Chapter 22
The Best Desalination Technology for the Persian Gulf

Akbar Adibfar
MAPNA Group, Iran

ABSTRACT

One in six people worldwide do not have access to safe freshwater. The world has been divided into 3 areas: Scarce, Stressed and Sufficiently available potable water by World Health Organization (WHO). The countries around Persian Gulf in the Middle East are in Scarcity area. Desalination solution has been proved as the primary response to water scarcity. This region ranks among the world's top ten desalinating countries, namely, in descending order: Saudi Arabia, United Arab Emirates, Kuwait and Qatar. There are some key parameters in selecting different technologies for desalination, including temperature. The temperature can be quite low in some countries such as Australia, while it is rather high in Persian Gulf. Total dissolved Solid (TDS) which is representative of salinity is a critical factor, similar to temperature, in selecting the desalination technology. The value encountered in Persian Gulf is extremely high as compared to the normal range of sea water salinity. The three principal desalination technologies used all over the world are multi-stage flash (MSF), reverse osmosis (RO), and multi-effect distillation (MED). This study looks at the different aspects of development such as costs, capabilities and state-of-the-art technologies. A comparative analysis of these technologies is presented and the best technology from financial and technical point of view is introduced and discussed.

1. INTRODUCTION

Water scarcity is a function of supply and demand. The supply is essentially affected by nature and demand rises with population and economic activities. In the other word by 2025, the average renewable water resources in the region will be 1,063 m^3/*capita/yr*, compared with a world average of 5,416 m^3/*capita/yr*. In many parts groundwater levels have sunk more than one *kilometer* below the surface, and the lack of water is curtailing agricultural and industrial activities. The water

DOI: 10.4018/978-1-4666-3613-2.ch022

supply and demand balance in most Persian Gulf Cooperation Council (PGCC) countries is in serious deficit. The availability of conventional water resources is affected by growing water demands and the deterioration of surface and groundwater quality. In order to compensate this deficit, PGCC member countries can manage their existing water resources more efficiently through demand side management tools or by increasing the supply of freshwater through the development of non-conventional water resources particularly desalination, such as thermal (MSF/MED) or membrane (RO) technologies introduced as follows.

1.1. Thermal Technologies

Thermal technologies, as the name implies, involve the heating of saline water and collecting the condensed vapor (distillate) to produce pure water. Thermal technologies have rarely been used for brackish water desalination, because of the high costs involved. They have however been used for seawater desalination and can be sub-divided into three groups: Multi-Stage Flash Distillation (MSF), and Multi-Effect Distillation (MED).

1.1.1. Multi-Stage Flash Distillation (MSF)

This process involves the use of distillation through several (multi-stage) chambers. In the MSF process, each successive stage of the plant operates at progressively lower pressures. The feed water is first heated under high pressure, and is led into the first 'flash chamber', where the pressure is released, causing the water to boil rapidly resulting in sudden evaporation or 'flashing'. This 'flashing' of a portion of the feed continues in each successive stage, because the pressure at each stage is lower than in the previous stage. The vapor generated by the flashing is converted into fresh water by being condensed on heat exchanger tubing that run through each stage. The tubes are cooled by the incoming cooler feed water. Generally, only a small percentage of the feed water is converted into vapor and condensed.

Multi-stage flash distillation plants have been built since the late 1950s. Some MSF plants can contain from 15 to 25 *stages*. MSF distillation plants can have either a 'once-through' or 'recycled' process. In the 'once-through' design, the feed water is passed through the heater and flash chambers just once and disposed of, while in the recycled design, the feed water for cooling is recycled. Each of these processes can be structured as a 'long tube' or 'cross tube' design. In the long tube design, tubing is parallel to the concentrate flow, while in the cross tube design, tubing is perpendicular to the concentrate flow. MSF plants have been built all over the world, primarily in the Middle East, where energy resources have been plentiful and inexpensive (Buros, 2000).

1.1.2. Multi-Effect Distillation (MED)

The MED process has been used since the late 1950s and early 1960s. Multi-effect distillation occurs in a series of vessels (effects) and uses the principles of evaporation and condensation at reduced ambient pressure. In MED, a series of evaporator effects produce water at progressively lower pressures. Water boils at lower temperatures as pressure decreases, so the water vapor of the first vessel or effect serves as the heating medium for the second, and so on. The more vessels or effects there are, the higher the performance ratio. Depending upon the arrangement of the heat exchanger tubing, MED units could be classified as horizontal tube, vertical tube or vertically stacked tube bundles.

MED with Thermal Vapor Compression (MED-TVC), steam from the power plant is directed to the evaporators in the desalination units. Product water is obtained as condensate of the vapor from each vessel. Several MED plants are found in the Middle East and in the Caribbean (Krishna, 1989).