Case Study

SOLAR GEYSER TECHNOLOGY

Pakistan

February 2013

Asim Mahmood
Director of Environmental Consultancies & Options
Email: asim@eco-intl.org

Quick facts	
Zone	Entire Territory
Topic	Solar Energy
Website	www.solar-geyser.com

Background Information

Pakistan's energy status quo is characterized by very limited natural gas resources which lead to shortages in energy supply. At the same time, due to geographic and climatic conditions, it has an abundant amount of solar energy which has been hardly tapped into, albeit having great potential as an alternative energy source.

The majority of low-income households do not have direct access to electricity; therefore they use kettles, paraffin stoves and coal burners as a means of heating water. Using these technologies to heat water can place a high financial burden on poorer households, both in terms of energy costs but also in terms of the costs associated with the adverse health effects and safety issues of burning coal and paraffin indoors.

Solar Water Geysers (SWGs) provide an excellent alternative for heating water. They draw on solar energy to heat water in a clean, safe and sustain-able manner. Energy security is also achieved by using this method, due to the independence from the market price fluctuations of non-renewable resources. SWGs are a significant solution to the national electricity generation crisis as well as the local electricity distribution constraints brought about by the increasing demand. By installing SWGs, communities can develop and improve their quality of life without straining the distribution network.

A solar Geyser works on two basic principles: firstly, dark objects absorb more heat than light ones, and secondly, when water gets hot it rises due to density differences between hot and cold water (thermo siphon effect). SWGs can be designed to function as high water pressure systems or low water pressure systems. Higher pressure systems are generally more expensive than low pressure systems. This is because the materials used for high pressure systems must be of high quality and strength in order to withstand the pressures created by the system. Low pressure systems need to be durable, but do not need to withstand any pressure other than that generated by the weight of the water they contain, keeping material costs down. Low pressure systems also do not require any additional valves to regulate the internal pressure of the system, further reducing costs. Low pressure systems are 'gravity fed' - therefore the higher the SWG is off of the ground, the stronger the water pressure will be at the water point. Mixing water, for example in a shower, is difficult with low pressure systems, as the cold water supplied by the municipality is at a substantially higher pressure than that supplied by the SWG; there are however means to overcome this issue.

The Geyser is comprised of three main parts: the collector, the storage tank and a heat transfer fluid. The collector is the part of the SWG that captures the incoming solar energy as heat, which is then transferred to the water either directly or indirectly via a heat transfer fluid. The two most common collector types are Flat Plate and Evacuated Tube collectors. The main components of a Flat Plate Collector are a transparent front cover, the collector housing, and an absorber. This technology has been used for over 50 years by manufacturers and has a well-established track record of reliability and performance. Evacuated Tube Collectors are made up of a closed glass tube, inside which is a metal absorber sheet with a heat pipe in the middle, containing the heat transfer fluid. Evacuated Tubes are a newer technology manufactured mainly in China; they generally have exceptional performance but due to their recent coming into the market, a track record of reliability has yet to be established.

As mentioned above, heat transfer can either be done directly or indirectly. In a direct system, the collector heats the water directly and the water then circulates between the collector and the storage tank; the water in the system is therefore the heat transfer fluid. A direct system can only be used in areas which are frost and lime free. In an indirect system, the collector heats a heat transfer fluid that flows around a jacket which surrounds the storage tank. The water in the storage tank is then heated indirectly. An indirect system can be used in all conditions. The fluid/water in both systems can either be circulated actively by using a pump, or passively by relying on natural convection.

There are two installation methods with regards to SWGs, Close Coupled or Split Coupled System. Close Coupled System is the most energy efficient and commonly used installation. It consists of a roof-mounted solar collector, combined with a horizontally mounted storage tank which is located immediately above the collector. Split Coupled Systems instead refer to installations where the water storage tank is situated elsewhere, usually within the roof. Where the tank can be installed above the collectors passive systems can be used (using thermo siphon to circulate water), otherwise, if this is not possible, a pump (active system) would need to be installed to circulate water through the collectors.

Cold water, which used to go directly to the electric water heater, now goes first to the bottom of the solar storage tank. As the water in the solar tank is heated by the sun (via a heat exchanger coil wrapping the bottom half of the tank), the temperature of the tank rises. The hottest water collects at the top of the tank by stratification. The pre-heated solar water then moves from the top of the solar tank to the back up heater whenever hot water is turned on in the house. As long as the SWG system has pre-heated the water, less energy is required by the back up heater. If for instance the back up water heater is set at 120 degrees Fahrenheit, and the solar pre-heat temperature is above 120 degrees, the back up water heater will not activate itself. If the solar pre-heat temperature is less, the back up heater will turn on to boost the temperature to the thermostat setting off the conventional water heater.

The SWG system is fully automatic, powered directly by the small photovoltaic module. The brighter the sun, the faster it pumps. The pump will effect some circulation if there is enough sun to cast a slight shadow. Thus, it is self-regulating. If there is no sun, the pump has no power to operate, and the system will be in a state of rest, or drained back. In the drained back state, the solar collector is empty. The system is not pressurized, so a small reservoir tank located just below the collector holds enough fluid to keep the pump primed during circulation. With the pump off, the operating fluid drains back into the reservoir tank by gravity. There is no possibility of freezing and even in the event of a power outage, the solar system can still operate during relatively sunny conditions.

Policy Details

The feasibility of installing an SWG for a small hotel currently being constructed in the city of Karachi, Sindh, Pakistan, has been assessed. The hotel will require 3,000 L of hot water per day at a temperature of 70ºC. The 8-storey building is expected to be in use 24 hours a day, 7 days a week, with an estimated occupancy rate of about 90% as it is located in the heart of the city close to the railway and bus.

Based on previous project experience, the technology proposed is a locally manufactured thermosiphon SWG system consisting of 14 glazed flat plate solar collectors with a total area of 32.3 m^2, with a rooftop-mounted water storage tank. Auxiliary water heating is to be provided via electric resistance elements in the rooftop tank. In the absence of a SWG system, the hotel would most likely install conventional gas water heaters. The conventional fuel mix that would supply the energy provided by the SWG has been analyzed to be approximately 50% from coal and 50% from large hydro. Compared with a conventional energy mix, using the SWG is expected to yield a discount of 12%. The current electricity tariff is 10/kWh and is expected to increase by 3% annually. The inflation rate is projected to be 2.5% over the 20-year life of the project, and concessional loans are available to cover up to 85% of the cost of the system at an interest rate of 5% for a period of 5 years.

The Hotel was completed in early 2002, and its SWG has enabled it to drastically reduce its potential electricity consumption since the solar energy in Karachi is particularly strong. Average daily solar radiation on a collector surface tilted at an angle of 25° to the horizontal is 5 kWh/m^2 per day, equivalent to 1,800 kWh/m^2 per year. The system proved to be very satisfactory from environmental, aesthetic and technical points of view.

A number of factors have contributed to the large-scale use of SWGs in Pakistan, especially in the commercial sector. Hot water is a major requirement for hotels, restaurants and other food processing establishments. The continuing increases in the sector's electricity tariffs as well as problems associated with the electricity supply such as outages and voltage fluctuations have spurred a market for SWG systems, which have a high financial viability due to the continuous solar exposition. The combination of these factors has contributed to the installation of over half a million square meters of collector area in the country.

SOLAR GEYSER TECHNOLOGY

Pakistan

February 2013

Case Study

References

The following documents informed the development of this paper:

http://www.emsd.gov.hk/emsd/e_download/sgi/EMSD_Eng.pdf

http://www.cheme.utm.my/cheme/images/research/journal_articles/2012/journal-17-2012.pdf

http://www.geogroup.co.za/files/content/docs/fact_sheet_-_how_does_solar_water_heating_work.pdf