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Alternative primary energy for power desalting plants in Kuwait: the nuclear option II — The steam cycle and its combination with desalting units

M.A. Darwish[a]*, M.E. Eleshaky[b]**, N.M. Al-Najem[a], B.S.A. Alazmi[a]

[a]*Mechanical Engineering Department, Kuwait University, POB 5969, Safat 13060, Kuwait*
Tel. +965 498 8888, ext. 5739, Fax: +965 484 7131; email: darwish@kuc01.kuniv.edu.kw
[b]*Department of Mechanical Engineering, College of Technological Studies Public Authority for Applied Education & Training, POB 42325, Shuwaikh, 70654, Kuwait*

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ABSTRACT

In the first part of this study, it was shown that the use of nuclear option to fuel the cogeneration power desalting plants (N-CPDP) in Kuwait is more economical than the most efficient gas/steam turbines combined cycle GSCC using oil or natural gas. The power cost produced by N-CPDP was found to be at least 35% less than that of the GSCC. Furthermore, the use of fossil fuel in Kuwait would consume all of its oil reserves in less than 30 years if its present rate of fuel consumption prevails. The very high cost of oil fuel and the emission of greenhouse gases due to its burning (with its negative environmental effects) favor the use of nuclear energy. It was found that Kuwait, Saudi Arabia, Egypt, and United Arab Emirates satisfy the conditions required to consider the nuclear option in terms of: (1) needed additional power capacity, (2) needed seawater desalting capacity, (3) size of the electricity grid, and (4) the basic infrastructure required to build the N-CPDP. The use of a light water pressurized water reactor, the AP-600 (600 MW nominal power output), in N-CPDP was anticipated for Kuwait. This paper gives the details of the AP-600 steam cycle and its combination with thermal desalting plants with multi-effect distillation (MED), multi-stage flash MSF), and thermal vapor compression (TVC) desalting systems. The water costs due to the coupling of MED, MSF, or TVC to the AP-600 nuclear power plant (NPP) were also calculated. Based on the required water-to-power ratio, either a back pressure steam turbine (BPST) or an extraction condensing steam turbine (ECST) was chosen. For the BPST, a maximum water-to-power ratio of 97 MIGD to 451 MW was obtained. Then, the use of ECST was chosen with a seawater desalting capacity of 50 MIGD. The results show that the cost of desalinating water with nuclear power is cheaper than that produced by fossil-fired plants, given the high cost of fossil fuel. Further, the estimated costs of producing electricity and water with MED+NCPP are lower than MSF+NCPP and TVC+NCPP. The unit product cost of the desalted water was calculated to be in the range of \$0.87–1.4 per m^3 of product water based on a plant capacity of 227.3×10^3 m^3/d. The presented technoeconomic results for the different desalination scenarios can help decision makers in choosing the best option that is suitable for the Kuwaiti conditions.

Keywords: Nuclear cogeneration power desalting plants; Nuclear plants coupled with desalination systems; Economics of nuclear desalination

* Corresponding author.
**On leave from Mechanical Engineering Department, Faculty of Engineering, Alexandria University, Egypt, 21544.