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# Power Generation Using Organic Rankine Cycle by Utilising a Salt Gradient Solar Pond

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**ABSTRACT:** Solar energy is an abundant and renewable energy source. We have built a solar pond capable of producing 41.8kwh per day of power in our university campus. Energy was transformed to usable electricity using turbine and applying rankine cycle. Through this project we have shown that although the efficiency of a solar pond is low, a solar pond is an inexpensive means of energy and solar power, which as we know is a very clean way of power.

**Key words** – solar energy, solar ponds, power generation

## I. INTRODUCTION

A solar pond is a solar energy collector, generally fairly large in size, that looks like a pond. This type of solar energy collector uses a large, salty lake as a kind of a flat plate collector that absorbs and stores energy from the Sun in the warm, lower layers of the pond. These ponds can be natural or man-made, but generally speaking the solar ponds that are in operation today are artificial. When solar radiation (sunlight) is absorbed, the density gradient prevents heat in the lower layers from moving upwards by convection and leaving the pond. This means that the temperature at the bottom of the pond will rise to over 90 °C while the temperature at the top of the pond is usually around 30°C. The heat trapped in the salty bottom layer can be used for many different purposes, such as the heating of buildings or industrial hot water or to drive a turbine for generating electricity.

To meet the increasing demand for energy in the world, the use of fossil fuel to produce power has become very prominent. Unfortunately, fossil fuels are non-renewable energy sources, that causes pollution in the environment by emitting large quantities of carbon dioxide, which is a major cause of green house effect, which in turn causes global warming and climate change. This problem can be solved by utilizing renewable energy sources. Out of many forms of renewable energy sources available, this paper will focus on solar energy. Extraction of thermal energy using solar pond via Rankine cycle is the objective of this paper.

## II. DESIGN CONSIDERATIONS

- **The Design and Performance of Solar Ponds**

Design is a very important characteristic of any system. It affects every part of the working and performance of the solar pond. By choosing certain configurations and measurement we can alter the efficiency , work output , energy production and several factors like that.

Design plays a very crucial role in the performance of the solar pond.the type of application , usage of the output depends upon the performance and design of the pond system.

- **Site Selection**

Selection of site is the first and primary step in the solar pond technology. Correct place, with proper necessicities for pond setup is a must requirement.

- **Several important factors for selecting the site are :**

✓ The selected place should be of high solar radiation insolation
✓ Wind speed of the place should be low so that the mixing of top surface of pond should be minimum.
✓ The place should be having minimum vegetation so that the construction work could be performed easily.

- ✓ The soil should be having good cohesion properties which will be important for the stability of pond walls.

- **Design Considerations and Sizing**
- ✓ The size and dimensions of the solar pond depends on solar radiation along with the temperature and requirement of the heat for various application purposes. It issuggested that local data should be analyzed and studied well
- ✓ For the construction of larger ponds , rectangular shape is advised as heat loss from ground is not an important factor.

- **Excavation and Lining**

Before going towards the earthwork, the design for evaporation ponds/storage ponds should be included first. The pattern of drainage and layout of sites that includes the pipeline for extraction of heat, systems for monitoring and recording purposes must be considered at the design stage. This process of design should be done with proper planning as the cost of excavation contributes to almost 40 % of the total cost for the construction of solar pond system. The soil used for the construction of solar pond should be having low permeability.

Liners plays very crucial part to prevent the saline water from the solar pond leaking into the underground water table and putting environment under danger[1] .The leakage will carry away the salt from saturated storage zone along with heat and this will affect the whole working and operation of the pond. Leak detection system must be implemented in the construction of the solar pond.

- **Salinity Gradient Establishment :**

Some of the methods to establish the salinity gradient of solar pond are:

- ✓ Natural Diffusion
- ✓ Stacking
- ✓ Redistribution

In redistribution method[2], firstly a solar pond is filled with a saturated brine mixture up to a depth of the lower storage zone and half the thickness of the gradient zone. From the interface of the lower storage zone and the gradient zone, fresh water is injected with a diffuser. The point where the fresh water is injected, it should rise twice as fast as the surface of pond rises. This method is used very commonly.

- **Heat Extraction**

The heat which is stored in the storage zone and the gradient zone can be used for many applications. Two methods have been used to extract heat from a solar pond.In the first method, a submerged heat exchanger is used to circulate fresh water[3].The second method which is used to extract heat from the solar pond is by using brine extraction method[4].In this method, hot brine which is present in the bottom of the interface of gradient zone is made to pass through an external heat exchanger with the use of a diffuser. After the heat exchange, the hot brine is pumped back into the storage zone of the solar pond.Heat which is extracted from the gradient zone is added to the storage zone helps to improve the overall efficiency of the solar pond.

- **FIXING OF THE AREA OF THE POND** (Calculations)

**STEP: 1** The UCZ, NCZ and LCZ thicknesses for the solar pond have been chosen as **0.3m, 1.35m and 0.95m**.

**STEP: 2** $Q_{load}$ can be estimated with a knowledge about the Geo-climatic condition of the site of the Solar Pond at DTU Delhi, from the following relation.

$$\mathbf{Q_{Load} = Q_d - Q_{LOSSES}}$$

The annual average value of solar insolation recorded at the pond site comes out to be **181.66 watts/m$^2$**. The amount of solar radiation reaching a depth of 1.65m at the LCZ - NCZ interface is estimated by using using **Bryant and Colebeck[5] relation h(x) = 0.36 - 0.08 ln(x)** as

$Q_d$ = 58.115 W/m$^2$

the total heat loss is estimated as

$Q_{Loss}$ = 30.065 W/m$^2$

$Q_{load}$ = 28.05W/m$^2$

The pond is meant to provide a heat output ($Q_{load}$) of 350 Kwh estimated on 24 hour basis and on the hourly basis it would be approximately equal to ($Q_u$) 14.58 kW. The area ($A_{LN}$ ) of the NCZ - LCZ boundary is calculated using

$$\mathbf{A_{LN} = Q_u / Q_{LN} = 519.78m^2}$$

For a given surface area of the pond, a square type pond has been planned.

Assuming a length of 22.80m, and the breadth of the 22.80m. So the dimensions of the solar pond at the LCZ - NCZ interface is = 22.80m X 22.80m.

**Step:3** To maintain stability of pond, slope is needed. For minimum stability against the wall generated convective layers comes to 49° by analysis done by (Akbarzadeh et al., 2005)[6]. Hence for the present design, a convenient sloping angle of 45° which would make the pond more stable has been selected which gives 1:1 slope for the walls. As a result of this, the pond will assume a trapezoidal shape.

**Step: 4** the top surface area of the solar pond has been estimated for the total vertical NCZ + UCZ thickness of 1.65m, and it is = 681.21 m$^2$ (26.10m*26.10m).

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**Step: 5** the dimensions of the pond bottom floor which is at a depth of 0.95m from the LCZ - NCZ boundary works out to be 20.90m X 20.90m.

**Table 1 : Estimation of bottom LCZ thickness and floor area by finite element analysis**

| DEPTH (m) | SIDE (m) | MEAN AREA ($m^2$) | VOLUME STORED IN EACH LAYER ($m^3$) | TOTAL VOLUME FROM LCZ TO EACH DEPTH ($m^3$) |
|---|---|---|---|---|
| 1.65 | 22.80 | 519.84 | | |
| 1.84 | 22.42 | 502.6564 | 95.505 | 95.505 |
| 2.03 | 22.04 | 485.7616 | 92.295 | 187.8 |
| 2.22 | 21.66 | 469.1556 | 89.140 | 276.94 |
| 2.41 | 21.28 | 452.8384 | 86.040 | 362.98 |
| 2.60 | 20.90 | 436.81 | 82.994 | 445.974 |

Estimated Thickness of LCZ = 0.95 m

Dimension of the Bottom floor = 20.90m X 20.90m

The present solar pond is intended to deliver daily a total thermal power output of 350 Kwh extracted in 1 hour. With an temperature drop of 5°C and Cp of 3270 J/kg/°C the required mass flow rate of hot brine is estimated using the relation,

$$m = Q_u / C_p . \Delta T = 21.4 \text{ Kg/s}$$

For a brine density of 1160 kg/$m^3$ , the brine volume to be circulated through the heat exchanger is **66.414 $m^3$/hr**. The total volume of the storage zone is 445.974$m^3$ . So the hot brine withdrawal at a rate of 66.414 $m^3$/hr is not expected in anyway to affect the zone boundary and produce mixing, because of the cushioning/smoothening effect provided by the large volume (445.974$m^3$ ) of brine stored in the LCZ of thickness 0.95m.

## I . AREA:

a) Solar collection area of the pond at its top surface = 681.21 $m^2$ (26.10m*26.10m)

b) Solar collection area of the pond at its bottom Floor = 436.81 $m^2$(20.90m*20.90m)

c) Solar collection area of the pond at LCZ-NCZ Interface =519.78$m^2$ (22.80m*22.80m )

d) A free board (0.2m) the top peripheral dimension and its area are =702.25$m^2$ (26.50m*26.50m)

## II. ZONE THICKNESS

Thickness of UCZ = 0.3 m

Thickness of NCZ = 1.35 m

Thickness of LCZ = 0.95 m

## III. TOTAL DEPTH OF THE POND = 2.6 m

**IV.** a. Expected Thermal power extraction from the pond = 350 Kwh/Day

b. Hot brine flow rate = 66.414 $m^3$ /Hr

c. Desired temperature drop across the heat exchanger = 5°C

- **Power Production (Calculations)**

### 1. Rankine cycle solar pond power generator

A schematical daigram for extracting solar thermal energy is shown in figure 1.

Heat is transferred from solar pond to the working fluids in an evaporator. The heat transfer process that drives a closed Rankine power cycle proceeds as follows, the working fluid is circulated through a cycle of evaporation, vapor transfer, condensation, and liquid return, and this cycle repeats itself for generate power. The heat that is absorbed evaporates the working fluid at an elevated pressure in the evaporator. The less dense vapor then rises, expanding from a higher pressure to a lower pressure. Useful work is extracted from this expansion process. The kinetic energy of the working fluid is increased as the working fluid flows from the evaporator to the condenser in the vapor phase. When a turbine and generator are incorporated into the high velocity vapor stream, electric power can be generated and hence extracted. The vapor passing through the turbine loses its kinetic energy and in the process of energy transfer to the turbine. the pressure and temperature of the vapor decreases. The vapor at state 4 is then sent to the condenser where heat is transferred from the vapor to cold water and thus, the working fluids returns to a saturated liquid at state 2 back to the first heat exchanger where the process is repeated.

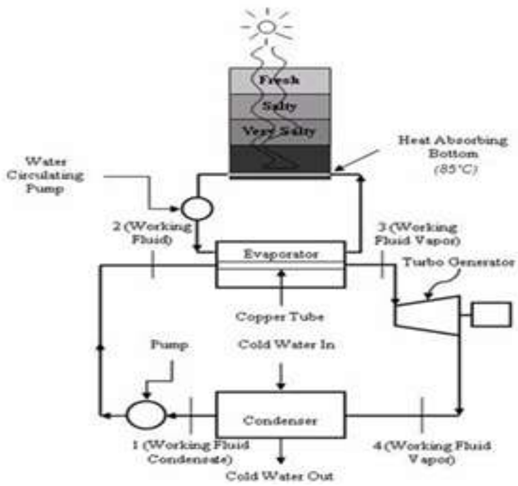


**Figure 1 : Schematic diagram of Rankine cycle solar pond power generator**

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**2. Heat Source and Heat Sink**

The temperature for a solar pond has been recorded upto 85˚C. A reasonable temperature for the ambient temperature of the air is 21˚C. For this reason, a heat sink temperature of 21˚C is assumed. Since not all the heat would be transferred from the heat sink and heat source to the Rankine cycle, the assumed evaporator temperature in the cycle is 80˚C and the condenser temperature of our Rankine cycle is 20˚C.

**3. Working fluid for the Rankine cycle solar pond power generator**

The working fluid for a phase-change cycle like the one found in a Rankine cycle power plant has the following desirable characteristics. Critical temperature well above the highest temperature that can be used in the cycle. This makes it possible to vaporize the working fluid and thus adds a considerable amount of heat to it at the maximum temperature. Neither very high nor very low saturation pressures at the maximum and minimum temperatures of the cycle. In this investigation, **R-134a** is used as working fluid because of its superior high thermal efficiency, conductivity and ozone-friendly nature.

**4. Analysis of closed Rankine cycle solar pond power generator**

The system analyzed here is a 350 kW power plant, which assumes warm water entering temperature of 82.5˚C and exiting temperature of 77.5˚C, cold water entering temperature of 17˚C and exiting temperature of 21˚C, the specific state points 1, 2, 3 and 4 at temperatures of 20˚C, 34.45˚C, 80˚C and 20˚C, respectively. Also temperature differences across both heat exchangers are modeled as isobaric (both hot and cold side). In addition, the two heat exchangers are assumed to have an overall coefficient (U) of 1 kW/$m^2$K.

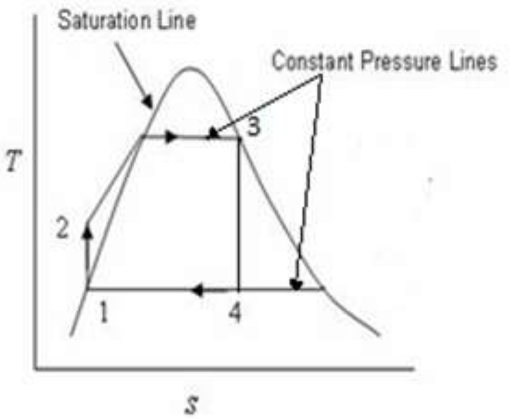


**Figure 2 : Ideal Rankine cycle on a temperature entropy diagram**

The cycle is assumed to be an idealized Rankine cycle. The figure 2 shows the different steps of the Rankine cycle according to Nguyen et al. (Nguyen, 1994)[7]. The first process (From 1-2) consists of adiabatic compression of the liquid. During the second process (From 2-3) heat is added isobarically to convert the liquid to a vapor. The third process (From 3-4) consists of adiabatic expansion of the vapor to lower pressure. During the fourth process (From 4-1) there is isobaric heat rejection that condenses the vapor back to a liquid. The above four processes are repeated over and over again to produce the Rankine cycle.

Figure 1 shows a simplified flow diagram of the closed cycle plant. Where, h is the enthalpy at the indicated state point. It follows that the heat-added plus the pump-work is equal to the heat-rejected plus the turbine work. From the state point enthalpies, the heat transferred to the working fluid in the boiler, the heat transferred from the working fluid in the condenser, work generated by the turbine, work generated by the pump, net work generated by the heat engine, thermodynamic cycle efficiency, mass flow rate of the refrigerant, boiler and condenser heat transfer rate, mass flow rate of warm and cold water, boiler and condenser surface area and specific power output of the closed Rankine cycle plant can be calculated from the equations as follows (Wu, 1998)[8].

**State 1-2**

Reversible adiabatic pumping process in the pump

Pump work (kJ/kg) $W_{pump} = V_1 (P_2 - P_1)$

$W_{pump} = 1.670$ kJ/kg

$W_{pump} = h_2 - h_1$

$\mathbf{h_2 = 229.17}$ **kJ/kg**

**State 2-3**

Heat supplied from evaporator at constant temperature to change state 2 into saturated R-134a at constant pressure.

Heat added (kJ/kg) $q_A = h_3 - h_2$

$\mathbf{q_A = 199.63}$**kJ/kg**

Acknowledging the fact that is a 14.58 kW power plant, the mass flow rate of the working fluid ($m_R$) can be found via;

Mass flow rate of warm water (kg/s)

$\mathbf{m_{warm} = 21.4}$ **kg/s**

Boiler heat transfer rate (kJ/s)

$$m_{warm} * [C_{p(water)}(T_{w1} - T_{w2})] = Q_{boil}$$

$$Q_{boil} = 350\text{kJ/s}$$

$$Q_{boil} = m_R (q_A) , m_R = \frac{Q_{boil}}{q_A}$$

$\mathbf{m_R = 1.753}$ **kg/s**

Surface area of the boiler ($m^2$)

$$A_{boil} = \frac{Q_{boil}}{\{U_{boil}\left[\frac{T_{w1}+T_{w2}}{2} - \frac{T_2+T_3}{2}\right]\}} = \mathbf{15.367m^2}$$

Where,

$T_{w1}$ Temperature of the warm water entering the boiler (82.5°C)

$T_{w2}$ Temperature of the warm water exiting the boiler (77.5°C)

**State 3-4**

Isentropic expansion of the vapor across the turbine, including partial condensation.

$$x_4 = \frac{S_4 - S_{f@22°C}}{S_{v@22°C}} = 0.947$$

$$h_4 = h_{f@22°C} + x_4 h_{v@22°C}$$

$\mathbf{h_4 = 400.04\ kJ/kg}$

Turbine work (kJ/kg) $W_{turb} = h_3 - h_4$

$\mathbf{W_{turb} = 28.76\ kJ/kg}$

Cycle Network (kJ/kg) $W_{net} = W_{turb} - W_{pump}$

$\mathbf{W_{net} = 27.09\ kJ/kg}$

**State 4-1** Complete condensation in the condenser at constant temperature.

Heat rejected (kJ/kg) $q_R = h_4 - h_1$

$\mathbf{q_R = 172.5kJ/kg}$

Condenser heat transfer rate (kJ/s)

$$Q_{cond} = m_R(q_R)$$

$\mathbf{Q_{cond} = 302.39kJ/s}$

Surface area of the Condenser ($m^2$ )

$$A_{cond} = \frac{Q_{cond}}{\{U_{boil}\left[\frac{T_1 + T_4}{2} - \frac{T_{c1} + T_{c2}}{2}\right]\}}$$

$\mathbf{A_{cond} = 302.39\ m^2}$

Mass flow rate of cold water (kg/s)

$$m_{cold} = \frac{Q_{cond}}{[C_{p(water)}(T_{c2} - T_{c1})]}$$

$\mathbf{m_{cold} = 0.989\ kg/s}$

Where,

$T_{c1}$ Temperature of the cold water entering the condenser (17° C)

$T_{c2}$ Temperature of the cold water exiting the condenser (21°C)

**Thermal Efficiency (%)**

$$\eta_{thermal} = \frac{W_{net}}{q_A} = \frac{[h_3 - h_4] - [h_2 - h_1]}{[h_3 - h_2]}$$

$\mathbf{\eta_{thermal} = 13.57\%}$

The final calculation is that of the Specific power (P). It is accomplished by the following equation

$$P = \frac{Q_{boil}}{(A_{boil} + A_{cond})}$$

$\mathbf{P = 1.1015\ kW/m^2}$

**Total power output** $\mathbf{P_{out} = 47.488\ kW}$

**Solar Efficiency,**

$$\eta_{solar} = \frac{\text{Energy Output}}{\text{Solar Energy Recieved}}$$

$\mathbf{\eta_{Solar} = 13.568\%}$

## III. COST CONSIDERATIONS

- **Energy, Environment & Economic (EEE) Evaluation of Solar Pond**

One of the main advantages of a solar pond over other thermal systems is that it is an integrated energy collection and storage system. Due to the built-in storagecapacity of the solar pond, the pond can deliver heat whenever it is required on a reasonable continuous basis. Solar pond situated at a suitable location with the ability to use local resources can operate at a relatively lower cost when compared to other technologies for large scale collection, storage and solar thermal energy delivery systems. Solar pond operation is environmentally friendly which is sustainable. Solar pond for heating can be highly competitive and economical when compared to providing heat energy utilising Liquefied Petroleum Gas (LPG) or oil.

Organic Rankine cycle (ORC) is currently used for electrical power generation from solar ponds. This results in higher unit costs of producing base load electric power when compared to conventional energy sources. This is due to the high capital cost for ORC and the low overall efficiency of the conversion of thermal energy from solar ponds to electrical energy (≤ 7%). Nevertheless, it is very important not to compare the cost of solar pond power generation with today’s emission-intensive technologies heavily relying on coal.

- **Economic and Environmental Savings**

The solar pond constructed in Solvay Mineral facilities located in Granada produces part of the low-temperature water required for the mineral purification process, allowing a significant decrease in the amount of fuel oil used by the system. The Economic analysis was performed considering the fuel oil bill and the data obtained by monitoring the performance of the solar pond. It is worth mentioning that operational expenses depend on the amount of fuel consumed and the volatile fossil fuel market.

In the years before the construction of the solar pond (2011–2013), the amount of fuel consumed per year by the flotation unit ranged between 22700 and 25330 L with an average hourly consumption of 5.2 L/h. The extractions from the solar pond saved 11060 L and 7845 L of fuel oil during the first and second periods of operation. Therefore, the hourly average consumption decreased to 2.9 and 3.2 L/h, resulting in reductions of 44 and 38% in the amount of fuel oil burned during each operation period. Additionally, during the initial six months of the first operation period, the average consumption achieved a minimum value of 1.67 L/h, reducing the fuel oil consumption by almost 68%.

- **Economic Considerations**

The cost-effectiveness of a salt-gradient solar pond depends on site-specific factors: a well-designed and built salt-gradient solar pond extremely attractive at one location may not be cost-effective at another location. The essential site-specific ingredients that will affect the cost and performance of a salt-gradient solar pond are Insolation, Salt, Soil Structure, Water Supply, Wind, Liner and Land costs, which have an important effect on cost-effectiveness, though not considered site-specific factors.

- **COST ESTIMATION**

As we have discussed above about all the different factors and various equipments that will cost in the production of power from a solar pond, in this segment we will showcase the total cost of making and maintaining a solar pond and a small power generation unit using cost of equipment available online.

**Table 2 : Estimation of System cost and Revenue generated**

| **System Cost** | **In Rupees (₹)** |
|---|---|
| Salt | 58,690.8 |
| Liner | 14,616 |
| Labour Cost | 7,016 |
| Water Cost | 12,680 |
| Excavation Cost | 11,372 |
| Turbine | 5,91,380 |
| Pump | 9,098 |
| Condensor | 1,59,217.6 |
| Evaporator | 45,490.8 |
| R134-a | 4,000 |
| **REVENUE GENERATED** | |
| (1day) = 7.75*47.488 | 368 |

In the above mention table we have given not only the cost of setting up the project but also the revenue/savings that it will generate. Hence, we can now calculate the payback period easily.

So, the payback period is = **System Cost/Revenue Generated**

**Payback Period** = 9,13,562/368

= **2,482.5 days**

= **6.8 years**

## IV. TECHNOLOGIES RELATED

- **Applying Solar Ponds to Real Life**

As we have deduced until now solar pond's main function is to store solar energy at its depth in the LCZ layer. We also used it to generate electricity. But are there any other relevant uses of this solar energy? In this section we have discussed about the different types of application that have utilized the power generated from solar ponds, below is a list of technologies related to solar ponds. These technologies have used solar pond as the power source because it is a very cheap form of solar energy. Using solar pond and increasing its efficiency will help us to achieve clean and cheap solar power helping in a cleaner environment.

- **APPLICATIONS OF SOLAR POND**

Power Production, Green House Heating, Space Heating, Agriculture, Desalination, Potash Mining, Industrial process heating, Dairy Plants, Swimming pool heating, Refrigeration and Air conditioning, Heating and Cooling of Buildings.

❖ **Benefits, Drawbacks & Future Scope**

- **BENEFITS**

✓ Diffuse radiation (cloudy days) can be used.

✓ It is a unique energy trap with built-in long term energy storage capacity.

✓ For low grade heat (below 100˚C) collection cost/$m^2$ of collector area of SGSP is 1/$5^{th}$ that of flat plate collector

✓ 1 kg of salt as salt-water concentrate can produce energy 3 times more than the heat produced by burning the same amount of coal in the combustion chamber.

✓ Pollution free.

In Germany, cost of producing 1kWh of electricity by a SGSP is only 21% of that produced by photovoltaic cells.

- **DRAWBACKS OF SOLAR POND**

✓ **Efficiency Problems**

Although we can construct solar pond easily,but they are very costly in relation of of energy efficiency. the efficiency of solar pondis less than the power plant.

✓ **Maintenance**

To use the stored thermal energy in the solar pond , the hot saltwater at the bottom of the pool needed to be pumped out. This decreases the amount of water in the pool, so new saltwater needed to be added to the pool regularly. Furthermore, salt crystals, which could accumulate in the water, should be removed to prevent buildup.

✓ **Land**

The basic consideration in the design of any pond is the area of the pond. The size of the pond is inseparably related to the heat demand required for the application, the temperature of the heat required, and the availability of solar radiation. Also as we know that the efficiency of the solar pond is not good so larger area is required for making adequate energy.

- **SCOPE AND FUTURE DIRECTION OF SOLAR PONDS**

Evaluation of the principles of Solar ponds have occoured greatly since the starting of the pioneering work in the 1950s. many solar ponds were constructed all over the globe for experimental purposes as well as for the applications at large scale . The applications in present are industrial process heating, thermal desalination, saline effluent management and biogas production. Among renewable energy technologies, it is hard to compete economically with conventional fossil fuels .

Lot of Research and Development of solar ponds technology throughout the world adds to the benefit in terms of the design and installation of new pond projects. Further working on the alternative salts, new lining techniques, cost effective and simple construction methods, artificial solar pond liquids provide the possibility for development of new generation solar ponds. With abundant, exceptional sites for solar ponds and the increase in the prices of fossil fuel , solar pond technology can become an economical viable resource that provides for a sustainable energy system.

## V. RESULTS

In this project we built a salt gradient solar pond and generated power using organic rankine cycle.

Acording to our analysis, we decided the UCZ, NCZ and LCZ thickness for the solar pond to be 0.3m, 1.35m, and 0.95m. The solar collection area of the pond at LCZ-NCZ interface was calculated to be 519.78m$^2$ (22.80m*22.80m). The temprature of bottom zone, isothermal ground and surface water were 85°C, 25°C and 30°C respectively.

By using organic rankine cycle the output power came out as 47.488 Units.

After considering the cost of all the various system components we concluded that in order to establish a power generation unit using solar pond technology the cost comes out to be Rs. 9,13,562 (approx.)

Lastly we calculated payback period by taking the cost of 1 unit as Rs.7.75 which comes out to be 6.8 years.

## VI. CONCLUSION

By selling electricity at the rate of 7.75 Rs per kilowatt-hour, our team reached on the conclusion that the design of a Power generation by utilising a salt gradient solar pond with organic rankine cycle is possible.

An alternative to selling the power to the public at a price 7.75 Rs per kilowatt-hour would be to present the design to an industry for use solely in its plant operations as back-up power.

The final recommendation from our team is to continue research efforts in the field of this working system and explore more measures to enhance the efficiency of power generation. This would require concentrated analysis of power generation system in order to meet the design specifications.

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