Preliminary Economic Assessment of KALIMER-600

Kee-Hwan, MOON, Seung-Su, Kim, Dohee, Hahn
1045, Daedeokdaero, YuseongGu, Daejeon, 305-353, Korea
mkh@kaeri.re.kr, sskim5@kaeri.re.kr

1. Introduction

The GIF((GEN IV International Forum) established an Economic Modelling Working Group(EMWG) in 2003 to create economic models and guidelines to facilitate in a future evaluation of the Generation IV nuclear energy systems and assess progress toward the GIF economic goals. These goals are to have a life cycle cost advantage over other energy sources, and to have a level of financial risk comparable to other energy projects. To do this, EMWG has been developed the G4-ECONS model, which is a generic EXCEL-based model for computation of the projected levelized unit electricity cost and/or levelized non-electricity unit product cost from GEN IV energy systems.

KALIMER-600 has been developed as a new design concept based on the KALIMER-150 design. KALIMER-600 is a unique design concept which has a potential to achieve GEN IV technology goals even though there is a room for a design improvement in order to make the KALIMER-600 more competitive with future generation reactors. The objective of this study is to the assess economics of KALIMER-600 by using the G4-ECONS model.

2. Evaluation Method

G4-ECONS model consists of three models, 'Reactor Economic Model', 'Energy Product Model', and 'Fuel Cycle Facility Economic Model', as shown in figure 1.

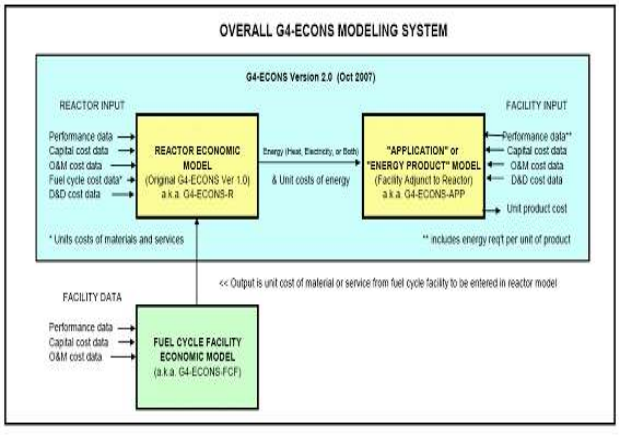

Figure 1. Overall G4-ECONS Modelling System

'Reactor Economic Model' calculates the unit cost of thermal and/or electrical energy from the reactor facility. 'Energy Product Model' consists of a simple economic model for the adjunct facility using the nuclear energy, such as a hydrogen plant, a water desalination plant, or any other facility requiring dedicated process heat or electricity. 'Fuel Cycle Facility Economic Model' can calculate the projected cost of a fuel cycle service or material in much the same way that the 'Reactor Economic Model' calculates the levelized cost of thermal energy or levelized unit product cost.

In this study, we only used the 'Reactor Economic Model' to assess the cost of KALIMER-600.

There is a currently a large amount of uncertainty regarding the cost of future plants. So costs for those plants that are having a different size from the current commercial or similar plant with detailed design can be inferred from previous experienced and/or similar plant data. For KALIMER's construction cost estimate, it is expedient to examine the cost scaling relationships between ALMR and KALIMER.

The relationship of size versus cost shown below may be used for rough estimates of KALIMER-600. Table 1 shows the scaling factors are to be used to estimate a KALIMER cost.

$$C_N = C_B \times (MW_N / MW_B)^{SF}$$

C_N = New plant cost, C_B = Base plant cost
MW_N = New plant size, MW_B = Base plant size
SF = Scaling factor

Table 1. Scaling factors of each cost item

Cost Item	Scaling Factors (Fraction)
Land & Land Rights	0.00
Buildings and Structures	0.59
Reactor Plant Equipment	0.55
Turbine Generator Pant Equipment	0.83
Electric Equipment & I&C Plant Equipment	0.49
Water Intake and Heat Rejection	1.06
Miscellaneous Plant Equipment	0.60
Special Materials(Heavy water)	0.50
Simulator	0.50
Owner's Costs	0.50
Engineering and Home Office Services	0.60
Home Office Project Management	0.60
Plant Site Engineering, Design, Layout, and Support Services	0.69
Plant Site Project Management	0.69
Construction Site Supervision	0.69
Commissioning Costs incurred by A/E and Vendors	0.50
Staff Training and Technology Transfer	0.50
Construction & Worker-related Services	0.69

3. Results

2.1 Overnight Construction Cost(FOAK plant)

To estimate the overnight construction cost of KALIMER-600(FOAK plant), which has developed based on the ALMR concept, ALMR's cost data was referred to. Table 2 shows a preliminary assessment of the overnight construction cost of KALIMER-600. It is estimated as about 1.43 billion dollar(2,380$/kWe), which is based on its present design concept. The direct cost has the largest share (63%) of the overnight construction cost. And also COA 21(Building, Structures & Improvements on site) and COA 22(Reactor Plant Equipment) are the major parts of the direct cost. Therefore, KALIMER development team should focus on the new design concept and/or design improvement for a cost saving of these parts.

Table 2. Overnight construction cost of KALIMER-600(FOAK plant)

EMWG COA	Cost Description	Total Cost (1000$)	Specific Cost ($/kWe)
2	Capitalized Direct Costs (subtotal accounts 21-29)	899,000	1,498.3
3	Capitalized Support Services (Subtotal accounts 31-39)	229,000	381.7
4	Capitalized Operations costs (Subtotal accounts 41-49)	170,000	283.3
5	Capitalized Supplementary Costs (subtotal accounts 51-59)	0.000	0.00
	Contingency	130,000	216.7
Total (1-5)	Total Overnight cost	1,428,000	2,380.0

Note) FOAK plant: First-of-a kind plant

2.2 Overnight Construction Cost(NOAK plant)

KALIMER development team has a plan for an economic improvement as shown in table 3. It assumes that the NOAK plant cost can be obtained by considering the following factors of the FOAK plant cost in this study.

Table 3. Cost reduction and increase factor

Cost Reduction Factors	System simpification	-5%	COA 22
	Arrangement of reactor and auxiliary buildings	-5%	COA 21
	S-CO2 system	-5%	COA 24,25
	BOP	-7%	COA 23
Cost Increase Factors	Auxiliary safety design features	+4%	COA 21
	Provision against sodium-water reaction	+3%	COA 24,25
Others	Direct Costs	-2%	COA 31-49
	contingency	-5%	COA 69

Table 4 shows a summary of the overnight construction cost of KALIMER-600(NOAK plant). The results shows that the total specific capital cost is 2024$/kWe. It is about 15% lower than the FOAK plant cost due to cost reduction factors.

Table 4. Overnight construction cost of KALIMER-600(NOAK plant)

EMWG COA	Cost Description	Total Cost (1000$)	Specific Cost ($/kWe)
2	Capitalized Direct Costs (subtotal accounts 21-29)	786,000	1,498.3
3	Capitalized Support Services (Subtotal accounts 31-39)	207,000	381.7
4	Capitalized Operations costs (Subtotal accounts 41-49)	163,000	283.3
5	Capitalized Supplementary Costs (subtotal accounts 51-59)	0.000	0.00
	Contingency	58,000	216.7
Total (1-5)	Total Overnight cost	1,214,000	2,024.0

Note) NOAK: Nth-of a-kind plant

4. Conclusions

According to the results, overnight construction cost of FOAK and NOAK for KALIMER-600 are 1.43(2380$/kWe) and 1.21(2024$/kWe) billion dollars respectively. The results of this study suggest that KALIMER-600 has a potential to achieve GEN IV's competitive economics goal. G4-ECONS model is a useful tool for assessing the economics of GEN IV reactors such as KALIMER-600. In order to go ahead with a successful SFR program, the SFR team should continuously develop design improvements, a reduced construction time, and a material for a cost reduction.

REFERENCES

[1] GIF/EMWG/2007/04, Cost Estimating Guidelines for Generation IV Nuclear Energy Systems(Revision 4.2), September 26, 2007
[2] GIF/EMWG/2007/06, A User's Guide for G4-ECONS; A Generic EXCEL-based Model for Computation of the Projected Levelized Unit Electricity Cost(LUEC) and/or Levelized non-Electricity Unit Product Cost(LUPC) from Generation, November 19, 2007
[3] KAERI/TR-3381/2007, KALIMER-600 Conceptual Design Report, KAERI. 2007
[4] ORNL/TM-1999-243, J. G. Delene, An Assessment of the Economics of Future Electric Power Generation Options and the Implications for Fusion, September 1999