ECONOMY ASPECT FOR NUCLEAR DESALINATION SELECTION IN MURIA PENINSULA

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ABSTRACT

ECONOMY ASPECT FOR NUCLEAR DESALINATION SELECTION IN MURIA PENINSULA. An assessment of economy aspect for nuclear desalination selection has been carried out. This study compares the costs of water production for the Multi Stage Flash Distillation (MSF), Multi Effect Distillation (MED) and Reverse Osmosis (RO) desalination process coupled to PWR. Economic analysis of water cost are performed using the DEEP-3.1. The results of the performed case study of Muria Peninsula showed that the water cost to desalination process coupled with PWR nuclear power plant (at 5% interest rate, 2750 m^3/day capacity, 28^oC temperature, 28.700 ppm TDS) with MSF plant is the highest (1.353 \$/m^3), compared to 0.885 \$/m^3 and 0.791 \$/m^3 with the MED and RO plants respectively. As for MSF process, water cost by RO are also sensitive to variables, such as the interest rate, temperature and total salinity. However, MED process is sensitive to interest rate and temperature based on the economic aspect. MSF and MED plants produce a high-quality product water with a range of 1.0 – 50 ppm TDS, while RO plants produce product water of 200 – 500 ppm TDS. Water requirements for reactor coolant system in PWR type is about 1 ppm. Based on economic aspect and water requirements for reactor coolant system in PWR type, so co-generation of PWR and MED may be a favourable option for being applied in Muria Peninsula.

Key Words: Desalination, RO, MSF, MED, Coupling, Nuclear Power Plant, Economic.

INTRODUCTION

There is a plan to introduce nuclear power plants (NPP) into Java-Madura electricity grid.

- A comprehensive study on different energy sources shows that NPP is economically and technically viable to be introduced into the grid in 2016/2017.
- NPP is included to be a part of the national energy mix. According to the document, nuclear share in the energy mix is projected about 4% by 2025. The candidate site is Muria Peninsula in Central Java.

The objective of the economic evaluation is to help the decision-maker to eventually implement an integrated nuclear desalination plant, generating both electricity and fresh water.

METHODOLOGY

- Selection of thermodynamic scheme
  - nuclear energy source with steam turbine is selected.
- Determination of parameters:
  - General parameters: required capacity (m^3/day), sea water salinity (ppm), interest rate (%), sea water feed temperature (^oC), purchased electricity cost ($/kWh).
  - NPP related parameters: thermal power (MWt), electric power (MWe), NPP fuel cost ($/MWh) and NPP construction cost ($/kW).
  - Distillation plant related parameters for MSF and MED: brine maximum temperature (^oC), heating steam temperature (^oC) and MSF/MED construction cost ($/$m^3$/day),
  - Distillation plant related parameters for RO: energy recovery fraction (%), recovery ratio (%), design flux (l/m^2.hour) and desalination plant construction cost ($/$m^3$/day).
- Data input and computer program running.

Table 1. Calculation Base for the MSF, MED AND RO Plants

Parameter	MSF	MED	RO
Base year	2009	2009	2009
Interest rate, (%)	5	5	5
Life time of water plant, (Years)	20	20	20
Initial year of operation	2017	2017	2017
Year of construction	2011	2011	2011
Currency	$	$	$
Purchased electricity cost ($/Kwh)	0,04	0,04	0,04
Seawater salinity, (ppm)	28700	28700	28700
Seawater temperature (°C)	28	28	28
Construction cost of water plant ($/m3/day)	1200	900	700

RESULT

Table 2. Capital Cost, O &M Cost, Water Cost of MSF, MED and RO Processes

Parameter	MSF	MED	RO
Capital Cost ($/m^3)	0.483	0.366	0.217
O&M (($/m^3)	0.114	0.119	0.453
Water cost ($/ m^3)	1.353	0.885	0.788

Table 3. Interest Rate Effect to Water Cost of MSF, MED and RO Processes

Installation	Water Cost ($/m^3)		
	IR 5%	IR 8%	IR 10%
MSF	1.353	1.407	1.445
MED	0.885	0.918	0.941
RO	0.788	0.796	0.802

Table 4. Water Cost of MED, MSF and RO with Temperature and TDS Variables

TDS (ppm)	Temperature (°C)	Water Cost ($/m^3)		
		MSF	MED	RO
28000	27	1.337	0.859	0.788
	29	1.352	0.885	0.786
	31	1.369	0.917	0.784
	27	1.339	0.859	0.793
	29	1.354	0.885	0.790
	31	1.371	0.917	0.788
	27	1.341	0.859	0.798
32000	29	1.357	0.885	0.795
	31	1.374	0.917	0.793

Table 5. Water Cost for Back-Pressure and Extraction Schemes of MSF and MED Installations

Parameter	Water cost ($/m^3)			
	Back-Pressure		Extraction	
	MED	MSF	MED	MSF
Capital Cost	0.366	0.483	0.348	0.460
O&M cost	0.119	0.114	0.453	0.449
Water Cost	0.885	1.353	1.181	1.570

CONCLUSION

Having analysed water cost for co-generation installation of PWR+RO, PWR+MED, PWR+MSF by considering some variables, the following conclusion are drawn.

- Water cost of PWR+RO installation is the least. The higher one is that of MSF.
- Interest rate affect the water cost for all installations. An increase in the interest rate of a certain value will increase the water cost produced by PWR+MSF installation more than others.
- Seawater temperature affect differently to water cost of MED, MSF and RO. An increase of seawater temperature increases water cost of MED and MSF, but it decreases the cost of RO.
- An increase of TDS causes water cost increase in MSF and RO. Water cost of MED is not affected by TDS at all.
- Back-pressure turbine scheme produce cheaper water than that of extraction.
- MSF and MED plants produce a high-quality product water with a range of 1.0 – 50 ppm TDS, while RO plants produce product water of 200 – 500 ppm TDS.
- Based on economic aspect and water requirements for reactor coolant system in PWR type, so co-generation of PWR and MED may be a favourable option for being applied in Muria Peninsula.