MANAGING ECONOMIC RISKS DUE TO ELECTRICAL EQUIPMENT CONTAINING PCBS: ANALYTICAL TOOLS TO SUPPORT UTILITY DECISIONS

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ABSTRACT

For industries that make use of hazardous materials, the direct economic consequences of alternative courses of action are often the most important factors in decisions about how to manage risks, but may be difficult to predict. The analysis of alternatives can be very complex, and uncertainty about actual and perceived risks may impede company efforts to manage risks. A mathematical model designed to assist electric utility personnel in the financial analysis of management options for PCB-containing equipment has been developed and implemented as an interactive software tool. Based on the methods of decision analysis and utility finance, this specific application allows the user to represent uncertainty about possible PCB incidents (fires or spills), including frequency of occurrence, incident severity, and the costs of cleanup, plant shutdown, and legal liabilities. Predictions of total life-cycle equipment and incident costs can be compared for utility ratepayers and shareholders in order to facilitate risk management decisions. While the approach is general enough to be useful for many types of hazardous materials, this paper presents a PCB transformer risk management case study using this tool.

KEY WORDS: Risk management, Risk analysis, PCB, Software, Utility, Decision, Model, Transformer

The PCB Economic Risk Management Model (ASK) and the Contaminated Oil Economic Risk Management Model (COIL) are decision support tools designed to help utility personnel manage equipment containing or contaminated with PCBs. Based on the methodology of decision analysis, the models provide techniques for comparing alternative strategies in terms of equipment costs and the costs of potential incidents such as fires and spills.

INTRODUCTION

Electric utilities typically have a variety of equipment containing or contaminated with PCBs. Accidents or failures involving such equipment may lead to very large economic costs for the utility. These costs can include cleanup of the facility and the surrounding area, repair or replacement of utility and third-party equipment, and possible legal liabilities. The possibility of incurring such losses may exist even when the PCB contamination is very low. The need to weigh these highly uncertain but potentially large losses against the costs of various management alternatives prompted the development of the two decision support tools discussed in this paper. The development of ASK was motivated by the need to manage askarel transformers and PCB capacitors in the face of the potential for large financial impacts due to incidents such as fires. COIL was developed to help utilities choose management alternatives for potentially contaminated mineral oil equipment. Both tools focus on economic risks, which include direct equipment and cleanup costs, and costs that may be incurred due to real or perceived health or environmental effects from releases of PCBs.

Management Alternatives

Utilities have a variety of options available to manage equipment containing PCBs, including replacing existing equipment with one or more alternative types of equipment, isolating the equipment or installing electrical protection devices to reduce risks, retrofilling to reduce PCB levels, or retaining the existing equipment as is. Replacement may involve significant costs for a new unit and for installation, but may improve the operating efficiency and will eliminate the possibility of a PCB incident. Incidents involving substitute equipment may occur with greater frequency and with greater risk of conventional damage, but probably will not lead to the larger costs sometimes associated with PCB incidents.

There is often considerable uncertainty regarding the degree of PCB contamination of mineral oil transformers. Testing the equipment can help guide the choice of a management strategy and may help a utility avoid the costs associated with an incident involving PCBs. If the likelihood of severe contamination is low and incidents are rare, however, the cost of testing may exceed the value of the information gained.

Balancing Equipment Costs Against Economic Risks

Choosing the best management strategy requires careful weighing of uncertain losses against known cost and performance considerations. Is an investment in risk reduction measures or new equipment merited to remove the possibility of a potentially very expensive but relatively unlikely incident? Management questions such as these are challenging due to the large uncertainties in the likelihood, severity, and cost of incidents, as well as the complexity of the cost, performance, and financial considerations.

For example, consider the case of a utility that has a number of askarel transformers in its generating stations. There is a small chance that a fault in one of the transformers could lead to a major fire, one in which PCBs and combustion by-products would be distributed widely through the plant in the form of smoke and soot. How large would the probability of a major fire need to be, and how great would the likely costs of an incident need to be, before the company should decide to remove its askarel transformers and replace them with non-PCB equipment? The cost of installing new equipment is relatively easy to determine, but the potential incident costs are not. Utility personnel may find it difficult to estimate the costs since incidents are unlikely and the costs could be quite large. The challenges posed by decisions such as this have motivated the development of the risk management models and decision support tools described in this paper.

ASK AND COIL: AIDS TO DECISION MAKING

ASK and COIL are designed to help utility personnel make the difficult management decisions regarding PCB and contaminated mineral oil equipment. Both ASK and COIL incorporate equipment cost and performance calculations, a financial model to account for costs to ratepayers and shareholders, and explicit representation of uncertainties in the occurrence, severity, and cost of incidents. These features are combined in interactive software packages that implement the risk management models. The software implementations have been designed to facilitate and guide analyses performed by relatively inexperienced computer users, yet remain convenient and efficient for experienced users. They provide complete capabilities for the user to enter, display, edit, save, and retrieve data, to run the models, and to display and save both summary and detailed results.

Decision Trees

The management decisions and key uncertainties are represented in ASK and COIL using decision trees. The tree for ASK, shown in Figure 1, can be used to calculate expected costs and the range of uncertainty over a large number of scenarios. The tree in this figure is a shorthand representation of the complete tree, in which specific decision alternatives and uncertain events are defined, and each node is connected to every branch of the previous node. The decision tree for COIL is similar, but includes explicit representation of the sample/no sample choice prior to the equipment management alternative.

If each of five uncertainty nodes shown in the ASK decision tree had three possible outcomes, there would be a total of 243 scenarios, represented as distinct paths through the tree. The likelihood, or probability, of each scenario is simply the product of each likelihood associated with the branches along its path through the tree.

Models

For each scenario defined by the tree, the calculations in ASK and COIL are carried out using the models shown in Figure 2. The equipment model calculates all costs associated with existing and replacement equipment. It can take into account different operating and maintenance costs and efficiencies for different types of equipment. The incident occurrence model calculates the likelihood, potential timing, and likely severity of an incident using values for the uncertain parameters, such as

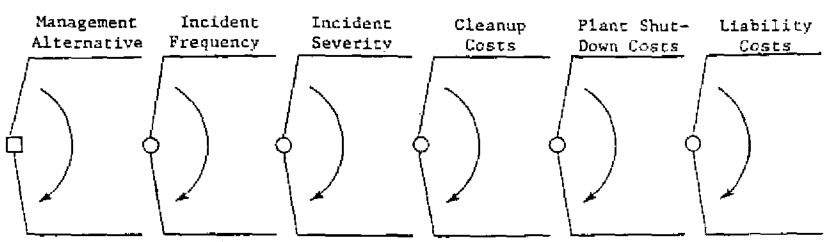

Figure 1

Key Uncertainties Are Represented as a Decision Tree in ASK

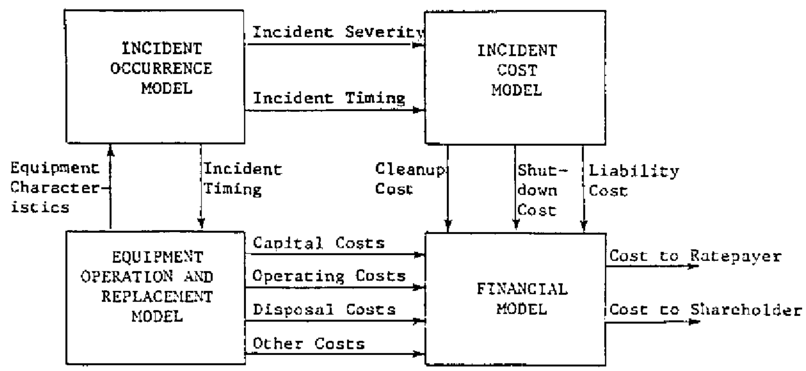

Figure 2

A Set of Models Are Used to Calculate Costs in ASK and COIL

the rate of occurrence of incidents, from the decision tree.

The incident cost model calculates all costs of an incident, given that one occurs. Cost elements can include equipment replacement costs, cleanup and repair costs, costs of legal liabilities, and costs due to the shutdown of a generating plant during the cleanup and repair period. The frequency and cost probabilities and estimates will depend on the specific scenario or path through the tree. The model incorporates utility cost-of-service calculations, distinguishes between capitalized and expensed costs, and calculates costs to both ratepayers and shareholders.

AN EXAMPLE USING ASK

As an example of a PCB equipment management decision problem, consider the question of whether an askarel transformer in a generating station should be replaced with a mineral oil transformer. Suppose the total capital cost of replacement is $75,000 for a 1000 KVA mineral oil transformer. Assume that the existing askarel would be replaced in about 14 years if no incident occurs, and the useful life of the slightly more efficient new transformer would be about 30 years. Also, assume that ratepayers will pay all of the costs associated with new equipment, but shareholders will pay a portion of the costs of an incident involving PCBs.

Utility personnel are typically uncertain about how likely an incident might be and what one would cost. Most utilities have not had major fires involving their askarel equipment, and thus have no historical data to draw upon to estimate fire frequencies or potential PCB fire costs. Using the decision tree structure in ASK, the uncertainty can be represented as two or more possible scenarios and industry data and subjective judgment can be used to assign likelihoods to each representative scenario [1,2]. Figure 3 shows the decision tree for this example and contains estimates for the uncertain parameters. For example, it has been assumed that the frequency of fires ranges from once every 1000 to 10,000 transformer-years and that fires in mineral oil equipment

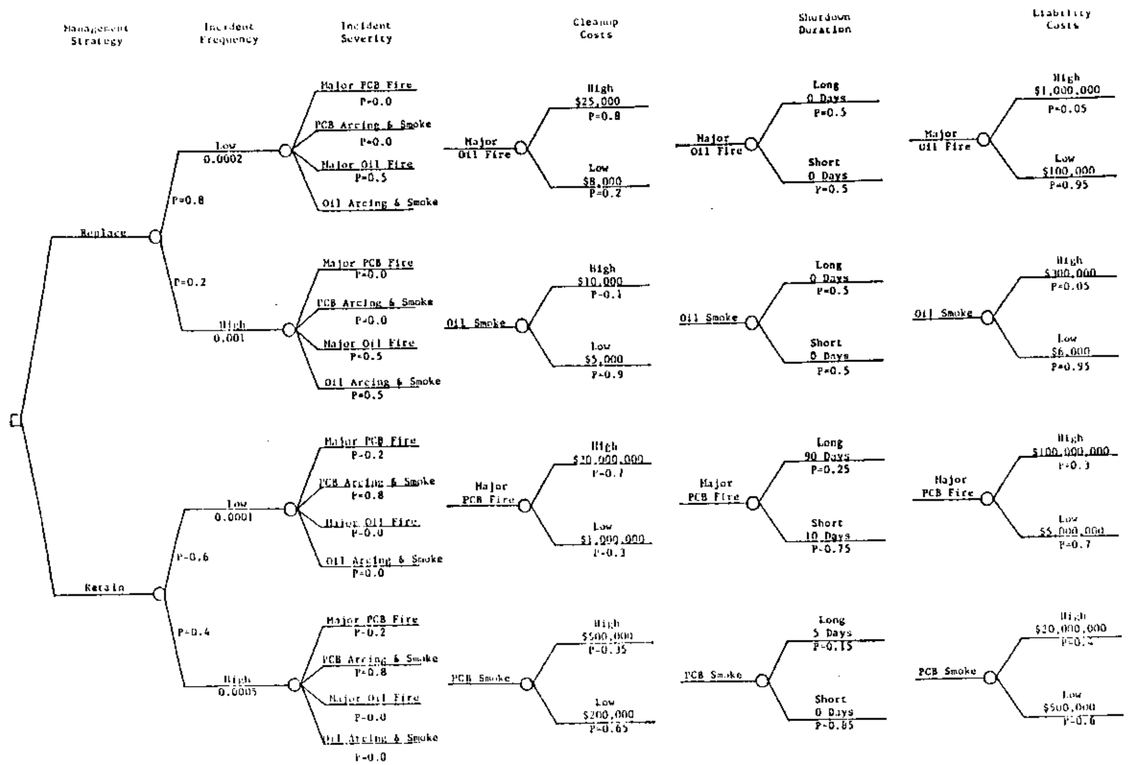

Figure 3

Decision Tree for ASK Example

are twice as likely as fires in askarels, but less expensive to clean up.

Rolling back this decision tree using ASK, it becomes apparent that the total expected life cycle cost of replacing the equipment is only slightly less than the expected cost of doing nothing and risking a fire. Figure 4 summarizes the expected equipment and incident costs by category. The nonincident costs are significantly higher when the equipment is replaced, but they are more than offset by the lower incident costs when no PCBs are present. Also, the decision tree generates a cumulative distribution that can be used to compare the range of possible costs for the management alternatives. Using the cumulative distribution, we find that for this example there is approximately a one in one thousand chance that the cost of choosing to replace the transformer will be $250,000 or more, which may be compared to the same chance that the cost of doing nothing will be $11 million or more. A utility may be unwilling to accept the chance of the higher cost.

What if fires in mineral oil transformers are ten times more likely than in askarels, rather than twice as likely? Figure 5 shows that changing this assumption about mineral oil fire frequency increases the cost of the option of replacing the askarel, but would probably not lead one to switch the choice of options, since the total expected cost of replacement is still lower. When should the decision change? Figure 6 shows the results of a sensitivity analysis performed using ASK. Assumptions about askarel incident frequency are compared with assumptions about the liability costs of major PCB incidents, and the curve indicates the points where the decision switches. For a wide range of expected liability costs, the frequency of incidents need not be very high before replacement becomes the preferred option. This figure demonstrates the advantages offered by a tool that can be used to quickly analyze the implications of differing judgments about the uncertain factors in this decision problem.

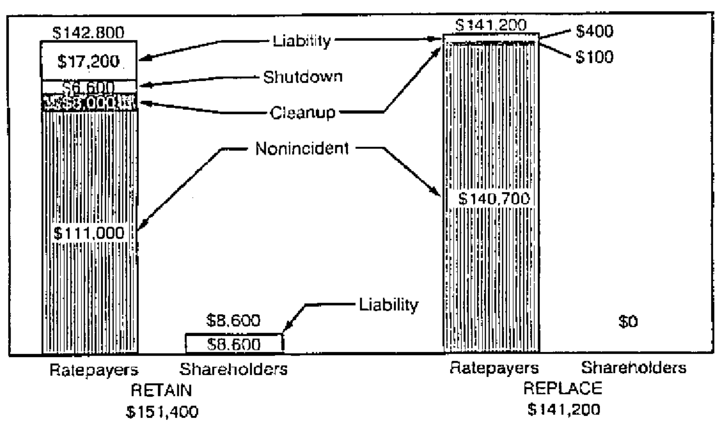

Figure 4

Present Value of Expected Equipment and Incident Costs

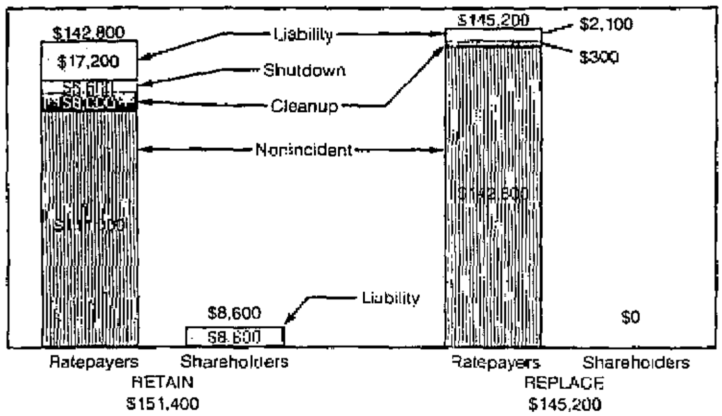

Figure 5

Expected Costs When Mineral Oil Fires are 10 Times as Likely

AN EXAMPLE USING COIL

COIL provides the same capabilities for analysis as ASK, but adds the ability to examine the value of testing, since the PCB content of a potentially contaminated transformer may be uncertain. Consider a 1000 KVA mineral oil transformer that might contain PCBs. Should it be retrofilled with clean insulating fluid to remove the risk of PCB spread in a spill incident? Retrofilling will not change the likelihood of a spill, but could substantially reduce the costs to the utility should an incident occur.

Assume that there is an 80 percent chance that the transformer contains less than 50 ppm PCB, a 15 percent chance of moderate contamination in the 50-500 ppm range, and a five percent chance that it contains 500 ppm or more. Retrofilling costs $5,000 and testing for PCB level costs $400. Assume that cleanup and liability costs will depend on the severity of an incident, which in turn will depend on the extent of PCB contamination in the transformer. Suppose that cleanup costs may range from $3,000 to $25,000 for an oil spill, and from $60,000 to $400,000 for a PCB spill. Assume that no liability costs are incurred in an oil spill, but that liabilities may range from $200,000 to $50,000,000 when PCBs are spilled.

Table 1 presents the a summary of the COIL results from an analysis of this example. The value of sampling is found to exceed the cost of sampling for PCBs, and the contamination level where action should be taken to reduce risks is identified as above 50 ppm PCB. In general, testing is worthwhile if it can change the choice of equipment management options. For this example, there is a significant chance that the transformer will contain less than 50 ppm, and testing has the potential to save the utility from the cost of retrofilling such a unit.

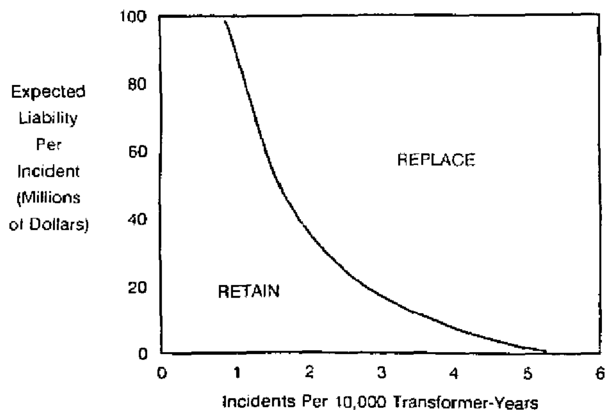

Figure 6

When the Decision Should Change

Table 1

Summary of Results in Coil Example

Sampling Alternative		Expected Cost
* SAMPLE		92,987
DON'T		93,769
	The Value of Sampling Is:	1182
	The Cost Of Sampling Is:	400

Contamination Level	Response Alternative	Expected Cost
Less than 50ppm	* NO ACTION	91881
	RETROFILL	93359
50 to 500 ppm	NO ACTION	99154
	* RETROFILL	94761
More than 500ppm	NO ACTION	108801
	* RETROFILL	97364
Uncertain	NO ACTION	93818
	* RETROFILL	93769

SUMMARY

ASK and COIL are decision support tools that allow utility personnel to evaluate PCB equipment management options for a wide range of situations. Comprehensive analyses can be carried out quickly and efficiently, comparing different management options in terms of direct costs and costs due to incidents. Uncertainties in incident occurrence, severity, and cost may be accounted for explicitly, and a wide variety of "what if?" questions can be answered rapidly.

In addition to serving as a useful analytical aid, ASK and COIL can help utility personnel communicate with top management, regulators, and public groups about the complex nature of PCB and contaminated mineral oil problems, as well as provide key insights from the analyses. The tables produced by ASK and COIL show both the assumptions and the results clearly. The implications of alternative viewpoints and opinions can be tested and displayed quickly and easily, thus facilitating discussion and consensus building on difficult PCB management issues.

REFERENCES

1. Resource Planning Corporation, "Report of the Study of Risks Posed by Askarel Transformer Fires," for the Edison Electric Institute and the Utilities Solid Waste Activities Group, June 1984.
2. Decision Focus Incorporated, "Economic Risk Management Models for Electrical Equipment Containing PCBs: A Guide to the ASK and COIL Decision Support Models," Draft Final Report to the Elecric Power Research Institute, RP 2595, July 1985.