# Solar Power for Metal Finishers

Part 2

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**In this second article on using alternative energy in electroplating businesses we will focus more specifically on solar thermal energy, different technologies available and we will touch on some of the key issues relevant to making an investment decision.**

We have mentioned before that between 35% and 45% of the energy used in an electroplating business is used for thermal heating applications. In other metal finishing operations like anodising and powder coating this percentage may well be lower, but this should not rule out consideration of alternative energy sources. Several different technologies for generating solar heating and even cooling are available. Most common is the classic solar water heater, which can be combined with an unglazed, glazed, evacuated tube or even a compound parabolic trough collector.

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Unglazed collectors are typically used in low temperature regimes and are highly efficient when attempting to heat a fluid medium to maximum 20 degrees above ambient temperature. Also due to their design they are able to handle much higher volumes. Depending on the usage, typical heating temperatures and other variables we may use collectors made of polyethylene, polyurethane high density nylon or even EPDM rubber. These are best used when heating a fluid to temperatures of 25 to 35 degrees.

Glazed collectors are the typical flat plate collectors seen with most domestic water heaters. Typically it is constructed with a copper heating manifold in a box with a heat absorber fin and a single glass cover on top. The absorbers could be made of mild steel or even copper and coated with a variety of different surface treatments that vary from ordinary black paint to highly selective coatings. The specific application and operating environment will dictate the best construction and design.

Depending on the design, a flat plate collector will provide an efficiency of between 50% and 60% when used to heat a fluid medium up to 50 degrees above ambient temperature. As a general rule of thumb a single glazed flat plate collector will yield about 2 times ambient temperature. Double glazed and vacuum drawn flat plate collectors have very different profiles up to 5 times ambient but with similarly higher capital cost.

**A plate collector will provide an efficiency of between 50% and 60%**

Vacuum tube collectors consist of a double glass tube with a vacuum drawn between the two layers of glass. These are designed for use in cold climates with lower radiation and thus more efficient when attempting to heat a fluid to above 60 degrees over ambient. Using a vacuum tube collector to heat a fluid below 20 degrees over ambient results in efficiencies much below flat plates or unglazed collectors. It is thus counter intuitive to use a vacuum tube collector to heat a medium to $40^{\circ}C$ if the ambient temperature is $30^{\circ}C$ outside. Vacuum tubes are better suited to heat fluids to between $85^{\circ}C$ and $95^{\circ}C$.

**A compound parabolic concentrating collector is in a way similar to a flat plate collector**

A compound parabolic concentrating collector (CPC) is in a way very similar to a flat plate collector. Instead of having a flat absorber plate however it has a small parabolic trough underneath the absorber riser, which concentrates sunlight on to the absorber much like a standard parabolic trough. They are designed for low to medium temperatures in the range of 120 to $150^{\circ}C$.

There is a common misconception that one technology is more efficient than another. The efficiency of the collector is a function of both the design and application. An expensive high spec collector, used for the wrong application could end up being much worse than a different more affordable solution.

**The efficiency of a collector is a function of both design and application**

Each of the above technologies has the advantage that as long as there is available solar radiation it uses NO electricity but will have operating temperatures and efficiencies directly correlated to the level of solar radiation.

On the other side of the spectrum we have thermal heat pumps that use a combination of thermal heated air and or direct solar radiation to heat the refrigerant gas for the compressor. Heat pumps work very well to heat large volumes of fluid to medium temperature $45^{O}C$ to $55^{O}C$ and with collectors heating the gas will see higher efficiency and lower electrical consumption but not higher temperatures. The upside of a heat pump is that it is less dependent on direct solar radiation but the down side is that when there is no electricity it does not work at all. A factory operating on a 24/7 schedule could use a heat pump as part of the thermal energy generation mix at night when a solar collector is of no use for heating.

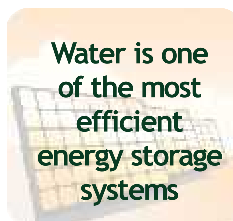
From the summary above it should be clear that there is no “one” solution that is better than the other under all conditions. It is critically important to understand the end objective and specific operating conditions and then to work with a design that will best suit the particular application. The longer the operating day of the plant the more important to use a mix of different technologies. This not only shields the business from a energy security risk but allows it to maximize the usage of the right technology at the time thus reducing electricity consumption. Also bear in mind that this


summary is purely focused on thermal heating and the use of a thermal flat plate collector for night-sky cooling applications has not been covered yet.

Now for some of the energy mathematics behind all of these technologies.

The generally accepted solar radiation constant is 1,000 watts per square meter radiation. In South Africa we typically use a solar radiation exposure of 5.5 hours per day thus a number often used in these calculations is 5.5kWh per $m^2$ per day. This is a good national annual average but will depend on the specific region where the business is located.

Durban has a higher average annual cloud cover than Upington and therefore the daily average useful radiation in Durban is in the range of 4.75 $kWh/m^2$ whereas the average daily radiation in Upington is in the range of 7.0 $kWh/m^2$, Cape Town is in the region of 5.9 $kWh/m^2$ and Johannesburg 6.2 $kWh/m^2$.




Different fluids have different specific energy levels. Water ($H_2O$) has the highest specific energy at 4.19 Joules per litre per degree and is one of the most efficient energy storage mediums. In the design of an alternative energy system, we have to consider whether we want to directly heat the process fluid during the application process or heat the process fluid through an indirect or heat exchange process with water, glycol or synthetic oil as an energy bank for later use.

Constantly processing cold metals in a preheated tank consumes a lot of thermal energy, as the energy transfers from the process tank to the process medium. The process and contact time plays a role in energy lost and is a critical factor to be brought into the

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total calculation. If the process medium (the work piece) is at the same temperature as the process solution less energy is "lost" from the tank. This in itself opens a whole new debate around architectural design of factory facilities, as many factories are poorly designed from an energy efficiency perspective. Seeing tons of ice-cold steel lying in the open and bay doors the size of Texas wide open to the outdoors while steam is flashing off process tanks is a sorry sight for an energy minded eye!

It is not difficult to add a hydronic floor heating solution that pre-heats work pieces with waste heat from the tank and other processes before it goes through the solar system and is reheated. This will greatly reduce the energy required to process the work.

As an example a 20,000 litre heated aqueous degreasing tank losing 20 degrees per hour to the process and 10 degrees per hour to the ambient conditions needs 30 degrees of make up temperature per hour, thus 30 x 20,000 x 4.19 joules of energy per hour represents 696 kW of energy. If a solar energy field delivers 5.5kWh per $m^2$ at 60% efficiency we would need 210 $m^2$ of ordinary flat plate collectors to maintain the make-up energy. 696kW @ 45c/kWh @ 8 hours per day costs R2,505 per day.

At roughly R70 per litre of process tank size it would take about 2.3 years to recoup the investment with offset energy cost. Bearing in mind that these are purely illustrative numbers and do not include future energy cost, there is a strong business case to consider using some if not all solar energy or heat pump in the total energy mix.

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Storage of energy is generally more complicated and expensive and in any investment decision should receive the bulk of the attention. Generation on the other hand is far more modular assuming the available roof or floor space can be added in bits every year.

As a general rule of thumb storage is sized at 60L for every one $m^2$ of solar collector area. It is better to invest in the biggest or perfect storage solution and start with a lower solar fraction in the beginning and make incremental investments every year to increase the solar fraction.

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Again no two businesses are the same and thus it is near impossible to give a finite answer to any single business's energy woes in an article like this. For enquiries please feel free to contact the author.

*Helmut Hertzog is the managing director of Atlantic Solar, a company with a 25 year history in the solar industry in South Africa. Helmut has a commercial background with an MBA from the UCT Graduate School of Business. He has been with Atlantic Solar since 2003 where amongst other things he constantly drives research on new and innovative applications of solar energy.*