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Geothermal sea water desalination system (GSWDS) using abandoned oil/gas wells

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ABSTRACT

Nowadays, the water crisis has turned to be a major problem in all over the world. Fresh water shortage and energy intensive process are the reasons underlying water crisis. Seawater desalination can be a solution for the fresh water shortage, but this process needs plenty of energy. Abandoned oil and gas wells are useless geothermal heat sources which can be used as a heat source for water desalination. Abandoned oil wells are capable of providing valuable amount of heat without the necessity to drill expensive deep wells. In this paper, the results of numerical simulation of an abandoned oil well in the Southern part of Iran, in "Ahwaz oil field", is used for simulation of multi-effect seawater desalination process which uses oil well as a heat source and can approximately produce 565 m^3/day of fresh water. There are thousands of abandoned oil/gas wells in Iran that can be used as a heat source for this desalination system. This innovative use of abandoned wells is capable of not only solving the fresh water issues in Southern part of Iran, but also leading the country to go through sustainable developments. The process is environmentally-friendly, and significantly reduces the production of emissions, that are considered to be one of the main challenges in conventional desalination systems.

1. Introduction

In the near future, the water crisis will be one of the major issues international community will face. Definitely, in arid areas over the world, such as Iran, this issue will have more negative consequences. Statistics show that about 97% of the total water on the earth is saline water. Of the 3% of remaining water about 2% are polar ice, which cannot be used as drinking water. The remaining 1% is the main source of fresh water and usually found in groundwater reservoirs (El-Ghonemy, 2012; Kalogirou, 2005; Gorjian et al., 2014). As a result, with population growth and reduction of available water sources, the earth is facing a water crisis and the challenge will be intensified in the near future. Estimations indicate that within the next few years human being will face a serious threat because of water shortage and water will be known as the main strategic resource (Gohari et al., 2013). While population has extremely increased over the past century, the water consumption increased more than six-fold which warns the world leaders to find solutions for this issue (Gude, 2016). Currently, the existing fresh water resources do not meet the needs of the world population. This enforces the officials to find new alternative sources, or new conversion processes for producing fresh water, such as seawater desalination. The majority of the world population lives along the coastlines. About 70% of world population is living within a distance of less than 70 km from the shoreline (Ettouney, 2002; Ghaffour, 2009). As a result, seawater desalination using renewable energy system is a practical choice for these regions.

Over the recent decades, water desalination capacity gradually has increased. For example, in 2007 world desalination capacity was 47.6 million m^3/d and in 2008, rose to 58 million m^3/d. In 2011, and 2012 it reached to 65.2 million m^3/d and 74.8 million m^3/d, respectively (Bennett, 2013). As shown in Fig. 1, water desalination capacity rises up dramatically in the recent forty years, 55% per year in average (Intelligence, 2013). Percentage of desalination capacity differs in the regions. Fig. 2 illustrates the regional percentage of desalination capacity. As it is shown Middle East desalination capacity is about half of the world capacity. Desalination technologies also vary in different regions and climates. Membrane technologies are usually used in regions which water dissolved solid content is less than 35,000 ppm, for instance in European countries. Thermal technologies are used for distillation seawater which contents more than 35,000 ppm of dissolved solid. These technologies are used usually in the Middle East regions. All types of water desalination have the potential to be integrated with

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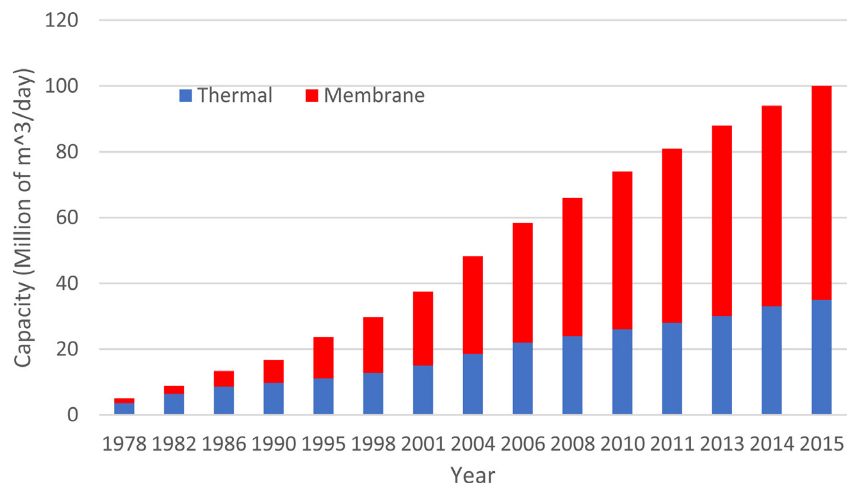

Fig. 1. World desalination capacity by technology (Intelligence, 2013).

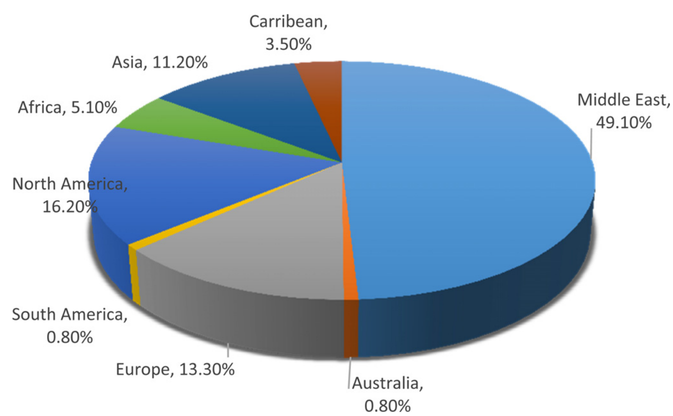

Fig. 2. Regional share of desalination capacity (Wangnick, 2002).

renewable energies. Generally, renewable energies supply heat or electricity for the process. One of the possible choices in renewable energy used for desalination, is the geothermal energy, which is available all day long. The most important drawback of using geothermal energy is that it needs expensive excavation. The purpose of this paper is to analyze an abandoned oil well as a heat source for desalination and examine the environmental impact of this technology.

2. Iran desalination status

Iran is located in the Middle East and is surrounded by three main seas: "the Persian Gulf", "Sea of Oman" in the Southern part of it, and "the Caspian Sea" in the Northern border. The Southern part of Iran has a very hot and arid climate which suffers from water shortage; therefore, seawater distillation could help to solve this dilemma. According to what was said above, most of the seawater desalination plants take place in this region (Gorjian and Ghobadian, 2015). Table 1 demonstrates desalination projects in Iran.

3. Conventional desalination technologies

There are many types of desalination technologies which have been developed and used in past centuries. In general, desalination technologies divide into two categories: Thermal and Membrane desalination processes. The thermal desalination process is also called: "phase change desalination", because in these types of technologies, there are evaporators and condensers in which phase change happens. In membrane desalination system which is also called: "non-phase change system", by using a membrane, the salt is separated from the saline water (Gude et al., 2010). Usually, thermal processes require more thermal energy which is produced from fossil fuels, while membrane processes need mostly electrical energy. Providing energy for these technologies to produce freshwater is the biggest concern of future water crisis.

'Multi-effect desalination', was the first large-scale seawater desalination technology. Depending on the amount of fresh water production and costs, this process has side effects. These effects have been vacuumed to help water evaporates with less heat. Vapor generated as a result of the first effect, is the heat source underlying the second effect. This procedure goes on for as many as effect needed. The seawater usually sprayed onto the evaporator tubes which vapor goes through them. This causes the seawater to boil and evaporate (Al-Shayji, 1998).

Every thermal desalination process needs a heat source for starting the process. In this case, our purpose is to find a new heat source for desalination, namely abandoned oil wells. Abandoned oil wells can be used as a heat source with less operating cost than a geothermal heat source because they make no drilling costs. Two important factors about abandoned oil wells that are worth noting include: first, they are environment friendly and do not produce any emissions, and second, they are useless now. So, using abandoned oil wells is a good alternative for fossil fuels, which can lead to sustainable development.

Reddy and Ghaffour (2007) studied water desalination Cost Methods to choose suitable technology for a specific location. Their methodology included all parameters of cost, energy, location, and feed water component. Yılmaz and Söylemez (2012) developed a mathematical model of multi-effect desalination which integrated with renewable energies in Turkey. Their model included continuity equation, thermodynamic laws, heat transfer equations and thermodynamic relation for each subsystem. They use the Visual Basic language for the simulating program. Khademi et al. (2009) simulated and optimized a six-effect evaporator. They proposed a model which equations in each block were written in a steady-state condition. With these equations, they presented a simulation and optimization of the process. Their results are in good agreement with experiment data. Abdel-Jabbar et al. (2007) presented a program using Visual Basic code to simulate single and multi-effect evaporation desalination. Their program included heat transfer area, power consumption, and costing equations. The program results showed a good agreement with actual data. Darwish et al.