Full Cost Accounting

A Course Module on Incorporating Environmental and Social Costs into Traditional Business Accounting Systems

Noellette Conway-Schempf, Ph.D.
Carnegie Mellon University
Pittsburgh, PA 15213

Overview:

This module describes methods for incorporating environmental information into accounting management information systems to allow financial decision makers to include environmental criteria in their decisions. The module is subdivided to permit a progression of detail concerning accounting systems and their role in encouraging the design and development, marketing, and use of more environmentally-conscious products, services, and manufacturing processes.

The module is suitable for use as part of an engineering or business environmental management course, at either the undergraduate or graduate level, through the selection of various components of the module. Thus for example, in an MBA course, the early material on types of accounting systems would be unnecessary, or in an engineering environmental management course, more emphasis could be placed on the managerial/cost accounting section than on the national accounting section.

The module is subdivided as follows:

1) Introduction

- What is accounting?
- Relevance of accounting and capital budgeting to environmental management and engineering issues
- Types of accounting systems
- Shortcomings of accounting systems as environmental information systems
- Full cost accounting

2) Incorporating social and environmental costs into accounting systems:

- National accounts
- Financial accounts

- Cost accounting systems and capital budgeting

3) Valuing the environment

4) The ultimate goal – full cost pricing

5) Difficulties associated with full cost accounting

6) Additional teaching resources available

- Case studies
- Readings

Appendix 1: Example short class projects and assignments

Appendix 2: Case study of environmental cost accounting for scrap at an automobile manufacturing facility- Instructor's version and student version.

Appendix 3: Example of a pollution prevention investment analysis

1.0 Introduction

1.1 What is accounting?

Accounting is the collection and aggregation of information for decision makers - including managers, investors, regulators, lenders, and the public. Accounting systems affect behavior and management and have affects across departments, organizations, and even countries. Information contained within an accounting system has the power to influence actions. Accounting information systems are particularly strong behavioral drivers within the context of a corporation - where profits and the bottom line are daily concerns. In order for environmental concerns to be important criteria in everyday business management decisions, they need to be encapsulated within the accounting systems of the organization.

In this educational module we will discuss efforts to include environmental and other social information into accounting systems. We provide an overview of the three main types of accounting systems used by developed nations and discuss their shortcomings in terms of environmental information content. Although we will discuss the three types of systems, we will focus the bulk of the discussion on managerial or cost accounting systems - the day to day accounting information systems used by decision makers in enterprises. Example overheads for lectures are included in Appendix I.

1.2 Relevance of accounting and capital budgeting to environmental management and engineering design issues

Accounting systems inform and motivate behavior, thus any information included therein has the potential to influence behavior. Including environmental information in accounting systems is a prerequisite to linking sound environmental management and the principles of sustainable development with everyday business and personal decisions.

Historically, the environmental effects of doing business have been excluded from financial information systems unless they directly affect the entity's profitability or future - for example fines or accidents. Environmental effects, which are not regulated or scrutinized by the government, are often ignored because they may be considered to be:

- Unimportant (for example, there appear to be unlimited resources)
- Not pertinent to the core business function or the bottom line
- Part of the price of progress
- Difficult to estimate and to assign financial values

More recently, there has been a shift by corporations and governments towards viewing the environment as a perishable resource which needs to be managed for prolonged use - be that use commercial or social. There has also been a realization that damaging the environmental is costly - to individuals, corporations, and society. These costs need to be avoided. Managing and avoiding environmental costs requires recognizing that these costs exist, ensuring that these costs are recognized by the parties responsible for the costs, and providing incentives to reduce these costs.

Most environmental effects are the result of design and engineering decisions. For example, a product which contains toxic materials has the potential to have a high environmental cost. However, these environmental costs may not have been apparent to the product designer. Manufacturing processes which generate large amounts of waste will result in high disposal costs, in addition to the costs of inefficient resource utilization and the costs associated with handling and managing materials which do not ultimately become marketable product. The process engineer may be aware of the waste handling costs, but is unlike to fully realize additional costs associated with waste.

While many decision makers are not environmental experts, all are probably familiar with financial systems of some form or another and most face cost constraints. The consumer in the supermarket has a finite amount to spend, the manager has spending limits. The aim of full cost accounting is to encapsulate environmental effects within the financial measures used to make decisions.

1.3 Types of accounting systems

There are three main types of accounting systems - each with a different purpose and involving data gathering at different levels of aggregation:

National Accounting Systems

National accounts are national income and production accounts, such as the Gross National Product (GNP) and Gross Domestic Product (GDP) which aim to measure and track an economy's contribution to the well-being of its inhabitants. National income accounts show the national demand or goods and services and are used to track and measure economic growth. Conventional economic thinking has assumed that the increases in goods and services produced domestically (GDP) and national income (GNP) are adequate yardsticks of economic health. For example, the World Bank uses per capita GNP as a major criterion for classifying national economies.

An international Standard System of National Accounts (SNA) and procedural rules for calculating GNP were agreed upon in 1968 and are codified in the "blue book" produced by the UN Statistical Office.

Specific definitions of a number of national accounting measures are shown in Table 1.

Table 1. Defining national economic performance (Adapted from Duthrie, 1993)

Gross Domestic Product	This is the total production of a country measured as: i) the monetary

	value of final goods and services; ii) the expenditures on goods and services produced; or iii) the income received for goods and services.
Gross National Product	This is the total income of a country including GDP PLUS payments, profits, interest etc. flowing in from abroad, minus profits, interest, payments etc. flowing out to other countries.
Per Capita GDP or GNP	GDP or GNP divided by the population. This is a crude estimate of the average standard of living.
Net National Product	GNP minus an allowance for depreciation of capital.
Net Income	NNP minus any indirect taxes paid by producers to the government.

Financial Accounting Systems

Financial accounts, such as balance sheets and income statements are used to keep track of business incomes and outflows. These financial reports are for use by persons outside the firm - for example, lenders or investors. There are relevant to the enterprise as a whole and are generally subject to strict government rules.

The most common financial accounting reports are for external use by are the financial statements in a firm's annual report to shareholders. In the United States and most developed countries, these reports conform *to generally accepted accounting principles* developed predominantly by the Financial Accounting Standards Board (FASB) and the Securities and Exchange Commission (SEC).

The overall objectives of a firm's financial accounting statements are: (Stickney et al, 1991):

1) To provide information useful for making rational investment and credit decisions.
2) To allow investors and creditors to assess the amount, timing, and uncertainty of cash flows.
3) To provide information about the economic resources of a firm and the claims on those resources.
4) To provide information about a firm's operating performance during a period.
5) To provide information on how a firm obtains and uses money and other financial resources.
6) To provide information on how management has discharged its stewardship responsibility to owners and the public.

The main types of financial accounting statements are presented in Table 2.

Table 2. Principal Financial Accounting Statements.

Balance Sheet	Balance Sheets present a snapshot of the investing and financing activities of a firm at a particular moment in time (usually the last day of the firm's fiscal year). The balance sheet presents a summary of the firm's assets, liabilities and shareholder's equity. In a balance sheet the sum of the assets must equal the sum of the liabilities and shareholder's equity. There are strict guidelines governing the estimation of assets and liabilities.
Income Statement	The Income Statement presents the results of the operating activities of a company for a specific period of time - usually the fiscal year. The statement summarized the revenues and expenses and reveals the net income or earnings of the firm during the period of time covered.
Cash Flow Statement	The Cash Flow Statement shows the net cash flows related to operating, investing, and financing activities for a specific period of time - usually the firm's fiscal year.

Management or Cost Accounting Systems and Capital Budgeting

Management or cost accounting systems are part of an enterprise's information system and refer to the internal cost tracking and allocation systems to track costs and expenditures. These are internal rather than external accounting systems. There are no fixed rules governing how an entity should keep track of cash flows internally, although there are many formal methods available for users. Capital budgeting is basically a form of predictive cost accounting over a set time frame which is used to analyze the costs of alternative projects or expenditures over the specified period of time.

Managerial or cost accounting measures are the predominant financial drivers in day to day business decision making affecting every aspect of the firm's activities. Good cost accounting is vital to understanding the profitability of current activities and to predicting the profitability of future activities. There are many examples of firms who discovered non-profitable services or

products once thorough cost accounting procedures were implemented. The bulk of this module will focus on these types of accounting information systems.

The main objectives of managerial/cost accounting are (Hilton, 1988):

1) Providing managers with information for decision making and planning.
2) Assisting managers in directing and controlling operations.
3) Motivating managers towards the organization's goals.
4) Measuring the performance of managers and sub-units within the organization.

Basic cost classifications are demonstrated in Table 3. - Note, these classifications are not exclusive, for example a cost may be fixed and indirect, or variable and direct for example.

Table 3. General Cost classifications

Variable Costs	Variable costs change in total in proportion to the level of activity. For example if a carmakers production increases by 5%, its tire costs will increase by about 5%.
Fixed Costs	A fixed cost remains unchanged in total as the level of activity varies. For example, the property tax on a rental apartment is the same regardless of the number of building occupants.
Direct Costs	A direct cost is the cost of direct labor and material used in making the product or delivering the service.
Indirect Costs/Overhead Costs	Indirect costs are costs of an activity which are not easily associated with the production of specific goods or services.
Opportunity Costs	The benefit that is sacrificed when the choice of one action precludes an alternative course of action.
Sunk Costs	Costs that have been incurred in the past and cannot be changed by current actions.

1.4 Shortcomings of accounting systems as environmental information systems

National Accounting Systems

It is possible for a country to act in such a way as to deplete its forests, exhaust its mineral resources, pollute its waters, and deplete its fisheries and wildlife without affecting measured GDP or GNP. In fact, activities such as mining or environmental cleanup, will actually contribute positively to a countries national account measures. Conversely, a country could vastly improve the quality or fertility of its land and natural resources and these improvements would not be reflected as increases in GDP/GNP.

National accounts are actually inadequate measures of a country's long-term economic welfare as they do not take into account activities, such as resource depletion, which will ultimately affect economic growth. The accounting systems also ignore or mislabel many of the costs and benefits associated with natural resources and environmental quality. The costs of reducing the adverse effects of environmental degradation are treated as ordinary investment and consumption activities. Damages caused by pollution usually are included only to the extent that they influence productivity. Environmental services provided by the natural environment (waste disposal, pollution clean-up and dispersion etc.) are not accounted for at all.

Financial Accounting Systems

Corporate financial statements also exclude estimates of social costs beyond those directly impacting the bottom line. However, there are guidelines on the reporting of environmental liabilities - these pertain to likely remediation and liability issues, rather than long-term social issues. These liabilities are often reported in the statement footnotes since their magnitude is unknown.

Managerial/Cost Accounting Systems

Most corporate managerial accounting systems do not track costs closely. Easily identifiable costs, such as labor or raw materials, are often finely tracked and allocated to particular product

or process lines, but many costs - such as administration costs and environment, health, and safety costs, are considered to be indirect or overhead costs and are allocated broadly across product and process lines. Placing a cost in an overhead account allows it to be shared across activities, but generally removes cost responsibility from any one particular product line or manager. If no one is responsible for a cost, it is likely to be ignored, or in the worst case, may increase as a result of efforts to reduce other costs.

1.5 What is Full Cost Accounting?

Full cost accounting describes how goods and services should be priced to reflect their true costs (including environmental and other social costs). Depending on the type of accounting system involved it can thus relate to national, financial, or managerial/cost accounting. With full cost accounting, natural resources would be factored into calculations of a country's GDP; natural resources would be redefined as assets on company ledgers; and environmental costs would be built into a product's cost.

To confuse issues slightly, within each type of accounting system, the term full cost accounting may be used to refer to either the full private (or bottom line) costs to an enterprise of an activity, or more correctly, the full social costs to society of the activity including externalities (such as health impacts resulting from ozone depletion). Externalities are costs not borne by the responsible entity, for example, the ecological impacts of climate change resulting from automobile emissions are not included in the price consumers pay for petroleum. In its correct formulation, full cost accounting should refer to all social costs. However, this is difficult in practice and many attempts at full cost accounting (particularly in managerial accounting efforts) have stopped at the level of incorporation of private costs. Figure 1 demonstrates the difference between current accounting systems, full "private" accounting systems, and full 'social" accounting systems.

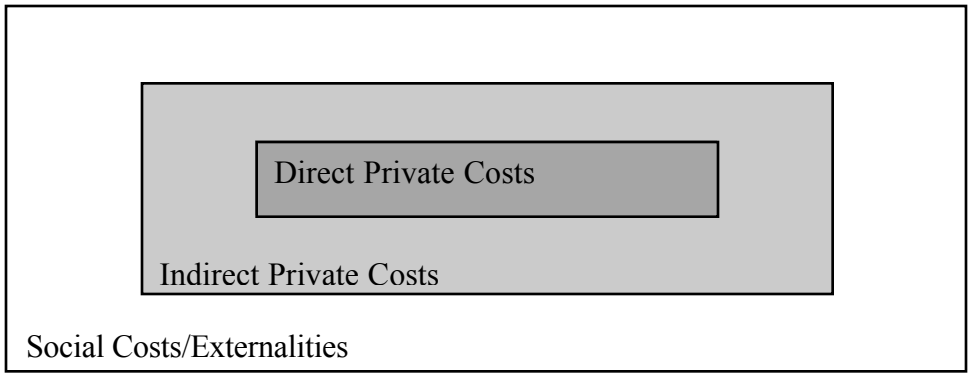


Figure 1a) Typical accounting framework: dark shaded area shows direct private costs allocated to products or activities, light shaded are shows indirect private costs (including some environmental costs) allocated to overhead accounts. Unshaded area shows social costs resulting from corporate activities but not charged to the company.

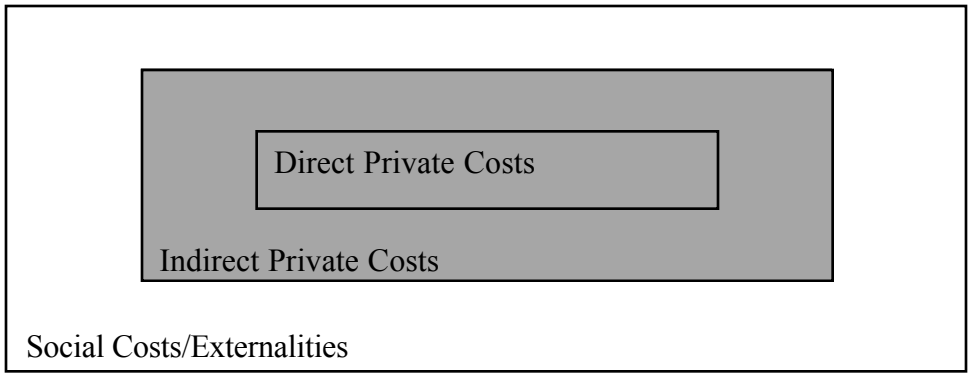


Figure 1b) Modified full cost accounting framework: dark shaded area donotes all private costs allocated to products or activities. Unshaded area shows social costs resulting from corporate activities but not charged to the company.

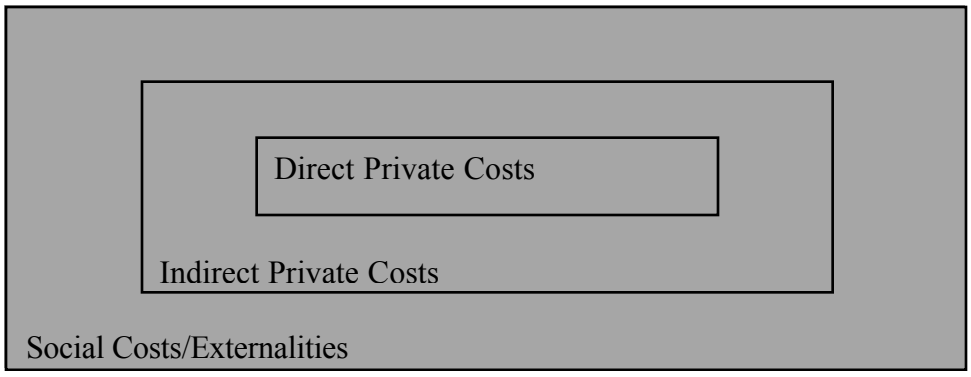


Figure 1c) Full social accounting framework: dark shaded area denotes all costs (both private and social) allocated to products or activities.

2.0 Incorporating social and environmental costs into accounting systems:

National Accounts

As discussed earlier, national accounts do not record changes in environmental quality and most natural resources and ignore or mislabel many of the costs and benefits associated with natural resources and the environment. Amending the accounts to correct these problems requires:

1) Expanding the set of goods treated as national assets to include uncounted environmental and natural resources - this is called expanding asset account boundaries. This would also involve computing values for depletion and degradation of natural assets.

Some economists have attempted to calculate Net Domestic Product (NDP) measures by subtracting the values resulting from the depreciation of natural assets, and the depletion and degradation of natural resources from GDP measures. For example, the GDP measures for a country in Indonesia were adjusted for resource depletion and consumption by Repetto for the World Resources Institute in 1989. This study showed that the conventionally measured GDP overstated the true growth of net income. While the GDP increased by about 7.7% annually, the NDP figures rose by only 3.9% annually. This means that half of the recorded growth during the period was generated by drawing down natural resources rather than by sustainable productivity increases.

2) Expanding the set of goods and services included in measures on national income to include services flowing from the environment or natural resources - this is called expanding the production boundaries. Such services include the provision of recreation , biodiversity, and aesthetic benefits.

3) Reclassifying some of the economic activities measured in the accounts by identifying activities that protect against environmental degradation and recognizing the contribution of the waste disposal services of the environment - this is called reorganizing the production boundaries.

A number of nations, including the United States, have begun to develop environmental national accounts. For example, in France, "National Heritage Accounts" are produced by the National Institute of Statistical Studies in Paris. These accounts attempt to integrate economic, ecological, and socio-cultural functions of the environment. Raw physical data is collected on water, air, soil, flora and fauna, and 'others'. This information is aggregated into "state of the environment" reports, and various forecasting and simulation models and a modified GDP is calculated. This modified GDP is not very comparable with the official GDP however.

Cost Accounting Systems and Capital Budgeting/Investment Analysis

(Much of this section is derived from EPA, 1995)

Environmental costs are one of the many types of costs incurred during the operation of an enterprise. Environmental costs need management attention because:

1) Many environmental costs can be reduced through changes in business activities and decisions, e.g. waste minimization activities.
2) Environmental costs are often allocated to overhead accounts rather than to specific activities and thus get overlooked.
3) Better management of environmental costs can result in improved environmental performance and health and safety measures.
4) Understanding the source and amount of environmental costs encourages more accurate costing and pricing of goods and services, and allows unprofitable activities to be highlighted.

5) Understanding environmental costs can help companies determine the advantages of developing environmentally-conscious goods and services - these will often 'cost' less, especially on a life cycle basis.
6) Detailed accounting of environmental costs can help support the development and management of a corporate environmental management system.

The term environmental costs can be used to describe **private** environmental costs - the costs that directly impact a firm's bottom line, and **public or social** environmental costs - the costs to society as a whole. To date, attempts to focus on better tracking and allocation of environmental costs within management accounting frameworks have predominantly focused on private costs and we will deal with these in detail. However, attempts are underway in some companies to begin to estimate and include social or "full" costs in their internal management information systems.

The EPA has developed a system of examining costs in order to focus management attention on environmental issues. These are also summarized in Table 1.

Tier 0. Usual or Conventional Capital and Operating Costs (equipment, materials, labor etc.)

Usual costs are costs that are directly associated with the project. Included would be capital expenditures, such as the costs of buildings, equipment, materials, utilities, installations costs, etc. Also included are operating and maintenance expenses such as, materials, labor, insurance, training, and permitting.

Tier 1. Hidden Costs (monitoring, paperwork, reporting requirements, etc.)

There area number of environmental costs that may not be accounted for as such. These include upfront environmental costs, regulatory or voluntary environmental costs, and backend

environmental costs (see Table 1). Upfront costs are incurred prior to the operation of the process or facility and related to the siting of facilities, qualification of suppliers, evaluation of alternative pollution control equipment etc. Regulatory and voluntary environmental costs include items such as environmental insurance, permitting costs, environmental monitoring and testing, recordkeeping, voluntary audits, remediation, recycling activities etc. These costs are often assigned to overhead accounts rather than allocated to departments of products directly. Backend environmental costs are usually also ignored in current decision making as they are not incurred at the present time. Such costs include the future costs of decommissioning a laboratory, or product takeback requirements.

Tier 2. Contingent Costs (penalties, fines, future liabilities)

Contingent costs are costs that may or may not be incurred at some point in the future. They can only be estimated in probabilistic terms - their expected value, or the probability of their occurrence. Examples are personal injury claims related to product use, future remediation costs, fines or penalties etc.

Tier 3. Less tangible Costs (corporate image, community relations, consumer response etc.

These are the difficult to estimate costs associated with maintaining corporate image, good relationships with investors, employees, and customers etc. These costs would include the costs of environmental outreach activities (annual community cleanup days or treeplanting days for example), and publication of environmental reports etc.

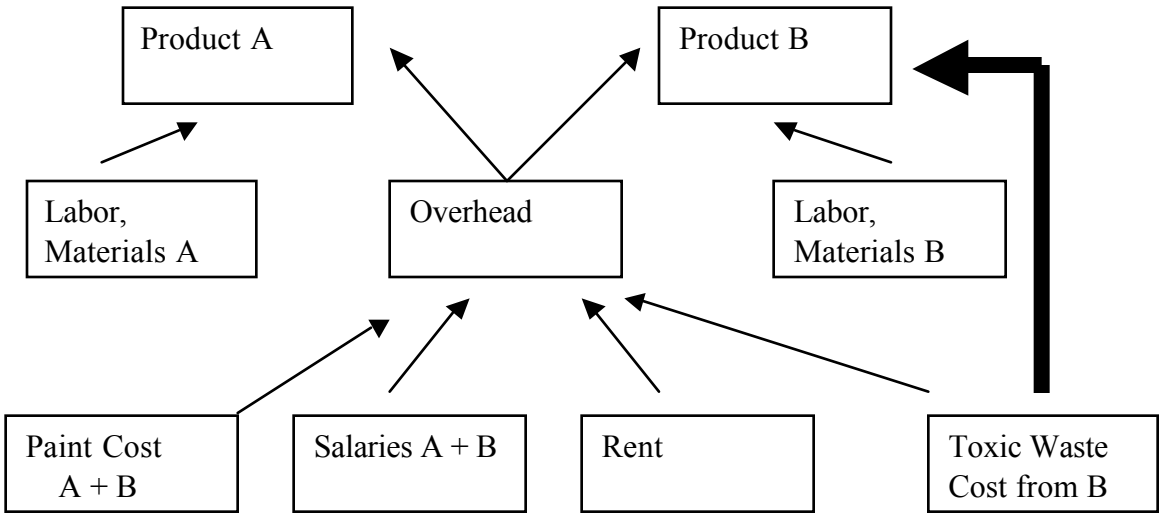
All of the costs outlined above are private costs borne by the company. This analysis does not include the social costs or externalities not directly borne by the company.

Once environmental costs have been identified and quantified or estimated, they need to be allocated to the originating activities. By allocating theses costs, a company will motivate managers and decision makers to find creative pollution prevention alternatives which will lower these costs. However, good allocation of these costs will probably involve overhauling or augmenting the current cost accounting system. Activity-based costing, a managerial accounting technique which attempts to allocate all or almost all a firm's costs is well suited to efforts to implement full cost accounting efforts within a firm, as once the costs have been identified, allocation does not require a new type of accounting framework. A theoretical example of better environmental cost allocation is shown in Figure 3. In this scenario, toxic waste from product B is being incorrectly charged to widget A increasing the apparent cost of production of product A while reducing the apparent cost of production of product B. Better cost allocation reveals the true private costs of product B and may result in efforts to reduce these wastes. **Additional examples of tracking and allocating environmental are provided in EPA, 1993, NPPC, 1994, and EPA, 1995.** Similar cost analyses can be used in capital budgeting or investment analysis. By including the tier 1-tier 3 costs where possible, expected environmental costs and savings can estimated, to result in a more complete understanding of the costs and benefits associated with particular projects or investments. **Appendix 2 demonstrates the potential environmental cost savings associated with scrap reduction at an automobile manufacturing facility. Appendix 3 reproduces sections of EPA, 1993 which details an investment analysis for a pollution prevention project .**

Table 1. Examples of environmental costs incurred by firms (adapted from EPA, 1995).

Potentially Hidden Costs		
Regulatory	**Upfront**	**Voluntary**
Notification	Site Studies	Community Relations
Reporting	Site preparation	Monitoring/testing
Monitoring/testing	Permitting	Training
Studies/Modeling	R&D	Audits
Remediation	Engineering/Procurement	Qualifing Suppliers
Recordkeeping	Installation	Reports (e.g. Env. Reports)
Plans		Insurance
Training	**Conventional Costs**	Planning
Inspections	Capital Equipment	Feasibility Studies
Manifesting	Materials	Remediation
Labelling	Labor	Recycling
Prepardness	Supplies	Environmental studies
Protective Equipment	Utilities	R&D
Medical Surveillance	Structures	Habitat/Ecosystem Protection
Env. Insurance	Salvage Value	Landscaping
Financial Assurance		Financial Support
Pollution Control	**Back-end**	
Spill Response	Closure/Decommissioning	
Stormwater Management	Disposal of Inventory	
Waste Management	Post-closure Care	
Taxes/Fees	Site Survey	
Contingent Costs		
Future Compliance Costs	Remediation	Legal Expenses
Penalties/Fines	Property Damage	Natural Resource Damages
Response to Future Releases	Personal Injury Damage	Economic Loss Damages
Image and Relationship Costs		
Corporate Image	Relationship with Staff	Relationship with Lenders
Relationship with Customers	Relationship with Suppliers	Relationship with community
Relationships with Investors		Relationship with regulators
Relationships with Insurers		

Figure 2. Demonstration of incorrect cost allocation (adapted from EPA, 1995)
Under the traditional cost accounting system, the toxic waste generated only by Product B is allocated to both products. Better environmental cost accounting would result in the toxic waste charges being taken out of the overhead account and allocated directly to Product B (see shaded arrow).



3.0 Valuing the Environment

Once we move beyond the concept of private costs to the quantification and allocation of full social costs, we are faced with a dilemma - how do you assign costs to social and environmental intangibles such as a pretty view, untouched ecosystem, species existence and genetic diversity? Some environmental impacts can be estimated or measured through estimates of human health-related costs or impacts on the economy. However, many are difficult to determine - such as the costs of species extinction or ecosystem loss. Recognizing these externalities makes long-term sense for corporations and governments - today's external costs become tomorrow's internal costs as a result of regulation and legislation. In fact, instances where there is a large discrepancy between internal and external costs are probably good indicators of areas where regulation will appear.

Before it is possible to implement full social cost accounting at either the managerial, financial, or national level it is necessary to have agreed upon estimates of the costs and benefits of environmental resources. The main methods used to date to assign costs to environmental damage are as follows:

3.1) Market Prices

Direct measurement of the market prices for various natural resources such as timber and fisheries can be used to estimate the economic damage resulting from damage or depletion of these resources.

3.2) The Hedonic Price Approach

The hedonic approach attempts to identify how much of a given difference in property or land price is due to differences in environmental quality and to infer how much people are willing to pay for improvements in quality. Identification of property price differences are done through multiple regression which takes into account other reasons for price differences, such as accessibility, proximity to amenities, the amount of property available, etc. For example, Pearce and Markandya (1988) show that pollution appears to significantly affect property values once other variables are taken into account.

3.3) Contingent Valuation

Contingent valuation usually involves directly asking people what they are willing to pay for a particular benefit (in this case environmental benefit), or what they would be willing to accept in compensation to tolerate the loss of the particular benefit. The aim of the questions is to find out what prices would be revealed if markets for the asset existed.

3.4 The User Cost Approach

This method relies on attempting to estimate the total costs associated with an activity. For example, the true cost of visiting a park or other environmental attraction includes the lost income associated with not working, the additional cost of food etc.

Less direct approaches to estimating environmental costs also exist. In general these take the form of estimating dose-response relationships such as the effect of pollution on health or on physical assets such as buildings.

4) The Ultimate Goal - Full Cost Pricing

Full cost pricing implies that all the private and social costs associated with a product or activity (and determined using full cost accounting) are included in the price of the activity. This is quite different to our earlier discussions where the attempt was to determine and allocate all costs to aid in internal decision making. Full cost pricing would extend this concept to the consumer. For example, if all the environmental costs associated with cup manufacturing were included in the price of paper and plastic cups, one would expect the least environmentally damaging to have the lowest price. Thus the consumer can make an environmental choice based on price –or can choose the more environmentally-damaging alternative at a higher price, knowing that the additional environmental costs have been paid for.

It is important to remember that currently we (society) do pay the full social cost of activities and products – however, much of the costs are paid to government agencies or less directly, in the form of increased health costs or reduced living quality. Full cost pricing attempts to ensure that the costs are paid by the users rather than by society at large.

5) Difficulties Associated with Full Cost Accounting

Obviously full cost accounting is not straightforward. There are many barriers that need to be overcome before it becomes a mainstream practice.

Generic problems associated with FCA include the difficulties of estimating the costs of environmental damage. As shown earlier, there is no easy way to calculate many environmental and social costs, and in many instances it can become a question of personal values. Additionally, detailed full cost accounting would require an understanding of the life cycle environmental impacts of a product, process, or activity. Life cycle assessment (LCA) is the tool being developed to provide information on life cycle impacts, however, at present, there is no accepted methodology for LCA and the topic is a subject of controversy.

Specific difficulties associated with developing full cost National and financial accounts include:

- Comparing present and historical measures. National and financial accounts are used to do historical analyses. Changing the rules would make such comparisons difficult, if not impossible.
- How to do international comparisons. Comparing accounts internationally would also be problematic if different countries arrive at different methods for full cost accounting.

Specific difficulties associated with full cost accounting and capital budgeting include:

- Consistency among companies. There are no rules regarding how an entity is to do its internal cost accounting and cost accounting data is not audited. Generating consistent methodologies will be difficult.
- Translating costs into prices. As described above, the ultimate goal is to have a society where there are no social costs – all costs are included in price. This is not straightforward in a competitive global market. There is an incentive to "cheat" and exclude some environmental or social costs as excluding costs will lead to lower prices and competitive advantage.
- The lack of internal incentives. There needs to be a strong motivation to change accounting and financial practices. In a world where budgetary constraints exist there are incentives to reduce, rather than increase, costs.

6.0 Additional Information Sources and Bibliography – many of these publications include examples:

Pearce, D.W. and Markandya, The benefits of Environmental Policy, OECD, Paris, 1988.

P.E. Bailey, Full Cost Accounting for Life Cycle Costs - A Guide for Engineers and Financial Analysts, Environmental Finance, 13-29, Spring, 1991.

Congressional Budget Office, "Greening the National Accounts", CBO, Washington, D.C. 77pp, 1994

David Duthrie, How to Grow a Green Economy, New Scientist, January 1993, 39-43.

EPA, 1992, Total Cost Assessment: Accelerating Industrial Pollution Prevention through Innovative project Financial Analysis. Free Publication, EPA/741/R-92/002, EPA, May 1992.

EPA, 1993, A Primer for Financial Analysis of Pollution Prevention Projects. Free Publication, EPA/600/R-93/059, EPA, April, 1993.

NPPC, 1994, Homework/Exam Problem: Overhead Allocation for Pollution Prevention, William Lannen, Pollution Prevention in Accounting Example, National Pollution Prevention Center for Higher Education, Ann Arbor, MI, August, 1994.

EPA, 1995, An Introduction to Environmental Accounting as a Business Management Tool: Key Concepts and Terms. Free Publication, EPA 742-R-95-001, EPA, June 1995.

EPA, 1995(b)Environmental Accounting Resource List, Free Publication, EPA742-B-95-001, February 1995.

Appendix 1: Example class projects and Assignments

Many of the publication above include examples of accounting problems. Additional suggested projects and exercises include:

1) Take a simple product that is relatively inexpensive, for example, a pen or a sheet of paper. Do a preliminary life cycle assessment by listing the various activities involved in the manufacture of the product and estimating the environmental consequences of these activities. List the environmental consequences that are regulated and likely to be addressed by the company. List the environmental consequences that are likely to be excluded from the company's accounts and product prices.
2) List as many environmental and social consequences of car ownership as possible. Similar lists can be developed for other activities or products, e.g. TV usage, tourism, etc. How many of these do you think are private versus social?
3) Develop your own contingent evaluation questionnaire pertaining to an area of interest. The questionnaire should contain questions designed to elicit the values the reader places on certain items or issues. Divide your audience into two groups. Provide one group with the questionnaire only. Provide the other group with some reading material about the topic/area, and then ask them to fill in the questionnaire. Compare the results of the two groups.
4) Do a similar exercise to 2), however in this case, give the first group a questionnaire which frames the questions in terms of willingness to pay; give the second group a questionnaire which frames the questions in terms of willingness to accept. Compare the answers of the two groups.

Appendix 2

Developed By Rebecca Cassler and Cheryl Horney, Carnegie Mellon University

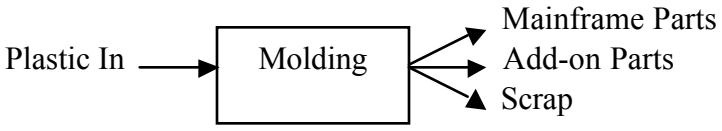
INSTRUCTOR'S VERSION

True Costs of Plastic Scrap: An Environmental Cost Accounting Case Study

Overview for Instructor: This example goes through a step-by-step analysis of determining the full "private" costs of scrap in an automobile parts facility. Part 1 describes a simple mass balance that leads to an initial scrap cost estimation. Part 2 investigates the income from scrap sales and the disposal costs of scrap. Part 3 includes a detailed analysis of scrap effects in the manufacturing facility including materials, labor, parts loss and electricity costs. Part 4 illustrates the financial usefulness of environmental cost accounting and asks for discussion. Understanding the full costs of scrap will provide incentives for scrap reduction: decreasing impacts on the environment and improving the bottom line.

Part 1:
An automobile manufacturer makes the plastic interiors of cars in an injection molding facility. In one year the facility buys 21,600,000 pounds of polycarbonate plastic for $1.39 per pound. The polycarbonate is molded into: 1,360,000 mainframe parts totaling 18,300,000 pounds and 1,360,000 add-on parts totaling 2,720,000 pounds. The balance of the polycarbonate is scrap.

Questions:
a) Approximately how much material is scrapped?
b) What percent of the total purchased plastic does this represent?
c) What is the cost of scrap?



Answers:
a) Pounds of Scrap: 21,600,000 – 18,300,000 – 2,720,000 = 580,000lbs
b) Percent Scrap: 580,000/21,600,000 = 3%
c) 580,000 lbs * $1.39/lb ~ $806,000

Part 2:
Although a significant amount of scrap is directly recycled back into manufacturing processes, a large amount of scrap must be taken off site that was not considered above:

- Approximately 346,400lbs of polycarbonate are recovered from molding the mainframes' component carriers and another 193,600lbs are recovered from add-on parts molding. This scrap is sold for $0.31/lb.
- Purges from the molding machine total 21,600lbs and are landfilled at a cost of $0.025/lb.
- Another 691,000lbs of scrap representing 51,400 parts are recovered from subassembly, painting and final and sold at $1.47/part.

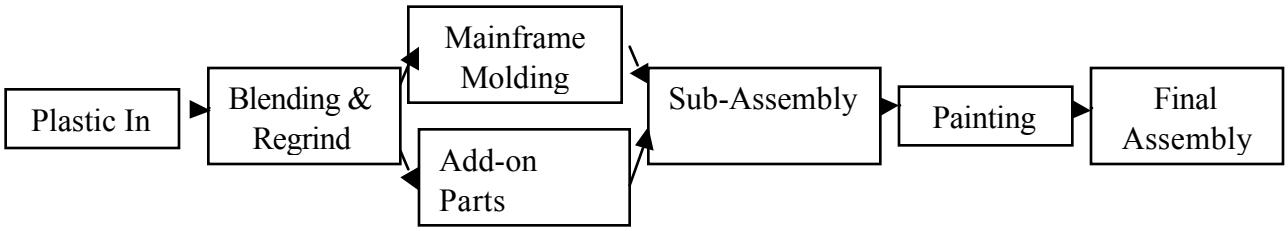
Question:

a) What is the net income (revenues – costs) from the scrap?

Answer:

a) Scrap Income: (346,400+193,600)(.31) – 21,600(.025) + 51,400(1.47) = $242,418
Material Cost of Scrap: (540,000+21,600+691,000)(1.39) = $1,741,114
Net Income from Scrap: $242,418 - $1,741,114 = -$1,498,696 (about -$1.5 million)

Part 3:
The automobile manufacturer is evaluating the injection molding facility through full cost accounting to determine the true cost of scrap. The materials cost of the scrap was easily calculated from a mass balance as shown above. However, scrap is produced at five main points in the manufacturing process: mainframe molding, molding of add-on parts [component carriers], subassembly, painting and final assembly. To recover the scrap, there are associated costs throughout manufacturing such as: labor, regrind/rework, loss of parts and additional electricity usage.



To process scrap, there are two full-time blending/regrind skilled personnel in the facility. Their salaries, including overtime and benefits, total $130,000/year/person. In addition to those two laborers, employees regrind and rework approximately 24,000 scrap parts from subassembly, painting and final assembly. For each of these scrapped parts, initial materials cost $18.70/part, regrind labor costs $2.70/part, and the facility sells the reground scrap for $4.20/part. From other parts of the facility, there are approximately 220,000 lbs of scrap that can immediately be

recycled into manufacturing and approximately 160,000 lbs that are reground and sold. This reground material can be sold for $0.30/lb and was initially purchased for $1.39/lb.

In addition to the materials and labor costs of the scrap, the facility is also losing revenue from overall parts loss. The 24,000 parts are composed of 14,800 parts from subassembly, 5,900 parts from painting and 3,300 parts from final assembly. The values of parts (i.e. the value added from labor, materials, etc.) after each of the processes are: $4.80/part for subassembly, $8.00/part for painting and $35.40/part for final assembly. These prices are representative of the approximate production costs for each part after each process.

To replace these parts that are eventually scrapped, a significant amount of overtime labor is also needed. Labor is broken down into three categories: direct, indirect, and skilled. For mainframe molding, molding of add-on parts [component carriers], subassembly, painting and final assembly, there are all three different types of laborers. Mainframe manufacturing handles an extra 54,000 parts that result in $56,000 of overtime labor. Add-on parts require a total of $70,000 of overtime labor. Subassembly, painting and final assembly use the $87,000, $9,500 and $41,000 of overtime respectively.

Additional electricity usage is required to manufacture the scrapped parts. To make additional mainframes, 225 hours of work using 201kilowatts of energy are needed. Add-on parts require 153kW for 165 hours. Painting and final assembly use 383kW for 25 hours and 30kW for 15 hours respectively. One kiloWatt-hour costs $0.05.

Question:
What is the total cost of this scrap rate using full cost accounting? The table below can help organize and estimate the various scrap costs.

Scrap Activity	**Scrap Costs per Year**
Regrind Laborers	
Regrind/Rework Costs	
Parts Loss	
Overtime Labor	
Additional Electricity	
Materials Cost (from Part 2)	
Total	

Answer:

Regrind Laborers
- 2 laborers * $130,000/laborer = **$260,000**

Regrind/Rework Costs
- Scrap from Subassembly, Painting and Final Assembly:
  24,000 parts * ($18.70 + $2.70 - $4.20) = $418,000

- Molding Scrap that must be reground and sold:
  160,000 lbs * ($1.39 - $0.30) = $174,400

Total Regrind/Rework Costs: $418,000 + $174,400 = $592,400 ~ **$592,000**

Parts Loss
- Subassembly Parts: 14,800 parts * $4.80/part = $71,040
- Painting Parts: 5,900 parts * $8.00/part = $47,200
- Final Assembly: 3,300 parts * $35.40/part = $116,820

Total Parts Loss: $71,040 + $47,200 + $116,820 = $235,060 ~ **$235,000**

Overtime Labor
- Sum of mainframe, add-on, subassembly, painting and final assembly:
  $56,0000 + $70,000 + $87,000 + $9,500 + $41,000 = $263,500 ~ **$264,000**

Additional Electricity
- Mainframes: 225 hr * 201 kW * $0.05/kW-hr = $2,261
- Add-On Parts: 165 hr * 153 kW * $0.05/kW-hr = $1,262
- Painting: 25 hr * 383 kW * $0.05/kW-hr = $489
- Final Assembly: 15 hr * 30kW * $0.05/kW-hr = $23

Total Electricity Costs: $2261 + $1262 + $489 + $23 = $4035 **= $4000**

Scrap Activity	**Scrap Costs per Year ($)**
Regrind Laborers	260,000
Regrind/Rework Costs	592,000
Parts Loss	235,000
Overtime Labor	264,000
Additional Electricity	4,000
Materials Cost (from Part 2)	1,500,000
Total	**2,855,000**

Part 4:
This problem has estimated the materials costs of scrap from a simple mass balance calculation (Part 2) and taken a closer look at the specific costs of scrap that were not outwardly obvious (Part 3). Knowing this information, what is the difference in the estimations of scrap costs from the 3 parts above? Did the full cost accounting evaluation provide incentive for the manufacturer to be more concerned about scrap? What are the potential insights and other uses of full cost accounting analyses? Discuss.

Answer:
Difference in Scrap Cost Estimations:
Part 3 – Part 2: $2,855,000 – $1,500,000 = $1,300,000
Part 3 – Part 1: $2,855,000 - $800,000 = $2,000,000

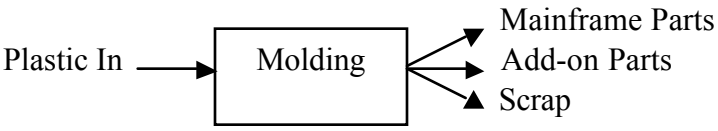
STUDENT VERSION

Developed By Rebecca Cassler and Cheryl Horney, Carnegie Mellon University

True Costs of Plastic Scrap: An Environmental Cost Accounting Case Study

Part 1:
An automobile manufacturer makes the plastic interiors of cars in an injection molding facility. In one year the facility buys 21,600,000 pounds of polycarbonate plastic for $1.39 per pound. The polycarbonate is molded into: 1,360,000 mainframe parts totaling 18,300,000 pounds and 1,360,000 add-on parts totaling 2,720,000 pounds. The balance of the polycarbonate is scrap.

Questions:
a) Approximately how much material is scrapped?
b) What percent of the total purchased plastic does this represent?
c) What is the cost of scrap?

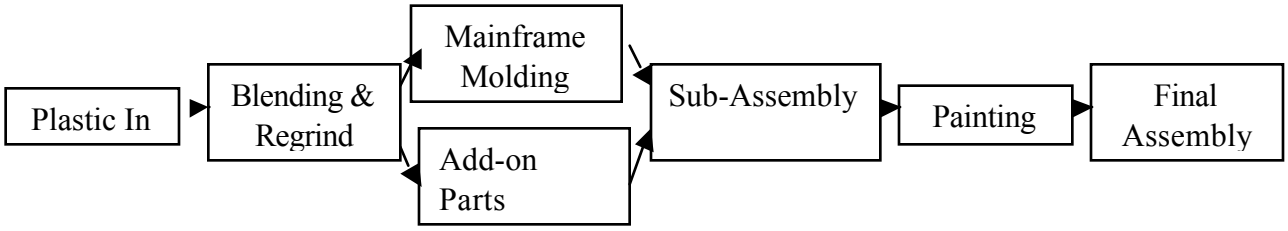


Part 2:
Although a significant amount of scrap is directly recycled back into manufacturing processes, a large amount of scrap must be taken off site that was not considered above:

- Approximately 346,400lbs of polycarbonate are recovered from molding the mainframes' component carriers and another 193,600lbs are recovered from add-on parts molding. This scrap is sold for $0.31/lb.
- Purges from the molding machine total 21,600lbs and are landfilled at a cost of $0.025/lb.
- Another 691,000lbs of scrap representing 51,400 parts are recovered from subassembly, painting and final and sold at $1.47/part.

Questions:
a) What is the net income (revenues – costs) from the scrap?

Part 3:
The automobile manufacturer is evaluating the injection molding facility through full cost accounting to determine the true cost of scrap. The materials cost of the scrap was easily calculated from a mass balance as shown above. However, scrap is produced at five main points in the manufacturing process: mainframe molding, molding of add-on parts [component carriers], subassembly, painting and final assembly. To recover the scrap, there are associated costs throughout manufacturing such as: labor, regrind/rework, loss of parts and additional electricity usage.



To process scrap, there are two full-time blending/regrind skilled personnel in the facility. Their salaries, including overtime and benefits, total $130,000/year/person. In addition to those two laborers, employees regrind and rework approximately 24,000 scrap parts from subassembly, painting and final assembly. For each of these scrapped parts, initial materials cost $18.70/part, regrind labor costs $2.70/part, and the facility sells the reground scrap for $4.20/part. From other parts of the facility, there are approximately 220,000lbs of scrap that can immediately be recycled into manufacturing and approximately 160,000 lbs that are reground and sold. This reground material can be sold for $0.30/lb and was initially purchased for $1.39/lb.

In addition to the materials and labor costs of the scrap, the facility is also losing revenue from overall parts loss. The 24,000 parts are composed of 14,800 parts from subassembly, 5,900 parts from painting and 3,300 parts from final assembly. The values of parts (i.e. the value added from labor, materials, etc.) after each of the processes are: $4.80/part for subassembly, $8.00/part for painting and $35.40/part for final assembly. These prices are representative of the approximate production costs for each part after each process.

To replace these parts that are eventually scrapped, a significant amount of overtime labor is also needed. Labor is broken down into three categories: direct, indirect, and skilled. For mainframe molding, molding of add-on parts [component carriers], subassembly, painting and final assembly, there are all three different types of laborers. Mainframe manufacturing handles an extra 54,000 parts that result in $56,000 of overtime labor. Add-on parts require a total of $70,000 of overtime labor. Subassembly, painting and final assembly use the $87,000, $9,500 and $41,000 of overtime respectively.

Additional electricity usage is required to manufacture the scrapped parts. To make additional mainframes, 225 hours of work using 201kilowatts of energy are needed. Add-on parts require 153kW for 165 hours. Painting and final assembly use 383kW for 25 hours and 30kW for 15 hours respectively. One kiloWatt-hour costs $0.05.

What is the total cost of this scrap rate using full cost accounting? The table below can help organize and estimate the various scrap costs.

Scrap Activity	**Scrap Costs per Year**
Regrind Laborers	
Regrind/Rework Costs	
Parts Loss	
Overtime Labor	
Additional Electricity	
Materials Cost (from Part 2)	
Total	

Part 4:
This problem has estimated the materials costs of scrap from a simple mass balance calculation (Part 2) and taken a closer look at the specific costs of scrap that were not outwardly obvious (Part 3). Knowing this information, what is the difference in the estimations of scrap costs from the 3 parts above? Did the full cost accounting evaluation provide incentive for the manufacturer to be more concerned about scrap? What are the potential insights and other uses of full cost accounting analyses? Discuss.

Appendix 3: Example of a Pollution Prevention Investment Analysis

This appendix reproduces pages 14 – 24 of EPA 1993, which provide an example of a pollution prevention investment analysis - this document has been scanned in verbatim. In this example, a hypothetical firm evaluates the costs and savings associated with switching from its current parts cleaning procedure to a less polluting procedure.

SECTION III

Example Calculations

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

How to Establish the Baseline.

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

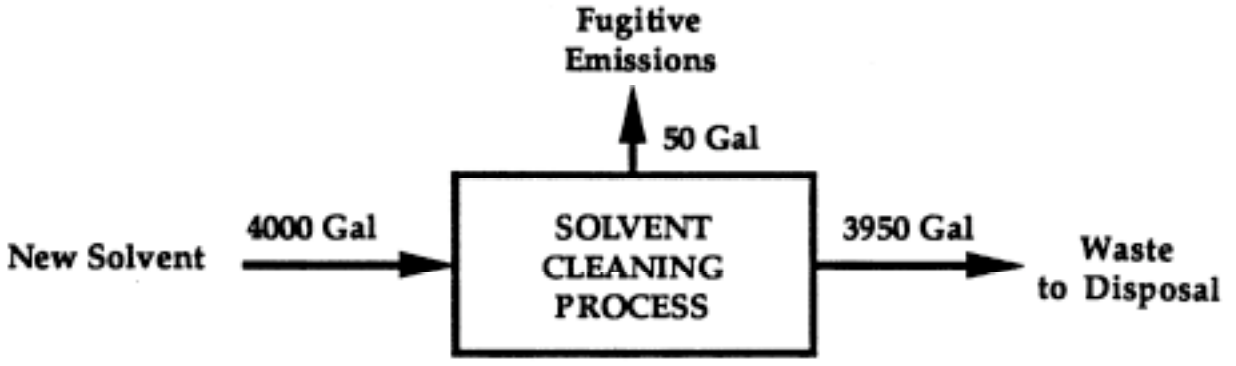


Figure 2. Baseline Material Balance

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

Table 3. Baseline Cost Analysis

Element	*Rate*	*Annualized Costs*
Procurement Expenses		
Operations Expenses		
Utilities		N/A[1]
Operating Expense		N/A
Maintenance/Spare Parts		N/A
Input Solvent	$3.50/gal	$14,000
Waste Disposal	$2.50/gal	$9,875

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

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

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

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

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

Table 4. Ten Year Baseline Costs

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

10	New Solvent	$23,652	
	Waste Disposal	$21,447	
			$45,099

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

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

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

Examining Pollution Prevention Option 1 - Recycle.

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

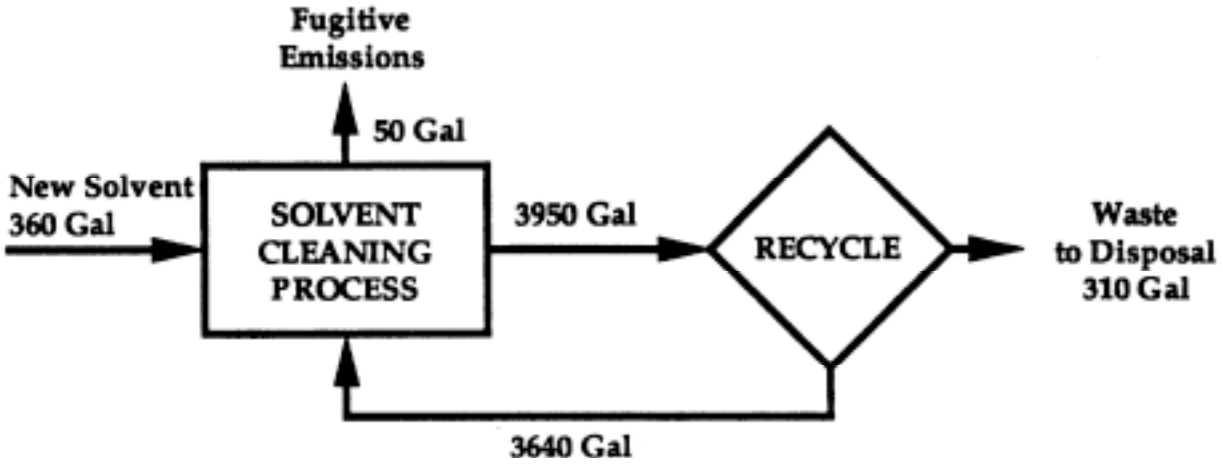


Figure 3. Material Balance for the Recycle System

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

This material balance in Figure 3 can be readily converted to a cash flow. As discussed earlier, the recovery equipment has a life of 10 years. Further, there is no salvage value; the solvent must be chemically treated at the end of year 5 to retain it's effectiveness at a cost of $1000;[2] and no additional permits, such as RCRA treatment permits or air permits, are required to operate or install the equipment. Given these assumptions, the annual costs are as shown in Table 5.

Table 5. Costs for Solvent Recycling

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

Other Expenses to Consider:

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

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

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

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

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

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

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

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

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

Table 6. Ten Year Costs for Recycle Option

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

	Depreciation Expense	$6,600	
	Operating Expenses	$9,442	
	New Solvent	$1,416	
	Waste Disposal	$921	
			$21,039
4	Depreciation Expense	$6,600	
	Operating Expenses	$9,915	
	New Solvent	$1,501	
	Waste Disposal	$1,004	
			$19,020

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

Year	*Item*	*w/o Recycle*	*Total*
5	Depreciation Expense	$6,600	
	Operating Expenses	$11,410[4]	
	New Solvent	$1,591	
	Waste Disposal	$1,094	
			$20,695
6	Depreciation Expense	$6,600	
	Operating Expenses	$10,931	
	New Solvent	$1,686	
	Waste Disposal	$1,192	
			$20,409
7	Depreciation Expense	$6,600	
	Operating Expenses	$11,477	
	New Solvent	$1,787	
	Waste Disposal	$1,300	
			$21,164
8	Depreciation Expense	$6,600	
	Operating Expenses	$12,051	
	New Solvent	$1,895	
	Waste Disposal	$1,417	
			$21,963
9	Depreciation Expense	$6,600	
	Operating Expenses	$12,654	
	New Solvent	$2,008	
	Waste Disposal	$1,544	
			$23,806
10	Depreciation Expense	$6,600	
	Operating Expenses	$13,287	
	New Solvent	$2,129	
	Waste Disposal	$1,683	
			$23,699

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

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

Examining Pollution Prevention Option 2 - Material Substitution.

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

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

Table 7. First Year Costs for the Material Substitution Alternative

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

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

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

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

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

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

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

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

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

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

Making the Financial Comparison:

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

Table 9: Annual Cost Comparison

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

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

10	45,099	23,699	21,400	28,544	16,555

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

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

Table 10: Present Values of the Costs and Benefits[6]

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

MAKING THE FINAL DECISION

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

The final task is to select between the two options. In that they have the same present worth of net benefits, they are equivalent under the financial criteria. However, as previously

[6] Costs are again indicated by parenthesis.

discussed, when projects appear financially equivalent, consideration of other tier costs can swing favor toward an option. In the above analysis, only tier 0 costs were included. If one considers the labor savings due to not having to manifest waste shipments, label drums, and so on., because the material substitution option eliminates hazardous waste generation, there is a substantial savings. Additionally, the elimination of hazardous waste limits the potential intangible tier 2 and 3 costs for remedial actions, lawsuits, etc.. Given these considerations, and the fact that material substitution was higher on the pollution prevention hierarchy, the material substitution option is clearly the most beneficial option.

SECTION IV

CONCLUSIONS

The key point to remember is that firms are in business to make a profit and pollution prevention can be critical to profitability. In the past, environmental expenditures were seen as pure cost sinks with no payback potential. It is becoming apparent that in the realm of pollution prevention there are a number of areas where expenditures can be cut significantly. One EPA study[7] of waste reduction projects showed that in 29 cases that included data on payback period, over 80% had payback periods of less than 3 years.

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

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

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

[7] ibid. Butler, Timm, and Fromm.

Finally, the financial results of the case study were evaluated and the meaning of those results was discussed.

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