Desalination and Water Treatment
www.deswater.com
10 (2009) 165–174
October
1944-3994 / 1944-3986 © 2009 Desalination Publications. All rights reserved.
doi: 10.5004/dwt.2009.822

Assessment of the world fresh water resources through energy requirements in desalination technologies

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Received 2 October 2008; Accepted in revised form 4 September 2009

ABSTRACT

The world water withdrawal is presently about 4,000 km^3/y, which is around the 30% of the total annual technically renewable world water resources. The tendency of water consumption is to keep rising, even quicker than the energy consumption. Thus, the use of objective methodologies for assessing a value to fresh water resources is a mandatory task at this moment, in order to provide policy makers with objective and global decision tools. When water availability is measured in terms of its energy requirements, sustainability of new water-providing techniques could be analyzed. The close relationship between energy demand and climate change also support the interest of the proposed approach. From a thermodynamic perspective, two main features give exergy (available energy) value to water: its quality (chemical exergy) and its location (potential exergy). Water composition makes it useful for different economic uses such as drinking, industry, irrigation, whilst potential energy can be used to produce shaft work and electricity. The approach proposed in this paper defines the value of fresh water through its exergy replacement cost, that is, the energy consumed by hypothetical technologies that restore consumed or degraded water by mankind. In this paper, the amount of exergy required to restore water used worldwide in a year was evaluated by continents. The exergy requirements to obtain fresh water, both in quality (by means of seawater desalination) and in altitude (by means of pumping) were calculated. Present mix of desalination techniques (with their corresponding performance efficiencies) were introduced to evaluate the exergy costs of restoring the natural water cycle. Then, those exergy costs were compared to worldwide power demand and land requirements (if power were obtained from solar energy): in particular, with photovoltaics and parabolic through collectors. From this point of view based on Thermodynamics, global results obtained here question the use of desalination as the definite solution to world water scarcity. The figures show that the energy required for restoring world fresh water renewable resources would exceed by twenty times the present electricity demand. When the analysis is restricted to only the world water withdrawal, that energy is almost twice that demand.

Keywords: Water resources assessment; Exergy; Exergy replacement cost; Thermodynamic efficiency

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Presented at EuroMed 2008, Desalination for Clean Water and Energy Cooperation among Mediterranean Countries of Europe and the MENA Region, 9–13 November 2008, King Hussein Bin Talal Convention Center, Dead Sea, Jordan.