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Reduction of effective cost for seawater desalination using floated solar energy in south of Jordan Aqaba Port

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Abstract. The major issue that prevails all over the world is potable water. Only 1% of all Earth's water exists as liquid, whereas less than 3% as freshwater, mostly glaciers, and 97% as salt water. Desalination is the process of removing salt from sea water in order to obtain fresh water.Nowadays, scientists are exploring seawater desalination for potable water. Another key concern that exists in any country is clean energy. The energy crisis is due to overconsumption of fossil fuels such as oil, gas, and coal. Engineers try various sources of renewable energy. The cost of potable water and clean energy, say, the cost pertaining to capital, operation, maintenance, performance, and fuel, has increased year after year. The technologies for generating renewable energy, like solar and wind, do not have fuel costs. Modern desalination techniques incur a high initial investment and a higher maintenance cost. The life-cycle cost per litre of potable water generated by the solar stills is lower than that of conventional methods. The most cost-effective way to power desalination plants is with solar power. Seawater desalination with the use of solar power is employed in these regions as a viable alternative solution. Jordan is a country in western Asia. Water and energy sources are scarce in Jordan, with water availability in Jordan is estimated to be less than 100 m3 per year. Jordan imports 95% of its energy needs. Jordan plans to generate 14% of the country's electricity by utilizing wind and solar energy. The use of solar stills in Jordan can reduce the dependency on oil and gas for power generation. The use of floating solar stills for seawater desalination represents a promising tool for Jordan. Solar stills work on the evaporation and condensation processes. They distil water by using the heat of the sun. Efficiency and productivity have been measured to quantify the performance of solar stills. Solar stills have the advantages of simplicity, low cost, ease of maintenance, and low environmental impact. In this paper, an attempt is made to analyze the types, materials, components, design, performance, cost, benefits, advantages, and limitations of solar stills. The paper also discussed the reduction of the effective cost of seawater desalination using floated solar energy in Jordan's Aqaba Port.

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1 Introduction

Around 71% of Earth's surface is covered by water. About 96.5% of water volume on earth exists in seas and ocean, 3% as freshwater mostly glaciers, and 1 % as liquid state as water. Water based susceptibility may reach half of the population in a decade. A population of one billion people has no access to potable safe clean water around the world. Nowadays scientists try to find the ways to receive safe potable water. One of such methods is desalination, that is, removal of salt from sea water to get fresh water. Natural gas price reached record high. The cost of oil price hits the highest level. Overconsumption of fossil fuels such as oil, gas, coal leads to energy crisis globally. Engineers put their effort to sort out the ways to get clean energy. Now they turn their focus on renewable energy, say, sun, wind, biomass tide, waves and geothermal. As the present and modern technologies incur high cost, the researchers globally seek a solution for potable water and clean energy with low cost. The cost effective method is sea water desalination using solar energy.

2 Literature

The contribution of electro dialysis with bipolar membrane for production of freshwater was tested by Marta et.al. The study results found that the photovoltaic solar energy decreases carbon foot print [1]. Performance parameter of solar driven electricity generation and water desalination hybrid system were obtained in a study by Qin Zaho et.al They found that hybrid system was 4.44 times improvement in power density and efficiency [2]. A study on concentrating photovoltaic membrane distillation system was proposed by Shen Liang et. Al. Their study resulted that electrical and water yield efficiency of the system can be 10% and 32%, respectively [3]. An experimental set up is designed of a concentrated photovoltaic and direct contact membrane distillation was tested by Andrew Krnac et. al. and the study showed that a mass flux of 7.096 L/m2.h [4]. A solar thermal-photovoltaic vacuum membrane distillation (STPVMD) system was tested by Hongling Deng et. al. and they found that the effectiveness and reliability of the models [5]. A decentralized water/electricity cogeneration system driven by solar energy is evaluated by Qian Chen et. al. and the study results revealed that life-cycle cost of desalinated water is \$0.7–4.3/m3 [6]. The assessment of the impact of the solar irradiation, the distance from the coast, and the altitude of the location for a Concentrated Solar Power + Photovoltaic + Multi-Effect Distillation was done by Carlos Mata-Torres et. al. and the cost maps of the thermo economic cost of electricity and water are presented [7]. Energy management of a hybrid grid-connected desalination process is investigated by Mohammad Amin Soleimanzade and MohtadaSadrzadeh and they found that particle swam optimization outperform common optimization algorithms like genetic algorithm [8]. The study examined the many kinds of humidification dehumidification desalination systems driven by solar energy sources and their key components by NejibGhazouani et. al. and the result showed that even though humidification–dehumidification was a promising method for decentralised small-scale fresh water production applications, it needed an additional improvement to optimise system performance in terms of economy and gain output ratio [9]. Different types of energy like wind, solar thermal and photovoltaic, geothermal, wave and pressure retarded osmosis are explained by ZeyadMoustafa Ghazi et al. and the study found that the correct combination of renewable energy and desalination technologies is the key to meeting water demand in a cost-effective, efficient, and environmentally responsible manner [10].

3 Methods

Solar still mimics the way nature makes the rain. It works on the two basic scientific principles, say, evaporation and condensation. It is a black bottomed vessel topped with clear glass. Black material absorbs sunlight and salt water evaporates. Salt and minerals do not evaporate with water and left behind. Clear topping trap the evaporation and funneled away. There are two types of solar stills. They are passive and active. The input energy of the passive solar still is the solar radiation. But the efficiency of the passive solar still is low. The efficiency of the passive solar still is increased by preheating the salt water in solar still. This method is called as active solar still. But it requires an additional source of thermal energy. The way of providing this additional source of energy wither by solar energy-based system or thermal energy contained in hot water. The challenge in the design of solar still is to make it air tight. Efficiency of the solar still decreases if the solar still is not air tight.

One interface is provided to convey the energy and collect the condensate in single-effect still. Multi effect still requires double the effort in regards to ensure tight seals. Water is inside an enclosure impervious material in basin type solar still. Capillary action to spread water in the system by using cloth like material is applied in wick still. Surface area is increased exponentially to increase productivity in multi-wick still. Multi effect still and wick still are combined in diffusion still.

Solar energy projects are implemented in countries with hot and dry climate. Heating of solar panels and high operating temperature reduce the energy output. This problem can be rectified with floated solar energy system in water bodies. The lower ambient temperature on the water surface and evaporative cooling effect of the water can reduce the operating temperature of the floated solar panels. The efficiency is increased and results in improvement of energy yield from the floated solar panel.

There are four types of panels that can be used for solar water desalination. They are crystal solar panels, amorphous silicon solar panels, monocrystalline silicon solar panels, and concentrated solar photovoltaic panels. Crystal solar panel does not tolerate heavy sunlight and needs to be renewed often. Amorphous silicon solar panel is made from silicon, copper, cadmium and suitable for small stations. Monocrystalline silicon solar pane is made from high purity monocrystalline silicon and suitable for large stations. Concentrated solar photovoltaic panel obtains large amount of photovoltaic energy. The curvature of the surface, tolerance to strong heat, cooling system and quality material make the concentrated solar photovoltaic panels high energy efficiency.

Fig. 1. Solar Energy.

The parameters affecting the solar still are climatic condition and water depth. Reflectors increase the amount of solar energy reaching the still. Fins in the base increase rate of heat transfer from basin to water. Heart storage absorbs heat during peak sunshine hours and then releases when the radiation decreases. Phase change materials achieve latent heat storage. This increases productivity and efficiency of the still. Triangular solar still may improve the yield over some days. Construction of solar still can be simplified with tubular solar still. The amount of solar energy can be increased by hemispherical cover. Vertical solar still gives low output. Multiple-effect solar stills achieve higher productivity, but additional basins increase cost and maintenance effort. Solar collectors, condensers, coolers are added to improve performance in active solar still. Air heater in the solar still increases water temperature in the basin and promotes evaporation rate. The still with integrated air heater has higher efficiency when combined with thermal energy storage and water spray array. A separate condenser increases the condensation rate inside the soar still. An external condenser improves the condensation rate of an active solar still. Total heat loss is reduced in the regenerative active solar still. Rotating shat breaks up thermal boundary layer of water in the basin which increases vaporization rate and condensation rate.

Jordan is a country in western Asia. Water and energy sources are scarce in Jordan. Hot arid desert climate exists in Jordan. Water availability of Jordan is estimated to be less than 100m3 / year. Jordan imports 95% of its energy needs. Jordan plans to generate 14% of the country's electricity by utilizing wind and solar energy. Government of Jordan is planning to develop sea water desalination in the city of Aqaba. It would be located in the sea-side city of Aqaba, in Aqaba Governorate, on the shores of the Gulf of Aqaba, a part of the Red Sea, in extreme southern Jordan. Jordan's Ministry of Water and Irrigation is planning a 1-billion-dollar Aqaba-Amman water desalination and conveyance project. This project will generate 250-300 million cubic meters of desalinated water a year, about 6,85,000-8,20,000 cubic meters a day, to be pumped across Jordan.

4 Results and Discussion

The date pertaining to the amount of water produced, the energy consumed and the cost of electrical energy for the year 2017, 2028, 2019, 2020, and 2021 was obtained and given in the Table 1. As the production of quantity of water increases, the amount of energy consumption also increases, and the cost incurred for electrical energy also increase. Even though the production of water is decreased during the 2020, the amount of energy

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consumed does not increase, but increased. It reflects in the cost of electrical energy consumed in that year as shown in Fig.2.

Table 1. Water, Energy and Cost.

Year	Water quantity (m3)	Energy Consumption (kWh)	Electrical Energy (Cost/year)
2017	22449917	23363241	65439695.96
2018	24391293	23046844	68644289.9
2019	24779209	27642485	87100643.68
2020	21614597	30258343	89294368.06
2021	22519659	24838305.08	86837502.19

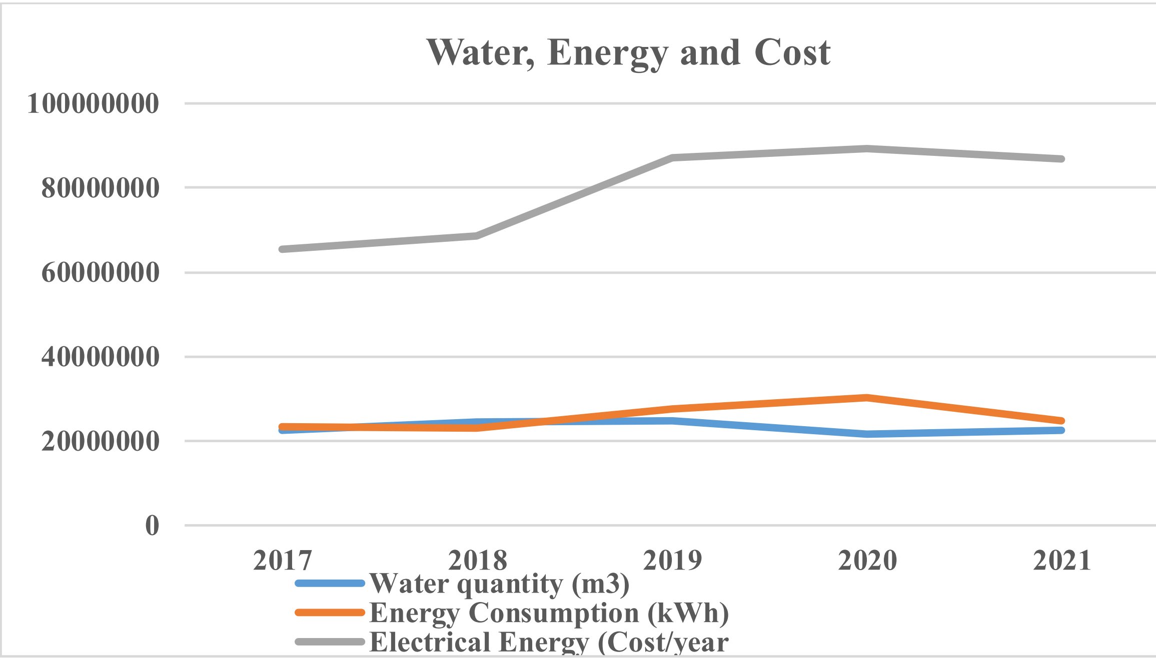

Fig.2 Water, Energy and Cost

5 Conclusion

One square meter of floated solar panels can produce 5 liters of pure water every hour. It is possible to provide clean water from desalination to large number of people. The floated solar panel for desalination is environmentally friendly and provides no emissions. Long term benefits make the floated solar panels for desalination worth the cost. In addition, it reduces the fossil fuel use and carbon footprint. The investment on the project of sea water desalination using floated solar energy can pay back after 5 to 10 years to time though pay back slowly starts from second year.
Water desalination using floated solar panels designed to be powered by renewable energy sources like solar energy. The solutions can be connected to the normal power supply as well. The seawater desalination solutions are energy efficient and equipped with integrated Energy Recovery Technology. This saves up to 70% of energy compared to traditional Water Makers. This applies especially to projects which require between 3.8 and 100m^3 (1,000 - 26,000 gallons) of water per day. Electricity costs for land-based systems are by far the highest cost component to run the system. The desalination solutions need much less

energy. We use under 3 kWh/m³ compared to traditional systems requiring up to 10 kWh/m³ for these smaller capacities. This makes it possible for us to integrate our system with renewable energy such as solar to run completely off-grid.

I have strictly adhered to the instructions for contributions. I hereby state that the article is original, unpublished, and is not being considered for publication anywhere. I hope to receive a positive response at the earliest.

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