

Feasibility of the concept of hybridization of existing co-generative plant with reverse osmosis and aquifer storage

Entisar Al-Katheeri*, Sergey P. Agashichev

National Energy & Water Research Center, ADWEA, P.O. Box 54111, Abu Dhabi, UAE
Tel. +971 2 694 7022; Fax +971 2 642 8994; email: eekatheeri@adwea.gov.ae

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Abstract

This study considers the feasibility of hybridization of existing co-generation plant with reverse osmosis and aquifer storage. This hybrid system is characterized by the following technological, economic and strategic advantages: (1) increased range of variation of power to water ratio; (2) possibility to use seasonal surplus of unutilized power for production of additional quantity of water; (3) decreased specific CO₂ emissions; (4) improved economic indicators of co-generative technology; (5) creation of strategic water reserve, etc.

The proposed study focuses on comparison of conventional co-generative system representing the reference case with the hybrid innovative scheme. The conventional system consists of: (1) power-generating plant, (2) MSF-desalination system. The hybrid system includes (1) power-generating plant, (2) MSF-desalination, (3) RO desalination and (4) aquifer storage and recovery (ASR) technology. Unlike the reference case being based on the conventional systems, the hybrid scheme implies the concept where the seasonal surplus of available unutilized power-generating capacity is consumed by RO and seasonal excess of water accumulated within underground aquifer.

Proposed study is based on the following assumptions: (1) available power generating capacity ranges from 80% to 100% of the maximum output being equal to 180 MW; (2) total available capacity of existing thermal desalination plant is 38 MGD; (3) seasonal variation of both water and power demand (within the range 100–60%) is considered in the model; and (4) specific energy consumption of projected RO is 6 kW h/m³.

For the scenario based on co-generation system (180 MW to 38 MGD) operating at 80–100% of the maximum generating capacity, the following data obtained: (A) unutilized capacity of power plant is sufficient for production of 40–80 MGD by RO; (B) unconsumed water supposes to be accumulated within underground aquifer. Calculated rate of seasonal variation of aquifer recharge ranges between 50 and 80 MGD.

Keywords: ASR; RO; Hybrid-desalination; Water resources management

*Corresponding author.

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1. Introduction and formulation of the problem

Analysis of published statistics on water demand for Abu Dhabi emirate [1] reveals high rate of growth of seasonal variation of water demand over the last years and increase of cumulative gross annual water demand over the same period. According to this data seasonal difference between the highest and lowest water demand increases from 1452 MG/month (in 1998) to 2629 MG/month in 2003, this represents to 80% growth. Cumulative annual water demand over the same period ranges from 63,064 MG/year (in 1998) to 113,484 MG/year in 2003. Relying upon the statistics by ADWEC [1] the prevalent trends in development of demand pattern for Abu Dhabi region can be summarized as follows: (1) growth of range of seasonal variation of demand; (2) disproportional degree of growth of water and electricity demand and (3) increase of cumulative annual gross power and water demand.

Existing trend in variation of power to water demand cannot be provided by conventional co-generative systems currently used in Abu Dhabi emirate. These technologies are characterized by inflexible limits of variations of the power to water ratio. (The criteria referred to as the power to water ratio, is an essential indicator specifying the performance of dual purpose co-generative plant. This criterion is equal to ratio of produced power to water output.) Systems of this type are preferred for countries where demand pattern is characterized by high value of the power to water ratio. (Unlike the majority of countries, Abu Dhabi with high level of water demand is characterized by low value of this criterion.)

The growth of demand and seasonal fluctuation of demand pattern require reorganization of management, in particular it dictates implementation of the concept of integrated water-resource management through integration and hybridization of different technologies [2,3]. (It would make the system more flexible that in turn, allows

optimization of water resource utilization.) Unfavorable disproportions between water and power demand can be reduced by implementation of additional desalination capacities and creation of water reserve. Within the context of the problem it is the hybridization of RO and the ASR technology with existing co-generative systems can be considered as a promising technological solution. The concept of ASR technology has been extensively scrutinized by many authors. Al-Katheeri [4,5] proposes restructuring the management through development of innovative co-generative systems including the ASR. According to the study done by Al-Katheeri [4,5], the hybridization of existing co-generative plants with the ASR technology is characterized by technological and economic advantages and expected to become a promising technological option. The ASR technology is an example of multipurpose technology; it can be used for (A) seasonal and water reuse water storage; (B) system for creation of strategic water reserve and it can be (C) integrated or hybridized with existing co-generative (or desalination) system.

Different functional, technical and economic aspects of the ASR technology are considered in [2–6]. Semi-analytical model for predicting the quality of water recovered by an ASR system is proposed by Ali Sedighi and Harald Klammler [7]. Some domains of potential applications of the ASR technology are outlined below:

(A) ASR as a technique for seasonal conservation and water reuse: The ASR is a well-known technology for accumulating large volumes of water where natural underground aquifer is used as storage. Along with seasonal storage the ASR technology can be applied as storage for reuse of reclaimed wastewater as well. Different aspects of the ASR technology were considered by Pyne [6]. The ASR-based technologies have been implemented in Australia, England, Canada, South Africa and India. The ASR technology has become attractive water conservative technology in Australia since 1980. The cases where

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