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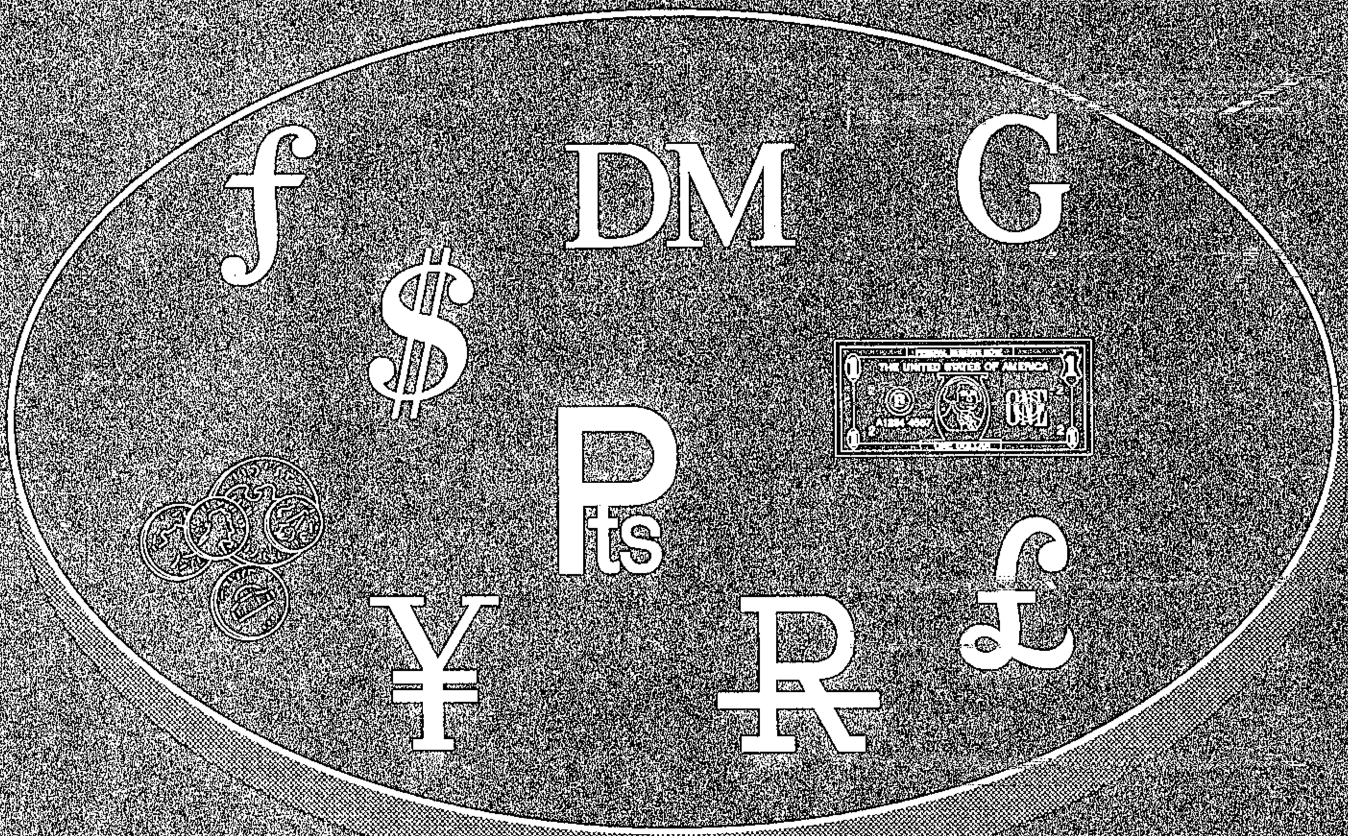
A Primer for Financial Analysis of Pollution Prevention Projects



AIPP
AMERICAN INSTITUTE
FOR POLLUTION PREVENTION

About the AIPP:

The American Institute for Pollution Prevention (AIPP) was founded in June, 1989 under a Cooperative Agreement between the EPA and the University of Cincinnati. The Institute is composed of a group of volunteer experts selected by the trade associations, professional societies or other organizations which they represent. Currently, the Institute has 27 members.

The mission of the Institute is to:

1) Serve as a bridge for communication on the subject of pollution prevention among regulators, legislators, educators, waste generators and others,

2) Promote the industrial, governmental and educational culture shifts necessary to catalyze the adoption of the pollution prevention ethic in environmental protection,

3) Identify and foster driving forces for pollution prevention and work to eliminate disincentives,

4) Define and communicate the economics of pollution prevention and

5) Identify emerging knowledge, opportunities and issues concerned with pollution prevention and influence the future directions for this field.

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A PRIMER FOR FINANCIAL ANALYSIS OF POLLUTION PREVENTION PROJECTS

by

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FOREWORD:

This document has been prepared as a guide to pollution prevention investment. It starts at the point that pollution prevention projects that are technically equivalent to current practice have already been identified. Hence, a financial comparison and justification for the investment is the only consideration. In the case of a small business, the justification may be needed to negotiate a loan at a bank. Conversely, if the company can fund the investment itself, justification is needed to compete for funds.

The emphasis of this paper is on the basic analytical techniques needed to justify pollution prevention investments. The concentration is on weighing economic and financial aspects of the various project options instead of the technical factors. In order to receive funding, it is essential that the project successfully compete in the company's capital funding sequence or before the bank's loan committee.

Although hazardous material usage generates a number of potential intangible costs such as future liability for waste cleanup, site remediation, potential legal action, etc., those issues are not being addressed in this paper except briefly in appendix 4. As a primer, it is appropriate for this paper to concentrate on the more definable costs such as utilities, labor, and capital costs. The intangible costs shall be addressed in future efforts by the American Institute of Pollution Prevention.

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SECTION I

Introduction

The Definition of Pollution Prevention

The scope of actions which constitute pollution prevention has long been the subject of debate. The major question has been whether or not to include end-of-pipe treatment in the definition. The Pollution Prevention Act of 1990 ended the debate by shifting emphasis away from treatment options and toward waste avoidance. The EPA defines pollution prevention as any effort to reduce the quantity of industrial, hazardous, or toxic waste through changes in the waste generating or production process at the source.

Hence, pollution prevention can encompass all actions, taken prior to the waste being generated, which provide for net reductions in either waste volume or hazard/toxicity. This is not to imply that end-of-pipe techniques such as recycling and volume reduction are not desirable. It does, however, indicate that while these methods can help, there are better approaches.

The Pollution Prevention Hierarchy:

The variety of waste reduction options available implies that some methods may be more desirable than others. Section 2 of the Pollution Prevention Act, Findings and Policy, establishes a Pollution Prevention hierarchy as a national policy, declaring that:

"- pollution should be prevented or reduced at the source whenever feasible;

- pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible;

- pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and

- disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner."

The first option is preferred as a true pollution prevention practice. However, any change to procedures or processes which would move a firm's waste management practices up the pollution prevention hierarchy is assumed to yield environmental benefits and should be evaluated.

Section II of this report explains the calculations which are needed to analyze various options and financially justify a pollution prevention project. Specific cost and revenue categories which should be considered are also presented in Section II. Section III introduces a case study of a hypothetical cleaning operation and demonstrates how to establish a baseline for financial comparison and to financially analyze recycling and material substitution as potential pollution prevention options. In examining each option, calculations are performed to allow a financial comparison to be made between the three scenarios (do nothing, recycle, or material substitution).

SECTION II

Financial Analysis

In the past, preparing a financial justification for pollution prevention projects has often been limited to declaring that if funding weren't awarded there would be an environmental incident and lawsuits would follow. Unfortunately, this led to many poor decisions. Projects with limited benefit have been funded and some projects that could have had large impacts on profit and cash flow were not. Pollution prevention investment must be able to stand up to every other funding request and effectively compete for monies on the projects' own merits.

Unfortunately, investment projects, such as pollution prevention, have often been among the first to be postponed in times of budget shortfalls. This has been due in a large part to the inadequate support and defense of environmental projects on an economic basis. Typically, when a production division requests money, all the necessary documentation, facts, and figures are ready for presentation. The production project is justified by showing how the project will increase revenue and how the added revenue will not only recover costs, but substantially increase the earnings of the company as well. Pollution prevention project justification requires this same emphasis. To be competitive, an understanding of the financial system is essential. Financial tools demonstrate the importance of the pollution prevention investment on a life cycle or total cost basis; in terms of revenues, expenses, and profits.

Key concepts and factors:

a. **Life Cycle Costing:** Sometimes referred to as Total Cost Accounting, this method analyzes the costs and benefits associated with a piece of equipment or a procedure over the entire time the equipment or procedure is to be used. The concept originated in the federal government and was first applied in procuring weapons systems. Experience showed that the up-front purchase price was a poor measure of the total cost; costs such as those associated with maintainability, reliability, disposal/salvage value, and training/ education had to be given equal weight in making financial decisions. Similarly, in justifying pollution prevention, all benefits and costs must be spelled out in the most concrete terms possible over the life of each option.

b. **Present Worth:** The importance of present worth, or present value, lies in the fact that time is money. The preference between a dollar now or a dollar a year from now is driven by the fact that the dollar in-hand can earn interest. Mathematically, this relationship is as follows:

$$\text{Present Value} = \frac{\text{Future Value}}{(1+\text{interest rate})^{\text{Number of years}}} \qquad P = \frac{F}{(1+r)^{n}}$$

where P is the present worth or present value, F is the future value, r is the interest or discount rate, and n is the number of periods. In the above example, $1 in one year at 5% interest compounded annually would have a computed present value of:

$$P = \frac{\$1.00}{(1+.05)^{1}} = \$.95$$

Because money can "work," at 5% interest, there is no difference between $.95 now and $1.00 in one year because they both have the same value at the current time.[1] Similarly, if the $1 was to be received in 3 years, the present value would be:

$$P = \frac{\$1.00}{(1+.05)^{3}} = \$.86$$

In considering either multiple payments or cash into and out of a firm, the present values are additive. For example, at 5% interest, the present value of receiving both $1 in one year and $1 in 3 years would be $.95 + $.86 = $1.81. Similarly, if one was to receive $1 in one year, and pay $1 in 3 years the present value would be $.95 - $.86 = $.09. As a result, present worth calculations allow both costs and benefits which are expended or earned in the future to be expressed as a single lump sum at their current or present value.

c. **Comparative Factors for Financial Analysis:** The more common methods for comparing investment options all utilize the present value equation presented earlier. Generally, one of the following four factors is used (additional information on all four factors is provided in appendix 2).

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[1] Economically, there is an additional factor at work in present value: Pure time preference (or impatience) - Pearce and Turner, Economics of Natural Resources and the Environment, 1977, pg. 213. However, this issue is generally ignored in business accounting in that the firm has no such emotions and opportunities can be measured in terms of per financial return.

1. **Payback Period:** This factor is often used in the research and development arena and is a measure of how long it takes to return the investment capital. Conceptually, the project with the quickest return is the best investment.

2. **Internal Rate of Return:** This factor is also called return on investment (ROI) or rate of return. It is the interest rate that would produce a return on the invested capital equivalent to the project's return. For example, a project with an internal rate of return of 23% would indicate that pursuing the pollution prevention project would be financially equivalent to investing the resources in a bank and receiving 23% interest.

3. **Benefits Cost Ratio:** This factor is a ratio determined by taking the total present value of all financial benefits of a pollution prevention project and dividing by the total present value of all costs of the project. If the ratio is greater than 1.0, the benefits outweigh the costs and the project is economically worthwhile to undertake.

4. **Present Value of Net Benefits:** This factor shows the worth of a pollution prevention project as a present value sum. It is determined by calculating the present values of all benefits, doing the same for all costs and subtracting the two totals. The net result would be an amount of money that would represent the tangible value of undertaking the project.

While firms may use any of these factors, the importance of life cycle costing or total cost analysis makes the Present Value of Net Benefits the preferred method.

DEFINING THE PROJECT'S COST

The first step in determining the cost of a project is to establish a baseline for the analysis. The "do-nothing" or "status quo" alternative is generally used as a baseline. Then any changes in material use, utility expense, etc., for other options being considered are measured as either more or less expensive than the baseline.

Cost Categories: McHugh[2] outlines four tiers of potential costs which have to be examined related to pollution prevention:

Tier 0: Usual costs such as direct labor, materials, equipment, etc.

Tier 1: Hidden costs such as monitoring expenses, reporting and record keeping and permit requirements.

Tier 2: Future liability costs such as remedial actions, personal injury under Occupation, Safety, and Health Act (OSHA), property damage, etc.

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[2] McHugh, R.T. , "The Economics of Waste Minimization," Freeman, Hazardous Waste Minimization, McGraw-Hill, 1990.

Tier 3: Less tangible costs such as consumer response, employee relations, and corporate image.

McHugh's Tier 0 and Tier 1 costs can be thought of as direct and indirect costs which would include the engineering, materials, labor, construction, contingency, etc., as well as waste collection and transportation services, raw material consumption (increase or decrease) and production costs. Conversely, his Tier 2 and Tier 3 represent intangible costs. They are much more difficult to define and include potential corrective actions under the Resource Conservation and Recovery Act (RCRA), possible site remediation at third-party sites under Superfund, liabilities that could arise from third party lawsuits for personal/property damages, and benefits of improved safety and work environments. Although these intangible costs often cannot be accurately predicted, they can be most important. To this end, there is a considerable amount of ongoing research to enhance our understanding and ability to predict intangibles. Present Value analysis under uncertainty is addressed in appendix 4. When it is not possible to analyze the intangible costs and benefits financially, they should be listed as additional factors to consider when making the pollution prevention investment decision.

Procurement vs. Operating Costs:

In analyzing the financial impact of projects, it is often useful to further categorize costs as either Procurement costs or Operations Costs to aid in projecting costs over time. Procurement costs are of shorter duration and refer to all costs required to bring a new piece of equipment or a new procedure on line. Conversely, operations costs are long term and represent all costs of operating the equipment or performing the procedure in the post procurement phase.

THE STARTING POINT – BASELINE COSTS

To illustrate the concept of the "do-nothing" or "status quo" option, an example of a small electronics firm will be used to illustrate the computation of a baseline cost. Presently, the firm cleans metal parts with a chlorinated solvent. Because the solvent is hazardous, the wastewater from rinsing the parts must be labeled as hazardous waste. The company is considering ways to reduce the volume of hazardous waste generated.

To establish the baseline, the current cost of doing business must first be determined. Once the present costs are known, all potential alternatives such as substituting a non-hazardous solvent for the current hazardous material would then be related to this baseline cost.

How to Compute the Baseline Costs:

The simplest way to establish a baseline cost is to add up the relevant input and output materials for the process and then compute their appropriate dollar value. This is started by first balancing the material entering and leaving the operation which contributes to the waste. Figure 1 shows this for a typical tank-line that generates the hazardous waste.

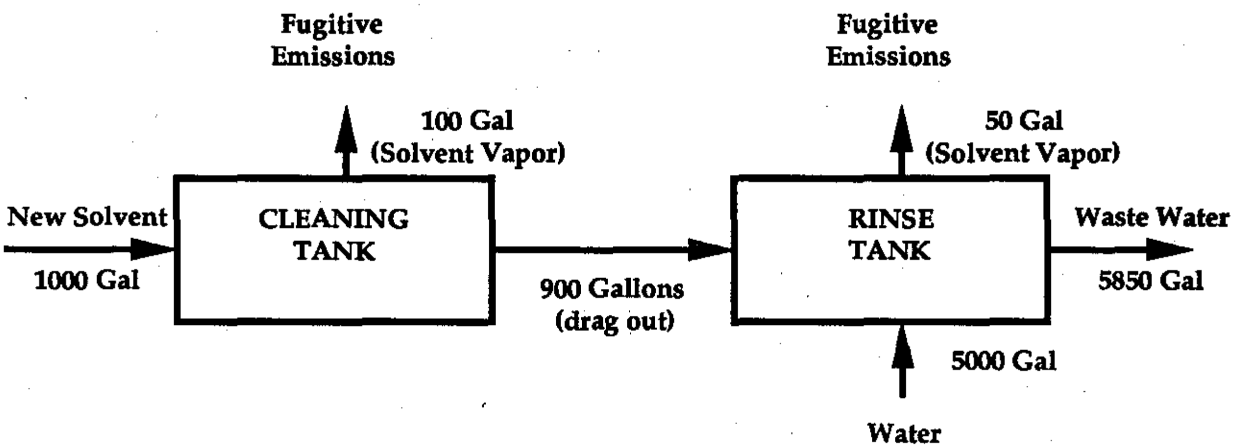

Figure 1: Annual Material Balance for the Hazardous Solvent

The next step is to ensure the material balance makes sense; i.e., the volume of solvent purchased must be accounted for in the losses, product, inventory, and/or waste. In the example, the solvent purchased is equal to that lost to evaporation, plus that lost in the waste rinsewater. Once accomplished, determining the baseline cost becomes a simple matter of pricing each input and output and multiplying their volumes by the appropriate unit. The baseline costs for this example are shown in Table 1.

Table 1 - Current Costs for Parts Cleaning

Item	*Cost/Unit*	*# Units*	*Cost/year*
Solvent	$3.25/gal	1000 gal	$ 3,250.00
Water	$2.10/1000 gal	5,000 gal	$10.50
Waste disposal	$2.50/gal	5850 gal	$14,625.00
		Total Annual Cost	**$17,885.50**

Although the next step would be to examine expected business changes such as business expansions, new accounts, rising prices, etc., for simplicity, the Table 1 costs and volumes will be assumed constant. This means that the current annual costs will be the same in the out-years except for one very important aspect, the time value of money.

How to Account for the Effects of Interest: Due to the assumptions made regarding constant cost, the $17,885 annual cost shown in Table 1 will be repeated each year. The present value calculations shown earlier enable this annual expenditure to be expressed as a single sum which includes the effects of interest. The first year's cost, assuming the bills were paid at the end of the year, would be the amount of money that would have to be banked starting today, to pay a $17,885 bill in one year. Computationally, using a 10% interest rate, the computation is as follows:

$$P= \frac{\$17,885}{(1+.10)^1} =\$16,260$$

This means that if $16,260 was banked at 10% interest, it would provide enough monies to pay the $17,885 bill at the end of the year. Similarly, the second, third, fourth, etc., years expenditures can also be expressed in present value. This is done in Table 2.

Table 2: Present Value Calculations for the Electronics Firm

Year	*Expenditure*	*Present Value*
1	$17,885	$ 16,260
2	$17,885	$ 14,781
3	$17,885	$ 13,437
4	$17,885	$ 12,216
5	$17,885	$ 11,105
6	$17,885	$ 10,096
7	$17,885	$ 9,178
8	$17,885	$ 8,343
9	$17,885	$ 7,585
10	$17,885	$ 6,895
		TOTAL $109,896

The bottom line to the analysis is that the total cost of the cleaning system over the next 10 years, given a 10% interest rate, is $109,896 in present value terms. In other words, $110,000[3] invested today at 10% interest would be sufficient to pay the entire material and disposal costs for the circuit board cleaning operation for the next 10 years. Hence, any changes to the operation of the firm can now be compared to this $110,000 baseline. Any change which would result in a lower 10 year cost would be a benefit in that it would save money; any option with a higher cost will be more expensive and should not be adopted from a financial or economic standpoint.

[3] Given the number of assumptions regarding costs, growth, etc., that must be made in these calculations, rounding the calculated values to 2 significant figures is generally wise.

WHAT TO CONSIDER IN THE ANALYSIS - REVENUES AND EXPENSES

Simple pollution prevention projects often require little more financial justification than the savings related to tier 0 or possibly tier 1 costs. However, as a firm gets more and more sophisticated in its subsequent efforts, the less tangible tier 2 and 3 costs will become more important. Even if these costs cannot be accurately predicted, in cases where two investment options appear to be financially equivalent, if one is a pollution prevention project, the tier 2 and 3 considerations can favor that option.

With few exceptions, the goal of most business endeavors is to make a profit. As a result, the costs and benefits cash flows for each option can be related to the basic profit equation:

Revenues - Expenses = Profit.

The most important aspect is that profits can be increased by either an increase in revenues or a decrease in expenses. A benefit of pollution prevention is often lowered expenditures and increased profit. In the remainder of this section, the different categories of pollution prevention revenues and expenses will be examined.

Revenues: In its simplest definition, revenue is money coming into the firm; from sale of goods or services, rental fees, interest income, etc. From the profit equation, it can be seen that a revenue increase leads to a direct increase in profit and vice versa if all other revenues and expenses are held constant.[4]

It is always possible for a pollution prevention project to either increase or decrease production rates so revenue impacts must be examined. For example, often firms can cut wastewater treatment costs if water use (and in turn the resulting wastewater flows) is regulated to non-peak times at the wastewater treatment facility. However, this limitation on water use could hamper production. Consequently, even though the firm's actions to regulate water use could reduce wastewater charges, unless alternative methods could be found to maintain total production, revenue could also be decreased.

Conversely, a change in production procedure as a result of a pollution prevention project could increase revenue. For example, a process change such as moving from liquid to dry paint stripping can not only reduce water consumption, but also affect production output. Since clean up time from dry paint stripping operations (such as bead blasting) is generally much shorter than from using a hazardous, liquid based stripper, it could mean not only the elimination of the liquid waste stream (the direct objective of the pollution prevention project), but less employee time spent in the cleanup

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[4] The condition of other expenses/revenues being held constant is assumed throughout this report.

operation. Hence, production, and in turn revenues could be enhanced through pollution prevention.

Although less common, one more potential revenue effect is the generation of marketable byproducts as a result of pollution prevention efforts. Hence, pollution prevention has the potential to either increase or decrease revenue and profits.

Expenses: Expenses are monies leaving the firm to cover the costs of operations, maintenance, insurance, etc. The following sections review the major cost categories for pollution prevention investment consideration and their effects on expenses.

Insurance Expense: Depending upon the pollution prevention project, insurance expense could either increase or decrease. For example, OSHA has set limits on worker's exposure to a number of chlorinated solvents. If one pollution prevention option was to eliminate a hazardous, chlorinated solvent from production operations, there could be savings in employee health coverage, liability insurance, etc. Likewise, using a non-flammable solvent in place of a flammable one could lead to a decrease in the fire insurance premium.

Conversely, insurance expense could be increased. For example, if a heat recovery still was added to a process operation, fire insurance premiums could increase. Depending upon the premium change (if any), expenses, and in turn profits, could be increased or decreased by pollution prevention.

Depreciation Expense: If the pollution prevention project involves the purchase of capital equipment with a limited life (such as storage tanks, recycle or recovery equipment, new solvent bath systems, etc.), the entire cost is not charged against the current year. Instead, a system of depreciation spreads that expense over time. Depreciation expense calculations allocate the equipment's procurement costs (including delivery charges, installation, start up expenses, etc.) by taking a percentage of the cost each year over the life of the equipment.

For example, if a piece of equipment was to last 10 years, an accounting expense of 10% of the procurement cost for the equipment would be charged each year.[5] Even though a firm must use a different depreciation system for tax purposes, e.g., the Accelerated Cost Recovery System (ACRS), it is acceptable to use other methods for bookkeeping and analysis. In any event, any pollution prevention capital equipment must be expensed through depreciation.

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[5] This method is straight-line depreciation. Although there are other methods available, all investment projects under consideration at any given time should use a single depreciation method to allow for accurate comparisons of expense and revenue impacts between the alternatives. Since straight-line depreciation is easy to compute, it is the method of choice.

Interest Expense: Pollution prevention investment implies one of two things must occur; either a firm must pay for the project out of its own cash, or it must finance the cost by borrowing money from a bank, issuing bonds, etc. In the case where a firm pays for a pollution prevention project out of its own cash reserves, the action is sometimes called an opportunity cost which is discussed later. If cash for the project must be borrowed, there is an interest charge connected with using someone else's money.

Interest is a true expense and must be treated like insurance expense as an offset to the project's benefits. The magnitude of the expense will vary with bank lending rates, returns required on corporate notes issued, etc., however, there will be an expense. Example computations are included in the Section III example.

Labor Expense: In most cases, the firm's labor requirements will change due to the pollution prevention project. As pointed out in the dry paint stripping example, this could be a positive effect which increases available productive time, or, if extra man hours were required to run new equipment, perform preventive maintenance, etc., there could be a decrease in employee's production time.

When computing labor expenses, the tier 1 costs could be significant. For example, if a material substitution project eliminated a hazardous input material which eliminated a hazardous waste, there could be a significant decreases in labor required to complete and track manifests, costs of labeling, handling and storing hazardous waste drums would be eliminated, etc. Hence, both direct, tier 0, expenses (e.g., 2 hours per week preventive maintenance on the pollution prevention equipment) and secondary, tier 1, expenses can have an effect on manpower costs.

Labor expense calculation can be simplistic or comprehensive. The most basic approach is to multiply the wage rate times the hours of labor. More comprehensive calculations include the associated costs of payroll taxes, administration, and benefits. Many companies routinely track these costs and establish an internal "burdened" labor rate to be used in financial analysis.

Training Expense: Pollution prevention may also involve the purchase of equipment or new, non-hazardous input materials which require additional operator training. In computing the total training costs, both the direct costs and the man hours spent in training must be considered as an expense. In addition, any other costs for refresher training or training for new employees, which is above the level currently needed, must be included in the analysis.

Computing direct costs is simply a matter of adding the costs of tuition, travel, per diem, etc. for the employees. Similarly, to compute the labor costs, simply multiply the employee's wage rate by the number of hours spent away from the job in training.

Floor Space Expense: As with any opportunity costs, the floor space cost must be based on the value of alternative uses. For example, multiple rinse tanks have long been used to reduce water use in electroplating. If a single dip rinse tank of 50 square feet were replaced with a cascade rinse system of 65 square feet, then the floor space expense would be the financial worth of the extra 15 square feet and must be included as an expense in the financial analysis for the pollution prevention project. Unfortunately, computing this floor space opportunity cost is not always as straightforward as it was with the case of training costs. In instances where little square footage is required, there may be no other use for the floor space which implies a zero cost. In other cases, if the area is currently only being used for storage of extra parts, bench stock, feed materials, etc., the costs may involve determining the worth of having a drum of chemical or an extra part closer to the operator.

Alternatively, as square footage increases, calculating floor space costs becomes more straightforward. For example, if a new building was needed to house the pollution prevention equipment, it would be easy to compute a cost. Similarly, if installing the equipment at the production site displaces enough storage room to require additional sheds be built, the cost would again be easy to compute.

As a default, the cost of floor space can be estimated from information available from realtors. The average square foot cost for new or used warehouse, or administrative, or production space, that would be charged to procure the space on the local market, is the average market worth of a square foot of floor space. Unless there is a specific alternative proposal for the floor space, this market analysis should work as a proxy.

OTHER FACTORS WHICH COULD AFFECT THE DECISION:

Cash Flow: Although cash flow does not have a direct effect on the firm's revenues or expenses, the concept must be considered with any pollution prevention project. If the pollution prevention project involves procurement costs, they often must be paid upon delivery of the equipment. Conversely, cash recovery could take years. Hence, three things can effect a firm's available cash. First, cash is used at the time of purchase. Second, it takes time to realize financial returns from the project through enhanced revenues or decreased expenses. Finally, depreciation expense is calculated at a much slower rate than the cash was spent. As a result of the investment, a firm could find itself cash poor.

Conversely, pollution prevention efforts can have a very positive effect on cash flow. For example, eliminating a hazardous waste via an input material substitution could result in a large amount of cash available from not having to pay for hazardous waste disposal every 90 days. Hence, even though cash flow does not have a direct impact on revenues and expenses, it may be necessary to consider in analyzing pollution prevention projects.

Opportunity Cost: If in purchasing pollution prevention equipment a firm pays for the project out of its own cash, some feel this action should represent a cost to the project because of opportunity costs. The basis of the argument is that if cash is used on pollution prevention, it is unavailable to use for other opportunities or investments. As a result, revenues which could have been generated by the cash (e.g., interest from a Certificate of Deposit at a bank) should be treated as an expense and reduce the value of the pollution prevention project.

Although the reasoning seems sound, opportunity costs are not expenses. It is true that the cash will be unavailable for other investments; however, opportunity cost should be thought of as a comparison criteria and not an expense. The opportunity forgone by using the cash is considered when the pollution prevention project competes for the firm's funds and is expressed by one of the financial analysis factors discussed earlier (e.g., net value of present worth, pay back period, etc.). It is this competition for the firm's funds that encompasses opportunity cost and opportunity cost should not be accounted directly against the project's benefits.

A minimum rate of return or hurdle rate is often used to express this opportunity cost competition between investments. For example, if a firm can draw 10% interest on cash in the bank, then 10% would be a valid choice for the hurdle rate as it represents the firm's cash opportunity cost. Then in analyzing investment options under a return on investment criteria, not only would the highest returns be selected, but any project which pays the firm a return less than the 10% hurdle rate would not be considered.

Pollution prevention has good investment potential. In reducing or eliminating waste generation and the related disposal/treatment expenses, pollution prevention can have a significant impact on the firm's bottom line. Even in cases where revenues are not generated, reducing the expenses and liabilities that are connected with generating hazardous waste represent a substantial reduction in overall expenses and an increase in profit. The next section illustrates how to analyze the worth of a pollution prevention investment.

SECTION III

Example Calculations

This section provides a step by step outline of the process of analyzing a pollution prevention project. The hypothetical firm under review takes in used parts, cleans them in a dip tank using a hazardous solvent, and applies a new finish. The financial analysis will be between the current solvent cleaning operation and two pollution prevention alternatives: a solvent recycle system and non-hazardous material substitution.

How to Establish the Baseline.

As indicated before, the first step is to define the baseline cost of the process. Once accomplished, the financial effects of any change to business as usual can be judged as either equal to, more expensive, or cheaper than the baseline case. To do this, the expenses resulting from the baseline, the recycle system and the non-hazardous solvent must be computed and compared. Figure 2 shows the material balance for the current system.

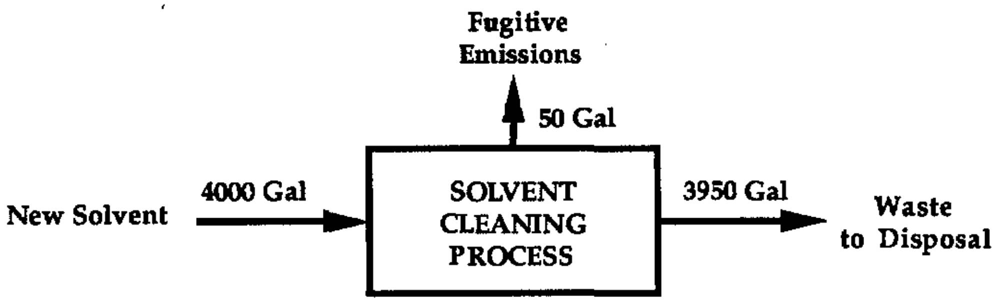

Figure 2. Baseline Material Balance

With the mass balance complete, annual costs can be assigned for the process. The resulting cash flow would be as shown in Table 3.

Table 3. Baseline Cost Analysis

Element	*Rate*	*Annualized Costs*
Procurement Expenses		None
Operations Expenses		
Utilities		N/A[6]
Operating Expense		N/A
Maintenance/Spare Parts		N/A
Input Solvent	$3.50/gal	$14,000
Waste Disposal	$2.50/gal	$ 9,875

None of the other expenses previously discussed in Section 2 need be addressed at this point as they will be computed, as applicable, as changes from this baseline.

To express these annual costs in present value terms, a time reference must be selected so that each option can be considered over the same length of time. Since the recycle equipment has an expected life of 10 years, the baseline and both options will be examined over this time period.

For the purpose of illustration, the firm's discount rate (the firm's internal interest or "hurdle" rate) shall be taken as 15% and the inflation rate is assumed at a constant 5% per year. Since the discount rate and inflation work in opposite directions (i.e. interest makes your money more valuable over time and inflation makes it less valuable over time), they can be combined. However, for simplicity, they shall be treated separately. All present value computations shall be made using 15% interest and all expenses shall be increased at an inflationary rate of 5% per year.

To account for prices which rise faster than inflation, annual real price increases (in excess of inflation) of 1% of the cost of solvent and 4% of the cost of disposal shall be assumed. In these cases, the cost of solvent shall increase 6% per year (5% inflation + 1% real price increase) and waste disposal shall increase 9% per year. Given these assumptions, the baseline expenses for the next decade are as shown in Table 4.

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[6] These expenses are not applicable for the baseline because we need only consider increases/decreases when analyzing the options

Table 4. Ten Year Baseline Costs

	Annual Cost		
Year	*Item*	*w/o Recycle*	*Annual Total*
1	New Solvent	$14,000	
	Waste Disposal	$9,875	
			$ 23,875
2	New Solvent	$14,840	
	Waste Disposal	$10,764	
			$ 25,604
3	New Solvent	$15,730	
	Waste Disposal	$11,732	
			$ 27,462
4	New Solvent	$16,674	
	Waste Disposal	$12,788	
			$ 29,462
5	New Solvent	$17,674	
	Waste Disposal	$13,939	
			$ 31,613
6	New Solvent	$18,734	
	Waste Disposal	$15,194	
			$ 33,928
7	New Solvent	$19,859	
	Waste Disposal	$16,561	
			$ 36,420
8	New Solvent	$21,050	
	Waste Disposal	$18,051	
			$ 39,101
9	New Solvent	$22,313	
	Waste Disposal	$19,676	
			$ 41,989
10	New Solvent	$23,652	
	Waste Disposal	$21,447	
			$ 45,099

In many cases firms simplify the calculations by assuming costs will be constant over the life of the project. If this is the case, then all outyear costs would be the same as was done with the Table 1 example.

The intermediate step in the financial analysis will be to compare the annual costs of the two pollution prevention options with the annual costs of the baseline process. (This will be illustrated in Table 9) Then the present value of the annual cost savings (or cost increase) of the options will be calculated. This will be done for the base line and both options simultaneously at the end of the analysis.

The final step will be to sum the present values from each year to obtain the net present value. The net present value represents the quantifiable worth of the project.

Examining Pollution Prevention Option 1 - Recycle.

As before, the first step is to establish the mass balance diagram for this option. This is shown in Figure 3.

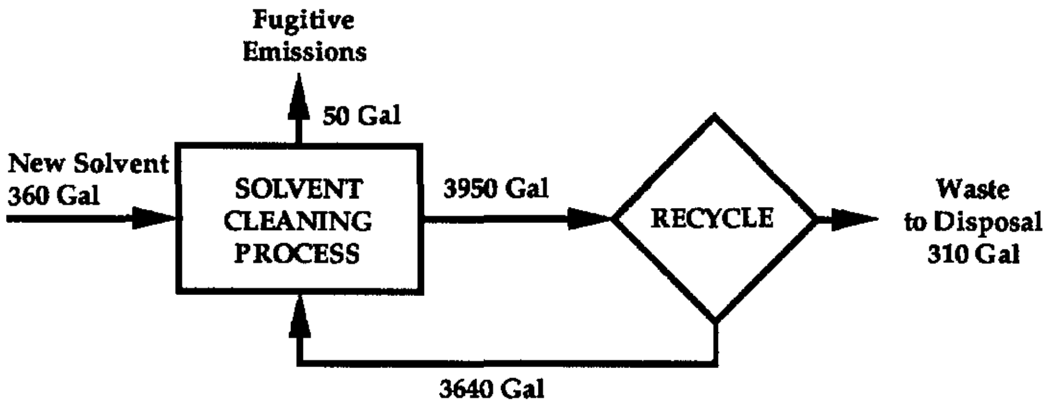

Figure 3. Material Balance for the Recycle System

As is the case with many recycle options, a salable by- product is generated (the recycled solvent), but instead of offering the solvent for sale, the firm is using it as an input to offset the cost of new solvent so there is no revenue impact. Further, since the actual cleaning operation has not changed, there should be no change in production rate as a result of this option. As a result, there are no revenue impacts to consider.

This material balance in Figure 3 can be readily converted to a cash flow. As discussed earlier, the recovery equipment has a life of 10 years. Further, there is no salvage value; the solvent must be chemically treated at the end of year 5 to retain it's effectiveness at a cost of $1000;[7] and no additional permits, such as RCRA treatment permits or air permits, are required to operate or install the equipment. Given these assumptions, the annual costs are as shown in Table 5.

[7] Even though the solvent has to be treated at year 5, the time scale is a full ten years. This is because the life of the recycle equipment is the key (10 years), not the life of the solvent (5 years)

Table 5. Costs for Solvent Recycling

Element	*Rate*	*Base Year Costs*[8]
Procurement Expenses		
Recycle Equipment:		
Tanks, Pumps, Mixers, etc.		$40,500
Installation: Design, Piping, Labor, etc.		$20,000
Contingency (@10%)		$6,000
	Total:	**$66,500**
Operations Expenses		
Recovery System		
Utilities		$240
Operating Expense	1 hr/day @$20/hr	$5,000
Maintenance/Spare Parts	5% of Capital Cost	$3,325
Input Solvent	$3.50/gal	$1,260
Waste Disposal	$2.50/gal	$775

Other Expenses to Consider:

Insurance: The recycle operation involves a drum evaporator which could significantly increase insurance expense. However, for simplicity, it is assumed there is no increase in insurance expense.

Depreciation: Straight line depreciation shall be used with the procurement costs being expensed at 10% each year for 10 years.

Interest: The firm borrowed the capital costs, will make annual payments for 3 years, and must pay 12% interest annually. Note: the principle ($66,500) will be repaid in three equal installments. The interest expense is calculated for each year based upon the current balance. (The actual monies borrowed, or repaid, are neither revenues nor expenses and do not appear in the financial analysis)

Labor: The equipment requires 1 hour of maintenance per day. This expense (@ $20/hr) has been included in the operations expenses listed above. For simplicity, the wage rate will be assumed constant except for cost of living increases due to inflation.

Training: The training was supplied by the recycle equipment supplier with training on site so there are no direct costs. Three operators must spend 2 hours each learning the operations. Their wage cost will also be taken as $20/hour.

[8] Costs shown are typical for drum evaporator recycle equipment; however, individual estimates must be made. This analysis is meant only to show the method of calculation.

Floor Space Considerations: The equipment is relatively compact, will be installed integral to the process, and will carry a zero floor space expense.

As done with the baseline, annual costs for the recycling option must also be spread over time as they will actually occur. Given our assumptions the costs, by year, for the 10 year life are shown in Table 6.

Table 6. Ten Year Costs for Recycle Option

Year	*Item*	*w/ Recycle*	*Total*
1	Interest Expense ($66,500 x 12%)	$7,980	
	Depreciation Expense	$6,600	
	Initial Training	$ 120	
	Operating Expenses		
	(Labor, Utilities, Maint)	$8,565	
	New Solvent	$1,260	
	Waste Disposal	$775	
			$25,300
2	Interest Expense ($44,333 x 12%)	$5,320	
	Depreciation Expense	$6,600	
	Operating Expenses (5%/yr. increase)	$8,993	
	New Solvent (6%/yr. increase) (360 gallons)	$1,336	
	Waste Disposal (9%/yr. increase)	$845	
			$23,094
3	Interest Expense ($22,166 x 12%)	$2,660	
	Depreciation Expense	$6,600	
	Operating Expenses	$9,442	
	New Solvent	$1,416	
	Waste Disposal	$921	
			$21,039
4	Depreciation Expense	$6,600	
	Operating Expenses	$9,915	
	New Solvent	$1,501	
	Waste Disposal	$1,004	
			$19,020

Table 6. Ten Year Costs for Recycle Option (con't)

Year	*Item*	*w/ Recycle*	*Total*
5	Depreciation Expense	$6,600	
	Operating Expenses	$11,410 [9]	
	New Solvent	$1,591	
	Waste Disposal	$1,094	
			$20,695
6	Depreciation Expense	$6,600	
	Operating Expenses	$10,931	
	New Solvent	$1,686	
	Waste Disposal	$1,192	
			$20,409
7	Depreciation Expense	$6,600	
	Operating Expenses	$11,477	
	New Solvent	$1,787	
	Waste Disposal	$1,300	
			$21,164
8	Depreciation Expense	$6,600	
	Operating Expenses	$12,051	
	New Solvent	$1,895	
	Waste Disposal	$1,417	
			$21,963
9	Depreciation Expense	$6,600	
	Operating Expenses	$12,654	
	New Solvent	$2,008	
	Waste Disposal	$1,544	
			$23,806
10	Depreciation Expense	$6,600	
	Operating Expenses	$13,287	
	New Solvent	$2,129	
	Waste Disposal	$1,683	
			$23,699

Again, these annual costs will be compared to the baseline after all cash flows for the options have been computed.

[9] This figure reflects the 5 year solvent reconditioning that was required at a cost of $1,000.

Examining Pollution Prevention Option 2 - Material Substitution.

This option consists of replacing the hazardous solvent used for cleaning in the baseline case with a non-hazardous cleaner which is used in the same manner. The firm has been fortunate to find a cleaning solution which is sewerable and does not require disposal as a hazardous waste. The cost of sewering the 3950 gallons is assumed to be negligible.

In pollution prevention projects which involve substituting a non-hazardous material for a hazardous material, part of the analysis must consider how well the new product or process works in relation to the current practice. In this example, it is assumed no operational changes are required so production levels can be maintained. However, the cost of the cleaner is nearly 25-percent higher: $4.60/gal. The first year costs for implementing this option are shown in Table 7.

Table 7. First Year Costs for the Material Substitution Alternative

Element	*Rate*	*Annualized Costs*
Procurement Expenses		None
Operations Expenses:		
Operating Expense		N/A
Maintenance/Spare Parts		N/A
Input Solvent	$4.60/gal	$18,400
Waste Disposal		$ 00
Training		$120

Insurance: Since the material substitution operation involves less risk to the employees, there could be an insurance reduction; however, because insurance cost is very site/circumstance specific, and to not bias the analysis, it will again be assumed to be a constant cost.

Depreciation: Since there is no capital expenditure, there is no equipment to depreciate.

Interest: The company has the cash reserve to absorb the additional cleaner cost without borrowing any additional capital. Hence, there is no interest expense.

Labor: There is no additional equipment maintenance requirement and the wage rate is again constant except for cost of living increases due to inflation.

Training: As before, we will assume the training needed to use the new cleaner was supplied by the vender and 3 operators spent 2 hours learning how to handle, test, and maintain the cleaner. Their wage rate will be taken as $20/hour (from the previous example).

Floor Space Considerations: The current solvent storage capacity for the firm is adequate for the new material.

With the same assumptions regarding cost increases, the annual costs for switching to the non-hazardous cleaner, over the ten year period, are shown in Table 8.

Table 8. Ten Year Material Substitution Costs (5% / yr. increases)

Year	*Item*	*Annual Cost*
1	New Cleaner	$ 18,520 [10]
2	New Cleaner	$ 19,320
3	New Cleaner	$ 20,286
4	New Cleaner	$ 21,300
5	New Cleaner	$ 22,365
6	New Cleaner	$ 23,484
7	New Cleaner	$ 24,658
8	New Cleaner	$ 25,891
9	New Cleaner	$ 27,185
10	New Cleaner	$ 28,544

Making the Financial Comparison:

With all annual costs computed, the final comparisons can be made. Table 9 shows the annual baseline costs (from Table 4) in the first column; columns 2 and 3 show the annual costs for recycle (from Table 6) and the increase or decrease from the baseline; and finally, columns 4 and 5 show the annual costs for material substitution (from Table 8) and their associated change from the baseline.

[10] The $120 training costs have been included in the first year's. annual cost

Table 9: Annual Cost Comparison

Year	*Baseline*	*Recycle*	*Savings*	*Material Substitution*	*Savings*
1	23,875	25,300	(1,425)	18,520	5,355
2	25,604	23,094	2,510	19,320	6,284
3	27,462	21,039	6,423	20,286	7,176
4	29,462	19,020	10,442	21,300	8,162
5	31,613	20,695	10,916	22,365	9,248
6	33,928	20,409	13,519	23,484	10,444
7	36,420	21,164	15,256	24,658	11,762
8	39,101	21,963	17,138	25,891	13,210
9	41,989	23,806	18,183	27,185	14,804
10	45,099	23,699	21,400	28,544	16,555

If an option's annual costs are less than the baseline, the difference is considered a benefit. Conversely, if the option's annual costs are higher than the baseline (indicated by parenthesis), the difference is considered a cost. So that the two options can be compared, the final steps are to bring each option's costs and benefits back to present value, compute the net difference, and make the financial decision. These calculations are shown in Table 10. The present value calculation uses the formula from page 4 with the interest rate set at 15%. (Recall that 15% was set as the example firm's "hurdle" rate the acceptable internal interest rate)

$$P = \frac{F}{(1+r)^n}$$

Table 10: Present Values of the Costs and Benefits [11]

	Recycle Option		*Material Substitution*	
Year	*Difference*	*Present Value*	*Difference*	*Present Value*
1	(1,425)	(1,239)	5,355	4,657
2	2,510	1,898	6,284	4,752
3	6,423	4,223	7,176	4,718
4	10,442	5,970	8,162	4,666
5	10,916	5,427	9,248	4,598
6	13,519	5,844	10,444	4,515
7	15,256	5,735	11,762	4,422
8	17,138	5,602	13,210	4,318
9	18,183	5,169	14,804	4,208
10	21,400	5,290	16,555	4,092
NET PRESENT VALUE		**$43,919**		**$44,946**

[11] Costs are again indicated by parenthesis.

MAKING THE FINAL DECISION

In this example, both options display a positive effect on profitability. The two proposals each generate a net benefit compared to the baseline, status quo, option. Likewise, the proposals also meet the firm's internal hurdle rate (15%), because their present values are positive when calculated using a 15% discount rate.

The final task is to select between the two options. In that they have the same present worth of net benefits, they are equivalent under the financial criteria. However, as previously discussed, when projects appear financially equivalent, consideration of other tier costs can swing favor toward an option. In the above analysis, only tier 0 costs were included. If one considers the labor savings due to not having to manifest waste shipments, label drums, and so on., because the material substitution option eliminates hazardous waste generation, there is a substantial savings. Additionally, the elimination of hazardous waste limits the potential intangible tier 2 and 3 costs for remedial actions, lawsuits, etc.. Given these considerations, and the fact that material substitution was higher on the pollution prevention hierarchy, the material substitution option is clearly the most beneficial option.

SECTION IV

CONCLUSIONS

The key point to remember is that firms are in business to make a profit and pollution prevention can be critical to profitability. In the past, environmental expenditures were seen as pure cost sinks with no payback potential. It is becoming apparent that in the realm of pollution prevention there are a number of areas where expenditures can be cut significantly. One EPA study[12] of waste reduction projects showed that in 29 cases that included data on payback period, over 80% had payback periods of less than 3 years.

There is no doubt that environmental management can make a difference in reducing a company's expenses. The task becomes one of selling improvements in the expense side of the profit equation. Reducing an expense is as effective as increasing revenues when it comes to profit.

The final considerations in justifying pollution prevention investments are the tier 2 and 3 potential liability costs. Many types of projects can effect revenues, expenses, and/or cash flow, but pollution prevention projects are relatively unique in their additional positive effects. Although difficult to express in concrete financial terms, both environmental compliance and pollution prevention can have far ranging benefits in terms of reduced long term liability, customer relations, public goodwill, and employee morale. While these factors may not serve to justify the investment in a project by themselves, they must enter into the analysis.

This primer has provided a working definition of pollution prevention and presented the hierarchy of waste management methods. Basic financial tools were described and a preference was put forth for the use of Net Present Value as an appropriate method of financial comparison. Suggestions were made on what types of costs should be considered in evaluation of a pollution prevention project, and how those costs should be calculated over the project lifetime. An example case study of an industrial process and two pollution prevention options was illustrated. Finally, the financial results of the case study were evaluated and the meaning of those results was discussed.

In conclusion, this primer presents financial tools and a suggestion of other less tangible benefits which can be used to justify pollution prevention projects on an equal basis with all other funding requests.

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12 ibid. Butler, Timm, and Fromm.

APPENDICES

Appendix 1

The Effects of Interest/Discount Rates

In determining the value of a pollution prevention project, the discount rate used becomes critical. If pollution prevention project benefits are accrued far into the future, or if a larger discount rate is used, the effect on the present value (and hence the apparent value of the pollution prevention project) could be dramatic. Figure A1 shows the relationship between percent of future worth regained over time at varying interest rates.

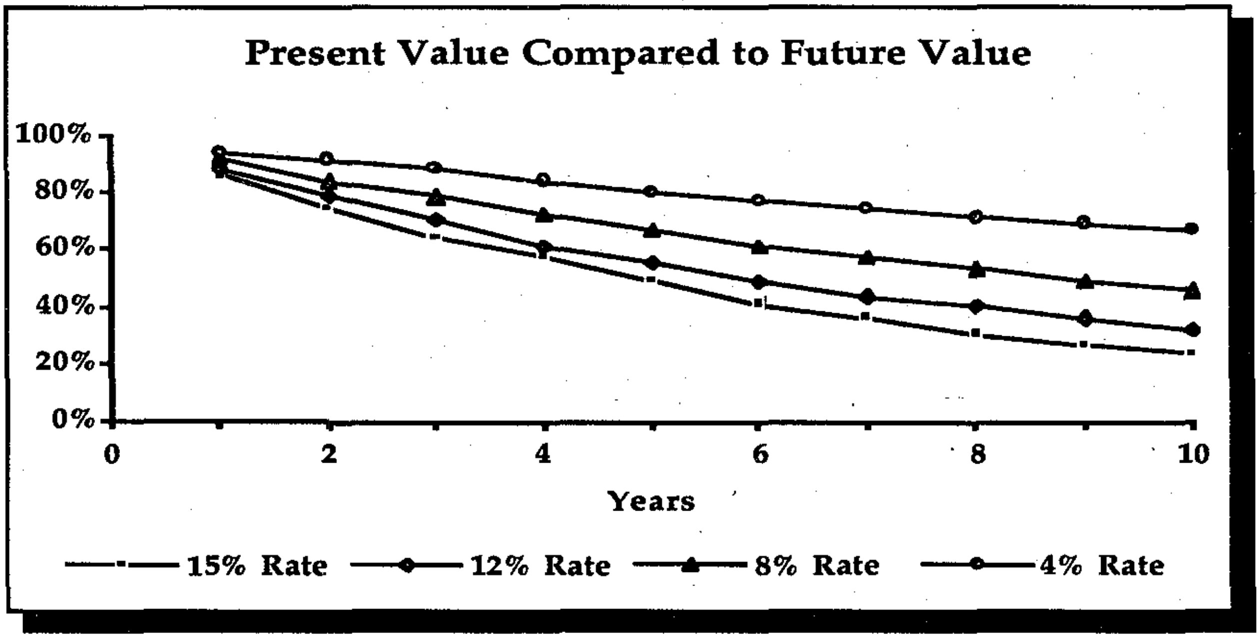

Figure A1. The Effect of Time on Present Value.

Most companies prefer an return on investment (ROI) or hurdle rate in the range of 10-15% (the federal government uses a 10% standard). At 10% over half of a future benefit stream can be lost due to the time value of money within the first 10 years. This factor works against the acceptability of projects which provide benefits far in the future. Hence, to justify pollution prevention projects with long term benefit cash flows it is often necessary to move to tier 2 or 3 criteria (See Section IV, Financial Criteria).

Appendix 2

Methods of Financial Comparison

1: Payback Period: The technique for determining payback period again lies within present value; however, instead of solving the present value equation for the present value (P), the cost and benefit cash flows are kept separate over time. First, the project's anticipated benefit and cost is tabulated for each year of the project lifetime. Then these values are converted to present values by using the present value equation with the firm's discount rate plugged in as the discount factor. Finally the cumulative total of the benefits (at present value) and the cumulative total of the costs (at present value) are compared year by year. At the point in time when the cumulative present value of the benefits start to exceed the cumulative present value of the costs, the project has reached the payback period. Ranking projects then becomes a matter of selecting the projects with the shortest payback period.

While some firms have gone to the point of establishing a minimum payback time standard, this method is not recommended for comparing investment options dealing with pollution prevention because of two factors. First, because the pollution prevention benefit stream generally extends far into the future, discounting makes its payoff period very long. Second, the highest costs and benefits associated with most environmental projects are generally due to catastrophic failure, also a far future event. Since the payback period analysis stops when the benefits and costs are equal, the projects with the quickest positive cash flow will dominate. Hence, for a pollution prevention project, with a high discount rate, the long term costs/benefits may be so far into the future that they do not even enter into the analysis. In essence, the importance of life-cycle costing is lost in using this method because it only considers costs and benefits to the point where they balance instead of considering them over the entire life of the project.

2: Internal Rate of Return: Again, this method is based in the net present value of benefits and costs; however, it does not use a predetermined discount rate. Instead, the present value equation is solved for the discount rate (r). The discount rate that satisfies the zero benefit is the rate of return on the investment and project selection is based on the highest rate. Computationally, the present value equation is solved for (r) after setting the net present value to zero and plugging in the future value obtained by subtracting the future costs from the future benefits over the lifetime of the project. Although this method is frequently used in business, the net benefits and costs must be determined for each time period and brought back to present value separately. Computationally, this could mean dealing with a large number of simultaneous equations.

3: Benefit/Cost Ratio: Again, the present values of the benefits and costs are kept separate and expressed in one of two ways. First, there is the pure benefit/cost ratio which implies that if the ratio is greater than 1, the benefits outweigh the costs and the project is acceptable. Second, there is the net ratio which is the net benefit (i.e. benefits less costs) divided by the costs. In this latter case, the decision criteria is that the benefits must outweigh the costs which means the net ratio must be greater than zero (e.g. if the benefits exactly equaled the costs, the net B/C ratio would be zero). In both cases, the highest B/C ratios are considered as the best projects.

There is a potential for altering the actual ratios using this method. Take for example, if the present value of a project's benefits were $100 and costs were $60, the B/C ratio would be $100/$60 or 1.67. If however the proponent of the project were to reassess the project and declare that some of the costs were not "true" costs, but instead simply offsets to benefits, then the ratio could be changed considerably. In our above example, if $50 of the $60 total cost was for waste disposal, and $70 of the $100 in benefits due to waste minimization, then one could use them to offset each other. Under this line of thinking both the numerator and denominator of the ratio could be reduced by $50 with the following effect: ($100 - $50) / ($60 - $50) = 5.0. Hence, without changing the project, the new B/C ratio would make the project seem to be considerably better.

4: Present Value of Net Benefits: This comparison evaluates all benefits and costs at their current or present values. If the net benefit (i.e., the benefits less costs) is greater than zero, the project is worth undertaking; if the net is less than zero, the project should be abandoned on a financial basis.

This technique is firmly grounded in microeconomic theory and is ideal for total cost analysis (TCA) and pollution prevention financial analysis. Even though it requires a preselected discount rate which can greatly discount long term benefits, it assures all costs/benefits over the entire life of the project are included in the analysis. Once the present value of all options with positive net values are known, the actual ranking of projects using this method is straight forward; those with the highest Present Value of Net Benefits are funded first.

Appendix 3

The Effects of Income Tax

Although many firms use only revenue and expense figures in comparing investment projects, income tax effects can enter into each calculation if either revenues or expenses are changed from the baseline values; more expenses mean lower profits and less taxes, and vice versa. If the effect of income taxes on profit is needed, the computations are simple and can be done during or after the analysis.

As with expenses and revenues, the total tax liability for each option does not need to be computed. Instead, only the difference in tax liability resulting the changes in revenues and/or expenses from the baseline due to the options being considered is required.

The profit equation shown in Section II reflects gross or pre- tax profits. Income tax is based on the gross profit figure from this equation and cannot be computed until the changes in revenues/ expenses are known. For the purposes of illustration, the income tax rate shall be taken as constant at 40% of gross profit.

Taxes act to soften the impact on net profit due to changes in revenue/expenses as follows. If revenues increase by $100 with no other changes, pre-tax profits would also increase $100. Since income taxes take $40 of this increase, the effect on net profit would be to soften the $100 revenue increase to a $60 net profit increase. Similarly, if expenses increase $100, pre-tax income would decrease $100. The tax liability would be $40 less, so in this latter case, the -$100 pre-tax impact would be softened to a $60 net-profit decrease. This is shown in Table A3-1.

Table A3-1

The effect of changes in revenues and expenses on pre-tax and net profits.

Revenue Increase:	
Initial Condition:	
Beginning pre-tax profit:	$100
Tax liability:	$ 40
Net Profit without pollution prevention project:	$ 60
Post Pollution Prevention:	
Revenue increase subsequent to project:	$100
New pre-tax profit:	$200
New tax Liability:	$ 80
New net Profit:	$120
Increase in net profit due to +$100 in revenues	+$ 60

Table A3-1 (cont.)

Expense Increase

Initial condition	
Beginning pre-tax profit:	$100
Tax liability:	$ 40
Net Profit without pollution prevention project:	$ 60
Post Pollution Prevention:	
Expense increase subsequent to project	$100
New pre-tax profit:	$ 00
New tax liability:	$ 00
New net profit:	$ 00
Decrease in net profit due to +$100 in expenses:	-$ 60

As the table shows, the profit impact of an increase or decrease in revenues or expenses is limited by 1 minus the tax rate (1-t). If the tax rate is different from 40%, it can be inserted into (1-t) and used in calculating the impact. For example, for a 33% tax rate, a $100 increase in revenue would increase profit by (1-.33) or $67.

Tax credits are a special case allowed by the IRS at various times. For example, during the energy crunch of the seventies, certain capital expenses which reduced energy consumption (such as solar energy projects) were given special treatment as tax credits. Unlike the more familiar personal tax deductions, tax credits could be deducted directly from the tax obligation of a firm. As a result, in this special tax credit case, capital expenses which would otherwise lower pre-tax income can be subtracted directly from the tax liability and increase profit. While there are currently no tax credit projects available, given the political emphasis on pollution prevention, it is a possibility for the future that cannot be overlooked.

Appendix 4

Present Value Computation Under Uncertainty

Tier 2 and 3 costs are by their nature very difficult to quantify or predict. For example, a typical tier 3 cost would be cost of lost sales due to adverse public reaction to a pollution incident. The variables would include the types of incidents that could occur, the severity of each incident, the ability of the firm to control or respond to the emergency, the public's reaction to the incident, the firm's ability to sate the public's concerns, etc. At the very least, a complex situation.

In many cases, there is a probability that can be connected with the event. This enters into the calculation of expected value. The expected value of an event is the probability of an event occurring times the cost or benefit of the event. Once all expected values are determined, they are totaled and brought back to present value as done with any other benefit or expense. Hence, the expected value measures the central tendency or the value that an outcome would have on the average.

For example, there are a number of games at county fairs that involve betting on numbers or colors much like roulette. If the required bet is $1, and the prize is worth $5, and there are 10 selections (e.g., the numbers 0-9) the expected value of the game can be computed as:

(benefit of success)x(probability of success)
\- (cost of failure)x(probability of failure)
($5)x(.1) - ($1)x(.9) = -$.40.

Hence, on the average, the player will lose (i.e., the game operator will win) $.40 on every $1 wagered.

For tier 2 and 3 expenses, the analysis is the same. For example, there is a great deal of data available from Occupational Safety and Health Administration (OSHA) studies regarding employee injury in the workplace. In justifying a material substitution pollution prevention project, if the probability of injury and a cost could be found, the benefit of project could be computed.

The concept of expected value is not complicated although the calculations can become somewhat involved. For example, even though each individual's chance of injury may be small, given the number of employees, their individual opportunity costs, the various probabilities for each task, etc., could mean a number of calculations. However, if one considers the effect of the sum of these small costs, or the large potential costs of environmental lawsuits or site remediation under either the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the expected value computations can be quite important in the financial analysis.

Appendix 5

Additional Reading

Managerial Finance
By: Joe K. Shim & Joel G. Siegel
Published by: Schaum's Outline Series (067306-9)

This instructional text describes financial analysis and includes sections on the time value of money and capital budgeting.

Managerial Accounting
By: Joe K. Shim & Joel G. Siegel
Published by: Schaum's Outline Series (067303-0)

This instructional text describes management accounting and includes sections on cost concepts, terms and classifications, cost allocation, and capital budgeting.

Hazardous and Solid Waste Minimization
By: A. H. Purcell
Published by: Government Institutes, Inc.
ISBN/ISSN: 0865871361

This document describes waste minimization and resource recovery. It includes the whys and wherefores of waste minimization, considers the economics of waste management decisions, and covers waste minimization planning, auditing, and implementation.

Waste Minimization Manual
Published by: Government Institutes, Inc.
ISBN/ISSN: 0865877319

This document discusses waste minimization, economic imperatives, legal and regulatory incentives, and how to conduct waste minimization audits. It also contains waste minimization case histories for Dow, DuPont, Chevron, Hewlett Packard, and the Navy.

Costing & Financial Analysis of Pollution Prevention Projects
By: Marlene R. Wittman
Published by: Massachusetts Office of Technical Assistance

This text provides a curriculum which is intended to familiarize environmental professionals with basic business terms, and to increase their awareness of the factors that influence an investment in pollution prevention options.