Fresh Water For Agriculture powered By Solar power Plant

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Abstract

Middle East and Africa regions are increasingly facing the lack of fresh water supplies these regions have high solar radiation levels, which make them good candidates for the installation and development of concentrating solar power plants. This paper investigates the strong potential of solar thermal energy to filter out seawater by using parabolic trough system combined with Reverse Osmosis. This process is not yet developed at a commercial level, where this process may provide a key solution for the freshwater deficit and energy problems in many regions of the world.

Overview

Our main goal is to Design a small Solar Power Trough System with Reverse Osmosis to produce fresh water for agriculture and personal use in Senegal. This technology will help move rural areas in the Senegal to advance their economy from depending on fishing to agriculture, by providing them with fresh water to grow crops. The plant will be divided into 4 parts:

1. Solar Field
2. Thermal Energy Storage
3. Power Block
4. Reverse osmosis

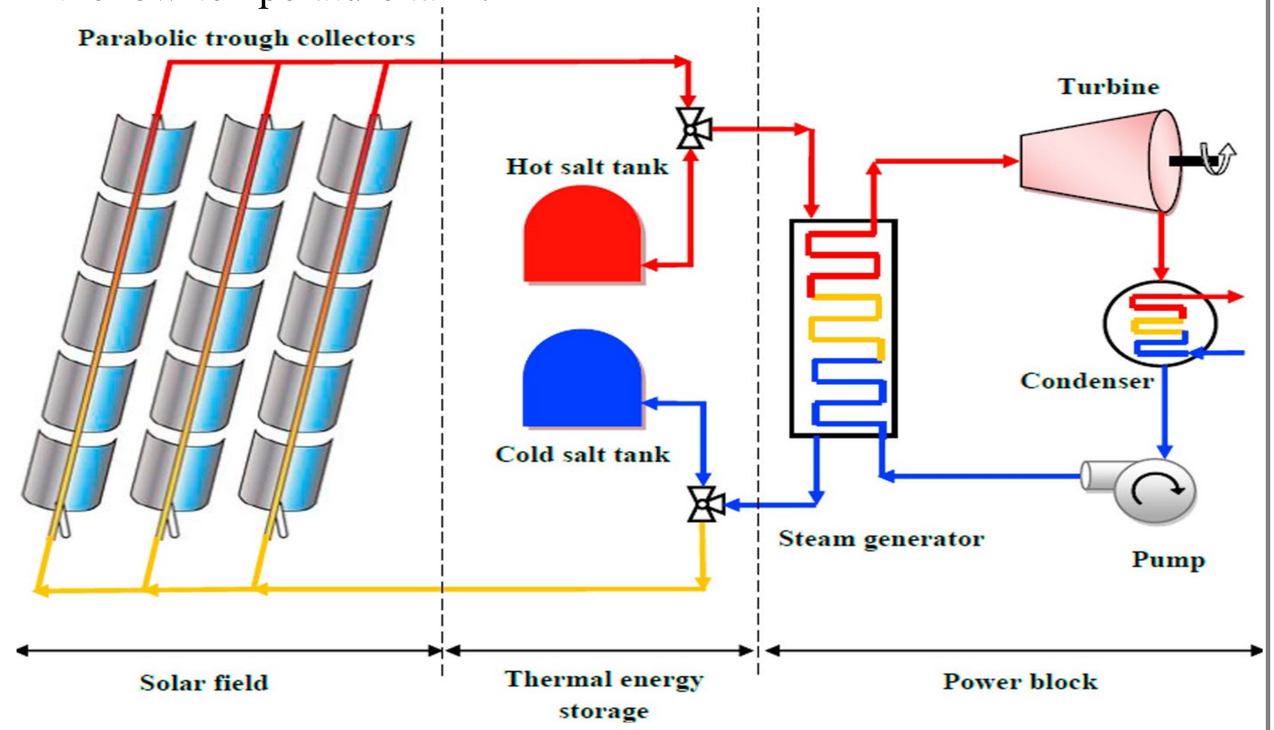
1. Solar field: Parabolic Trough Mirrors

The EuroTrough collector models are made up of identical 12 m long collector modules. Each module comprises 28 parabolic mirror panels - 7 along the horizontal axis between pylons and 4 in a vertical cross-section. Each mirror is supported on the structure at four points on its backside. This permits the glass to bend within the range of its flexibility without effect on the focal point. The 150 m long ET150 has 12 collector modules and an aperture area of 817.5 m².

EuroTrough Model	ET150
Focal Length	1.71 m
Absorber Radius	3.5 cm
Aperture Width	5.77 m
Aperture Area	817.5 m²
Collector Length	148.5 m
Number of Modules per Drive	12
Number of Glass Facets	336
Number of Absorber Tubes (4.1 m)	36
Mirror reflectivity	94%
Weight of steel structure and pylons, per m² aperture area	18.5 kg

2. Thermal Storage: TWO-TANK SYSTEM

- Solar thermal energy in this system is stored in the same fluid used to collect it.
- The fluid is stored in two tanks—one at high temperature and the other at low temperature. Fluid from the low-temperature tank flows through the solar collector or receiver, where solar energy heats it to a high temperature, and it then flows to the high-temperature tank for storage.
- Fluid from the high-temperature tank flows through a heat exchanger, where it generates steam for electricity production.
- The fluid exits the heat exchanger at a low temperature and returns to the low-temperature tank.



3. Power Block

Turbine:

- In the power block of the system, the low-pressure steam spins the turbine to produce AC power coming out. The generator used has an output power of 5 MW electricity through a generator, then to the reverse osmosis system. We achieved what we needed from the whole system, which to generate fresh water from a renewable resource and store what we do not need to use, so we can rely on later when needed.

Steam generator:

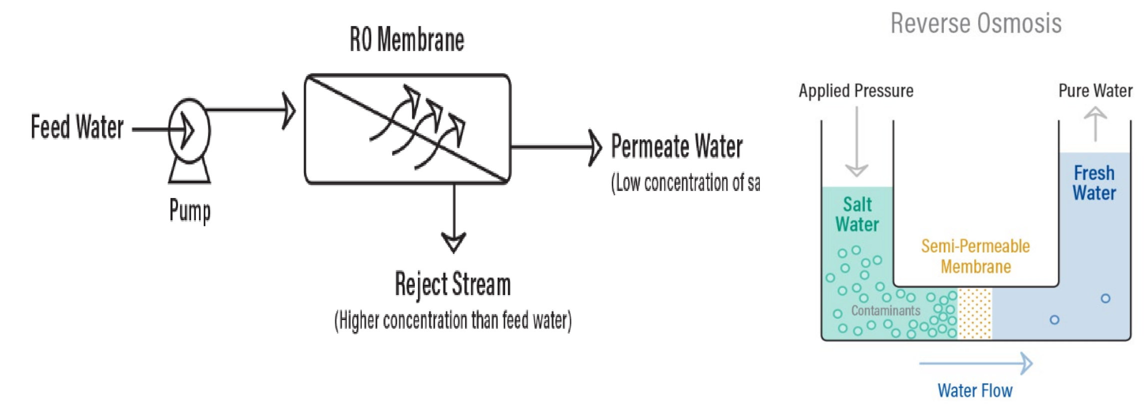
- Salt enters the system at 563C (1045F) to produce 541C (1005F) main and reheat steam. Since steam enters the reheater at approximately 342C (648F), the temperature of the salt leaving the reheater must be higher than this value.

Condenser:

- Saturated water in the steam drum maintains the feedwater temperature above the salt freezing point [221C (430F)] during part-load operation. Drum water can be blended with the incoming feedwater to achieve the required temperature.
- Incoming feedwater uses the fresh water from the reverse osmosis to cool down the steam back to cold temperatures in order to travel back to the heat exchanger. On the other hand, also from the heat exchanger we got steam.

Metric	Value
Annual energy (year 1)	1,301,673 kWh
Gross-to-net conversion	64.1 %
Capacity factor (year 1)	3.3%
Annual Water Usage	1,058 m^3

4. Reverse Osmosis

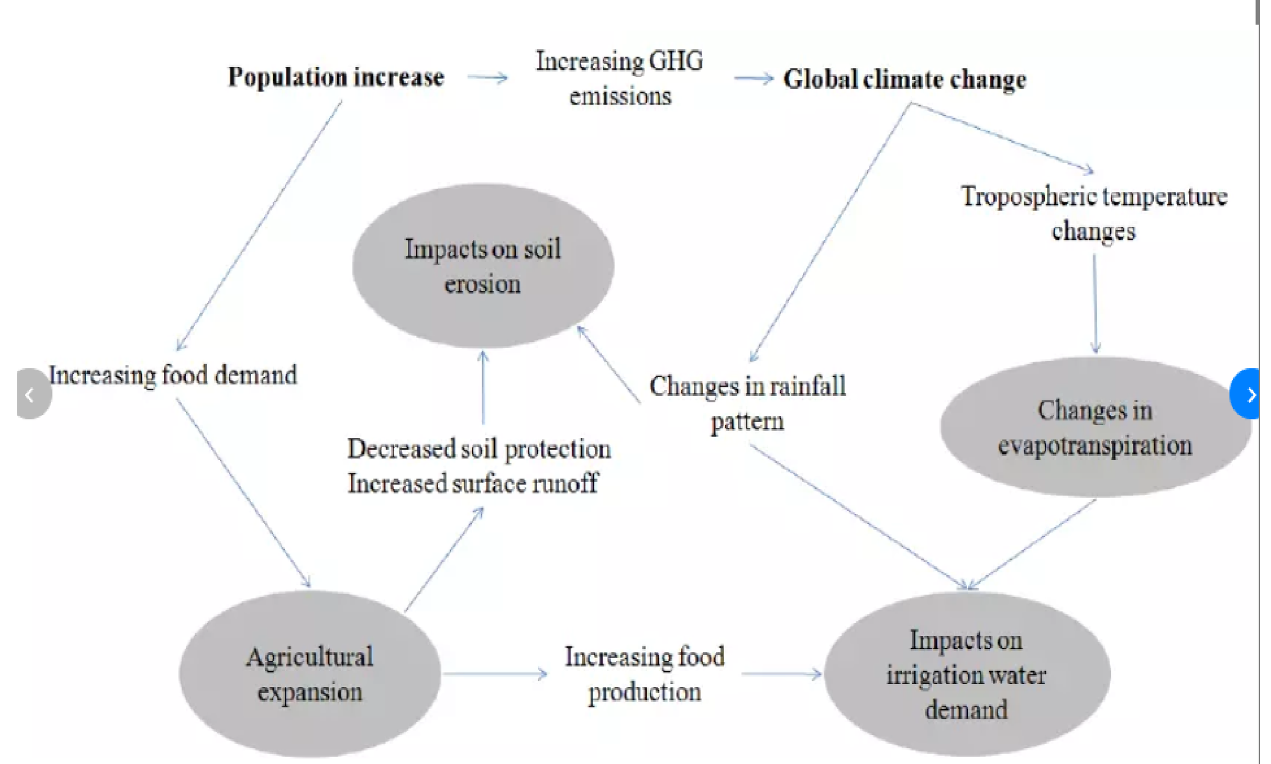


- Since we need a technology to produce water for small communities, Reverse Osmosis is the best choice because it is easy to maintain, uses less energy, and more efficient than other technologies.
- As the feed water enters the RO membrane under pressure (enough pressure to overcome osmotic pressure) the water molecules pass through the semi-permeable membrane and the salts and other contaminants are not allowed to pass and are discharged through the reject stream (also known as the concentrate or brine stream), which goes to drain or can be fed back into the feed water supply in some circumstances to be recycled through the RO system to save water.
- The water that makes it through the RO membrane is called permeate or product water and usually has around 95% to 99% of the dissolved salts removed from it.
- Typical seawater reverse osmosis plant, 3 to 10 kWh of electric energy is required to produce one cubic meter of freshwater. In our case we calculated that the energy consumption can be Reduced to 2.46 KWh.

Agriculture

The reason why we chose seawater as a source that needs to be purified is because we focused on countries that rely on fish as a source of diet. We want to also make people to rely on agriculture by providing fresh water for them to irrigate crops and grow more diversified type of agriculture. It can be beneficial, because people do not have to relocate in times where fish is not available and instead have more alternatives within the same region. And not only that they can grow crops that can be sold to other people and grow economically.

Adding on water can be used for other reasons such as cooking, showering and most essential drinking. Using our calculations and estimations of how much an average person needs water for in a daily basis plus water for irrigating crops helped us to determine that our generation has enough energy to concentrate about 1482 cubic meter per day, that should be enough to provide water for 600 of people within small villages within an area specially where water is more crucial in third world countries.



Flow chart showing a simplified illustration of interactions between agricultural expansion, climate and environment addressed in this thesis. The gray balloons indicate specific topics addressed in the research papers from this thesis.

Calculation and Data

Water Production calculation:

W= Total Water Produced Yearly

$$\mathbf{W} = \frac{\text{Total Energy Produced Yearly (KWh)}}{\text{Energy Consumption per 1 m}^3\left(\frac{\text{KWh}}{\text{m}^3}\right)} = \frac{1,301,673\ (\text{KWh})}{2.44\left(\frac{\text{KWh}}{\text{m}^3}\right)} = 533472.541\ \text{m}^3 \text{ a year}$$

$$1\ \text{m}^3 = 264.172 \text{ Gallons}$$
$$533472.541\ \text{m}^3 = 140928536 \text{ Gallons a year}$$

95% of the total water produce will go for Agriculture:

A= Agriculture water consumption

$$A = 0.95 * 140928536 \text{ Gallons} = 133882109 \text{ gallons a Year}$$
$$= 11156842 \text{ gallons a Month}$$
$$= 371895 \text{ gallons a Day}$$

5% of the total water produce will go for 600 people in the Village:

H= Water consumption a day per Person

V= Water Consumption a day for 600 people

$$V = 0.05 * 140928536 \text{ Gallons} = 7046427 \text{ gallons a Year}$$
$$= 587202\text{gallons a Month}$$
$$= 19573 \text{ gallons a Day}$$

$$H = \frac{19573 \text{ gallons a Day}}{600 \text{ person}} = 32.6 \text{ gallons per person a Day}$$

Agriculture Calculation: Corn Fields

1 lb of Corn = 60 gallon of water
1 Bushels of Corn = 56 lb of corn
1 Acer = 130 Bushel of corn

CY= Yearly Pounds of corn produced

$$CY = \frac{98649975\ gallons\ a\ year}{60\ gallon\ for\ 1\ lb\ of\ corn} = 2231369\ lb\ of\ Corn\ a\ Year$$

B= Bushel of corn

$$B = \frac{2231369\ lb\ of\ corn}{56\ lb\ (1\ bushel)} = 39846\ Bushel$$

AC= Total Acers of corn

$$AC = \frac{39846\ Bushel}{130\ Bushel\ in\ 1\ acer} = 307\ Acers\ of\ corn$$

1 Acer of corn feeds 2 people a year

307 acers of corn a year x 2 people for 1 acer = 614 people a year

Conclusion

This paper discussed the main goal of using Solar Parabolic Trough Power Plant with Seawater Reverse Osmosis. In addition, it also clarifies how the system work to improve the Agriculture for rural village. Finally, not so many countries could generate electricity from regular sources of generation nor they cannot get a pure fresh water for living. However, by using this kind of simple technology that we may build from basic materials that could be found anywhere, and mostly depends on the reverse osmosis, we could help those countries to generate electricity with low costs and get fresh water Our team implemented the idea of solar renewables which is solar energy, we focused on Solar Parabolic Trough Power Plant with Seawater Reverse Osmosis in order to come with a solution to help developing nations use clean energy and comparing them with current burning fossil fuel power plants.