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Seawater desalination using renewable energy sources

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Abstract

The origin and continuation of mankind is based on water. Water is one of the most abundant resources on earth, covering three-fourths of the planet's surface. However, about 97% of the earth's water is salt water in the oceans, and a tiny 3% is fresh water. This small percentage of the earth's water—which supplies most of human and animal needs—exists in ground water, lakes and rivers. The only nearly inexhaustible sources of water are the oceans, which, however, are of high salinity. It would be feasible to address the water-shortage problem with seawater desalination; however, the separation of salts from seawater requires large amounts of energy which, when produced from fossil fuels, can cause harm to the environment. Therefore, there is a need to employ environmentally-friendly energy sources in order to desalinate seawater.

After a historical introduction into desalination, this paper covers a large variety of systems used to convert seawater into fresh water suitable for human use. It also covers a variety of systems, which can be used to harness renewable energy sources; these include solar collectors, photovoltaics, solar ponds and geothermal energy. Both direct and indirect collection systems are included. The representative example of direct collection systems is the solar still. Indirect collection systems employ two sub-systems; one for the collection of renewable energy and one for desalination. For this purpose, standard renewable energy and desalination systems are most often employed. Only industrially-tested desalination systems are included in this paper and they comprise the phase change processes, which include the multistage flash, multiple effect boiling and vapour compression and membrane processes, which include reverse osmosis and electrodialysis. The paper also includes a review of various systems that use renewable energy sources for desalination. Finally, some general guidelines are given for selection of desalination and renewable energy systems and the parameters that need to be considered.

Keywords: Desalination; Renewable energy; Solar collectors; Solar ponds; Photovoltaics; Wind energy; Geothermal energy; Solar stills; Phase change processes; Reverse osmosis

Contents

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1. Introduction

The provision of fresh water is becoming an increasingly important issue in many areas of the world. In arid areas potable water is very scarce and the establishment of a human habitat in these areas strongly depends on how such water can be made available.

Water is essential to life. The importance of supplying potable water can hardly be overstressed. Water is one of the most abundant resources on earth, covering three-fourths of the planet's surface. About 97% of the earth's water is salt water in the oceans and 3% (about 36 million km^3) is fresh water contained in the poles (in the form of ice), ground water, lakes and rivers, which supply most of human and animal needs. Nearly, 70% from this tiny 3% of the world's fresh water is frozen in glaciers, permanent snow cover, ice and permafrost. Thirty percent of all fresh water is underground, most of it in deep, hard-to-reach aquifers. Lakes and rivers together contain just a little more than 0.25% of all fresh water; lakes contain most of it.

1.1. Water and energy

Water and energy are two inseparable commodities that govern the lives of humanity and promote civilization. The history of mankind proves that water and civilization are two inseparable entities. This is proved by the fact that all great civilizations were developed and flourished near large sources of water. Rivers, seas, oases, and oceans have attracted mankind to their coasts because water is the source of life. History proves the importance of water in the sustainability of life and the development of civilization. Maybe the most significant example of this influence is the Nile River in Egypt. The river provided water for irrigation and mud full of nutrients. Ancient Egyptian engineers were able to master the river water and Egypt, as an agricultural nation, became the main wheat exporting country in the whole Mediterranean Basin [1]. Due to the richness of the river, various disciplines of science like astronomy, mathematics, law, justice, currency and police were created at a time when no other human society held this knowledge.