COST ANALYSIS

OVERVIEW: The Cost Analysis module identifies the costs associated with the baseline and alternatives, and calculates comparative costs between them. As a minimum, the cost analysis should identify and compare the direct and indirect costs of the baseline and the substitutes. If time and resources permit, data are also collected on future liability costs and less-tangible benefits that occur through the implementation of a substitute.

GOALS:

- Categorize and determine the costs that are incurred by the baseline and the substitutes.
- Identify less-tangible benefits that can result from the implementation of a substitute.
- Perform a comparative cost analysis of the baseline versus the substitutes.

PEOPLE SKILLS: The following lists the types of skills or knowledge that are needed to complete this module.

- Knowledge of current bookkeeping and accounting practices.
- Knowledge of, and ability to perform, cost analysis practices and procedures.
- Knowledge of product and customer buying base to identify less-tangible benefits.
- Knowledge of costs incurred by the baseline and substitutes and other aspects of direct cost allocation.

Within a business or a DfE project team, the people who might supply these skills include a purchasing agent, marketing specialist, floor manager, an accountant, or an economist. Vendors of process equipment or chemicals may also be a good resource.

DEFINITION OF TERMS:

Cost Allocation: The method of assigning costs that have been incurred to the products and processes that generated the costs.

Direct Costs: Costs that are readily assignable to a specific process or product. These costs include capital expenditures, and operating and maintenance costs (e.g., labor, materials, utilities, etc.).

Discounting: Economic analysis procedure by which monetary valuations of benefits and/or costs occurring at different times are converted into present values which can be directly compared to one another.

Expanded Time Horizon: The concept of evaluating an economic analysis over an extended period of time (e.g., 10-20 years) as opposed to the traditional 3-5 year period. This concept is important to identifying the pollution prevention benefits of a substitute, because many of the liability costs and less-tangible benefits occur over a longer period of time.

Indirect Costs: Costs that are incurred by the operation of a business but not typically allocated to a specific process or product. Administrative costs, regulatory compliance costs, and workman's compensation costs are all examples of indirect costs.

Internal Rate of Return (IRR): The discount rate at which the net savings or net present value of an investment are equal to zero. An investment is economically justifiable when the IRR equals or exceeds a company's desired rate of return.

Less-Tangible Benefits: Benefits that may occur but cannot be readily quantified (e.g., reduced health maintenance costs due to a safer work environment, or increased product sales due to better product performance, etc.).

Liability Costs: Difficult to quantify costs incurred as a consequence of uncertain future liability for clean-up of hazardous substance releases or for liabilities from personal injury claims stemming from environmental releases or product use.

Net Present Value (NPV): The present value of future cash flows of an investment less the current cost of the investment.

Present Value (PV): A concept which specifically recognizes the time value of money, i.e., the fact that $1 received today is not the same as $1 received in ten years. Even if there is no inflation, $1 received today can be invested at a positive interest rate (say 5 percent), and can yield $1.63 in ten years. Present value refers to the value in today's terms of a sum of money received in the future. In the example above, the PV of $1.63 received in ten years is $1, i.e., $1 received today is the same as $1.63 ten years in the future. Alternately, the PV of $1 received in ten years is $0.61. The rate at which future receipts are converted into PV terms is called the discount rate (analogous to the interest rate given above). The formulation for calculating PV is given in the Methodology Details section.

APPROACH/METHODOLOGY: The following presents a summary of the approach or methodology for performing a cost analysis. Further methodology details for Steps 1, 2, 4, 5, 6, 7, and 8 follow this section.

Step 1: Determine data requirements for the cost analysis and provide them to the Performance Assessment module so that cost data can be collected during the performance demonstration project. Data should be collected on a per unit production basis, or some other basis that allows a comparative evaluation of the trade-off issues (e.g., energy impacts, resource conservation, risk, etc.).

Step 2: Obtain the data identified in Step 1 from the Performance Assessment module. Obtain additional cost-related data from the Energy Impacts, Resource Conservation, Control Technologies Assessment, Regulatory Status, Process Safety, Market Information and International Information modules. Energy, chemical, and resource consumption data are usually collected in the Performance Assessment module and compiled in the Energy Impacts and Resource Conservation modules, respectively.

Step 3: Review the Workplace Practices & Source Release Assessment module to determine if resource consumption rates, waste generation rates, and worker activities reported for the baseline and alternatives are consistent with the data obtained in Step 2. If the data are not consistent, it may be necessary to have knowledgeable industry personnel review and resolve any inconsistencies.

Note: To ensure that the cost analyses for alternatives are comparable, data from the Workplace Practices & Source Release Assessment module should be used in actual cost calculations only if the data are available for all of the alternatives being evaluated. The Workplace Practices & Source Release Assessment module may not contain information on new or novel alternatives that are not widely used.

Step 4: Calculate the direct costs associated with the operation of the baseline and the alternatives using the data gathered in Step 2 and checked in Step 3. Direct costs include capital expenditures, operating costs, and maintenance costs. Waste management costs are also examples of direct costs, but many businesses allocate these costs to overhead.

Step 5: Calculate indirect costs for the baseline and alternatives. The data gathered in Step 2 will determine many indirect costs, while other indirect costs can be estimated from other sources. Indirect costs are considered hidden costs because they are often allocated to overhead rather than their source, or are omitted altogether from a cost analysis.

Step 6: If time and resources permit, identify future liability costs associated with the operation of the baseline and alternatives. In most instances, the estimation of future liability cost is subject to a high degree of uncertainty. Therefore, the need to quantify the future liability may be less important than recognizing that the future liability exists.

Step 7: If time and resources permit, identify any less-tangible benefits that could result from the implementation of a substitute. The benefits of a cleaner product, process, or technology can be substantial and should not be overlooked when performing a cost analysis.

Step 8: Perform cost analyses of the baseline and alternatives using the cost data collected in Steps 3 through 6. The cost analyses should be performed using a traditional cost accounting method or an alternative cost method. An example of a cost analysis can be found in Appendix G.

Step 9: Provide the results of the cost analysis to the Risk, Competitiveness & Conservation Data Summary module.

METHODOLOGY DETAILS: This section presents the methodology details for completing Steps 1, 2, 4, 5, 6, 7, and 8. If necessary, additional information on conducting a cost analysis can be found in the published guidance. Appendix G contains the cost analysis from the Lithography CTSA.

Details: Step 1, Collecting Cost Data

The following information may be needed for the cost analysis:

- Labor requirements (e.g., cycle time to produce a product unit, ease of use, number of employees to operate process, maintenance labor costs).
- Waste generation rates (e.g., waste water discharges, solid wastes generated).

Equipment and/or chemical costs may also be collected from suppliers during the performance demonstration if this information was not compiled in the Market Information (cost of U.S. supplied equipment and /or chemicals) and International Information modules (cost of foreign supplied equipment and/or chemicals).

If an actual performance demonstration is not planned during the CTSA (e.g., if performance data are being collected from existing sources instead of tests performed as part of the CTSA), cost estimates can be obtained using standard cost estimating techniques and/or cost estimation software combined with data from equipment vendors or other sources.

Details: Step 2, Obtaining Cost-Related Data From Other Modules

Cost-related data are obtained from the following modules:

- Chemical and other resource consumption rates (e.g., water, raw stock, etc.) should be obtained from the Resource Conservation module.
- Energy consumption rates should be obtained from the Energy Impacts module.
- Control technology equipment requirements should be obtained from the Control Technologies Assessment module. Costs of controls can be estimated using information contained in regulatory background documents or obtained from vendors and suppliers.

- Regulations requiring specific disposal methods for process wastes (e.g., processes that generate listed hazardous wastes) should be obtained from the Regulatory Status module. Costs of these disposal methods can be estimated using information contained in regulatory background documents or obtained from suppliers or disposal companies.
- OSHA requirements for special conditions or equipment needed to ensure process safety should be obtained from the Process Safety module. Costs of these requirements can be estimated using information contained in regulatory background documents or obtained from vendors and suppliers.
- Chemical and process equipment costs should be obtained from the Market Information module (U.S. supplied), International Information module (foreign supplied), and/or from supplier information provided to the performance demonstration, as noted in Step 1.

Details: Step 4, Calculating Direct Costs

Direct costs include the following:

- Capital expenditures (e.g., process equipment, control technologies, installation, project engineering, etc.).
- Operating costs (e.g., direct labor, raw materials, utilities, quality assurance testing, etc.).
- Maintenance costs (e.g., equipment cleaning and repair).

The details for Step 8, below, discuss how to calculate present value for costs that are incurred over time.

Details: Step 5, Calculating Indirect Costs

Indirect costs are hidden costs obscured in a cost category of overhead, or omitted completely. They include:

- Supervision and administrative costs.
- Regulatory compliance costs (e.g., permitting, monitoring, manifesting, employee training, etc.).
- Waste management expenditures (e.g., on-site pollution control costs, waste disposal charges, etc.).
- Insurance, rent, taxes, etc.

Not all indirect costs will be relevant to the cost analysis. For example, costs that are constant for both the baseline and the alternative may be excluded from the analysis.

The details for Step 8, below, discuss how to calculate present value for costs that are incurred over time. The following is a discussion of two methods for determining indirect costs.

Traditional Estimation Method: This method determines and allocates indirect costs to a process or product based on some measurable parameter (e.g., labor hours, capital investment). For example, maintenance costs for a piece of equipment can be estimated based on the capital cost of that equipment, where maintenance costs equal some function of capital cost. This method is the most common accounting method used throughout industry.

Activity-Based Costing (ABC) Method: This method of accounting allocates indirect costs to products or processes, based on how the products or processes actually incur these costs. This allocation is done using a series of cost drivers that are keyed to the activities required to produce the products. For example, the operating costs of an ion exchange bed used to treat liquid waste streams from various sources would be divided and attributed directly to each individual source in proportion to the percentage of its overall use.

Traditional Estimation Method vs. ABC Method: Traditional estimation methods are less complicated and time consuming than ABC methods. Little or no change to the current financial accounting methods are typically required. In contrast, ABC provides for a more accurate picture of costs by evaluating the actual activities of each process. ABC allows managers to cite specific problem areas in a process that would otherwise go undetected. As a result, the direct benefits of a substitute that addresses these problems are more easily identified. ABC, however, is time consuming because of the considerable effort needed to track each activity in the process. Therefore, additional administrative costs may be incurred to set up an ABC system, but the opportunities for cost savings identified by the ABC method probably would more than offset this cost.

In many cases it may be difficult to determine all indirect costs for substitutes that are not in widespread use. In these cases, ABC methods can be supplemented with the traditional estimation methods for the unavailable data. For example, determining if a waste stream is hazardous as defined by RCRA may not be possible until an alternative is fully implemented and the nature of the waste realized. Assumptions that are made about the applicability of environmental regulations and the associated costs should be explicitly stated. The Regulatory Status module helps to identify potential compliance issues.

Details: Step 6, Identifying Liability Costs

Liability costs include the following:

- Penalties and fines (e.g., penalties stemming from non-compliance with current or future environmental regulations).
- Personal injury (e.g., liability claims stemming from environmental releases of chemicals or consumer use of a product).
- Property damage (e.g., liability claims stemming from environmental releases from disposal sites).
- Clean-up costs (e.g., Superfund mandated corrective action).
- Natural resource damages (e.g., Superfund mandated damages).

Details: Step 7, Identifying Less-Tangible Benefits

Less-tangible benefits include:

- Increased sales due to improved product quality, enhanced public image, consumer trust in green products, or other effects.
- Reduced health maintenance costs due to a safer work environment.

- Improved worker productivity due to cleaner working conditions (e.g., fewer volatile solvents in cleaning area, less dizziness).
- Increased worker productivity due to improved employee relations.

Details: Step 8, Conducting a Cost Analysis

When conducting the cost analysis, the project team should select long-term financial indicators that account for the time value of money and all cash flows from implementing the baseline or a substitute. Two commonly used financial indicators include NPV and IRR. Formulas for calculating PV and NPV are discussed below. Discussions on IRR and other financial indicators may be found in economic analysis textbooks.

Calculating Present Value and Net Present Value

For a one-time cost or benefit, PV is given by the formula:

$$PV = \frac{CF_t}{(1 + r)^t}$$

where:

CF_t represents the value of a one-time cash flow, CF, received in year t, and r represents the discount rate

For a series of benefits to be received over several years, present value is given by the formula:

$$PV = \sum_{I=1}^{T} \frac{CF_t}{(1 + r)^t}$$

where:

$\sum$ represents the summation of benefits in the time period which ranges from year 1 to year T

NPV is given by the formula:

$$NPV = PV - I$$

where:

I is the initial outlay or investment cost

Costing Methods

Traditional costing methods or Total Cost Assessment (TCA) can be used to perform the cost analysis. Both methods allow for the calculation of a net cash flow, IRR, or NPV. The methods differ in which costs are calculated and how costs are allocated. The following is a discussion of the advantages and disadvantages of different costing methods.

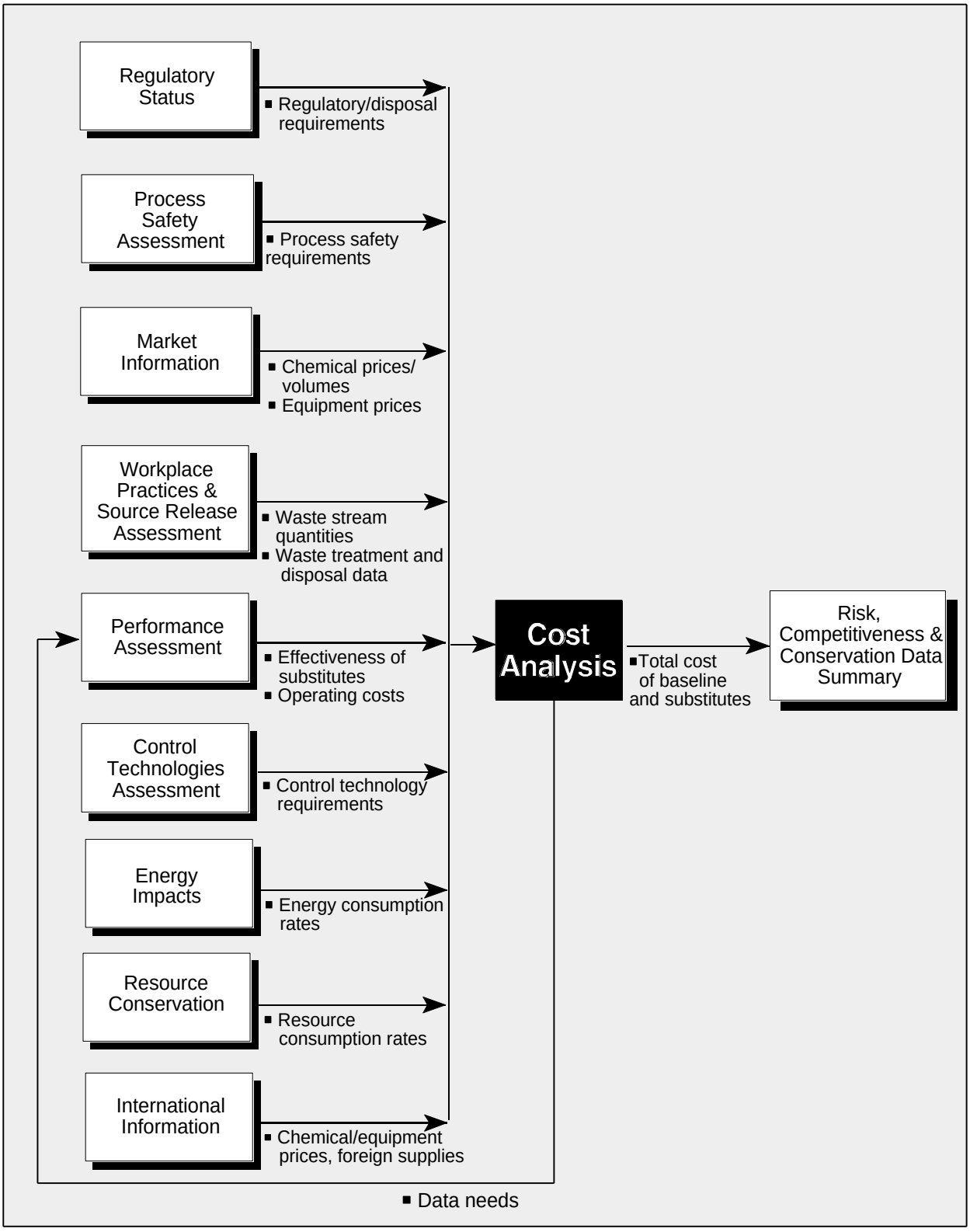
Traditional Costing Method: This method of cost analysis typically ignores future liability costs and considers all indirect costs as overhead or omits them altogether. These overhead costs, if considered, are randomly allocated to a process or product based on some measurable, yet arbitrary parameter (e.g., labor hours, capital equipment costs). This method is the most common accounting method used throughout industry.

Total Cost Assessment (TCA): This accounting method attempts to analyze all of the costs and liabilities, along with the potential benefits, over an expanded time horizon to gain a more comprehensive profile and comparison of alternatives.

Traditional Costing Methods vs. TCA: Traditional cost accounting is the easiest and least complicated of the cost analysis methods. The need to quantify or estimate difficult-to-determine indirect costs and future liabilities is minimized or eliminated. The potential impacts the substitutes have on indirect costs are considered qualitatively. In contrast, TCA is an important improvement over traditional costing methods. By using an expanded time horizon, including indirect costs, and quantifying less-tangible costs, TCA is a more representative cost accounting method. One limitation of the TCA method is that there are no commonly accepted methods of quantifying some future liability costs, and little or no agreement on how less-tangible benefits should be valued. Both methods require little or no changes to the current financial/managerial accounting methods typically used in industry.

FLOW OF INFORMATION: This module provides data needs to the Performance Assessment module, receives information from the Regulatory Status, Process Safety Assessment, Market Information, Workplace Practices & Source Release Assessment, Performance Assessment, Control Technologies Assessment, Energy Impacts, Resource Conservation, and International Information modules, and transfers information to the Risk, Competitiveness & Conservation Data Summary module. Example information flows are shown in Figure 7-3.

FIGURE 7-3: COST ANALYSIS MODULE: EXAMPLE INFORMATION FLOWS



ANALYTICAL MODELS: Table 7-3 lists references for computer models to assist with a cost analysis. Tellus Institute, with funding from the EPA DfE Program and the National Institute for Standards and Technology, is developing environmental cost accounting and capital budgeting software designed to help small and medium-sized businesses cost pollution prevention projects. Currently, software is available for screen printers; software packages for lithographers, flexographers, the metal fabrication and finishing industries, and printed wiring board manufacturers are under development.

TABLE 7-3: ANALYTICAL MODELS FOR COST ANALYSIS

Reference	Type of Model
Tellus Institute. 1993. *P2/Finance: Version 2.0*.	Financial analysis and cost evaluation software for the personal computer.
Tellus Institute. 1995. *P2/Finance for Screen Printers: Version 1.0*.	Financial analysis and cost evaluation software for the personal computer.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

PUBLISHED GUIDANCE: Table 7-4 presents references for published guidance on cost analysis.

TABLE 7-4: PUBLISHED GUIDANCE ON COST ANALYSIS

Reference	Type of Guidance
Brimson, James A. 1991. *Activity Accounting - An Activity-Based Costing Approach.*	Describes activity based costing method.
Brown, Lisa, Ed. 1992. *Facility Pollution Prevention Guide.*	Provides overview of total cost assessment issues and method.
Collins, Frank, Ed. 1991. *Implementing Activity Based Costing.*	Describes activity based costing method.
Northeast Waste Management Officials Association. UNDATED. *Costing and Financial Analysis of Pollution Prevention Investments.*	Provides methods of financial analysis.
Tellus Institute. 1991a. *Alternative Approaches to the Financial Evaluation of Pollution Prevention Investments.*	Describes and compares various costing methods.
Tellus Institute. 1991b. *Total Cost Assessment: Accelerating Industrial Pollution Prevention Through Innovative Project Financial Analysis, with Applications to the Pulp and Paper Industry.*	Describes total cost assessment methods.

TABLE 7-4: PUBLISHED GUIDANCE ON COST ANALYSIS	
Reference	**Type of Guidance**
U.S. Environmental Protection Agency. 1989c. *Pollution Prevention Benefits Manual: Phase II*.	Formulas for incorporating future liabilities into a cost analysis.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

DATA SOURCES: None cited.