Desalination of Water

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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. Desalination is a process of removing dissolved salts from seawater to produce fresh water for consumption. 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 There are two major types of desalination technologies around the world, namely membrane desalination and thermal desalination. The former technology features the use of a special filter (membrane) to produce desalinated water, whereas the latter technology involves the boiling/evaporation of seawater to give off water vapour which, on condensation, yields salt-free liquid water. 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 electro dialysis. Reverse osmosis ("RO") is a predominant form of membrane desalination. For thermal desalination, the most commonly adopted technologies are multi-stage flash evaporation ("MSF") and multi-effect distillation ("MED"). RO is currently the most widely used method for desalination. In 2012, it accounted for 63% of the desalination production capacity worldwide, followed by MSF (23%) and MED (8%).The paper also includes a review of various systems that use for desalination. Finally, some general guidelines are given for selection of desalination and the parameters that need to be considered.

Keywords: Desalination, Reverse Osmosis, Membrane, Multi-Stage Flash Evaporation ("MSF"), Multi-Effect Distillation ("MED")

I. INTRODUCTION

As the world population is growing, the need for fresh water is increasing. Water desalination is a mean for producing. World water resources are mainly salty (97.5%) and fresh water (2.5%). Salty water is found in oceans, seas and some lakes while fresh water is either stored underground (30%) or in the form of ice / snow covering mountainous regions, Antarctic and Arctic (70%) but only 0.3% is usable by humans fresh water from saline water abundant in seas and oceans. Thus, tremendous efforts are now required to make available new water resources in order to reduce the water deficit in countries which have shortages, According to World Health Organization (WHO) guidelines, the permissible limit of salinity in drinking water is 500 ppm and for special cases up to 1000 ppm. Most of the water available on the earth has salinity up to10 000 ppm and seawater normally has salinity in the range of 35 000–45 000 ppm in the form of total dissolved salts. The desalination of seawater has become one of the most important commercial processes to provide fresh water for many communities and industrial sectors which play a crucial role in socioeconomic development in a number of developing countries.

II. OVERVIEW OF DESALINATION PROCESSES

Desalination technologies are divided into three major groups, namely: (i) thermally activated systems in which evaporation and condensation are the main processes used to separate salts from water, (ii) pressure-activated systems where a pressure is applied on the salty water that forces it through a membrane, leaving salts behind and (iii) chemically-activated desalination methods. Thermally activated systems include: multi-stage flash distillation (MSF), multiple-effect distillation (MED), vapor compression distillation (MVC), humidification - dehumidification desalination (HDH), solar distillation (SD) and freezing (Frz). In these systems, heat transfer is used either to boil or freeze the seawater orbrackish water to convert it to vapor or ice so the salts are separated from the water. Pressure- activated systems use permeable membranes to create two zones where water can pass through leaving salt behind.

These technologies consist of reverse osmosis (RO), forward osmosis (FO), electro-dyalysis (ED) and Nano filtration (NF). Chemically-activated desalination systems include ion-exchange desalination (I.Ex),liquid–liquid extraction (LLE) and gas hydrate (G.Hyd) or other precipitation schemes [1, 2]. Recently, adsorption technology (Ads) has been investigated for desalination application. In this technology an adsorbent material with high affinity to water like silica gel can be used to separate the water from the salts [1]. Figure 1 shows flow chart of the various desalination technologies [1, 2]. This work aims to critically assess the performance of all available desalination systems in terms of energy required, cost, quality of feed and produced fresh water and environmental impact.

