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Probability Analysis of the Construction Cost of an APR1000 Single Unit

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1. Introduction

The nuclear power plant market is expected to grow rapidly in order to address issues of global warming, cutting CO_2 emissions and securing stable electricity supplies. Under these circumstances, the main primary goal of the APR1000 development is to ensure export competitiveness in the developing countries in the Middle East and Southeast Asia. To that end, APR1000 (1,000MWe, 3rd generation) will be developed based on the OPR1000 (Korean standard nuclear power plant, 2.5 generation) by incorporating and improving the general requirements such as the 60 year design life time, comprehensive site requirement of 0.3g seismic design, stability improvement, operability improvement and provisions for severe accidents. The APR1000 adds 16 advanced design features to its predecessor, as outlined below in Table 1.

Table 1. Summary of APR1000 advanced design features

	Item	APR1000
1	Plant life time	60 yr
2	Seismic design	0.3g
3	30% MOX fuel and 24months fuel cycle	Adopt if necessary
4	Daily load follow operation/Frequency control operation	Automatic / Partial
5	CDF	10E-5/Ry
6	Containment Integrity	Aircraft impact
7	Construction schedule(FC-FL)	40 months
8	MMIS system	Adoption
9	50 Hz RCP	50/60 Hz RCP
10	Severe accident	IVR/ERVC, RX cavity flooding system
11	Site envelop	Foreign
12	Fluidic device	Adopt if necessary
13	Natural cooling tower	Adopt if necessary
14	Operator action margin time	≥ 30 minutes
15	GA optimum	Optimizing RCFS Optimizing MMIS
16	Cold head RV design	Application

∗ RCFS : Reactor Cavity Flooding System
IVR/ERVC : In-Vessel Corium Retention/ External Reactor Vessel Cooling

2. Construction Cost Conversion Factor from Dual to Single Unit

In Korea, nuclear power plants have been usually constructed a dual unit in the same site at the same time. Therefore most construction cost data exists dual unit. However in many cases, foreign nations construct nuclear power plants with only a single unit. It is possible to estimate the single unit construction cost using by the learning factor in Chapter 1, Appendix C Cost Estimating Ground rules of the EPRI ALWR URD.

$$\text{Cost for Project Number N} = Io \times (LF)^{D}$$

where Io : Initial Plant Cost
$D = \ln(N)/\ln(2)$,
LF : Learning Factor

Table 2. Learning factor

Cost items	LF	Remarks
Equipment cost	0.95	
Installation cost	0.95	Different site
	0.90	Dual unit at same site

3. A Probability Cost Analysis of APR1000

The probability density functions(PDFs) of ten construction cost elements were developed through expert group meetings. Many cost field experts were invited to undertake the PDFs for the elements of nuclear power plants. The cost experts invited to select high level uncertainty elements minimum, maximum, and median values were determined through discussions, their experiences, and engineering judgments. The cost evaluator developed PDFs for each cost element. Next, the screening analysis was undertaken. If an uncertainty problem existed, the problem was returned to the cost experts. The cost experts then discussed the problem again and provided a more efficient PDF. The final PDFs were determined and the simulation was performed.

Table 3. Construction Cost Elements

No	Cost Element	No	Cost Element
1	NSSS	6	Owner
2	T/G	7	Shipping
3	BOP	8	Contingency
4	Installation	9	Exchange rate
5	A/E	10	Construction schedule

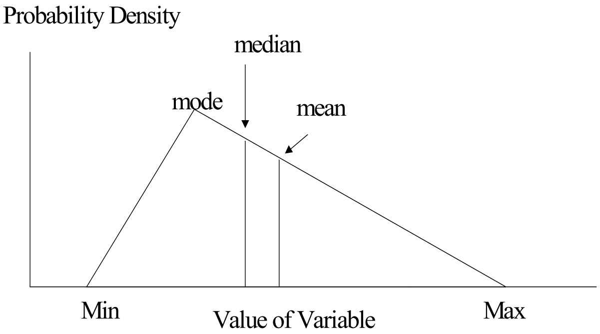

Figure 1. Triangular PDF

As a result of performing the probability cost analysis, using the Crystal Ball software from Oracle, the most sensitive cost element was shown to be the installation cost. The next costs were the interest during construction(IDC), BOP, exchange rate, contingency, and so on, as shown in Figure 2.

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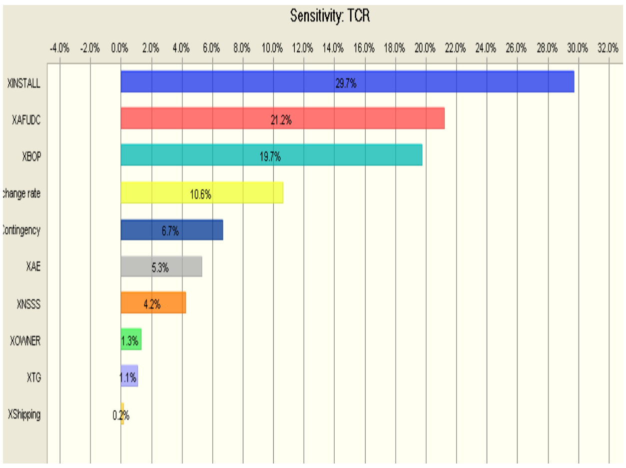
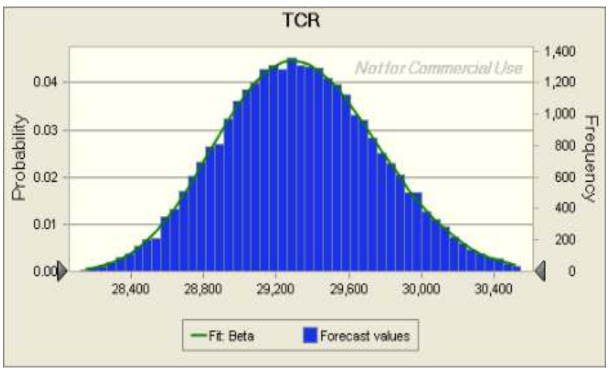


Figure 2. Sensitivity Chart

The median(50% cumulative probability value) total capital requirement(TCR) value was 29,321×100 million won, the 0% non-exceedance value was 27,954×100 million won, and the 100% non-exceedance value was 31,222×100 million won for APR1000 single unit construction cost.



Forecast: TCR (cont'd)

Percentiles:	Forecast values
0%	27,954
10%	28,780
20%	28,960
30%	29,091
40%	29,208
50%	29,321
60%	29,435
70%	29,557
80%	29,701
90%	29,904
100%	31,222

Figure 3. Probabilistic cost analysis results for the APR1000

4. Conclusions

In this simulation, the results of the construction cost of the APR1000 single unit were determined using the probability cost analysis technique, the TCR range was shown to be 27,954×100 million won ~ to 31,222×100 million won.

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