Environmental Costs: Measurement and Control

CHAPTER 16

AFTER STUDYING THIS CHAPTER, YOU SHOULD BE ABLE TO:

1. Explain how environmental costs can be measured and reduced.
2. Discuss environmental costs, and show how they are assigned to products and processes.
3. Describe the life-cycle cost assessment model.
4. Compare and contrast activity-based and strategic-based environmental control.

Historically, firms have often released contaminants into the atmosphere and water without bearing the full cost of such activities. Many people believe that polluters should bear the full cost of any environmental damage caused by production of goods and services (the polluter pays principle). By bearing the full cost (it is argued), firms may then seek more ecoefficient production methods. Interestingly, some initial experiences suggest that it may be possible to improve environmental quality without reducing useful goods and services while simultaneously increasing profits.

Responsible environmental management is an important focus for many companies. In fact, many companies spend hundreds of millions of dollars each year on environmental activities. Yet, environmental decisions are often made with little support from the cost management information system. Often, environmental decisions are made simply to comply with environmental regulation. In other words, a reactive approach, rather than a proactive approach to environmental cost management seems to be the norm. A proactive approach, however, is more promising if evidence exists that environmental damage can be prevented while simultaneously reducing costs. Proactive environmental decisions require information about

environmental costs and benefits—information that has not existed as a separate and well-defined category.

Defining, Measuring, and Controlling Environmental Costs

OBJECTIVE 1

Explain how environmental costs can be measured and reduced.

The emergence of a proactive approach means that management of environmental costs is becoming a matter of high priority and intense interest. Several reasons can be offered for this increased interest, but two in particular stand out. First, in many countries, environmental regulations have increased significantly. Often, the regulatory laws carry enormous fines or penalties; thus, strong incentives for compliance exist. Furthermore, the costs for compliance can be significant. Selecting the least costly way of compliance becomes a major objective. To satisfy this objective, compliance costs must be measured and their fundamental causes identified. Second, regulators and companies are beginning to realize that it may be more cost effective to prevent pollution rather than to clean it up. The approach to environmental regulation seems to be shifting from a command-and-control approach to a market-driven approach.[1] This new market-driven approach means that successful treatment of environmental concerns is now a significant competitive issue. Corporations are discovering that meeting sound business objectives and resolving environmental concerns are not mutually exclusive. To understand this critical observation, it is important to examine a concept known as *ecoefficiency*.

The Ecoefficiency Paradigm

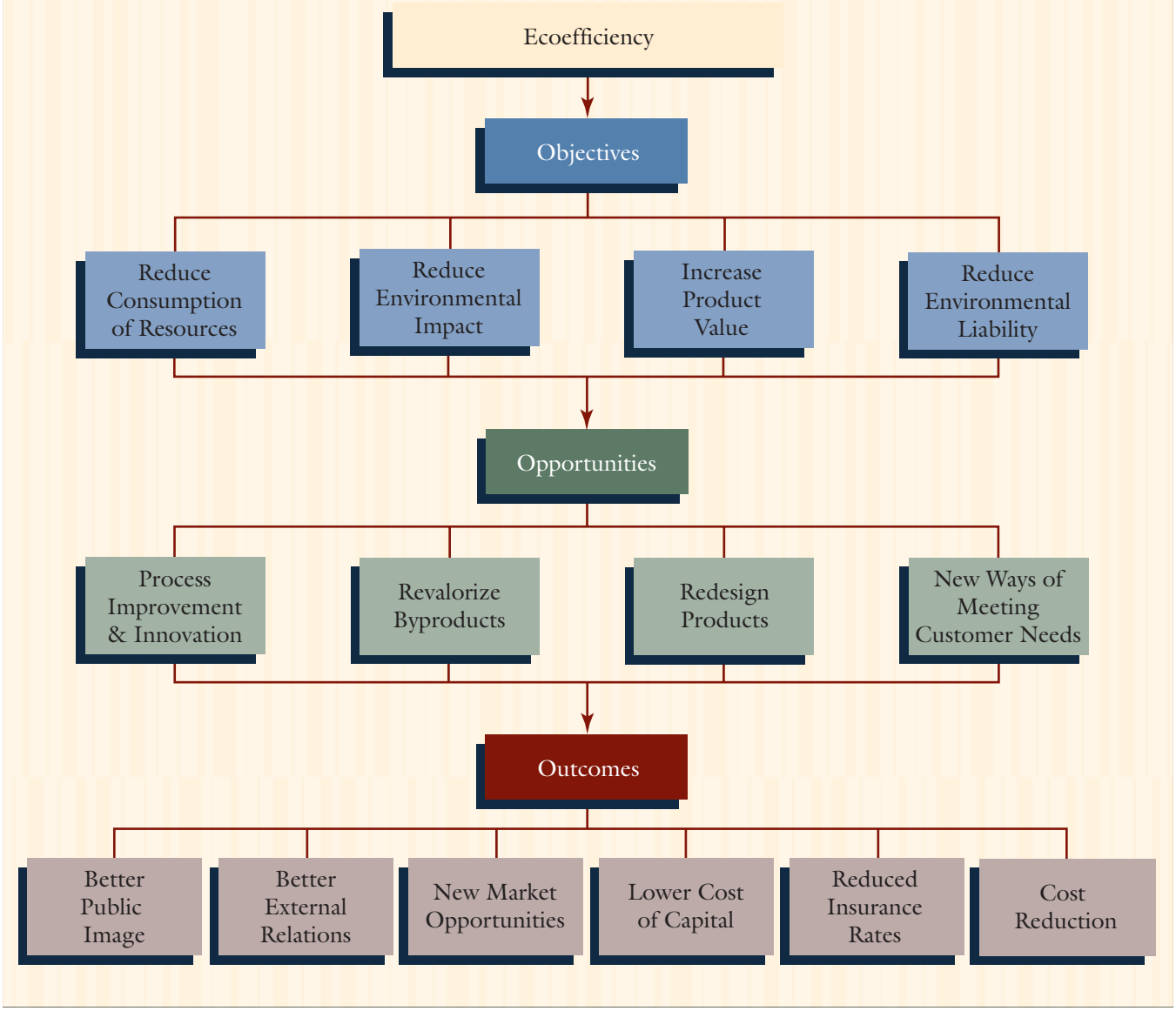
Ecoefficiency is defined as the ability to produce competitively priced goods and services that satisfy customer needs while *simultaneously* reducing negative environmental impacts, resource consumption, and costs. Ecoefficiency means producing more goods and services using less materials, energy, water, and land, while, at the same time, minimizing air emissions, water discharges, waste disposal, and the dispersion of toxic substances. However, perhaps the most important claim of the ecoefficiency paradigm is that preventing pollution and avoiding waste is economically beneficial—that it is possible to do more with less. Moreover, it is complementary to and supportive of *sustainable development*. **Sustainable development** is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Although absolute sustainability may not be attainable, progress toward its achievement certainly seems to have some merit.

Ecoefficiency implies a positive relationship between environmental and economic performance. Exhibit 16-1 illustrates the objectives, opportunities, and outcomes that define the relationships envisioned by ecoefficiency.[2] Four broad objectives are revealed: (1) reduce the consumption of resources, (2) reduce the environmental impact, (3) increase product value, and (4) reduce environmental liability. Reducing the consumption of resources entails such things as reducing the use of energy, materials, water, and land. It also includes increasing product durability and enhancing product recyclability. Reducing environmental impact is primarily concerned with minimizing releases of pollutants into the environment and encouraging the sustainable use of renewable resources. Increasing product value means that products are produced that provide the functionality that customers need but with fewer materials and less resources. It also means that products are

1. David Shields, Beth Beloff, and Miriam Heller, "Environmental Cost Accounting for Chemical and Oil Companies: A Benchmarking Study," an online Environmental Protection Agency (EPA) article at http://www.epa.gov/opptintr/acctg/ as of October 19, 2004.
2. The objectives and opportunities are those identified by the World Business Council for Sustainable Development (WBCSD). See the WBCSD paper, "Ecoefficiency: Creating More Value with Less Impact," online at http://www.wbcsd.ch as of October 20, 2004.

produced without degrading the environment, and their use and disposal are environmentally friendly. The fourth objective, reducing environmental liability, requires that a company identify and efficiently manage the risks and opportunities relating to the environment. Achievement of the objectives requires a firm to seek opportunities to improve ecoefficiency, which brings us to the second level of Exhibit 16-1.

EXHIBIT 16-1 **Ecoefficiency Relationships**



Process improvement and innovation are familiar methods for increasing efficiency. In this case, however, the objective is to increase ecoefficiency, which means that process changes must focus simultaneously on reducing costs and improving environmental performance. Process improvement is most useful for improving relative environmental performance, but process reengineering is probably more suitable for major advances in ecoefficiency. Revalorizing by-products describes the search for ways to convert waste materials into useful products or useful inputs for other companies' products. **Lura Group**, for example, converted the sludge from its wastewater treatment facility into

commercial compost.[3] Product design is another key method for improving ecoefficiency. Products can be redesigned so that they use fewer materials, a smaller variety of materials, and less toxic materials and are easier to take apart for recycling while simultaneously providing a high degree of functionality for users. **Volkswagen**'s Lupo 3L TDI passenger car, for example, is designed to facilitate the segregation of materials in the dismantling and recycling processes.[4] Finally, ecoefficiency can be improved by finding different and better ways of satisfying customer needs. This may entail redefining markets and reshaping supply and demand. For example, providing a service instead of selling a product has the potential of creating higher resource efficiency and less pollution. Car sharing is an example of this last approach. **Mobility**, a car-sharing company in Switzerland, provides a service to people who want to use a car without buying their own. These cars are parked at convenient locations such as railway stations. Clients arrange to use the cars for a prearranged period of time. Interestingly, this service has changed travel behavior. Car-sharing clients increase their use of public transportation and, thus, reduce the need for cars and fuel.[5]

The third and final level of Exhibit 16-1 illustrates the payoffs of ecoefficiency. Pursuing the opportunities just discussed can produce a number of beneficial outcomes. Reduced environmental impacts can create social benefits like a better public image and better relations in the community and with regulators. This, in turn, improves the company's image and enhances its ability to sell products and services. Efforts to improve ecoefficiency also may increase revenues by creating new markets (e.g., creating outputs that were formerly classified as useless residues). Ecoefficient firms tend to reduce their environmental risks and, consequently, capture external benefits such as a lower cost of capital and lower insurance rates. Finally, cost reductions follow improvements in environmental performance.

The cost reduction and competitiveness incentive is particularly important. Environmental costs can be a significant percentage of total operating costs; interestingly, many of these costs can be reduced or eliminated through effective management. For example, knowledge of environmental costs and their causes may lead to redesign of a process that, as a consequence, reduces the materials used and the pollutants emitted to the environment (an interaction between the innovation and cost reduction incentives). Thus, current and future environmental costs are reduced, and the firm becomes more competitive. For example, **bpi.industrial**, a supplier of heavy duty polythene sacks for animal feed, chemicals, and other industries, has saved over £700,000 per year in materials, solvents, and energy by improving process controls and switching to solvent-free processes.[6]

Effective cost management leading to cost reduction such as that described for bpi.industrial means that environmental cost information must be provided to management. To provide this financial information, it is necessary to define, measure, classify, and assign environmental costs to processes, products, and other cost objects of interest. Environmental costs should be reported as a separate classification so managers can assess their impact on firm profitability. Furthermore, assigning environmental costs to products and processes reveals the sources of these costs and helps identify their fundamental causes so that they can be controlled.

Competing Paradigms

Ecoefficiency is not the only environmental cost paradigm. A competing paradigm is that of *compliance management*. **Compliance management** is simply the practice of achieving the minimal environmental performance required by regulations—and to do so as cheaply as possible. No effort is made to go beyond this minimal environmental

3. WBCSB paper, "Ecoefficiency: Creating More Value with Less Impact."
4. Ibid.
5. Ibid.
6. "CS 274, *Process Changes at Plastics Company Saves Costs and Waste*," *Envirowise*, at http://www.envirowise.gov.uk/envirowisev3.nsf/key/CROD4W6H6D as of October 22, 2004.

performance because the belief held is that improving environmental performance and improving economic performance are incompatible objectives. This view is driven by the concept that pollution, a negative output, could be reduced only by using resources that could have been used to produce good output. Thus, improving environmental performance is virtually always a costly activity for a firm.

A second competing paradigm is that of *guided ecoefficiency*. **Guided ecoefficiency** maintains that pollution is a form of economic inefficiency and that properly designed environmental regulations will stimulate innovation such that environmental performance and economic efficiency will simultaneously improve. Under this view, the type of regulation required is that which specifies the required level of improvement in environmental performance *without specifying how this improvement is to be achieved*. According to this view, regulatory intervention is required because managers have bounded rationality and if left to themselves will not voluntarily undertake actions to improve environmental performance. Regulation signals to managers that economic inefficiencies are present and that, through innovation, cost savings can be realized with attendant improvement in environmental performance.[7]

Environmental Costs Defined

Before environmental cost information can be provided to management, environmental costs must be defined. Various possibilities exist; however, an appealing approach is to adopt a definition consistent with a total environmental quality model. In the total environmental quality model, the ideal state is that of zero damage to the environment (analogous to the zero-defects state of total quality management). Damage is defined as either direct degradation of the environment such as the emission of solid, liquid, or gaseous residues into the environment (e.g., water contamination and air pollution) or indirect degradation such as *unnecessary* usage of materials and energy. Accordingly, environmental costs can be referred to as *environmental quality costs*. In a similar sense to quality costs, **environmental costs** are costs that are incurred because poor environmental quality exists or *may* exist. Thus, environmental costs are associated with the creation, detection, remediation, and prevention of environmental degradation. With this definition, environmental costs can be classified into four categories: prevention costs, detection costs, internal failure costs, and external failure costs. External failure costs, in turn, can be subdivided into realized and unrealized categories.

Environmental prevention costs are the costs of activities carried out to prevent the production of contaminants and/or waste that could cause damage to the environment. Pollution prevention activities are often referred to as "P2" activities. Examples of prevention activities include evaluating and selecting suppliers, evaluating and selecting equipment to control pollution, designing processes and products to reduce or eliminate contaminants, training employees, studying environmental impacts, auditing environmental risks, undertaking environmental research, developing environmental management systems, recycling products, and obtaining ISO 14001 certification.[8]

Environmental detection costs are the costs of activities executed to determine if products, processes, and other activities within the firm are in compliance with appropriate environmental standards. The environmental standards and procedures that a firm seeks to follow are defined in three ways: (1) regulatory laws of governments, (2) voluntary standards (ISO 14000) developed by the International Standards Organization, and (3) environmental policies developed by management. Examples of

7. Michael Porter and Class van der Linde, "Toward a New Conception of the Environmental Competitiveness Relationship, *Journal of Economic Perspective* 9(4) (1995): 97–118.

8. ISO 14001 certification is obtained when an organization installs an environmental management system that satisfies specific, privately set international standards. These standards are concerned with environmental *management* procedures and do not directly indicate acceptable levels of environmental performance. The certification, therefore, functions primarily as a signal that a firm is interested and willing to improve its environmental performance.

detection activities are auditing environmental activities, inspecting products and processes (for environmental compliance), developing environmental performance measures, carrying out contamination tests, verifying supplier environmental performance, and measuring levels of contamination.

Environmental internal failure costs are costs of activities performed because contaminants and waste have been produced but not discharged into the environment. Thus, internal failure costs are incurred to eliminate and manage contaminants or waste once produced. Internal failure activities have one of two goals: (1) to ensure that the contaminants and waste produced are not released to the environment or (2) to reduce the level of contaminants released to an amount that complies with environmental standards. Examples of internal failure activities include operating equipment to minimize or eliminate pollution, treating and disposing of toxic materials, maintaining pollution equipment, licensing facilities for producing contaminants, and recycling scrap.

Environmental external failure costs are the costs of activities performed *after* discharging contaminants and waste into the environment. **Realized external failure costs** are those incurred and paid for by the firm. **Unrealized external failure (societal) costs** are caused by the firm but are incurred and paid for by parties outside the firm. Societal costs can be further classified as (1) those resulting from environmental degradation and (2) those associated with an adverse impact on the property or welfare of individuals. In either case, the costs are borne by others and not by the firm even though the firm causes them. Of the four environmental cost categories, the external failure category is the most devastating. For example, the General Accounting Office estimated $259 million in cleanup costs of hazardous materials at six military installations.[9] Furthermore, during fiscal year 2003, more companies spent $2.9 billion in cleanup activities resulting from enforcement actions of the federal government.[10] Examples of realized external failure activities are cleaning up a polluted lake, cleaning up oil spills, cleaning up contaminated soil, using materials and energy inefficiently, settling personal injury claims from environmentally unsound practices, settling property damage claims, restoring land to its natural state, and losing sales from a bad environmental reputation. Examples of societal costs include receiving medical care because of polluted air (individual welfare), losing a lake for recreational use because of contamination (degradation), losing employment because of contamination (individual welfare), and damaging ecosystems from solid waste disposal (degradation).

Exhibit 16-2 summarizes the four environmental cost categories and lists specific activities for each category. Within the external failure cost category, societal costs are labeled with an "S." The costs for which the firm is financially responsible are called **private costs**. All costs without the S label are private costs.

Environmental Cost Report

Environmental cost reporting is essential if an organization is serious about improving its environmental performance and controlling environmental costs. A good first step is a report that details the environmental costs by category. Reporting environmental costs by category reveals two important outcomes: (1) the impact of environmental costs on firm profitability and (2) the relative amounts expended in each category. Exhibit 16-3, on page 702, provides an example of a simple environmental cost report.

The report in Exhibit 16-3 highlights the importance of the environmental costs by expressing them as a percentage of total operating costs. In this report, environmental costs are 30 percent of total operating costs, seemingly a significant amount. From a practical point of view, environmental costs will receive managerial attention

9. GAO-02-117, "Environmental Liabilities: Cleanup Costs from Certain DOD Operations Are Not Being Reported," December 2001.
10. Bruce Geiselman, "Polluters Pay Billions in Cleanup Costs," *Business Insurance*, Vol. 38, Issue 1 (January 2004): 21.

EXHIBIT 16-2 Classification of Environmental Costs by Activity

Prevention Activities

- Evaluating and selecting suppliers
- Evaluating and selecting pollution control equipment
- Designing processes
- Designing products
- Carrying out environmental studies
- Auditing environmental risks
- Developing environmental management systems
- Recycling products
- Obtaining ISO 14001 certification

Detection Activities

- Auditing environmental activities
- Inspecting products and processes
- Developing environmental performance measures
- Testing for contamination
- Verifying supplier environmental performance
- Measuring contamination levels

Internal Failure Activities

- Operating pollution control equipment
- Treating and disposing of toxic waste
- Maintaining pollution equipment
- Licensing facilities for producing contaminants
- Recycling scrap

External Failure Activities

- Cleaning up a polluted lake
- Cleaning up oil spills
- Cleaning up contaminated soil
- Settling personal injury claims (environmentally related)
- Restoring land to natural state
- Losing sales due to poor environmental reputation
- Using materials and energy inefficiently
- Receiving medical care due to polluted air (S)
- Losing employment because of contamination (S)
- Losing a lake for recreational use (S)
- Damaging ecosystems from solid waste disposal (S)

Note: "S" = societal costs.

only if they represent a significant amount. Considerable evidence now exists concerning this issue. Companies like **GM**, **Commonwealth Edison**, and **Andersen Corporation** have saved millions of dollars by reducing or eliminating significant environmental impacts associated with their supply chains.[11] Other companies like **Xerox Europe**, **Ipiranga Group**, and **UPM-Kymmene** have produced significant savings while simultaneously improving environmental performance and operating efficiency.[12] It appears that reducing environmental costs by improving environmental performance can significantly increase a firm's profitability.

The cost report also provides information relating to the relative distribution of the environmental costs. A relative distribution of environmental costs is shown in Exhibit 16-4 on page 703. Of the total environmental costs, only 20 percent are from the prevention and detection categories. Thus, eighty percent of the environmental costs are failure costs—costs that exist because of poor environmental performance. This distribution emphasizes the need to increase P2 activities. Like the quality costing model, the underlying concept is that increasing prevention activities will drive down the costs of failure activities in a way that is cost-beneficial.

11. EPA, *The Lean and Green Supply Chain: A Practical Guide for Materials Managers to Reduce Costs and Improve Financial Performance*, EPA 742-R-00-001, January 2000.
12. See the case studies described at http://www.wbcsd.ch as of October 2004.

EXHIBIT 16-3 **Environmental Cost Report**

Verde Corporation
Environmental Cost Report
For the Year Ended December 31, 2007

	Environmental Costs		Percentage of Operating Costs*
Prevention costs:			
Training employees	$ 180,000		
Designing products	540,000		
Selecting equipment	120,000	$ 840,000	2.80%
Detection costs:			
Inspecting processes	$ 720,000		
Developing measures	240,000	960,000	3.20
Internal failure costs:			
Operating pollution equipment	$1,200,000		
Maintaining pollution equipment	600,000	1,800,000	6.00
External failure costs:			
Cleaning up lake	$2,700,000		
Restoring land	1,500,000		
Property damage claim	1,200,000	5,400,000	18.00
Totals		$9,000,000	30.00%

*Total operating costs are $30,000,000.

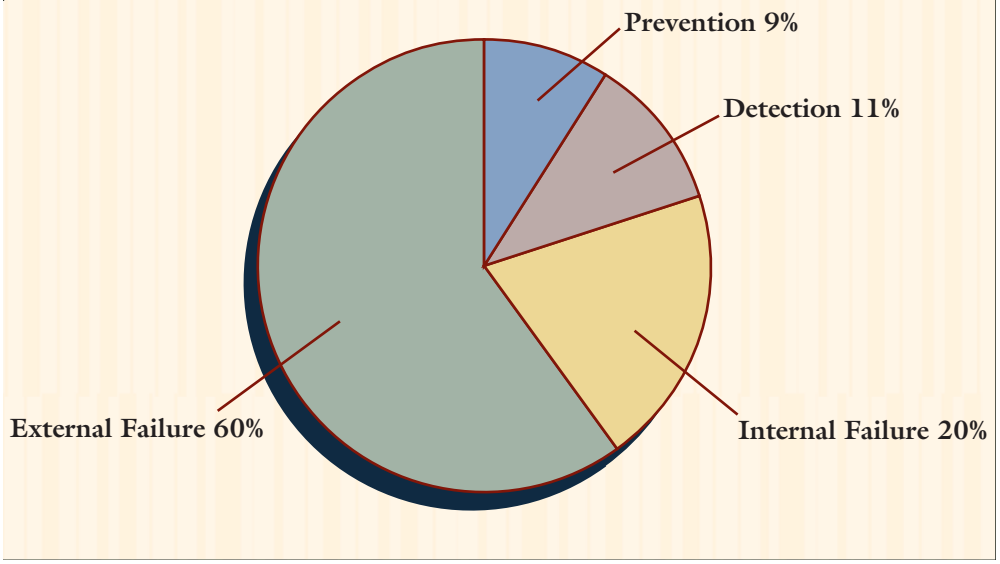
Environmental Cost Reduction

Investing more in prevention (P2) and detection activities can bring about a significant reduction in environmental failure costs. For example, **Texas Petrochemicals Corporation** modified its existing on-site electrical generating system with the objective of reducing the consumption of energy, water, and chemicals. These objectives were all achieved and produced savings of $2.3 million annually, with a capital investment of $650,000 to bring about the modifications. Thus, the payback was just a little over three months.[13] In the organic chemical industrial sector, studies concerned with efforts to prevent toxic waste have shown that for every dollar spent on prevention activities, $3.49 was saved from environmental failure activities (per year).[14]

Environmental costs appear to behave in much the same way as quality costs. The lowest environmental costs are attainable at the *zero-damage point* much like the zero-defects point of the total quality cost model. Thus, an ecoefficient solution would focus on prevention with the usual justification that *prevention is cheaper than the cure*. Analogous to the total quality management model, zero damage is the lowest cost point for environmental costs.

13. From "The Virtual Tour of Regulations and P2 Information (case studies)," at http://www.chemalliance.org/Handbook/plant/index.htm as of October 23, 2004.
14. Michael E. Porter and Claus van der Linde, "Green and Competitive: Ending the Stalemate," *Harvard Business Review* (September–October 1995): 120–134.

EXHIBIT 16-4 **Relative Distribution: Environmental Costs**



COST MANAGEMENT Technology in Action

E-commerce has produced a rather interesting means of promoting and facilitating recycling. **Throwplace.com** is what one might call the "Internet's landfill alternative." Throwplace.com provides a site where surplus inventory and outdated equipment can be listed—without cost—for donation to charities, nonprofit institutions, and businesses for reuse. Items can be placed into one of three categories: Charity, Business, or Up-For-Grabs. In the Charity category, charities and nonprofit businesses can make requests for listings and are required to provide receipts to donors. In the Business category, businesses and individuals claim the listed items for reuse or recycling. The Up-For-Grabs category provides items such as bottle caps, corkscrews, and egg crates—items that can be of interest to those doing art projects or looking for unusual items to collect.

The tax write-off for listed items often produces more benefit to retailers than having the items tie up valuable shelf space. Furthermore, the site provides a means for businesses involved in recycling and refurbishing to locate equipment that can be refurbished and resold or used as a source of parts. Throwplace.com is also a forum where collectors and recyclers can place ads for specific items. The motto for Throwplace.com is "Take what you need, and Throw what you don't." The site claims to be a place where "the public and sustainable business communities interact, raising awareness of our world-wide need to reuse and recycle consumables."

Source: Throwplace.com, "The Internet's Landfill Alternative," September 21, 2004.

Evidence exists that zero degradation is the low cost point for many types of contaminating activities. For example, **Texas Eastman**, a producer of resins, produced a waste by-product that was being sent to landfills at the rate of 500,000 pounds per year. A system was installed to rework the waste material back into the production process and refine it into an acceptable product.[15] The cost of the system was $435,000, the 500,000 pounds of waste were totally eliminated, and the savings were $395,000 per year (from sale of the recovered product and reduced disposal fees). The payback of the new system was just a little over a year. It is interesting to point out that the decision to invest in the zero-waste system was economically sound and was not a charitable act on the part of

15. From "The Virtual Tour of Regulations and P2 Information (case studies)," at http://www.chemalliance.org/Handbook/plant/index.htm as of October 23, 2004.

Texas Eastman. Even without regulatory mandates, the investment in the new system was justified. As more firms become aware of ecoefficient possibilities, the demand for command and control approaches to environmental management should decrease.

An Environmental Financial Report

Ecoefficiency suggests a possible modification to environmental cost reporting. Specifically, in addition to reporting environmental costs, why not report *environmental benefits*? In a given period, there are three types of benefits: additional revenues, current savings, and cost avoidance (ongoing savings). Additional revenues are revenues that flow into the organization due to environmental actions such as recycling paper, finding new applications for nonhazardous waste (e.g., using wood scraps to make wood chess pieces and boards), and increased sales due to an enhanced environmental image. Cost avoidance refers to ongoing savings of costs that had been paid in prior years. Current savings refer to reductions in environmental costs achieved in the current year. By comparing benefits produced with environmental costs incurred in a given period, a type of environmental financial statement is produced. Managers can use this statement to assess progress (benefits produced) and potential for progress (environmental costs). The environmental financial statement could also form part of an environmental progress report that is provided to shareholders on an annual basis. Exhibit 16-5

EXHIBIT 16-5 Environmental Financial Statement

Verde Corporation
Environmental Financial Statement
For the Year Ended December 31, 2007

Environmental benefits:	
Income sources:	
Recycling income	$ 600,000
Revenues from waste-derived products	150,000
Ongoing savings:	
Cost reductions, contaminants	900,000
Cost reductions, hazardous waste disposal	1,200,000
Current savings:	
Energy conservation cost savings	300,000
Packaging cost reductions	450,000
Total environmental benefits	$3,600,000
Environmental costs:	
Prevention costs:	
Designing processes for the environment	$ 640,000
Supplier evaluation and selection	200,000
Detection costs:	
Testing for contamination	560,000
Measuring contamination levels	400,000
Internal failure costs:	
Waste treatment, transport, and disposal	1,500,000
Operating pollution control equipment	300,000
External failure costs:	
Inefficient materials usage	1,400,000
Cleaning up soil	4,000,000
Total environmental costs	$9,000,000

provides an example of an environmental financial statement. The benefits reported reveal good progress, but the costs are still two and one-half times the benefits, indicating that more improvements are clearly needed.

OBJECTIVE 2

Discuss environmental costs, and show how they are assigned to products and processes.

Environmental Costing

Both products and processes are sources of environmental costs. Processes that *produce* products can create solid, liquid, and gaseous residues that are subsequently introduced into the environment. These residues have the potential of degrading the environment. Residues, then, are the causes of both internal and external environmental failure costs (e.g., investing in equipment to prevent the introduction of the residues into the environment and cleaning up residues after they are allowed into the environment). Production processes are not the only source of environmental costs. Packaging is also a source. For example, in the United States, thirty percent of all municipal solid waste is packaging material.[16]

Products themselves can be the source of environmental costs. After selling a product, its use and disposal by the customer can produce environmental degradation. These are examples of *environmental post-purchase costs.* Most of the time environmental post-purchase costs are borne by society and not by the company and, thus, are societal costs. On occasion, however, environmental post-purchase costs are converted into realized external costs.

Environmental Product Costs

The environmental costs of processes that produce, market, and deliver products and the environmental post-purchase costs caused by the use and disposal of the products are examples of *environmental product costs.* **Full environmental costing** is the assignment of all environmental costs, both private and societal, to products. **Full private costing** is the assignment of only private costs to individual products. Private costing, then, would assign the environmental costs to products caused by the internal processes of the organization. Private costing is probably a good starting point for many firms. Private costs can be assigned using data created *inside* the firm. Full costs require gathering of data that are produced outside the firm from third parties. As the firm gains experience with environmental costing, it may be well advised to expand product cost assignments and implement an approach called *life-cycle cost assessment*, which is discussed later in the chapter.

Assigning environmental costs to products can produce valuable managerial information. For example, it may reveal that a particular product is responsible for much more toxic waste than other products. This information may lead to an alternative design for the product or its associated processes that is more efficient and environmentally friendly. It could also reveal that with the environmental costs correctly assigned, the product is not profitable. This could mean something as simple as dropping the product to achieve significant improvement in environmental performance and economic efficiency. Many opportunities for improvement may exist, but knowledge of the environmental product costs is the key. Moreover, environmental costs must be assigned accurately.

Unit-Based Environmental Cost Assignments

In most cost accounting systems, environmental costs are hidden within overhead. Using the environmental cost definitions and classification framework just developed, environmental costs must first be separated into an environmental cost pool. Once separated into their own pool, unit-based costing would assign these costs to individual products using unit-level drivers such as direct labor hours and machine hours. This approach may

16. T. E. Graedel and B. R. Allenby, *Industrial Ecology* (Englewood Cliffs, NJ: Prentice Hall, 1995): 243.

work well for a homogeneous product setting; however, in a multiple-product firm, with product diversity, a unit-based assignment can produce cost distortions.

Suppose, for example, that a company produces two products: window and door parts. There are 200,000 parts of each type produced, and each part requires *one-fourth* of a machine hour. Assume that machine hours will be used to assign environmental costs to products. In producing the parts, methylene chloride emissions occur. To produce these emissions, a special government permit must be purchased that costs $600,000. The permit must be renewed every three years. Thus, the permit cost is $200,000 per year. The permit authorizes a certain level of methylene chloride emissions. If emissions exceed the allowed level, a fine is imposed. One unannounced inspection occurs each quarter. The firm averages $100,000 per year in fines. Thus, the annual cost of methylene chloride emissions is $300,000 ($200,000 + $100,000). The environmental cost per machine hour is $3 ($300,000/100,000 machine hours). Use of this rate produces an environmental cost per unit of $0.75 for each product ($3 × 1/4 machine hour).

The accuracy of the assignment is critical. For example, what if the window parts are responsible for all or most of the emissions? If window parts are responsible for all of the emissions, then the environmental cost should be $1.50 per unit for this product and $0 per unit for door parts. In this case, the window parts were undercosted, and the door parts were overcosted. This possibility is not imaginary. Something very similar happened with **Spectrum Glass**, a producer of specialty glass. In producing its glass products, cadmium emissions occurred. It discovered that only one product, "Ruby Red," was responsible for all its cadmium emissions.[17] Yet, its cost accounting system was assigning a portion of this cost to every product produced.

Activity-Based Environmental Cost Assignments

The emergence of activity-based costing facilitates environmental costing. Tracing the environmental costs to the products responsible for the environmental costs is a fundamental requirement of a sound environmental accounting system. Assigning costs using causal relationships is needed. This approach, of course, is exactly what ABC does.

The Methylene Chloride Example Revisited

Emitting methylene chloride is the environmental activity (in this case, an external failure activity). The cost of the activity is the cost of the fine and the permit fees: $300,000. Assume now that the quantity of emissions is the activity output measure. Let that quantity be 60,000 units. The activity rate is $5.00 per unit ($300,000/60,000 units). If window parts produce 60,000 units of emissions and door parts produce zero units, then the cost assignments are as they should be: $300,000 to window parts ($5.00 × 60,000) and $0 to door parts. This ABC assignment produces a unit environmental cost of $1.50 for window parts ($300,000/200,000) and $0 for door parts.

The costs assigned in this example are all private costs. Societal costs are also possible. If they occur and can be estimated, then a fuller costing approach can be used. For example, suppose that methylene chloride emissions cause $300,000 per year in medical expenses for those who live in the community affected by the emissions. In this case, the cost per unit for window parts would double.

Example with Multiple Activities

The methylene chloride example had only one activity. In reality, there will be multiple environmental activities. Each activity will be assigned costs, and activity rates will be computed. These rates will then be used to assign environmental costs to products based on usage of the activity. Exhibit 16-6 shows the assignment of environmental costs to two products (two different types of industrial solvents) when there are a variety of activities. This cost assignment allows managers to see the relative environmental economic

17. Daniel Baker, "Environmental Accounting's Conflicts and Dilemmas," *Management Accounting* (October 1996): 46–48.

impact of the two products. To the extent that environmental costs reflect environmental damage, the unit environmental cost can also act as an index or measure of product cleanliness. The "dirtier" products can then be the focus of efforts to improve environmental performance and economic efficiency. Exhibit 16-6 reveals, for example, that Solvent IIY has more environmental problems than Solvent IX. Solvent IIY's environmental costs total $760,000 ($7.60 × 100,000) and are 19 percent of the total manufacturing costs. Furthermore, its environmental failure costs are $700,000 ($7.00 × 100,000), representing 92 percent of the total environmental costs. Solvent IX portrays a much better picture. Its environmental costs total $156,000, which is 8 percent of the total manufacturing costs ($156,000/$1,960,000), and the failure costs ($0.46 × 100,000) are 29.5 percent of the total environmental costs ($46,000/$156,000). It is evident that Solvent IIY offers the most potential for environmental and economic improvement.

EXHIBIT 16-6 ABC Environmental Costing

Activities	Solvent IX	Solvent IIY
Prevention and Detection Activities:		
Evaluate and select suppliers	$ 0.40	$ 0.10
Design processes (to reduce pollution)	0.20	0.20
Inspect processes (for pollution problems)	0.50	0.30
Subtotal	$ 1.10	$ 0.60
Failure Activities:		
Capture and treat chlorofluorocarbons	$ 0.10	$ 2.00
Maintain environmental equipment	0.00	1.00
Toxic waste disposal	0.20	3.50
Excessive material usage	0.16	0.50
Subtotal	$ 0.46	$ 7.00
Environmental cost per unit	$ 1.56	$ 7.60
Other (nonenvironmental) manufacturing costs per unit	18.04	32.40
Total unit cost	$19.60	$40.00
Units produced	100,000	100,000

OBJECTIVE 3

Describe the life-cycle cost assessment model.

Life-Cycle Cost Assessment

The environmental product costs may reveal a need to improve a company's *product stewardship*. **Product stewardship** is the practice of designing, manufacturing, maintaining, and recycling products to minimize adverse environmental impacts. *Life-cycle assessment* is the means for improving product stewardship. **Life-cycle assessment** identifies the environmental consequences of a product through its entire life cycle and then searches for opportunities to obtain environmental improvements. **Life-cycle cost assessment** assigns costs and benefits to the environmental consequences and improvements.

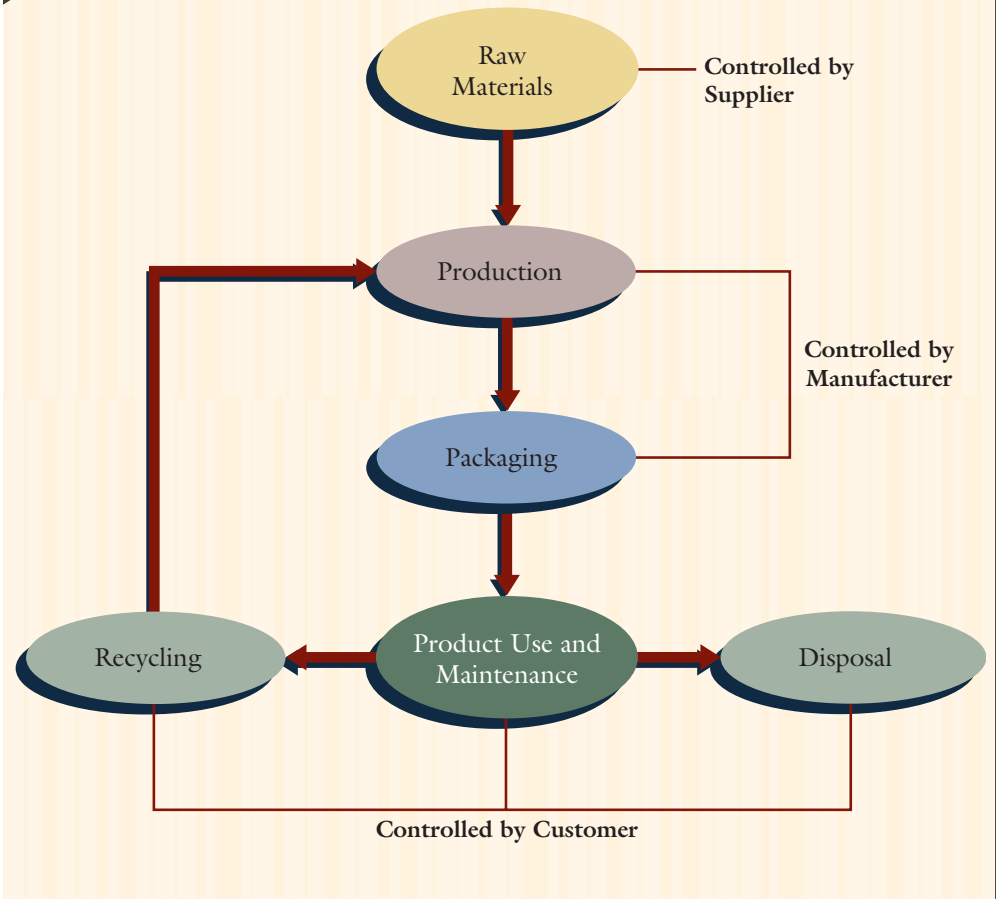
Product Life Cycle

The EPA has identified four stages in the life cycle of a product: resource extraction, product manufacture, product use, and recycling and disposal.[18] Another possible stage, not explicitly considered by the EPA guidelines, is that of product packaging. Product

18. *Life-Cycle Assessment: Inventory Guidelines and Principles*, EPA/600/R-92/245 (February 1993).

life cycle, including packaging, is illustrated in Exhibit 16-7. As illustrated, the different life-cycle stages can be under the control of someone other than the producer of the product. Note that the source of materials for the product can come through extraction (raw materials) or from recycling. If all or some of the product's components cannot be recycled, then disposal is required, and waste management becomes an issue.

EXHIBIT 16-7 Product Life-Cycle Stages



The life-cycle viewpoint adopted combines supplier, manufacturer, and customer viewpoints. Thus, both internal and external linkages are considered important in assessing environmental consequences of different products, product designs, and process designs. If the cost accounting system is going to play a role in life-cycle assessment, then the most obvious system is assessing and assigning the environmental costs caused by the producer in each of the life-cycle stages. Managers will then be able to compare the economic effects of competing designs. However, before discussing cost assessment, a more detailed understanding of life-cycle analysis is needed.

Assessment Stages

Life-cycle assessment is defined by three formal stages: (1) inventory analysis, (2) impact analysis, and (3) improvement analysis.[19] **Inventory analysis** specifies the types and quantities of materials and energy inputs needed and the resulting environmental releases in

19. Graedel and Allenby, *Industrial Ecology*, 108–121.

the form of solid, liquid, and gaseous residues. Inventory analysis spans the product's life cycle. **Impact analysis** assesses the environmental effects of competing designs and provides a relative ranking of those effects. **Improvement analysis** has the objective of reducing the environmental impacts revealed by the inventory and impact steps.

Inventory Analysis

To illustrate inventory analysis, consider single-use, hot-drink cups for fast-food restaurants. A producer can choose to make the cups using either paper or polystyrene foam. Each stage in the cup's life cycle produces certain key questions:

- What are the materials required for each type of cup?
- What are the energy requirements to produce each product?
- What kinds of effluents and emissions are produced by each?
- What is the recycle potential?
- What are the resources required for ultimate disposal?

Answering these questions defines inventory analysis. Exhibit 16-8 provides answers for the questions based on data reported in a study by Martin Hocking.[20]

EXHIBIT 16-8 Inventory Analysis

	Paper Cup	Polyfoam Cup
Material usage per cup:		
Wood and bark (g)	33.0	0.0
Petroleum (g)	4.1	3.2
Finished weight (g)	10.0	11.5
Utilities per Mg of material:		
Steam (kg)	9,000–12,000	5,000
Power (GJ)	3.5	0.4–0.6
Cooling water (m^3)	50	154
Water effluent per Mg of material:		
Volume (m^3)	50–190	0.5–2.0
Suspended solids (kg)	35–600	trace
BOD(kg)	30–500	0.07
Organochlorides (kg)	5–70	0
Metal salts (kg)	1–20	20
Air emissions per Mg of material:		
Chlorine (kg)	0.5	0
Sulfides (kg)	2.0	0
Particulates (kg)	5–15	0.1
Pentane (kg)	0	35–50
Recycle potential:		
Primary user	Possible	Easy
After use	Low	High
Ultimate disposal:		
Heat recovery (Mj/kg)	20	40
Mass to landfill (g)	10.1	11.5
Biodegradable	Yes	No

20. M. B. Hocking , "Paper versus Polystyrene: A Complex Choice," *Science*, 251 (1991): 504–505.

Impact Analysis

Impact analysis next assesses the meaning of the values provided by the inventory analysis step. For example, one advantage of paper cups is that paper is made from a renewable resource (wood and chips), whereas the polyfoam cup relies on petroleum, a nonrenewable resource. More careful examination, however, reveals that paper cups actually use more petroleum than polyfoam cups! The reason? To convert wood chips to pulp to paper cups uses energy. Effluents and emissions produced during the products' life cycles are also listed in Exhibit 16-8. Interestingly, the only significant environmental release for polyfoam cups is pentane, a blowing agent. On the other hand, production of paper cups requires extensive use of inorganic chemicals and large amounts of water effluents. Furthermore, recycling seems to favor polyfoam cups. However, ultimate disposal, at least in landfills, tends to favor paper cups because of their biodegradability. Yet, this advantage is called into question by recent studies indicating that biodegradable materials in anaerobic landfills remain *undegraded* over relatively long periods of time.[21] From the viewpoint of a variety of environmental impacts, perhaps polyfoam cups are better than paper cups!

Cost Assessment

Up to this point, the analysis has used only nonfinancial measures and qualitative factors. The hot-drink cup example, however, does offer the opportunity to introduce costs and discuss their value in life-cycle assessment. Life-cycle cost assessment is determining the financial consequences of the environmental impacts identified in the inventory and improvement steps of life-cycle assessment. Assessing environmental costs for the inventory stage can facilitate impact analysis. In the paper cup versus polyfoam cup example, the comparisons of operational data were fairly clean in the sense that one product's environmental impacts were almost always less than the other product's. But even here, some questions can be raised. For example, what is the cost of producing pentane emissions compared to the cost of water effluents and particulates? What are the economic benefits from recycling polyfoam cups? The advantage of assigning costs is that the total environmental costs provide an index that can be used for ranking the competing alternatives. How are costs assigned?

The answer to the cost assignment question has already been given. Materials costs are assigned through direct tracing. We can identify the amount of materials consumed per unit and then multiply by the price paid for the materials. Energy costs and the costs of producing environmental releases are assigned through driver tracing. Thus, for existing products (or processes, if they are the cost object), we simply identify the associated environmental activities and their costs, calculate an activity rate, and assign those costs to the respective products. If some of the energy consumption and environmental releases are associated with the use of the product after purchase, then a full environmental costing analysis requires their inclusion. It is also possible to assign only private costs. Recycling and disposal are separate but important issues. Many of the costs here are societal costs, and their measurement becomes more difficult. Taking only a private costing approach is also possible for recycling and disposal.

For example, assume that the following environmental costs per unit have been determined for the two cups:

	Paper Cups	*Polyfoam Cups*
Material usage	$ 0.010	$ 0.004
Utilities	0.012	0.003
Contaminant-related resources	0.008	0.005
Total private costs	$ 0.030	$ 0.012
Recycling benefits (societal)	(0.001)	(0.004)
Environmental cost per unit	$ 0.029	$ 0.008

21. Graedel and Allenby, *Industrial Ecology*, 149.

The unit life-cycle costs provide a summary measure of the relative environmental impacts of the two products and serve to support the qualitative interpretations of the operational and subjective environmental data found in Exhibit 16-8.

These observations are borne out by actual experience. **Chrysler Corporation**, for example, used life-cycle cost management analysis to choose a mercury-free switch over a mercury switch for an underhood convenience lighting package. Before considering the associated environmental costs, the mercury switch had a $0.12 price advantage over the mercury-free switch. However, after factoring in environmental costs stemming from such sources as recyclability, end-of-cycle disposal costs, tooling costs (to manufacture labels), labeling requirements, insurance premiums, environmental training, personal protective equipment, and emissions, the cost advantage shifted to the mercury-free switch (producing a $0.12 advantage over the mercury switch—a $0.24 turnaround).[22]

Improvement Analysis

Assessing the environmental impacts in operational and financial terms sets the stage for the final step, that of searching for ways to reduce the environmental impacts of the alternatives being considered or analyzed. It is this step that connects with the control system of an organization. Improving the environmental performance of existing products and processes is the overall objective of an environmental control system.

OBJECTIVE 4

Compare and contrast activity-based and strategic-based environmental control.

Strategic-Based Environmental Responsibility Accounting

The overall goal of improving environmental performance suggests that a continuous improvement framework for environmental control would be the most appropriate. In fact, an environmental perspective is a possible fifth perspective for the Balanced Scorecard framework that we discussed in Chapter 13. The creators of the Balanced Scorecard mention a specific instance where a company added an environmental perspective to their Balanced Scorecard.[23] If one accepts the ecoefficiency paradigm, then an environmental perspective is legitimate because improving environmental performance can be the source of a competitive advantage (the criterion for a perspective to be included). A strategic-based environmental management system provides an operational framework for improving environmental performance. For example, linking the environmental perspective to the process perspective is critical for improving environmental performance. Knowledge of root causes for environmental activities is fundamental to any process design changes needed to improve environmental performance. Thus, the Balanced Scorecard framework supplies objectives and measures that are integrated to achieve the overall goal of improving environmental performance.

Environmental Perspective

We can identify at least five core objectives for the environmental perspective: (1) minimize the use of raw or virgin materials; (2) minimize the use of hazardous materials; (3) minimize energy requirements for production and use of the product; (4) minimize the release of solid, liquid, and gaseous residues; and (5) maximize opportunities to recycle.

Two environmental themes are associated with materials and energy (the first three core objectives). First, no more energy and materials should be used than absolutely

22. *Environmental Accounting Data Base*, Case Studies, http://www.emawebsite.org as of October 15, 2004.
23. Robert S. Kaplan and David P. Norton, *The Balanced Scorecard* (Boston: Harvard Business School, 1996): 35.

necessary (conservation issue). Second, means should be sought to eliminate the use of materials and energy that damage the environment (hazardous substance issue). Performance measures should reflect these two themes. Thus, possible measures would be total and per-unit quantities of the different types of materials and energy (e.g., pounds of toxic chemicals used), productivity measures (output/materials, output/energy), and hazardous materials (energy) costs expressed as a percentage of total materials cost.

The fourth core objective can be realized in one of two ways: (1) using technology and methods to prevent the release of residues, *once produced*, and (2) *avoiding* production of the residues by identifying fundamental causes and redesigning products and processes to eliminate the causes. Of the two methods, the second is preferred. The first method is analogous to obtaining product quality by inspection and rework (*inspecting in quality*). Experience with quality management has revealed that this approach is much more costly than *doing it right the first time*. This same outcome is likely to be true for the control of residues once produced. It makes more sense to avoid residues than to contain them once produced. Performance measures for this objective include pounds of toxic waste produced, cubic meters of effluents, tons of greenhouse gases produced, and percentage reduction of packaging materials.

The fifth objective emphasizes conservation of nonrenewable resources by their reuse. Recycling reduces the demand for extraction of additional raw materials. It also reduces environmental degradation by reducing the waste disposal requirements placed on end-users. Measures include pounds of materials recycled, number of different materials (the fewer, the better), number of different components (the fewer, the better for recycling), percentage of units remanufactured, and energy produced from incineration. Exhibit 16-9 summarizes the objectives and measures for the environmental perspective.

EXHIBIT 16-9 Objectives and Measures: Environmental Perspective

Objectives	Measures
Minimize hazardous materials	Types and quantities (total and per-unit) Percentage of total materials cost Productivity measures (output/input)
Minimize raw or virgin materials	Types and quantities (total and per-unit) Productivity measures (output/input)
Minimize energy requirements	Types and quantities (total and per-unit) Productivity measures (output/input)
Minimize release of residues	Pounds of toxic waste produced Cubic meters of effluents Tons of greenhouse gases produced Percentage reduction of packaging materials
Maximize opportunities to recycle	Pounds of materials recycled Number of different components Percentage of units remanufactured Energy produced from incineration

The Role of Activity Management

Analysis of environmental activities is critical for a sound environmental control system. Of course, as we already know, identifying environmental activities and assessing their costs are prerequisites for activity-based environmental costing. Knowing the environmental costs and what products and processes are causing them is absolutely essential as a first step for control. Next, environmental activities must be classified as value-added and non-value-added.

Non-value-added activities are those that are not necessary if the firm were operating in an optimal environmentally efficient state. Interestingly, Porter and van der Linde claim that environmental pollution is equivalent to economic inefficiency.[24] If production of contaminants is equivalent to economic efficiency as they claim, then all failure activities must be labeled non-value-added. Adopting an ecoefficiency paradigm implies that activities will always exist that can simultaneously prevent environmental degradation and produce a state of economic efficiency better than the current state. Failure activities, of course, are not the only non-value-added activities. Many detection activities, such as inspection, are non-value-added as well.

Non-value-added environmental costs are the costs of non-value-added activities. These costs represent the benefits that can be captured by improving environmental performance. The key to capturing these benefits is identifying root causes for non-value-added activities and then redesigning products and processes to minimize and ultimately eliminate these non-value-added activities.

Design for the Environment

This special design approach aimed at minimizing non-value-added activities is called *design for the environment*. It touches products, processes, materials, energy, and recycling. In other words, the entire product life cycle and its effects on the environment must be considered. Manufacturing processes, for example, are the direct sources of many solid, liquid, and gaseous residues. Many of these residues end up being released into the environment. Often, redesign of a process can eliminate the production of such residues. Product designs can also reduce environmental degradation. **Eastman Kodak**, for example, has designed its expendable cameras to facilitate recycling.[25] The expendable cameras have components that are color-coded. These components can be separated and used to build new cameras. Approximately 86 percent of each new camera is made of recycled materials. It is estimated that five million units have been recycled since the introduction of this product, totaling about 700,000 pounds of materials.

Financial Measures

Environmental improvements ought to produce significant and beneficial financial consequences. This means that the firm has achieved a favorable trade-off among failure activities and prevention activities. If ecoefficient decisions are being made, then total environmental costs should diminish as environmental performance improves. Thus, environmental cost trends are an important performance measure. One possibility is preparing a non-value-added environmental cost report for the current period and comparing these costs with the non-value-added costs of the prior period. An example of such a report is shown in Exhibit 16-10 on the following page. Some care should be taken in how costs and trends are measured. Cost reductions should be attributable to environmental

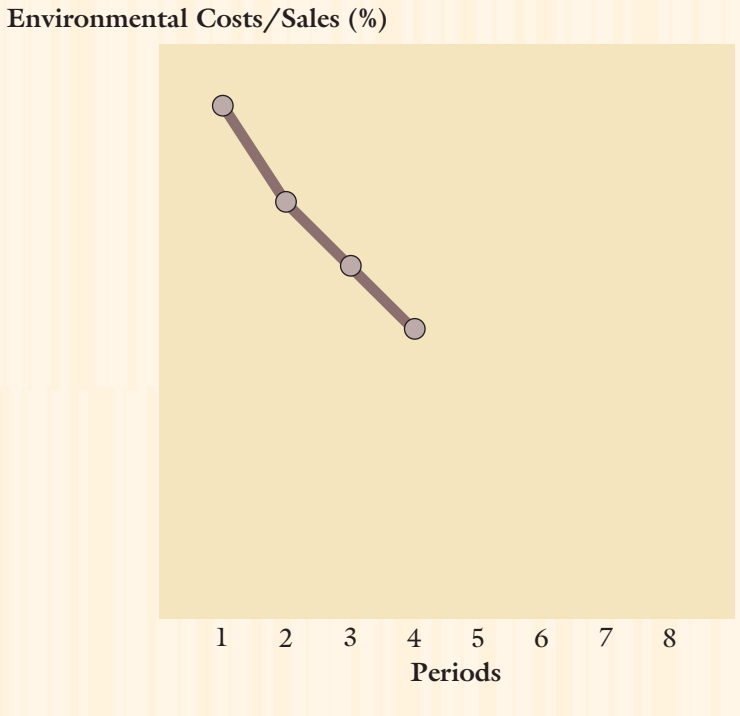
24. Michael E. Porter and Claus van der Linde, "Green and Competitive: Ending the Stalemate," *Harvard Business Review* (September–October 1995): 120–134.
25. Joseph Fiskel, "Competitive Excellence through Environmental Excellence," *Corporate Environmental Strategy* (Summer 1997): 55–61.

EXHIBIT 16-10 Non-Value-Added Cost Trends: Environmental Costs

Non-Value-Added Environmental Activity	Year 2006	Year 2007
Inspecting processes	$ 720,000	$ 600,000
Operating pollution equipment	1,200,000	1,050,000
Maintaining pollution equipment	600,000	600,000
Cleaning up water pollution	2,700,000	2,100,000
Property damage claim	1,200,000	900,000
Totals	$6,420,000	$5,250,000

improvements and not simply to discharging some environmental liability. Thus, external failure costs should reflect the average annual obligations resulting from current environmental efficiency. Therefore, the cost of cleaning up water pollution in 2006 is the expected annual cost, assuming current environmental performance remains the same. The $2,700,000 cleanup cost, for example, could be the annual amount that must be set aside to make available total funds necessary to execute cleanup efforts five years from now. As actions are taken to improve environmental performance, this may

EXHIBIT 16-11 Environmental Cost Trend Graph



mean that the amount of future cleanup will diminish, thus reducing the annual fund amount to $2,100,000. The $600,000 trend improvement, then, is attributable to improved environmental performance.

Another possibility is computing total environmental costs as a percentage of sales and tracking this value over several periods. Exhibit 16-11 illustrates such a trend graph. This graph is of particular interest because it tracks all environmental costs, not just non-value-added environmental costs. If ecoefficient decisions are being made, we should observe a reduction in *total* environmental costs. This implies that there is a favorable trade-off between investments in environmentally related prevention activities and reduction of environmental failure costs. The trend should be downward as ecoefficient investments are made.

Other graphical illustrations for specific areas can also be used to show progress. For example, a bar graph can be used to show the total amount of a pollutant emitted on a year-by-year basis. A downward trend would be a favorable indication. Pie charts can be useful as well. For example, a pie chart could visually display hazardous waste management by category: percentage of waste incinerated, percentage of waste treated, percentage of waste recycled/reclaimed, percentage of waste landfilled, and percentage of waste deep well injected. Exhibit 16-12 illustrates a bar graph analysis of CFC (chlorofluorocarbon) releases over a 4-year period, and Exhibit 16-13, on the following page, shows a pie chart for hazardous waste management.

EXHIBIT 16-12 Bar Graph for Trend Analysis

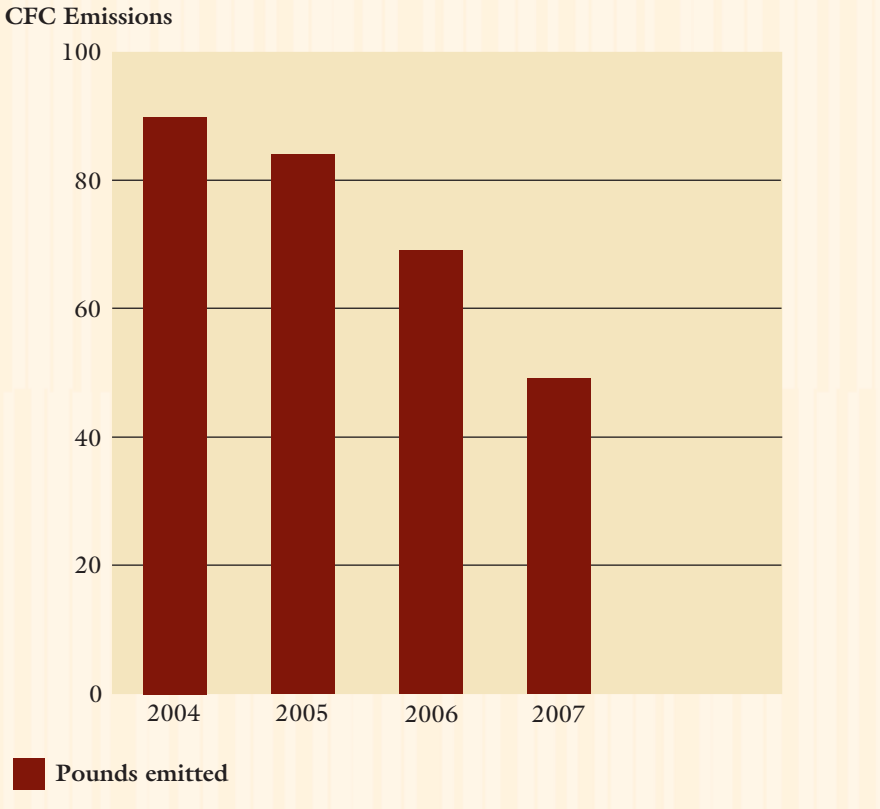
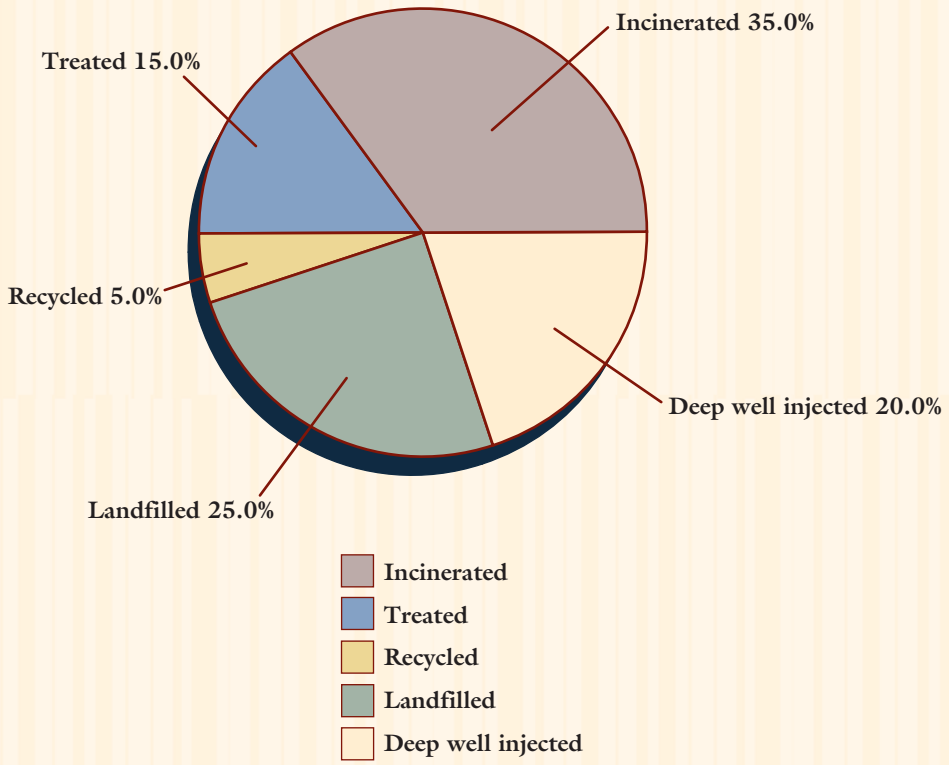


EXHIBIT 16-13 Hazardous Waste Management Pie Chart



SUMMARY

Increasing compliance costs and the emergence of ecoefficiency and guided ecoefficiency as competing views to compliance management have intensified interest in environmental costing. Ecoefficiency implies that cost reductions can be achieved by increasing environmental performance. Furthermore, for many companies, environmental costs are a significant percentage of total operating costs. This fact, coupled with ecoefficiency, emphasizes the importance of defining, measuring, and reporting environmental costs. Environmental costs are those costs incurred because poor environmental quality exists or may exist. There are four categories of environmental costs: prevention, detection, internal failure, and external failure. The external failure category is divided into realized and unrealized costs. Realized costs are those external costs the firm has to pay; unrealized or societal costs are those costs caused by the firm but paid for by society. Reporting environmental costs by category reveals their importance and shows the opportunity for reducing environmental costs by improving environmental performance.

Managers must decide whether they will assign only private costs or whether they want all costs to be assigned (full costing). Next, they must choose to use either a unit-based approach or an activity-based approach. Under unit-based costing, an environmental cost pool is created and a rate is calculated using unit-level drivers such as direct labor hours or machine hours. Environmental costs are then assigned to each product

based on their usage of direct labor hours or machine hours. This approach is probably satisfactory for those firms with little product diversity. For firms with product diversity, activity-based assignments are likely to be superior. ABC would assign costs to environmental activities and then calculate activity rates. These rates are then used to assign environmental costs to products.

Life-cycle cost assessment is a fundamental part of life-cycle assessment. Life-cycle cost assessment assigns costs to the environmental impacts of competing product designs. These costs are a function of the materials used, the energy consumed, and the environmental releases resulting from the manufacture of a product. Thus, before assessing these cost assignments, it is first necessary to do an inventory analysis that details materials, energy, and environmental releases. This analysis is carried out over the life cycle of the product itself. Once completed, the financial and operational impacts can be assessed and steps taken to improve environmental performance.

Controlling environmental costs relies on a strategic-based responsibility accounting system. This system has two important features: a strategic component and an operational component. The strategic component uses the Balanced Scorecard framework. The adaptation for environmental control is the addition of a fifth perspective: the environmental perspective. The environmental perspective has five objectives relating to materials and energy usage, production and release of environmental residues, and recycling. Operational measures such as pounds of hazardous materials and pounds of recycled materials are developed for each objective. Activity-based management provides the operational system that produces environmental improvements. Non-value-added environmental activities and their root causes are identified. Design for the environment approaches are then used to eliminate these non-value-added activities. Ecoefficient improvements should produce favorable financial consequences that can be measured using trends in non-value-added environmental costs and total environmental costs.

REVIEW PROBLEMS AND SOLUTIONS

1 Environmental Costs

At the beginning of 2007, Greener Company initiated a program to improve its environmental performance. Efforts were made to reduce the production and emission of contaminating gaseous, solid, and liquid residues. By the end of the year, in an executive meeting, the environmental manager indicated that the company had made significant improvement in its environmental performance, reducing the emission of contaminating residues of all types. The president of the company was pleased with the reported success but wanted an assessment of the financial consequences of the environmental improvements. To satisfy this request, the following financial data were collected for 2006 and 2007 (all changes in cost are a product of environmental improvements):

	2006	*2007*
Sales	$60,000,000	$60,000,000
Evaluating and selecting suppliers	0	1,800,000
Treating and disposing of toxic materials	3,600,000	2,400,000
Inspecting processes (environmental objective)	600,000	900,000
Land restoration (annual fund contribution)	4,800,000	3,600,000
Maintaining pollution equipment	1,200,000	900,000
Testing for contaminants	450,000	300,000

Required:

1. Classify the costs as prevention, detection, internal failure, or external failure.
2. Prepare an environmental cost report for the most recent year, where costs are expressed as a percentage of sales (instead of operating costs).

SOLUTION

1. Prevention costs: Evaluating and selecting suppliers; Detection costs: Testing for contaminants and inspecting processes; Internal failure costs: Maintaining pollution equipment and treating and disposing of toxic materials; External failure costs: Land restoration.

2.

Greener Company
Environmental Cost Report
For the Year Ended December 31, 2007

	Environmental Costs	*Percentage of Sales*
Prevention costs:		
Evaluating and selecting suppliers	$1,800,000	3.00%
Detection costs:		
Testing for contaminants	$ 300,000	
Inspecting processes	900,000	
Total detection costs	$1,200,000	2.00
Internal failure costs:		
Maintaining pollution equipment	$ 900,000	
Treating and disposing of toxic materials	2,400,000	
Total internal failure costs	$3,300,000	5.50
External failure costs:		
Land restoration	$3,600,000	6.00
Total environmental costs	$9,900,000	16.50%

2 Assigning Environmental Costs, Life-Cycle Cost Assessment, Environmental Cost Control

Searle Company produces two types of fertilizers: Rapidfeed and Timefeed. Searle has recently received significant criticism from environmental groups, local residents, and the federal government concerning its environmental performance. John Taylor, president of Searle, wants to know how the company's environmental activities affect the cost of each product. He believes that the main source of the environmental problems lies with Rapidfeed, but he would like some evidence to support (or refute) this belief. The controller has assembled the following data to help answer this question:

	Rapidfeed	*Timefeed*
Pounds of fertilizer produced	3,000,000	6,000,000
Engineering hours (process design)	4,500	13,500
Pounds of solid residues treated	90,000	30,000
Inspection hours (environmental)	30,000	15,000
Cleanup hours (local lake)	24,000	6,000

Additionally, the following environmental activity costs were reported:

Designing process	$ 450,000
Treating residues	1,800,000
Inspecting processes	360,000
Cleaning up lake	600,000

Required:

1. Calculate the environmental cost per pound of fertilizer for each product.
2. Based on the calculations in Requirement 1, which product appears to be the most environmentally harmful?
3. Would life-cycle cost assessment provide stronger evidence for the environmental suitability of each product? Explain.
4. Explain how a strategic-based responsibility accounting system can be used to help improve Searle's performance.

SOLUTION

1. First, calculate activity rates:

Designing process	\$450,000/18,000 = \$25 per engineering hour
Treating residues	\$1,800,000/120,000 = \$15 per pound of residue
Inspecting processes	\$360,000/45,000 = \$8 per inspection hour
Cleaning up lake	\$600,000/30,000 = \$20 per cleanup hour

Second, use rates to assign environmental costs and calculate unit environmental costs:

	Rapidfeed
\$25 × 4,500	\$ 112,500
\$15 × 90,000	1,350,000
\$8 × 30,000	240,000
\$20 × 24,000	480,000
Total	\$ 2,182,500
	÷ 3,000,000
Unit cost	\$ 0.7275

	Timefeed
\$25 × 13,500	\$ 337,500
\$15 × 30,000	450,000
\$8 × 15,000	120,000
\$20 × 6,000	120,000
Total	\$ 1,027,500
	÷ 6,000,000
Unit cost	\$ 0.17125

2. As measured by the environmental cost per unit, Rapidfeed appears to be the product causing the most environmental damage, confirming the president's beliefs.

3. Life-cycle assessment has three steps: inventory analysis, impact analysis, and improvement analysis. Of the three steps, the first two are concerned with identifying the materials and energy requirements, environmental releases, and the environmental effects of competing process and product designs (over the life cycle of the products). Thus, a life-cycle assessment provides a more comprehensive analysis of environmental effects than the environmental cost per unit (unless the cost per unit is a life-cycle environmental cost per unit).

4. The environmental perspective can improve environmental performance by translating an environmental improvement strategy into operational objectives, measures, targets, and initiatives. For example, consider the five core environmental objectives. These objectives, if followed, will reduce the amounts of materials and energy used (including hazardous materials) and will also reduce residues

released. Furthermore, the environmental perspective is tied to the other four perspectives of the Balanced Scorecard. Thus, it is explicitly recognized that improving environmental performance means that capabilities, processes, customers, and financial consequences must be considered.

KEY TERMS

Compliance management 698
Ecoefficiency 696
Environmental costs 699
Environmental detection costs 699
Environmental external failure costs 700
Environmental internal failure costs 700
Environmental prevention costs 699
Full environmental costing 705
Full private costing 705
Guided ecoefficiency 699
Impact analysis 709
Improvement analysis 709
Inventory analysis 708
Life-cycle assessment 707
Life-cycle cost assessment 707
Private costs 700
Product stewardship 707
Realized external failure costs 700
Sustainable development 696
Unrealized external failure (societal) costs 700

QUESTIONS FOR WRITING AND DISCUSSION

1. What is ecoefficiency?
2. What are the four objectives associated with ecoefficiency?
3. Describe the four opportunities for improving ecoefficiency.
4. What is an environmental cost?
5. What are the four categories of environmental costs? Define each category.
6. What is the difference between a realized external failure cost (environmental) and an unrealized external failure (societal) cost?
7. What does full environmental costing mean? Full private costing?
8. What information is communicated by the unit environmental cost of a product?
9. What is life-cycle assessment?
10. How can life-cycle costing improve life-cycle analysis?
11. What is the justification for adding an environmental perspective to the Balanced Scorecard?
12. What are the five core objectives of the environmental perspective?
13. Do you agree that all environmental failure activities are non-value-added activities? Explain.
14. What is the meaning of design for the environment? What is its role in activity-based management of environmental activities?
15. Describe the possible value of financial measures of environmental performance. Give several examples.

EXERCISES

16-1 ECOEFFICIENCY

LO1 For years, companies dealt with pollution problems through compliance management (ensuring that a company follows environmental laws and regulations as cheaply as pos-

sible). No effort was made to improve environmental performance beyond the minimal performance that satisfied environmental regulations (improving environmental performance and increasing economic efficiency were viewed as incompatible objectives). Recently, two alternative views of managing environmental cost have been proposed: (1) ecoefficiency and (2) guided ecoefficiency.

Required:

1. Explain why ecoefficiency may be a better view of the world than that espoused by compliance management. Discuss factors that may support this view.
2. Some believe that even if the ecoefficient view is true, regulatory intervention still may be needed. The type of intervention, however, must be carefully designed. Explain what is meant by properly designed regulation, and identify the key assumptions that must hold for the guided ecoefficiency view to be valid.

16-2 Ecoefficiency and Sustainable Development

LO1 Achieving sustainable development will likely require the cooperation of communities, governments, and businesses. The World Business Council for Sustainable Development (WBCSD) claims that ecoefficiency is "the business contribution to sustainable development."

Required:

1. What is sustainable development?
2. Explain why the WBCSD's claim about ecoefficiency may be true.
3. WBSCD has recently noted (http://www.wbcsd.ch): "the good news is that ecoefficiency is working in the companies that try it. The troubling news is that it is not being tried on a large enough scale, even though it makes good business sense." Why do you think the ecoefficiency paradigm is not as widely accepted as it perhaps ought to be? What would you suggest to increase the number of companies involved in ecoefficient projects?

16-3 Ecoefficiency: Objectives and Opportunities

LO1 Consider the following ecoefficient actions:

a. Improve the performance of a steam system used to generate electricity, reducing the use of energy and water.
b. Install a system that converts a waste product into a salable product.
c. Replaced solvent-based additives in a detergent blend with plant-extracted essential oils (reducing health and safety concerns).
d. Encoding plastic components to enable easier identification for disassembly and recycling.
e. Installation of a closed-loop water treatment plant to prevent the discharge of wastewater into a local river.
f. Redesigning a process reduces toxic releases and decreases energy consumption.
g. Converting sludge from a wastewater treatment facility into commercial compost.
h. Substitution of lower-cost, water-based solvents for flammable, toxic solvents.

Required:

Refer to Exhibit 16-1 (on page 697). Identify the objectives and opportunities associated with each of the actions listed above.

16-4 Classification of Environmental Costs

LO1 Classify the following environmental activities as prevention costs, detection costs, internal failure costs, or external failure costs. For external failure costs, classify the costs

as societal or private. Also, label those activities that are compatible with sustainable development (SD).

1. A company takes actions to reduce the amount of material in its packages.
2. After the activated carbon's useful life, a soft-drink producer returns this material used for purifying water for its beverages to the supplier. The supplier reactivates the carbon for a second use in nonfood applications. As a consequence, many tons of material are prevented from entering landfills.
3. An evaporator system is installed to treat wastewater and collect usable solids for other uses.
4. The inks used to print snack packages (for chips) contain heavy metals.
5. Processes are inspected to ensure compliance with environmental standards.
6. Delivery boxes are used five times and then recycled. This prevents 112 million pounds of cardboard from entering landfills and saves two million trees per year.
7. Scrubber equipment is installed to ensure that air emissions are less than the level permitted by law.
8. Local residents are incurring medical costs from illnesses caused by air pollution from automobile exhaust pollution.
9. As part of implementing an environmental perspective for the Balanced Scorecard, environmental performance measures are developed.
10. Because of liquid and solid residues being discharged into a local lake, the lake is no longer fit for swimming, fishing, and other recreational activities.
11. To reduce energy consumption, magnetic ballasts are replaced with electronic ballasts, and more efficient light bulbs and lighting sensors are installed. As a result, 2.3 million kilowatt-hours of electricity are saved per year.
12. Due to a legal settlement, a chemicals company must spend $20,000,000 to clean up contaminated soil.
13. A soft-drink company uses the following practice: In all bottling plants, packages damaged during filling are collected and recycled (glass, plastic, and aluminum).
14. Products are inspected to ensure that the gaseous emissions produced during operation follow legal and company guidelines.
15. The cost of operating pollution control equipment.
16. An internal audit is conducted to verify that environmental policies are being followed.

16-5 Environmental Cost Report

LO1 At the end of 2007, Hender Chemicals began to implement an environmental quality management program. As a first step, it identified the following costs in its accounting records as environmentally related for the year just ended:

	2007
Settling personal injury claims	$1,200,000
Treating and disposing of toxic waste	4,800,000
Cleanup of chemically contaminated soil	1,800,000
Inspecting products and processes	600,000
Operating pollution control equipment	840,000
Licensing facilities for producing contaminants	360,000
Evaluating and selecting suppliers	120,000
Developing performance measures	60,000
Recycling products	75,000

Required:

1. Prepare an environmental cost report by category. Assume that total operating costs are $60,000,000.

2. Use a pie chart to illustrate the relative distribution percentages for each environmental cost category. Comment on what this distribution communicates to a manager.

16-6 Reporting Social Costs

LO1

Refer to **Exercise 16-5**. Suppose that the newly hired environmental manager examines the report and makes the following comment: "This report understates the total environmental costs. It fails to consider the costs we are imposing on the local community. For example, we have polluted the river and lake so much that swimming and fishing are no longer possible. I have heard rumblings from the local citizens, and I'll bet that we will be facing a big cleanup bill in a few years."

Subsequent to the comment, environmental engineering estimated that cleanup costs for the river and lake will cost $3,000,000, assuming the cleanup efforts are required within five years. To pay for the cleanup, annual contributions of $525,000 will be invested with the expectation that the fund will grow to $3,000,000 by the end of the fifth year. Assume also that the loss of recreational opportunities is costing the local community $1,200,000 per year.

Required:

1. How would this information alter the report in **Exercise 16-5**?
2. Current financial reporting standards require that contingent liabilities be disclosed if certain conditions are met. Thus, it is possible that Hender may need to disclose the $3,000,000 cleanup liability. Yet, the opportunity cost for the recreational opportunities need not be disclosed to outside parties. Should Hender voluntarily disclose this cost? Is it likely that it would?

16-7 Environmental Cost Assignment

LO2

Coyle Pharmaceuticals produces two organic chemicals (Org AB, and Org XY) used in the production of two of its most wide-selling anti-cancer drugs. The controller and environmental manager have identified the following environmental activities and costs associated with the two products:

	Org AB	*Org XY*
Pounds produced	7,500,000	18,750,000
Packaging materials (pounds)	2,250,000	1,125,000
Energy usage (kilowatt-hours)	750,000	375,000
Toxic releases (pounds into air)	1,875,000	375,000
Pollution control (machine hours)	300,000	75,000
Costs of activities:		
Using packaging materials	$3,375,000	
Using energy	900,000	
Releasing toxins (fines)	450,000	
Operating pollution control equipment	1,050,000	

Required:

1. Calculate the environmental cost per pound for each product. Which of the two products appears to cause the most degradation to the environment?
2. In which environmental category would you classify excessive use of materials and energy?

(continued)

3. Suppose that the toxin releases cause health problems for those who live near the chemical plant. The costs, due to missed work and medical treatments, are estimated at $2,025,000 per year. How would assignment of these costs change the unit cost? Should they be assigned?

16-8 Environmental Costing, Ecoefficiency, and Competitive Advantage

LO1, LO2

Refer to the data in **Exercise 16-7**. Suppose that Coyle's manager decides to launch an environmental performance improvement program. First, efforts were made to reduce the amount of packaging. The demand for packaging materials was reduced by 10 percent. Second, a way was found to reuse the packaging materials. Usage of packaging materials changed from one time to two times. Both changes together saved $1,856,250 in packaging costs. Third, the manufacturing processes were redesigned to produce a reduced environmental load. The new processes were able to reduce emissions by 50 percent and private emission costs by 75 percent. The new processes also reduced the demand for energy by one-third. Energy costs were also reduced by the same amount. There was no change in the demand or cost of operating pollution control equipment.

The cost of implementing the changes was $753,750 (salaries of $450,000 for hiring six environmental engineers and $303,750 for treating the packaging materials so they can be reused). Engineering hours used for each process are 11,250 for the Org AB process and 3,750 for the Org XY process.

Required:

1. Calculate the new cost per pound for each product. Assume that the environmental reductions for each product are in the same proportions as the total reductions.
2. Calculate the net savings produced by the environmental changes for each product, in total, and on a per-unit basis. Does this support the concept of ecoefficiency?
3. Classify the activities as prevention, detection, internal failure, or external failure.
4. Describe how the environmental improvements can contribute to improving the firm's competitive position.

16-9 Life-Cycle Cost Assessment

LO3

Jackman Cleanser Division produces surfactants, ingredients used in producing laundry detergents. (Surfactants are the components that help release soil from clothing.) It is possible to make different types of surfactants, depending on the nature of the material input. One possibility, for example, is to use petrochemical stock as the primary material input. Another possibility is the use of beef tallow as the primary material input. The primary input plus other inputs and energy sources are used to produce the surfactants. An inventory analysis produces the following for the production of surfactants:

	Petrochemical	*Tallow*
Materials (kg per 1,000 kg of surfactant)	900	850
Water usage (kg per 1,000 kg of surfactants used)	50	500
Energy usage (kilowatt-hours per 1,000 kg of surfactants):		
For production of materials	55	30
Transportation	10	20
Processing (production of surfactants)	60	60

(continued)

	Petrochemical	*Tallow*
Residues (emissions per 1,000 kg of surfactants):		
Particulates (air contaminant)	2	12
Hydrocarbons (air contaminant)	40	30
Dissolved solids (liquid contaminant)	6	4
Land contamination (solid residue)	80	160

The greater water usage for tallow relates to the requirement that water must be used to produce feed for beef. The cost per kilogram of petrochemical stock is $0.40. The cost per kilogram of tallow is $0.60. Water costs $0.50 per kilogram, and energy is $1.20 per kilowatt-hour. When air contaminants exceed five per 1,000 kilograms, pollution control equipment must be purchased and installed. The cost of acquiring and operating this equipment is $500 per five units of contaminants. Liquid contaminants are more trouble. If dumped into local streams over the life cycle, the costs are estimated to be $120 per unit of liquid contaminant. If a water treatment system is used, the cost is $60 per unit of contaminant. Finally, soil cleanup is estimated at $20 per unit of solid residue.

Required:

1. Assess the relative environmental impacts of the two approaches to producing surfactants using only operational environmental measures. Which of the two approaches would you recommend? Justify your choice.
2. Use the cost information and calculate an environmental impact cost per 1,000 kg of surfactants. Which of the two approaches would you now recommend? Does the life-cycle cost approach have limitations? Explain.
3. Which parts of the life cycle described by the inventory analysis are controlled by the supplier? By the producer? What part of the inventory analysis is missing?

16-10 Life-Cycle Assessment: Packaging and Product Use, Impact Analysis

LO3 Burnham Munchies, Inc., is an international producer of potato chips. At the end of 2006, Mandy Pohlson, president of Burnham, appointed a task force to focus on the packaging and product use segments of its product's life cycle. Since customers consumed the contents of the package (if not consumed, the contents are biodegradable), the main concern was on the ability to conserve, recycle, and dispose of packaging materials. A new packaging proposal was being considered. A partial inventory analysis of the current packaging and the new packaging is as follows:

	Current	*New*
Delivery boxes:		
Recycle potential	Low	High
Times used before disposal	1	5
Paper bags:		
Average package weight (ounces)	2	1.5
Ink with heavy metals	Yes	No
Ultimate disposal:		
Safe for incineration	No	Yes

Upon seeing the inventory analysis, Mandy was pleased to see the apparent environmental benefits of the new packaging. However, she wanted a more detailed analysis of the impact of the new packaging. In response to this request, environmental engineering and cost accounting provided the following estimates:

Annual packages produced and sold	200,000,000
Current demand for delivery boxes	300,000,000 pounds
Recycle forecast	90% of delivery boxes used
Cost per ounce (package)	$0.02
Cost per pound (delivery boxes)	$0.60

The company's environmental engineers also indicated that in Europe and Japan about 75 percent of the packaging will participate in waste-to-energy combustion programs for the generation of steam or electricity. In the United States, only about 25 percent of the packaging will participate in such programs. Environmental engineering also noted that saving 300 pounds of paperboard is equivalent to saving one tree.

Required:

1. Calculate the total pounds of delivery boxes saved because of the new packaging. How much does this save in dollars? How many trees are saved because of recycling and reduction in demand for boxes? Because of recycling, how many pounds of cardboard are diverted from landfills?
2. Calculate the total pounds of materials saved by reducing packaging (bag) weight. What are the dollar savings? Now, assume that a design engineer has indicated that by reducing the packaging seal from the industry standard one-half inch to one-fourth inch, an additional 5 percent reduction in bag packaging can be achieved. How many pounds of materials are saved? Dollars saved?
3. Explain why the ultimate disposal qualities of packaging are important environmental considerations.
4. Why emphasize saving a material that comes from a renewable resource (trees)?

16-11 Environmental Performance Measures and Core Objectives

LO4 Identify the *core environmental objective* associated with each of the following measures:

a. Tons of greenhouse gas emissions
b. Tons of hazardous waste delivered for off-site management
c. Pounds of plastic recycled
d. British thermal units (BTUs)
e. Cars produced/pounds of steel used
f. Percentage of vehicles powered by propane gas
g. Percentage of recycled paper used (green purchasing)
h. Pounds of toxic chemical releases
i. Hazardous waste cost/Total materials cost
j. Pounds of nonhazardous waste/Pounds of materials issued
k. Percentage reduction in packaging materials
l. Pounds of organic chemicals in effluents sent to local river
m. Percentage of nonhazardous waste recycled

PROBLEMS

16-12 Cost Classification, Environmental Responsibility Accounting

LO1, LO4 At the beginning of 2004, Limon Company, an international telecommunications company, embarked on an environmental improvement program. The company set a goal

to have all its facilities ISO 14001 registered by 2007. (There are 30 facilities worldwide.) It also adopted the Balanced Scorecard with an environmental perspective added as a fifth perspective. To communicate the environmental progress made, management decided to issue, on a voluntary basis, an annual environmental progress report. Internally, the accounting department issued monthly progress reports and developed a number of measures that could be reported even more frequently to assess progress. Limon also asked an international CPA firm to prepare an auditor's report that would comment on the reasonableness and fairness of Limon's approach to assessing and measuring environmental performance.

At the end of 2007, the controller had gathered data that would be used in preparing the environmental progress report. A sample of the data collected is as follows:

Year	*Number of ISO 14001 Registrations*	*Energy Consumption (BTUs)*[a]	*Greenhouse Gases*[b]
2004	3	3,000	40,000
2005	9	2,950	39,000
2006	15	2,900	38,000
2007	24	2,850	36,000

[a]In billions (measures electricity, natural gas, and heating oil usage).
[b]In tons.

Required:

1. What is the justification for adding an environmental perspective to the Balanced Scorecard?
2. Limon Company decided to do the following: obtain ISO 14001 registration, prepare an annual environmental progress report, prepare internal environmental progress reports, and request an audit of the external report. How do these decisions fit within the Balanced Scorecard framework? To what environmental cost categories do these activities belong?
3. Using the data, prepare a bar graph for each of the three environmental variables provided (registrations, energy, and greenhouse gases). Comment on the progress made on these three dimensions. To which core objectives do each of the three measures relate?

16-13 Environmental Responsibility Accounting, Cost Trends

LO4

Refer to **Problem 16-12**. As part of its environmental cost reporting system, Limon tracks its total environmental costs. Consider the following cost and sales data:

Year	*Total Environmental Costs*	*Sales Revenue*
2004	$30,000,000	$250,000,000
2005	25,000,000	250,000,000
2006	22,000,000	275,000,000
2007	19,250,000	275,000,000

Required:

1. Prepare a bar graph for environmental costs expressed as a percentage of sales. Assuming that environmental performance has improved, explain why environmental costs have decreased.

(continued)

2. Normalize energy consumption by expressing it as a percentage of sales. Now, prepare a bar graph for energy. Comment on the progress made in reducing energy consumption. How does this compare with the conclusion that would be reached using a nonnormalized measure of progress? Which is the best approach? Explain.

16-14 Cost Classification, Ecoefficiency, Strategic Environmental Objectives

LO1, LO2, LO4

The following items are listed in an environmental financial statement (issued as part of an environmental progress report):

Environmental benefits (savings, income, and cost avoidance):
- Ozone-depleting substances cost reductions
- Hazardous waste disposal cost reductions
- Hazardous waste material cost reductions
- Nonhazardous waste disposal cost reductions
- Nonhazardous waste material cost reductions
- Recycling income
- Energy conservation cost savings
- Packaging cost reductions

Environmental costs:
- Corporate-level administrative costs
- Auditor fees
- Environmental engineering
- Facility professionals and programs
- Packaging professionals and programs for packaging reductions
- Pollution controls: Operations and maintenance
- Pollution controls: Depreciation
- Attorney fees for cleanup claims, notices of violations (NOVs)
- Settlements of government claims
- Waste disposal
- Environmental taxes for packaging
- Remediation/Cleanup: On-site
- Remediation/Cleanup: Off-site

Required:

1. Classify each item in the statement as prevention, detection, internal failure, or external failure. In classifying the items listed in the environmental benefits category, first classify the underlying cost item (e.g., the cost of hazardous waste disposal). Next, think of how you would classify the cost of the activities that led to the cost reduction. That is, how would you classify the macro activity: *reducing hazardous waste cost disposal*?
2. For each item in the environmental benefits category, indicate a possible measure or measures (i.e., pounds, tons, kilowatt-hours, etc.) and the core strategic environmental objective that would be associated with the measure. Is it possible that a measure may be associated with more than one objective? Explain.
3. Assuming ecoefficiency, what relationship over time would you expect to observe between the environmental benefits category and the environmental cost category?

16-15 Environmental Financial Reporting, Ecoefficiency, Improving Environmental Performance

LO1, LO2, LO4

Refer to **Problem 16-14**. In the environmental benefits section of the report, three types of benefits are listed: income, savings, and cost avoidance. Now, consider the following data for selected items for a 4-year period:

Year	*Engineering Design Costs*	*Cost of Ozone-Depleting Substances*
2004	$ 180,000	$3,240,000
2005	1,440,000	2,160,000
2006	720,000	1,440,000
2007	90,000	360,000

The engineering design costs were incurred to redesign the production processes and products. Redesign of the product allowed the substitution of a material that produced less ozone-depleting substances. Modifications in the design of the processes also accomplished the same objective. Because of the improvements, the company was able to reduce the demand for pollution control equipment (with its attendant depreciation and operating costs) and avoid fines and litigation costs. All of the savings generated in a given year represent costs avoided for future years. The engineering costs are investments in design projects. Once the results of the project are realized, design costs can be reduced to lower levels. However, since some ongoing design activity is required for maintaining the system and improving it as needed, the environmental engineering cost will not be reduced lower than the $90,000 reported in 2007.

Required:

1. Prepare a partial environmental financial statement, divided into benefit and cost sections for 2005, 2006, and 2007.
2. Evaluate and explain the outcomes. Does this result support or challenge ecoefficiency? Explain.

16-16 Environmental Financial Report

LO1 The following environmental cost reports for 2005, 2006, and 2007 are for the Communications Products Division of Kartel, a telecommunications company. In 2005, Kartel committed itself to a continuous environmental improvement program, which was implemented throughout the company.

Environmental Activity	*2005*	*2006*	*2007*
Disposing hazardous waste	$200,000	$150,000	$ 50,000
Measuring contaminant releases	10,000	100,000	70,000
Releasing air contaminants	500,000	400,000	250,000
Producing scrap (nonhazardous)	175,000	150,000	125,000
Operating pollution equipment	260,000	200,000	130,000
Designing processes and products	50,000	300,000	100,000
Using energy	180,000	162,000	144,000
Training employees (environmental)	10,000	20,000	40,000
Remediation (cleanup)	400,000	300,000	190,000
Inspecting processes	0	100,000	80,000

At the beginning of 2007, Kartel began a new program of recycling nonhazardous scrap. The effort produced recycling income totaling $25,000. The marketing vice president and the environmental manager estimated that sales revenue had increased by $200,000 per year since 2005 because of an improved public image relative to environmental performance. The company's finance department also estimated that Kartel saved $80,000 in 2007 because of reduced finance and insurance costs, all attributable to improved environmental performance. All reductions in environmental costs from 2005 to 2007 are attributable to improvement efforts. Furthermore, any reductions represent ongoing savings.

Required:

1. Prepare an environmental financial statement for 2007 (for the Products Division). In the cost section, classify environmental costs by category (prevention, detection, etc.).
2. Evaluate the changes in environmental performance.

16-17 Assignment of Environmental Costs

LO2

Refer to **Problem 16-16**. In 2005, Jack Carter, president of Kartel, requested that environmental costs be assigned to the two major products produced by the company. He felt that knowledge of the environmental product costs would help guide the design decisions that would be necessary to improve environmental performance. The products represent two different models of a cellular phone (Model XA2 and Model KZ3). The models use different processes and materials. To assign the costs, the following data were gathered for 2005:

Activity	*Model XA2*	*Model KZ3*
Disposing hazardous waste (tons)	20	180
Measuring contaminant releases (transactions)	1,000	4,000
Releasing air contaminants (tons)	25	225
Producing scrap (pounds of scrap)	25,000	25,000
Operating pollution equipment (hours)	120,000	400,000
Designing processes and products (hours)	1,500	500
Using energy (BTUs)	600,000	1,200,000
Training employees (hours)	50	50
Remediation (labor hours)	5,000	15,000

During 2005, Kartel's division produced 200,000 units of Model XA2 and 300,000 units of Model KZ3.

Required:

1. Using the activity data, calculate the environmental cost per unit for each model. How will this information be useful?
2. Upon examining the cost data produced in Requirement 1, an environmental engineer made the following suggestions: (1) substitute a new plastic for a material that appeared to be the source of much of the hazardous waste (the new material actually cost less than the contaminating material it would replace) and (2) redesign the processes to reduce the amount of air contaminants produced.

   As a result of the first suggestion, by 2007, the amount of hazardous waste produced had diminished to 50 tons, 10 tons for Model XA2 and 40 tons for Model KZ3. The second suggestion reduced the contaminants released by 50 percent by 2007 (15 tons for Model XA2 and 110 tons for Model KZ3). The need for pollution equipment also diminished, and the hours required for operating this equipment for Model XA2 and Model KZ3 were reduced to 60,000 and 200,000, respectively. Calculate the unit cost reductions for the two models associated with the actions and outcomes described (assume the same production as in 2005). Do you think the efforts to reduce the environmental cost per unit were economically justified? Explain.

16-18 Life-Cycle Assessment

LO3

Thomas Manufacturing produces automobile components used in automobile assembly. One of its divisions manufactures automotive front-end pieces. The division is currently considering two different designs: one using galvanized steel and the other using

a polymer composite. Both products are considered equally durable. The main issue being considered is the environmental effects of the designs. To help in this assessment, an inventory analysis and associated cost information for the two designs are as follows:

	Polymer	*Galvanized Steel*
Materials:		
Virgin materials (pounds)	8	14
Reused production scrap (pounds)	1	6
Energy:		
During production (kilowatts/pound)	15	10
During product use (pounds of petroleum used per year per unit)	66	110
Contaminants:		
Gaseous residues (pounds per unit)	0.4	0.2
Solid residues (pounds per unit)	0.6	2.0
Recycle potential:		
Incineration (pounds)	7.0	—
Quantity to landfill (pounds)	1.0	0.5
Recycled (pounds)	—	8.5
Financial information:		
Cost per pound of materials	$ 30.00	$ 15.00
Cost per kilowatt-hour 0.50	0.50	0.50
Cost per pound of petroleum	0.70	0.70
Cost per pound of gaseous residue	100.00	100.00
Cost per pound of solid residue	40.00	50.00
Incineration benefits per unit	2.00	—
Recycle benefits per unit	—	20.00

Required:

1. Using the operational measures, assess the environmental impact of each design. What other information would be useful?
2. Using the financial information, calculate an environmental life-cycle cost per unit. Discuss the strengths and weaknesses of this information.
3. Explain why a manager might wish to include product use and disposal information in the assessment of environmental performance. After all, these costs are not incurred by the company. For example, the petroleum consumption per year is a cost incurred by the end user.
4. Based on all the information, what recommendation would you make?

16-19 Environmental Responsibility Accounting, Balanced Scorecard

LO4

Carol Thayn, president of Milton, Inc., a consumer products firm, has decided to follow an environmental improvement strategy. The goal is to increase profits by increasing revenues and decreasing environmental costs. Carol is convinced that revenues could be increased if she could improve the company's environmental image. Customers have been demanding cleaner products, and her marketing manager had indicated that producing "greener" products would definitely lead to an increase in market share. Furthermore, Carol had recently returned from an environmental management seminar where she had learned about ecoefficiency. She now believes that costs could be reduced while simultaneously improving environmental performance. She has two objectives in mind: Reduce packaging and reduce production and release of contaminating

residues. Carol has decided on the following actions to achieve the desired improvements:

1. Hire two environmental engineers to provide the capabilities needed to improve environmental performance. One engineer would be responsible for a new packaging design and reduction process. The other would be given responsibility to redesign products and processes with the objective of reducing the production of residues. Carol expected the actions to reduce packaging costs and pollution control costs.
2. All employees would be sent to several training seminars to learn about environmental management. They would then be empowered to make improvements in environmental performance (e.g., ways to reduce contaminants and packaging materials).
3. Once the processes and products were redesigned, she would participate in a third-party environmental certification program so that customers would be assured that the environmental improvements were valid.

Required:

1. Explain why adding an environmental perspective to the Balanced Scorecard is considered to be legitimate.
2. Express the environmental improvement strategy as a series of cause-and-effect relationships expressed as if-then statements.
3. Illustrate the strategy using a causal flow diagram with one important modification: add an environmental perspective (the flow diagram should then illustrate five perspectives). Place the environmental perspective in between the customer and process perspectives.

16-20 Collaborative Learning Exercise

LO1, LO4

During the past four years, Monticello Company has made significant efforts to improve its environmental performance. Two of the strategic objectives that have received considerable attention are those of minimizing hazardous materials and minimizing release of liquid residues. Actually, two objectives are associated with hazardous waste. First, the company wants to reduce the amount produced. Second, the company wants to shift the ways of dealing with hazardous waste from landfill and deep well injections to such methods as incineration, treatment, and recycling. Lori Anders, president of Monticello, also required the accounting department to track and report on environmental progress. Internal and external environmental progress reports are prepared. The following data pertain to the two strategic objectives that have been emphasized.

Hazardous waste objective (measure is in tons):

Year	*Incinerated*	*Treated*	*Recycled*	*Landfilled*	*Injection*	*Total*
2004	2,000	2,000	1,000	35,000	10,000	50,000
2005	4,000	2,000	2,000	30,000	10,000	48,000
2006	8,000	3,000	3,000	25,000	7,000	46,000
2007	15,000	3,000	3,500	15,000	3,500	40,000

Liquid residue objective:

Year	*Tons of Sulfates*
2004	100
2005	92
2006	81
2007	73

The cost of landfilling hazardous waste is $50 per ton; injection is $60 per ton; incineration is $70 per ton; treatment is $100 per ton; and recycling produces a benefit of $10 per ton. Recycling, however, can be done only for a certain type of hazardous waste and only with a 70 percent successful yield. Treatment is also limited to certain types of waste. Fines, pollution control equipment, and expected cleanup costs are $4,000 per ton for the liquid residues.

Required:

Form groups of three to five members, where the total number of groups is at least four. Assign the letters A through D to each group. Groups with the A designation will solve Requirement 1, B will solve Requirement 2, C will solve Requirement 3, and D will solve Requirement 4. The groups will then share their answers with the other groups.

1. Prepare a bar graph for hazardous waste that shows trends. Comment on the progress revealed.
2. Prepare a pie chart for hazardous waste for the years 2004 and 2007. Comment on the progress in reducing reliance on landfills and injections.
3. Prepare a bar graph for the liquid residue.
4. Calculate the environmental cost for hazardous waste and liquid residue in 2004 and 2007. Comment on environmental progress as measured by the financial outcomes. Is it possible that the savings are understated? Explain.

16-21 Cyber Research Case

LO1, LO2, LO3, LO4

Many companies are now preparing corporate sustainability reports. Many such reports are found at http://www.sustainability-reports.com. Other reports can be found at the Web sites of individual companies. For example, **Baxter** and **3M** voluntarily prepare and publish reports on health, safety, and the environment. In 2000, Baxter expanded its environmental reporting to include a report on sustainability reporting. 3M has indicated that it intends to change its environmental reporting to better reflect the three elements of sustainability: environmental effects, economic effects, and social effects. To this end, 3M gathered data throughout 2001 and issued its first report on sustainability performance in 2003. You can find the reports for these two companies at http://www.3m.com and http://www.baxter.com. Find the environmental reports of three companies, where at least one is a U.S. company. Examine the environmental reports of these three companies, including their reports on sustainability performance. Answer the following questions for each firm.

1. How much has been saved due to environmental actions? Which firm has saved the most?
2. Describe each firm's packaging reduction efforts and the resulting savings. (Savings can be expressed in nonfinancial terms.)
3. Describe each firm's recycling activities—both for their own products as well as the materials they receive from suppliers.
4. What kinds of environmental performance measures are being used by each firm? Can you relate these to the core strategic objectives discussed in the chapter?
5. Evaluate the sustainability performance of each firm. Which do you think is closer to the concept of sustainable development?
6. What reasons do they offer for providing environmental information?
7. How do the environmental reports compare? Which report did you like best? Why?