A Solar Pond Tower is a combination of a Solar Tower, a Solar Pond and a Hurricane, Towertaking the advantages of all of them. The largest advantage comes from the application of the cheap heat generating Solar Pond, which is far cheaper than the large solar heat collecting green house of the Solar Tower. It is estimated that the Solar Pond Tower can produce power at a cost of 3-5 €ct/kWh.

Introduction

The problem of a Solar Tower is that the efficiency is low, though a very large collector area is needed to produce power; for instance a 1000 m high 200 MW tower requires an expensive 20 km^2 large green house, which causes the main part of the cost.

The problem of a Hurricane tower is that the height is small, so besides a pump a fan is needed to lift the air for the production of fresh water. If integrated in a solar tower no fan is needed and even power is generated, while both the Solar tower and the Hurricane tower can use the same tower.

Instead of a large collector surface the Solar Pond Tower applies the natural collector surface of a lake that is heated by the sun. The lake will also store the heat to apply it during the night or at lower sun shine. For a good efficiency the temperature of the water should be as hot as possible but lower than 100 °C to avoid boiling at the bottom of the lake. To reach this high temperature the water should be insulated, which is natural possible if the lake has a high salt content in a so called salt gradient solar pond. With a high salt content water with a high temperature can contain at saturation more salt and is heavier than water at saturation at a lower temperature realizing a insulating gradient layer. So below a thick insulating gradient layer a hot bottom layer heated by the sun can store heat for several days. The mean temperature of the bottom layer of the pond will be 60 °C and of the cold upper layer 30°C. If the intermediate gradient layer is 0.5 m thick then 30 * 0.6/0.5 = 36 W/m^2 of heat is lost, which is a loss of only 20% of the incoming solar heat.

Due to this principle high temperatures of 90 °C or more are possible. To generate energy by the chimney effect the Solar Pond Tower should be fed by hot air heated by the hot water of the solar pond. This mechanism is the motor for the big hurricanes in tropical regions causing a lot of kinetic energy and rain but with water of 30 °C, imagine what will happen if the water is 90 °C. Now the Solar Pond Tower provides fresh water as well.

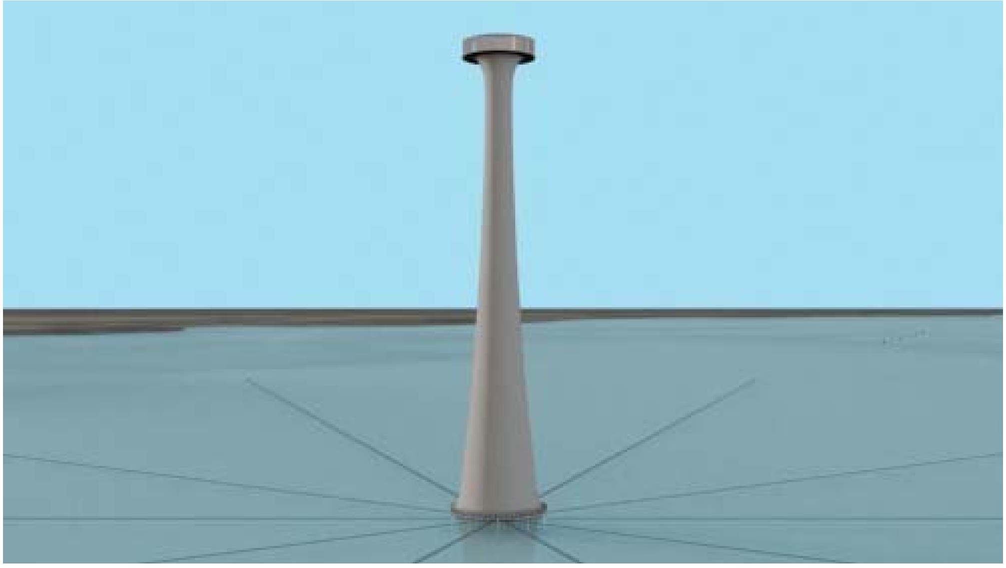


Figure 1: Solar Pond Tower with slowly to and from rotating heat exchanger tube web in the hot bottom layer of the pond

Global description

The Solar Pond Tower will consist of a specific type of cooling tower located in a lake. The inlet air will be heated by hydrophobic heat wheels that are heated by the hot water of the bottom layer of the lake. The inlet air comes over the lake surface and will be saturated by vapor at a temperature of 30 °C, which contains 25 gram water per kg air. After heating, the air will have a temperature of 80 °C and will have a specific mass of 1 kg/m³. Because the specific mass of the air around the tower is 1.2 kg/m³ a pressure difference of (1.2-1)*9.81*1000=1,962 Pa will be generated if the tower height is 1000 m. The kinetic energy generated by this pressure difference is transferred in useful electrical power by turbines. For simplicity in the artist impression axial turbines are presented in the throat of a nozzle shaped tower, which looks rather aesthetic as well. Due to this shape compact turbines can be used. However because the diffuser/condenser has a disk shape maybe a radial turbine is more suitable. Other solar tower concepts apply less compact wind turbines at the tower base. Never the less for further development it should be investigated which turbine type and tower type is most suitable. For a tower with a throat area of 1400 m² and a turbine-efficiency of 60% the net power is 200 MW.

To minimize pressure losses the tower is provided with a concentrator before the turbine and a diffuser behind the turbine to make it possible to exchange heat with the inlet air at a low velocity with low pressure losses. Also at the outlet where the demister is located the air velocity should be low to avoid large pressure losses.
Behind the turbine the air should be mixed with cold outside air to let the original damp at the lake condense in a venturi shaped diffuser which sucks cold air from the environment. At the end of the diffuser the valuable distilled water can be subtracted by a demister.

Due to gravity the damp/air mixture will in its way up decrease in pressure and cool down to 73°C. If further cooled down by mixing with ambient cold air it is assumed that 10% of the original damp can be demist, which is 2.5 gram/kg air or approximately 120 kg/s and 10000 m^3/day, which is a lot of fresh water.

To avoid disturbance of the gradient layer between the hot and cold water of the pond the heat will be subtracted by a web of tubes, which sucks water from the cold upper layer from the edge of the area the Solar Pond Tower provide heat. The tubes float in the hot bottom water below the gradient layer of the lake and are secured by floaters. While the water in the tubes flow to the tower by a pump it will be heated by the hot bottom water. To cover the entire area the web of tubes will rotate axially as a wheel and slowly through the bottom layer around the tower.

After the heat is transferred to the inlet air by the heat wheels the water is pumped back to the surface of the lake from where it will flow back to the edge, which closes the cycle.

Because the heat transfer in water is approximately 10 times better than in air the heat wheels turn for 7% in the water and for 70% in the inlet air. They should be corrosion resistant and hydrophobic to avoid evaporation of possible sticking water. Extra evaporation will consume too much heat and will reduce the performance of the Solar Pond Tower. For this reason 23% of the wheel is used to release possibly still present droplets by the centrifugal force of the turning wheels. Heat wheels consume low pressure losses, are compact in heat transfer and rather cheap though very suitable for the Solar Pond Tower. Because normally heat wheels are used for air to air transfer it might not work from water to air, which should be investigated. If not possible another application is the use of Fiwihex, which is compact and cheap as well.

Because the fresh water is generated by the Solar Pond Tower at a height of 1000 m, extra energy can be generated with it by a water turbine of about 2 MW, which is sufficient to drive the water pump and the heat wheels.

The performance of the tower will improve when the tower becomes higher, but the cost will increase as well. In the table below the estimated performances of higher and lower towers with 1400 m^2 cross section and a required lake area of 20 km^2 are presented.

Height	Power	Ttop	Fresh water
m	MW	°C	m^3/day
200	20	77	1500
500	70	73	5000
1000	200	67	10000
1500	360	60	15000
2000	560	54	20000

Benefits

The benefits of the Solar Pond Tower compared with a Solar Tower are:

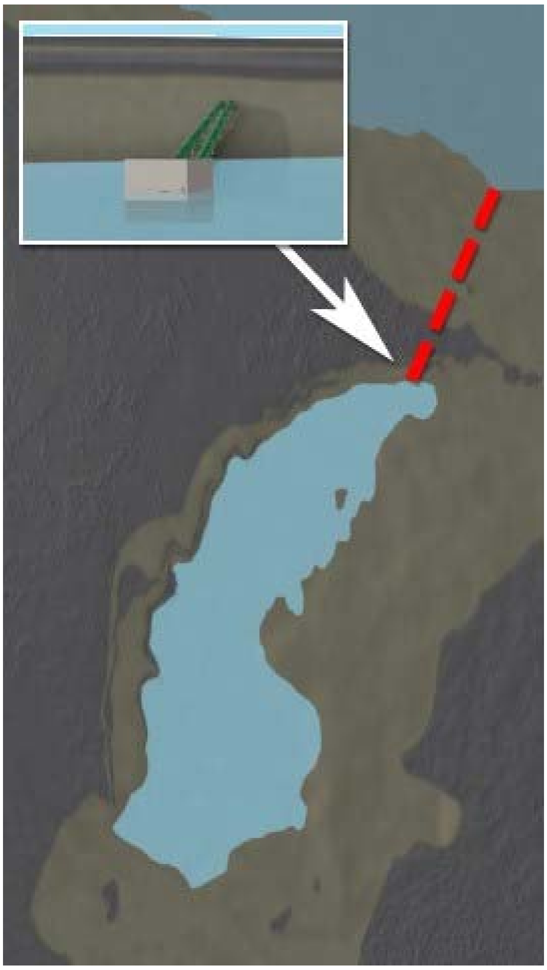
- No expensive large green house is needed;
- No storage of sun energy is needed, because the lake already stores an enormous amount of energy;
- Valuable fresh water is generated.

The benefits of the Solar Pond Tower compared with the Hurricane Tower are;

- No expensive fan is needed;
- No expensive heat exchanger for the condenser is required, because heat is exchanged in situ by condensation in direct contact with mixed ambient air.
- Can use the already available tower from the Solar tower

Possible locations

A favorite location for the Solar Pond Tower is a dessert depression with a water inlet as the Death sea where the salt content is already high. A depression is the opposite of a barrier lake but can also generate power if sea water is supplied and evaporated in the depression. An excellent location is Qattara depression in Egypt, where a possible lake level can be around 60 m below sea level. From this level difference with the Mediterranean sea energy can be provided if a canal or tube will connect it. For the Qattara lake a 56 km long canal or tube should be built through the sand hills. In a study it is found that 640 MW of electricity can be generated. Another possibility is to pump water up to hill height in a intermediate reservoir where over complete sun energy can be stored. Then in periods of energy shortage the energy can be recovered by a multiplication factor if the water is led from the intermediate reservoir to the depression lake. With this combination in the same study it is found that up to 2500 MW of electricity can be generated. Due to the inlet of salt Mediterranean water the created lake will soon have a high salt content and besides the energy of the level difference even more energy can be generated by placing Solar Pond Towers.


Possible future Qattara depression lake with detail of salt Mediterranean water inlet by future Qattara hydro plant