed solution. You will see which is the most cost-effective way to go. Your return on investment will be faster. And you will often get a more powerful system.

In considering some of the regulatory requirements that restrict the offer of incentive to the public to install solar water heating systems, one can't help but question the motives for some of the regulations? Certain seem to defy good logic.

A word about configurations

Technical Yes, but really quite simple.

There are many different types of Solar Water Heater now coming on to the market offering various levels of performance and various configuration possibilities.

Pre heat vs. Primary system.

A pre heater configuration heats water in a separate secondary tank using solar energy and then feeds this pre-heated water into your normal electric primary geyser. The theory being that this can reduce the amount of work your electric geyser has to do and so save some money.

Whilst this method can provide some benefit, the down side to this is that the pre-heated water is only transferred to the main geyser when you draw water. This means that the water in the electric primary geyser must still be kept hot electrically. Therefore still using quite a lot of electricity to keep the water hot, overnight.

The power rating, i.e the Q factor, is still just as important as you still need to know if the solar collector can produce as much hot water as your will draw each day. If not the electric geyser will have still more work to do than just keeping the water hot.

A primary heating configuration on the other hand can be configured to allow the water in the tank to be hotter than required from solar input prior to the evening. Thus providing some additional energy to stay hot over night or at very least, reduce the amount of electricity required to do so.

Conclusion: Wherever possible one should opt for a Primary configuration

Thermosyphon vs. Active Circulation.

The most common image one has of a solar heater is of a roof tank with a flat plate collector positioned beneath it in what is known as a close-coupled configuration. This is the most common configuration. Known as thermosyphon, it relies on the fact that hot water rises.
Whilst this is the simplest of all configuration options, like many older designs, it has a number of disadvantages when compared to current technology.

Firstly the heat transfer rate is very slow. Secondly and more importantly it has no means to control top end temperatures.
For this reason many thermosyphon configurations are sized to prevent overheating and even boiling in summer conditions. Being undersized to prevent overheating also prevents them from offering adequate performance in winter.
Conversely correctly sized systems having no control often present dangerously hot water temperatures.

Active circulation mechanisms however whilst being slightly more complicated are able to control temperature delivery and so can provide superb winter performance without the problem of overheating in summer or if the system is unused when the property is vacant for example during holidays, etc.

This is achieve by one of two methods, either diverting water flow to a heat dump to dissipate the excess energy on large scales systems or by allowing the collector to stagnate in the case of small systems.

Whilst it can be possible to locate a thermosyphon tank out of sight in a “separated” configuration, another benefit that active circulation brings is that the storage tank or geyser can be placed anywhere as opposed having to be above the collector.

In many cases active systems can employ the existing geyser as the primary storage tank rather than having to install a second or new one.

Although flat plate systems are more commonly used in close-coupled arrangements, certain manufacturers of evacuated tube systems also offer a close-coupled thermosyphon arrangements.

These systems however are equally as prone to overheating for the same reason having no means to turn off the energy delivery once the water is at the required temperature.

The result again is that such systems are under specified in order to prevent excessively high temperatures being reached in summer.

Not withstanding this these systems can still boil if left unused during holiday periods. This is of course is potentially dangerous as well as being wasteful of water, as ultimately the systems safety valve will discharge the entire volume of water to bring the temperature under control.

To borrow a statement from a Pirelli advertisement: – Power is nothing without control

Conclusion: Active circulation provides control to achieve year round performance and protect against overheating.