# Acknowledgements

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# Part I Overview

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## 1.1 Background

The BC Ministry of Environment, Lands and Parks (MELP) is working towards a more flexible, efficient, and effective approach to protecting the environment.

Total Cost Assessment (TCA), a tool used to assess the true profitability of investments, is an important component of this new approach. TCA was originally developed by the Tellus Institute in Boston and has subsequently been refined through practical application in a variety of industrial and commercial settings. These guidelines build on Tellus's original approach by providing additional analytical techniques and practical implementation considerations.

Although TCA is relevant for firms who are undertaking P2 planning, it can also be used by firms or agencies who are simply interested in improving their business decision-making.

## 1.2 Purpose and Objectives

The primary purpose of these guidelines is to give companies the practical knowledge and techniques to apply TCA so they can prevent pollution *and* improve profitability. The goal is not to provide a comprehensive overview of environmental cost accounting, but rather, to focus on one tool for assessing the business case of any change to a company's management and/or operational system (i.e., an option). In particular, the guidelines are designed to:

- provide an overview of TCA, including some simple steps for getting started; and
- describe how to implement TCA.

## 1.3 Target audience and Organization of the document

TCA is equally relevant to small and medium-sized firms, public sector agencies and non-profit organizations. In fact, any organization that faces environmental issues, regardless of size or activity, can make use of TCA.

These guidelines can be used by senior executives, managers, accountants, engineers, legal staff, environmental staff, and operations/maintenance personnel. To meet the needs of different audiences, the document is organized into two parts. Senior executives and managers will find the overview in Part I useful. Part II provides more detailed advice for practitioners.

*Part I Overview*

**Section 2** provides an overview of TCA: what it is, how it's used and what the basic steps are. **Section 3** provides some advice on getting started, including potential barriers and ways to address them.

*Part II Implementation*

Part II is designed to provide additional detail for practitioners. Although it is useful to read the whole document from start to finish, you can also focus on individual sections of interest.

**Section 4** outlines some of the preliminary steps to take in preparation for a TCA, including establishing information needs. It also illustrates the use of a process flow diagram for identifying sources of potential costs and savings.

**Section 5** provides guidance on identifying and understanding costs. It includes an inventory of costs that can be used as a checklist when evaluating your own projects. It also shows how you can use TCA iteratively - so that you minimize the amount of effort needed to complete the analysis. In many cases, a preliminary TCA may be all that is necessary. For smaller firms, it may be all that is practical.

For more complex analyses, **Section 6** offers some practical advice on how to track down indirect costs without overhauling accounting systems. **Section 7** illustrates a number of techniques for characterizing contingent (or uncertain) costs including risk rating schemes, critical value analysis, the use of event trees and expected value calculations. These vary in the level of effort required and the accuracy achieved. Less-quantifiable, more strategic issues such as corporate image or employee relations, are also addressed.

**Section 8** provides details on evaluating the financial performance of options. It includes an explanation of discounted cash flow analysis (including some tax implications and funding sources that may affect the profitability of P2 options) and a discussion on calculating financial indicators. More detail is provided in **Appendix B**.

Techniques for making a final decision incorporating both quantitative and qualitative indicators of profitability, are included in **Section 9**. The use of tools such as decision trees, scenario analyses, and Multiple Account tables is illustrated.

Throughout the document, techniques or results are illustrated using examples from a small electronics firm that performed a TCA on a P2 option. These mini-cases are drawn together in a full case study shown in **Appendix A**. Examples of the cash flow analysis, sensitivity and scenario analysis and a Multiple Account table are shown.

Sample forms that may be adapted for use in doing your own TCA are included in **Appendix C**. A contact list of people and agencies involved in TCA and pollution prevention is provided along with a bibliography of useful references in **Appendix D**. A Glossary of Terms is presented in **Appendix E**.

# Overview of TCA

OVERVIEW OF TCA

2

## 2.1 What is TCA and What is it Used For?

TCA is a tool for assessing the true profitability of business investments. It can be used to:

- evaluate alternative capital investments;
- operational expenditures or procurement decisions; and
- can enhance decision making by improving the underlying cost information on which decisions are based.

TCA is not a new "method" of cost accounting but, rather, a tool for thinking about costs and project evaluation in a different and more comprehensive way.

Although TCA is useful for any kind of option, it is particularly relevant for evaluating P2 options (i.e., options that address a pollution prevention opportunity). P2 options, because of their nature, often produce financial savings that are overlooked in conventional financial analysis, either because they are misallocated, uncertain, hard to quantify, or occur more than three to five years after the initial investment. TCA involves identifying *all* of the relevant costs and savings associated with an option so that it can compete for scarce capital resources fairly, on a "level playing field".

TCA builds on conventional project evaluation methods by facilitating long-term, strategic approaches to financial analysis that improve decision-making. Relative to conventional cost accounting and project evaluation approaches, TCA:

- takes into account a wider range of direct and indirect costs and savings;

**Key questions that can be addressed by TCA**

What are our future compliance costs likely to be and how much should we spend to reduce them?

What have we been spending on end-of-pipe approaches to compliance and how much can we save by investing in P2?

How much are we spending to correct accidents - cleaning up spills, shutting down production - and would a P2 approach produce net savings?

Which of our major purchases have the greatest total costs?

Can we justify a higher-priced but less toxic input to our production process with the potential savings in downstream costs?

How much money can we save by improving resource-use efficiency by 30%?

- considers longer time horizons that reflect the full economic or commercial life of a project;
- uses financial indicators that incorporate the time value of money;
- reveals "hidden" costs, by relating them to the activities that cause them; and
- considers uncertain or less quantifiable costs.

There is no fixed formula for doing TCA. The basic steps can be applied to many business decisions in many different ways. TCA is a complement - rather than a replacement - for existing project evaluation, capital budgeting, environmental spending and cost tracking systems that are already in place in many organizations. For example, TCA can be used:

**A P2 Opportunity is:**

i) any material or energy loss (or risk of loss)

ii) any toxic material that can be eliminated, substituted or reduced, and/or

iii) any environmental concerns brought forward by a Public Advisory Committee (e.g., noise, traffic flow or visual effects).

- *For preparing business cases.* Many firms conduct "business cases" to evaluate major capital investments or operating decisions. A TCA approach can be used to develop consistent evaluation guidelines for all business cases, or to assess the profitability of any single operating or investment decision. The application to large single capital investments is the most relevant one for smaller businesses.

- *For capital budgeting.* While a business case typically provides an evaluation of individual decisions (capital or operating), capital budgeting refers to the allocation of capital among multiple options. In conjunction with criteria related to environmental and technical objectives, TCA can be used as a tool for prioritizing options competing for scarce capital resources.

- *For procurement decisions.* TCA can also be used to select from competing options based on the relative profitability of switching suppliers, or changing the mix of inputs (e.g. substituting non-toxic materials for toxic materials) without significant process changes or capital investments.


It is important to note that TCA does *not* require a major overhaul of existing accounting and information systems. Nor does it necessarily require extra staff or major expenditures. Even modest changes in the way cost data are identified, collected, and analyzed can reveal significant environmental and financial benefits that would not otherwise be evident.

**A few key definitions:**

- **Externalities** — The positive or negative impacts associated with a firm's products, services, or activities that are borne by external, third parties and for which the firm is generally not held responsible and would not normally build into its costs.
- **Full Cost Assessment (FCA)** — The practice of assigning all costs, both internal to the firm as well as externalities, to products, processes or activities (sometimes called *social costing*).
- **Life Cycle Analysis (LCA)** — An assessment of the environmental impacts of a product or process throughout its life cycle (i.e., from cradle to grave).

**Mid-sized printing firm uses TCA to improve its profitability and reduce waste.**

Quebecor Printing wanted to upgrade its wastewater treatment system at one of its mid-sized commercial printing facilities, but the project did not appear to be sufficiently profitable under a conventional financial evaluation. A TCA was conducted to ensure that all relevant direct and indirect costs were included in the analysis. The project's internal rate of return actually turned out to be 17.8% using TCA, compared to 14.7% under a conventional analysis. Further, its 10-year net present value rose from $51,887 to $81,152, and payback dropped from 6.9 years to 5.6. In addition to better immediate financial performance, the new facility will generate less hazardous waste and instead generate a potentially marketable byproduct.

### 2.2 How Does TCA Relate to Other Accounting Approaches?

TCA is generally viewed as one tool within the broader field of environmental accounting. Environmental accounting means accounting for the costs of past, present and future environmental activities, and may or may not include external costs borne by society.

Figure 2-1 shows the relationship between TCA and other approaches to environmental accounting. On one hand, TCA differs from conventional accounting and evaluation approaches by considering a broader range of costs that are particularly applicable to pollution prevention. However, TCA has a more narrow focus than, for example, *full cost assessment* or *life cycle analysis*[1] techniques because it doesn't necessarily (and usually does not) include external social costs for which a company is not legally accountable or financially liable.

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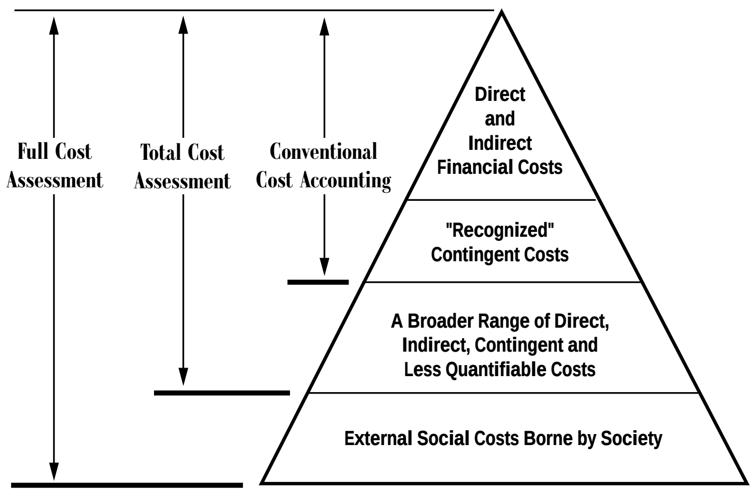
*1 See Glossary of Terms for definitions.*

### Figure 2-1 Relationship Between TCA and Other Forms of Accounting




Note that life cycle analysis focuses on the environmental impacts of a product or process (from inception to disposal) and therefore has a more narrow scope than full cost assessment (FCA). FCA looks at a broader range of firm activities as well as social considerations.

## Some Broader Benefits of TCA

*The primary benefit of TCA is that it provides a better assessment of the "true" profitability of P2 options. Other benefits include:*

- *Enhancing Environmental Management System activities (including ISO 14000) and broader quality management initiatives by providing better cost information with which to assess performance.*

• *Enhancing P2 performance by enabling firms to evaluate a range of options for moving beyond compliance* and *improving profitability.*

• *Becoming more "future-ready." TCA gives staff a better understanding of how environmental costs arise and makes them more aware of how the boundary between private and social costs is changing. As governments shift from regulatory to market-based mechanisms, businesses may increasingly be forced to take responsibility for environmental externalities. Firms that have adopted TCA will be much more ready to adapt to these changes.*

### 2.3 The Basic Steps

There are four basic steps in conducting a total cost assessment that will help to reduce the likelihood of overlooking real financial savings (Figure 2-2).

**STEP 1: Defining the Decision — Options**

A good understanding of the competing options under consideration helps to identify the kinds of cost information that will be needed. Some options are driven primarily by non-financial considerations. In these cases, a full quantitative understanding of profitability may not be critical to decision making. Usually, options are competing with many alternative investment

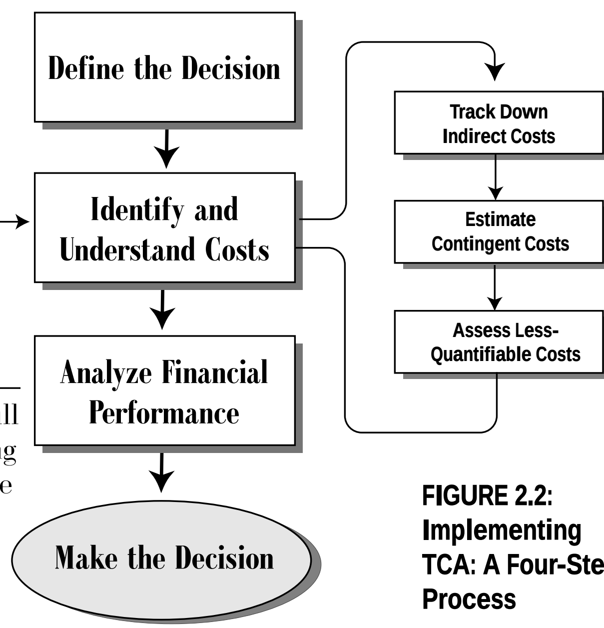



**FIGURE 2.2: Implementing TCA: A Four-Step Process**

proposals primarily on the basis of profitability. In these cases, a broad range of information on relevant costs is critical to good decision making. This will include:

- determining the scope of the TCA (i.e., what will be included in the analysis);
- clarifying how the options address core business objectives; and
- identifying what internal approvals are required.

### STEP 2: Identifying and Understanding Costs

Typically, the costs and savings that are readily available through accounting records are included in financial evaluations. However, for a number of reasons, P2 options often produce financial savings that get overlooked in conventional financial analysis. Some costs are lost because they are misallocated or lumped into overhead accounts. Others are ignored because they are uncertain (such as potential liabilities), hard to quantify (such as corporate image or customer relations), or occur more than three to five years after the initial investment (such as decommissioning or remediation).

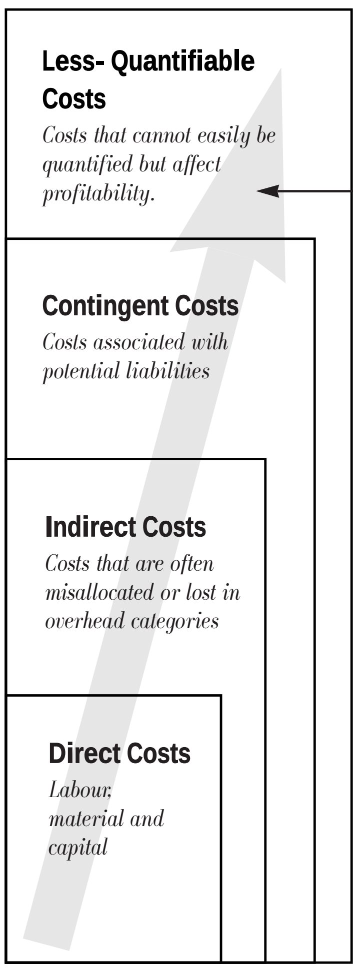
Four types of costs are commonly associated with options.

- **Direct Costs** (or "conventional" costs) include the costs that are usually identified in a conventional financial analysis (e.g., up-front capital costs, raw material inputs, labour, etc.).

- **Indirect Costs** are costs that are either not allocated to individual products, processes or facilities at all (i.e., they are left in overhead accounts), or they are lumped with several unrelated costs and allocated on the basis of some relatively arbitrary factor (such as square footage). This is a common occurrence with conventional accounting systems. They may be up-front costs (e.g., siting, design, etc.); operating costs (e.g., regulatory, monitoring, or compliance costs), or back-end costs (e.g., decommissioning, site clean-up, etc.).

- **Contingent Costs** are costs that may or may not be incurred at some point in the future. They can be described qualitatively, or quantified in terms of their expected magnitude, frequency and timing. Examples include compensation for future accidental chemical releases, fines for future regulatory infractions, or remediation costs for site clean up. Because these costs may not currently need to be formally recognized for accounting purposes, they may not be identified during the project evaluation stage. However, they often provide relevant information for forward-looking management decisions.

**FIGURE 2-3: Four Categories of Costs**




- **Less-Quantifiable Costs** are costs that require some subjective interpretation to assess and quantify. They include a wide range of strategic considerations and are realized as changes in revenues (through market share) or underlying costs. The most common are costs arising from changes in corporate image, customer relations, employee morale, and government or regulator relations. They differ from externalities in that, though hard to quantify, they nonetheless affect the firm's bottom line.

Identifying all these costs involves finding practical ways of *finding indirect costs, estimating contingent costs and assessing less-quantifiable costs.* These issues are discussed in Sections 6 and 7. Understanding costs means knowing which ones are relevant to the decision at hand, and which are significant enough to warrant further effort.

## STEP 3: Analyzing Financial Performance

TCA is a tool for finding the most profitable investment opportunities. True measures of profitability account for the time *value of money* (for terms in italics, see inset). TCA uses a *discounted cash flow* to recognize that costs, savings and revenues fluctuate over time. It also extends the time horizon of the evaluation to account for costs and benefits that occur more than three to five years in the future. Particularly in the case of P2 options, these future costs and benefits - and their timing - can significantly affect financial performance.

Financial indicators that account for the time value of money include *Net Present Value* (NPV), Internal Rate of Return (IRR), and Discounted Payback (DP). None of these are overly complex to use, but they do require an understanding of some basic principles about the selection of *discount rates* and how to interpret the results. This is reviewed in Section 8.

The process of identifying and analyzing costs is an iterative one. Some options will be easily justified on the basis of readily available cost information. However, if management feels that

**A few key definitions:**

- **Time Value of Money** — A recognition that the value of a sum of money depends on when it is received. $1000 today is worth more than $1000 received in the future because it could be invested today and earn a return over time.

- **Present Value** — The value today of cash received or spent in the future, calculated using an appropriate discount rate. *Net* present value subtracts future cash outflows (expenditures) from cash inflows (receipts). Also referred to as the discounted value of future cash flows.

- **Discount Rate** — The rate of interest or return that businesses can earn on the best alternative use of money at the same level of risk. Used to account for the time value of money.

- **Discounted Cash Flow** — Cash flow is the stream of cash outflows (expenditures) and cash inflows (receipts) related to a given project. A discount rate is used to translate these inflows and outflows (which occur at various points in time) into present values.


an option has merit, yet a financial analysis based on a limited set of cost data fails to justify it, then further effort may be warranted to track down indirect costs, estimate contingent costs and assess less-quantifiable costs. A more comprehensive financial analysis, based on more complete cost information, may change the investment decision.

### STEP 4: Making the Decision

Decision making is about integrating all of the factors that are relevant to the profitability of an investment opportunity. Some factors may be monetized (e.g., in a net present value calculation). Others may be quantified but not monetized (e.g., percentage increase in market share). Still others may be simply identified and characterized qualitatively (e.g.,"anticipated changes in future regulatory requirements are expected to increase compliance costs substantially").

A Multiple Account (MA) table[2] is a useful means of presenting all of the information about how an option affects core business objectives, most of which will be related ultimately to profitability. An MA table is simply a matrix showing how each option under consideration performs with respect to each "account" or business objective. Factors that affect profitability - which can be described in dollars, numerical ratings, or qualitative ratings - are presented and receive consideration in the decision making process. The actual method of decision making depends on the nature of the option and the magnitude of the potential costs and savings. Some practical advice about integrating cost information and making the decision is provided in Section 9.

*2 Often called a Multiple Account Evaluation.*

### 2.4 Who Should Be Interested in TCA?

To understand whether TCA may be relevant to your business, consider the following:

- Do you face potential environmental risks, even if they have a small chance of occurring?
- Do you have environmental permitting costs?
- Do you have spill prevention and clean up costs?
- Do you frequently have non-compliance incidents?
- Do you consume energy and water?
- Do you generate waste, particularly hazardous waste?
- Do you worry that you may face sudden environment-related pressures from customers, investors, employees or the public?
- Do you feel that your true environmental costs are larger than they appear in your accounting records?
- Are you engaged in, or considering, a P2 planning process?

**When to Use TCA?**
TCA is particularly appropriate and effective when[3] -

- the amount of money involved is large relative to the size of the firm;
- the business faces potential risks and uncertain outcomes arising from a particular decision;
- contingent costs exist but have not been accounted for in the project;
- there are likely to be indirect costs that may be misallocated or hidden in overhead accounts;
- the timing of cash flows is not obvious; and
- P2 options face stiff competition for financial resources from more conventional capital projects - making a level playing field essential.


If you answered yes to three or more of the above statements, chances are that TCA would be helpful to your business.

*3 Adapted from a list generated by the Environmental Financial Management Collaborative at BC Hydro.*


# 3

## GETTING STARTED

This section outlines some practical steps for companies to get started on applying TCA. While it is designed for firms with no previous environmental accounting experience, it may nonetheless provide useful insights for firms that are already active in this area. Some suggestions may be more appropriate for different sized companies, however the underlying principles are universal.

### 3.1 Gain Commitment

Because TCA is simply a tool to improve decision-making, it can be used effectively by any individual who wants to make a better purchase or investment decision. However, for TCA to achieve its full potential, it requires the broad support and commitment of all staff and senior management. If the leaders of the organization state their support for TCA and demonstrate a willingness to use the new cost information it produces, it helps greatly to legitimize subsequent TCA tasks. Their support can also help to overcome some common barriers to TCA, which are presented in Figure 3-1.

Some strategies to gain initial employee and senior management support, include the following:

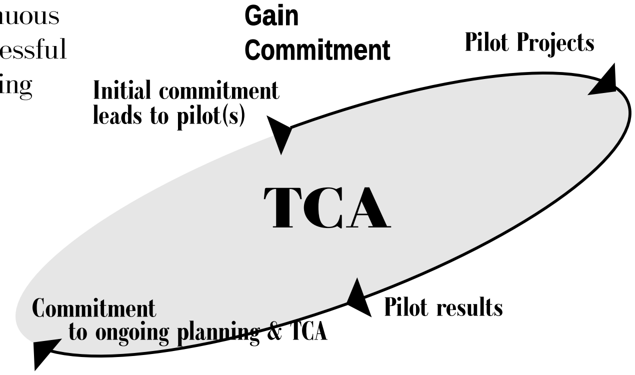
- Provide information about the techniques and benefits of TCA to all staff.
- Distribute "success stories" about similar firms that have benefited from TCA.
- Establish a mini-library of TCA resource materials.
- Issue a corporate policy statement on TCA.
- Conduct a training session to educate employees about the benefits of TCA.

## FIGURE 3-1 Overcoming Barriers

| Common Barrier to Adopting TCA | Possible Solution |
|---|---|
| It is seen as one more business tool that will result in extra work by overworked staff. | Use TCA as a tool to replace, not add to, existing accounting /evaluation methods. |
| It appears to be to complicated. | Begin with some easy pilot projects that give staff practice with it and some early success. |
| The firm is already committed to using another accounting, purchasing or project evaluation system. | Demonstrate how TCA can complement and augment almost any decision making approach. |
| Staff do not believe that it will make a significant difference to their business success. | Create an incentive program to reward staff that identify cost saving ideas using TCA. |
| The firm's cost data is considered inaccurate, therefore diminishing the value of TCA | If the data is inaccurate, it is probably causing other problems. The use of TCA will improve cost information and may address these other problems. |
| No systems exist to track and collect the new cost information required to apply TCA. | Start with procedures to manually track down data. Show staff how the cost information will lead to better decisions and emphasize that the goal is better information, not perfect information. |
| Staff believe that they already know what the costs are. | Use a pilot project to demonstrate that many costs are not obvious but can be significant. |
| The firm is quite small and doesn't have sufficient resources to implement TCA. | Begin by using TCA to evaluate potential capital purchases. This is where TCA is most valuable to small firms. |
| There is disagreement about who should manage the TCA process because it is multidisciplinary. | Position the person responsible for TCA as a coordinator as opposed to someone who controls the flow of cost information. |

However, the most effective strategy to gain employee commitment to apply TCA is to conduct a pilot project. A relatively small commitment to TCA - enough to initiate a pilot project - will result in a continuous improvement loop, where successful pilots lead to gradually increasing commitment (Figure 3-2).

**FIGURE 3-2**
**Using Pilots to Gain Commitment**




### 3.2 Conduct Pilot Projects

While there are many ways to conduct a TCA pilot project, they generally follow a number of similar steps, as follows:

- **Assemble a core team**. The first step in conducting a pilot project is to assemble a few staff who are interested in applying TCA and have some relevant expertise to contribute.

- **Select a project**. The next step is select a project with clearly defined boundaries.that is representative. This will ensure that the findings are transferable to other areas of the company.

- **Identify financial and staff resources**. Resource needs will vary greatly depending on the size of the pilot project. Many TCA's require only one or two days of staff time. A more comprehensive initiative might require three to four people working part time for several weeks or months. You may need to augment the core team after assessing specific resource needs for the project.

- **Conduct the TCA**. When analyzing the results, remember that in addition to direct cost savings and environmental improvements from specific projects, TCA can also lead to broader and long-lasting changes. This is because TCA often uncovers systemic biases in the allocation of environmental costs and reveals general business or process improvement opportunities. These, in turn, could – but don't necessarily have to - lead to changes in firm-wide operating, accounting, and environmental practices. For example, you may find that for some costs that are currently allocated to overhead, it would be relatively easy to flag the entry to ensure it gets allocated in the future to the appropriate process or product.

- **Implement the results**. Too many pilot projects fail because the individuals who need to implement the changes do not have the same commitment to TCA as those who identified the changes. This underscores the need for strong senior management support.

- **Evaluate performance and celebrate success**. As with any business management tool, it is important to evaluate the impact that completed TCA projects have had on the environmental and financial performance of the firm. This allows you to develop a positive track record of success. Communicate TCA achievements through internal and external communication channels as well as employee "recognition events".

### 3.3 Form Inter-Departmental Teams


As commitment to TCA grows, you may want to establish more permanent inter-departmental teams that meet routinely to work out ways of enhancing cost information and potential applications of TCA. In small firms, this may simply involve setting aside some time at management meetings to examine TCA applications (particularly capital purchase evaluations). Some of the


key roles and responsibilities to implement TCA are provided in Figure 3-3.

While broad participation across the firm is desirable, it is better to settle for a less well-rounded team of committed individuals than to choose less interested team members solely on the basis of their position. It may be useful to assign a TCA coordinator to lead the initiative. This individual should be a senior level employee with sufficient authority and resources to make decisions quickly.

**Figure 3-3**
**Roles and Responsibilities to Implement TCA**

| **Position/Title** | **Potential TCA Role/Responsibility** |
|---|---|
| Senior Executive | • Establish corporate policy to implement TCA.<br>• Demonstrate senior management support for TCA. |
| Process Engineer | • Use TCA in preparing feasibility studies. |
| Cost Accountant | • Adjust cost tracking systems to capture environmental costs<br>• Adapt accounting systems to include environmental costs |
| Manager, Environmental Affairs | • Identify overall options that could be evaluated using TCA |
| Manager, Purchasing | • Apply TCA to purchases with significant environmental management costs. |
| Manager, Communications | • Communicate TCA successes to staff and external stakeholders |
| Manager, Health and Safety | • Identify options with a health and safety benefit that could be evaluated using TCA |
| Director, Legal Affairs | • Identify environmental compliance concerns that could be included as contingent costs in a TCA evaluation |
| Head, Maintenance | • Identify options in the context of reducing non-product outputs. |

### 3.4 Improve Cost Information Over Time

It is not necessary to re-invent systems and procedures overnight. Progress, not perfection, is the primary goal. As firms become more skilled with TCA they become better able to identify and allocate costs.

Perhaps the area with the greatest opportunity for improvement is the estimation of future, uncertain costs. These are, by definition, difficult to calculate, yet tools are emerging to make their estimation more reliable. A number of firms are supplementing TCA with other accounting and environmental management techniques such as life cycle analysis, environmental performance indicators, and risk management. These tools allow firms to take into account costs that may arise in the future but do not currently exist.

The ultimate measure of success for TCA is whether or not it becomes second nature to all staff and fully integrated into the core decision making processes of the firm. Including TCA formally in standard planning activities like capital and operations budgeting, or in performance evaluations for management, are good ways to enhance its use throughout the firm.

# Part II Implementation

**4**

**DEFINING THE DECISION — OPTIONS**

## 4.1 Identifying All Inputs, Processes and Outputs

> A non-product output encompasses everything that is not an intended, marketable product, including all losses to the site, another operational system and/or the environment. All non-product outputs (that cannot be eliminated) represent an investment of money, labour and resources. Therefore, finding a market for them, reducing or eliminating their production, or putting them back into the operational system is simply good business. For this reason, the word "waste" is seldom used in this publication.

The first step in defining the decision is to identify those options that could result in a net cost savings (or revenues) to the organization. Techniques for conducting a comprehensive Environmental Review from which an inventory of opportunities and, in turn, a set of options can be derived are beyond the scope of this guide. For assistance with the Environmental Review, refer to the relevant sections in "The P2 Guide and Tool Kit", produced by the BC Ministry of Environment, Lands and Parks.

Once a particular set of options has been targeted for TCA, a useful tool is a simple process flow diagram that illustrates the existing and proposed changes. This will help to assess "what will change as a result of this option?" and "what are the *incremental* costs and benefits?". With the aid of a process flow diagram (Figure 4-1), ask the following questions:

- What are the boundaries of the evaluation - e.g., does the evaluation extend to neighbouring departments or business units, to the gates of the plant, or even beyond, to the community, customers or suppliers?

- What are the inputs, and product and non-product output at each stage of the relevant processes?

- What are the specific activities associated with each input, waste or emission - e.g., storage, recycling, treatment, disposal, discharge or training?

- Could the option result in unexpected events causing injury, damage or other contingent costs to arise – e.g., spills, leaks or fires?

- Are there product quality, reliability, employee safety or other strategic implications arising from the option?

These questions will also help you understand the kinds of cost data you may need and potential sources of information[4]. Most decisions will involve both operating changes and capital investments. However, some decisions may be procurement decisions only. For example, purchasing a process input from a different supplier because of packaging or transport safety considerations may have no downstream impacts on a process if all the specifications for the actual input remain unchanged. The process flow diagram helps to define the scope of all potential impacts the decision or option will cause. It may also help to define whether any further decisions are precluded or necessitated by the proposed changes.

### Defining the Decision at Precision Circuits Inc.

Precision Circuits, Inc. is a small Northwest circuit board manufacturer. The company has 30 employees, one of whom is primarily responsible for environmental management. On average, they produce 100,000 sq. ft. of circuit board per year.

In 1993, Precision identified an option involving its wastewater treatment process. A new process was proposed that would reduce the volume of wastewater sludge and change its composition. Figure 4-1 compares the process flow diagram for the existing process (base case) with the proposed changes.

The existing process generated three hazardous non-product outputs 1) nitric acid, 2) tin/lead stripper and 3) wastewater sludge material. Under the new process, the reductant (a process input) is eliminated, a new precipitator used, and two of three hazardous non-product outputs are eliminated. Precision anticipates that, pending regulatory changes, the new sludge material may eventually be reclassified as non-toxic, and sold for revenues.

Costs that may change under the new process include:

- purchasing costs – e.g., new precipitator, elimination of reductant;
- investment and operational costs – e.g., from process changes;
- contingent costs – e.g., from reduced number, volume and toxicity of treatment materials and residuals; and
- potential revenues – e.g., from the sale of new sludge material.

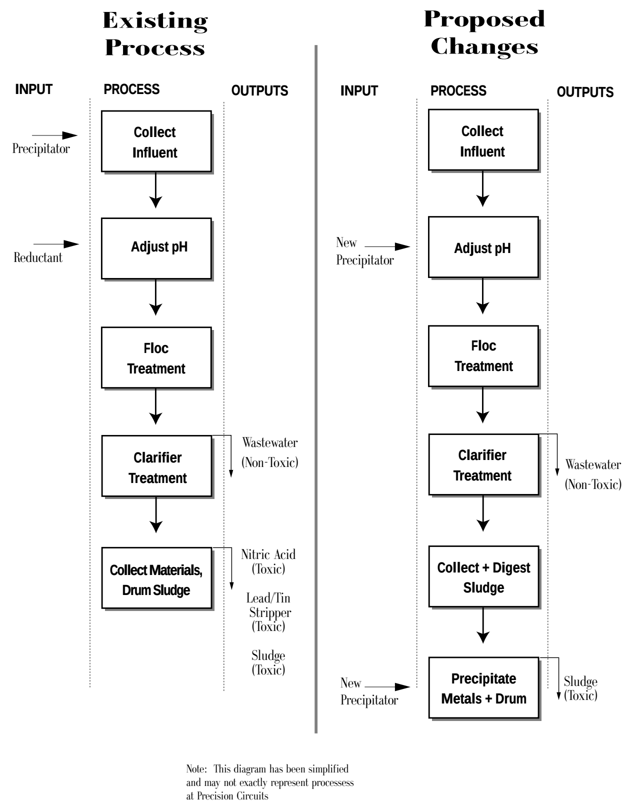
*4 It will eventually be important to determine if these costs are relevant to the decision (see Section 5-2). However, at this stage, the emphasis is on simply identifying all sources of costs.*

### 4.2 Assessing Information Needs

Before investing a lot of time tracking down cost data, you will want to understand what factors are going to affect the final invest-ment decision, and what internal approvals will be needed. As pre-paration for conducting a TCA on a particular investment, consider:

- How does the option address core business objectives?
- Are there com-pelling reasons for pursuing the option regardless of its financial performance?
- Is there more than one option for address-ing this particular P2 opportunity (and addressing the relevant core business object-ives)? Do they all warrant investigation?
- Do all options under consideration deliver the same perform-ance with respect to potential liabilities or strategic objectives?

**FIGURE 4-1: Process Flow Diagrams - Precision Circuits Wastewater Process Change**



Answering these questions will guide the next steps of the TCA. For example:

- If the option is going to be implemented because of compelling non-financial reasons, a full TCA may not be warranted.

- By identifying the core business objectives affected by the option, you may be able to prioritize cost items, and allocate time and resources for the TCA appropriately.

- If all alternatives under consideration provide the same strategic benefits, the decision will probably be based on the assessment of financial performance alone. If not, it will be necessary to develop a formal decision making framework to ensure that all factors affecting profitability – including non-monetized factors – are included in the analysis (see Section 9).

# *Identifying and Understanding Costs*

**IDENTIFYING AND UNDERSTANDING COSTS**

5

**TCA doesn't depend on recognizing and classifying "environmental" costs**

"It may not always be clear whether a cost is 'environmental' or not; some costs fall into a gray zone or may be classified as partly environmental and partly not. Whether or not a cost is 'environmental' is not critical; the goal is to ensure that relevant costs receive appropriate attention."
— *US Environmental Protection Agency, 1995.*

Total cost assessment is not about formulas, equations or accounting rules. Nor is it specifically about environmental costs. It's about understanding costs - all costs - and what drives them. It is intended to evaluate the true profitability of investments, not to provide a "break" for P2 options. In fact, there is no guarantee that TCA will always improve the outlook for a P2 option. There is also a chance that a more thorough cost analysis of a proposed P2 option will turn up more costs than savings (see inset).

**TCA may uncover more costs than savings...**

The Environmental Management division of a large paper coating mill conducted a TCA on a coating conversion project in order to improve the project's financial outlook. The conversion involved the switch from a solvent/heavy metal base coat to an aqueous/heavy metal-free formulation. Expected environmental benefits included reduced flammability and explosivity, employee exposure to solvents, VOC emissions, hazardous waste and solvent/heavy metal usage. However, when the TCA was conducted, previously omitted utility costs outweighed the savings found in waste management. The project's 15-year Net Present Value, already negative at -$203,000, dropped to -$395,000 under TCA. Its Internal Rate of Return dropped from 11% to 6%, and the payback rose from 7.6 to 11.7 years.

### 5.1 Finding All the Costs

A comprehensive inventory of costs is a critical component of any financial analysis, but is particularly important for P2 planning. Since all investments should be evaluated on a discounted cash flow basis (see Section 6), a comprehensive inventory will include both capital and operating costs.

An inventory of direct and indirect costs is shown in Figure 5-1. Whether a cost is direct or indirect depends on the nature of the project and the specifics of a firm's accounting methods, tracking systems (e.g., materials, waste, etc.) and normal project evaluation procedures. For example, utility or permitting costs may be directly attributed to a specific product line in one firm but hidden in overhead accounts in another.

Some sample contingent and less-quantifiable costs are listed in Figure 5-2.

### 5. 2 Understanding Relevant Costs

For any given option, it is impractical to rigorously evaluate all items in the cost inventory. "Relevant" costs are those that have a material impact on the decision. There are two tests of relevance:

1) *"Will any of the options under consideration eliminate, reduce or increase this cost item?"* Costs which cannot be avoided under any of the proposed alternatives need not be considered further.

2) *"Is the potential impact on this cost item likely to be significant in relation to the overall cost of the option and the cash flow of the business?"* If not, and particularly if the cost is difficult to quantify, it can be dropped from the analysis.

There is no way to classify costs generically as relevant or not. Relevance will depend on the individual facility, process and option under consideration. For example, the elimination of one waste stream from a facility may have limited cost savings, and thus limited relevance, if it is one of a dozen toxic materials on site. The elimination of the same amount of the only toxic material on a site may eliminate a whole range of related monitoring, training and manifesting activities, and thus be very relevant to the decision.

**Some Notes on Terminology**

TCA concentrates on finding all of the costs associated with alternative investments. What about the *savings* or *benefits* of these investments?

In fact, any costs that are incurred under an existing process that can be avoided by an alternative process are the savings attributable to the alternative. Cost savings and new revenues are the financial benefits of an option.

**Figure 5-1: Inventory of Direct and Indirect Costs**

## Capital Costs

**Purchased Equipment**
Equipment cost
Delivery
Sales Tax
Insurance
Initial Spare Parts

**Materials**
Piping
Electrical
Instrumentation
Structural
Insulation
Misc (e.g., painting, ducting, etc.)

**Utility Systems and Connections**
General Plumbing
Electricity
Steam
Water (e.g., cooling, process)
Fuel (e.g., gas, oil)
Plant Air
Inert Gas
Refrigeration
Sewerage

**Site Preparation***
In-house
Contractor, Vendor, Consulting Fees
Demolitions and Clearing
Old Equipment / Rubbish Disposal
Grading, Landscaping
Equipment Rental
Salvage Value

**Construction/ Installation***
In-house
Contractor, Vendor, Consultant Fees
Equipment Rental

**Planning/ Engineering***
In-house (e.g., design, drafting accounting)
Contractor, Vendor, Consultant Fees
Procurement

**Start-up/Training***
In-house
Contractor, Vendor, Consultant Fees
Trials, Manufacturing Variances
Training

**Permitting***
In-house
Contractor, Vendor, Consultant Fees
Permit Fees

**Working Capital**
Raw Materials
Other Materials and Supplies
Product Inventory

**Contingency**

## Operating Costs

**Direct Materials**
Raw Materials
Solvents
Catalysts
Transport
Storage

**Direct Labour**
Operating (e.g., worker productivity changes)
Supervision
Manufacturing
Clerical
Inspection (QA/QC)

**Utilities**
Electricity
Steam
Water (e.g., cooling, process)
Fuel (e.g., gas, oil)
Plant Air
Inert Gas
Refrigeration
Sewerage

**Management of Non-product Outputs***
Emergency (Contingency)
Planning
Residual Collection
Pre-treatment
On-site Handling
Containment
Storage
Treatment of Residuals
Hauling
Disposal
Insurance
Tracking/Information Systems
Recycling/Reuse

**Regulatory Compliance**
Permit Amendments
Training (e.g., WHMIS, etc.)
Monitoring/ Inspections
Sampling and Testing
Labeling & documentation
Recordkeeping
Reporting
Generator Fees/Taxes
Site Closure and Reclamation

## Revenues

Product Sales (e.g., from changes in manufacturing throughput / production)
By-Product Sales

**Insurance**

**Marketing**
Product Marketing
Public Relations

*Adapted from the Tellus Institute (Savage & White, 1995)*
**Including Labour, Supervision and Materials*

**Figure 5-2 Inventory of Contingent and Less-Quantifiable Costs**

## Contingent Costs

**Future Liability**
Fines, Penalties
Cost of Legal Proceedings
Personal Injury Claims (e.g., employees or community members)
Property Damage Claims
Natural Resource Damage
Site Remediation

**Production Effects**
Production Losses (e.g., from accidents or clean-up)

## Less-Quantifiable Costs

*Strategic issues that may lead to increases or decreases in market share, new revenue streams or more efficient operations include:*

Corporate Image
Customer Satisfaction and Relations
Product Quality or Certification
Investor Relations
Credit Rating
Employee and Community Relations
Employee and Community Health and Safety
Relations with Regulators, Insurers, Lenders
Reliability or Production Capability
Flexibility / Option Preservation (e.g., preserving the ability to market a new product in the future)
Innovation (e.g., converting waste streams to revenue streams, acquiring new technology that enhances a product or management system)

*Adapted from the Tellus Institute (Savage & White, 1995)*

### Dealing with Employee Time Savings – Are they Relevant?

*There are two standard schools of thought on employee time savings:*

*1. Unless actual staff layoffs occur, these savings are not realized in practice and should not be included in the evaluation.*

*2. Even if no actual layoffs occur, staff are available to pursue other initiatives. Increased productivity will be reflected in other aspects of the business and are likely to contribute to improved overall profitability. The value of time savings is a good proxy for the value of this increased productivity so these savings should be included in the calculation of financial performance.*

*In practice, how to treat savings in staff time may vary not only by company, but also by department and by individual project. If incorporating employee time savings in any given case is likely to be controversial or to call the calculation of* ▶

5

### 5.3 Conducting a Preliminary Assessment

Identifying all of the costs associated with a an option can consume a lot of time and resources. A preliminary assessment can help to identify options that are clear winners with a minimum of effort.

Screening is not a detailed or resource-intensive process. It simply involves identifying the most obvious costs, either quantitatively or qualitatively. As a first step, develop or review a process flow diagram that identifies all of the inputs, outputs and waste streams associated with the option or set of options (see Section 4). Review the inventory of costs in Figures 5-1 and 5-2. Which of these will change as a result of the option? Use this as a starting point for identifying relevant costs.

An attempt should be made to identify costs in all categories (i.e., direct, indirect, contingent and less-quantifiable), at least qualitatively. Move on to conduct a preliminary evaluation of financial performance at this stage (see Section 8). Some indirect, contingent or less-quantifiable costs can be estimated based on readily available information; others can be described qualitatively.

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*financial performance into question, a compromise strategy may be more practical, namely:*

*3. Increases in productivity resulting from staff time savings have a real impact on profitability. However, they are clearly different from the direct financial performance of the project. They can be addressed by:*

- *Estimating staff time savings in person-hours or -days.*
- *Calculating the dollar value of the estimated time savings as an average annual amount (i.e., hours per week x weeks per year x hourly wage rate = annual savings).*
- *Calculating financial performance without including these savings.*
- *Including these savings as a separate consideration in the decision making process. Like other real but less-quantifiable benefits of the project, this number can still figure prominently in the final decision (see Section 9).*

By relating qualitative information directly to core business objectives or other valid business concerns, this information may carry significant weight in the decision process, in spite of a lack of hard data. Many options may be justified on the basis of quite limited cost data, along with a formal assessment of qualitative considerations (see Section 9).

**Conducting a Preliminary Assessment at Precision Circuits Inc.**

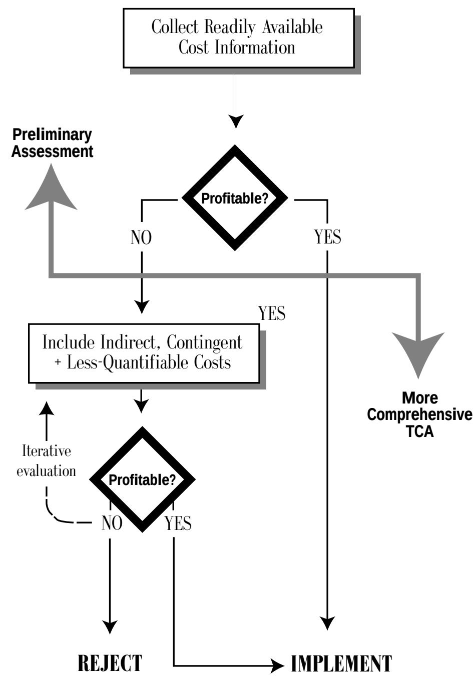
Precision Circuits also evaluated a P2 option that would eliminate the use of nitric acid as a stripping agent by replacing stainless steel racks with plastic coated racks. Under a conventional cost analysis, only the purchase price of the new racks and the savings associated with eliminating the purchase and subsequent disposal of nitric acid were included (i.e., no labour, paperwork, permitting or analytical costs were included). This approach suggested that the project would just begin to yield a positive return in its fifth year. In contrast, a TCA of this investment, discounted at 15%, shows a five-year net present value of $33,000. Combined with qualitative consideration of product quality improvements and employee health and safety benefits, the project was easily approved without a rigorous quantitative evaluation of contingent and less-quantifiable costs. The total time investment to collect the additional cost data was roughly twelve hours.

If the savings identified in the preliminary assessment process are not sufficient to justify the option, but you or your management team feel the option has merit, further effort to uncover indirect, contingent and less-quantifiable costs may be warranted (Figure 5-3). The same level of effort is not necessarily appropriate for every cost item. Consider each cost item individually and determine whether the item is significant enough to warrant further examination.


The specific challenges of finding and dealing with cost information vary by cost category. These are discussed in Section 6 (Finding Indirect Costs) and Section 7 (Assessing Contingent and Less-Quantifiable Costs).

**Caution!**
Preliminary assessment processes can be dangerous. It is not uncommon to drastically underestimate indirect, contingent or less-quantifiable costs. In fact, a persistent bias toward underestimating these costs was the driving force behind developing TCA in the first place. If you screen out too many alternatives too early in the process, you may miss significant potential savings. Note too, that you also run the risk of overlooking or underestimating additional *costs*, and too cursory a screening may result in adopting new processes that are, in fact, net losers. Nonetheless, a simplified preliminary assessment can save a tremendous amount of time and identify many clear P2 winners. Use it, but use it cautiously.

**FIGURE 5-3:**
**Iterative TCA Analysis**



# *Finding Indirect Costs*

FINDING INDIRECT COSTS

6

## 6.1 Cost Allocation

While some costs are easily found in accounting records, others are "hidden" in conventional cost accounting systems. This is particularly true for companies that have more than one product, process or facility, where conventional cost accounting can distort the relative costs of each.

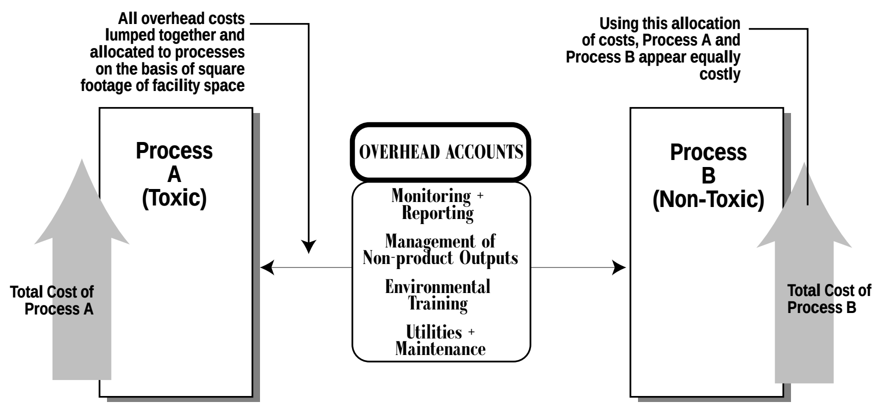
In conventional cost accounting, costs are traditionally categorized as either direct labour; direct materials, or overhead. Overhead often includes a wide range of costs that are particularly relevant to P2, 3R (recycle, reduce, or re-use) or pollution control options including:

- management of non-product outputs
- monitoring and reporting
- permits and fees
- labeling and documentation
- utilities and depreciation
- safety and response training
- cleaning and protective equipment
- taxes and insurance.

In conventional cost accounting, these costs are either not allocated to individual products, processes or facilities at all (i.e., they are left in overhead accounts), or they are lumped with several unrelated costs and allocated on the basis of some relatively arbitrary factor - such as production volume, square footage of facility space, labour hours or materials. This administratively-driven allocation of costs may bear little resemblance to where the money is really spent.

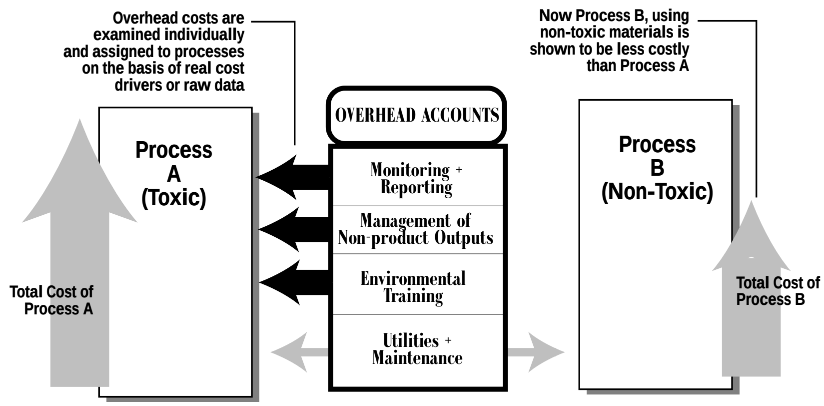
In Figure 6-1, Process A involves the use of toxic materials. Process B does not. The costs associated with monitoring and reporting, management of non-product outputs and environmental training are all incurred as a result of Process A. However, a misallocation occurs because these environmental costs are lumped together in an overhead cost pool and subsequently divided - along with utilities and building maintenance costs - on the basis of the square footage of the facility.

**Figure 6-1: Overhead Allocation Using A Conventional Cost Accounting Approach**




TCA requires that these lumped overhead costs be broken down and examined more discretely. By going back behind accounting records to the primary sources of data (purchase orders, work orders, etc. - see Table 6-1), a more accurate picture of the costs associated with particular products, processes or facilities can be drawn (Figure 6-2). Now, when evaluating alternatives to the existing process, you will have a better understanding of all the costs that are incurred by the firm as a result of Process A. If an alternative is found that eliminates or reduces the use of the toxic input, you will be able to find and count these avoided costs as savings attributable to the option. The process of crediting revenues from sale or use of by-products should be treated in a similar way.

**Figure 6-2: Overhead Allocation Using A TCA Approach**




Activity-Based Costing is a formal accounting method designed to allocate overhead costs to specific activities and ultimately to different product lines, processes or facilities[5]. However, it requires substantial changes to conventional accounting systems in order to automate the allocation process, and the costs and benefits of making these changes need to be carefully evaluated. TCA does not require an activity-based costing approach. TCA can be implemented without substantial changes to accounting systems, through less systemic, but more practical approaches. This will involve manually - and creatively - tracking down the data.

### 6.2 Tracking Down the Data

The process of tracking down the data will not be elegant. The first round will involve numerous phone calls (internally and externally), manual reviews of old business cases[6], new business cases, departmental budgets, work orders, purchase orders, maintenance logs and other similar sources.

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*5 For more information on Activity Based Costing see the references in Appendix D.*
*6 The term "business case" refers to a formal project justification. Some firms may use different terminology.*

*Sources of Data*

Some possible sources of information are shown in Table 6-1. For smaller businesses, the departmental locations and titles in Table 6-1 may not apply, but many of the formats will be similar (e.g. purchase orders, maintenance records, internal memos, internal studies, budgets, etc.).

*Allocating Indirect Costs*

By going back to the source (e.g., work order, purchase order, etc.), you will often be able to allocate costs precisely as they were incurred. For example, individual work orders may actually describe the quantity of a purchased input, the processes it was purchased for, and the allocation to each process. You may be able to obtain detailed records over the course of one or several years.

In other cases, you may find that previous business cases, internal memos or departmental budgets provide cost information at the level of detail you need. Project engineers preparing justifications for similar options may have already done your leg-work for you. However, check to make sure that your predecessor went back to the raw data or other reliable source to get the information.

In many cases, this information will not be readily available, and you will need to find a way to approximate a division of costs that most closely corresponds to the way costs are really incurred. Often materials or equipment tracking systems or inventories will help you do this. Table 6-2 provides some examples of indirect costs, their underlying drivers, and some measurement units that may be useful in allocating costs among products, processes or facilities.

### Table 6-1: Sources of Data

| Type of Cost | Internal | | External |
|---|---|---|---|
| | Location | Format | |
| **Direct Costs** (Equipment, materials, labour, supplies, salvage value, maintenance) | • Purchasing<br>• Individual Facilities<br>• Sponsoring Business Unit<br>• Accounting<br>• Project Management | • Work orders<br>• Invoices<br>• Project reports<br>• Existing failure reports<br>• Purchase orders<br>• Billing records<br>• General ledger | • Proposals<br>• Price lists |
| **Indirect or Indirect Costs** (permitting, monitoring, remediation, management of non-product outputs, taxes, training, insurance, closure, recycling) | • Sponsoring Business Unit/department<br>• Related Business Units<br>• Individual facilities<br>• Environmental Staff<br>• Accounting<br>• Legal Department<br>• Project Management | • Work orders<br>• Maintenance records, Existing failure reports<br>• Facility or departmental budgets and actuals<br>• Public relations budgets<br>• Operation log books | • Case/benchmarking studies within the same industry<br>• Case/benchmarking studies in different industries but with comparable issues<br>• Research institutions |
| **Contingent Costs** (fines, legal costs, property damage, personal injury, future compliance) | • Environmental Staff<br>• Legal Department<br>• System Operations | • Corporate risk assessments<br>• Failure reports<br>• Internal memos and Business cases<br>• Facility or departmental budgets and actuals | • Case/benchmarking studies<br>• Databases of failure information<br>• Original equipment manufacturer failure rates, IEEE databases<br>• Regulators |
| **Less-quantifiable Future Costs** (indirect revenue losses, reliability losses, negative image with customers, investors, staff, insurers, and regulators). | • All Business Units<br>• Corporate Comptroller<br>• Environmental Staff<br>• Legal Department | • Corporate policies, strategic plans and revenue projections<br>• Public relations budgets<br>• Previous judgements<br>• Internal studies | • Case/benchmarking studies of companies who have a track record of decisions in the face of high "image" costs.<br>• Industry associations<br>• Event studies of stock market reaction to environmental incidents |

## Table 6-2 : Measuring and Allocating Indirect Costs

| COST | UNDERLYING DRIVERS | MEASUREMENT UNITS |
|---|---|---|
| **Monitoring** | # of toxics, and/or # of processes using toxics | *Labour Costs* from monitoring, measured as # toxics x hours/toxic/year x $/hour |
| **Incident Reporting** | # of incidents | *Labour Costs* from reporting, measured as # incidents/year x hours/incident x $/hour |
| **Incident Clean-up** | # of incidents | *Labour Costs* from clean-up, measured as # incidents/year x hours/incident x $/hour; + *Equipment Costs*, measured as # incidents/year x machine-hours/incident x $/machine-hour; + *Materials Costs*, measured as # incidents/year x $/incident; + *Disposal Costs*, measured as # incidents/year x $/incident |
| **Safety Training** | # of training sessions | *Labour Costs* from conducting or taking training, measured as sessions/year x hours/session x $/hour |
| **Personal Protective Equipment** | # of employees | *Equipment Costs*, measured as # employees x $/employee |
| **Labelling** | # of containers shipped off-site | *Labour Cost*, from labelling, measured as # containers/year x hours/container x $/hour |
| **Permitting and Fees** | # of toxics on site, or tonnes discharged | *Labour Costs* from waste permitting, measured as no. of toxics x hours/chemical/ year x $/hour; + *Fees*, measured as $/chemical/ year or $/tonne/year |
| **Equipment Maintenance and Repair** | # of machines/equipment by equipment type | *Labour* Costs, measured in # machines x hours/machine/ year x $/hour; + *Spare Parts*, measured as $/part x parts/machine/year |
| **Management of Non-Product Outputs** | # of containers, or tonnes of residuals | *Contracting Costs* or *Tipping Fees*, measured as #containers x $/drum or $/tonne |




*Note: "hours/toxic/year" is hours per toxic per year, etc.*
*Adapted from NEWMOA (1994)*

# *Finding Indirect Costs*

In addition to these examples, there are many other possible ways to measure and allocate indirect costs. Choose a method that best reflects the way costs are really incurred in your facility. In some cases, you will want this information expressed on a *per unit* basis - e.g., dollars per spill, dollars per container, etc.. However, for most options, you will eventually want to translate unit costs into estimated *annual* costs.

*Automated Data Retrieval*

Some companies have automated maintenance management and accounting systems. You may be able to do some automated searching of these systems, but you should do so with caution. Often, they are simply not set up to collect or provide the information you need. Even some systems that are specifically designed to collect environmental costs will not necessarily collect the right information to feed the capital and operational budgeting processes (see inset on *Finding Missing Costs*).

| Incident | Captured in Environmental Expenditures Report | Not Captured in Environmental Expenditures Report | Grand Total |
|---|---|---|---|
| Stream Damage | $ - | $ 100,000 | $ 100,000 |
| Failed Weld | 13,072 | 30,650 | 43,722 |
| Ongoing Fluid Leaks | - | 198,242 | 198,242 |
| UST Leaks | 240,650 | - | 240,650 |
| Explosions | - | 23,698 | 23,698 |
| Stream Damage | - | 75,000 | 75,000 |
| Equipment Washing | - | 10,100 | 10,100 |
| Permit Compliance/ monitoring costs | 264,040 | 1,119,813 | 1,383,853 |
| Equipment Failure | - | 932,012 | 932,012 |
| Oil Recycling /Site Remediation | 127,324 | - | 127,324 |
| Equipment Failure | - | 128,939 | 128,939 |
| **Current Total** | **$ 645,086** | **$ 2,618,454** | **$ 3,263,540** |

**Finding Missing Costs at a Large Resource-Based Company in BC**

*At one BC Company an environmental expenditure report showed that the mitigation costs for a sample of incidents totalled about $600,000. However, deeper research into each incident revealed that the actual remediation and other indirect costs associated with these incidents totalled on the order of $3.2 million. If capital or operational budgeting decisions were made on the basis of the expenditure report alone, the benefits of P2 options aimed at these issues would be understated by $2.6 million.*

*Improving Data Over Time*

A second round of data collection may be needed to re-check the inputs with providers of data, accommodate new information or address inconsistencies that come to light as the analysis proceeds.

Along the way it is important to develop a framework that can easily accept cost data and keep track of it. Once you have a system in place, the conversion of "data" to "information" will become more efficient. The exact framework will vary depending on the issue or decision you are facing. An example of a simple framework for collecting data on site clean-up costs is shown in Table 6-3. This straightforward table accepts evidence of past clean-ups and computes the weighted-average which can then be used as the basis for an "expected clean-up cost" calculation[7]. You can adjust the weighting to de-emphasize events that are less relevant to the current decision. Alternatively, you can use the straight average, or the cost of any single event that is most comparable to the current decision.

**Table 6-3: Example of a Weighted Average "Cost of other Site Clean-ups"**

| **Remediation of Contaminated Sites** | Date | Weight | Cost of Clean-up |
|---|---|---|---|
| Site A | 1994 | 30% | $ ( 81,500) |
| Site B | 1996 | 30% | ( 5,000) |
| Site C | 1997 | 10% | (295,000) |
| Site D | 1995 | 30% | ( 10,600) |
| **Straight Average** | | | **$ ( 98,025)** |
| **Weighted Average** | | | **( 58,630)** |


*7 This is an example where data on contingent costs are hidden in the cost accounting system. For more detail on contingent costs, see Section 8.*

# *Finding Indirect Costs*


Rarely will a decision to either accept or reject an option close the issue forever. The changing risk and regulatory landscape mean that numbers (particularly for contingent costs) must be periodically updated, each quarter or year as appropriate. This information should provide on-going feedback to operational and capital budgeting processes and can be used to:

- update financial evaluations on options that have been delayed;
- assess the actual financial performance of implemented options (actions);
- decide whether to implement further initiatives or transfer resources elsewhere; or
- provide data for new but similar options.

TCA should not be abandoned because of imperfect cost information. The goal is to build better cost information over time. With good record keeping, each individual TCA that is conducted will lead to better systems of cost-tracking, and evaluating alternative investments or operating procedures will become easier and more accurate over time.

## Summary

Where relevant costs have been lumped into overhead cost pools, you may need to:

- manually re-check the data in automated accounting systems;
- go back to the sources of raw cost data (e.g., work orders, purchase orders, etc.) – this may tell you exactly how to divide pooled costs;
- find ways to allocate costs based on underlying drivers and meaningful measurement units;
- find cost data that was used in previous business cases or departmental budgets, but be careful in interpreting these – previous analyses may not have gone back to raw data sources;
- if raw data doesn't provide definitive information, interview engineering, maintenance and operational staff for judgements about how to allocate pooled costs; and
- set up simple tracking systems to record your findings and allow for new data to be added – this will improve the accessibility and accuracy of cost information over time.

# Assessing Contingent and Less-Quantifiable Costs

**7 ASSESSING CONTINGENT AND LESS-QUANTIFIABLE COSTS**

## 7.1 Understanding Contingent and Less-Quantifiable Costs

In some cases, changes in direct and indirect cash flows may be sufficient to justify a particular option. However, many options will have less certain or less-quantifiable costs and benefits that could greatly influence their attractiveness. This section summarizes some pragmatic techniques for identifying, characterizing, and evaluating contingent and less-quantifiable costs or benefits.

*Contingent costs* are broadly defined as any costs which are uncertain or subject to chance. These are sometimes also referred to as *liabilities*. However, in financial accounting, a liability tends to be narrowly defined as an obligation or stated intention to pay. Liabilities are generally recognized in financial statements only where the obligation has already been incurred and is both highly probable and reasonably estimable. Although some costs may be too uncertain to include in a financial statement, they should still be considered in forward-looking managerial decision making. The term contingent cost is used in these guidelines to refer to any uncertain future cost, regardless of its probability or estimability.

Contingent costs may arise from a variety of activities, but are most often related to the management (storage, handing, disposal, or discharge) of inputs, and non-product outputs. Less-quantifiable costs are most often strategic in nature, and related to customer relations, employee relations, corporate image, etc. Some examples of contingent and less-quantifiable costs are listed in Figure 5-2.

In many cases, there is not a clear distinction between contingent costs and less-quantifiable costs and benefits. Many less-quantifiable costs eventually give rise to either direct or contingent costs - e.g., poor public image may increase the likelihood regulators will enforce a regulation and levy the maximum penalty.

Furthermore, both contingent costs and less-quantifiable considerations are characterized by uncertainty about their exact nature, probability, timing, and magnitude. Nevertheless, they typically have a monetary value greater than zero and may be crucial to justifying your choice of options.

Most companies already recognize other uncertain costs in project evaluation. For example, many include blanket contingencies in large construction projects - sometimes as high as 30% — to account for additional costs they know will arise but which cannot be itemized or quantified exactly. The unique nature of environmental risks and liabilities does not lend itself to this simple approach. However, there are practical techniques for considering these issues in your decision making processes.

**Less-Quantifiable Costs Have Always Been an Important Part of Business Decision Making**

Pollution prevention decisions are no different from many other decisions facing most businesses today. Decisions to invest in market share (e.g., through loss leaders), acquire new businesses, develop new products and services, settle labour disputes, or enhance a corporation's image often cannot be justified entirely on the basis of simple financial measures. Financial performance is a key input to these decisions, but so is information on factors such as potential business risks, strategic positioning, and other less quantifiable costs or rewards.

### 7.2 Identifying Contingent Costs

There is no single correct method for assessing contingent costs. The purpose of this section is to provide a pragmatic approach that can be adapted to your particular decisions.

The most important step in the analysis of contingent costs is identifying those costs that may be prevented or reduced as a result of the option under study.

Here we are interested only in the incremental changes in contingent costs that may make a difference to the evaluation of the option.

For example, in the case of Precision Circuits (Section 4), changes in the wastewater treatment process reduced the number, volume and toxicity of treatment materials and wastes. This, in turn, could decrease potential contingent costs associated with spills during the storage and transportation of residuals (e.g., clean-up costs, production losses, and third-party liability), or exposure to higher managment costs arising from more stringent standards of care over time.[8]

The same process diagrams used to identify changes in direct or indirect costs also provides a useful starting point for identifying potential changes in contingent costs with various options. Some key questions to consider in identifying relevant contingent costs include:

- What are the inputs, and product and non-product outputs at each stage in the process?
- What are the specific management activities associated with each input and product and non-product output (e.g., storage, recycling, treatment, disposal, or discharge)?
- What are the pathways or events by which injury, damage or other contingent costs may arise from these inputs, and product and non-product outputs (e.g., management of spills, leaks, or fires)?

*8 These contingent costs were not actually quantified in this case since the direct and indirect cost savings were more than sufficient to justify the cost of wastewater treatment process changes. However, if assumptions about productivity improvements or up-front capital requirements change, the decision could become more sensitive to these contingent costs.*

- What and who could be affected - e.g., workers, company property, community members and their property, consumers of the product?

- Will the option prevent or reduce these potential contingent costs?

For very complex scenarios, this step may require the involvement of different professionals, including engineers, environmental scientists and lawyers. In particular, identification of some contingent costs requires an understanding of both current and probable future laws, standards, and conditions. However, many contingent costs can be adequately characterized in small firms simply by pooling the management and technical resources on-site.

You will also need to place some boundaries around your analysis, both in terms of the geographical scope and time frame for the contingent costs to be considered. For example, some externalities (see inset) may sometimes be included in the evaluation to assess your firm's exposure to potential changes in regulations (e.g., emission regulations or taxes) or to assess other strategic issues.

### 7.3 Characterizing Contingent Costs

After identifying the most relevant contingent costs, you will need to characterize and rank the potential reduction in risks. Specific questions include:

- What is the causal relationship between an uncertain event and the costs that are likely to be incurred as a result of it?

- How likely is the event giving rise to the contingent costs?

- What is the nature and magnitude of the potential consequences?

**Externalities**

An externality is any positive or negative effect associated with a firm's products, services, or activities that are borne by a third party or the environment, but for which a company is not accountable under existing laws, regulations, or standards. Although not the focus of TCA, some externalities may be included in the analysis as either contingent or less-quantifiable considerations. This may be justified if the corporation believes it could be held accountable for these costs at some future date, either through legal precedents, changes in regulations, shifts in consumer and community values, or new certification standards for products and suppliers. A proactive corporate policy may also support consideration of certain externalities in the analysis. This may be justified where the company hopes to gain an edge over their competition, similar to corporations that seek competitive advantage through continual innovation or quality improvements.

- How soon might a potential event or cost occur?

- Will the option significantly alter the nature or reduce the likelihood, magnitude or imminence of a particular contingency?

*Qualitative Approaches*

Where quantification of contingent costs is not possible or the probability and magnitude of risk reduction is highly subjective, qualitative approaches may be preferred over quantitative methods. However, even qualitative descriptions of risk can be expressed with some quantitative anchoring. There are several methods.

*Rating Schemes or Risk Reduction Factors*

The use of rating schemes or risk factors involves creating scales to characterize risks. For example, a scale can be applied to the likelihood of an event as follows:

| Risk Factor | Description |
|---|---|
| 1 | Not expected to occur in long term. |
| 2 | May occur once over the long term. |
| 3 | May occur several times over the long term |
| 4 | May occur more than once in a year. |

The second step is to construct a scale for the magnitude of consequences. Usually a different scale is developed for each *type* of consequence. For example, the following table shows risk factors for possible public safety consequences:

| Risk Factor | Description |
|---|---|
| 1 | No injury or health effects are expected. |
| 2 | Potentially minor injury/health effects. |
| 3 | Potentially moderate injury/health effects. |
| 4 | Death or severe illness is likely. |

By multiplying the "likelihood" rating with the "magnitude" rating, a total "risk factor" is calculated, both with and without the option. Additional scales can be developed for employee safety consequences, production consequences, mitigation costs, and others. They are commonly added to get a total risk factor. A "risk reduction factor", calculated as the difference between the risk factors of the existing system and the proposed option, and may include the potential benefit of implementing the option.

The difficulty with this method is that the selection of the scale (i.e., in this case, 1 to 4) and the range of likelihoods or consequences that fall within each numerical category (i.e., the "description") is entirely up to the judgment of the analyst and dramatically affects the outcome. Further, the practice of adding individual risk factors (for public safety, employee safety, mitigation costs, etc.) assumes that they are equally important - which may be a significant over-simplification. Decision makers, faced with a set of constructed risk factors, don't get an explicit picture of what the contingent costs really are. A more useful method for interpreting the implications of relative risks and contingent costs, is the use of critical value assessment[9].

*Critical Value Assessment*

Decision making is made simplest when risks are characterized in concise and explicit language. For example, it is more useful for decision makers to know that "without this project, a major spill is highly probable within the next five years, with a likely clean-up cost in excess of $1.0 million", than it is to know that the "risk reduction factor for the project is 1.2". Another explicit and useful way of framing risks is to know "how much would a spill have to cost before this project becomes attractive?"


The "critical value" of a contingent cost is the cost that would make the option financially attractive. It's a useful tool

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*9 Risk factors and other rating schemes may be useful for some applications in P2 planning and project prioritization, but for the evaluation of individual projects, other methods are preferred.*


when you know that a contingent cost exists, but are unable to estimate it.

To calculate the critical value, conduct the financial evaluation for TCA, excluding the contingent cost(s). The difference between the calculated NPV and an acceptable NPV (usually zero) is the critical value (see inset). You can also calculate a critical value using other financial indicators, such as the internal rate of return or payback. Experts and decision makers can then use judgment to assess whether the contingent cost is worth at least this amount.

The critical value will be sensitive to other assumptions in the analysis. So it may also be useful to calculate a range of critical values reflecting the sensitivity to changes in individual assumptions or entire sets of assumptions (scenarios). This is an important component of the decision making stage and is further discussed in Section 9.

**An Example of the Use of Critical Value Techniques**

Based only on direct and indirect costs and benefits, the NPV of an option turns out to be a loss of $10,000. However, the option is also expected to eliminate potential spills of hazardous waste. A spill would trigger environmental remediation requirements, including excavating and treating surface soils, which is very expensive. The NPV of any future spill must be greater than $10,000 in order for the option to make sense. This is the critical value of this contingent cost.

Only one spill has occurred in the past 5 years, but it cost nearly $50,000 to clean up. Assuming a 15% discount rate, a similar spill any time within the next 5 years would produce an NPV of greater than $25,000. As long as the probability of a similar spill is greater than 40% , the avoided contingent cost is at least $10,000 (0.4 X $25,000) and potentially as high as $20,000 (0.4 X $50,000) if the spill occurs immediately (see Expected Value calculations on page 53).

*Benchmarking*

Another useful technique for evaluating certain contingent costs or management responses is the use of benchmarks and other comparative studies with other firms. You may be able to compare your environmental risk exposure or certain types of prevention spending with competitors, industry leaders or industry associations. For example, proactive electric utilities have chosen to pursue all no- or low-cost options for reducing their greenhouse gases in an effort to reduce the chance of legal reduction requirements or to reduce their exposure to any future tax on carbon emissions. In some cases, utilities have even set a threshold such that they will approve any option that reduces carbon dioxide emissions for less than $2 per tonne, subject to annual capital constraints.

**The Effect of Major Events on Stock Price**

An emerging technique for assessing the impact on corporate performance of different risks and and options for risk reduction is to study the effect of public events or news on the stock price of a publicly traded company. Stock price reflects the market's assessment of firm value and its expected financial performance. Market theory suggests that all public information about a firm will be assessed, valued and reflected in its stock price. Thus, any sudden change in stock price following a specific event or piece of news can signal the market's valuation of impact on financial performance. Recent event studies have found significant negative returns associated with weak environmental performance as indicated by environmental crises (e.g., Klassen and McLaughlin 1996).

Simplified approaches to characterizing contingent costs are summarized in Figure 7-3. Regardless of the specific approach, the most important goal is to *describe the relevant contingent costs in a simple, explicit and intuitive fashion.* This will go a long way to helping decision makers with subjective trade-offs and may prove more useful than more advanced, and more complex, risk characterization frameworks.

**Figure 7-1 Summary of Simplified Approaches to Characterizing Contingent Costs**

| | |
|---|---|
| **Critical Value Analysis** | Calculate the value the avoided contingent cost(s) would have to be in order for the option to make financial sense. Decision makers can then decide subjectively whether the contingent cost is at least equal to this value. |
| **Rating Schemes / Risk Factors** | Assign numerical risk factors to qualitative descriptions of the likelihood and magnitude of consequences. Add these together, for a total risk factor, and count the difference between the risk factors of the base case and proposed option as the risk reduction factor. |
| **Benchmarking** | Compare the relevant risk exposures and management systems with other firms (e.g., competitors or industry) to provide a reference point for decision making. |

*Quantitative Approaches*

Ideally, risks should be characterized quantitatively whenever possible. To do this, you will need to:

- assign some probability to the events that may trigger a contingent cost;
- identify and assign a probability to each of the possible consequences of those events;
- attach a cost or range of costs to each potential consequence.

There are a variety of techniques available for assigning probabilities and costs to different consequences (Figure 7-2). Different approaches may be more relevant to different types of contingent costs.

7

### Figure 7-2 Approaches to quantifying Contingent Costs

| | |
|---|---|
| **Professional Judgment** | Consult engineers, scientists, lawyers and other experts for their professional opinion regarding the likelihood, timing and/or magnitude of contingent costs. |
| **Engineering Studies & Simulations** | Use equipment or process design parameters and simulation models to estimate the likelihood, timing or magnitude of events and associated contingent costs. |
| **Actuarial Methods** | Analyze historical data to determine the statistical probability, timing and/or magnitude of events and associated contingent costs. |
| **Case Studies** | Use studies of similar situations or events to provide anecdotal estimates of contingent costs. If multiple case studies are available, some average of observed costs may be used. This approach provides a useful reference point for decision making where there is insufficient data to compute statistical estimates (as in the actuarial method) or conduct simulation studies. |

The inset on *Demonstrating the Actuarial Method* (page 55) describes the use of the method to estimate a firm's liability of continuing to use PCB-filled transformers.

*Quantifying Verbal Expressions of Probability*

In the case of professional judgment, some people may use more qualitative expressions of probability. These can be translated into quantitative ranges of probability (Figure 7-3).

**Table 7-3 Rough Correspondence between Verbal Expressions of Probability and Numerical Values (Adapted From Boritz, 1990)**

| Expression | Average Probability (%) | Range (%) |
|---|---|---|
| **extremely remote** | <1 | 0 - 5 |
| **remote** | 10 | 0 - 25 |
| **slight** | 15 | 0 - 30 |
| **unlikely** | 20 | 5 - 35 |
| **possible** | 50 | 25 - 75 |
| **probable/likely** | 65 | 40 - 80 highly |
| **probable** | 85 | 70 - 100 |

*Calculating Expected Value*

Once you have estimated the probabilities and costs associated with different events and their consequences, you can compute an *expected value* for the magnitude of each contingent cost. This is simply the product of the probability of an event and its consequences. For example, if the probability of a spill is 40% and the financial consequences are $100,000 in remediation costs and lost production, the expected value of a spill is (0.4 X $100,000) or $40,000. Where there are several possible consequences, you will need to:

- attach probabilities and magnitudes to *each* consequence;
- calculate the cumulative probability of each consequence by multiplying the probability of the trigger event with the probability of each consequence, given the trigger event; and
- compute a weighted average of the expected value of the consequences.

From Figure 7-4, the expected value of a major fire is -

(probability of spill) x (probability that the spill will be major) x (consequences if the spill is major) +

(probability of spill) x (probability that the spill will be minor) x (consequences if the spill is minor)

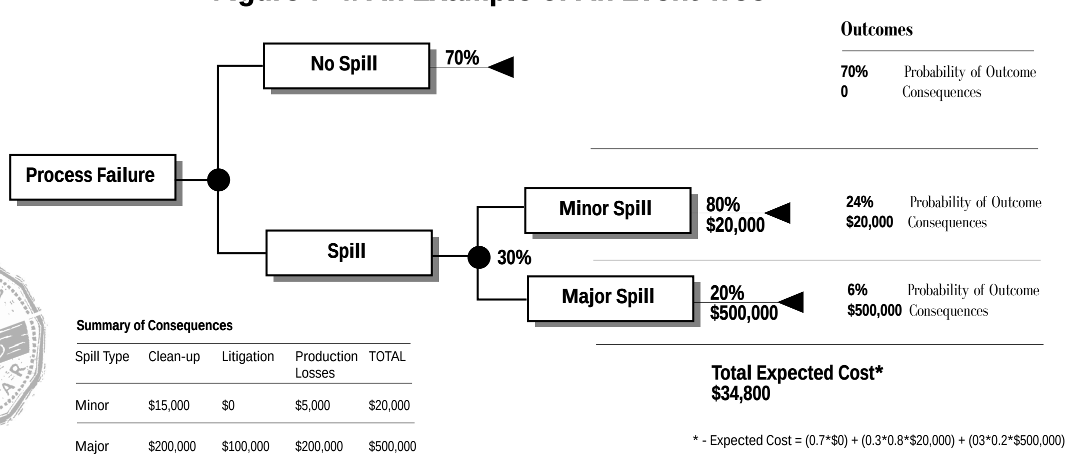
or;

(0.3 x 0.8 x $20,000) + (0.3 x 0.2 x $500,000) = $4,800 + $30,000 = $34,800.

**Drawing Event Trees**

Event trees are a useful tool for describing and calculating the expected value of multiple outcomes or consequences (Figure 7-4). A separate event tree is required for each unrelated event. For example, a spill and a fire are unrelated since the probability of a fire is not related to the occurance of a spill and vice versa. However, each tree should show all possible consequences resulting from the event[10].

## Figure 7-4: An Example of An Event Tree




**Summary of Consequences**

| Spill Type | Clean-up | Litigation | Production Losses | TOTAL |
|---|---|---|---|---|
| Minor | $15,000 | $0 | $5,000 | $20,000 |
| Major | $200,000 | $100,000 | $200,000 | $500,000 |


*10 These conditions are called mutually exclusive and collectively exhaustive respectively.*


**Demonstration of Actuarial Method for Assessing Contingent Costs**

*The Tellus Institute recently used an actuarial approach to evaluate the reduction in liability costs from an accelerated corporate-wide PCB transformer phase-out at a large U.S. manufacturing firm. The project involved replacing all PCB transformers in the company over a 5 year time frame versus an otherwise expected time frame of 30 years. A transformer fire or a transformer spill could give rise to a number of costs including clean-up, litigation, higher insurance, and production shut-downs.*

*The cost of either event is contingent upon the probability of that event and the probability and magnitude of each of these consequences. The probabilities of a transformer fire and spill were developed from historical databases (an actuarial approach) and were estimated at about 0.000018 and 0.0034 events per transformer-year, respectively. In other words, at a site with 1000 transformers, there will be on average 3.4 spills in any given year. An annual "expected" cost (i.e., $ / transformer / year) was calculated by multiplying the annual probability of each event and the various costs associated with it (see table below). Thus, although the costs of a fire are much higher than a spill, the expected cost of a fire is lower than a spill because of the probability of a fire is much smaller. For example,*

Clean-Up Costs = (Probability of Event) x (Cost of Clean-Up)
Clean-up Costs (Fire) = (0.000018) x ($7.8 million) = $140
Clean up Costs (Spill) = (0.0034) x ($100,000) = $339

Litigation costs involve two probabilities, as follows:

Litigation Costs = (Probability of Event) x (Probability of Litigation) x (Amount of Award)

*The calculation of shut down costs was more complex since it depends upon the probability of an event, the probable number of days of a shutdown, and the cost per day of lost production. Furthermore, production shutdowns may have* *secondary effects at downstream facilities if the output is an intermediate input at other plants. These secondary costs depend upon the number of facilities that are dependent upon the output and the inventory carried by each facility.*

| | Contingent Cost ($ / Transformer / Year) (Expected Value) | | Source(s) of Estimate |
|---|---|---|---|
| | Fire | Spill | |
| **Clean-Up** | $ 140 | $339 | • External & internal databases on PCB-transformer events. |
| **Litigation** | $ 68 | $ 3,213 | • External personal injury database for chemical exposure and industrial suits. |
| **Insurance*** | N/A | N/A | |
| **Shutdowns** | $10 | $1,560 | • Professional judgment. |
| **Total** | **$218** | **$ 5,112** | |

**Because the firm was self-insured, insurance costs were not considered in this analysis.*

*Each PCB transformer on site is, therefore, expected to cost the company a total of $5,330 each year. That is, this contingent cost reflects the firm's liability of continuing to use PCB-containing transformer units. The analysis suggests that it is worthwhile for the company to invest up to this amount on a program to accelerate the phase-out of PCB transformers.*

*Incorporating Contingent Costs into the Cash Flow Analysis*

If you quantify your contingent cost as an expected value (or range of expected values), you can incorporate it into your discounted cash flow analysis and ultimately your financial performance indicator. To do so, you will also need to assess its likely timing. For example, you can calculate the contingent cost of site reclamation but the cost won't be incurred until you close the site, which may be five (or twenty) years in the future. The cost should appear in your cash flow analysis in the year in which it is expected to occur. Contingent costs should, like any other cost item, be adjusted to ensure that they reflect after-tax dollars (see Section 8 for details on developing a discounted cash flow analysis).

In some cases, there will be an equal probability of incurring the contingent cost in every year. For example, in the accelerated PCB transformer change-out program described above, the probability of a spill or a fire is characterized as an annual probability per transformer. An annual expected contingent cost is calculated as the probability of the event times all of the relevant costs of that event. This expected cost can be included as a line item under the operating costs in your base (existing) case, and excluded or reduced as appropriate under the operating costs for the alternative option. A new NPV can then be computed for the incremental cash flows associated with the option.

Both the probability and real costs of some events may change over time, reflecting factors such as increasing equipment age or tighter standards. This can be addressed in your analysis either by manually changing the entries in each year of the cash flow analysis (e.g., by adjusting probabilities and consequences as appropriate and re-calculating an expected value for the contingent cost), or applying a reasonable escalation factor to the real (or nominal) values over the evaluation time frame (see Section 8).[11]

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*11 Where there is actually a range of probabilities and costs, Monte Carlo simulation techniques may provide a more accurate estimate of the contingent cost. Users may consult any advanced text on financial evaluation for a detailed description of these techniques.*

### 7.4 Assessing Less-Quantifiable Considerations

There are a variety of costs or benefits which may be more strategic and less-quantifiable in nature. However, these may also be essential to evaluating options. But what are the most relevant strategic or less-quantifiable considerations to include in the evaluation? The following questions provide a useful starting point for identifying relevant strategic values:

- Does your company have guidelines for the preparation of business cases that identify any non-financial or strategic evaluation criteria?

- Does your company have specific policies or guidelines for innovation, quality, environmental performance, community relations, or employee relations that may be used as a basis for measurement?

- Does your company subscribe to any industry standards or product certification protocols (e.g., emerging eco-labeling standards)?

- Does your company have a strategic plan? What are the strategic objectives and targets of your company?

- What are the strategic issues or broad societal trends facing your company or your industry?

Once you have identified a few critical strategic considerations, rank them according to their significance given the specific circumstances of the decision being made.

Many of these strategic considerations may be hard to monetize. However, they may still be characterized in some quantitative fashion.

For example, management had a stated objective to reduce the use and generation of hazardous materials and wastes by 50%. It should be possible to measure the contribution of each option or set of options to this goal, even if the financial impact of the goal cannot be estimated. In some cases, a strategic consideration may be characterized in a simple yes / no answer. For example, "Does the process or product meet standards for certification of the firm or its products under a new labeling system?". Some strategic objectives may reflect specific constraints that management has already determined must be met. Finally, historical comparisons, benchmarks, and case studies may provide useful information for characterizing a strategic consideration.

Again, critical value analysis can provide a useful technique for helping decision makers understand the minimum value they would have to place on the relevant strategic values to make a particular option attractive. As with contingent costs, simple and intuitive characterization of strategic considerations is an essential aid to decision making.

**Caution!** In all cases, it is essential to screen all of the strategic considerations to ensure there is no "double-counting" with costs and benefits already addressed in earlier analyses. For example, reduced regulatory oversight should not be highlighted as a strategic benefit if the dollar costs of regulation or benefits of regulatory efficiency have already been included in direct or indirect costs and benefits. Similarly, increased market share should not be included here if product prices and sales were already accounted for in determining the expected financial performance of the option.


CANADA
DOLLAR

# *Analyzing Financial Performance*


**Analyzing Financial Performance**

8

Once the cost information for an investment or operating decision has been assembled, an analysis of financial performance can be conducted. In some cases, you may choose to do this analysis after a preliminary assessment of costs has been completed based on readily available information (see Section 5.3). In other cases, you may have thoroughly investigated all relevant costs and have a wide range of direct, indirect and contingent costs that can be included in the analysis.

In either case, analyzing financial performance under TCA consists of four major steps:

1) estimating incremental cash flow – that is, the difference between the cash flow under the option and the cash flow under existing (base case) conditions;

2) calculating financial indicators that account for the time value of money;

3) interpreting financial indicators and the implications for profitability;

4) conducting sensitivity analysis to test how changes in assumptions (about discount rates and other factors) affect projections of financial performance.

The material included in this section can act as a guide to conducting standalone analyses of options, or as a complement to the P2/FINANCE software developed by BC Environment as part of "The P2 Tool Kit." Readers wishing a more in-depth treatment of the issues can refer to Appendix B, and to any text on financial analysis.

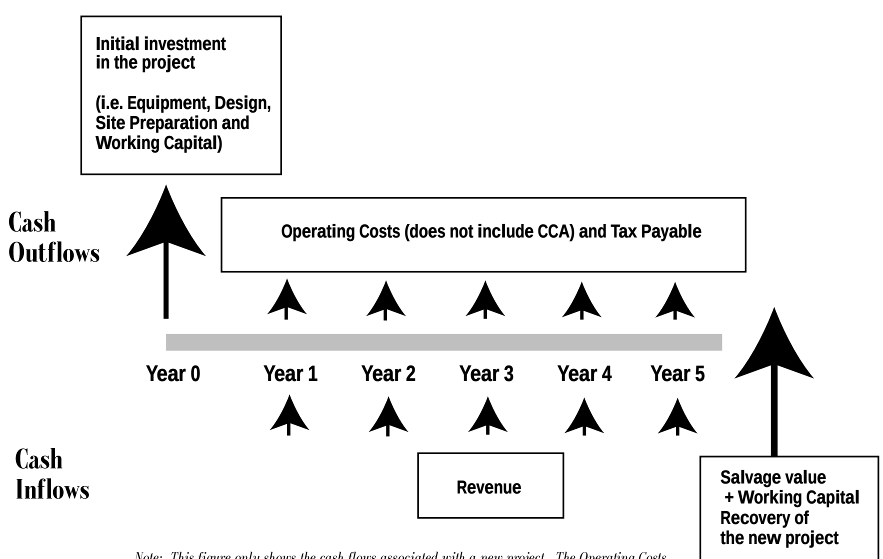
## 8.1 Estimating Incremental Cash Flow

### 8.1.1 Overview

In order to incorporate all of the costs and savings over time, TCA uses an incremental cash flow approach (Figure 8-1). Cash outflows are the expenditures (or costs) incurred to implement an option over its full commercial life. Cash inflows are the receipts that result from implementing the option, also over its full commercial life. The total cash flow in any given year is simply the difference between cash outflows and cash inflows[12].

In Figure 8-1, the concept of cash flow is illustrated for an option with a commercial life of five years. Outflows are shown at the top. Some outflows are up-front costs which occur at Year 0, while others are on-going operational or maintenance costs, which occur during Years 1 to 5. Across the bottom are some examples of inflows. Again, some occur at the beginning, while others occur during Years 1 to 5, and still others occur at the end of the option's commercial life.

**Figure 8-1: Illustration of the Concept of Cash Flow**




*Note: This figure only shows the cash flows associated with a new project. The Operating Costs, Salvage Value/Working Capital Recovery[13] and Revenues associated with the existing process would need to be subtracted from this to arrive at incremental cash flow. This is discussed below.*

The concept of *incremental* cash flow is relevant when comparing an existing situation (base case) and an option. In this case it is the *difference* between the cash flows under each scenario (existing and proposed) that is important. The *incremental* cash flow is simply the projected cash flow (i.e. with the option) minus the current cash flow (i.e. with the base case). The financial analysis of an option relative to an existing process or situation is based on this incremental cash flow. The calculation is shown in Figure 8-2.

**Figure 8-2 Calculating Incremental Cash Flow**

In any given year, the incremental cash flow associated with a project is calculated as –

**Net Cash Inflows** *minus* **Net Cash Outflows**

*Where Net Cash Inflows* =
(cash inflows **with** option) – (cash inflows **without** option)

*And Net Cash Outflows* =
(cash outflows **with** option) – (cash outflows **without** option)

*12 Cash flow is distinct from accounting income because accounting income may sometimes include non-cash items such as capital cost allowance (CCA). CCA is the maximum rate of depreciation that is permitted for tax purposes. For treatment of CCA, see Section 8.1.4.*

*13 Note that Salvage Value and Working Capital Recovery of the existing process would occur in Year 0.*

## An Example of Incremental Cash Flow Analysis

8

*The incremental cash flow analysis from Precision Circuits' plastic-coated rack investment is shown in Figure 8-3. This example shows an initial outflow of $22,522 in Year 0 (due to the initial investment). In this case, no actual inflows (e.g., revenues, working capital recovery, salvage value, etc.) resulted from the option. However, the option reduced the operating costs of the existing process, and as a result, net cash outflows (outflows with the option minus outflows without the option) are negative. So in Year 1, the incremental cash flow is:*

| Net Inflows (Year 1) – | Net Outflows (Year 1) | = Incremental Cash Flow (Year 1) |
|---|---|---|
| **0** | **– ($22,216) + $7,085** | **= $15,132** |

A positive cash flow means that the option yields net savings.

### Figure 8-3 Incremental Cash flow Analysis of the Plastic-Coated Rack Investment

| | Yr 0 | Yr 1 | Yr 2 | Yr 3 | Yr 4 | Yr 5 |
|---|---|---|---|---|---|---|
| **Cash Flow Calculation** | | | | | | |
| Revenues | $ - | $ - | $ - | $ - | $ - | $ - |
| Working Capital Recovery | $ - | $ - | $ - | $ - | | |
| Salvage Value | $ - | $ - | $ - | $ - | | |
| | $ - | $ - | $ - | $ - | $ - | $ - |
| less: | | | | | | |
| Operating Costs | $ - | $ (22,216) | $ (23,684) | $ (25,243) | $ (26,898) | $ (28,657) |
| Total Tax | $ - | $ 7,085 | $ 7,672 | $ 8,295 | $ 8,957 | $ 9,661 |
| Initial Investment Costs (Sum of) | $ 22,522 | | | | | |
| | $ 22,522 | $ (15,132) | $ (16,012) | $ (16,947) | $ (17,941) | $ (18,996) |
| After-Tax Cash Flow | $ (22,522) | $ 15,132 | $ 16,012 | $ 16,947 | $ 17,941 | $ 18,996 |

*Notes:*

1. *Savings were estimated for each year over the life of the project. Only five years are shown here because of space limitations.*
2. *Details of underlying cost information can be found in Appendix A.*
3. *Brackets denote negative values.*

**Cash Flow Analysis Essentials**

*Investigate, understand and record cash flows for both the existing (base case) process and the P2 option.* If you do not articulate the cost implications of the existing process clearly, you may miss significant cost savings associated with the option.

*Forget sunk costs.* Sunk costs are those that cannot be affected by the decision to reject or accept an option. For example, $100,000 that has been paid for existing equipment is sunk and not relevant. However, salvage value - the market value of equipment at the end of its useful life - is relevant and must be included.

*Include opportunity costs.* Even if no cash changes hands, all resources (e.g. land) have an opportunity cost if they can be sold or put to another use. The opportunity cost is the value of the resource in its next best use. For example, if a parcel of land could be sold for $100,000 but is instead used for a settling pond, the opportunity cost is $100,000. If the settling pond is part of an existing process and will no longer be needed with the proposed option, then this item should be included in the salvage value of the existing process.

*Estimate inflows and outflows for the commercial life of the option, not the physical life of the equipment.* The commercial life of the option is the period over which the equipment is expected to be used by the company. For example, a piece of equipment may have a physical life of 20 years, but the company may expect to salvage it after five years due to an expected product change. In this case the commercial life of the option is five years.

### 8.1.2 A Description of Some Common Cash Outflow Items

*Initial Investment Costs*

This includes items such as equipment, utility connections, installation, materials, site preparation, planning and engineering (see Figure 5-1 for a full inventory). From a cash flow perspective, these costs will generally occur in Year 0. However, there may also be cases where a portion of the investment must be made in stages. In these cases, the costs that occur in later years should be allocated to the appropriate year in the analysis.

*Working Capital Requirements*

Working capital is comprised of a balance of cash, accounts receivable, accounts payable, and inventories that must be carried during the project. This item should be included in the estimate of the option's up-front costs as it is generally incurred in Year 0. It will be recovered again at the end of the option but this is discussed below as a Working Capital Recovery under "Inflows".

*Operating Costs*

Included here are direct, indirect and contingent cost items such as materials, waste management, utilities, monitoring, insurance, fines and production shutdowns (see Figures 5-1 and 5-2). Rarely will these items occur as constant annual flows. For this reason it is easier (and more accurate) to allocate them over time as they occur.

Note that by subtracting the operating costs of the option from the operating costs of the existing process, you will find the incremental savings associated with the option. Thus you do not need to address these savings as a separate cash flow item on the inflow side.

*Corporate Income Tax*

Cash flow analysis must always deal in "after-tax" cash flows. This is particularly true for P2 analyses because a P2 option may be eligible for tax incentives that affect the corporation's tax payable.

Tax payable can be recorded as a separate cash-flow item, and then subtracted (along with operating costs and initial investment costs) from cash inflow items such as revenues, working capital recoveries and salvage value to arrive at the after-tax cash flow. This is shown in Figure 8-3 and is the method used in the P2/Finance software[14].

To calculate tax payable, multiply the corporate income tax rate by the taxable income. Most organizations use a standard marginal corporate income tax rate. Table 8-1 offers a few simple examples for how to combine underlying rates. The underlying corporate income tax rates for 1997 are provided in the Appendix B[15].

### Table 8-1: A FEW SUGGESTIONS FOR PICKING A RATE

| Circumstances | Suggestion |
|---|---|
| A large public corporation that has taxes payable most years. | 45.62% (29.12 plus 16.50) |
| A small Canadian Controlled Private Corporation with less than $200,000 in taxable income. | 22.12% (13.12% plus 9%) |
| A large public corporation that has taxes payable most years but the P2 option is eligible for Manufacturing & Processing Deductions. | 38.62% (22.12% plus16.5%) |

### 8.1.3 A Description of Some Common Cash Inflow Items

*Revenues*

Any change in revenues, including increased market share, the sale of marketable by-products and the sale of recyclables should be included. From a timing perspective, these are likely be low or non-existent in the early years and build gradually over time.

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*14 Some methods do not add a separate line item for tax payable. Instead, they simply multiply the incremental operating cash flow by 1 minus the corporate income tax rate to arrive at the after tax cash flow. Either method will lead to the correct answer.*
*15 Note that some companies may use a different* effective *corporate income tax rate. An effective rate considers the fact that large unused CCA balances or expected losses could reduce tax payable to zero.*

*Salvage Value*

Salvage value is the market value of equipment at the end of its useful life in its current use (i.e., the amount you can sell it for). Salvage values for the *existing process* are realized when the option is implemented, while salvage values associated with the option occur at the end of its commercial life. Therefore there will generally be two items to be recorded for this line item.

*Working Capital Recovery*

Working capital recovery is the cash inflow that arises when the balance of cash, accounts receivable and accounts payable that had been tied up becomes available for another use. As with salvage value, working capital recoveries associated with the existing process would occur when the option is implemented while working capital recoveries associated with the option would occur at the end of its life[16].

*Other Tax and Funding Issues*

P2 options may be eligible for a number of special funding programs (e.g., the Industrial Research Assistance Program) and tax credits (e.g., Scientific Research and Experimental Development Investment Tax Credits). These and other tax-related issues and their implications for cash flow analysis are discussed in Appendix B.

### 8.1.4 Capital Cost Allowance (CCA)


For tax purposes, the initial investment in an option is not deducted from income in a single year. Rather it is "capitalized" and a fraction of the capitalized value is deducted from income in a given year. This process is referred to as depreciation and the maximum rate of depreciation that is permitted for tax purposes is

*16 Note that working capital, as it is recovered at the end of the option, is not subject to CCA.*

referred to as the Capital Cost Allowance.[17] Each asset belongs to a particular "CCA Class" that determines the percentage that may be deducted each year for tax purposes.

CCA is not itself a cash flow item, but it does indirectly affect some cash flow items (see Tax Issues in Appendix B).

Accelerated Capital Cost Allowance (ACCA) is a special CCA provision (class 24 or 27) that allows pollution control equipment to be depreciated at an accelerated rate. Following successful application to Environment Canada, equipment may be written off in 3 years (25% in the first year, 50% in the second year and 25% in the third year).

For further background on basic CCA concepts, eligibility for the Accelerated Capital Cost Allowance provision, and an example of the calculation of ACCA refer to Appendix B.

**8.2 Calculating Financial Indicators**

Once an option's incremental cash flow has been recorded, the financial performance of the option can be calculated. True measures of profitability account for the time value of money, which is simply a way of saying that a sum of money today is worth more than the same sum received in the future because it could be invested today and earn a return over time.

Financial indicators that account for the time value of money include Net Present Value (NPV), Internal Rate of Return (IRR) and Discounted Payback (DP)[18]. Table 8-2 provides a summary

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*17 In most cases CCA is calculated on a "Declining Balance" basis, where CCA is calculated as a percentage of the remaining "Undepreciated Capital Cost" (UCC) of the assets in a given class. In a few cases CCA is computed on a "Straight Line Basis", where CCA is calculated as a percentage of the original investment. Some examples and further detail are provided in Appendix B.*

*18 Some companies also use a* Profitability or Benefit/Cost Ratio. *Depending on the company, this ratio may be calculated as the present value of the net-benefits divided by the initial investment in Year 0, or it may be the ratio of all cash inflows divided by all cash outflows. This can cause confusion and, in complex cases, the ratio will generally not serve its intended purpose (which is to rank projects in the face of a capital constraint).*

of these indicators and the key benefits and drawbacks of each. These are the same indicators that are used in the P2/FINANCE software.

**Table 8-2: Financial Indicators**

| | DEFINITION | BENEFITS | DRAWBACKS |
|---|---|---|---|
| NET PRESENT VALUE (NPV) *IF NPV > 0, ACCEPT* *IF NPV < 0, REJECT* | The present value (PV) of a future cash flow stream minus the PV of the original investment. | Provides the most direct and consistent indication of the value of the project to the shareholder | None (relative to other indicators). |
| INTERNAL RATE OF RETURN (IRR) *IF IRR > HURDLE RATE[19], ACCEPT* *IF IRR < HURDLE RATE, REJECT* | IRR is the discount rate that would cause the given cash flow to yield an NPV of 0. | Can compare IRR of a given project whose cost of capital is relatively uncertain against a known "hurdle rate". | Can return more than one answer if cash flow swings back and forth from positive to negative over the years |
| DISCOUNTED PAYBACK (DP) *ALL ELSE BEING EQUAL, SHORTER PAYBACK IS PREFERRED* | Determines the number of years it takes to recover the original investment. | For two projects of equal NPV, some decision-makers might prefer the one that provides the quicker payback | Gives no indication of the scale. Can also yield more than one answer if project involves lumpy investments over the years |

The use of Net Present Value and Discounted Payback require that a discount rate be used to translate future cash flows into today's value.

### 8.2.1 Choosing a Discount Rate

The discount rate should reflect the rate of interest or return that the company could earn on an investment of similar risk. This is also referred to as the opportunity cost of capital.

Larger companies should consult their finance department for a recommended rate. For companies that wish to estimate their own discount rate, a reasonably straightforward approach is to use the "Adjusted Cost of Capital" formula. This eliminates the need to account separately for interest tax shields. The formula for this and a discussion of interest tax shields is included in Appendix B.

*19 Many companies have an established rate of return that projects must meet or exceed before they are approved. This is referred to as the hurdle rate.*

Small businesses that do not wish to estimate their own discount rate can assume that the adjusted cost of capital is in the range of 10% to 15% (real)[20].

Whichever rate is used, you should clearly state the assumptions that went into choosing the discount rate and perform a sensitivity analysis to see how sensitive the profitability of the option is to changes in the discount rate (see Section 8.4). If the option is very sensitive to your choice of discount rate, you may want to spend more time ensuring that the rate you have chosen accurately reflects your cost of capital and the risk of the investment.

**Be consistent with inflation.** Be sure to discount real cash flows at a real discount rate and nominal cash flows at a nominal discount rate.[21] This is the source of many errors in NPV analysis. It is usually best to conduct the analysis in real terms because it allows you tell at a glance which cost items are increasing or decreasing in real terms and which are simply keeping pace with inflation.

### 8.2.2 Calculating Net Present Value (NPV)

Net Present Value is most important financial indicator because it provides the best representation of the true profitability of an option. Some firms may be more familiar with Internal Rate of Return or Discounted Payback. There is no reason to stop using these indicators, but you should augment them with a calculation of NPV. Conducting parallel calculations will help you familiarize yourself with NPV and how to interpret it. However, be aware that

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*20 See Appendix B for converting from real to nominal discount rates and back again.*
*21 If a project is evaluated in real terms, a $1000 annual cost that is expected to remain constant with the exception of inflation, is expressed as $1000 in each year and the stream is discounted at a real discount rate that does not include inflation. If the project is evaluated in nominal terms, the same $1000 annual cost is shown to rise each year with inflation and the stream is discounted at a nominal discount rate (real discount rate adjusted for inflation). As long as inflation is treated consistently, either approach will lead to the same answer, but an analysis performed in real terms will generally be more transparent.*

some options may look profitable under IRR or DP and unprofitable under NPV (or vice versa). In these cases, NPV is the more reliable indicator.

A simple example of an NPV calculation is the following:

| | | |
|---|---|---|
| **Cash Outflow in Year 0** | = | - $100 |
| **Cash Inflow in Year 1** | = | $100 |
| **Discount rate** | = | 10% |
| **NPV** | = | $- \$100 + \$100/(1+.1)^1 =$ |
| | | $- \$100 + 90.91 = - \$9.09$ |

Figure 8-3 shows an NPV calculation as computed using a spreadsheet. Line A shows the years in the life of the option, line B shows the corresponding formula (expressed using spreadsheet conventions where the "^" indicates that the number following it is an exponent) and line C shows the discount factor that results from calculating the formula in Line B. Line D is the cash flow (expressed in real terms) and Line E is the discounted cash flow.

Figure 8-3: An Example of an NPV Calculation

Sample NPV Calculation — 12% real

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | Year | | 0 | 1 | 2 | 3 | 4 | 5 |
| B | Formula | | =1/(1+.12)^0 | =1/(1+.12)^1 | =1/(1+.12)^2 | =1/(1+.12)^3 | =1/(1+.12)^4 | =1/(1+.12)^5 |
| C | Discount Factor | (result of line B) | 1.00 | 0.89 | 0.80 | 0.71 | 0.64 | 0.57 |
| D | Cash Flow | (sample input) | $ (10,000) | 5000 | 5000 | 5000 | 5000 | 5000 |
| E | Discounted Cash Flow | (C x D) | $ (10,000) | $ 4,464 | $ 3,986 | $ 3,559 | $ 3,178 | $ 2,837 |
| F | NPV | (sum of row E) | $ 8,024 | | | | | |

The Net Present Value is the sum of the items in Line E.

### 8.2.3 Calculating Internal Rate of Return (IRR)

**Internal Rate of Return (IRR)** can be computed by repeatedly testing values of the discount rate until the NPV of the option is zero. This involves substituting a new value into an NPV calculation and computing NPV. If the NPV comes out positive, a higher discount rate must be substituted in the calculation. If the NPV comes out negative, a lower discount rate must be substituted.

This process is repeated until the NPV computation equals zero. The rate that sets the NPV to zero is the IRR.

This calculation is best computed using the IRR function that is built into most spreadsheet packages.

### 8.2.4 Calculating Payback

Payback calculates the break-even point for the option – that is, when the cumulative savings pay back the initial capital investment. As an indicator of profitability, it provides very limited information, because it doesn't consider any savings that occur after the break-even point. It will tend to favour options with quick returns over more long-term options that are in fact more profitable.

**Discounted Payback** is computed by summing the discounted cash flow cumulatively, starting in Year 0. The year in which the cumulative cash flow turns positive represents the Payback year.[22] This computation can be seen in the case study in Appendix A.

**Simple Payback** is the simplest technique for evaluating financial performance. It is calculated by summing the *non-discounted* cash flows until the cumulative cash flow turns positive. It is the least useful indicator in terms of understanding profitability, because it doesn't consider the time value of money.

> **Which indicator is best?**
> NPV is widely considered to be the best and most consistent indicator of the value of an option. IRR and Discounted Payback can sometimes yield ambiguous results with respect to profitability and should never be used independently. However, when combined with NPV, they can provide a number of useful insights. The use of Simple Payback should be avoided.

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*22 Subject to limitations regarding multiple changes in signs (+/-) of the cash flows.*

## 8.3 Interpreting Financial Indicators

A positive Net Present Value (NPV) (assuming it has been computed correctly) indicates that the sum of the discounted cash inflows exceeds the sum of discounted cash outflows. Because these flows are discounted at a rate that reflects what the company would have earned in another investment of similar risk, the company can be confident that they are better off investing in the option if NPV is positive. A negative NPV indicates that they are better off *not* investing in the project. (This conclusion does not include consideration of less-quantifiable factors that are not included in the NPV calculation, but nonetheless affect overall profitability. These are discussed further in Section 9 “Making the Decision”.)

The Internal Rate of Return (IRR) can be compared against a rate the company has determined as being reasonable for projects of similar risk.[23] If the IRR is much higher than the rate that the company has determined would be reasonable, then the option should proceed (subject to the qualifiers mentioned in Table 8-2).

Discounted Payback indicates the number of years it would take to recover the initial investment. All else being equal, a shorter payback is preferred to a longer payback. This is a popular measure because of its ease of use, but it must be used cautiously to avoid passing up longer term options that are in fact more profitable.

Refer to the case study in Appendix A for an applied discussion on interpreting indicators.

## 8.4 Conducting Sensitivity Analysis


Because many of the inputs to the calculation of financial performance may be uncertain, it is essential that sensitivity analysis be conducted to test the performance of an option under various assumptions. This can be done by varying individual

*23 This rate is referred to as the hurdle rate.*

variables such as a particular cash flow item, or the discount rate. Or it can take the form of Scenario Analysis where multiple variables are changed at once in order to test the combined impact of changing assumptions. Both approaches should be used because they yield different (but complementary) insights. Refer to the discussion of sensitivity in the case study in Appendix A for further discussion.

# *Making the Decision*


**MAKING THE DECISION**

9

When all of the costs and benefits of an option can be reduced to straight-forward dollar values, financial indicators can be used to screen, rank and select candidate options. However, where a decision involves less certain, hard-to-quantify or hard-to-compare costs and benefits,[24] senior managers may be required to make more subjective trade-offs among both financial and non-financial criteria.

### 9.1 Structuring the Relevant Information

The most important task at this stage is to identify and characterize the trade-offs among different decision criteria. A useful framework for characterizing decisions with multiple dimensions and trade-offs is a Multiple Account (MA) table[25].

An MA table presents decision criteria in the first column, and management alternatives (options) in the first row (Table 9-1). The performance of each alternative with respect to each criterion is shown in the cells of the table. These are the indicators (e.g., net present value, tonnes of emissions, etc.). It is important to limit the presentation to the most relevant decision criteria by grouping together those that can be reduced to a single combined measure (such as dollars, tonnes of emissions, health and safety effects, etc.). Other essential criteria may be those that require subjective judgment on the part of the manager, engineer or other individual(s) who will be making the decision.

In some cases, the performance of an alternative may be measured in dollar terms. In others, it may be more appropriate to use physical units or scales to characterize qualitative impacts. Each indicator may reflect either the mean performance or a range of expected performance.

*24 For example, although contingent costs may be reduced to a financial value and reflected in the financial indicators, it may still be useful to present the underlying assumptions about contingent costs to allow decision makers to see explicitly their effect on profitability.*
*25 Often called a Multiple Account Evaluation (MAE).*

The value of the MA format is that it helps to identify key trade-offs, either within a single alternative or among several alternatives. The decision maker can quickly see trade-offs between expected returns, other forms of risk, and strategic costs or benefits. The MA table can also highlight options that do not meet critical constraints (e.g., operating or emission standards) or that perform poorly across multiple dimensions, relative to other potential options.

Uncertainty can be reflected in the presentation through a variety of different approaches:

- Appropriate ranges can be provided for some attributes instead of point estimates.

- The results of sensitivity analyses can be shown as separate line items.

- "Critical values" can be calculated for non-financial attributes and shown in brackets or separate line items.

- The results of scenario analyses can be presented as separate columns showing the performance of each alternative against each decision criterion and under different scenarios separately (as in Figure 9-3).

### Table 9-1 Sample Multiple Account Table

| Categories of Evaluation Criteria | Base Case | Alternative 1 | Alternative 2 |
|---|---|---|---|
| **Profitability** (Direct and Indirect Costs) | | Trade-Offs Among Options → | |
| **Monetized Contingent Costs** | ↓ | | |
| **Expected Profitability** (Including Contingent Costs) | Trade-Offs within Options | | |
| **Other Contigent Costs** | | | |
| **Other Strategic Considerations** | | | |
| **Critical Value of Non-Financial Criteria** | | | |

**9.2 Assessing Portfolios of Options**

For firms that are evaluating multiple options that are not mutually exclusive, it may be useful to apply TCA to a group or portfolio of options so as to capture cost or other strategic interactions among them.

For example, consider a situation where you have four different P2 options. Two involve mutually exclusive changes in an upstream production process (R1 and R2) and two involve mutually exclusive changes in a downstream production process (S1 and S2). Assume you evaluate each option separately and discover NPV's as follows:

| | R1 | R2 | S1 | S2 |
|---|---|---|---|---|
| **NPV** | $10,000 | $15,000 | $35,000 | $25,000 |

At first glance, it would appear that options R2 and S1 would provide the highest combined NPV. However, further evaluation reveals cost synergies (i.e., materials and labour savings from joint implementation or operation) between options R1 and S2 that produce larger combined savings than if implemented individually. In terms of combined labour and operating savings, you may find that NPV's are as follows:

| | R1 & S1 | R1 & S2 | R2 & S1 | R2 & S2 |
|---|---|---|---|---|
| **NPV** | $45,000 | $55,000* | $40,000 | $40,000 |

** Higher combined NPV from cost synergies achieved through joint implementation.*

This highlights the value of examining potential cost synergies that may occur through joint or staged implementation of several related options.

## 9.3 Conducting Sensitivity and Scenario Analyses

As an aid to decision making, it is often useful to conduct sensitivity analyses on key assumptions or to develop scenarios reflecting simultaneous (and plausible) changes in multiple assumptions. Examples of key assumptions may include discount rates, future regulations, discharge fees, permit costs, and revenue streams. Sensitivity and scenario analysis help to identify options that are profitable under a range of assumptions, and to highlight assumptions or uncertainties that greatly influence the attractiveness of an option. With the aid of this analysis, decision makers can quickly focus on key assumptions and trade-offs.

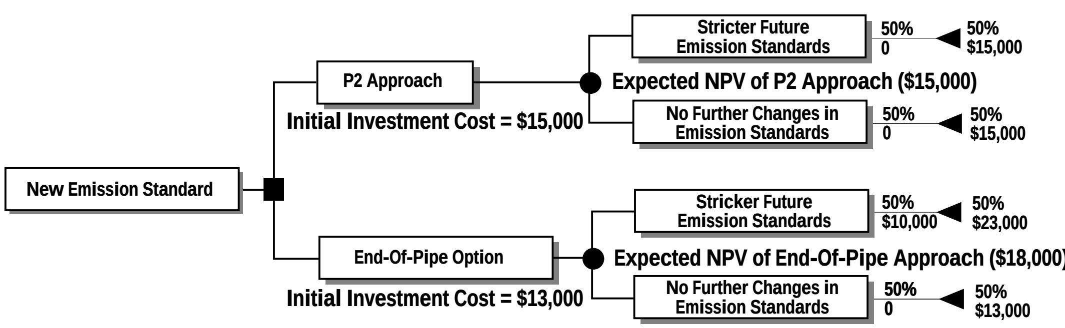
A few scenarios are generally sufficient to bracket a wide range of possibilities, represent diverse views and challenge managerial thinking. Scenarios can also be useful for communications, providing a systematic tool to think and talk about the future. The results of both sensitivity and scenario analyses can be summarized in the MA table either in a separate row (identifying the main change associated with a given change in assumptions) or as separate columns showing the changes in each attribute for different options.

## 9.4 Sequencing and Other Issues

Budgets and human resources may place constraints on the number of options that you can pursue at any given time. Options will have to be sequenced subject to these constraints. In addition, there may be inherent value in staged implementation to allow easy adaptation to new information and circumstances. For example, some options may be more adaptable to future changes in regulations than others.

*Decision trees* are a convenient tool for assessing the effect of simple sequencing decisions or less certain future events on the net benefits generated by different options. For example, Figure 9-3 shows a company facing a decision regarding the most appropriate response to a new emission standard. One option involves a lower cost end-of-pipe treatment while the other is a higher cost P2 option. On the surface, the decision seems simple - the end-of-pipe option meets the new emission standard and for a lower *up-front* cost. However, there is a reasonably high probability that the government will tighten the emission standard within two years. Under the end-of-pipe option, the company would need to undertake further investment in control equipment to meet a higher standard, at a present value of at least $10,000. On the other hand, the P2 option already meets the higher emission standard and would require no further outlays. The expected present value of the end-of-pipe approach is more than $18,000. A sensitivity analysis shows that the end-of-pipe option has a higher expected present value as long as the probability of stricter standards is greater than 25% (i.e., the probability of stricter standards was reduced until the NPV of the P2 option was equal to the NPV of the end-of-pipe option).

**Figure 9-3 Example of a Simple Decision Tree to Evaluate Future Uncertainties**




### 9.5 Making a Final Decision

Once the relevant information is structured into an MA table, decision makers may choose from a variety of decision making methods, ranging from straightforward judgment to more structured approaches to making trade-offs.

The simplest approach to decision making is to rank the alternatives based on a subjective review of the available information. The MA table provides information in a structured and intuitive form to aid in identifying trade-offs. A variety of decision making approaches are then possible:

*Holistic Approach* - Trade-offs are made implicitly by decision makers. This can be as simple as asking them whether they believe the probable reduction in future risks or the addition of other strategic benefits outweighs any apparent financial cost.

*Critical Value Analysis* - The nature of the trade-off can be highlighted for decision makers through the use of critical value analysis. This involves calculating the minimum value a qualitative trade-off or set of trade-offs would have to have in order to make the project financially attractive (see Section 7-3 for an example). Decision makers can then decide if they believe the actual value of the qualitative trade-off is worth at least this amount. For example, is the identified potential improvement in worker safety and corporate image worth more to decision makers than a slightly negative expected NPV?

*Rating and Weighting* - This involves assigning weights to each criterion (account) to reflect relative importance, assigning a numerical score to show how each alternative performs relative to each criterion and calculating the weighted average score.

*Multi-Criteria Decision Making Techniques* - More structured approaches can also be used as an aid to decision making. These techniques are described in more detail in any advanced text on decision analysis.

No single decision making method is universally better than the others, nor is there any "right" answer to a decision problem. Often the use of a combination of methods provides the most insight into different costs, benefits, and ultimately, profitability.

**Structured decision-making techniques can be a useful tool to:**

- ensure that all factors affecting long term profitability are considered by decision makers;
- clearly state all assumptions, and document methods and calculations;
- identify key trade-offs;
- improve communication among individuals and departments to help identify key uncertainties and build a common understanding of complex issues;
- identify potential linkages and synergies among options, possibly generating entirely new alternatives; and
- provide consistent treatment of all of the options under consideration.

# Making the Decision

## Making the Decision at Precision Circuits

The financial performance of Precision Circuit's plastic-coated rack investment was calculated based on an improved inventory of direct and indirect costs. Precision made assumptions about a number of uncertain parameters and then performed sensitivity analysis to determine how each parameter individually affected overall financial performance.

Figure 9-3(a) shows an MA table for Precision's investment decision. Precision evaluated only one alternative, and calculated the *incremental* costs and savings of the option relative to the base case. Thus, the table shows only one alternative. For the plastic-coated rack investment, the MA table shows the performance of the project with respect to multiple decision criteria, and under multiple scenarios reflecting different assumptions about uncertain parameters.

In the scenario analysis, several parameters are varied at once. A plausible range of values was estimated for each parameter (see Table 9-3(b)). To create the "worst case" scenario, each parameter was adjusted in the direction that would lower overall NPV, while "likely case" and "best case" represent values for the parameters yielding an average and high NPV.

Benefits of that were not quantified included reduced liability, improved employee morale (resulting from improved safety) and product quality enhancements. Under "likely" or "best" conditions, the option is clearly profitable without consideration of contingent costs or strategic issues. In the worst case scenario, decision makers would need to decide if these benefits are worth *at least* $25,933.

## Figure 9-3(a) Sample MA Table

| EVALUATION CRITERIA | PLASTIC-COATED RACK INVESTMENT | | |
|---|---|---|---|
| | SCENARIOS<br>Worst | Likely | Best |
| Profitability (1) | | | |
| NPV (1996$) | $ (25,933) | $ 33,589 | $ 36,897 |
| Discounted Payback (years) | >5 | 2 | 2 |
| Monetized Contingent Costs | - | - | - |
| Expected Profitability (2)<br>NPV (1996$) | $ (25,933) | $ 33,589 | $ 36,897 |
| Qualitative Contingent Costs | • Decreased risk of spills associated with storage, handling, use and disposal of nitric acid.<br>• Decreased risk of third-party liability. | | |
| Other Strategic Considerations | • Improved worker safety and morale.<br>• Improved product quality. | | |
| Critical Value of Non-Financial Criteria Required to Make Project Attractive (1996$) | $ 25,933 | 0 | 0 |

*Notes:*

1. *Profitability calculations are based on an initial assessment of direct and indirect costs only.*
2. *Expected Profitability equals NPV in this case because there are no monetized contingent costs.*
3. *In this case, the plastic coated rack alternative was compared against the existing process and all values shown are incremental costs relative to the existing process. If further options were under consideration, the table could be expanded to the right to compare the performance of several alternatives against the same evaluation criteria.*

## Table 9-3(b) Summary of Scenario Analysis Assumptions

| PARAMETERS | WORST CASE | LIKELY CASE | BEST CASE |
|---|---|---|---|
| Inflation - General | 3% | 5% | 7% |
| Inflation - Disposal | 7% | 10% | 20% |
| Discount Rate | 15% | 15% | 15% |
| Productivity Gains (hrs / day) | 0 | 2.75 | 2.75 |
| Capital Cost | $ 50,000 | $ 18,372 | $ 18,372 |
| Quality Changes ($ / year) | $ - | $ (8,660) | $ (8,660) |
| **PROFITABILITY** | | | |
| NPV | $ (25,933) | $ 33,589 | $ 36,897 |
| IRR | -7% | 66% | 69% |
| Payback (years) | >5 | 2 | 2 |