1. Introduction

Solar Ponds are artificial lakes, created to store solar energy by the process of water convection between three different layers of water formed in a solar pond. The three layers refers to a typical pond which is relatively warm at the top thanks to the heat from the sun, the middle layer which is a little cooler and the bottommost layer which is the coldest since it receives very little solar radiation. However, in a solar pond, the layers are arranged such that the temperature gradient is reversed from the normal. Thus the layer which has the highest temperature is located at the bottom of the pond. This property of the pond allows for its use as an ideal solar energy collector.

Solar ponds are also known as salt gradient ponds. These ponds have high concentrations of dissolved salts in the bottom layers and much more dilute solutions at the surface. The gradients of salinity and temperature in an operating solar pond are shown in figure 1. The top layer consists of a homogenous layer of solution of low concentration and is referred to as an upper convecting zone. The layer below the top layer is a thick non convecting zone which provides insulation. Heat is transferred up out of the heated layer. The bottom layer is another homogenous layer, the lower convecting zone which has a high concentration of salt. The density and the temperature of the concentrated solution in the bottom zone are much higher than that of the more dilute layers above it.

Solar radiation that takes place is transmitted from the upper to the lower layers of the pond. At near normal incidence, the reflectance of a smooth water surface for solar radiation is around 5%. The remaining 95% of the radiation is transmitted through the water.

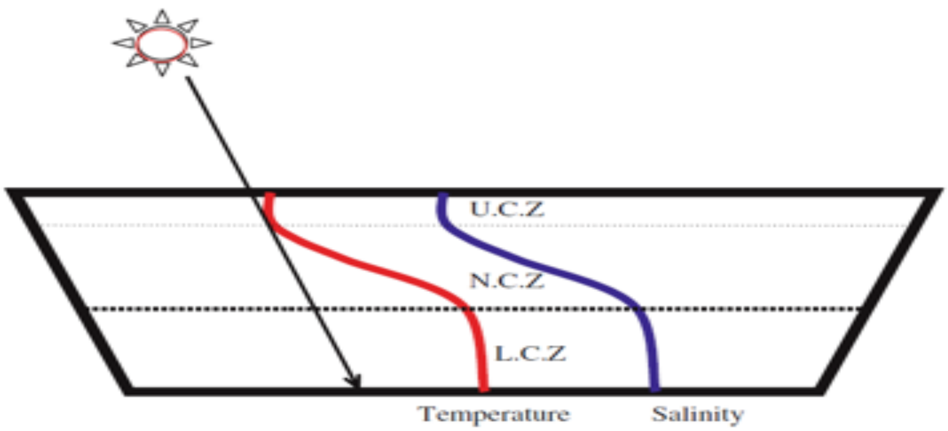


Figure 1 Salinity and temperature profiles for salt-gradient pond

While the radiation is transferred through water, the longer wavelengths get absorbed near the surface. To maintain the stability of the pond, salt is added to the lower layer and removed from the upper layer. Heat addition and extraction is done by brine extraction and injection at LCZ. The solution in the pond must be injected and removed, as there is an additional upward flow due to water addition and removal. Solar ponds are around 1 to 3 meter deep. Mostly it is constructed on level ground by excavation and putting embankments. The inner walls of the pond are constructed with membrane liners, to make it leak proof. While constructing a pond, there is a huge advantage in making it large. Larger ponds have higher perimeter to area ratio. Since edge losses can be significant, performance of larger ponds are better than that of smaller ponds. Wall effects such as convection and conduction in the walls gets minimized. Ponds need to be regularly cleaned and recycled, so that the contaminants don't affect the transmittance. The contaminants are removed from the pond by filtration.

In recent years, there has been a steady increase in the effort to promote renewable energy in developing countries. Salinity gradient solar ponds are essentially low cost solar collectors with integrated storage. This gives it a significant advantage in developing countries.

2. Theory

2.1 The Mechanics of a Solar Pond

A solar pond works on a simple principle. In an ordinary pond, the sun's rays heat the water, and the heated water within the pond, rises and reaches the top, but loses the heat into the atmosphere. Due to the process, the pond remains at the same temperature as that of the atmosphere. Solar ponds restrict this tendency; by dissolving salt in the bottom layer of the pond, thus making it too heavy to rise. The solar pond has three main functions:

- Collection of radiant energy and its conversion into heat (around 95C)
- Storage of heat
- Transport of thermal energy out of the system

Ground and edge losses are the most common mode of heat loss in a solar pond. It is represented by the following equation.

Q_u = A -- 1

Where

k- Thermal conductivity

Δx -Thickness of the gradient zone

g -ground loss coefficient

T_{LCZ} – Temperature of the lower convecting zone

T_{UCZ}- Temperature of higher convecting zone

Ground loss coefficient has its own equation and it is:

g= --- 2

Where

P = perimeter of a pond

k_g = effective thermal conductivity of the ground under the pond,

x_g = distance from the bottom of the pond down to the water table.

Radiation is absorbed at various levels and wavelengths, as the optical extinction coefficient is a strong function of wavelength in the solar energy spectrum.

2.2 Thermal Efficiency of a Solar Pond

On average, a solar pond sustains a temperature which is about 4 times higher than the ambient temperature. Solar ponds are an example of a Carnot cycle. For example if the ambient temperature is 25^{o} C, the solar pond temperature can soar up to a 100^{o}C. By the second law of thermodynamics, the maximum theoretical efficiency of a solar concentrator is calculated by the equation of a Carnot cycle. Assuming steady state:

$Q_u = Q_a - Q_e$

Where

Q_u = useful heat extracted

Q_a = solar energy absorbed

Q_e = heat loss

The thermal efficiency is defined as:

$n = Q_u/I$

where *I = solar energy incident on the pond*

$n = n_o – Q_e/I$ ---3

n_o = optical efficiency of the pond.

$n_o = Q_a/I$

$Q_e = U_o(T_s – T_a)$ ---4

Where

U_o = overall heat loss throughout the solar pond,

T_s = surface temperature of solar pond and

T_a = ambient temperature.

For uniformity and convenience the heat losses from the bottom and sides are neglected. The temperature of the upper mixed layer and lower mixed layer remains similar to the ambient. It is represented as:

$U_o = k_w/b$ ---5

Where

k_w = conductivity of water

b = thickness of the gradient zone.

The efficiency can be represented in a more simplified way

n= **1-** -- 6

On an average, the efficiency of a solar pond varies from 20-25%.

2.3 Categories of Solar Ponds

A solar pond is constructed with certain conditions in mind. The size of a solar pond ranges from a hundred to thousands of square meters in surface area and its depth ranges from 1 to 5 meters. Solar ponds are lined with a layer of sand and an impermeable dark plastic or rubber material for insulation. Most commonly, sodium chloride is used as the salt. Sometimes other compounds such as Magnesium chloride, sodium nitrate, sodium carbonate and sodium sulphate are also utilized.

There are two main categories of Solar ponds: convecting and non-convecting ponds. Non-convecting solar ponds reduce heat loss by preventing convection from occurring within the pond, while convecting ponds reduce heat loss by hindering evaporation with a cover over the surface of the pond. A convecting pond is a shallow solar pond. It consists of pure water enclosed in a large bag which allows convection but hinders evaporation of water, thus maintaining the salt concentration. The large bag is black in color which encourages water heating.

2.4 Heat Extraction

When solar ponds absorb the solar radiation and the bottom of the pond warms up. This layer inhibits convection. Pumping the brine through an external heat exchanger or an evaporator removes the heat from the bottom layer. An alternative method suggests that the heat removal be achieved by extracting heat with a heat transfer fluid via a heat exchanger located within the convective zone of the pond. Both the processes have their advantages, but pumping the hot brine to a heat exchanger outside the pond tends to be more cost effective and economic. A schematic diagram representing the working of a solar pond and the method of generating electricity from a part of the heat energy stored is represented in figure 3.

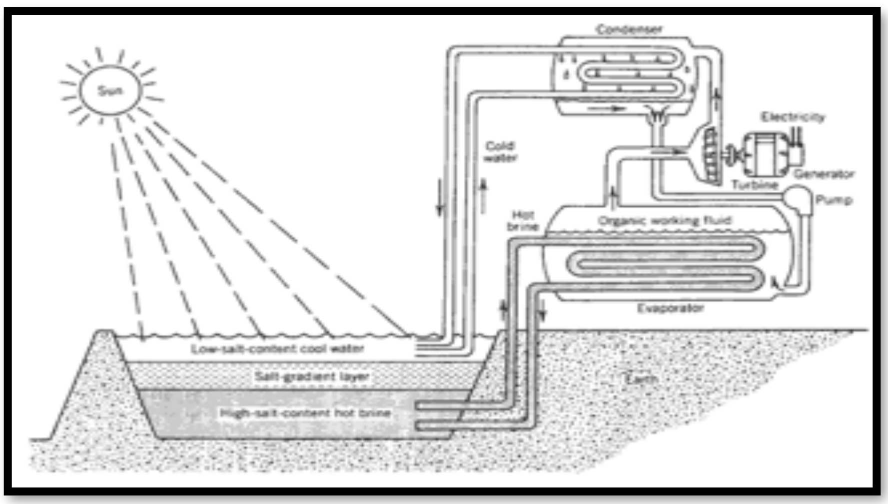


Figure 3 Schematic diagram of Solar Pond and its working

The salt gradient always needs to be maintained in order to keep the process working. Salt diffuses to the surface to homogenize the solution and to inhibit this, artificial maintenance is required. Extraction of stored heat energy by pumping stabilizes the pond environment. The gradient layer concentration and energy balances between the layer changes randomly, and thus the stability of the gradient layer is dynamic. Surface wind and storage layer convection are some of the other destabilizing factors. The whole process of stabilizing the salt gradient in solar ponds falls under the category of brine re-concentration system. Figure 4 shows the process schematically

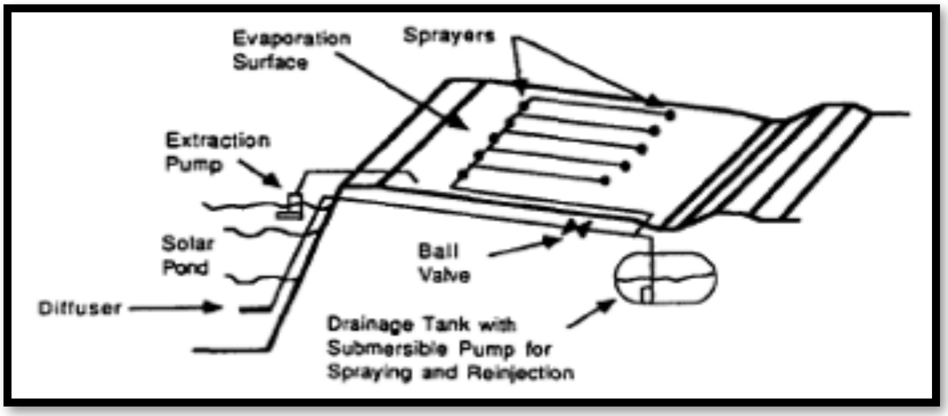


Figure 4 Brine Re-concentration System

Pumping Brine from the pond storage zone to an out-of-pond heat exchanger is a technique for heat extraction. The pump and related pipes are modeled for the anticipated heat demand and predicted temperature of the solar pond.

2.5 Material and Corrosion

To transfer the hot brine, the material should be non-metallic so as to minimize corrosion. The storage zone of the solar pond normally contains very little dissolved oxygen. Corrosion is thus minimized; unless the solar pond is aerated. Certain conditions should be met in order to have a long lasting solar pond:

- The pumps used to circulate the brine water inside the pond, should have appropriate seals to prevent air from being taken into the system. Significant amounts of air discharged into the storage zone will rise to pond surface, which might have a tendency to destabilize the salt gradient.
- The pump material used inside should be stainless steel, or some other non-corrosive material.
- Filtration system should be manufactured by plastic with some few metal parts.
- Brine heat exchangers external to the pond should be designed by using copper-nickel or brass tubing, due to its high thermal expansion coefficient.

2.6 Stability of the Pond

This factor depends on the heat flow and heat loss in different layers of the pond. The heat loss from the storage zone of the pond to the atmosphere is dictated by the depth of the gradient zone. However solar radiation penetration into the storage zone (lowest zone) is influenced by the depth and clarity of the gradient zone. When the gradient zone depth is increased, the heat loss from the upward region decreases as per the following equation.

Q=K, --------7

where

Q is the heat flow.

K is the thermal conductivity and

dT is the temperature difference and

D is the gradient zone depth.

The solar radiation depends on the equation

T=55.4 --------8

T is the radiation transmission efficiency in percent, which depends on the gradient zone

S is the depth of the surface convective zone in meters.

The salt gradient zone has an approximate thermal conductivity which varies from 0.6 W/m^2C^o to 0.8 W/m^2C^o.

The maintenance of a salinity gradient is an important factor for the pond stability. The transport of salt through different gradient zone inside the pond is defined by the equation

$Q_M = (S_l - S_u) D/b$ -------- 9

Where b is the thickness of the gradient

S_l and S_u are the salinity in lower and mixed layer respectively.

2.7 Location of a Solar Pond

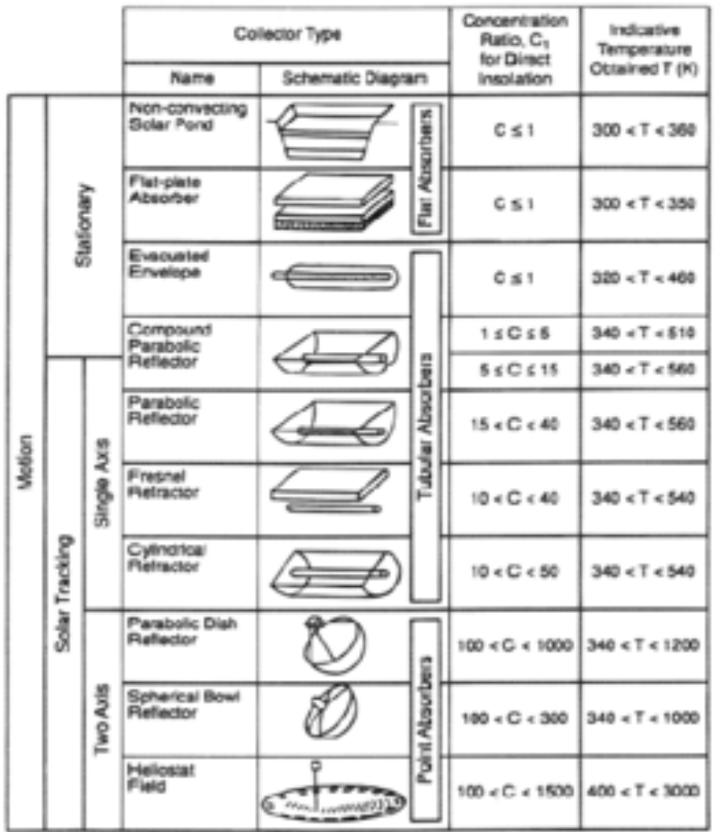
Solar ponds are horizontal collectors and hence it should be located at regions where there are low to moderate northern latitudes, which is between -40 to +40 degree. However it is fit to be used in any place, unless there are some extreme weather conditions. However, it functions most effectively in regions which receive a high amount of solar radiation. This would include deserts and tropical regions. When it comes to regions which experience long spells of cold winter, solar ponds are still capable of working, although it is not ideal. This is as solar ponds provide a massive heat sink which traps the radiation that enters the pond. However, due to the cold ambient temperature, the storage zone (lowest zone) temperatures might not be as high as they were in the summer.

3. Comparison of Solar Ponds with other types of Solar Collectors

3.1 Efficiency and Performance:

Solar ponds are used to absorb and store solar energy. If conditions are favorable, they can be heated up to 180F (82C). In the case of flat plate collectors, the efficiency is relatively higher and it can heat water up to 160F (71C). This is because FPC (Flat Plate Collectors) can collect both direct and diffuse radiation. Evacuated tube collectors (absorber plate is surrounded by vacuum), can supply super hot water up to 350F (177C). The vacuum helps in reducing thermal loss and hence have high efficiency. The collectors discussed above have a low temperature range. If temperatures above 300F (149C) are desired, then a concentrating type collector has to be used. Concentration ratio (C) is an important factor influencing the efficiencies of the collector and is defined as the ratio of the aperture area to the receiver/absorber area. Table 1 shows the C value for different type of collectors.

Table 1 Concentration Ratio for Various Solar Devices at Indicative Temperature



Motion			Collector Type: Name	Absorber	Concentration Ratio, C_1 for Direct Insolation	Indicative Temperature Obtained T (K)
Stationary			Non-convecting Solar Pond	Flat Absorbers	$C \leq 1$	$300 < T < 360$
Stationary			Flat-plate Absorber	Flat Absorbers	$C \leq 1$	$300 < T < 350$
Stationary			Evacuated Envelope	Tubular Absorbers	$C \leq 1$	$320 < T < 460$
Stationary / Solar Tracking	Single Axis		Compound Parabolic Reflector	Tubular Absorbers	$1 \leq C \leq 5$	$340 < T < 510$
					$5 \leq C \leq 15$	$340 < T < 560$
Solar Tracking	Single Axis		Parabolic Reflector	Tubular Absorbers	$15 < C < 40$	$340 < T < 560$
Solar Tracking	Single Axis		Fresnel Refractor	Tubular Absorbers	$10 < C < 40$	$340 < T < 540$
Solar Tracking	Single Axis		Cylindrical Refractor	Tubular Absorbers	$10 < C < 50$	$340 < T < 540$
Solar Tracking	Two Axis		Parabolic Dish Reflector	Point Absorbers	$100 < C < 1000$	$340 < T < 1200$
Solar Tracking	Two Axis		Spherical Bowl Reflector	Point Absorbers	$100 < C < 300$	$340 < T < 1000$
Solar Tracking	Two Axis		Heliostat Field	Point Absorbers	$100 < C < 1500$	$400 < T < 3000$

The ratio of the efficiency of the solar pond with F_R is calculated as a function of $\Delta T/I$ for ponds. It is represented in the figure below. Curves B and C represent the top and lower convecting zones of the pond. There is a difference in the intercepts which represents additional radiation absorption by an additional meter of solution. The line C represents additional meter of insulation over the lower convecting zone. The curve represents a one cover, selective flat plate collector. The figure shows that at high operating points, the performance of the ponds appears to be better than a flat plate collector.

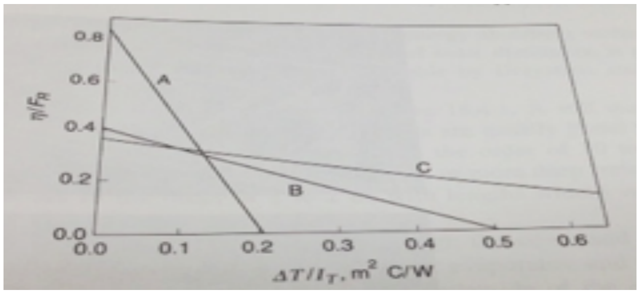


Figure 5 Calculated n/FR verses the difference in temperature by I value

3.2 Economic Analysis

Economic Analysis was performed on Solar Ponds, by comparing it with other solar energy devices in terms of the cost of manufacturing and installation. The overall cost was estimated by the maintenance expense and the fuel cost the device will consume in order to run it. A fair comparison was done by creating a cash flow system with various solar devices to compare the exact investment. Comparing all other devices, a solar pond turns out to be the cheapest. The most expensive systems are those systems that use electrical energy. Functionally, themosiphons using coal are comparable with solar energy systems, although they are 40% more expensive than the latter.

3.2.1 Cost of Installation and Price

A survey was carried out to analyze the cost of installation and manufacturing a solar pond. The analysis is done on the basis of the initial costs of different heating systems. The ratio between the initial costs of flat plates collectors, solar ponds and other alternative systems vary from 2 to 6. If the comparison is performed between solar pond and flat plate collector, the solar ponds comes out with half the cost of flat plate collectors. Comparing it to other alternatives, the electric geysers are the cheapest and the LPG geysers are the most expensive. In the Table 1 provided, the analysis of various solar energy system in terms of cost of installation along with other additional prices are shown.

TABLE 1:

System	Price ($)	Additional expenses $ (TL)	Total $ (TL)
Flat Plate Collectors	1,388,280	874,566	2,262,846
Solar Ponds (insulated)	832,000	400,000	1,232,000
Electric Geyser	280,000	125,000	405,000
LPG Geyser	830,000	250,000	1,080,000
Electric Thermosiphon	800,000	150,000	950,000
Kerosene Geyser	500,000	75,000	575,000
Thermosiphon	365,000	75,000	440,000

3.2.2 Maintenance Cost

A comparison was done on the cost of maintaining a solar pond, its fuel expenses and the overall cost it consumes after installation. Compared to the Solar flat plate collectors, solar ponds need a maintenance cost of 1.5 times less. However both the systems do not need any fuel cost, which is advantageous, as fuel costs always vary depending on economic flux. Secondly fuel produces excessive, non-essential heat energy, which sometimes might affect some other parts of the system, leading to unwanted problems. Table 2 provided below shows an analysis of the maintenance cost and the fuel price. Solar pond has the minimum overall cost required to maintain, compared to other systems.

TABLE 2:

System	Maintainence	Fuel $ (TL)	Overall Total $ (TL)
Flat Plate Collectors	335,800	0	335,800
Solar Ponds (insulated)	200,000	0	200,000

Electric Geyser	40,500	977361	1,018,361
LPG Geyser	108000	904,729	1,012,729
Electric Thermosiphon	95,000	1,204,526	1,299,526

3.2.3 Life time of the System

The useful lifetime of a Solar Pond is about 10 years. After 10 years, its efficiency becomes very low. Thus a typical solar pond cannot be used for practical purposes in a large scale basis to perform solar heating, as its insulation along its sides becomes thinner, and more heat loss takes place along its side. Secondly the insulating layer, in between the upper and lower convecting zone loses lot of its insulation as the salt dissolved in the water in the lower and upper convecting zone gets transfused to the sides of the pond,due to the low insulation of the sides. As a result the pond becomes more prone to heat loss, other than storing heat. So the entire pond needs to be reconstructed and reinstalled to perform efficiently.

Comparing the lifetime with other solar energy devices, the solar pond has a similar lifetime.

3.2.4 Cash Flow of the System

The useful life of the systems are approximately 10 years for most of the solar energy systems, except the electronic thermosiphon. A cash flow chart of an entire 10 year period was done to analyze the overall cost of a solar pond in the long run, with a 0 interest rate for ease of calculation.

TABLE 3:

System	Initial Cost	Scrap Value	End of the 0 th year	1-10 TL	Total TL

Flat-plate Collector	2,262,846	212, 709	2,050,137	335,800	5,408137
Solar Pond	1,232,000	100,000	1,132,000	300,000	4,132,000
Electric Geyser	405,000	30,375	374,625	1,018,361	12,056,735
LPG Geyser	1,080,000	81,000	999,000	1,012,729	11,126,290
Electric Thermosiphon	950,000	71,250	878,750	1,299,525	13,874,010
Kersosene Thermosiphon	575,000	43,125	531,875	1,202,788	12,559,755
Coal Thermosiphon	440,000	33,000	407,000	718,089	9,762,000
Lignite Thermosiphon	440,000	33,000	407,000	933,500	9,762,000
Thermosiphon	440,000	33,000	407,000	991,900	10,326,000

Table 3 shows that solar ponds have the lowest cash flow, in its lifetime. This shows that it requires the least amount of investment.

4. Common applications of Solar Ponds

In most places in Southern Australia, water supplied is overused and a lack of fresh water limits the pace of growth in certain regions. Groundwater based supply for both town water and irrigation often undergo salinization and this limits the supply of drinkable water. In many places like Eyre Peninsula, development came to a standstill due to limited supply of adequate quality water. This added to a scarcity in rainfall and a booming population increases the demand for water. Installing solar ponds in all these areas have helped to obtain fresh drinkable water to sustain a healthy environment for living. By the process of desalination in solar ponds, saline water can be made fresh, and thus it can be used for drinkable purposes. The process of making fresh water from sea water is called reverse osmosis and it requires a lot of electrical power and thus it produces unfavorable greenhouse emissions. However the vast, cheap supply of solar heat from solar ponds has caused the primitive technology of solar distillation system to improve and increase the output of conventional heating systems, reducing the emission of greenhouse gases.

Figure 6 Solar Pond built at Alice Springs in 1972

5. Solar Ponds Yesterday and Today – A regional timeline study

The idea of a solar pond was first thought of when it was observed as a natural phenomenon around the 1902 in the Medve Lake in Transylvania, Hungary. During summer, temperatures of up to 70 C were often recorded at a depth of 1.32m. The reason for this abnormality was its unusually high salt (NaCl) concentration of 26 percent. From this, researchers deduced that if the salinity gradient could be maintained, the sun could heat up the water and this could potentially provide a renewable, non-polluting source of energy.

Since then some other naturally occurring solar ponds have been discovered around the world. One of them is at Oroville, Washington where a maximum temperature of 50 C was measured in the summer at a depth of 2 m. Some other similar ponds were found in the Sinai Peninsula, Hungary, Romania, and the eastern coast of the Red Sea.

However, natural solar ponds are few and far between. This is as natural convection would eventually cause the water to evaporate if it is not constantly replenished. Therefore, conventional solar ponds are artificially constructed.

Now let’s look at some of the earliest solar ponds developed.

The Israelis were the first to exploit the potential of solar ponds. The Americans swiftly followed and so did a few other countries, notably India and Australia.

Israel

During the 1950’s interest in solar ponds was sparked by research by a Dr. R. Block, the research director of Dead Sea Works in Israel. He is considered the pioneer in envisioning energy production using artificially constructed solar ponds. In 1948, he suggested a scheme for greatly reducing evaporation losses by constructing a density gradient. This, he righty believed would eliminate convection in a solar pond collector. Dr. Block was convinced that this was a viable alternative energy and so he pushed for a research program to Israel National Research Council.

A Professor Tabor from Dead Sea Works then went a step further and built the first recorded artificial solar pond which measured temperatures in the vicinity of 103 C. Collection efficiency of 15 percent for heat extraction was predicted.

Large scale interest, however, was only achieved due to the Oil Embargo of 1973. When oil prices skyrocketed with no end in sight, researchers scrambled to find alternative energy options. The Israeli government, aiming to reduce their national dependence on oil, financed and built a number of solar ponds.

The first solar pond which was used to extract energy from was constructed in 1975. It was a 1100 m2 pond at the Dead Sea Works. This solar pond paved the way for better, more efficient ones in the future. Then a 1000 m2 pond was built in Eilat on the shore of the Red Sea. A third was then constructed the same year in Yavne by Ormat Industries Ltd. It was a 1500 m2 pond and was used for testing a complete Rankine cycle for energy conversion using a 6 kW turbine. This solar pond was the first attempt at generating a continuous supply of electric power.

Ein-Boqek

The fourth solar pond built was the most ambitious one yet. It was a 6250 m2 solar pond situated in Ein-Boqek, at the shore of the Dead Sea. This was also constructed by Ormat industries Limited. It had a depth of over 2.5 m and the whole pool was lined with a reinforced rubber covering which functions to prevent seepage of the brine water into the ground. However, the En-Boqek installation does not utilize an insulated layer though it might be desirable in most conditions to ensure the saline water is kept at an optimum temperature. The solar power plant is capable of providing 150 kW of power.

To use the solar pond as an energy source, they first pump the hot brine through a heat exchanger which has vessels filled with a refrigerant. The heat exchanger is directly connected to a turbine that is specifically designed to be functional even when a relatively lower-temperature propellant (compared to a conventional steam turbine which requires steam at high temperatures) is used. The refrigerant then transforms to pressurized steam which powers the turbine. When the refrigerant vapor has passed through the turbine, it is cooled by water taken from the top layer of the solar pond which is relatively cool. By this method, both the refrigerant liquid and more importantly, the water in the solar pond are recycled. This ensures wastage is minimal.

The biggest advantage of a solar pond similar to the one in Ein-Boqek is that it provides a near constant stream of energy, irrespective of whether the sun is shining constantly or not. This is as the pond acts as a massive heat sink that traps the heat in. One disadvantage, however is that it can get windy sometimes and this increases heat losses by convection. To reduce this, plastic nets are placed on the surface of the pond. The plant was in operation until 1983 when it was dismantled.

Beit Ha-Arava

The success of the Ein-Boqek plant encouraged the government to sponsor the construction of a 5000 kW solar pond. It was built near Beit Ha-Arava in the north of the Dead Sea and was 250,000 m2 in area. In contrast to the previous solar ponds, due to its high energy generation, it was actually connected to the grid in 1984. It operated continuously for a year and on and off until 1988. This was and remains the world’s largest solar pond for electricity generation.

United States

Solar ponds were first researched in the US by Professor Nielson from the Ohio State University. It began in the mid 1970's thanks to ERDA funding. After lab experiments were conducted to study the absorption of radiation in water, a prototype 200 m2 pond was built at Ohio State University, Columbus. Following this, a larger 400 m2 pond was built. Both of these ponds were for purely academic reasons: to verify theoretical models, measure heat loss, conduct heat extraction experiments, etc.

A relatively big, 2020 m2 solar pond with a depth of 3 m was built in the DOE Mound Lab., Miamisburg, Ohio. This pond was successfully completed in 1978. It functioned to provide heat to a city recreational building and swimming pool. The development of a host of solar ponds quickly ensued. They were built in the University of New Mexico, Albuquerque, Ohio Agricultural and Development Centre, Wooster, Ohio, Living History Farms, Iowa and the University of Illinois.

As interest in solar ponds increased in the US, a 3238 m2 pond was built in 1983 and has been in operation since 1985 at the University of Texas, El Paso. Through the course of its operation, it has been used to demonstrate applications such as desalination, industrial process heat production, electricity generation and waste brine management. It is capable of producing up to 70 kW of energy.

India

Examples of solar ponds in India include ones in Central Salt and Marine Chemical Research Institute, Bhavnagar, Lake Estate Farm of Sri Aurobindo Ashram, Pondicherry and Bhurj, Gujerat. The first two are relatively small ones which are used for experimental purposes but the third; the Bhurj in Gujerat is the largest solar pond in India.

The Bhurj was constructed in 1993 in the wake of the news about the threat of global warming and the increasing scarcity of fossil fuels. The 6000 m2 pond supplied industrial process heat to Kutch Dairy, a dairy company. To cut costs, instead of having a specialized imported membrane lining, it used a cheap indigenous lining scheme made of clay and plastics. This turned out to be a success and would reach temperatures of up to 99.8 C. However, it was shut down in the year 2000 when financial losses and a devastating earthquake left it in disrepair.

Australia and other countries

Solar pond research in Australia began in 1964 and around this time an experimental 2000 m2 solar pond was built in Alice Springs. It supplies 20 kW of energy to a Rankine cycle turbine.

Other functional soar ponds include Alexandria Pond, Egypt (1986), 1700 m2 pond in Kuwait (1989), and others in Iran, Argentina, Zambia, Portugal, Mexico, Japan and China.

6. Problems Regarding Solar Ponds

Even though solar ponds have a high heat capacity, and can store large amounts of heat for a long time, it eventually it loses heat, until heat is supplied into the system. Alternatively cold salt water can be removed from the surface of the solar pond and pass through external heating. The bottom of the solar pond is designed to absorb maximum solar radiation, thus the bottom surface sometimes has a black cover. However, sometimes on long usage, the bottom surface becomes less effective and the heat storage capacity of the lower layers becomes much less than usual, reducing its entire efficiency. If the water loss is due to evaporation in the pond at the surface and filtration of the surface is not continuously compensated for a supply of fresh water, or if crystallized salt is not removed from the bottom of the pond, the pond will dry out over time and eventually dry out. Sometimes a covering is provided over a solar pond to reduce the evaporation. However, there is a downside to providing a layer of covering; it reduces the pressure between the bottom of the cover and the surface of the water and this could potentially cause issues with the pond. Therefore, to negate this effect, it is recommended to flood the cover with water periodically and drain it again.

6. Conclusion

Solar ponds are an efficient source of renewable energy. It is a cost effective system, with the lowest amount of initial cost, installation cost and manufacturing cost compared to solar collectors and other solar energy systems. Since solar energy takes the direct radiation from the sun and utilized the renewable energy as its fuel, there is no fuel consumption, which is advantageous since the price of fuel is constantly on the rise. Solar ponds are also eco-friendly. A major use of solar ponds is to process saline water to drinkable water and this is performed in many developed and developing countries.

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Appendix