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A Case Study of Risk Informed Asset Management (RIAM) for Nuclear Power Plant

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1. Introduction

Recently, the concern for Nuclear Asset Management (NAM) is increasing in nuclear industry. Asset Management is management of the financial assets of a company in order to maximize return. However, asset management in the nuclear industry is needed for coincidental consideration of nuclear safety and risk. Over fast several years, efforts for development of safety concerned and financial asset maximizing method, process and tools have been continued internationally.

Risk Informed Asset Management (RIAM) is a methodology, process, and (eventually) software tool by which analyst review historical performance and develop predictive logic models and data analyses to provide plant manager and company decision-makers critical quantitative performance indicators. [1]

2. Methods and Results

For case study of RIAM application, we adopted RIAM conceptual model by developed EPRI, and assumed that plant has problem in major equipment (Main Turbine) owing to deterioration. Finally we calculated total asset value classified by decision maker's options according to time.

2.1 Model Structure

Any decision affecting the design, operation, and maintenance will not only impact on plant safety, availability (or efficiency) but also affect the economic performance (cost, revenue and benefit etc.). For these overall interactions, EPRI suggested following Nuclear Asset/Risk Management framework.

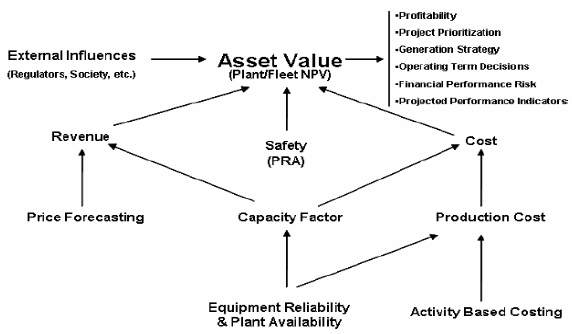

Figure 1. Nuclear Asset/Management Framework [2]

2.2 Problem Statement

The NPP has a trouble in Main Turbine for aging. Current statuses of this Main Turbine are;
Operation Periods: 15 yrs (Lifetime: 40 yrs), Power Generation: 1000MWe, Sales Price: $40.0/MWH, Turbine Failure Rate: 0.01, Power Decrease: 0.1MWe/yr, Inflation Rate: 2.8%, Discount Rate: 4.5%.

Plant decision makers consider the Turbine replacement. There are some advantages in Turbine replacement case in power increase from 1000MWe to 1020MWe, Preventive Maintenance (PM) / Corrective Maintenance (CM) cost decrease etc. Considered options are as following;
Option 1: Keep up current status (No change)
Option 2: Turbine Replacement at now
Option 3: Turbine Replacement after 10yrs

2.3 Calculation Method

In this case, total benefits are calculated using the Net Present Value (NPV) method from total costs and revenues.

$$Net\ Benefit(\$2006) = \left[\frac{(1+IR)}{(1+DR)}\right]^{(Effective\ Year-NPV\ Year)} \quad (1)$$

Where IR is interest rate and DR is discount rate.

The total costs are sum of the costs associated with Main Turbine replacement, PM/CM cost and Safety Cost. The total revenues are sum of the PM/CM saving and Power loss saving from new turbine.

We assumed that turbine trip cause reactor trip and each reactor trip induce the core damage and safety cost. The power price, interest rate and discount rate is considered a constant value during plant life time.

2.4 Calculation Parameters

Total Cost		Unit	Option 1	Option 2	Option 3 First 10 yrs	Option 3 After 10 yrs
PM Cost	Labor Cost	$/man-hr	10	10	10	10
	#of Labors	#	50	50	50	50
	Maint. Time	hr/yr	500	250	500	250
	Material	k$	10	10	10	10
	PM Cost	k$/yr	260	135	260	135
CM Cost	Labor Cost	$/man-hr	10	10	10	10
	#of Labors	#	100	100	100	100
	Failure Rate	#/yr	0.010	0.001	0.010	0.001
	Maint. period	hr	250	250	250	250

	Material	k$	20	20	20	20
	CM Cost	k$/yr	22.5	20.25	22.5	20.25
Replacement Cost		M$	-	30	-	30
Safety Cost	Failure rate	#/yr	0.010	0.001	0.010	0.001
	Weigh		0.001	0.001	0.001	0.001
	Cost for CD	B$	2	2	2	2
	Safety Cost	k$/yr	20	2	20	2

Table 1. Input parameters of the RIAM in cost part

Total Revenue		Unit	Option 1	Option 2	Option 3	
					First 10 yrs	After 10 yrs
PM Saving	time	hr/yr	100	100	100	100
	price	$/MWh	40	40	40	40
	Power	kMWe	1	1.02	1	1.02
	PM gain	M$/yr	4	4.08	4	4.08
CM Saving	Failure rate	#/yr	-	0.099	-	0.099
	time	hr/failure	250	250	250	250
	price	$/MWh	40	40	40	40
	Power	kMWe	1	1.02	1	1.02
	CM gain	k$/yr	-	1,009.8	-	1,009.8
Power Gain	Power	MWe/yr	-0.1	-	-0.1	-
	Price	$/MWh	40	40	40	40
	Time	hr/yr	8,760	8,760	8,760	8,760
	Power gain	k$/yr	-35.04	-	-35.04	-

Table 2. Input parameters of the RIAM in revenue part

2.5 Results

As shown in figure 2, cumulated benefits of option 2 (Turbine Replacement at now) is larger than others at the end of plant life time. We can also calculate when is the best replacement time in plant asset (or net benefit). Figure 3 shows the cumulated net benefit at the end of plant life time according to turbine replacement time.

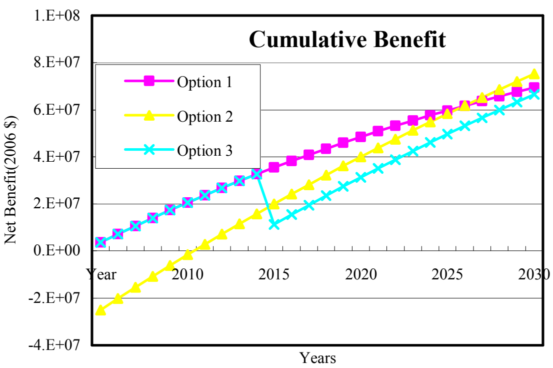

Figure 2. Cumulative net benefit in three options according to plant life time using NPV calculation.

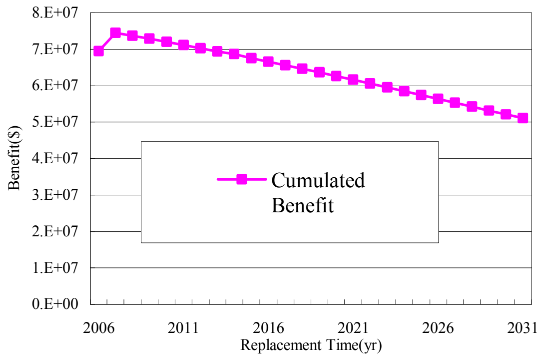

Figure 3. Cumulative net benefit at the end of plant life time according to turbine replacement time.

2.6 Discussions

The focus of these RIAM applications is to continuously support development and implementation of effective and efficient station investment options.[3]

For practical application of RIAM, first of all, evaluation of case study cost, failure rate, repair time, and other key input data parameters are must developed. And each plant should establish their major performance indicator (i.e., Net Benefit, Return on Investment etc.) and decision criteria for results (for example, △NPV >0). In most cases, the risk information will be shown the combination of the failure rates, and RIAM software developer has to consider this.

3. Conclusion

This case study presents the risk-informed asset management application roughly. We calculated plant cumulative net benefit with point values. But these process and results are helpful for plant decision maker in major equipment replacement case even though various failure rate and risk information was not considered. And this risk–informed asset management method seemed to be easily adopted and to increase the nuclear power plant asset value if the input data system is appropriately prepared.

REFERENCES

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