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The Economics of a SMART Desalination in Foreign Countries

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1. Introduction

According to the 6th report by IPCC issued recently, it warns that a temperature increase in the air will come to 1.8 ~ 4.0℃ while the sea level might rise by 18~58cm around the end of 21st century when compared to the present. In the meantime, a water deficiency problem is certainly expected to be a main issue in our future life when thinking over the overseas warnings that the world will suffer much more difficulties than the present in securing usable water due to the aggravations of climate change as well as the environmental pollution.

Korea has recently been developing the SMART of small size for producing water and electricity simultaneously as a nuclear reactor to be coupled to the MED(Multi Effect Distillation) desalination technology. This study is focused on the economic evaluation of the SMART as a dual purpose desalination plant in Indonesia and UAE. The sensitivity analyses for the economic and technical variables are also analyzed considering the recent rapid fluctuation in energy market. The main objective of this study is to give an insight on the policy establishment for nuclear desalination in Korea.

2. Methodology

The economic evaluation of the SMART-MED option, where the SMART and the MED desalination technology is combined for the simultaneous production of water and electricity, is performed by using the levelized costing method. That is, the levelized unit costs for water and electricity are the criteria for evaluating the economics of the dual purpose plants. As for the cost allocation between water and electricity, a power credit method is applied which all combined benefit is attributed to a water cost.

The DEEP computer model developed by IAEA is also used to calculate these levelized costs including the various technical and economic outputs. The sensitivity analysis is performed for the variables such as a SMART construction cost, a SMART availability factor, an interest/discount rate, and a nuclear fuel cycle cost.

3. Results

Madura, Indonesia and Abu Dhabi, UAE are chosen as the proposed sites for the SMART-MED plant to be firstly built. The main input data used for the economic evaluation in each country is shown in Table 1. The discount rates applied in each case are reflecting each country's economic situation at present. Energy plant here means a SMART unit that supplies heat energy for an electricity generation and water production. The water plant capacities are determined by considering each country's demand for water.

Table 1. The basic input data for the analysis

Item	Indonesia (Madura)	UAE (Abu Dhabi)
Energy Plant/Desalination type	SMART/Multi Effect Distillation	
Cost reference date	The year 2005	
SMART construction cost	$1,714/kWe	
Availability Factor	90%	
Energy/Desalination Plant lifetime	40years	
Nuclear fuel cycle cost(NFC)	8mills/kWh	
Required water plant capacity	4,000㎥/d	77,000㎥/d
MED construction cost	927$(㎥/d)	900$(㎥/d)
Discount/Interest rate	10% p.a.	8% p.a.
Cooling water temperature	30℃(28~31)	30℃(20~36)
Seawater total dissolved solids	34,000ppm	43,000ppm
Mgt./Labor salaries p.a.	$6,000/$3,600	$66,000/$29,700

The result of a reference scenario is shown in Table 2 and Table 3. Table 2 represents the cost and technical performances for the SMART section in cases with or without the MED section. In the meantime, Table 3 shows the cost and performance result for a desalination section. The difference in the levelized generation costs by country mainly results from a differential discount rate, followed by an availability factor. This generation costs have a critical influence on a water production cost through a heat energy cost and an electricity consumption cost used in a water plant.

Table 2. The result for the SMART section in the reference scenario

Item	Unit	Madura	Abu Dhabi
Cost calculation for single purpose power plant			
Specific investment cost	$/kWe	2,006	1,952
Levelized fixed charge rate	%	10.23	8.39
Total annual required revenue	Million$/a	30.9	26.8
Levelized annual capital cost	Million$/a	20.2(65%)	16.1(60%)
Levelized annual O&M cost	Million$/a	4.4(14%)	4.4(16%)
Levelized annual fuel cost	Million$/a	6.3(21%)	6.3(24%)
Annual electrictiy production	GWh	777	777
Levelized electricity generation cost	$/kWh	0.040	0.035
performance calculation as a dual-purpose power plant			
Site specific net output of SMART plant	MWe	98.56	98.56
Maximum brine temperature	℃	70	70
Lost electricity(for heat	MWe	0.6	9.7

supply)			
Net electricity produced	MWe	97.9	88.8
Net salable power	MWe	97.7	83.7

Table 3. The result for the MED section in the reference scenario

Item	Unit	Madura	Abu Dhabi
	Cost calculation for MED plant		
Total specific base cost(base cost+interm.Loop+In/outfall)	$\$/(m^3/d)$	1,537	988
Specific investment cost(incl. owner's cost&IDC)	$\$/(m^3/d)$	1,862	1,186
Annual water plant fixed charge	Million\$/a	0.8(67%)	8.4(54%)
Annual water plant heat cost	Million\$/a	0.2(17%)	2.5(16%)
Annual water plant electricity power cost	Million\$/a	0.1(9%)	1.4(9%)
Water plant annual O&M cost	Million\$/a	0.2(17%)	3.4(21%)
Total annual expense(required revenue)	Million\$/a	1.21	15.67
Levelized water cost	$\$/m^3$	0.96	0.65
	The performance calculation for MED plant		
Install water plant capacity	m^3/d	4,010	84,000
Number of MED effects	numbers	15	18
GOR(kg water product/kg steam)	figure	12.0	14.4
Total water plant power use(interm.loop pumping, internal power use, incremental seawater pumping)	MWe	0.3	5.2
Total(combined) water production availability	%	86	86
Average daily water production	m^3/d	3,457	66,549

From the results of the sensitivity analysis, which are shown in Figure 1 and Figure 2, a discount rate is shown to be the most influential factor to the water and electricity production costs. As mentioned in the reference scenario, this variable influences concurrently on the generation cost of a power plant as well as the construction cost of a water plant. Even though an availability factor is also a quite important one in determining the water and power production costs. The degree of improvement for this variable is thought to be limited to a certain level.

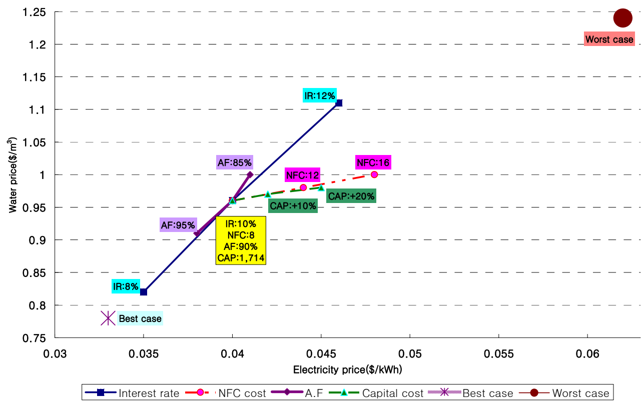

Figure 1. Sensitivity analysis for Madura, Indonesia

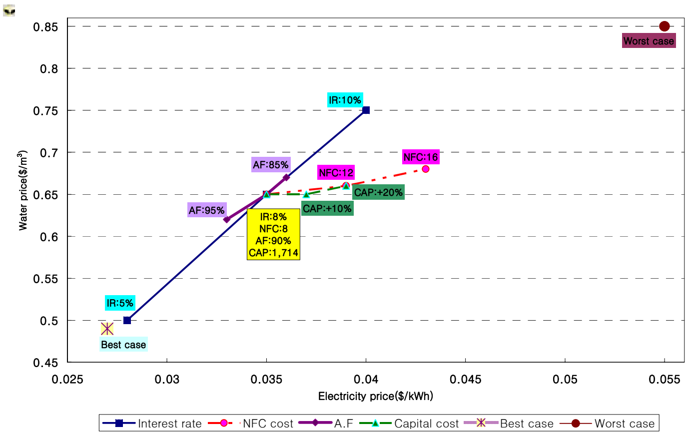

Figure 2. Sensitivity analysis for Abu Dhabi, UAE

3. Conclusion

Water and electricity are imperative to economic growth as well as the continuation and improvement of life standards. Energy market has been more unstable in recent years. From this analysis we found that the minimization of financing cost by the decrease of interest/discount is very important for securing the SMART economics. Therefore, it is thought that we have to focus on supplying a low financial scheme to an export country in order to promote the competitiveness for the SMART plant's export.

Without special changes in a macroeconomic condition and an overseas energy market, it is analyzed that the SMART desalination plant is very competitive when compared to other energy sources. Beyond the above situation, an effort for a cost reduction in the SMART construction will have to be executed actively and continuously.

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