Economic and Financial Assessment of Nuclear Desalination Plant in Madura Island

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INDONESIA
Andaman Sea
Gulf of Thailand
VIETNAM
PHILIPPINES
THAILAND
South China Sea
Strait of Malacca
BRUNEI
Pulau Ligitan
Pulau Sipadan
Celebes Sea
MALAYSIA
MALAYSIA
Borneo
Medan
SINGAPORE
Pekanbaru
Equator
PAPUA NEW GUINEA
Biak
Kalimantan
Sumatra
Sulawesi (Celebes)
Palembang
IRIAN JAYA
Puncak Jaya
New Guinea
Ambon
Java Sea
Makassar
JAKARTA
Semarang
Madura
Cirebon
Java
Surabaya
Cilacap
Denpasar
Banda Sea
INDIAN OCEAN
Kupang
EAST TIMOR
Arafura Sea
Timor Sea
AUSTRALIA
0 200 400 km
0 200 400 mi
10
100
110
120
130
140

Madura ISland

INTRODUCTION

- Availability of potable water as well as water for industry is important factor for social development
  - In some regions of Indonesia as in Madura Island, supply of clean water, potable water and industry qualified water is not adequate
  - Beside increase of water demand, also electricity demand increases more and more
- Supply system of electricity and water in Madura Island
  - In Madura Island, there is no power plant so electricity demand is supplied from Java, Madura and Bali electricity grid system (JAMALI grid)
  - Supply for water in Madura Island is in scarcity
- One alternatives to overcome electricity and water supply is Seawater Nuclear

INTRODUCTION

Desalination Plant (SNDP)

- SNDP is coupling of Nuclear Power Plant (NPP) (produces electricity) and Seawater Desalination Plant (SDP) (produces fresh water)
- In this study, NPP which used is SMART type developed by KAERI, while SDP uses MED (Multi Effect Distillation) technology

- Economic and Financial Assessment
  - Economic assessment covers calculation of electricity generation cost, water production and construction cost
  - Financial assessment covers calculation to know financial feasibility criteria such as NPV, IRR and Payback Period
  - The economic and financial assessment are carried out using DEEP ver. 2.1 from IAEA

Desalination Processes

- **Desalination processes are divided into:**
  1. **Thermal Methods: involve heating water to produce water vapour. The main thermal methods is distillation processes.**
  2. **Membrane Processes: use a relatively permeable membrane to transport either water or salt to induce two zones of differing concentrations to produce fresh water**

- **Distillation Processes consists of:**
  - **Multi Stage Distillation (MSF),**
  - **Multi Effect Distillation (MED)**
  - **Vapour Compression Distillation (VCD)**

- **Membrane Processes consists of:**
  - **Reverse Osmosis (RO)**
  - **Electrodialysis**

Financial Feasibility Criteria

- **Financial Net Present Value, FNPV**

  FNPV is present value of revenue flow, which is produced by investor. This parameter is multiplication between cash flow and discount factor

$$FNPV = \sum_{t=1}^{n} (Pn - Cn) / (1+d)^n$$

with: Pn is total gross revenue year-*n*
Cn is total gross cost year-*n*
d is discount rate
$(1+d)^n$ is discount factor

The feasibility criteria of FNPV gives indication as follow:

NPV = positive	Project feasible / can be accepted, higher NPV better
NPV = negative	Project not feasible / can not be accepted
NPV = 0	neutral / break even

Financial Feasibility Criteria (cont'd)

- **Financial Internal Rate of Return, FIRR**

  FIRR of investment can be defined as interest rate *i* that will cause the value of cost/investment equals to the value of benefit, or value of discount rate so that FNPV = 0

$$FIRR = i_1 + \Delta i(AK_{i1} / (AK_{i2} - AK_{i1}))$$

where:

i_1	= lowest capital interest
Δi	= difference of highest and lowest capital interest
AK_{i1}	= cash flow at lowest interest
AK_{i2}	= cash flow at highest interest

Feasibility criteria of FIRR gives indication as follow:

IRR > wanted interest rate (*i*), project feasible / accepted
IRR < wanted interest rate (*i*), project not feasible / not accepted
IRR = wanted interest rate (*i*), project not feasible / not accepted

Financial Feasibility Criteria (cont'd)

- **Capital Payback Period, *p***

  ***p* is duration needed to return investment capital, which is calculated from net cash flow. Net cash flow is a difference between revenue and expenditures every year. *p* is an indicator on how many years are needed for the project to cover the investment cost.**

$$\sum_{t=1}^{t=p} b = M$$

With:

t = time

p = Payback Period

b = benefit of profit

M = capital

Financial Feasibility Criteria (cont'd)

Table I. Project Financial Feasibility Indication

Feasibility Criteria	Unit	Feasibility Indication
FNPV	(US $)	Positive
FIRR	%	> *i* (where *i* is wanted interest rate)
Payback Period	years	Faster better

Assumptions

1. Reference Currency is US$ (January 2004)

2. Construction period 3 years (2012 – 2014)

3. Level of financing disbursement during construction period

   1st year: 19%
   2st year: 43% and
   3st year: 38%

4. Tariff/selling price of desalination water product is assumed 0 US$/$m^3$ because it is subsidized totally from electricity tariff

Input Data

Table II. Technical Parameter

Technical Parameter	Unit	Value
Average annual seawater temperature	^{o}C	30
Environmental air temperature	^{o}C	32
Total Dissolved Solid (TDS)	ppm	34,000

Table III. Economic Parameter

Item	Reference Value
Operation Date	1 January 2015
Economic Plant Life of SMART	40 years
Availability	
- Base power plant	80%
- Desalination plant	96%
Discount Rate	10%
Interest Rate	8%
Nuclear Fuel Escalation	0%/year

Input Data (cont'd)

Table IV. Data of SMART

Item	Unit	SMART
Capacity	MWe	2 x 100
Net thermal efficiency	%	33
Construction lead time	Month	36
Specific construction cost]	US$/kWe	1,615
O&M cost	US$/MWh	5.59

Table V. Data of MED desalination plant

Item	Unit	MED
Unit size	M^3/d	4,000
Base unit cost	$\$/(m^3/d)$	926.7
Water plant lead time	Month	12
Average management salary	$/a	6,000
Average labor salary	$/a	3,600
Specific O&M spare part cost	$\$/m^3$	0.03

Input Data (cont'd)

Table VI. Data of MED desalination plant

ITEM	SCOPE OF SUPPLY	SMART	
		1 Unit	2 Units
NSSS & T/G	NSSS Package including system design and T/G Package	48,938	95,429
Civil/Structure, Architecture	Equipment & Site Materials for construction works, including consumable, construction equipment and tools, etc.	27,883	52,978
Electrical and Mechanical Work	-Equipment & Site Materials for Installation work, including site materials, consumable, construction equipment and tools, etc. -Commissioning and Start-up testing	67,262	127,797
DIRECT COST (1000 US$)		144,083	276,204
Engineering	Design and Engineering including civil/arch., piping, electric and I&C, etc., Project Management	13,403	20,105
Owner's cost	Ocean Freight & Insurance, Owner's Organization	6,717	12,897
INDIRECT COST (1,000 US$)		20,121	33,002
PROJECT CONTINGENCY (1,000 US$)		7,204	13,810
TOTAL COST (Defined as Overnigh Costs) (1,000 US$)		171,408	323,017
CAPACITY (MWe)		100	200
UNIT CAPITAL COST (US$/kW)		**1,714**	**1,615**

Source of Fund

- **Foreign Loan**
  - Source : Korean EXIM Bank
  - Amount : 85% of total supply of foreign component
    US$ 230,290,000
  - Currency : Dollar America (US$)
  - Interest Rate : 7.65%/year
  - Financial Fees : Commitment fee 0.5%, Insurance fee 3.4%, Management fee 0%

- **Domestic Loan**
  - Source : Local Commercial Bank
  - Amount : 85% of total supply of local component
    US$ 47,400,000
  - Currency : Dollar America (US$)
  - Interest Rate : 13%/year
  - Financial Fees : Commitment fee 0.5%, Insurance fee 0%, Management fee 0%

- **Equity**
  - Amount : 16.3% of total supply of local and foreign component
    US$ 48,600,000
  - Currency : Dollar America (US$)
  - Interest Rate : 13%/year

Result and Analysis

Levelized electricity generation cost : 4.06 cents/kWh

Total water production cost : 104.3 cents/m^3

Table VII. Construction cost of Nuclear Desalination Plant

No.	Investment Profile	Base Cost (10^6 US$)
1	NSSS & T/G	95.4
2	Civil/Sturcture, Architectual	53.0
3	Electrical and Mechanical Work	127.8
4	Design & Engineering	20.1
5	Owner's Cost	12.9
6	Contigency	13.8
	Overnight Cost of SMART	**323.0**
7	Desalination plant (MED)	3.7
	Basic cost of SMART + MED	**326.7**
8	Escalation	217.0
	Fixed cost of SMART + MED	**543.7**
9	Interest	40.4
10	Financial Fee	15.1
	Construction Cost of SMART + MED	**599.2**

Result and Analysis (cont'd)

Table VIII. Financial Feasibility Criteria of Nuclear Desalination Plant

No.	Parameters	Unit	Value
1.	Rate of Return (Total)	%	10.00
2.	Financial Internal Rate of Return (FIRR) for PROJECT	%	12.73
3.	Financial Net Present Value (FNPV) for PROJECT	M US $	75.29
4.	Tariff	cent/kWh	
	Before VAT		4.733
	After VAT		5.417
5.	Investment Payback Period for PROJECT	Year	8

VAT = Value Added Tax

Conclusion

1. With electricity tariff in amount of 5.417 cents/kWh, for total project funded by foreign loan, local loan and equity, obtained FIRR 12.73%, FNPV in amount of US$ 75.29 million and Payback Period is 8 years.

2. Based on the indicators, nuclear desalination project in Madura Island can be said as feasible, and from the investment point of view this project is very beneficial.

Thank You for Your Attention