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Environmentally Smart Accounting: Using Total Cost Assessment To Advance Pollution Prevention

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Conventional project financial analysis often fails to capture the full range of costs and savings associated with pollution prevention (P2) investments. Thus, managers need to rethink their approach to cost inventory, cost allocation, time horizon, and profitability analysis to ensure that P2 investments are treated fairly in the capital budgeting process. This article shows how total cost assessment can often help level the playing field for P2 investments that might otherwise be tagged as uncompetitive and unprofitable.

DESPITE MOUNTING REGULATORY pressures and market incentives, industry has been slow to shift from end-of-pipe control strategies to more prevention-oriented practices.[1] If, as many argue, pollution prevention (P2) serves the interests of business by increasing efficiency and profits, what explains industry's continuing reluctance to move aggressively toward a preventative mode of environmental management? And why, in light of the much-heralded benefits of prevention strategies, are firms often surprised with the profitability potential of P2 projects in contrast to the "must-do," compliance-driven capital investments?

The explanation for these contradictions stems from at least two aspects of corporate environmental management. First, organizational structure and management behavior may impede pollution prevention projects from entering the firm's capital budgeting process from the outset, thereby precluding such projects from systematic consideration. Second, once a P2 project successfully enters the capital budgeting process and competes with other projects for limited capital resources, current methods of profitability analysis may discriminate against the P2 project.

Profitability analysis reflects how managers inventory and allocate costs, and what time horizons and financial indicators are selected to estimate the return on investment. This article examines the proposition that conventional methods of profitability analysis may systematically diminish the prospects of prevention-oriented investments in the highly competitive capital budgeting arena. This analysis is based on recent studies for the Environmental Protection Agency's (EPA) Pollution Prevention Division[2] and the New Jersey Department of Environmental Protection and Energy,[3] a recent update of these studies for the Organization for Economic Cooperation and Development (OECD),[4] and ongoing work with a number of firms that are exploring alternative methods of project profitability analysis.

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Biases in Conventional Capital Budgeting

Conventional capital budgeting processes often fail to capture the full range of benefits from pollution prevention projects due to two distinct, but related, biases. The first bias arises from the tendency of firms to place prevention projects in the category of "profit-sustaining" or "must-do" compliance investments. This stands in contrast to "profit-adding" (including cost reduction) projects and market-expansion projects that are invariably the higher management priorities in terms of corporate growth and market development. By lumping prevention projects into the "must-do" category, the typical tendency is to draw narrow boundaries around costs, savings, and revenues, dispense with in-depth analysis, and thereby omit or underestimate the potential returns from undertaking the investment.

The second bias in conventional budgeting processes is inherent in the nature of prevention investments. Because prevention, by definition, implies upstream changes in material inputs and choices of process technologies, such investments tend to trigger multiple, and often indirect or second-order midstream and downstream effects in the production process. These may take the form of reduced compliance, insurance, and waste management costs, reduced worker absenteeism, as well as avoidance of contingency costs linked to acute events caused by a sudden release of hazardous materials. Furthermore, prevention measures increasingly are tied to less tangible and difficult-to-quantify benefits such as corporate and product image, and gaining a foothold in the marketplace for green products. To the extent that prevention investments create such advantages, they tend to occur over periods longer than the two to five years often used in conventional project financial analysis. They also require the firm to identify and allocate costs at a level of detail that goes beyond what is typically practiced in capital budget analyses.

The Building Blocks of Total Cost Assessment

Profitability analysis of a capital investment in pollution prevention contains four elements: (1) cost inventory, (2) cost allocation, (3) time horizon for profitability analysis, and (4) profitability indicators. Total Cost Assessment (TCA) is an approach to these elements that accounts for the particular characteristics of P2 projects.

Cost inventory

Identifying all costs and savings associated with a pollution prevention investment is the first element of TCA. As with any industrial investment, such costs may be classified as one-time capital costs incurred at the outset of the project, or as recurrent (normally annual) operating costs that are incurred repeatedly over the life of the project. Unlike most investments, however, environmental projects are associated with certain costs, savings, and revenues that are relatively uncertain in character (what are they?), magnitude (how large will they be?), and timing (at what point in the project life cycle will they occur?).

This uncertainty results from two conditions: (1) the complexity of assessing risks associated with the use and transport of, and possible exposure to, hazardous substances; and (2) changing regulatory and judicial decisions that result in upward and downward shifts in project costs. Some costs are straightforward, although they are not necessarily routinely identified by managers. Such costs may include monitoring, training, and preparing manifest forms for the off-site shipment of hazardous waste. Others, however, fall into the category of contingent costs—those that may materialize if certain events occur. These could be exceeding a permitted emissions limit, an off-site spill during transport of waste, a leak in a lined and permitted hazardous waste landfill, disposal of wastes at an unpermitted site, or an acute event leading to an environmental release in an abutting neighborhood. All of these are events are probabilistic in nature, that is, they may occur, but we hope they won't. If they do, certain costs will be borne by the firm.

Whereas conventional project financial analysis generally includes only the most obvious, direct, and tangible capital and operating items, TCA expands the inventory to encompass a broader range of costs, savings, and revenues. Selected examples from each of these categories are shown in **Table 1**.

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It is essential to recognize that although an expanded cost inventory is an essential ingredient in rigorous profitability analysis, it does *not* incorporate the social costs of a proposed project. **Figure 1** illustrates these key differences. Costs conventionally covered in a project financial evaluation are shown inside the first rectangle. These costs are a subset of, or are nested within, a second rectangle that includes many of the indirect costs, liabilities, and less tangible items listed in Table 1. By our definition, this is what would appear in a project analyzed using the TCA approach.

An even broader approach than TCA is a larger inventory covering social costs resulting, for example, from health and ecological damages related to unregulated air toxics, wetlands loss, or unsustainable forest use. These externalities, which are no less real than TCA costs, are still conceptually distinct, because they have no financial consequences for the firm under current legal and regulatory conditions. Although the trend in environmental regulation suggests there may be a gradual convergence of the inner two rectangles with the outer rectangle, TCA should not be construed as a social accounting methodology.

Cost allocation

Cost allocation procedures define how production costs are assigned to specific product or process lines, or to overhead accounts. Allocation in medium and large firms is typically the responsibility of financial and production staff. They aim to properly debit and credit production processes/units on an activity basis, thereby providing the foundation for pricing according to real costs, a practice commonly

Table 1. Total Cost Assessment: Examples of Costs and Benefits

Direct Costs

- Capital expenditures
  - –buildings
  - –equipment
  - –utility connections
  - –equipment installation
  - –project engineering
- Operation and maintenance expenses/revenues
  - –raw materials
  - –labor
  - –waste disposal
  - –utilities: energy, water, sewerage
  - –revenue from recovered material

Indirect or Hidden Costs

- Compliance costs
  - –permitting
  - –reporting
  - –tracking
  - –monitoring
  - –manifesting
  - –training
  - –waste handling
  - –recordkeeping
  - –labeling
  - –testing
  - –emergency preparedness
  - –medical surveillance
- Waste storage
- Operation of on-site pollution control equipment
- Raw materials costs linked to nonproduct output (NPO)
- Environmental insurance (acute events, gradual impairment)

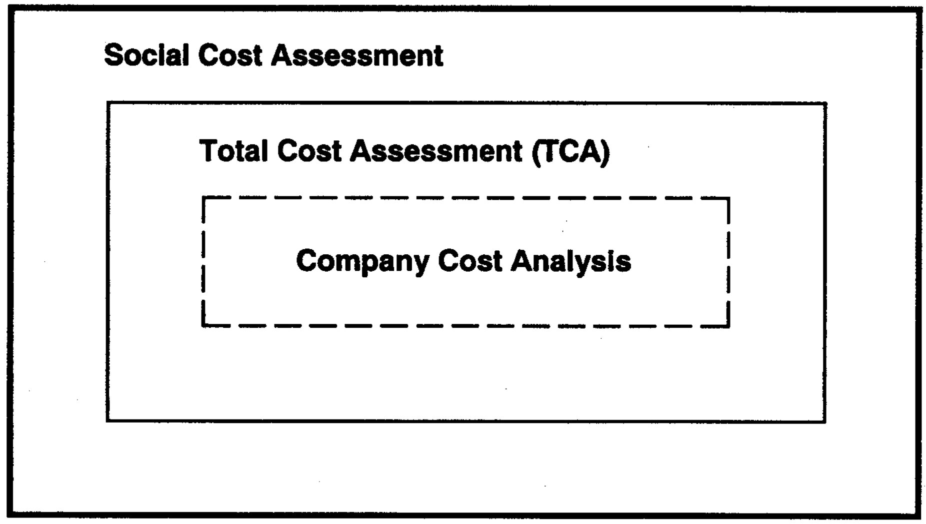
Liability Costs

- Penalties and fines
- Personal injury and property damage

Less Tangible Benefits

- Increased revenue from enhanced product quality
- Increased revenue from increased share of green product markets
- Reduced worker compensation and absenteeism costs from improved employee health
- Increased productivity from improved employee relations
- Reduced staff burdens in dealing with community concerns

Figure 1. Project Investment Cost Boundaries



known as full-cost accounting. Proper allocation is indispensable to sound investment profitability analysis. When costs are improperly allocated either by lumping them into overhead accounts and/or by assigning them incorrectly to production processes, profitability analyses cannot proceed on a rationale basis.

Two methods of cost allocation are commonly practiced. One relies on a materials balance approach, using standard unit, batch, lot, product input requirements or recipes. The other is materials accounting, based on inventory data of material inputs at the beginning and termination of a reporting period, or on measurement (e.g., volume or weight) of waste materials from production lines. In some instances, the two methods may be used in tandem to reconcile discrepancies between materials balance estimates (with batch model data) and materials accounting data (which rely on physical measurement). Such discrepancies invariably arise because of measurement/instrumentation shortcomings, excursions from standard recipes, and exclusion of certain steps in the production process that consume material inputs (e.g., cleaning during and between production campaigns or testing prior to introduction of new products).

For purposes of investment analysis, the ideal cost allocation system has two principal attributes. First, the system should allocate all costs to the processes responsible for their creation. This is a perennial challenge to financial officers and cost accountants who oversee the assignment of costs into either overhead or, alternatively, product or process accounts. Waste disposal costs, for example, are often placed in overhead accounts. A more rigorous approach would assign such costs to a discrete operating unit or process in the firm's production system.

Second, costs should be allocated in a manner that is reflective of the way that costs are actually incurred. Some firms, for example, allocate waste disposal costs across operating centers—administrative, research and development, and manufacturing—on the basis of floor space, rather than on the quantity and type of waste generated by each. This hampers a rigorous estimation of the financial benefits of reduced waste generation by uncoupling points of generation from points of reduction. Careful allocation, requires commitment, time, and financial resources, especially in large and complex production activities. Nonetheless, it is integral to identifying the sources of waste generation and the benefits of changing current practices to more preventative management.

Time horizon

Time horizons of five years or more enable the financial analysis to capture costs, savings, and revenues that occur well after the initial investment. This extends beyond the two-to-five year time frame used by many firms to evaluate investment profitability. A longer time horizon, preferably ten to fifteen years, is particularly critical to capture out-year liability, recurrent savings due to waste avoidance, and revenue growth linked to market development of environmentally friendly products. Without a longer horizon, the financial analysis runs the risk of failing to capture the very benefits for which the pollution prevention investment was originally targeted. Of course, the readiness of firms to extend their investment analysis to this longer horizon depends on numerous considerations, including size, capital availability, and competition from alternative investments of the same or higher priority. Notwithstanding these limitations, a longer time horizon should be applied at minimum to compare near and longer-term returns to a potential pollution prevention investment.

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Financial indicators

Financial indicators for pollution prevention projects should meet two criteria: (1) a capacity to incorporate all cash flows (positive and negative) over the life of the project; and (2) a capacity to integrate the time value of money through appropriate discounting of future cash flows. Indicators that meet these criteria are best equipped to capture the broadest range of costs, savings, and revenues, many of which may occur years after the initial investment. Net Present Value, Internal Rate of Return, and the Profitability Index are examples of such indicators; payback is not. A brief description of each shows why.

Under the *Net Present Value (NPV)* method, the present value of each cash flow, both inflows and outflows, is calculated and discounted at the project's cost of capital. The sum of the discounted cash flows is the project's NPV. A positive NPV means a project is worth pursuing; a negative NPV indicates it should be rejected. If the availability of capital is constrained (as it usually is), or if several projects are competing with one another, other things being equal, the project or combination of projects with the highest positive NPV should be chosen. The NPV method, particularly as applied to long-term projects with significant cash flows in later years, is very sensitive to the level of the discount rate. Thus, for a project with most of its cash flows in the early years, its NPV will not be lowered much by increasing the discount rate. On the other hand, the NPV of a project with cash flows that come later will be substantially lowered for an increased discount rate, rendering the project a much less attractive investment opportunity.

The *Internal Rate of Return (IRR)* method calculates the discount rate that equates the present value of a project's expected cash inflows to the present value of the project's expected costs. Thus, the basic formula to calculate the IRR is the same as that for the NPV; for the IRR, the NPV is set to zero and the discount rate is calculated; for the NPV, the discount rate is known and the NPV is calculated. A project is worth pursuing when the calculated IRR is greater than the cost of capital to finance the project. When several projects are vying for limited resources, all else being equal, the project with the highest IRR should be pursued.

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The *Profitability Index (PI)* is simply the present value of benefits (cash inflows) divided by the present value of costs (cash outflows). It shows the relative profitability of a project, or present value benefits per dollar of costs. Projects with profitability indices greater than 1.0 should be pursued, and the higher the PI, the more attractive the project.

Payback is the simplest and most common of the indicators for evaluating investment profitability. It provides a quick, back-of-the-envelope appraisal of the financial prospects of a project. Although the payback calculation may suffice for a preliminary assessment, it should not be relied upon as the sole method for project evaluation. The payback period is the expected number of years required to recover the original project investment; it can be calculated before or after taxes, and serves as a type of break-even calculation. If cash flows materialize at the expected rate until the payback year, then the project will break even. The regular payback, however, does not account for the cost of capital, so that the cost of the debt and equity used in the investment is not reflected in the cash flows or the calculation. Another major drawback of the payback method is that it does not take into account cash flows beyond the payback year. The payback period does, however, provide an estimate of how long funds will be tied up in a project. Thus, it is often used as an indicator of project liquidity.

TCA in Practice

To assess how TCA works in practice, we offer the following example of a TCA project analysis from one of several firms that collaborated with the Tellus Institute in its TCA studies. The company's manufacturing facility is a specialty paper mill that produces a variety of uncoated and on-machine and off-machine coated papers, as well as carbonizing, book, and release base papers. The coating used is a latex (i.e., nonsolvent) formulation containing clay, styrene butadiene, starch, and polymers. This example was chosen because it is a particularly powerful illustration of the value of a TCA approach. Other cases may demonstrate more or less dramatic results for reasons discussed below.

Background on the manufacturing process

Paper machine white water, a mixture of water and residual fiber and filler (clay and calcium carbonate) that drains out of a sheet of paper as it travels across the paper machine, is usually captured by a white water collection system dedicated to one paper machine. Typically, some or all white water is recycled back into the papermaking system to recapture water, fiber, and filler. As a pollution prevention measure to reduce water use and wastewater treatment, white water may be passed through a save-all screening device to separate fiber and filler from water; fiber, filler, and water are then recycled back into the system. The save-all produces a clear stream of water that can be used in numerous paper machine operations.

In this mill, two paper machines, sharing a common white water system, produce a variety of paper grades made with either acid-, neutral-, or alkaline-sizing chemistry.[5] Machine 1 has a save-all system that filters fiber and filler prior to discharging into the joint white water system. This material is recycled back into the papermaking system. When the machines are using different sizing chemistry (e.g., when Machine 1 is producing acid-sized paper and Machine 2 is producing alkaline-sized paper), the mixed white water from both machines is not reusable and must be sewered. Under these conditions, a large flow of potentially reusable water from both machines, and fiber and filler from Machine 2, is lost to the sewer.

Prompted primarily by the lack of spare water effluent pumping capacity and a desire to better understand the rather complex, old white water piping system, the mill commissioned a study titled "White Water Recycle Feasibility Study" in 1988. The study, completed in August of 1989, had several objectives: ". . . to review the design and operation of the mill and recommend changes that would help reduce peak effluent flows, reduce BOD [biological oxygen demand] in the effluent and reduce total fresh water intake on a millwide scale." The resulting report contained detailed engineering drawings of the fresh water, white water, and paper machine systems and two recommendations for process modifications.

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Pollution prevention project description

The first recommendation (called Phase I) in the feasibility study was the installation of a second save-all to handle the white water from Machine 2. Because the white water systems under this scenario would remain separate for Machines 1 and 2, this phase would allow recovery of fiber from white water, but only permit recovery of clarified white water if the grades being produced on the machines were compatible. Otherwise, the water would have to be sewered.

Under Phase II, the white water systems would be split, so that each machine would have a dedicated system. In combination with Phase I, Phase II would permit fiber, filler, and water reuse on both machines at all times. This phase would require installation of a new save-all, a new pump, piping, and controls. Available pulping and stock storage capacity could be used to pulp separately for each machine.

At the request of the mill, we focused our analysis on the combined Phases I and II. This option was most interesting to the mill because it maximizes recovery of water, fiber, and filler and reduction of BOD and solids in wastewater.

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Company financial analysis versus TCA

The company analysis consists of the 1989 capital estimate (adjusted for inflation and escalated by 12.5 percent) and only those operating costs and savings that the company typically includes in project financial analyses for projects of this type, which are

- Raw material—fiber and filler;
- Energy and chemical use for new equipment;
- Wastewater treatment fees; and
- Changes in labor costs.

The TCA contains these and other operating costs and savings that were developed in the course of this study. On the savings side, the TCA includes the following:

- An average reduction in fiber and filler loss of 1,200 tons a year for an annual savings of $421,530;
- A reduction in fresh water usage of 1 million gallons a day and a commensurate reduction in cost for fresh water treatment and pumping, for a savings of approximately $112,420 a year;
- A reduction in energy use for fresh water heating amounting to a savings of approximately $393,400; and
- A reduction in wastewater generation of approximately 1 million gallons a day for a savings of approximately $54,750 a year in wastewater pumping and $68,240 a year in wastewater treatment fees.

Annual operating costs are expected to increase in the following areas:

- Chemical flocculating agents used in the save-all to promote solids/water separation will cost approximately $28,700 a year;
- Electric costs for new equipment operation will increase operating costs by approximately $107,280 a year; and

Table 2. Overview of Cost Inclusion by Company and TCA for Whitewater/Fiber Recycle Project

Costs	*Company*	*TCA*
Capital Costs		
Purchased equipment	X	X
Materials (e.g. piping, elec.)	X	X
Utility systems	X	X
Site preparation	X	X
Installation	X	X
Engineering/contractor	X	X
Start-up/training		
Contingency	X	X
Permitting		
Initial chemicals		
Working capital		
Salvage value		
Operating Costs		
Direct Costs[a]		
Raw materials/supplies	P	X
Waste disposal		
Labor	X	X
Revenues—general		
Revenues—by-products		
Other:		
transportation		
Indirect Costs[b]		
Waste management:		
hauling		
storage		
handling		
waste-end fees/taxes		
hauling insurance		
Utilities:		
energy	P	X
water		X
sewerage (POTW)	X	X
Pollution control/solvent recovery		
Regulatory compliance		
Insurance		
Future liability		

X = Cost(s) Included P = Cost(s) Partially Included

[a] We use the term "direct costs" here to mean costs that are typically allocated to a product or process line (i.e., not charged to an overhead account) *and* are typically included in project financial analysis.

[b] We use the term "indirect costs" here to mean costs that are typically charged to an overhead account *and* typically not included in project financial analysis.

- An increase in labor cost of approximately $3,120 a year is expected for operation of new equipment.

Table 2 presents a comparison of the company versus TCA cost inventory. The company entries reflect those normally included by the firm in a project justification analysis. The *"P"* in Table 2 indicates costs that are partially included in conventional analysis. The TCA column incorporates a more expansive inventory based on discussions with the firm regarding cost items that rightfully belong in the analysis, but are normally omitted. To ensure comfort on the part of the collaborating company, only the most obvious and significant omissions were highlighted. This led to results that most likely err on the conservative side (lesser TCA effect) than a more expansive analysis incorporating, for example, regulatory compliance costs, might show.

In this white water/fiber reuse project, a number of cost items appear in the TCA column that are either partially or entirely omitted from the company analysis. These include savings in raw materials costs from recovery of fiber and filler; a savings in fresh water usage and costs, as well as associated fresh water treatment and pumping; a savings in energy use for fresh water heating; and a savings in wastewater pumping and treatment fees.

The dramatic difference in the analyses of the profitability for this project using the company and TCA methods can be traced to the partial and total omission of several key reductions in direct and indirect costs.

The dramatic difference in the analyses of the profitability for this project using the company and TCA methods can be traced to the partial and total omission of several key reductions in direct and indirect costs. **Table 3** shows the financial impact of these omitted savings by comparing the company and TCA profitability analyses. A project costing $1.47 million using the company analysis yields an annual savings of $350,670 versus $911,240 in the TCA analysis. NPV over a fifteen-year time horizon jumps from $360,301 to $2.8 million. The IRR over fifteen years increases from 21 percent to 48 percent. At the same time, the payback period declines from 4.2 to 1.6 years.

Neither the existing nor alternative technology generates Resource Conservation and Recovery Act (RCRA) wastes. Thus, the project does not affect wastestreams that require on-site management or disposal, nor does it affect any regulatory compliance activities at the site; therefore, the financial analysis does not include costs for these activities. Thus, unlike projects that potentially reduce or eliminate the use of hazardous materials, this project produces no significant regulatory compliance savings. In addition, no impacts on revenue are expected, because neither product quality nor production rates will be improved. A project of this nature is also unlikely to affect product or company image in a way that reduction or elimination of a major air toxic (e.g., volatile organic compound emissions from solvent-based coating processes) might achieve. Finally, no tangible impact on avoided future liability is expected for this project.

In sum, the TCA/company differential in profitability occurs in a pollution prevention project involving a relatively straightforward,

Table 3. Summary of Financial Data for White Water and Fiber Reuse Project

Costs and Savings	*Company Analysis*	*TCA*
Total Capital Costs	$1,469,404	$1,469,404
Annual Savings (BIT)[a]	$ 350,670	$ 911,240
Financial Indicators		
Net present value—years 1-10	$ 47,696	$2,073,607
Net present value—years 1-15	$ 360,301	$2,851,834
Internal rate of return—years 1-10	17 %	46 %
Internal rate of return—years 1-15	21 %	48 %
Simple payback (years)	4 .2	1 .6

[a] Annual operating cash flow before interest and taxes.

proven technology without inclusion of some of the more indirect, less tangible financial benefits that may well occur with more complex and hazardous production technologies.

Looking Ahead

Aside from the specifics of our white water/fiber reuse example, how TCA affects profitability depends on several conditions:

- The degree to which hazardous materials management and liability costs are part of each process;
- The extent to which savings actually materialize through, for example, reallocation of unneeded labor from waste management functions to new, productive activities;
- The extent to which company practices already have moved in the direction of TCA;
- The degree to which a proposed project yields a marketable green product or company image; and
- The degree to which alternative technologies generate new costs that may neutralize, or even exceed, cost savings associated with shifting away from an existing process.

A priori, TCA does not ensure profitability for a pollution prevention project. Depending on project specifics, projects can range from dramatically positive results (as shown above), to those with positive but modest advantages, to those in which NPV and IRR actually diminish when applying a TCA approach. Of course, even in the latter case, diminished profitability is not synonymous with social undesirability. In other words, it is entirely possible that a pollution prevention project may yield net positive benefits to society as whole, but still fail to meet the internal hurdle rate of the firm that is necessary to gain management approval. When this is the case, government corrective intervention in the form of market-based incentives, voluntary programs, or mandates is appropriate to induce modification of corporate investment behavior.

Though outcomes vary, one can be sure that TCA is in the self-interest of the firm. It rationalizes management decision making by leveling the playing field for all projects that enter the capital budgeting process.

Though outcomes vary, one can be sure that TCA is in the self-interest of the firm. It rationalizes management decision making by leveling the playing field for all projects that enter the capital budgeting process. This is particularly true for upstream projects involving process redesign, product reformulation, and materials substitution, that is, the core of pollution prevention strategies. These kinds of projects typically are rife with indirect, hidden, and intangible costs and savings that TCA is particularly adept at identifying.

In the long term, TCA can serve as a substantial force in recasting the must-do and inherent loser image of environmental projects into a more positive profit-adding and market-expanding image. TCA also serves to rationalize a firm's capital budgeting practices, helps to quantify and make transparent all project costs, and catalyzes new ways of thinking about pollution reduction. Effective application of TCA typically requires the involvement of multiple staff—financial, environmental, operations, purchasing, marketing, R&D—which promotes more integrated and innovative environmental strategies in the firm.

For these reasons, what firms may see as the high initial cost of gearing up for TCA is better viewed as an up front fixed cost to revamp accounting systems to become more environmentally-conscious. When viewed from this perspective, TCA yields recurrent benefits that may be amortized over many budgeting cycles and during the transition to more preventative management strategies. ◆

Notes

1. Hoffman, A., "Teaching Old Dogs New Tricks: How To Create Incentives for Industry To Adopt Pollution Prevention," *Pollution Prevention Review*, Winter 1993-94, pp. 1-11.

2. White, A. M. Becker, and J. Goldstein, "Total Cost Assessment: Accelerating Industrial Pollution Prevention Through Innovative Project Financial Analysis, With Applications to the Pulp and Paper Industry," prepared by Tellus Institute for U.S. EPA, Office of Pollution Prevention, December 1991.

3. White, A.M. Becker and J. Goldstein, "Alternative Approaches to the Financial Evaluation of Industrial Pollution Prevention Investments," prepared by Tellus Institute for the New Jersey Department of Environmental Protection, Division of Science and Research, November 1991.

4. White, A., "Accelerating Corporate Investment in Clean Technologies Through Enhanced Managerial Accounting Systems," Draft Background Paper, prepared by Tellus Institute for the Organization for Economic Co-Operation and Development, Programme on Technology and Environment, January 1993.

5. Sizing is added to pulp to reduce water absorbency in the final paper. The pH (i.e., acidity or alkalinity) of the pulp must be adjusted according to the type of paper desired and sizing used.