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Main Renewable Energies Utilized for Seawater Desalination Process: Review

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ABSTRACT: Desalination is a technique presented as a solution to future water scarcity problems, since it is known to all that in a few years the lack of water will affect many countries due to the population increase and the great demand of water in agriculture and industry.According to the UN in 2050 we will be 9.6 billion people inhabiting the planet and the amount of freshwater will not be enough to meet everyone, especially in underdeveloped countries that currently suffer from the lack of access to drinking water sources.The ocean is an inexhaustible source of water, but it has a high amount of salts that need to be removed for consumption. One of the main barriers to increased production of desalinated water is the cost and amount of energy used in this process. The largest energy source used to desalinate water comes from fossil fuels, a material harmful to the environment, and researchers and engineers are looking for ways to associate desalination of sea water and renewable energy sources, achieving a healthier process for the environment, with costs depending on the region and the source of energy chosen.

KEY WORDS: Seawater Desalination, Solar Energy, Wind Energy, Geothermal Energy.

I.INTRODUCTION

The minimum amount of water consumed per person per day should be 50 liters, but in a few years if nothing is done about the water crisis, this value can be reduced. It is currently estimated that about 1.1 billion people worldwide, especially in underdeveloped countries, do not have access to safe drinking water [1].Research shows that this figure can increase to two-thirds of the population by 2050.

In countries of arid and semi-arid regions such as the Middle East and North Africa, desalination methods have already been implemented as a way of obtaining fresh water for population and industry [2]. Due to increasing improvements in this technology that have made the processes economically viable, desalination for drinking water is already being carried out in many countries [3]. Saudi Arabia is the country that most desalinizes water in the world. [4]

The desalination process consists of removing or reducing the concentration of dissolved salts and solids in the saltwater, also eliminating other chemical components [5]. The processes used to remove salts from water are divided into thermal processes and membrane separation processes.

The process of separating salts from sea water requires large amounts of energy [6]. Desalination and renewable energies are two different technologies that can be combined. Both are well-developed technologies, but improvements need to be made in order to decrease operating costs, installation volume, and increase process efficiency. [7,8].

The energy collection systems are direct and indirect, where they use conventional and unconventional methods to distil water. Indirect collection systems employ two subsystems; one for the collection of renewable energy and one for the desalination, standard systems of renewable energy and desalination are used more frequently [6].

Desalination systems using renewable energy sources can be divided into three categories: geothermal, solar (photovoltaic and thermal) and wind energy.

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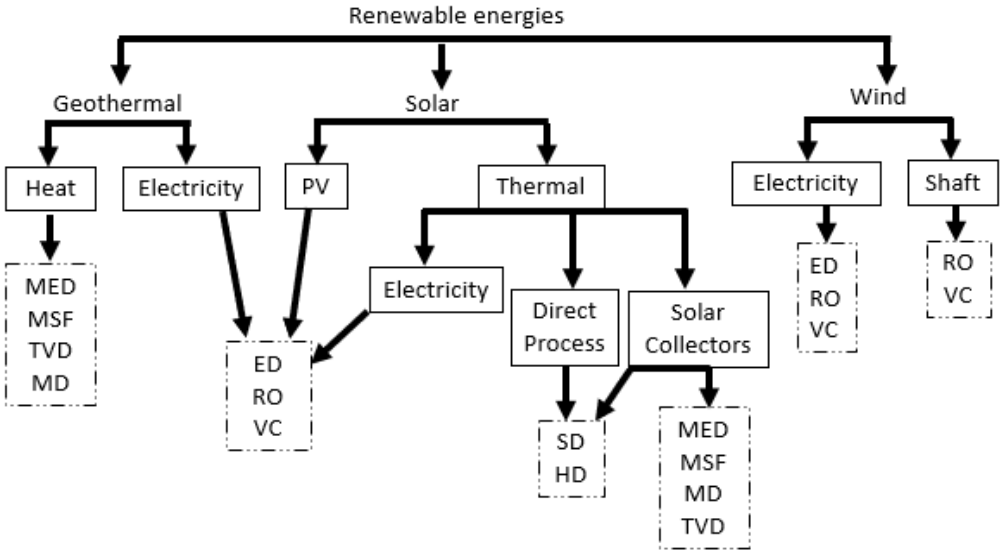

Fig. 1Possible technological combinations of the main renewable energies and desalination methods. Adapted from E. Mathioulakis et al.2007

In certain circumstances some of these combinations of systems that rely on renewable energy sources may not be viable. The choice of which of these technologies will be used depends on factors such as: available energy; cost; geographical conditions; salinity level of the region's water; production volume; among other aspects.

The place where both technologies should be employed is an important factor in remote locations where technical support is lacking the integration of advanced desalination solutions failed, despite several attempts [7,9].

II. METHODOLOGY

Solar Energy

The solar source is the most used of the renewable energies, this technology uses as raw material, solar radiation, an inexhaustible resource, and the most abundant when compared with the other renewable energy sources. 30% of the radiation emitted by the sun is reflected in the earth and 70% of that amount can be used as a source of solar energy. [7,10,11]

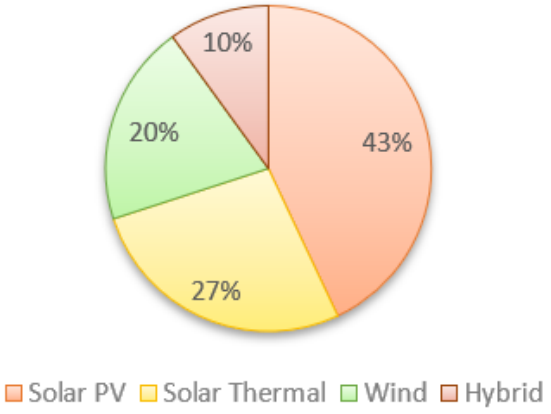

Fig 2: Renewable energy used in desalination

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Studies show that arid regions dependent on desalination to obtain potable water have high radiation spread from the sun, so there is much development of solar energy desalination [11].

Solar energy has 2 purposes, can be used as electricity directly, or as thermal energy in turbines that generate electricity. Because of this, solar energy desalination is subdivided into 2 types: solar photovoltaic and solar thermal[11].

A) Seawater Desalination Using Solar Thermal Energy

The thermal process draws energy from the heat of the sun, so it is seen as the most convenient for arid and sunny places. This method is composed of the collector and the distiller. The collector is where the solar radiation is received, and the distiller is where the desalination takes place.

This method can be classified as direct or indirect. The indirect is when the sun's radiation is obtained in a separate solar collector, commonly in solar collectors or solar ponds, and in the direct the system is all integrated. Solar collectors and ponds need a lot of area; therefore, it makes the process more expensive, but the operating costs are not so high [7,10,11].

The desalination processes that are usually combined with this type of energy are multi-effect distillation (MED) and multi-stage flash (MSF) [12].

A few years ago, it was a very expensive process, because it first needs to turn solar thermal energy into electricity and then desalination. In recent times there has been a breakthrough in this technology, as a result, this process is one of the most promising among renewable energy desalination methods [7,10].

B) Seawater Desalination Using Photovoltaic Solar Energy

The photovoltaic process is done in cells, which transform solar radiation into electricity through several layers that hold the photons. These photons generate energy to dislodge the electrons from the atoms in the semiconductor and the movement of the electrons between the two electrodes produces electric current. Only one cell generates little electricity, so it is common to join some cells forming a module, or panels, as they are also called. The panels can be interconnected in series or in parallel providing more electrical current [11,6].

The efficiency of the modules depends on the amount of solar radiation in the day, the duration of exposure to the sun, the dimensions of the panels, the ambient temperature, and the technology used in the cells [11].

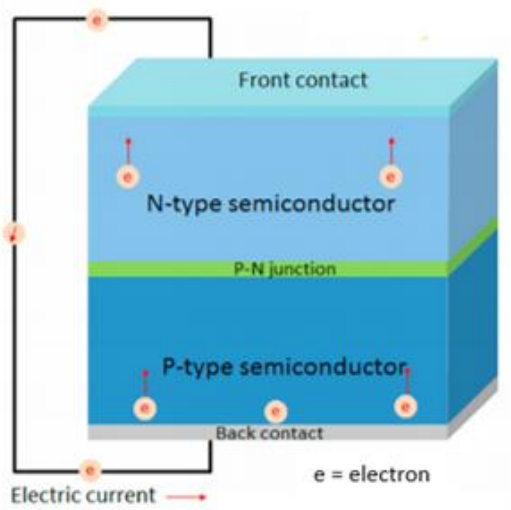

Fig 3. Typical photovoltaic cell

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This method usually needs batteries to maintain stored energy, so even if you do not have enough solar radiation on the day the desalination will not be impaired. Faced with this the cost becomes very high, in addition to the price of the cells which is also high, making it the main disadvantage [11,12].

Photovoltaic solar energy is usually associated with membrane desalination, reverse osmosis (RO) or electrodialysis (ED), producing up to 100 m3 of water / day, and is a solution for places with little space, such as islands, and sunny regions [7, 10].

This technology has been developed and rendered cheaper and feasible, consequently increasing the use, so the desalination associated with photovoltaic solar energy is the most used among the renewable energies, on average 43% of the total of all renewable energy used [12].

Wind Energy

The energy generated by a wind turbine, transformed into mechanical or electrical energy is used to power desalination plants [7]. This process happens when the wind generated by the difference of atmospheric pressure causes movements in a wind turbine installed on top of a tower, capturing the kinetic energy generated by the winds and converting it into electricity [6].

A simplest wind power turbine possible consists of three fundamental parts, the blades of the rotor, the shaft and the generator. The wind forces the blades to move by transferring part of their energy to the rotor, which is connected to an axis of the wind turbine, when the rotor rotates, the shaft rotates simultaneously, thereby the rotor transfers its rotational mechanical energy to the shaft , which at its other end is connected to an electric generator by turning the rotational energy into electricity.

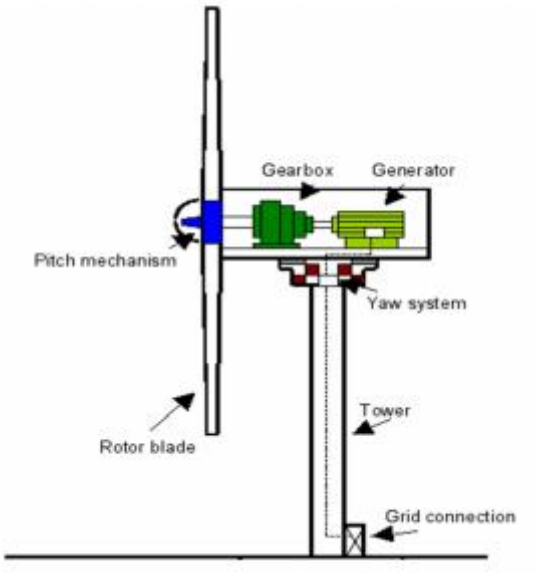

Fig.4Wind Turbine System
Adapted from Mohamed Ebeed Hussein, 2012.

This system is best implemented in remote areas and has potential, since wind energy needs the force of the wind. In coastal areas there is a greater facility to use this energy to feed the seawater desalination plant, which has the advantage of reducing production costs.

It is known that RO and ED desalination units, and the steam compression (VC) distillation process have a high affinity for integration with wind energy systems. In the MVC, the wind turbine energy is used directly for the VC without additional conversion into electricity [12]. According to the literature the RO unit when powered by wind power is a promising alternative to renewable energy desalination.

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This technology has a disadvantage, the force of the winds is not constant, generating a variation of energy that can cause an adverse effect on the performance and the useful life of the components of certain desalination equipment. However, in order to minimize the impacts of these effects it is possible to integrate backup systems, such as batteries, diesel generators or flyers to this system. [13]

Geothermal Energy

Geothermal energy is the energy in the form of heat contained within the earth [14]. The first indication that a region presents large amounts of heat in the rocks below are the geothermal activities seen on the surface, for example: hot springs, geysers and even active volcanoes. However, in order to have a geothermal potential there are three main elements: hot rocks known as reservoirs; the water; and fractures in the rocks so that the water leaves where it is being heated.

In areas of the earth's crust, the heat of a magma body heats the water that is confined to a reservoir rock at a certain depth. However, these geothermal bodies can also occur in places where due to the particular tectonic situation, there is anomalous heat flow generating large amounts of heat at shallower depths [14].

The thermal waters or steam that we see in certain places, happen when the cold rocks spread on the surface, the water of the rain penetrates that rock, following through cracks and fractures, that act like channels to connect the cold rocks with the rock heated reservoir, when arriving at the reservoir rock this water undergoes an increase of temperature, which causes a density variation, causing the water to move by convection inside the reservoir, transporting heat to surface.

Often hot reservoir fluids reach the surface, producing visible geothermal activity [6].

In a power plant, this process can happen artificially. In a location with a large geothermal potential, drill the rock to a suitable depth, creating a well for water injection, and two other wells on the side for heated water to rise to the surface.

The cold water is injected, traversing the cracks until reaching the reservoir rock. This water is highly heated through the heat contained in the reservoir and returns to the surface in liquid form or in the form of vapor. The liquid is then reinjected into the well, and the steam is piped to the plant. This steam uses its energy to turn a large turbine and is converted into electrical energy.

It is possible to use directly from a high-pressure geothermal source for the desalination process, but it is also possible to use the geothermal fluids to supply the RO or ED plants that are driven by electricity [7].

The direct use of this type of energy demands extra costs, which can cause a significant increase in the total cost of the system, since it would also be necessary to increase pumps, valves, meters, expansion joints and controls necessary for reliable operation from the Web.However, there are authors who believe that directly using a connection between thermal desalination technologies and geothermal fluid at elevated temperatures seems to be an interesting option [15].

If there is a nearby geothermal source, for different types of desalination processes, geothermal energy comes at a reasonable cost.

Low-temperature geothermal waters in the upper 100 m can be a reasonable energy source for desalination [7]. Even in sources whose heat varies between 70º C and 90º C can be considered adequate for MED desalination [12]. in addition, heat can be combined with thermal and membrane desalination technologies.

A major disadvantage of this technology is that it can only be extracted from certain locations, less than 10% of the planet presents adequate conditions to obtain this energy source, another disadvantage is that this technology generates three times smaller values of electricity than energy of fossil fuels.

When compared to other renewable energy sources, such as solar or wind energy, geothermal energy is less widely used, but can present a competitive production cost. Moreover, storage of this energy is not necessary, since its production is continuous and predictable [14]. If well managed, the reservoir can last for long years, ensuring that there is an energy source from the same source for a long time.

III. CONCLUSION

When compared to other renewable energy sources, such as solar or wind energy, geothermal energy is less widely used, but can present a competitive production cost. Moreover, storage of this energy is not necessary, since its production is continuous and predictable [14]. If well managed, the reservoir can last for long years, ensuring that there is an energy source from the same source for a long time.

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Desalination processes can use renewable energies, but not all combinations are possible, depends very much on local geographic conditions, on the salinity level of the region's water, among other things.

Photovoltaic solar energy is often associated with reverse osmosis (RO) or electrodialysis (ED), as well as wind power, which also works well with steam compression (VC) distillation. While geothermal energy can be combined with various desalination methods, solar thermal energy is commonly associated with multi-effect distillation (MED) and multi-stage flash (MSF) processes.

There are already desalination plants using renewable energy sources but are few in relation to the total installed plants, much of this is due to the cost and type of energy available at the plant site.

In some places, using fossil fuel is still more feasible, since the site has large reserves of non-renewable energy, which can reduce the cost of the process. As a result, the prospect is to increasingly expand and create new alternative methods of using renewable energies for saltwater desalination and cost reduction.

These processes can preserve the environment from harmful energy sources and solve the problem of water scarcity, a current problem that tends to worsen over time.Agrowth in the studies and development of new technologies in this area are being carried out with the purpose of approximating the use of renewable energy sources of the seawater desalination.

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