United States
Environmental Protection
Agency

Office of Pollution Prevention
and Toxics
Washington, DC 20460

May 1992

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EPA

Total Cost Assessment:

Accelerating Industrial Pollution Prevention through Innovative Project Financial Analysis

With Applications to the Pulp and Paper Industry

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All opinions expressed in this report and any remaining errors or omissions are the sole responsibility of the authors.

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EXECUTIVE SUMMARY

In its February 1991 *National Pollution Prevention Strategy*, EPA set in motion a series of initiatives aimed at deepening and widening both government and private sector activities in pollution prevention. Recognizing the inherent limitations of traditional "end-of-pipe" approaches, the Strategy called for joint agency-industry action to redirect resources toward elimination of pollutants instead of continued reliance on downstream, control-oriented approaches that, while effective in solving one pollution problem, often create others. Without a transition from control to prevention measures, cross-media shifting of pollution among land, water and air will continue, and reduction of pollution from dispersed, non-point sources will remain extremely difficult to achieve.

For many firms, EPA's call for accelerated prevention served as a reaffirmation of what they already knew and, to varying degrees, practiced--that in the medium and long-term, pollution prevention generally is more sensible than pollution control. Early initiatives, beginning in the 1970's, were motivated by a simple bottom-line consideration: continued expenditures on pollution control investments to handle steadily increasing waste volumes presented firms with the specter of an endless capital drain that would divert resources from more lucrative opportunities in R&D, product development, manufacturing and marketing.

By the mid 1980s, other forces were encouraging the shift to prevention-oriented strategies, including liability under the federal Superfund Act, public concerns with environmental degradation, increasingly stringent pollution disclosure requirements, and widely publicized industrial accidents in both the U.S. and abroad. As a result, firms have faced a rising tide of public demands for shifts to clean technologies and environmentally friendly products.

Notwithstanding pressures from various quarters, and the noteworthy progress of a few, typically large firms, manufacturers have been slow to move away from traditional end-of-pipe strategies toward more prevention-oriented practices. If, as many argue, pollution prevention pays, what accounts for this slow pace of change? If prevention investments are, in fact, in the self-interest of the firm, what accounts for the continuing reluctance to move aggressively toward a more preventative pollution management mode? And why, in light of the publicized benefits of pollution prevention, do firms, even large sophisticated ones, continue to be surprised when prevention-oriented projects produce advantages to the firm far beyond those expected of many conventional "must-do," compliance-driven capital investments?

The explanation for this apparent contradiction seems to be two-fold: (1) the organizational structure and behavior of firms inhibits pollution prevention projects from entering their decision-making process from the outset, thereby precluding these alternatives from consideration by the firm altogether; and (2) economic/financial barriers linked to methods of capital allocation and budgeting once a pollution prevention project successfully enters the capital budgeting process and competes with other projects for limited capital resources. A priori, it appears that both these factors, acting in concert, contribute to the sluggish pace of investment in industrial pollution prevention. The second factor, economic/financial barriers, with special emphasis on the pulp and paper industry, is the focus of this study. Within a capital budgeting framework, we examine if, and to what extent, conventional methods of investment analysis act to impede pollution prevention projects in favor of end-of-pipe alternatives. Two projects actively under consideration by firms in the pulp and paper sector, serve to demonstrate how different definition, measurement, and allocation of project costs/savings, longer time horizons, and the use of multiple profitability indices may remove the biases inherent to conventional analytical methods.

A major source of industrial pollution, the pulp and paper sector provides a useful context for examining these alternative methods. Historically, environmental regulation of the industry has focused on reduction of BOD and TSS in water effluent, and particulates, sulfur dioxide and organic sulfur compounds in air. Reductions of these pollutants have been achieved principally through end-of-pipe controls. Nonetheless, pollution prevention is by no means a new concept to pulp and paper firms. In-plant recovery and reuse of pulping chemicals, for example, is an integral part of the kraft pulping process. Other preventative measures include: in-plant fiber and water recovery and reuse in the paper mill, counter-current washing in the pulp mill, and dry wood debarking in the woodroom. These technologies have been widely implemented to reduce pollution generation and to reduce raw material and energy costs. Current environmental regulation of toxic air and water pollutants, toxic constituents in mill sludge, and pulp mill effluent standards for foam, odor, and color are posing new challenges to pulp and paper firms. Meeting many of these regulations will require materials and process changes rather than traditional end-of-pipe controls. Dioxin reduction, for example, requires process changes targeted at reducing dioxin formation, such as decreased use of chlorine in bleaching or oxygen delignification.

In a compliance context, a mill's choice between an end-of-pipe or a prevention strategy will depend heavily on the comparative economics of these options. This is so even in instances where profitability is negative, that is, when the firm expects a net loss on its investment. Unlike most end-of-pipe technologies, pollution prevention projects tend to reduce operating costs by reducing waste generation, regulatory activities, and pollution related liabilities. In addition, investments in pollution prevention may increase revenue by improving product or corporate image. Including these indirect or less tangible savings in the financial analysis of projects may enhance the estimated profitability of the prevention strategy, and may be decisive in selecting a pollution prevention versus an end-of-pipe option. It is at this decision point that the concepts and methods of Total Cost Assessment (TCA) -- the comprehensive, long-term financial analysis of pollution prevention projects -- can play a role in improving the financial picture of a pollution prevention investment, and enhance its competitiveness with pollution control projects. TCA techniques can also improve the projected financial performance of discretionary pollution prevention projects,
thereby increasing their ability to compete for limited capital resources.

To assess how TCA works in practice, we worked in close collaboration with the staff of two mills to analyze the economics of two pollution prevention projects. The first (Project 1) is a white water and fiber reuse project at a coated fine paper mill. This investment would permit fiber, filler, and water reuse on two paper machines at all times, thereby conserving raw materials and reducing water use, wastewater generation, and energy use for fresh and wastewater pumping and freshwater heating. The second (Project 2) is a conversion from solvent/heavy metal paper coating to aqueous/heavy metal-free coating at a paper coating mill. This investment would substantially reduce solvent and heavy-metal usage, VOC emissions, and hazardous waste generation. For both projects, we developed a "company analysis" comprising costs typically used by the firms. We compared these to "TCA analyses" of the same project, in which a full accounting for less tangible, longer term, and indirect costs and savings was made.

The comparative analyses for each project yield substantially different results. For Project 1, the white water and fiber reuse investment, the net present value for this \$1.7 million capital expenditure shifts from -\$0.6 million in the Company Analysis to \$1.8 million using a TCA approach; the internal rate of return (IRR) increased from 6% to 36%; and the simple payback of 11.4 years increased to 2.0 years. Similarly impressive results are produced in Project 2, the aqueous conversion investment. NPV for this \$0.6 million capital expenditure shifts from \$0.1 million to \$0.2 million in the company versus TCA analyses, respectively; IRR shifts from 16% to 27%; and simple payback drops from 5.3 to 3.0 years.

Analysis of a limited sample of two projects does not suggest that, *a priori*, more comprehensive treatment of project costs and savings necessarily yields higher performance for prevention investments. Much depends on the original capital cost of the project, the completeness of the company analysis, and the magnitude and timing of indirect and less tangible benefits. And, surprisingly, TCA is equally likely to turn up additional **costs** as additional **savings**, potentially diminishing the appeal of prevention investments. Moreover, the effort expended in preparing the TCA analysis, though partially attributable to startup costs of any new practice, is substantial enough to make even large firms wary of adopting such an approach for all projects competing for capital resources.

The limited number of cases examined here precludes generalizations about overall corporate receptivity to TCA approaches and the degree to which pollution prevention will be accelerated by its adoption. Within the limitations of our study, however, it is clear that TCA can serve as valuable tool for translating discretionary judgements into concrete dollar values during the capital budgeting process. Insofar as pollution prevention projects produce less tangible and indirect costs and benefits, TCA equips managers to develop a more precise estimation of the real economic returns to such projects. Though TCA does not insure an attractive profitability level for prevention projects, the cost characteristics of such projects suggests that their financial performance in general will be enhanced by TCA. This is likely to be particularly true for industrial prevention projects that are materials and process-focused, that is, well upstream in the production process. Over the longer 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.

Several approaches for promoting TCA in the context of EPA's pollution prevention strategy emerge from this study. In general, it is clear that moving firms to modify their analytical procedures requires a belief that TCA will produce a clearer picture of the profitability of prevention projects and thereby lead to enhanced business operations. Thus, the primary goal of a promotion program should be to convince firms that TCA is **not** simply another regulatory mandate, but a vehicle for rationalizing their internal capital budgeting process.

More concretely, EPA has already worked to promote TCA by developing the *Pollution Prevention Benefits Manual*, the *Waste Minimization Opportunity Assessment Manual*, and sponsoring the initial work on PRECOSIS, all of which contain discussions of TCA concepts and provide analytical tools. Further efforts to disseminate more widely these and other tools such as **P2/FINANCE**, a tool developed for this study, will accelerate the advancement of the TCA concept. Published case studies which use a TCA approach to project financial analysis could be a valuable supplement to past initiatives.

At the state level, TCA may be built into pollution prevention policies and programs in several ways. State technical assistance programs may offer TCA guidance and training as a complement to their technical services. States may provide TCA training seminars, with specialized modules aimed at large versus small firms, or for firms in certain lines of business. A number of states have instituted requirements for industry to develop pollution prevention plans that must contain technical and economic feasibility assessments of specific prevention projects. The New Jersey Pollution Prevention Act, for example, that explicitly requires that plans include a comprehensive analysis of the costs associated with the use, generation, release or discharge of hazardous substances for current production processes and the savings realized by investments in pollution prevention. "Planning for Success Through Waste Reduction", the planning guidance document created by the Washington State Department of Ecology under the State's Hazardous Waste Reduction Act, instructs companies to evaluate the costs and benefits of selected waste reduction options over a five year period and to describe the accounting systems used to track hazardous substance and waste management costs, which must include "liability, compliance, and oversight costs". Requiring a TCA approach in pollution prevention planning may direct firms to incorporate unconventional cost items and/or longer time horizons to enhance the competitiveness of prevention investments. The long-term effectiveness of this approach, however, is unproven and should be approached cautiously and with a strong emphasis on the compapny self-interest dimension alluded to earlier.

While rigid, prescriptive approaches are undesirable, some type of standard could facilitate the implementation of emerging federal and state regulations requiring TCA in pollution prevention planning. National standard guidelines, perhaps under the auspices of the American Society of Testing and Materials (ASTM), could serve this objective.

The limited sample size of firms in this study allows for only indicative findings that must be corroborated by the analysis of additional firms. Existing TCA methods have been available for several years, yet no systematic assessment of user experience among the several hundred purchasers of various systems is available. This presents a potentially rich data base for further assessing the organizational and economic issues in TCA adoption we uncovered in this study.

Quantifying the benefits of green technologies, green products and green corporate image remains a major challenge. Yet it is precisely these benefits that are heard by corporate managers as reasons for approving otherwise marginal projects. Developing methodologies to quantify these benefits and incorporate them into project financial analysis is an unfinished task.

Finally, what is financially optimal for the firm, of course, is not necessarily optimal from a social cost standpoint. In this sense, TCA is no substitute for lifecycle assessment (LCA), in which the choice of a material input or the manufacture of a product is assessed for its full *societal costs* regardless of whether they fall within or outside the purview of the firm.

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1. INTRODUCTION

In its February 1991 *National Pollution Prevention Strategy*[1], EPA set in motion a series of initiatives aimed at deepening and widening both government and private sector activities in pollution prevention. Recognizing the inherent limitations of traditional "end-of-pipe" approaches, the Strategy called for joint agency-industry action to redirect resources toward elimination of pollutants, instead of continued reliance on downstream, control-oriented approaches that, while effective in solving one pollution problem, have often created others. Without such a transition from control to prevention measures, cross-media shifting of pollution between land, water and air will continue, and reduction of pollution from dispersed, non-point sources will remain extremely difficult to achieve.

For many firms, EPA's call for accelerated prevention served as a reaffirmation of what they already knew and, to varying degrees, practiced--that in the medium and long-term, pollution prevention generally is more sensible than pollution control. As early as the late 1970s, large firms such as 3M, Dow Chemical, Polaroid, and Merck established corporate-wide strategies to eliminate pollution through product redesign, materials substitution and process changes. Early initiatives, such as those undertaken by 3M, were motivated by simple bottom-line considerations[2]: continued expenditures on pollution control investments to handle steadily increasing waste volumes presented firms with the specter of an endless capital drain that would divert resources from more lucrative investment opportunities in R&D, product development, manufacturing and marketing.

By the mid 1980s, other forces were encouraging the shift to prevention-oriented strategies. Corporate concern with liability escalated with the enactment of the federal Superfund Act, a law that holds waste generators responsible for cleanup costs under its "strict, joint and several" liability standard. Under this standard, even small contributions by a firm to a waste site might lead to large remediation costs, leaving those firms with "deep pockets" especially vulnerable to unpredictable court settlements potentially involving millions of dollars. Added to these liability issues were growing public concerns with environmental degradation, linked to both chronic pollution and highly publicized accidents in both the U.S. and abroad. Though it is difficult to precisely estimate the financial repercussions of such trends and events, corporations were faced with burgeoning public demand for higher standards of environmental responsibility from corporations and their products. Some public demands evolved into legislative action, particularly at the state level, to ban or severely restrict environmentally unfriendly products and to induce environmentally friendly technologies in manufacturing processes.

Perhaps the most powerful inducement to industrial pollution prevention thus far has been the publication of plant-specific toxic releases to air, land and water, under provisions of the Community-Right-To-Know Act of 1986.[3] For the first time, this law requires companies themselves to estimate and submit to EPA total releases, thereby allowing public scrutiny of the volume, type and location of toxic releases. Since releases include wastes placed in any medium, even entirely allowable shipments to land disposal sites and permitted air emissions are subject to public scrutiny. Though data weaknesses remain, the result is to give the public a glimpse of a facility's pollution profile that has, not unexpectedly, added pressure to achieve net waste reductions

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[1] 56 CFR 7849, February 26, 1991.

[2] Lois R. Ember, "Strategies for Reducing Pollution at the Source Are Gaining Ground," *Chemical and Engineering News (C&EN)*, July 8, 1991, 7-16.

[3] Section 313 of the Act requires manufacturers to report releases of over 300 chemicals. Approximately 28,000 facilities were covered in the 1989 data reporting, including those which use at least 10,000 pounds or manufacture at least 25,000 of any listed chemical. See U.S. EPA, *The Toxics-Release Inventory: A National Perspective*, 1987. Office of Toxic Substances. Washington D.C., U.S. Government Printing Office.

beyond those mandated by various federal and state regulations. Due in part to this unprecedented level of disclosure and public scrutiny of firms' pollution performance, prevention is emerging as an integral component of responsible corporate environmental management.

Why Hasn't Prevention Taken Off?

Despite impressive progress in adopting pollution prevention practices among many large firms, the vast majority of American manufacturers have been slow to move away from traditional end-of-pipe strategies. If, as many argue, pollution prevention pays, what accounts for this slow pace of change? If prevention investments are, in fact, in the self-interest of the firm, what accounts for the continuing reluctance to aggressively move toward a more preventative practice in implementing pollution management choices? Why, from a purely business standpoint, are firms seemingly slow to adopt potentially profitable material, process and product innovations that respond to these economic forces? And why, in light of the publicized benefits of pollution prevention, do firms, even large sophisticated ones, continue to be surprised when prevention-oriented projects produce advantages to the firm far beyond those expected of many conventional "must-do," compliance-driven capital investments?

The explanation for this apparent contradiction seems to be two-fold: (1) the organizational structure and behavior of firms that inhibits pollution prevention projects from entering their decision-making process from the outset, thereby precluding these alternatives from consideration by the firm altogether; and (2) economic/financial barriers linked to methods of capital allocation and budgeting once a pollution prevention project successfully enters the capital budgeting process and competes with other projects for limited capital resources.

Organizational structure, to which we devote only passing attention in this study, includes issues such as the status of environmental management and managers in the firm, and the flow of information among decision-makers. Impediments to pollution prevention may arise when top management fails to send a strong message that prevention should be the preferred option; when environmental managers lack the authority and/or resources to effectively press preventive thinking into research and development, design, production, and marketing units; when salary and promotion incentives fail to incorporate environmental criteria; or when deficiencies in information flow and pollution tracking lead to missed opportunities for pollution prevention.[4] Such organizational obstacles may block financially promising prevention investments from entering the firm's capital allocation process at the outset, thereby eliminating any prospect for gaining approval for such an investment. These barriers are complex and vary from company to company, and warrant much further exploration than we present in this study.

The second explanation for inaction on promising pollution prevention investments is tied to a set of external and internal economic conditions. A key external condition, for example, is the firm's access to, and the cost of, capital. A proposed project that is financed by debt, regardless of its rate of return to the firm, will languish if lenders and investors perceive unacceptably high levels of risk in the firm as a whole or in the specific project for which financing is sought. Internal economic conditions are reflected in hurdle rates (thresholds of acceptable profitability) that a project must surpass in order to successfully compete with other investment alternatives within and outside the environmental arena. Such rates vary widely among firms, depending in part on whether a firm is inclined to "flexible-budgeting" with decentralized decision-making and fixed rates of return

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[4] Christopher B. Hunt and Ellen R. Auster, "Proactive Environmental Management: Avoiding the Toxic Trap," *Sloan Management Review* 31(2), Winter 1990.

or, alternatively, to "capital rationing" where projects compete relative to one another rather than against a prescribed hurdle rate[5].

Surviving the Capital Budgeting Process

As projects enter the capital allocation process, managers are called upon to develop costs and benefits of the proposed investment. How firms approach project analysis varies widely, ranging from simple back-of-the-envelope estimates of profitability for an initial screening to more elaborate and complex estimates using multiple indicators of profitability. A firm acting in its best interest should, of course, account for all internal costs, leaving aside all those external costs that do not affect a project's financial profile. While external costs are no less real than internal costs in the sense that they use valued assets like clean air and clean water, their omission from project evaluation follows logically from standard business practices that account only for costs that accrue to buyers and sellers of goods and services, to debtors and creditors, and to the owners of the firm itself.[6]

The approach a firm uses to compile and analyze project costs and benefits is a critical determinant of how the project is ranked vis-a-vis competing project investment options. When, for example, costs are omitted because they are not identified, scoped or accurately estimated, the project analysis provides a misleading or incomplete picture of financial performance. Similarly, when revenues or avoided costs from an investment are missed owing to definitional shortcomings or to the selection of financial indicators insensitive to long-term benefits, managers again may fail to place a project in its appropriate place among all those competing for capital resources. While all types of projects may fall prey to incomplete analysis, pollution prevention projects, which yield savings through reduced waste management and compliance costs and avoided liability, are particularly vulnerable.

During the last decade, many of the more obvious, discretionary waste reduction projects have been funded, having been able to stand on their own without modification of conventional project evaluation and cost accounting techniques. Such is the case, for example, with chemical firms, where escalating costs of off-site disposal have led to on-site solvent recovery processes, and with pulp mills, where high chemical costs have induced on-site recovery of spent pulping chemicals. Both are cost-effective and proven technologies. Even using a less than comprehensive set of costs and benefits, investments such as these may easily surpass internal hurdle rates and proceed to implementation.

The next tier of pollution prevention projects, however, has not been so successful. In this class projects are more focused on upstream changes to manufacturing processes, requiring materials substitution and process redesign that by nature are more complex, costly and of higher risk to the firm. To meet the firm's hurdle rate or to compete with end-of-pipe projects targeted at the same compliance objective, analysis of these prevention projects may require inclusion of indirect or hidden regulatory and liability costs as well as the use of a longer time horizon for calculating profitability. An accounting approach that fails to capture these more comprehensive costs and benefits will also fail to place prevention investments on a "level playing field" with other competing investments whose returns are adequately covered using existing analytical approaches.

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[5] Ross, Marc 1986. "Capital Budgeting Practices of Twelve Large Manufacturers," *Financial Management*, Winter, 15-22.

[6] Rubenstein, Daniel Blake, October 1990. "Let Love Keep You Warm When Accounting For Environmental Obligations", Unpublished paper, Office of Auditor General, Government of Canada. In contrast to Total Cost Assessment which concerns only private or internal costs and benefits, Lifecycle Analysis (LCA) refers to all costs and benefits--both private and societal--associated with a production process or product.

We cannot *a priori* predict that all or most prevention-oriented projects will succeed if modified cost accounting procedures are adopted. We can, however, say that such projects are typically characterized by a stream of benefits that are more varied and accrue over a longer time horizon than conventional financial evaluation methods usually allow. At the same time, we know that firms of all sizes routinely omit costs of existing environmental management practices from their project analyses, thereby biasing their decision-making against prevention-oriented alternatives.

In sum, our focus in this study is on the financial/economic issues that underlie the seeming inconsistency between prevention project profitability and the slow pace of implementing such projects. Thus, our concern is with these interrelated questions: How do firms currently conduct environmental project analysis? Are prevention projects able to compete effectively using existing methods? For those that cannot, would a more comprehensive analytical approach make a difference? If so, are such differences marginal or substantial? Through the examination and application of Total Cost Assessment (TCA) -- the comprehensive, long-term financial analysis of pollution prevention projects -- we have begun to answer these and other questions related to the role of financial analysis in pollution prevention decision-making. This report presents the results of this research, with case study applications to the pulp and paper industry. Although the pulp and paper is our focus, our findings are applicable to other industrial sectors.

Research Design

Exploration of our research questions involved compilation and analysis of both primary and secondary data. Our goal was to bridge the gap between TCA concepts and TCA practices by examining the availability and strengths of existing methods, comparing these methods with extant project financial analysis in the pulp and paper industry, and alternative improvements necessary to accelerate TCA in that sector. Our methodology relied on case studies of four firms, with two providing material for an in-depth look at current financial analysis practices versus TCA alternatives.

We stress at the outset the exploratory nature of this research, owing to the limited sample size. With this limited sample size, we may only tentatively answer questions regarding current practices and receptivity to TCA within the pulp and paper sector.[7]

Details of our research design are as follows:

Task 1. Conduct literature review. This review covered three principal areas: (1) the economic and organizational aspects of industrial pollution prevention; (2) the role and methods of cost accounting in industry; (3) project evaluation methods currently available that fall under the broad rubric of TCA as defined herein.

Task 2. Select and secure access to case study firms. We contacted 14 pulp and paper coating mills, seeking a cross-section of integrated and coating operations. Our contacts were drawn from recommendations by the University Maine - Orono, the Northeast Waste Management Officials' Association (NEWMOA), Lockwood-Post's *Pulp and Paper Directory*, and personal contacts. Ultimately, four agreed to participate in the study, of which two collaborate on in-depth studies of pollution prevention projects that already had been subject to some level of technical and financial analysis:

1. Non-integrated coated fine paper mill

[7] A larger and more diverse sample is the subject of the companion report entitled: *Alternative Methods for the Financial Analysis of Industrial Pollution Prevention Investments, Draft Report.* Prepared by Tellus Institute for the New Jersey Department of Environmental Protection, Division of Science and Research, September 1991.

2. Paper coating mill
3. Integrated bleached kraft, market pulp and tissue mill
4. Non-integrated, specialty paper mill

Firms who agreed to meet with the research team received a Project Summary, TCA Overview, and a two-part questionnaire (Appendix D). Part I of the survey questionnaire, Company Profile, focused on general management, product lines and manufacturing processes; generation of air, water and solid pollutants; pollution control costs and their allocation within the firm; and pollution reduction initiatives. Part II of the questionnaire, Financial Analysis of Environmental Projects, focused on current project financial analysis methods, and receptivity to the TCA alternative. Included in this set of open-ended questions were several dealing with organizational issues, that is, the way the firm decides how to allocate capital and the way such decisions might favor or disfavor pollution prevention versus control strategies. We asked that Part I be completed before our first visit, whereas Part II would form the basis for discussion during the meeting. The decision to pursue in-depth project analysis was deferred pending the outcome of the first interview.

Task 3. Conduct First Round of Interviews. Interviews were conducted during February-May, 1991. Per our request, a mix of senior company representatives participated, ranging from environmental engineering and/or compliance specialists to financial, production and R&D staff. At the conclusion of the Phase I interviews, two firms were selected for Phase II, in-depth TCA project analyses.

Task 4. Conduct In-Depth Project Analyses. Two facilities agreed to collaborate on in-depth studies, one involved in paper coating and the second in production of coated fine papers. In both cases, key individuals within the environmental affairs/compliance area emerged as advocates of the project. Both saw the research project as an opportunity to advance a pending pollution prevention project, while our goals were to:

1. Gain in-depth knowledge of the procedures used by several firms to evaluate prevention projects;

2. Evaluate the quantitative impact of a TCA approach on the financial view of a project, as currently conducted by the firm;

3. Evaluate the availability of relevant data and the effort required to conduct a TCA;

4. Conduct a TCA analysis based on a hybrid approach to allow comparisons between company and TCA outcomes.

As we discussed options for in-depth analyses, these criteria emerged:

1. **The firm's decision to accept or reject the project is pending, or the project has been rejected.** By choosing such projects, it was our goal to either provide additional information to decision-makers on a project currently under evaluation, or to re-examine (and potentially resurrect), using a TCA approach, a project rejected for reasons of unsatisfactory profitability.

2. **Major project technical issues have been resolved.** Since our focus is on the financial aspects of the project, we did not want to select a project with significant outstanding technical questions that might undermine the development of a credible financial analysis.

3. **The firm has completed at least a preliminary project financial analysis.** Since one of our objectives for the in-depth studies was to compare a TCA to a financial analysis as typically constructed by the firm, our goal was to select projects that had already been analyzed.

4. **The firm is interested in the prevention project and committed to the preparation of an in-depth analysis.** Knowing that the studies would require many site visits, phone calls, and data collection and review, we sought firms that were enthusiastic about the project and participating in our study.

In the case of in-depth studies, we initiated an iterative process comprising data needs definition, compilation, manipulation and review. This was the most labor-intensive phase of our research, though specific project requirements varied according to technological and operational complexity of the proposed investment and the degree to which analysis already had been performed. Developing the TCA required many data requests and discussions, even when the firm had invested substantially in project financial analysis. In addition, as data compilation proceeded, the contributions of a wider range of company personnel were drawn into the process than had been the case with the original analysis. These developments were not unexpected given the nature of TCA; as the net of costs and savings is cast more widely, the "reach" of the project extends into more and more areas of the firm's operations. In the case of the paper coater, this process tended to raise cross-departmental issues concerning the potential operational and cost implications of the project.

Task 5. Assess Incentives/Barriers to Adoption of TCA in the Context of Pollution Prevention. Our objective in this task was to perform a preliminary assessment of barriers/incentives to TCA adoption from a regulatory perspective, and to assess how such barriers and incentives relate to the pulp and paper sector in particular. For this assessment, we explored three broad types of incentives/barriers to the adoption of TCA in advancing pollution prevention: (1) financial--i.e., grants, loan guarantees, state-issued loans, interest subsidies, tax credits and accelerated depreciation; (2) regulatory--e.g., requirements imposed by the Securities and Exchange Commission; and (3) organizational--including both management and internal accounting systems that influence how capital allocation decisions are made.

The remainder of this report is organized as follows. Section 2 discusses pollution prevention in the pulp and paper industry to provide context on the cases we subsequently analyze. Section 3 reviews and compares conventional and TCA methods of project financial analysis, and then reviews the major TCA methods developed thus far. Section 4 presents a summary of TCA analyses of two cases developed in collaboration with firms currently considering pollution prevention projects. Section 5 overviews the barriers and incentives to adoption of TCA. In conclusion, Section 6 presents directions for future policy development and research.

2. POLLUTION PREVENTION IN THE PULP AND PAPER INDUSTRY

The pulp and paper industry is one of the world's oldest and largest industries. Pulp and paper technology was developed largely in the nineteenth century, and since that time, technical advances have been dominated by engineering process improvements, as opposed to radical innovations in basic technology.

In the United States, the industry includes some 265 domestic firms and 640 plants engaged in pulping, paper and board making, coating, and converting. In 1989, among all US. industries, the pulp and paper industry ranked tenth in value of shipments at $120 billion, and employed approximately 160,000 people.[8] It is a major component of our domestic economy.

The pulp and paper industry is also a significant source of industrial pollutants discharged to air, water, and land. Historically, environmental regulation of the industry has focused on reduction of BOD and TSS[9] in water effluent, and air emissions of particulates, sulfur dioxide and organic sulfur compounds. Spurred by technology-based effluent standards, major reductions in emissions of these pollutants have been achieved using primarily capital-intensive, end-of-pipe control technologies such as primary clarification and biological wastewater treatment for control of water pollutants, and scrubbers and electrostatic precipitators for air pollutants. While these technologies reduce the flow of pollution into either water or air, they do so principally by shifting the pollutants from one medium to another.

Though pulp and paper mills have relied heavily on end-of-pipe technologies, pollution prevention is by no means a new concept. In-plant recovery and reuse of pulping chemicals, for example, is an integral part of the kraft pulping process. Other examples include: in-plant fiber and water recovery and reuse in the paper mill, counter-current washing in the pulp mill, and dry wood debarking in the woodroom. These technologies have been widely implemented to reduce pollution generation and to reduce raw material and energy costs.

During the past ten years, environmental regulation of pulp and paper manufacturing has expanded to include toxic air and water pollutants, and toxic constituents in mill sludge. In 1984, the industry received its first toxic effluent standards, when Best Available Technology (BAT) limitations were set for pentachlorophenol, trichlorophenol and zinc. In 1987, EPA's National Dioxin Study found evidence of a pattern of dioxin concentrations in stream bottom sediment and fish downstream of pulp mill waste outfalls. This discovery has led to strong pressure on the industry to reduce emissions of dioxin, and ultimately is likely to lead to dioxin effluent standards and restrictions on the land application of sludge from chlorine or chlorine-derivative pulp bleaching. According to the Toxics Release Inventory (TRI) data of 1988, the industry ranked fourth among U.S. industries in total discharges of TRI pollutants to air, water, and land. The industry ranked first in TRI emissions of chloroform (70% of total), and second in toluene emissions (13% of total). Under the new Clean Air Act, Maximum Achievable Control Technology (MACT) limits for chloroform must be promulgated for the industry by June 1994.[10]

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[8] Schilling, Hank. "EPA's Pollution Prevention Activity for the Pulp and Paper Industry." Conference Proceedings for "Reducing the Use of Toxic Chemicals in Pulp and Paper Manufacturing", March 1991, Durham, New Hampshire.

[9] BOD, biological oxygen demand, is a measure of organic pollution in a water. It represents the oxygen depletion potential of a wastewater stream. TSS, total suspended solids, is a measure of the entire amount of suspended solids in a wastewater stream.

[10] Schilling, Hank, 1991. Op. cit.

Added to this list is a movement by state environmental agencies to tighten pulp mill effluent standards for foam, odor, and color,[11] pollutants that are both difficult and costly to remove.[12] In addition, new permits issued under the Clean Water Act and the new Clean Air Act will contain more stringent emissions limitations for conventional water pollutants (e.g., BOD and TSS), and criteria air pollutants (e.g., SOx, NOx, and particulates).

Finally, the solid waste crisis and renewed public interest in resource conservation has brought to bear increased pressure on the paper industry to use more recycled paper in its products. Numerous federal, state, and local laws and purchasing policies exist, and many more are proposed, which require recycled content in paper products. If the federal bill "Resource Conservation and Recovery Act (RCRA) Amendment of 1991" (also referred to as the Baucus Bill) is passed, minimum recovery rates for newsprint-52%, corrugated paper products-66%, mixed paper grades-20%, and high-grade de-inking-50%, and pulp substitutes-100% would be required, placing additional pressure on the industry to utilize recycled paper.[13]

Regulatory and public pressures in the coming decade will continue to pose a challenge for the industry, particularly because the kinds of changes that are necessary to meet these demands tend to be complex, costly, and dependant largely on materials substitution and process redesign rather than traditional end-of-pipe controls. The industry already has taken some steps to reduce, for example, dioxin generation. As documented in a June 1991 report, EPA found 64 out of 104 mills surveyed have or are planning to implement process changes that are targeted at reducing dioxin formation. These include: increased chlorine dioxide substitution for chlorine, increased use of peroxide, and oxygen delignification. According to the report, mean concentrations of dioxin (2,3,7,8-TCDD) in treated effluent were reduced by 50% between late 1988 and 1989. Preliminary data from 1990 effluent samples indicates that dioxin emissions have declined further.[14]

If we consider two general contexts within which companies implement pollution prevention--a compliance context (either existing or anticipated regulations) and a discretionary context (motivated by efficiency or market gains), it appears that pollution prevention efforts in the pulp and paper industry will fall primarily in a compliance framework within the next few years. This seems likely for several reasons. First, the significant number of new and tightened regulations affecting the industry will require significant resources--both direct capital and human (i.e., engineering, legal, etc.) resources--to implement "must-do" compliance projects. Second, the industry is coming off a record-setting period of capital spending for new and upgraded equipment, and analysts expect a sharp drop in discretionary spending for the next few years[15]. Finally, like many sectors, the industry is experiencing an economic down-turn that is expected to reduce capital spending. These trends point to a likely reduction in discretionary capital spending in the industry for the next few years. While the financial benefits of product image and market-expanding

[11] Maine, for example, passed legislation in 1990 requiring pulp and paper mills to reduce color, odor, and foam emissions.

[12] According to one mill in Maine, pulp mills in the State will have to spend an estimated $210 million in capital investment to meet the State's new requirements.

[13] Under this proposed legislation, these standards would not be enforced if 40% of all paper generated in 1995 were recovered for recycling.

[14] U.S. Environmental Protection Agency, June 1991. "1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities, Preliminary Summary Report of Questionnaire Responses for Mills Which Bleach Chemical Pulps," prepared by Radian Corporation.

[15] Capital spending by the pulp and paper industry in 1989 reached an estimated $15.1 billion, up from 34.6 percent from 1988, the largest gain registered by any U.S. manufacturing industry. U. S. Department of Commerce, January 1990. *1990 U.S. Industrial Outlook, Prospects for Over 350 Manufacturing and Service Industries.* Washington, D.C.

investments in, for example chlorine-free bleaching and heavy metal/solvent-reduced coatings, should not be dismissed, we do not expect that these incentives will be a prime motivation for investment in pollution prevention within the next few years.

If compliance is going to be the major force driving environmental investments in the industry, and if policy-makers seek to promote pollution prevention rather than end-of-pipe control, then the regulatory process is the logical vehicle for encouraging or mandating prevention investments. This could mean developing technology-based standards grounded in pollution prevention techniques,[16] educating state and federal permitting authorities to understand and promote prevention approaches in mill permitting, and providing direct or indirect incentives (see Section 5) for mills to choose prevention in developing compliance strategies and choosing among technology options.

Regardless of how options evolve, a mills choice between an end-of-pipe or a prevention strategy in order to meet a regulatory standard will depend heavily on comparitative economics of these options. This is so even in instances where profitability is negative, that is, when the firm expects a net loss on its investment. Even under these conditions, the inclusion of certain indirect or less tangible costs and benefits may make the difference in selecting a pollution prevention versus an end-of-pipe option. It is at this decision point that the concepts and methods of Total Cost Assessment (TCA) can play a role in improving the financial picture of a pollution prevention investment, and enhance its competitiveness with pollution control projects. We now turn to a discussion of the concepts and methods of TCA to demonstrate how this may occur.

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[16] EPA plans to base new effluent standards and guidelines, scheduled for promulgation in October 1995, on low- or no-chlorine technologies to "force" pollution prevention by mills (from text of presentation by Hank Schilling, NEWMOA conference).

3. CAPITAL BUDGETING: THE CONTEXT FOR FINANCIAL ANALYSIS OF POLLUTION PREVENTION INVESTMENTS

All manufacturing firms, whether large or small, face the task of determining how to allocate scarce capital resources to competing projects. Whether financed internally with capital reserves or current cash flow, or externally with equity or debt, most pollution prevention projects are subject to some type of profitability analysis used to assess their competitiveness vis a vis other competing projects and/or a prescribed hurdle rate established by the firm. In the next few sections, we describe the capital budgeting process, and specific issues concerning the evaluation of environmental projects and environmental costs. These sections set the stage for a discussion of Total Cost Assessment (TCA), an new approach to financial analysis of pollution prevention projects, and several TCA methods.

Capital Budgeting

Capital budgeting is the process of analyzing alternative investments and deciding whether they will be included in the firm's investment budget. Capital budgets provide information on planned and approved expenditures of fixed assets, and often extend over five to ten or more years into the future. Thus, the capital budget is strategic in nature, identifying the financial resources available and required, and assisting in the corporate planning process. Small, privately held firms generally budget in an informal manner, focusing on short-term operations and profitability. This reflects the need for small businesses with little capital to recoup their investments quickly, as well as the absence of in-house expertise to develop more sophisticated financial analyses. At the other extreme, large, publicly-owned corporations employ formalized procedures, requiring involvement of several departments within a company. Where investments are large, the demand by top management and lenders for a rigorous analysis of costs and risks necessitates more sophisticated methods for determining profitability.

Capital budgeting decisions are based on a combination of financial analysis of proposed investments and subjective judgement, reflecting experience, current corporate and market conditions, instincts and vision. These two types of information--the concrete and quantitative plus the instinctive and qualitative--guide the allocation of capital resources during the budgetary process. Depending on the sophistication and resources of the firm and the nature of the project itself, such decisions range from complex, multi-year technical and financial evaluations to quick decisions based on "back-of-the-envelope" calculations of costs and returns.

Analyzing Environmental Projects

What are the special features of environmental projects that defy conventional cost analysis procedures and the utilization of various financial indicators of project performance? When "environmental costs and savings" (e.g., waste management, regulatory compliance, future liability costs) are introduced into project analysis, certain limitations in traditional methods immediately surface. The source of these limitations lies to a large degree in the *uncertainties of environmental costs themselves*, namely: What are they? How large are they? When will they occur?

For all of these questions, the degree of uncertainty can be high and stems from two conditions: (1) the complexity of assessing risks associated with the use, transport and exposure to hazardous substances; and (2) the rapidly changing regulations and shifts in judicial decisions that define and continually alter costs. These two conditions combine to create a high degree of uncertainty and flux to which traditional project financial analyses have not fully adjusted.

Consider, for example, the case of solvents, one of the most common families of chemicals used in a wide array of manufacturing operations ranging from electronics to paper coating, metal plating and pharmaceuticals. Prior to the environmental laws of the 1970s, companies freely chose among solvents best suited to their needs. The versatility and effectiveness of solvents brought about rapid growth in their industrial use and in solvent wastes, leading inevitably to an elevated profile among both regulators and the public. Beginning in the mid-1970s, as their human health and environmental risks became better documented, both virgin and waste solvents have become targets of federal and state regulation. In a period of little more than a decade, these materials were transformed from a favorite among manufacturers to a priority target for reduction. At this juncture, firms in many industrial sectors are aggressively seeking technologies to substitute non-solvent materials in processes where solvents previously represented a critical ingredient.

The experience with solvents exemplifies the rapid change in industry's use of hazardous materials and the volatility in defining the cost implications of their use. Prior to the regulatory flurry of the 1970s, solvents were treated as a material input, the same as any other input connected with an industrial process. During the same period, waste solvents typically were shipped off-site for disposal or reclamation. Costs were recorded as operational, usually in the overhead category along with a multitude of other waste management activities.

Today, however, the picture has changed dramatically. Depending on the location of the firm, solvent use and waste generation expose the firm to a plethora of regulatory requirements and judicial rulings including: RCRA reporting; the air toxics provisions of the amended Clean Air Act; state Toxics Use Reduction (TUR) laws; the federal Toxics Release Inventory (TRI) reports; potential claims for health damages due to environmental exposures or cleanup of hazardous waste sites; and worker claims tied to occupational exposures. To these may be added pressures for firms to participate in voluntary programs such as EPA's 33/50 Project (formerly Industrial Toxics Project).

Accounting for Environmental Costs

Linked to each of the regulations listed above is a set of potential costs. Some are straightforward, though not necessarily routinely articulated by managers; for example, monitoring, training and preparing manifest forms for the off-site shipment of waste under RCRA requirements. Others, however, fall into the category of contingent costs, those which **may** materialize **if** certain events occur: 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 these events are probabilistic in nature, and are dependent upon a range of circumstances over which the firm exercises various levels of control. From a cost accounting standpoint, this probabilistic feature is critical and stretches the capacity of traditional cost accounting methods to incorporate them into project evaluation.

From an external reporting standpoint, dealing with contingent costs of the above type is not new to corporate managers. Guidelines are in place, though their interpretation remains fluid. Existing FASB standards (FAS #5, 1975) require inclusion of contingencies in the balance sheet or income statement when a firm experiences a probable loss or impairment of assets[17]. To date, application of this rule has been reserved for major losses associated with acute, one-time events. The trend in recent court rulings

[17] Todd, Rebecca, 1989. "Accounting and the Environment: Patching the Information Fabric," presented at the *Waste Reduction: Research Needs in Applied Social Sciences Workshop*, National Research Council, Committee on Opportunties in Applied Environmental Research and Development, Annapolis, Maryland, May, 1989.

is to require firms to include in their financial reporting recurrent or longer-term environmental damages without an acute or sudden event.

Reinforcing this requirement are SEC standards (explored in greater depth in Section 5) that require disclosure of all effects that are "material" to the firms' capital expenditures, earnings and competitive position[18]. These include **future** expenditures on environmental controls, as well as any actual or **contemplated** governmental proceeding, that has or **may** effect the financial health of the firm. Certain additional guidelines are in place, namely: (1) that the proceeding is primarily focused on damages involving monetary sanctions or capital expenditures representing more than 10 percent of current assets; and, (2) if the government is a party the proceeding may result in sanctions in excess of $100,000.

The net effect of these accounting and disclosure requirements is substantial discretion, and risk, to the firm in estimating contingency costs. Too little disclosure may result in violation of FASB or SEC requirements; too much may result in creating liabilities where none existed before. The latter, in turn, may have the ironic effect of breaching the fiduciary responsibility of the firm to its stockholders.

The mandate to disclose certain liability costs in external reporting has direct implications for project analysis. By ignoring such costs in analyzing projects, management incurs the risk of misallocation of scarce capital resources by shifting investment dollars toward projects that continue to generate future liability. In so doing, one of the key distinctive benefits of pollution prevention projects--their capacity to root out liability at its source--is omitted from project financial evaluation. A pattern of such omission presents the risks of unanticipated losses, which may undermine the financial condition of the firm and, in the process, its ability to raise capital for future investments from investors and lenders.

The uncertainty associated with estimating liability costs is also characteristic of many benefits of pollution prevention investments related to market performance of the firm. Investments that create advantages to the firm through enhanced corporate or product image are no less real than cost reduction advantages of lower waste disposal costs. Thus, paper products made without chlorine bleaching and coated papers made without solvents or heavy metals may translate into measurable, though uncertain, market advantages. In these instances, environmental projects no longer fit conveniently into a profit-sustaining or cost-reducing category, but take on the attributes of market-expanding projects that are traditionally the favored targets for capital investment.

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[18] Wallach, Paul G., 1988. "The SEC and Corporate Environmental Responsibilities," *Hazmat World*, November, 1988.

The TCA Alternative

The TCA approach, as defined in this study, consists of four elements: expanded cost inventories, time horizon, and use of long-term financial indicators in project analysis and proper allocation of environmental costs to processes or product lines within the company's cost accounting system. Each element is discussed in turn.

Expanded Cost Inventory. While conventional cost analysis practices generally include only the capital costs directly associated with the investment, plus obvious operational costs and savings such as waste disposal and labor, TCA considers a broader range, including certain probabilistic costs and savings. These include four cost categories:

1) 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
  - value of recovered material

2) Indirect or Hidden Costs:

- compliance costs
  - permitting
  - reporting
  - monitoring
  - manifesting
- insurance
- on-site waste management
- operation of on-site pollution control equipment

These costs are considered hidden in the sense that they are either allocated to overhead rather than their source (production process or product), or are altogether omitted from the project financial analysis.

3) Liability Costs:

- penalties and fines
- personal injury and property damage

Liability costs originate from two principal sources: penalties and fines for non-compliance; and legal claims, awards, settlements for remedial action, personal injury and property damage due to routine or accidental hazardous releases under CERCLA[19].

A pollution prevention project by definition reduces or eliminates potential liability costs by reducing or eliminating the source of the hazard from the production process. Two of the methods described in the following section provide a procedure for estimating these potential costs and the year in which they will occur, and recommend their incorporation into financial calculations. In this way, liability is treated in the same way as the more conventional capital and operating costs. However, liability costs are by nature difficult to estimate and equally difficult to locate at a point in the lifecycle of a project. By including estimates of future liability directly into a financial evaluation, the analyst introduces considerable uncertainty that top management may be unaccustomed, or unwilling, to accept as part of a project justification.

Firms currently use several alternative approaches to considering liability costs in project analysis. For example, in the narrative accompanying a profitability calculation, a firm may include a calculated estimate of liability reduction, cite a penalty or settlement that may be avoided (based on a claim against a similar company using a similar process), or qualitatively indicate without attaching dollar value the reduced liability risk associated with the pollution prevention project. Alternatively, some firms have chosen to loosen the financial performance requirements (e.g., raising the required payback period from 3 to 4 years, or lowering the required internal rate of return from 15 to 10 percent) of the project to account for liability reductions.[20]

For publicly traded companies, liability estimation is controversial because the Securities and Exchange Commission requires firms to report liabilities to stockholders and accrue assets to cover these future costs. Also, a liability estimate may be damaging to a firm if it is made public in a legal proceeding. For all these reasons, if firms consider liability costs in project analysis, they normally exercise substantial caution in assigning a quantitative estimate of liability to a specific investment.

4) Less Tangible Benefits:

- increased revenue from enhanced product quality
- increased revenue from enhanced company and product image
- reduced health maintenance costs from improved employee health
- increased productivity from improved employee relations

A pollution prevention project may deliver substantial benefits from an improved product and company image or from improved employee health. These benefits, like liability, are difficult to predict and estimate. A TCA analyst may find a qualitative analysis more appropriate and saleable to management.

Expanded Time Horizon. In addition to a more comprehensive cost inventory, a second feature of a TCA evaluation is its longer time horizon, usually five or more years, because certain costs and savings from

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[19] Comprehensive Emergency Response Compensation and Liability Act of 1980 (also called Superfund) which holds companies financially responsible for environmental damage caused by previous waste disposal and management practices.

[20] U.S. Environmental Protection Agency, Hazardous Waste Engineering Research Laboratory. *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003). July 1988. p. 22.

pollution prevention take many years to materialize. Conventional project cost analysis, on the other hand, often confines costs and savings to a 3-5 year time period. Retaining the typical 3-5 year horizon in project financial analysis will lose track of the very cost and benefits that TCA is designed to capture. For this reason, an extended time horizon is integral to the effective application of TCA. The willingness of firms to extend the time horizon varies with their size, structure, capital availability and competition from alternative investments.

Long-term Financial Indicators. To consistently provide corporate decision-makers with accurate and comparable project financial assessments for capital budgeting, the project assessment tools must meet at least two criteria: 1) they must consider all cash flows (positive and negative) over the life of the project; and 2) they must consider the time value of money (i.e. it must appropriately discount future cash flows. The Net Present Value (NPV), Internal Rate of Return, and Profitability Indicator (PI) methods meet both these criteria. Where projects are competing against each other for limited resources the NPV method is preferred because there are certain conditions under which the IRR or PI methods fail to identify the most advantageous project.[21] The payback method, commonly used by small companies, does not meet either of these criteria. NPV, IRR, PI, and payback are introduced here in their simplest fashion.

Net Present Value (NPV): Under the 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 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 whose cash flows come later will be substantially lowered, rendering the project a much less attractive investment opportunity.

Internal Rate of Return (IRR): The 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. Where several projects are vying for limited resources, all else being equal, the project with the highest IRR should be pursued.

Profitability Index (PI): The profitability index is also known as the **benefit/cost ratio.** The PI is simply the present value of benefits (cash inflows) divided by the present value of costs (cash outflows), and 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.

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[21] Specifically, if two projects either differ in size (i.e. dollar value), or have different time patterns of cash flows, the NPV analysis of the projects could be in conflict with the IRR analysis. Though NPV, in theory, is the preferred approach, many corporate decision-makers are more familiar with and prefer the IRR (and to some extent the PI) method.

Payback: Payback is the simplest of the techniques for evaluating capital project investments. It provides a "quick-and-dirty" or "back-of-the-envelope" appraisal. While 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. The payback period can be calculated before or after taxes, and serves as a type of "breakeven" calculation in that if cash flows come in at the expected rate until the payback year, then the project will break even from a dollar standpoint. However, the regular payback does not account for the cost of capital, meaning that the cost of the debt and equity used in the investment is not reflected in the cash flows or the calculation.[22] Another major drawback of the payback method is that it does not take account of 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 and is therefore often used as an indicator of project liquidity.

Cost Allocation. A firm's cost accounting system is used to track and allocate production costs to a product or process line, principally for budgeting (i.e. operational budgeting) and pricing. When costs for waste management, regulatory compliance, and pollution control are properly allocated to processes or product lines, the cost accounting system provides a rich source of data for TCA.

For purposes of investment analysis, the ideal cost accounting system has two primary features. First, the system should allocate all costs to the processes that are responsible for their creation. This is a perennial challenge to financial officers and cost accountants who decide on the placement of costs into either overhead or product or process accounts. Waste disposal costs, for example, are often placed in overhead accounts, while a process or product allocation would assign such costs based on some activity or component of the manufacturing process.

Second, it is not enough to simply allocate costs to appropriate processes. Costs should be allocated in a manner that is reflective of the way in that costs are actually incurred. For example, waste disposal costs in some companies are allocated 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 impedes a rigorous estimation of the financial benefits of reduced waste generation. Thus, effective cost accounting is critical to directing management attention to the sources of waste generation and the benefits of changing current waste management practices.

TCA METHODS

Several TCA methods have been developed to facilitate the comprehensive analysis of pollution prevention investments. These methods are illustrated here as alternative approaches to structuring project analyses that meet several, but not all, of the foregoing methodological objectives. None of the three methods have achieved widespread acceptance in the business community, despite their availability for as long as four years. This attests to a number of barriers to corporate acceptance, ranging from excessive complexity, intensive data demands, regulatory impediments, to management inertia. Some of these are examined in this section, while others are treated in the Section 5 case studies and Section 6 assessments of TCA barriers and incentives.

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[22] A variant of the regular payback is the discounted payback period in which the expected cash flows are discounted by the project's cost of capital.

What features should a TCA method have to make it useful and useable to businesses? Since TCA methods have not yet received widespread application, no definitive assessment is possible, however, our research into the budgeting and project analysis methods of a range of firms in the Northeast, has revealed three highly desirable features.

First, a desirable system is one that encourages and helps the user to include a complete set of costs and savings, yet provides the **flexibility** to tailor the level of the analysis to the needs of the firm, project type, and size.

Second, the **simpler the method, and the less time it takes to learn and use**, the better. Environmental managers, project engineers and others responsible for financial analysis of pollution prevention projects usually have little extra time to learn or use complicated tools. Many, even in large firms, do not have a sophisticated understanding of computers or financial terminology. A system that requires only rudimentary computer skills and basic knowledge of financial language and calculations will find greatest receptivity.

Finally, to allow users maximum flexibility to conduct the analysis manually or with the use of a computer, **the availability of both paper worksheets and software** is desirable. While computerized tools clearly introduce flexibility and speed, they should not stand in the way of adoption by those who prefer less automated methods of project evaluation.

Several TCA approaches have been developed to facilitate analysis of pollution prevention investments. Three of the most prominent among these are:

- **Financial Analysis of Waste Management Alternatives**, developed by General Electric Corporation ("GE Method");

- **Pollution Prevention Benefits Manual**, developed for the U.S. Environmental Protection Agency ("EPA Method");

- **PRECOSIS**, developed by George Beetle Company.

Each of these methods contain some, but not all, of the features we have described. None have achieved widespread acceptance in the business community, despite their availability for as long as four years. This attests to a number of barriers to corporate acceptance, ranging from excessive complexity, intensive data demands, regulatory impediments, to management inertia. Nonetheless, they serve a valuable illustrations of progress to date and as points of reference for formulating additional methods for use in the industrial community. More detailed review appears in Appendix B. To round out our assessment, we also briefly describe two additional approaches:

- The Economic Feasibility section and Worksheets for Economic Evaluation in the U.S. EPA, **Waste Minimization Opportunity Assessment Manual;**

- Part of Waste Advantage, Inc.'s report titled, **Industrial Waste Prevention, Guide to Developing an Effective Waste Minimization Program.**

The General Electric Method (GE)

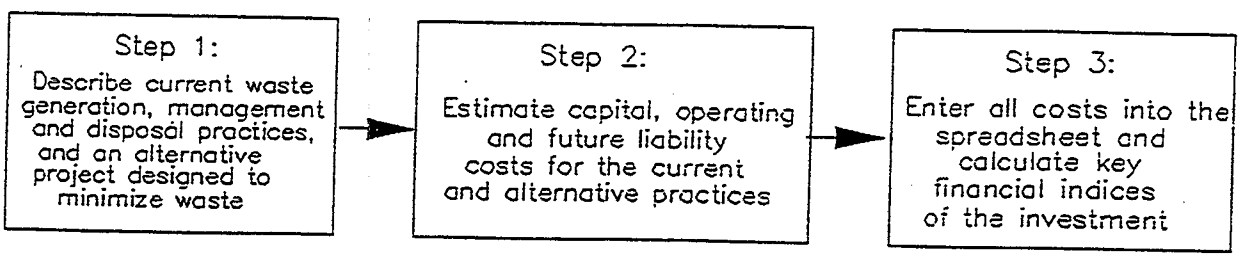
Prepared for:	General Electric, Corporate Environmental Programs Richard W. MacLean, Manager
Prepared by:	General Electric and ICF Incorporated
Publication date:	1987
Contents:	Workbook, Worksheets and Financial Calculation Software developed with Lotus 1-2-3, version 2.01.

Description. The GE workbook and software are tools for identifying and ranking waste minimization investment options.[23] The user quantifies **direct costs** (out-of-pocket cash costs routinely associated with waste management and disposal) and **future liability costs** (including potential environmental liabilities for remedial action costs, and related costs for personal injury and property damage) of a current waste management practice versus one or several alternative waste minimization options. To evaluate the profitability of waste minimization investments the user follows three steps outlined in Figure 3.1.

The Workbook employs a system of waste-flow diagrams and detailed checklists to help the user identify (Step 1) and estimate (Step 2) the direct capital and operating costs (Step 2) associated with generation and on- and off-site management of waste streams targeted for reduction. A procedure is presented for estimating the magnitude and timing of future liability costs associated with current and alternative waste management practices (also in Step 2). These estimates are based on the type and location of treatment, storage and disposal facilities (TSDF) utilized, and the quantity and nature of the waste generated. The user first develops a score for the TSDF based on the technology it employs and the location of the facility (i.e. surrounding population density, proximity to water supply, etc.). This score is then used to adjust--up or down--a per-ton cost estimate for corrective actions and claims developed for a base-case, generic hazardous waste landfill. Included in this estimate are the costs of: surface sealing, fluid removal and treatment, personal injury, real property claims, economic losses and natural resource damage claims.

FIGURE 3-1

SCHEMATIC OF GENERAL ELECTRIC METHODOLOGY



[23] The Manual provides the following definition of waste minimization: "Waste Minimization generally applies in a regulatory context to include reduction or elimination, of the amount of waste requiring ultimate disposal, through treatment steps, recycling steps, and/or waste source reduction". Waste source reduction is further defined as "any method which will reduce or eliminate the amount of hazardous waste before it is generated within the process". While the focus of the Manual is on waste minimization, it can be helpful in evaluating other pollution prevention investments.

The GE workbook provides step-by-step instructions for entering both **direct** and **future liability** cost data and relevant financial parameters into the financial software package or paper worksheets provided in the workbook (Step 3). The software calculates streams of after-tax incremental cash flow of the investment, the net present value (NPV) for the current and alternative practice, and the following financial indicators: a) break-even point, b) return on investment (ROI), and c) discounted cash flow rate of return. The workbook offers recommendations for using the financial indices to identify and rank waste minimization projects.

Data Requirements. To quantify **direct costs** of the waste minimization investment, the user needs the following cost data:

1. estimated capital cost of the waste minimization alternative(s);
2. operating costs for current waste generation, management, and disposal activities that will be affected by the waste minimization project, including labor, input chemicals, and energy; and
3. estimated operating costs for the waste generation, management and disposal activities under the alternative practice(s).

To estimate **future liability** costs and the expected year in which a claim may occur, the user must have the following:

1. Information on treatment, storage and disposal facilities (TSDF)
   a. type of TSDF,
   b. population density in surrounding communities,
   c. proximity to water supply,
   d. history of leaks.

2. Waste stream information:
   a. quantity of waste sent to TSDF, and
   b. hazardous constituents of the waste.

The information listed in item 1 should be available from either the TSDF used by the firm or from a state TSDF permitting office.

For the **financial analysis** of the waste minimization investment(s), the user must decide on an inflation rate, discount rate, investment tax credit rate (if applicable), federal tax rate, and depreciation schedule appropriate to the company. This information is generally available from the company Accountant, Financial Officer, or Comptroller.

Assessment. According to GE, approximately 170 industries, consulting firms, government agencies, educational institutions, and other organizations have obtained the workbook and software. Of the 170, approximately 130 are manufacturing industries. No systematic follow-up of these purchasers has been conducted.

Within General Electric the model has not been used exactly as conceived, but has been applied to support budgetary analysis of waste management and, more recently, as a communication tool to move management in the direction of waste minimization practices.

The GE system is flexible in that it can serve two principal categories of users. First, a user who is beginning to develop a strategy for waste minimization and is seeking guidance on relevant activities and costs for a TCA would benefit from working through the entire system as summarized in Steps 1-3 above. By developing the schematic diagrams and utilizing the check lists provided in the workbook, the user is guided in the identification of relevant waste streams and management activities that should be considered in the cost analysis.

Second, a user familiar with the full range of activities and costs that should be considered in a TCA may skip Steps 1 and 2, and proceed directly to the financial analysis procedure (Step 3). In this way, s/he can expedite the analysis of a specific project by taking only the time necessary to enter the relevant cost items in the worksheets, and examine the financial indices.

The GE financial software is programmed in Lotus, a software package familiar to many people, including small business managers. The system is simple in its design and is user-friendly in its application.

If a user does not wish to include future liability costs for reasons cited earlier, the software can be used to analyze direct costs only. The future liability calculation procedure in the GE workbook can serve as a useful qualitative procedure for assessing, without costing, future liability. It takes the user through a number of additive steps designed to evaluate various key considerations in analyzing this cost component. The process could help the firm qualitatively analyze the risk of a current practice and the effect of a waste minimization alternative.

Because the focus of the workbook is on waste minimization for the purpose of reducing disposal costs and long-term liability, the GE method does not encourage a more comprehensive pollution prevention approach involving materials substitution and process change. Nor does the Workbook provide guidance for the estimation of indirect and less tangible costs and benefits. However, a user can include these items in the evaluation performed with the GE financial analysis software.

Pollution Prevention Benefits Manual[24] (EPA Method)

Prepared for:	Office of Solid Waste/Office of Policy, Planning and Evaluation, U.S. Environmental Protection Agency,
Prepared by:	ICF Incorporated
Printing date:	October 1990
Contents:	Manual and Worksheets

Description. The EPA Manual is designed to assist in the cost comparison of one or more pollution prevention (PP) alternatives to a current industrial practice. The method sets up a hierarchy of costs as follows:

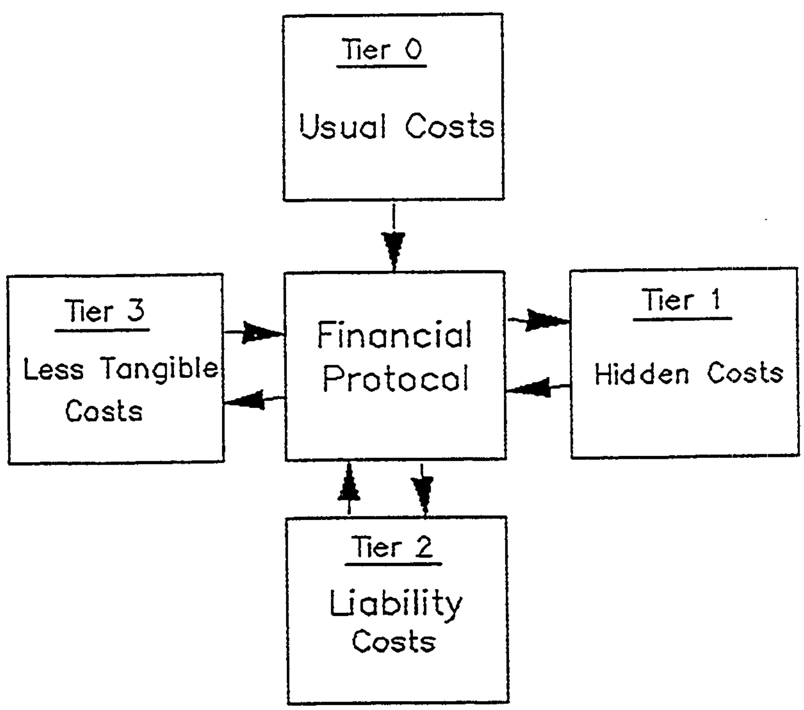
Tier 0 - Usual Costs:	e.g. equipment, labor, and materials
Tier 1 - Hidden Costs:	e.g. compliance, and permits
Tier 2 - Liability Costs:	e.g. penalties/fines and future liabilities
Tier 3 - Less Tangible Costs:	e.g. consumer responses and employee relations

[24] The Manual has not been officially published, however copies can be obtained by contacting the EPA, Office of Pollution Prevention, Washington D.C. 20460.

The hierarchy progresses from the most conventional and certain costs in Tier 0 to the most difficult to estimate and least certain costs in Tier 3. At each tier, the user first analyzes all costs associated with the current and alternative PP project, and then calculates key financial indicators of the economic viability of the PP project. Figure 3.2 illustrates the sequential nature of the method. Financial calculations for each tier are added a tier at a time, until the result concludes that the PP alternative meets the investment criteria (i.e. hurdle rate) of the firm, or all tiers (0 through 3) have been completed. For example, if the results of the Tier 0 financial calculation indicate that the alternative strategy meets the firm's investment criteria, the user may choose not to continue to include Tier 1-3 costs. If, however, the result falls short of the investment criteria, then the user may proceed to calculate and add the Tier 1 results to the Tier 0 results, and so on. Even if the Tier 0 or 1 calculation meets the criteria of the firm, a user may want to proceed to estimate Tier 2 and 3 costs to fully analyze the financial implications of the alternative practice.

FIGURE 3-2

SCHEMATIC OF EPA METHODOLOGY



The Manual provides *a Regulatory Status Questionnaire*, a summary of relevant regulatory programs and cost equations to assist the user in estimating Tier 1 regulatory costs for several compliance activities, including labeling, notification, recordkeeping, and monitoring. The Manual contains numerous cost equations for the estimation of the potential future liability costs such as: ground water removal and treatment, surface sealing, personal injury, and natural resource damage. In addition, the manual provides guidance for calculating three financial indicators: annualized savings, internal rate of return, and net present value. The manual does not come with software, however it does contain worksheets that aid in organizing and presenting results from the cost calculations.

Data Requirements. The following is a summary of the data requirements for each Tier included in the manual. While this list is exhaustive, one should keep in mind that a) not all Tiers are necessary to analyze all projects, and b) not all costs within each Tier need to be quantified if data are not available.

Tier 0: Usual Costs

- Depreciable Capital Costs
  - equipment
  - materials
  - utility connections
  - site preparation
  - installation
  - engineering and procurement

- Expenses
  - start-up costs
  - permitting costs
  - salvage value
  - training costs
  - initial chemicals
  - working capital
  - disposal costs
  - raw material costs
  - utilities costs
  - catalysts and chemicals
  - operating and materials (O&M) labor costs
  - operating and materials supplies costs
  - insurance costs

- Operating Revenues
  - from sale of primary products
  - from sale of marketable by-products

Tier 1: Hidden Costs

- Facility's regulatory status under RCRA, CERCLA, SARA Title III, Clean Air Act, OSHA, and relevant State regulatory programs

- Technology-forcing regulatory requirements and the costs associated with them

- Cost components for regulatory activities such as loaded wage rates, frequency of activity, and time required to complete activity, for the following regulatory activities:
  - notification
  - reporting
  - monitoring/testing
  - recordkeeping
  - planning/studies/modeling
  - training
  - inspections
  - manifesting
  - labeling
  - preparedness/protective equipment (maintenance)
  - closure/post closure assurance
  - medical surveillance
  - insurance and special taxes

Tier 2: Liability Costs

The Manual provides cost equations to assist in the calculation of the following future liability costs:

- Soil and waste removal and treatment
- Ground-water removal and treatment
- Surface sealing
- Personal injury
- Economic loss
- Real property damage, and
- Natural resource damage.

Each equation consists of several variables, for which the Manual provides suggested values. To illustrate, the equation for real property damage stemming from a hazardous material storage tank or disposal facility is:

Cost = a x b x c (in thousands of dollars), where:

a = property devaluation factor
0.15 to 0.30

b = land value ($000/acre)

c = area of the off-site plume
= $[0.33\ D^2 + (D \times W) - 0.5\ W^2]/4047$

Where

D = distance to nearest drinking water well (meters)
150 m to 3200 m

W = width of ground-water plume at facility boundary (meters)

Storage Tanks: W = 3 to 100 meters

Disposal Facilities: W = 500 to 700 meters

A similar equation and set of suggested variable values is provided to predict the expected year in which liabilities may be incurred. While the Manual provides a range of suggested values, the user must either choose from the range or use values based on actual information about a facility, the hydrogeologic characteristics of the facility site, distance to nearest drinking water well, and so forth. Since more than one company may be liable for a particular claim, the user must estimate his or her company's share of the potential liability costs.

Tier 3: Intangible Costs

The user supplies relevant information to estimate less tangible benefits of pollution prevention resulting from enhanced consumer acceptance, employee/union relations, and corporate image. The Manual recommends using the judgement of the analyst and provides some guidance on how to identify and estimate these benefits.

Assessment. Approximately 600 manuals have been distributed, but no systematic follow-up has been conducted to evaluate the user experience. ICF has also distributed the Manual, primarily to consulting firms.

The EPA Manual incorporates a wide array of costs--usual, hidden regulatory, liability, and less tangible--which both prompts the user to consider a full range of costs and encourages quantitative analysis. The multi-tiered structure of this system facilitates step-by-step analysis that starts with the most certain and defensible usual costs and, only if necessary, ends with the less certain, more subtle costs. Therefore, if the investment can be justified on the basis of usual costs, the user does not have to estimate the latter that may generate skepticism within management.

The method provides equations and default values for a number of key costs, which are generally difficult for users to estimate or calculate in the absence of such guidance. Specifically, assistance is provided for the calculation of compliance costs, liabilities resulting from penalties and fines, and liabilities associated with remediation, injury and property damage. In addition, the method provides useful summaries of relevant federal acts and regulations that assist the user in determining compliance requirements and costs.

The EPA system has no software. Given that some of the equations for calculating costs and financial indices involve long algorithms, a user may have difficulty utilizing these equations without aid from accompanying software. In addition, in the absence of software, users may have difficulty performing screening or scenario analyses to evaluate a number of different alternatives, or to experiment with variations on certain alternatives.

PRECOSIS

Prepared for:	U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, Ohio
Prepared by:	George Beetle, George Beetle Company
Publication date:	1989
Contents:	Manual and Software

PRECOSIS was designed to support the financial analysis of waste reduction projects.[25] The software is a menu-driven program consisting of ten data input tables and two output reports containing financial calculations. The programs can be used on any IBM-compatible microcomputer having 512 kilobytes or more of base memory.

Cost data are grouped into three categories:

- **resource effects** - costs of labor, material, and facilities;
- **revenue or value effects** - changes in output quantity and quality, and secondary products/services; and
- **waste management effects** - includes storage, handling, disposal, compliance, insurance, and litigation.

The financial assessment of alternative waste reduction strategies is conducted in four steps, as illustrated in Figure 3.3. First, data describing the baseline (or current) process are entered (Step 1). The user enters cost data for labor, materials, facilities, and waste management in unit cost format (e.g. cost per ton of a feedstock material, or cost per gallon for waste disposal), and then specifies the number of units needed for the current process (e.g. pounds of feedstock used per year or number of gallons of waste disposed per year). Revenue data are handled in a similar fashion. Using these costs and several financial parameters entered by the user, the system calculates the total cost of the current system.

To calculate costs associated with the alternative process, the user must enter an expected increase or decrease (called "effects") in the number of units of resources used, waste generated, and product produced as a result of the process change (Step 2). For example, if 500 units of waste is generated by the current system, and 50 units by the alternative system, then the expected decrease in the units of waste is 450.

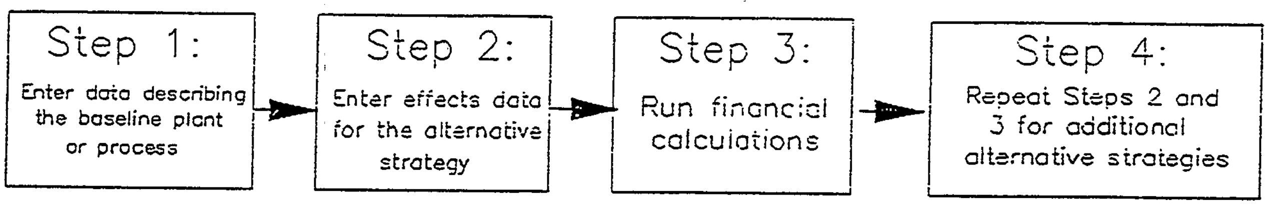
The software calculates net present value, estimated payback years, internal return on investment, and numerous other financial indicators to evaluate the profitability of the alternative process (Step 3).

[25] This system can also be used to evaluate other types of pollution prevention projects.

The user can repeat Steps 2 and 3 to compare financial differences among alternative waste minimization strategies (Step 4). Up to five alternatives can be compared.

FIGURE 3-3

SCHEMATIC OF PRECOSIS METHODOLOGY



Data Requirements. A PRECOSIS user is asked for the following information:

1) **Labor resources:**
- average hourly labor rates
- associated fringe benefits by labor class
- number of units of each class of labor for the current and alternative processes

2) **Materials:**
- physical units of measurement
- typical rates of use for the current process and expected change in use for the alternative strategy
- average delivered costs of materials

3) **Facilities:**
- equipment and building sizes or capacities, average service life, typical salvage value
- typical rates of use for the current process and expected change in use for the alternative strategy

4) **Revenues:**
- current production rates for primary and secondary products and expected changes in production rates for the alternative strategy
- current revenue rates for products and expected changes for the alternative strategy

5) **Waste Management:**
- waste stream volumes and expected changes for the alternative strategy
- waste management costs, including waste monitoring and reporting, and expected changes for the alternative strategy
- insurance for workers and third parties and expected changes for the alternative strategy

Assessment. Approximately 1,000 copies of an older version of the software (uncompiled and more difficult to use than the current version) were distributed at EPA Waste Minimization workshops in 1989. Since May 1990 approximately 100 licenses for the updated version have been sold. No systematic follow-up research has been conducted with firms that received the software at the workshop or those that recently purchased the updated version. We interviewed four company representatives who had attended the 1989 Waste Minimization Workshop.[26] None of the four company representatives have used the system subsequent to the workshop.

PRECOSIS facilitates analysis of both a) the economic feasibility of waste minimization projects, and b) the financial differences among waste minimization alternatives. The method is designed to allow side-by-side analysis of the incremental cost effects of up to 5 alternative projects.

The unit cost method simplifies the estimation of incremental cost effects based on units of raw material and energy used, and quantity of waste generated. It also is well suited to cost sensitivity analysis. For example, once the user has entered in sufficient data concerning the current practice, s/he can easily evaluate the financial effect of reducing an additional unit of waste or raw material, or calculate the effect of changes in waste disposal costs, insurance costs, or the price paid for recovered metals. However, a possible drawback of this sophisticated modelling approach is that PRECOSIS may appear too dissimilar as compared to conventional project financial analyses to which businesses are accustomed. The system may be better suited to financial scenario analysis of waste minimization options, particularly for larger firms with extensive resources committed to evaluating waste minimization opportunities.

The PRECOSIS user likely will need a significant amount of time to learn the method, and to understand the way it is structured. This may be a stumbling block for potential users, particularly those with little or no computer experience. Most of the calculations are not explained in the User's Manual, nor would the typical user be able to examine formulas in the software. Companies may not be willing to base important investment decisions on the output of a complex model that is not verifiable.

Other TCA Methods

In additional to GE, EPA and PRECOSIS, two additional cost analysis tools are available for industry and technical assistance providers. The first is a series of worksheets contained in the U.S. EPA's *Waste Minimization Opportunity Assessment Manual.*[27] This cost analysis framework consists of a series of data collection sheets and a profitability worksheet for calculating several financial indicators.

The data collection sheets contain the following entries:

1. Capital costs, including
   a. purchased process equipment,
   b. materials,
   c. utility connections,
   d. site preparation,
   e. estimated installation,
   f. engineering and procurement,
   g. start-up,

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[26] The companies are: a 400 employee metal working shop; a 350 employee plastics manufacturer, a 500 employee fiberglass building panel manufacturer; and a 1,400 employee manufacturer of electronic devices.

[27] U.S. Environmental Protection Agency, Hazardous Waste Engineering Research Laboratory, 1988. *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003). Cincinnati, OH.

h. training,
i. permitting,
j. initial catalysts and chemicals,
k. working capital, and
l. equipment salvage value.

2. Incremental operating costs and revenue, including
   a. waste disposal,
   b. raw material consumption,
   c. ancillary catalysts and chemicals,
   d. labor costs,
   e. maintenance and supplies, and
   f. insurance and liability,
   g. incremental revenues from increased/decreased production,
   h. incremental revenues from marketable by-products.

The profitability worksheet assists the user in calculating:

a. cash flows of the investment,
b. payback period,
c. annual cash flow,
d. present value cash flow, and
e. net present value.

This cost analysis tool is rather simple yet comprehensive, and does not come with computer software.

The second is a method developed by Waste Advantage, Inc. as part of their report titled *Industrial Waste Prevention, Guide to Developing an Effective Waste Minimization Program.*[28] This method assists the user in developing what is called a "waste generation cost". The waste generation cost is the waste disposal cost **plus** all costs associated with creating the waste. A waste generation cost is developed for each waste stream on a per year basis.

The system categorizes these costs as follows:

1. Treatment, storage, and disposal facility costs,
2. Waste transportation costs,
3. Wasted raw material costs,
4. Labor costs,
5. Other costs, including compliance, consulting fees, drums, and public image, and
6. Future waste disposal liability costs.

For each of the six cost categories above, the method provides a detailed list of the cost-bearing activities that should be included in the waste generation cost calculation.

[28] Waste Advantage, Inc. 1988. *Industrial Waste Prevention, Guide to Developing an Effective Waste Minimization Program*. Southfield, MI.

The per-gallon waste generation cost is calculated by dividing the annual cost by the number of gallons generated in a year. The payback period of a waste minimization investment is:

$$\text{payback period} = \frac{\text{capital investment}}{(\$/\text{gal waste generation cost}) \times (\text{gallon/year reduced})}.$$

The method includes one data collection sheet, a cost worksheet, and several useful sample analyses. The calculation of payback is illustrated in one of the examples. No other financial indicators are addressed.

If waste reduction is the focus of a pollution prevention project, this method can be used to calculate a comprehensive unit cost for waste generation. This unit cost can then be used to further calculate the payback period for one or several waste reduction projects. The methods presented in the Hazardous Waste Opportunity Assessment Manual and the Waste Advantage Guide are useful, simple tools that can serve to assist in pollution prevention project cost data collection and profitability analysis.

Summary

Time horizon, cost inventory, cost allocation and choice of financial indicators comprise the four dimensions of TCA. Our review of current methods reveals a strong emphasis thus far on the inventory issue, with changes to time horizon, cost allocation, financial indicators viewed as linked outcomes to make optimal use of a more comprehensive cost inventory. Insofar as management subscribes to one or more of these principles of TCA, the TCA process is likely to require managers from different units within the firm to view environmental projects in ways to which they are not accustomed. This in itself can be an invaluable step toward better articulation of the sources of pollution management costs, which typically escapes standard engineering and cost accounting systems.

Because the returns to pollution prevention investments are by nature longer term and more dependent on indirect benefits to the firm than conventional practices, a full picture of their financial performance can be revealed through TCA-type analyses. Potential users have different needs and constraints that will influence their receptivity to alternative methods. Offering a menu of TCA methods is one way of responding to these differences.

Our review of various methods reveals a spectrum of TCA approaches, each different in concept, data requirements, and user-friendliness. No single method meets the needs of all users. Moreover, the limited adoption of all the methods points to barriers to implementation that exist in all industry sectors.

Historically, there has been little a priori favoritism toward the prevention option. In retrospect, cost analyses practices have tended to skew investment choices in the direction of end-of-pipe technologies. This occurs because the preventative technologies--materials substitution, product reformulation, process modification--tend to require more complex changes in production systems, to yield benefits in many indirect ways and over longer periods of time, and to include numerous contingency cost savings in the spectrum of benefits that they create.[29] In other words, simplified cost analyses tend to handicap preventative projects in favor of more conventional, short-term end-of-pipe options.

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[29] White, Allen and Becker, Monica 1991. "Total Cost Assessment: Catalyzing Corporate Self Interest In Pollution Prevention." Paper presented to the National Academy of Engineering Workshop: "Engineering Our Way Out of the Dump," Woods Hole, MA, July 1-3, 1991.

In recent years, conventional wisdom and, to a lesser degree, project analysis methods, have shown signs of adjusting to the new environmental reality. This new reality is reflected in a slow shift away from the presumption that every environmental investment is a net loser. The reasons for this shift are several, ranging from the continued price escalation at off-site waste management facilities to the growing consumer demand for clean processes and "green products." In particular, the idea that environmentally-friendly processes and products in and of themselves may enhance the market position of the firm has begun to move some managers beyond the narrow confines of the "must-do", minimalist and compliance-driven approach to pollution management, toward a broader vision of leveraging environmentalism into concrete economic payoffs.

Like many other aspects of business management in the 1990s, rapidly changing environmental regulations and markets are likely to lead industry to reassess the presumption of environmental projects as economic losers. The "must-do" shows signs of giving way to "prefer-to-do" in the face of this redefinition of the role of environmentalism in product manufacturing and marketing. Alternative methods of cost accounting may serve to accelerate these developments by providing a vehicle for capturing the benefits of environmental investments that would otherwise elude project financial analysis.

Whether an environmental project originates in response to an external compliance mandate or to an internal, cost-savings measure, a more comprehensive analysis of costs and benefits equips managers to discriminate with greater precision between alternative technological solutions to the same compliance mandate. Though the more expansive cost inventory and time horizon of TCA will not necessarily direct management to a prevention-oriented solution, it will place end-of-pipe and prevention options on an equal footing. In the end, though financial indicators may remain negative, TCA will more clearly illuminate the **relative** returns to alternative options more effectively than conventional accounting procedures.

With these propositions in mind, we turn now to a more detailed look at how TCA operates when applied to two specific projects within the pulp and paper industry.

4. TCA AT WORK: CASE STUDIES IN THE PULP AND PAPER INDUSTRY

At this juncture, the concepts and methods of TCA are substantially more advanced than their application in the business community in general, and the pulp and paper industry specifically. Our review of three existing methods reinforces two general explanations offered earlier as to why firms have been slow to adopt TCA in project financial analyses. The first of these is organizational, that is, how the internal structure of the firm facilitates or impedes the entry of pollution prevention projects into the capital budgeting process. When such organizational barriers to entry are insurmountable, no form of economic analysis will matter.

The second explanation, and the principal focus of this study, relates to how projects once in the capital budgeting process are financially analyzed and prioritized. Key issues here are cost coverage, time horizon, financial indices and hurdle rates, as well as management's treatment of qualitative issues before rendering a final decision to approve or reject a project. Each firm has its own recipe, a mix of quantitative and qualitative information that yields a final judgement on the merits of a proposed project.

In this section, we bring together findings from our case studies to examine how the organizational and economic factors act and interact to affect a firm's receptivity to TCA concepts. We draw insights from both Phase I and Phase II case studies (Appendix A) to develop a composite picture of how capital budgeting is currently practiced in the sample firms; how their project analysis methods compare with TCA from both a qualitative and quantitative perspective; and how managers assess the value of and opportunities for introducing TCA into their project justification process.

The heart of this assessment is a comparison of two pending projects whose economics are analyzed and compared using company versus TCA methods. To these two core cases we add material from the Phase I studies, and more general information gathered during our literature reviews. With few case studies, our findings can only be exploratory in nature, with more definitive conclusions possible only with a larger sample size. Notwithstanding these limitations, our case studies provide a starting point for developing insights into TCA prospects in the pulp and paper industry.

Capital Budgeting and Environmental Projects

Capital budgeting in case study companies, the process by which firms identify and rank potential capital projects, tends to be systematic in accordance with methods used by most large corporations. Typically, multi-year capital investment plans are put in place to guide capital allocation decisions. In the case of the specialty paper firm, such a plan was developed for environmental projects after staff reviewed proposed regulations governing air, water, and storm water runoff. Because the industry will be subject to a continuous stream of state and federal regulations governing effluent standards, criteria and toxic air emissions, and restrictions on sludge disposal, such multi-year plans are an aid to rationalizing the budgetary process in response to conditions of substantial existing and anticipated regulatory requirements.

Pulp and paper mills are large scale operations, and capital investments are by and large costly. Projects we analyze below for a specialty paper mill and paper coating mill cost $0.6 million and $1.7 million, respectively, investment levels not uncommon to the industry. For this reason, proposed budgets are closely scrutinized by operations managers (e.g. pulp mill, and paper mill managers), mill management, and corporate management. For pollution prevention projects, this means a high level of scrutiny at numerous levels within the organization.

An environmental project's lifecycle normally begins with an initial needs identification by the environmental manager or staff engineer. In the specialty paper firm, an investment in excess of $5000 requires a Capital Improvement Form; in the remaining three cases an Appropriation Request is completed, though no minimum level of investment was identified. These standard forms present: the need for the project; a description of the proposed technical approach; proposed process outline and schematics; and project cost estimate. At the same time, they provide the basis for classifying projects as profit-sustaining (compliance), profit-adding (cost-reducing) and market-expansion categories. Unlike most smaller and medium-size firms, these pulp and paper mills view profit-adding projects as the core of their budgeting process. This is an industry where basic technologies remain constant and product lines change infrequently. Thus, competitiveness historically has been linked to maximizing output using existing capital stock while, at the same time, minimizing costs through timely, targeted capital or operating practice improvements.

Notwithstanding these historical patterns, one case study, the paper coating mill, demonstrates an incipient trend observed in our companion study for the State of New Jersey[30]--the gradual shift of environmental projects from the profit-sustaining category to the profit-adding and market expansion categories. This is, most often, not an overt decision by management, but rather the result of a subtle shift from viewing environmental projects as inherent losers (i.e. yielding a negative IRR or NPV) to a more flexible vision of their potential as contributors to improving market position. Environmental managers in the paper coating mill see this shift as a means of increasing a project's probability of approval. In this case, if an environmental project is determined to be profitable, the project is characterized as an "environmental, profit-adding project". In the integrated bleached kraft mill, if a proposed discretionary environmental project is expected to be profitable, the project is essentially reclassified as a "profit-adding project with environmental benefits" -- no different than any other non-environmental, profit-adding project with environmental benefits. In this scenario, a project conceived for its environmental merits virtually loses its identity as an environmental project in favor of a classification that is more likely to gain approval.

In the pulp and paper case studies, approval criteria for pollution prevention projects, over and above conventional financial indicators, suggest an implicit valuation of downstream benefits that are not monetized in financial analyses. This is reminiscent of other firms surveyed in the New Jersey study, where less tangible benefits of specific environmental projects were often mentioned in our interviews, but only qualitatively addressed in appropriations requests or not addressed at all. Such references included: projects undertaken "to do the right thing" (electric utility and pharmaceutical company); to project the correct image in a food-related business (refrigeration company); "to foster an environmentally friendly image" (pharmaceutical company); and "to stay out of the newspaper" (electric utility).

Though the notion that a pollution prevention project is market-expanding is rarely articulated, this is effectively what such comments represent. This appears to be especially true for consumer product firms, and perhaps less so with firms engaged in intermediate production where consumer tastes and credibility are less of an issue. However, in our New Jersey research, even a refrigeration firm referred to the "food image" factor as a motivation for adopting clean manufacturing technologies. Owing to differences in product line, we would expect greater willingness of pulp and paper companies producing brand name consumer goods to consider such benefits in their project analyses than would, for example, mills producing corrugated boxboard.

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[30] This study assessed TCA in 10 firms of varying size and product lines. See White, Allen, Monica Becker, James Goldstein, *Alternative Approaches to the Financial Evaluation of Industrial Pollution Prevention Investments.* Draft Report. Prepared for the New Jersey Department of Environmental Protection, Division of Science and Research, September 1991.

Current Versus TCA Project Analysis Practices: Qualitative Comparison

In the context of the capital budgeting process described above, how do the companies studied conduct project financial analyses, how do these practices compare to a TCA approach, and what effect does a "TCA style" analysis have on the estimated profitability of a pollution prevention investment? To answer these questions, we compare three aspects of current and TCA project analysis practices between the two Phase II mills: cost coverage, financial indices, and time horizons. This is done through the construction of a "Company Analysis" and a TCA Analysis for a project at each mill. A brief description of the two projects follows. Appendix A contains detailed project descriptions and the results of the Company Analyses and TCAs.

Project 1 - White Water and Fiber Reuse Project, Coated Fine Paper Mill

Papermachine white water, a mixture of water, residual fiber and filler (clay and calcium carbonate) drains out of the sheet of paper as it travels across the paper machine. White water is typically captured by a white water collection system dedicated to one papermachine. Typically, some or all white water is recycled back into the papermaking system to recapture water, fiber and filler. In some cases white water is passed through a saveall screening device to separate fiber and filler from water; fiber, filler and water are recycled back into the system. The saveall produces a clear stream of water that can be used in numerous papermachine operations.

In this mill two paper machines, sharing a common white water system, produce a variety of paper grades made with acid, neutral, or alkaline sizing chemistry.[31] Machine 1 has a saveall system that filters fiber and filler prior to discharging water into the joint white water system. The fiber, filler and water are all recycled back into the papermaking system. However, when the machines are using different sizing chemistry, e.g. when Machine 1 is producing acid-size 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.

The Water and Fiber Reuse project will permit fiber, filler and water reuse on both machines at all times, thereby conserving raw materials and reducing water consumption, wastewater generation, and energy use for fresh and wastewater pumping and freshwater heating. This project involves the installation of a second saveall to screen the white water from Machine 2 and the reconfiguration of the white water system to provide dedicated systems for each paper machine.

Project 2 - Conversion of Solvent/Heavy Metal Paper Coating to Aqueous/Heavy-Metal-Free Coating, Paper Coating Mill

Currently, the majority of colored, coated papers produced by this Paper Coating Mill are produced in two steps. First the paper is coated with a pigmented base coat, consisting of a variety of solvents, nitrocellulose, clay, calcium carbonate, and in approximately 50% of colored grades, a small amount of lead, chromium, and cadmium-based pigments. The base-coated paper is run through a dryer where most of the solvent is driven off and the remaining materials set on

[31] 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.

the paper. In the second step, the paper is again coated with a top coat of solvent and nitrocellulose. The paper is dried again and rolled onto a reel, and is ready to be converted into book covers, labels, menus and other applications. The vaporized solvent from the two dryers is collected and sent to a solvent recovery system. VOCs from solvents are emitted from several points in the process, and hazardous waste containing solvent and heavy metals is generated in the solvent recovery process. The conversion project involves switching from a solvent/heavy-metal base coat to an aqueous/heavy-metal free formulation. This project would substantially reduce solvent and heavy-metal usage, VOC emissions, and hazardous waste generation. The conversion requires several capital projects: coating mix room and coating machine modifications, a new coating drum shed heating system and waste water treatment system for wastewater from the aqueous coating process.

The conversion will reduce costs related to waste management, solvent recovery, and regulatory compliance, will increase utility costs, and will have a mixed effect on raw material costs.

In our discussion, we include findings from the Phase I mills that reported general company practices without reference to a specific project.

First, a brief description of the procedures used to develop the "Company Analyses" and the "TCAs" is in order.

Development of the "Company Analyses" and TCAs

The development of the financial analyses was structured to allow comparison between a TCA approach and that which has been previously used by the three Phase II firms to analyze the projects. Two steps were necessary.

First, we needed to develop a base line financial analysis for each project, which we term the "Company Analysis". The Company Analysis consists of only those costs that have been included in a firm's evaluation of either the complete project or components of the project thus far analyzed by the firm. The project descriptions in Appendix A contain detailed descriptions of the content of each Company Analysis.

Second, since the financial analyses undertaken by the firms come in numerous forms, it was necessary to convert disparate information into a uniform format to compare against a TCA. To do this, we used a spreadsheet system to collect and organize capital and operating cost data, to calculate cash flows and financial indices and to perform sensitivity analyses of the case studies.[32] For each project, detailed cost information and results of financial calculations can be found in Appendix A, following their project descriptions.

The comparison of the Company Analyses and the TCA solely on the basis of cost items included is relatively straightforward. We simply compare the capital, cash flow, and financial indicators derived from the company analysis with those derived from the TCA (Appendix A). This single dimension comparison shows the impact of an expanded list of costs and benefits on the financial indicators calculated for the project.

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32 *User's Manual for P2/FINANCE: Pollution Prevention Financial Analysis and Cost Evaluation System*. Tellus Institute, 1991.

Next, to evaluate the effect of a longer time horizon and the choice of financial indices on the financial performance of the project, we begin with the TCA analysis as a base case and proceed to extend the years over which return accrues and consider how more sensitive indicators (i.e. inclusive of depreciation, taxes, inflation and discount rate) alter the financial outlook of the project. The results of these evaluations are discussed below in the Quantitative Comparisons sub-section.

Cost Inclusion

While cost categories considered in a financial analysis will tend to differ according to the nature of the project, we can infer from the Company Analyses the types of costs that the these firms typically consider in project analysis. Table 4.1 presents an overview of the costs estimated in the Company Analyses and the TCA. The TCA column represents a complete set of known internal costs and revenues affected by the project. By comparing the Company Analysis column against the TCA column, a picture of the firm's project costing approach emerges.

Direct and Indirect Costs. In the case of project 2, the Paper Coating firm omitted all non-disposal waste management costs, utilities (energy, water and sewerage), solvent recovery, and regulatory compliance costs from its analyses of the aqueous conversion project. The firm also omitted several costs associated with the storage needs and shorter shelf life of aqueous coatings, namely a steam heating system for the coating storage shed, lost raw material value, and the cost to dispose of spoiled coating.

Had a full financial analysis of the white water/fiber reuse project been done by the mill prior to this study, energy savings associated with reduced fresh and wastewater pumping and treatment and freshwater heating would have been omitted. These energy savings, which are included in the TCA, represent a substantial benefit of the project. Their omission in a traditional financial analysis would have drastically underestimated the profitability of the investment.

Future Liability Costs. In this study we have focused on two general forms of future liability costs: liability from personal injury or property damage (e.g., Superfund liability stemming from a leaking landfill), and penalties and fines for violation of environmental regulations. Only the Bleached Kraft Mill has attempted to include liability in their project analysis, but has done so in a limited way, only where actuarial figures are reliable enough to warrant inclusion (e.g., in the evaluation of a new landfill project). In the case of Project 2, the Paper Coating firm did not include an estimate of avoided future liability costs owing to reduced hazardous waste disposal in their own financial analyses. They did, however, allude to this benefit in a qualitative way in their Appropriations Request: "...major reductions in levels of fugitive emissions, and amounts of solid hazardous waste going to landfill, is very positive from a regulatory and community standpoint". The TCA developed for this project includes an estimate of avoided future liability. Since Project 1 does not involve hazardous materials or waste, neither the Company Analysis nor the TCA contains a future liability estimate.

Less Tangible Benefits. Less tangible benefits from pollution prevention investments, such as increased revenue from enhanced product quality, company or product image, and reduced worker health maintenance costs or productivity are certainly the most difficult to predict and quantify. Neither Company Analyses nor TCAs contain estimates of less tangible benefits. In the case of Project 2, the coated paper product is sold domestically, on the basis of cost, visual appearance, and performance durability, to book publishers and other intermediate product manufacturers. Although the company expects some quality improvements using aqueous coating, it does not anticipate an increase in market value. Therefore, it expects no increase in domestic sales as a result of the conversion to the aqueous/heavy metal-free coating. The company hopes to improve its competitive advantage in the

European market if the European Economic Community implements lead-free packaging standards (which would apply to books) as expected. However, it would not speculate on the potential revenue effects associated with increased European market share.

The Coated/Fine Paper Mill does not expect an increase in market share or product value from its white water/fiber reuse project. Both the mills included in Phase II are manufacturers of intermediate, rather than consumer products and cannot directly market their products on the basis of environmental performance in the way that a consumer products company like Procter and Gamble can and does.

Table 4.1. Overview of Cost Inclusion by Company and TCA for Projects 1 and 2

X = Cost(s) Included *P = Cost(s) Partially Included*	Project 1[1] Company	Project 1[1] TCA	Project 2[2] Company	Project 2[2] TCA
Capital Costs				
Purchased Equipment	X	X	X	X
Materials (e.g. Piping, Elec.)			X	X
Utility Systems			X	X
Site Preparation			X	X
Installation			X	X
Engineering/Contractor	X	X	X	X
Start-up/Training	X	X		
Contingency			X	X
Permitting				
Initial Chemicals				
Working Capital				
Salvage Value				
Operating Costs				
Direct Costs:[3]				
Raw Materials/Supplies	P	X	X	X
Waste Disposal	P	X		
Labor	X	X		
Revenues - General				
Revenues - By-products				
Other:				
Transportation			X	X
Indirect Costs:[4]				
Waste Management				
Hauling	X	X		
Storage		X		
Handling		X		
Waste-end Fees/Taxes		X		
Hauling Insurance				
Utilities				
Energy		X	P	X
Water		X		X
Sewerage (POTW)		X	X	X
Pollution Control/Solvent Recovery		X		
Regulatory Compliance		X		
Insurance				
Future Liability		X		

Notes:
1. White water/fiber reuse project
2. Solvent/heavy-metal to aqueous/heavy metal-free coating conversion
3. 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.
4. We use the term "indirect costs" her to mean cost that are typically charged to an overhead account and typically not included in project financial analysis.

A reduction in solvent use at the Paper Coating firm will certainly reduce worker exposure to fugitive solvent emissions, and the elimination of nitrocellulose from the coating mixture will reduce flammability and explosivity hazards. While reduced solvent exposure may result in a lower incidence of worker illness over the long-term, and the elimination of nitrocellulose may result in fewer worker injuries, we had neither the information nor the resources to estimate the potential impact of these benefits on either the company's health care costs or long-term worker productivity. In this case, this issue was dealt with qualitatively in a section of an Appropriations Request, developed by the company, called "Safety/Health Impact of Converting from Solvent to Aqueous Coating". The section listed specific project benefits that will improve safety and industrial hygiene, such as:

"Reduce risk of fire in chemical storage, mixing and coating areas."

"Minimize employee physical activity and fire risk when loosening and removing nitrocellulose from drums."

"Minimize employee exposure to organic vapors reducing health risks and need for IH monitoring and record keeping."

"Minimize odor complaints in Mill and the administration building when retained solvents are released during converting or solvents are used to cle_n converting equipment."

Although many company representatives have said that project benefits are more persuasive if they are monetized and included in the project financial analysis, as suggested in Section 3, when costs are difficult or impossible to monetize a qualitative approach may be more credible to management.

Discovery of previously omitted non-environmental costs. In developing the TCAs for the two projects analyzed, we endeavored to add to the Company Analyses any capital or operating costs or savings that could be attributed to the project and reasonably estimated. While our focus was on environmental costs typically omitted from project analyses, the process of developing a more comprehensive list of costs (or "casting the cost net wider") unearthed other, "non-environmental" costs that were not considered by the company.. In the case of Project 2, all previous analyses of the aqueous/heavy-metal free conversion had omitted the costs of heating system installation, the energy needed to prevent the aqueous coating from freezing, and the additional energy needed to dry aqueous versus solvent-based coating. While the latter cost was acknowledged by several production engineers and managers in meetings with Tellus, it had never been estimated nor included in previous analyses. While probably not surprising to anyone involved in project analysis, the TCA of project 2 lead to a general finding that non-environmental direct and indirect costs may also be left out of project analyses.

Financial Indices

Financial indicators are used as a critical, though not exclusive, ingredient in analyzing pollution prevention projects. Firms typically use such indicators as guideposts rather than decisive elements in judging the merits of a proposed project. Their application tends to be flexible, that is, subject to substantial management discretion as proposals move through the formal or informal budgeting process and compete against one another for scarce capital.

For the relatively large companies included in this study, payback (or the slightly more sophisticated ROI) is typically used as a first screen. If a project passes a prescribed hurdle rate, a more in-depth analysis that computes NPV and/or IRR is common. The Paper Coating Company uses ROI to screen proposed projects before subjecting them to more in-depth NPV and IRR analyses. The Fine/Coated Mill uses payback in a similar fashion. This practice provides the project proponent with an informal estimate of expected performance prior to investment of staff resources (and personal capital) in advocating a proposal. Once this milestone is passed, the proposal typically moves into a divisional or sectoral review where more complex calculations are developed to capture the longer-term costs/savings.

In none of these cases is the hurdle rate inflexibly applied. Instead, there are perceptions associated with each project that are defined by the project's place in the strategic thinking of top management and the degree to which outside pressures from customers, regulators, or the community are applied. In the case of the Coated Fine Paper Mill, the professed hurdle rate for projects is a 2 year payback. However, certain production-oriented projects have been implemented without surpassing this rate; primarily because there was a general perception among decision-makers that these projects were needed to maintain productivity. On the other hand, discretionary environmental projects are more rigidly measured against the company's hurdle rate. This seems to be a result of an impression of environmental projects within the company as necessary but not profitable.

Time Horizon

Time horizon, of course, is closely tied to financial indicators. By their nature, simple payback and ROI calculations are not capable of capturing long-term costs/savings; a particularly severe shortcoming in the case of liability estimation where benefits may materialize 10 years or more into a project's lifecycle. NPV and IRR, on the other hand, can account for costs and savings they occur in future years. Their use is typically associated with large firms and large investments whose market and budgeting horizons are expansive, and who are able to wait many years for a stream of benefits to materialize.

In preparing the TCA for the Paper Coating Mill managers, they indicated that a time horizon of 10 years is typical for major investments. The need for extending this figure to 15 years, to capture the liability avoidance benefits, became evident in preparing the TCA analysis. In the case of the Fine/Coated Paper Mill, once a discretionary project, such as the white water/fiber reuse system, passes an informal payback screening, it is subjected to a 10 year discounted cashflow analysis. Since the TCA for this project did not involve any costs (e.g. future liability costs) that would be incurred in out years, the time horizon is less critical to capturing the full financial impact of the project. *In any case, the linkage between financial indicator, time horizon, and cost inclusion is essential to promoting and practicing TCA in pollution prevention project analysis.*

Company Versus TCA Project Financial Analysis Practices: Quantitative Comparisons

Full evaluation of a TCA approach on a project financial analysis requires inclusion of direct costs, indirect costs, liability costs, and less tangible benefits, may require evaluation of project costs and savings over a long time horizon; and use of profitability measures that reflect the long-term profitability of the project. In the following sections we discuss how these components of the TCA approach affect the financial analyses of pending projects under consideration by the Fine/Coated Paper Mill, and Paper Coating Mill.

Effect of Cost Inclusion on Financial Indicators

As shown in Table 4.2, the inclusion, in the Project 1 TCA, of savings associated with freshwater pumping, treatment, and heating, and waste water pumping dramatically increased the annual savings and financial indicators above the Company Analysis base case. These savings, which would typically not be included in the mill's calculation of profitability, bring the project in line with the mill's 2 year payback rule-of-thumb. By excluding these savings in the Company Analysis, the project looks highly "unprofitable" -- negative NPV and IRR of 6% (years 1-15).

For Project 2, the inclusion of previously omitted costs for waste management, regulatory compliance, future liability and other "non-environmental" costs in the TCA resulted in a net improvement in project cash flows and financial indicators as compared to the Company Analyses. Table 4.3 summarizes these results.

Table 4.2. Summary of Financial Data for Project 1 - White Water and Fiber Reuse Project

	Company Analysis	TCA
Total Capital Costs	$1,743,820	$1,743,820
Annual Savings (BIT)*	$ 116,245	$ 658,415
Financial Indicators		
Net Present Value - Years 1-10	($ 702,855)	$1,242,536
Net Present Value - Years 1-15	($ 587,346)	$1,808,384
Internal Rate of Return - Years 1-10	0%	36%
Internal Rate of Return - Years 1-15	6%	36%
Simple Payback (years)	11.4	2.0

* Annual operating cash flow before interest and taxes

Table 4.3. Summary of Financial Data for Project 2 - Aqueous/Heavy Metal Conversion Project

	Company Analysis	TCA
Total Capital Costs	$623,809	$653,809
Annual Savings (BIT)*	$118,112	$216,874
Financial Indicator		
Net Present Value - Years 1-10	($98,829)	$232,817
Net Present Value - Years 1-15	$13,932	$428,040
Internal Rate of Return - Years 1-10	12%	24%
Internal Rate of Return - Years 1-15	16%	27%
Simple Payback (years)	5.3	3.0

* Annual operating cash flow before interest and taxes

Table 4.4 illustrates the relative effect of each category of operating cost on net annual costs for the Project 2 Company Analysis and TCA. The data show that for this project, savings in waste management and solvent recovery, which were omitted from the Company Analysis, have the greatest effect on annual savings for the project. Whereas certain capital costs, raw materials, and utilities, which were unaccounted for in the Company Analysis but included in the TCA, reduce the annual savings under the TCA scenario. Within the waste management category, savings are spread across all phases of waste management -- from transport, to storage, to waste-end fees and disposal, and waste handling within the firm itself. The $122,371 difference occurs because only disposal fees are included in the Company Analysis, while other essential and costly phases of waste management appear only in the TCA.

Table 4.4. Summary of Costs for Project 2

	Company Analysis	TCA	Difference
Capital Costs	$623,809	$653,809	($30,000)
Net Operating Savings/(Costs):[1]			
a) Raw Material (Spoiled Coating)	$18,112	($27,488)	($45,600)
b) Waste Management	$121,500	$243,871	$122,371
c) Utilities	($5,000)	($87,029)	($82,029)
d) Labor	($8,000)	($8,000)	0
e) Other	($3,500)[2]	$84,520[3]	$88,020
f) Regulatory Compliance	($5,000)	$11,000	$16,000
Total	**$118,112**	**$216,874**	**$98,762**
g) Future Liability[4]	0	$35,000	$35,000

1. Before interest and taxes
2. Filters for wastewater ultrafiltration
3. Filters for wastewater ultrafiltration and solvent recovery
4. Not included in Annual Savings

Future Liability Costs. A savings of $35,000 in avoided liability costs appears in Project 2. In computing this figure, we used a component of the GE TCA method described in Section 3. Recalling one key variable in this method, i.e. adjustment of the liability cost estimate according to type of TSDF used, causes all waste destined for incineration to be heavily advantaged from a cost reduction standpoint under the assumption that incinerated waste is unlikely to result in downstream remedial action costs. Since the Paper Coating firm incinerates its waste, the modest savings that appears in this project analysis flows from this assumption as well as the diluting effect of discounting future savings (liability exposure is assumed to occur in year 13). The net effect is to yield only a modest difference in 10 versus 15-year IRR for the TCA.

The GE liability estimation procedures assume that incineration operates as a powerful safety net, preventing future damages against the firm. Underlying this premise are several assumptions: failure of an incinerator facility will leave the owner, not the waste generator, liable for personal and property damages; liability is most likely to occur in the distant future; incinerator capacity will continue to be adequate to handle all of the firm's waste; and interstate shipments of hazardous waste will continue more or less unimpaired, as historically has been the case. While the first of these assumptions appears to be fairly sound (though regulations are always subject to change), the remaining ones are more tenuous. Capacity shortfall, the continuing discovery of new waste sites, and interstate barriers are entirely plausible, if not already actual conditions, facing any waste generator during the next decade in view of recent waste market conditions, ongoing site investigations, and court rulings that have upheld taxes and surcharges on waste imports. Assuming this to be the case, inclusion of some measure of uncertainty into the liability avoidance calculation would alter the outcome and may lead to a more substantial savings from any proposed pollution prevention investment in which off-site waste disposal is a current cost.

Less Tangible Benefits. Less tangible benefits were not included in either of the TCA project analyses. We earlier defined these as benefits such as gains in market share owing to enhanced corporate or product image, increased worker productivity owing to a safer workplace and similar long-term payoffs reasonably ascribed to pollution prevention investments. These may stand on their own, or be tied to other more concrete benefits such as liability avoidance. In this case, "staying out of the newspaper," to quote one case company, may be one measurable gain from such an investment.

To demonstrate the sensitivity of the financial indicators to these benefits, we have created a hypothetical scenario using Project 2. In the preceding section we saw that the removal of lead from the paper coatings may increase the company's share of the European market. Assume that this share will net the company an extra $0.5 or $1 million dollars in profit (i.e. revenue minus cost to make the additional product) each year, starting in the fourth year after the investment. If we add this profit to the TCA financial calculation, the annual cash flow for the project increases from $216,874/year to $716,874/year for a $0.5 million/year profit increase, and $1,216,874/year for a $1 million increase. This yields an increase in IRR (years 1-15) from 29% for the TCA base case to 46% and 57%, respectively, a significant gain by most any company standard. Even introducing uncertainty into this analysis by cutting expected profits in half would produce a substantial incremental increase in IRR for the firm.

Are All Costs Created Equal?

By reducing waste, fewer drums need to be handled, labeled, and stored, and fewer manifests must be prepared.and managed. While these cost savings can be estimated, they only become **real** if, in the case labor, the payroll will be reduced or a worker will spend time doing productive work instead of managing waste. In the case of waste storage, estimated cost reductions only become real by reducing the number of drums stored if the company can either put that storage space into productive use, reduce space heating and lighting costs, or reduce it's rental costs on rented storage space. In other words, there is an "opportunity cost" associated with waste management activities.

In contrast to waste disposal costs, which are often visibly reduced when waste generation is reduced, estimated labor, waste storage, and other similar cost reductions may or may not be realized "on the books" of the company. This issue has clear implications for TCA. Many waste management and regulatory compliance costs are labor-based costs. This is particularly the case for small projects where a majority of savings added by a TCA are labor-related (disposal related costs excepted), or in the case of a small company where labor costs are a function of what the company can bear rather than the real workload. In these circumstances, TCA is likely be less persuasive than for a project with a majority of savings in disposal, raw material and energy cost reductions.

The Impact of Previously Omitted Non-Environmental Costs

In the discussion of qualitative effects of TCA above, we mentioned that the process of expanding the list of environmental costs may actually turn up previously omitted non-environmental costs. The effect of such costs on the project's financial performance depends upon whether the item represents a cost or a savings for the project. In the case of Projects 1 and 2, these non-environmental costs tended to increase the total cost of the project by adding to capital and operating costs.[33]

For example, capital cost (a direct cost) for the Project 2 TCA was 5% higher than the Company Analysis. The cost for additional steam that will be needed to dry the aqueous coated paper has a negative effect on the annual savings for the project. Thus, for these two projects the firms underestimated the costs, as well as the savings, for the project. Although the net effect is still positive, i.e. the TCA produces a more favorable financial bottom-line, these additional costs reduce the overall positive impact of the benefits.

While this finding is probably not a surprise to those who prepare project analyses, *it is important to point out that the TCA process may actually reveal additional costs as well as savings for the project.* If the financial impact from the addition of regulatory compliance or waste management activities is marginal, they may be negated by the addition of one or two previously omitted non-environmental costs.

Financial Indices and Time Horizon

To examine the effect of the choice of financial indicators and time horizon, we create two functional categories of indices: discounted cash flow methods that consider a stream of future cash flows for the investment (e.g. NPV and IRR), and those that do not (e.g. simple payback period and ROI).

By extending the time horizon of the investment analysis to 10 or more years, the effect of long-term costs or savings can be analyzed. Discounted cash flow methods are well suited to long-term investment analysis since they consider the time value of money, and can easily include tax, depreciation, and inflation effects. On the other hand, payback period and ROI typically consider only the average annual or net annual cash flow and capital costs for the investment, thereby overlooking costs or savings that may be realized in out-years.

While business experts recommend the use of discounted cash flow measures and reasonably long time horizons for investment analysis, the quantitative impact of these techniques in a TCA context depends upon whether the analysis includes costs or savings in years after the initial investment. If long-term costs are included in the analysis, an extended time horizon and use of discounted cash flow indicators are essential. In the case of Project 2, for example, if the time horizon was not longer than 13 years, the liability estimate would not have been incorporated into the financial indicators.

[33] While it is impossible to generalize, this phenomenon may reflect a predictable lack of complete knowledge of the costs for a project.

If long-term costs are not included in the analysis the importance of a long time horizon and use of discounted cash flow indicators is diminished. In the case of Project 1, since all costs and savings of the investment start accruing in the first year of the investment, time horizon and choice of indicators are not critical.

Even if a 10 or 15 year time horizon is chosen, and discounted cash flow indicators used, the outcome of the financial analysis will be greatly influenced by the magnitude of future costs (relative to first year costs), the year in which future costs accrue, and the discount rate used in the analysis. If the magnitude of future costs is small relative to first year costs, then despite the use of a long time horizon and NPV or IRR, the effect of these long term costs on financial indices will be small. As we noted earlier, the inclusion of an avoided liability cost of $35,000 in the Project 2 TCA increases the IRR by only 0.5%. Even if the future cost is high, by discounting the cost to present year dollars the impact of this future cost is diluted by discounting.

In a case study performed for New Jersey, though the estimate for future liability cost was $4,615,000 (1991 dollars), the effect on IRR was marginal--only a 3% gain over the Company Analysis. By performing sensitivity analyses on the TCA for this project, we were able to test the effect on financial indicators of the timing of future costs and choice of discount rate. If liability costs were predicted to materialize in year 5 rather than year 10, the IRR for the TCA would be 44% rather than 40%. And if a discount rate of 10% rather than 12% is used, the NPV would be $13,619,000 rather than $11,514,000.

If a firm accepts in principle the idea of including liability in its financial analysis, prudence would suggest the execution of this type of sensitivity analysis in order to establish reasonable ranges of savings from a pollution prevention investment. This task made more necessary by the many uncertainties in waste management conditions, and by the assumptions built into the GE and other liability estimation methodologies. Of course, this is one reason why firms have been reluctant to either quantify liability or include such savings items in their financial analyses. A firm willing to quantify, but stopping short of incorporation of a figure into a project financial analysis, will still have taken a step in the direction of prudence.

Perspectives on TCA

A comparison of financial indicators for the company versus TCA analysis for our two sample projects demonstrates a substantial improvement in estimated profitability for the TCA. Using a mix of extended time horizon, a more expansive cost and savings inventory, and more precise allocation of raw material use and waste management costs to specific processes, TCA produced impressive advantages in this small sample of pollution prevention projects.

Are these advantages enough to move managers to adopt TCA methods? Is accelerating adoption of TCA to foster pollution prevention investments merely a matter of demonstrating these financial gains? What role do organizational issues play in this process?

In general, our research of pulp and paper firms revealed an interest in the concepts and methods of TCA; stemming primarily from a belief held by many company representatives that *TCA offers the opportunity to translate heretofore subjective information regarding pollution prevention benefits into the language that top management understands and will respond to.* However, relative to firms included in the New Jersey study, we noted somewhat less enthusiasm (with the sole exception of the Paper Coating Mill) and less of a sense of relevance of TCA among the mill representatives (primarily environmental) interviewed.

In the case of the Fine Coated Paper Mill, the environmental engineer's interest in TCA is based on a desire to justify proactive, discretionary environmental projects that currently receive little attention and interest from management. As the primary advocate for environmental projects at the mill, he views TCA methods as tools that can help him demonstrate the benefits of a project, instead of relying solely on an engineer or financial analyst that does not have the same motivation.

Environmental managers at the Paper Coating Mill believe that a complete story of the financial benefits of environmental projects is not being told under the company's current system of project evaluation. They see TCA as a way to improve both their general understanding of the full financial implications, and the status, of such projects.

Representatives of the Integrated Bleached Kraft Mill view TCA as a way of refining project financial analyses of regulatory compliance investments where more than one technology option is available to meet a regulatory requirement. They do not, however, make the connection between pollution prevention projects and less tangible benefits (e.g. increased revenue from improved product or company image) because in their view public knowledge of a pollution prevention program, as in the case of dioxin reduction, generally intensifies rather than diminishes public demand for further reductions.

Environmental Management at the Specialty Paper Mill is interested in estimating potential future liability, primarily to apply such a methodology to evaluate waste management and disposal options. They are convinced of the merit of better allocation of environmental costs (e.g. compliance fees, fines, and penalties) to operation areas--an important step toward understanding the full costs of polluting activities and toward a TCA approach.

Contrasting our findings in this study to those in the New Jersey study, we found that the theme of future liability was not as pronounced in the pulp and paper case study mills compared to New Jersey firms. At virtually all of the New Jersey firms (e.g. an electric utility, an electroplater, a metal fabricator, and technology/chemical and pharmaceutical firm) we heard consistent mention of liability and liability avoidance as a powerful force in reducing or eliminating waste generation and disposal, and in many of these firms the continued tension between the realties of liability and the omission of quantitative estimates of liability avoidance benefits in project financial analysis was a strong selling point for TCA. This is not surprising given the nature of the wastes generated--solvents and heavy metals--and liabilities incurred--costly Superfund settlements--at many of these New Jersey plants. This is in contrast to the uncommon occurrence of similar liability costs in the pulp and paper industry.[34] For this reason, it is possible that a TCA approach has less appeal to this industry than in the industries represented in the New Jersey study.

In addition, we found fewer discretionary environmental initiatives in the pulp and paper mills studied compared to the array of New Jersey firms; and far fewer pollution prevention investments. In general, mill representatives offered fewer project examples of any kind for which a TCA approach could be beneficially applied.

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[34] While the use of solvents and heavy metal-based pigments at the Paper Coating Mill makes this firm similar to many firms included in the New Jersey study, their concern for liability is focused more on worker health and safety than on Superfund-type liabilities.

Several barriers to TCA adoption were cited by case study mills. The Paper Coating mill listed the following: difficulty in changing the practices of the company as a whole when the need for more and better environmental investments is not uniformly understood; difficulty in modifying the project justification procedures to include less-obvious environmental costs; difficulty in obtaining the necessary technical and cost data for a TCA; and extra time involved in preparing a more thorough TCA project analysis. One Environmental Manager stated at the conclusion of the in-depth project analysis, that he could only justify the time necessary to develop a TCA for projects with a capital cost of $2 million or more.

With respect to the TCA methods reviewed in this study, the environmental staff at the Fine Coated Paper Mill and the Specialty Mill emphasized that they lack the necessary time to learn and apply these methods.

While these findings provide insight into the views on TCA of four mills, it is not possible to definitively predict whether these or other mills will adopt either portions of, or the full TCA approach to project financial analysis. Given the current regulatory demands on this industry, its end-of-pipe orientation, and resource and organizational barriers cited above, it seems unlikely that pulp and paper mills acting on their own will actively seek to implement TCA.

In Section 5 we highlight several government incentive programs which may encourage mills to adopt a TCA approach; and state laws which may require these companies to adopt certain aspects of TCA.

5. INCENTIVES AND BARRIERS TO POLLUTION PREVENTION AND ADOPTION OF TCA APPROACHES

Introduction

To this point, we have focused primarily on the internal workings of industrial firms--accounting practices, approaches to project financial analysis and decision-making, management structure--and how such factors relate to the implementation of TCA approaches. The literature indicates, and our findings confirm, that effective pollution prevention programs require institutional change, a shift in the way companies think about and carry out their business. While regulatory requirements play an important role, the most effective way of changing corporate behavior is to convince industry that such a change is in a company's own best interest. It is in this context that incentives and barriers to TCA are most fruitfully addressed. In this section we turn our focus toward external factors, primarily government initiatives, and their relationship to corporate behavior concerning pollution prevention practices in general and TCA in particular. We are specifically interested in how government incentives and barriers contribute to the institutional change described above.

To date incentive programs have focused primarily on encouraging various pollution prevention/source reduction activities. Though most of the incentives and barriers discussed below do not address TCA explicitly, they nevertheless may influence how firms approach project financial analysis and three distinguishing features of TCA: cost coverage, time horizon, and financial indicators used in the analysis. In addition, as the usefulness of TCA methods become better understood, it may become much more common for incentive programs to be directly linked to TCA implementation. For example, eligibility criteria for state loans, grants, and preferential tax treatment could include a requirement that firms seeking state assistance for pollution prevention projects utilize TCA methods in project analysis. Such a requirement would familiarize industry with a TCA approach and encourage the inclusion of a broader range of costs and benefits, longer time horizons, and the use of more appropriate financial indicators in project analysis.

Several types of economic and regulatory measures have been or are currently being used at the state level to encourage pollution prevention. Economic incentives can be positive (e.g., loans, grants, tax credits) or negative (e.g., fees or taxes on generators). For the purposes of this report, we do not include broad state public information/education efforts, generic technical assistance and training, or facilitation of programs such as waste exchanges.

Many incentive programs were developed in the context of recent legislative initiatives. In the past two years about a dozen states have adopted pollution prevention legislation (including Illinois, Massachusetts, Minnesota, Oregon, and most recently New Jersey). While much of this new legislation is promising, the specific incentive programs and other initiatives are generally too new to assess their effectiveness.

At the same time, several kinds of barriers--regulatory, economic, and institutional --may impede the progress of pollution prevention programs in general and TCA implementation by industry in particular. Institutional issues relating to corporate structure and decision-making procedures were discussed in previous sections of this report; here the focus is largely on external barriers related to government intervention.

The following section reviews how various incentives and barriers relate to the first two of these TCA attributes. The discussion of the various initiatives draws heavily from the various state pollution prevention/source reduction programs around the country.

Coverage of Costs and Benefits

There are two major incentive approaches that encourage firms to be more inclusive in their approach to project analysis. One is to impose regulations that directly require a broader approach to project financial analysis in companies' reports on their pollution prevention efforts. The other approach is to provide technical assistance on TCA methods and their advantages.

A number of states have instituted requirements for industry to regularly plan for and/or regularly report on their pollution prevention activities. Under New Jersey's Pollution Prevention Act, certain industries will be required to develop five-year pollution prevention plans and to submit annual plan updates reporting on progress toward meeting the plans' goals. Similarly, Minnesota's Toxic Pollution Prevention Act requires those industries that must report release of toxic chemicals under the federal Emergency Planning and Right to Know Act to develop pollution prevention plans and to submit annual progress reports. Moreover, the New Jersey legislation requires that pollution prevention plans include a "comprehensive financial analysis of the costs associated with the use, generation, release, or discharge of hazardous substances that occur as a result of current production processes at the industrial facility including the costs of generation of non product output, the savings realized by investments in pollution prevention and the more efficient use of raw materials, the cost of the treatment and disposal of hazardous waste, and the cost of liability insurance." Though this is clearly an attempt to move firms towards the adoption of TCA-type methods, New Jersey is the only state reviewed in this study that has such a provision in its legislation, and, given the newness of the regulation, there is no evidence by which to judge its effectiveness.

Other than a direct regulatory requirement to employ TCA methods, there are few incentive options available to expand the costs considered in project financial analysis. Technical assistance is one incentive program used in several states' pollution prevention programs that could also apply directly to TCA. Though existing technical assistance programs generally have not explicitly addressed TCA issues, these programs could be modified to incorporate direct assistance with TCA methods to complement the overall technical assistance programs. Alternatively, use of a TCA approach or training on such methods could be required in order to receive other technical assistance in the pollution prevention area. Examples of existing technical assistance programs can be found in New Jersey, Connecticut, Minnesota, Illinois and several other states. The Minnesota Toxic Pollution Prevention Act of 1990 includes a provision for a technical research and assistance program, including on-site consultations, to identify alternative methods that may be applied to pollution prevention and to provide assistance for planning. The New Jersey Technical Assistance Program (NJ TAP) also focuses on encouraging specific pollution prevention activities, and staff from the New Jersey TAP have worked closely with the Project Team in the current project, and are receptive to TCA methods. The New Jersey Pollution Prevention Act calls for an annual allocation of $500,000 from the Pollution Prevention Fund for the Hazardous Substances Management Research Center at the NJ Institute of Technology to fund NJ TAP activities.[35]

There are, however, several important barriers that must be overcome in order to expand cost and benefit coverage and to make TCA adoption more likely. For example, certain **accounting regulations**

[35] This may provide an opportunity to expand the program to include assistance with implementation of TCA methods.

serve as barriers to the adoption of TCA methods. The Securities and Exchange Commission (SEC) requires publicly held companies to report fully and accurately any information that is "material" with respect to the company's business and financial position.[36] This applies to all information, including environmental claims and contingent liabilities.[37]

The SEC regulations contain three basic requirements for disclosure of environmental information. SEC Form 10K incorporates by reference Regulation S-K, which lists "items" that must be included in the annual 10K Report filed with the SEC. These "items" relate to environmental disclosure provisions. Item 101(c)(xii) requires disclosure of the material effects that compliance with federal, state, and local environmental protection regulations may have on a corporation's or subsidiary's capital expenditures, earnings, or competitive position. This item does not differ from the more general disclosure requirements and is not particularly controversial; however, its application is not always straightforward. While companies generally include estimates of capital expenses in their annual reports, they do not always develop and report estimates for **future** years, even if these expenses are anticipated to be materially higher.

The SEC has also indicated that companies should disclose potential indirect costs, such as restrictions on operations or other competitive disadvantages caused by compliance with environmental regulations. The costs of future remedial activities, such as those associated with clean-up of a contaminated site, must be disclosed if material.

Item 103 of Regulation S-K requires a company to disclose any litigation "incidental to the business that is pending or known to be contemplated by government authorities," including administrative or judicial procedures related to environmental protection statutes or regulations, if it meets any of the following three tests: 1) the proceeding is material to the business or financial condition of the company; 2) the proceeding is one primarily for damages, or involving a monetary sanction or capital expenditure, and the amount involved is more than ten percent of the assets of the company and its subsidiaries; or 3) it is a government proceeding and will result in sanctions of more than $100,000.[38]

The final disclosure requirement of the SEC involves the financial statements and the "management and discussion analysis" which must be included in all Form 10-Ks filed with the SEC. The preparation of these statements must follow generally accepted accounting principles (GAAP) and must include disclosure of unasserted (i.e. potential) loss contingencies if they exceed the materiality threshold. Thus, this report must include discussion of material events and uncertainties that would affect the company's future operating results or financial condition. All of these disclosures must be made in a specific (i.e. with dollar amounts) and timely manner.

Several practical issues arise in the process of preparing financial statements and their subsequent auditing by an independent accountant. First, should a company disclose an unasserted and potentially unknown liability involving an environmental problem? Second, what questions should an auditor ask regarding contingent environmental liabilities not disclosed by the company? And third, the company

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[36] The SEC defines "material" as any information a reasonable investor would likely deem important in determining whether to buy or sell the company's securities.

[37] The following information concerning SEC regulations is based primarily on "The SEC and Corporate Environmental Responsibilities," Paul G. Wallach, *Hazmat World*, November 1988.

[38] *Ibid.*

(usually outside counsel) must decide how to respond to the auditor's requests for information on potential liabilities, including those related to unasserted environmental claims.[39]

There is potential conflict between the SEC disclosure requirements and a company's fiduciary responsibilities to its shareholders. For example, if a company discloses an as-yet unknown and contingent environmental liability to the SEC, it runs the risk of exposing itself to new liability, which may violate its fiduciary responsibilities to shareholders.

As discussed previously, one of the ways in which TCA methods differ from traditional project financial analysis approaches is their explicit calculation and inclusion of potential liability costs. SEC disclosure requirements and the potential for incurring new liability simply because of such disclosure, therefore appear to be a significant barrier to the full adoption and implementation of TCA methods.

There are other regulatory barriers to expanding the costs considered in project financial analysis. The end-of-pipe regulatory approach itself can be considered such a barrier. Not only does it focus vast resources, including expensive capital equipment, on pollution control rather than on product, process, or raw material changes,[40] but it is also a barrier to TCA methods that require an integrated and more comprehensive cost analysis. Because current regulations are by and large media-specific (e.g., Clean Air Act, Clean Water Act, Resource Conservation and Recovery Act) and often result in shifting pollution from one environmental medium to another (e.g., air to land), project financial analyses associated with meeting such regulations may not consider the full range of costs and benefits (i.e. those relating to other media) associated with a project. Such analyses often occur in attempts to meet a regulatory limit in the least (direct) cost manner.

On the other hand, regulatory approaches stressing pollution prevention tend to foster more comprehensive analysis of processes and products and their associated costs, and thus are more compatible with TCA financial assessment methods. U.S. EPA's Pollution Prevention Strategy articulates the Agency's shift toward a new hierarchy of environmental management options, with pollution prevention as the first step in the hierarchy followed by responsible recycling, treatment, and finally disposal. The Pollution Prevention Act of 1990 formalizes this heirarchy and indicates a broad-based shift toward prevention in regulatory development and in non-regulatory programs. This should result in industry taking a more comprehensive look at the production processes and products, and ultimately encourage adoption of TCA methods, including more comprehensive project financial analyses.

States have taken the initiative in translating this policy shift into specific regulatory changes. Several states, including New Jersey, have begun to move in the direction of facility-wide regulation. For example, New Jersey's Pollution Prevention Act calls for the Department of Environmental Protection to issue facility-wide permits, first to a limited number of facilities, then on a widespread basis. Minnesota's Pollution Control Agency has issued a limited number of coordinated permits and is considering expanding its multi-media permitting and enforcement program. Again, such a regulatory approach should foster TCA approaches in general, and more inclusive project financial analyses in particular.

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[39] *Ibid.*

[40] Minnesota Office of Waste, 1991, *Report on Barriers to Pollution Prevention.*

Time Horizon of Project Financial Analysis

A second important feature of a TCA approach is the extension of the time horizon for project analysis from the typical 2-5 year analysis to 10 or more years. One pollution prevention incentive used in several states is a loan program for pollution prevention projects, usually focused on capital investments. Depending on the structure of the loan program, it may also act as an incentive, albeit an indirect one, for adopting TCA methods. That is, if a loan program allows a payback period that extends for 10 to 20 years, beyond the normal time frame for many conventional project financial analyses, it may move project analysis approaches to include longer time frames, more in line with TCA methods. There are many examples of state loan programs for pollution prevention projects. The recently enacted Pollution Prevention Act in New Jersey calls for an annual allocation of $2 million from the Pollution Prevention Fund to provide low interest loans and loan guarantees to owners or operators of industries to study or implement pollution prevention activities. Other states with grant or loan programs include Minnesota and New York.

Similarly, tax incentives and credits for pollution prevention projects may serve as an incentive for using longer time horizons for project analysis. In a recent survey of hazardous waste generators in Minnesota,[41] tax credits were cited as the most effective motivation for waste reduction. Under Oregon's Pollution Control Facility Tax Relief Program, a facility that aims to prevent, control, or reduce pollution is eligible to apply for a certificate from the state's Department of Environmental Quality. If the certificate is approved, personal income tax, corporate excise tax, or property tax exemptions may be applicable. Tax credits can total up to 50% of the project's total value, at a rate of up to 5% per year over ten years. As with other incentive programs, a more direct inducement to adoption of a TCA approach would be provided if eligibility for tax incentives and credits require a TCA analysis of the project.

Finally, programs that share the costs for capital investments encourage firms to take a longer term perspective in project financial analyses. In such a program, funds are provided directly to industry by the state in order to defray the cost of waste reduction investments, and to overcome the disincentive to industry posed by initial capital costs. This approach is similar to the third party split-savings system now well established in the field of energy conservation.[42] Programs could be structured whereby a state establishes a system to review and fund proposed pollution prevention projects. The program would fund all up-front costs (for audit and engineering advice, or even for capital equipment) for selected projects, and would be paid back over time from a share of the savings.

This type of program puts industry in a minimal risk position. Structured and managed properly, the majority of state funds provided to industry would be repaid over time (perhaps 10 - 20 years) and could be reused as a revolving fund. A state could require repayment of more than the initial state outlay (perhaps 125-150%), still out of savings over time, without negating the incentive to industry. Such a program would be especially appealing to smaller companies lacking access to significant capital resources. It may allow companies of all sizes to take source reduction steps they might otherwise consider too risky to be justified under their normal investment criteria. The link to TCA adoption could be formalized and strengthened by including such an analysis as a requirement for participating in the shared savings program. While this approach has proven to be quite effective in energy conservation, according to a 1986

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[41] *Ibid.*

[42] Under these energy conservation schemes, a vendor of energy conservation services or equipment receives as payment part of the energy cost savings resulting from the conservation investment.

report by the Environmental Defense Fund,[43] no state had at that time adopted this approach for source reduction of hazardous wastes, nor are we aware of any such programs having since been established.

Summary

As with pollution prevention in general, government programs can play an important role in fostering adoption of TCA approaches. While straightforward regulatory requirements may be useful in moving firms towards TCA implementation, it is important to recognize that TCA implementation generally implies institutional change on the part of industry (as well as government regulators). Thus, regulatory mandates will be most effective in combination with other incentives that recognize the need for and help foster institutional change. These incentive programs can focus directly on TCA training and information dissemination through a technical assistance program, or they can be indirect, tieing various other incentives (e.g., loans, grants, or tax credits) to use of a TCA approach.

While the provision of additional incentives is necessary to foster adoption of TCA, there remain formidable regulatory barriers that hinder widespread implementation. In general, overcoming a longstanding regulatory focus on narrow end-of pipe approaches, and the corporate environmental management programs that developed in response to this regulatory structure, is the most significant barrier. More specifically, overcoming the regulatory impediments to monetizing long-term liability is among the most difficult barriers to address. Bringing these barriers to the attention of industry and federal and state policymakers is an important first step in developing strategies to overcome such obstacles.

There is an important link among the key attributes of TCA: cost inclusion, time horizon, and choice of financial indicator. Some of the major cost items often left out of conventional project analysis--environmental externalities and liabilities--may not be incurred for several years, beyond the time frame of such analyses. Incorporating such costs virtually requires a longer time horizon for the analysis. Also, appropriately quantifying these costs requires more than a simple pay-back calculation. Future costs, especially those that may be speculative, must be appropriately discounted. This requires a more sophisticated financial indicator for project analysis, as called for in a TCA approach.

43 *Approaches to Source Reduction: Practical Guidelines from Existing Policies and Programs*, Environmental Defense Fund, 1986.

6. LOOKING AHEAD: TCA IN THE 1990s

In the next decade, the readiness of firms to shift toward a TCA approach in analyzing pollution prevention projects will depend on a combination of organizational and economic variables. From an organizational perspective, these include: the strength and persistence of directives from top management that stress a prevention ethic; the placement, responsibilities and authority assigned to environmental managers; and the financial rewards to managers for achieving prevention goals. These are examples of organizational conditions that will have a direct bearing on the receptivity and conduciveness to TCA approaches in the firm. These are best viewed as "door-openers" that can either facilitate or impair managers' willingness to take risks in expanding the traditional range of costs and benefits in advocating prevention investments.

In addition to these organizational variables, a range of economic variables come into play. Some of these are external to the firm, while others are a reflection of established business practices. These include, for example: the degree to which competition directs attention to new product development versus cost-cutting in existing product manufacturing, and thereby prompts consideration of potential market-related, long-term benefits of prevention investments; the frequency of technological change in the firm that presents opportunities to consider long-term and indirect costs and benefits of new capital investments; and the degree to which customer demand (intermediate or final) for environmentally-friendly products prompts managers to quantify expected increases in market share as one benefit of prevention investments.

Taken together, these organizational and economic variables act jointly to influence the firm's disposition toward innovation in both its choice of pollution management strategies and its approach to project analysis. Where conditions are right, the firm is more likely to explore the prevention option and be predisposed to innovate in the way it analyzes projects. Where conditions are not right, the tendency will be business-as-usual, retaining the traditional orientation to end-of-pipe approaches as well as analytical approaches that fail to incorporate the full range of costs and savings of prevention options. Under unfavorable conditions a prevention project faces a double hurdle: it is both unlikely to enter the capital budgeting process to begin with and, even if it does, is unlikely to achieve the hurdle rate necessary to win approval.

How is the pulp and paper industry likely to fare in this context? What forces drive pulp and paper firms toward prevention? And what role might TCA play in promoting such prevention investments?

The industry's position as a major force in the national economy and fourth largest source of industrial pollutants speak to the need for concerted policies and programs to move pulp and paper firms beyond existing end-of-pipe technologies. Since mounting regulatory programs will place compliance projects at the top of the industry's agenda, and since these programs come in the wake of record capital expenditures for new and upgraded equipment, efforts to promote prevention should be designed to elevate prevention over end-of-pipe options within a regulatory compliance context.

Beyond compliance, formidable obstacles may stand in the way of prevention initiatives in the pulp and paper industry. The reasons for this are several. The pulp and paper industry has not been characterized by major technological breakthroughs in either process or products relative to other technology-driven industries. Since process lines (i.e. pulping systems and paper machines) are large, costly and operate around-the-clock, process changes and materials substitution are highly disruptive to manufacturing operations. Process stability and product consistency are critical to sustained operations. Thus, upstream changes in processes historically have been approached with great caution.

Amidst all these constraints, the role of TCA becomes especially pivotal in assisting prevention projects to survive the capital budgeting process while reducing the tendency of management to seek quick-fixes to cope with intense compliance pressures. If properly applied, TCA provides a vehicle for incorporating into project analysis certain long-term, less tangible benefits of prevention that, if absent, will lead management to choose conventional end-of-pipe options. By adopting the costing procedures, financial indicators and time horizons of TCA, the built-in biases against prevention strategies characteristic of conventional project analysis methods will be minimized.

In reviewing existing TCA methods, interviewing a cross-section of firms, and applying a TCA approach to two specific projects in the pulp and paper industry, several key conclusions emerge:

1. **Bringing TCA to corporate capital budgeting is both an organizational as well as an analytical issue.** TCA approaches prompt new ways of defining project boundaries, collecting data, and assessing technology options. These often require management to consider linkages across processes, across departments within a plant and, in some cases, across plants within the company. The effect of this may extend well beyond the immediate project under consideration.

2. **TCA is a vehicle for translating management discretion in choosing among capital investment options into useable financial inputs.** Each firm operates with a set of formal or informal indicators to determine the financial merits of a project. These guidelines are routinely interpreted and bent to accommodate less measurable, tangible and quantifiable costs and savings of an investment. In the context of a prevention investment, an effective TCA method provides a means of translating such judgements into quantitative inputs understandable to top management.

3. **No single TCA method is appropriate to all firms.** Existing TCA methods tend to be data intensive and over complicated, even for relatively large sophisticated organizations. Simplifying such methods, however, runs the risk of depriving the analysis of the hidden and long-term costs and savings that lie at the heart of TCA. Firms need options that balance ease of operation with adequate depth of analysis, and that allow projects to be readily screened before proceeding to an in-depth analysis. TCA methods that achieve these objectives will be most acceptable to industry.

4. **TCA does not ensure that pollution prevention projects will be chosen as the most advantageous management strategy.** No *a priori* judgement of this type can be made without a thorough financial analysis of all options. In fact, TCA is as likely to uncover new costs associated with a prevention investment as it is to identify new savings. Nevertheless, TCA creates a "level playing" field such that prevention and end-of-pipe project investments may be compared on equal footing. Ultimately, project financial performance depends on a complex mix of project technology and economics.

5. **As traditional classification of environmental projects gives way to a more forward-looking approach, firms are likely to be increasingly receptive to TCA.** The movement toward clean technologies and "green" products will present further rationale for adoption of TCA methods. As pollution prevention projects increasingly shed their image as inherent financial losers, firms may seek to systematically incorporate their benefits into the capital budgeting process. TCA offers a vehicle for achieving this.

6. **Government actions to encourage TCA may be either direct or indirect, intentional or unintentional.** Numerous government programs under the heading of pollution prevention, waste reduction and waste minimization influence TCA adoption either by mandate or by incentive/disincentive. In its most direct form, TCA may be simply mandated as part of pollution prevention planning requirements, though such an approach by no means ensures rigorous application of the methods. Indirectly, state grant and loan programs may affect TCA adoption if these programs set project priorities in favor of prevention-oriented projects. Insofar as such programs also induce consideration of a longer time horizon and inclusion of indirect costs and savings, TCA adoption will be accelerated. Both direct and indirect approaches have their merits; the two working in tandem is optimal.

Firms adopting TCA in their project analysis methods act in their self-interest. Through more rigorous project costing and financial analysis, pollution prevention projects may be more accurately compared to end-of-pipe alternatives, and to other capital projects competing for a firm's limited capital resources. There are many possible vehicles for promoting TCA in industry. As a general rule, an effective promotion strategy will emphasize the value of TCA implementation to the company. If firms are convinced that TCA is first and foremost a vehicle for rationalizing the capital budgeting process to the long-term advantage of the firm, adoption of TCA approaches are likely to quickly attract the support of both environmental and non-environmental managers.

At the federal level, EPA has worked to promote TCA by developing the *Pollution Prevention Benefits Manual*, the *Waste Minimization Opportunity Assessment Manual*, and sponsoring the initial work on Precosis, all of which contain discussions of TCA concepts and provide analytical tools. Further efforts to disseminate, more widely, these tools and to develop brief guidance pamphlets would help advance TCA concepts. Published pollution prevention case studies, which use a TCA approach to financial analysis, could be a powerful sales tool for TCA.

At the state level, TCA can be built into pollution prevention policies and programs in several ways. State technical assistance programs can offer TCA guidance and training as a complement to their technical services. States may provide TCA training seminars, with specialized modules aimed at large versus small firms, or for firms in certain lines of business. A number of states have instituted requirements for industry to regularly develop pollution prevention plans that must contain technical and economic feasibility assessments of specific prevention projects. New Jersey's Pollution Prevention Act, for example, explicitly requires that plans include a comprehensive analysis of the costs associated with the use, generation, release or discharge of hazardous substances for current production processes and the savings realized by investments of pollution prevention. *Planning for Success Through Waste Reduction*, the planning guidance document created by the Washington State Department of Ecology under the State's Hazardous Waste Reduction Act, instructs companies to evaluate the costs and benefits of selected waste reduction options over a five year period, and to describe the accounting systems used to track hazardous substance and waste management costs, that must include "liability, compliance, and oversight costs". Requiring a TCA approach in pollution prevention planning may lead companies to recognize the benefits of comprehensive financial analysis, and ultimately to investments in pollution prevention. The long-term effectiveness of a mandatory approach, however, is unproven and should be approached cautiously and with strong emphasis on the self-interest benefits alluded to earlier.

While we would oppose rigid, prescriptive approaches, some type of standard could facilitate the implementation of emerging federal and state regulations requiring TCA in pollution prevention planning.

National standard guidelines, perhaps under the auspices of the American Society of Testing and Materials (ASTM), could serve this objective.

The limited sample size of firms in this study allows for only indicative findings that must be corroborated by analysis of additional firms. Existing TCA methods have been available for a few years, yet no systematic assessment of user experience among the several hundred purchasers of various systems is available. This presents a potentially rich data base for further assessing the organizational and economic issues in TCA adoption we uncovered in the present study. Organizational, economic and regulatory issues specific to certain sectors and industry types--pharmaceutical and chemicals, intermediate versus final consumer product manufacturers, and single versus multiplant operations--are promising avenues for future study.

Quantifying the benefits of green technologies, green products and green corporate image remains a major challenge. Yet it is precisely these benefits that are heard among corporate managers as reasons for approving otherwise marginal projects. Developing methodologies to quantify these benefits and incorporate them into project financial analysis is an unfinished task.

Finally, what is financially optimal for the firm, of course, is not necessarily optimal from a social cost standpoint. In this sense, TCA is no substitute for lifecycle cost assessment (LCA), in which the choice of a material input or the manufacture of a product is assessed for its full *societal costs* regardless of whether they fall within or outside the economic purview of the firm.

APPENDIX A

CASE STUDIES

APPENDIX A-1

COATED FINE PAPER MILL

Company Background

This specialty paper mill is part of a larger corporation of pulp, paper, and coating mills. The mill is not integrated, i.e. does not manufacture pulp. Most of the pulp used by the mill is purchased, via pipeline, from a neighboring bleached kraft mill. The mill supplements this pulp with a small amount of purchased market pulp. The mill produces approximately 190 tons per year of a variety of uncoated, and on-machine and off-machine coated papers, carbonizing, book and release base paper. The coating used is a latex (i.e. non-solvent) formulation containing clay, styrene butadiene, starch, and polymers.

Environmental Management

The mill first created an environmental department in 1988. The department consists of one engineer who reports to mill's Operations Manager. This engineer manages environmental and safety compliance and projects at the site, including oversight of the mill's only two permitted sources of pollutants--fuel oil burners and starch mixing tanks. To eliminate exposure to employees and the surrounding community, the engineer successfully persuaded mill management to replace the chlorine gas-based fresh water purification system with one using sodium hypochlorite. Although sodium hypochlorite still poses some handling risk to employees, it is safer than chlorine.

The mill produces a significant quantity of broke (i.e. unsalable paper product) that it cannot reuse. This problem is typical of specialty paper mills that produce many different grades, and frequently change from one grade to another on the same paper machine. The mill recycles 75% of this broke at other paper and paperboard mills and landfills the remainder.

Since it does not have its own wastewater treatment facility, wastewater from the mill is pumped to the neighboring mill for treatment. This wastewater constitutes between 10 and 12% of the neighboring mill's wastewater flow. In the per ton flow, TSS and BOD for the subject mill is reportedly higher than the industry average. The neighboring mill has asked the subject mill to reduce wastewater flow, although no such measures have been put into effect to date.

Wastewater treatment price was negotiated between the mill and the neighboring mill in 1977, and is based on the following formula:

finished tons produced x no. gallons discharged x cost factor = treatment charge

The treatment charge is not based on TSS or BOD so the subject mill has no direct economic incentive to reduce TSS and BOD in its wastewater. The contract between the mills establishes a ceiling for wastewater flow, BOD and TSS from the mill. Currently, the mill is meeting its flow limit, but is substantially exceeding its contract limits on BOD and TSS. In 1992, the neighboring mill will be required to significantly reduce its effluent BOD load and has, in turn, required the mill to reduce the BOD content of its wastewater prior to pumping it to the treatment plant. The subject mill is currently exploring BOD reduction options.

The treatment contract will be renegotiated in 1993, but it is not clear whether, or how, the terms will be changed. However, the environmental engineer speculated that the charge rate formula might be changed to include a BOD or TSS variable, and that the overall cost could increase.

Capital Budgeting and Project Analysis

A proposed project moves through three steps prior to implementation. First, a feasibility study is conducted to assess the technical aspects of the problem and the proposed solution. Second, a cost justification or Capital Appropriations Request (AR) is prepared for the project. The AR contains a detailed economic analysis of the project costs and savings; a narrative describing the need for, and benefits of, the project; and a financial spreadsheet printout containing a discounted cash flow analysis of the project for a 10-year period. The spreadsheet reports several financial indicators, including ROI, ROAE (return on assets employed), IRR, NPV and payback. The mill uses payback as a screening device for project profitability, and loosely applies a 2 year hurdle rate to discretionary, profit-adding projects. The AR form has a standard format for investment cost estimates with the following categories:

1. Direct costs:

   site preparation
   site improvements
   civil/structural/architectural
   process equipment
   support services
   spare parts

2. Indirect costs:

   permits/licenses
   AR preparation
   engineering
   process simulation/trials
   training
   project management
   construction management
   start-up costs
   tax
   escalation
   contingency

There is, however, no standard format for estimation of project benefits. Benefits quantified in the AR vary from project to project, but future liability and other intangible costs are not monetized.

Finally, once the AR is approved by management, the third step--an engineering design--is prepared and the project is implemented.

Perspectives on TCA

The environmental engineer, the likely champion of environmental projects within the mill, finds it difficult to justify economically projects that are not required by regulation. While he is interested in the TCA approach, he does not feel that it is possible to develop a credible estimate of future liability for use in a financial analysis. He cited a specific project in which he proposed to construct a containment system around the truck unloading area. Such as system would prevent spilled chemicals from running into the nearby river in the event of an accident. While he would have liked to estimate the avoided liability cost associated with this project, he felt that it was not possible to develop a defensible estimate.[1]

Project Background

Papermachine white water, a mixture of water and residual fiber and filler (clay and calcium carbonate) that drains out of the sheet of paper as it travels across the paper machine, is typically captured by a white water collection system dedicated to one papermachine. Typically, some or all white water is recycled back into the papermaking system to recapture water, fiber and filler. In some cases white water is passed through a saveall screening device to separate fiber and filler from water; fiber; filler and water are then recycled back into the system. The saveall produces a clear stream of water that can be used in numerous papermachine 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.[2] Machine 1 has a saveall 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-size 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 in the effluent and reduce total fresh water intake on a mill wide 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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[1] This project has not been implemented.

[2] 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.

Project Description

The first recommendation (called Phase I) made in the feasibility study is to install a second saveall 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 are 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 pump, piping, and controls. Available pulping and stock storage capacity could be used to pulp separately for each machine.

Project Financial Analysis

The feasibility study contains a capital estimate for Phases I and II. No other financial analysis of the project has been conducted by the mill. The capital estimate is 1,145,300 (1989 dollars), and is considered to be +/- 25% accurate. The estimate includes: purchased equipment (including saveall, stock chest, clear white water chest and associated equipment); process control instrumentation; electrical controls and lighting; a new building for the saveall; piping; installation (in-house and contracted labor); engineering; and contingency.

Company and TCA Analyses

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

The Company Analysis consists of the 1989 capital estimate (adjusted for inflation and escalated by 12.5%[3]), and only those operating costs and savings that the company typically includes in project financial analyses for projects of this type. These are:

a. raw material - fiber and filler;
b. energy and chemical use for new equipment;
c. wastewater treatment fees; and
d. 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 benefit side, the TCA includes the following:

a. An average reduction in fiber and filler loss of 1,200 tons/year, for a savings of $429,200/year;

[3] As suggested by the mill, capital costs were escalated by 12.5% to adjust the feasibility study estimate which was +/- 25%.

b. A reduction in fresh water usage of 1 million gal/day, and a commensurate reduction in cost for fresh water treatment and pumping, for a savings of approximately $112,420/year;
c. A reduction in energy use for fresh water heating amounting to a savings of approximately $377,250; and
d. A reduction in wastewater generation of approximately 1 million gal/day, for a savings of approximately $52,500/year in wastewater pumping and $68,000/year in wastewater treatment fees.

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

a. Chemical flocculating agents used in the saveall to promote solids/water separation will cost approximately $275,000/year;
b. Electric costs for new equipment operation will increase operating costs by approximately $102,870/year; and
c. An increase in labor cost of approximately $3,120/year is expected for operation of new equipment.

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. In addition, we do not expect any impacts on revenue since neither product quality nor production rates will be improved, nor does the mill expect to visibly enhance its product or company image. Finally, we do not expect any tangible impact on avoided future liability for this project.

Table A-1.1 summarizes the cost categories addressed in the Company Analysis and the TCA for this project, and Table A-1.2 reports the results of the financial analysis.

Table A-1.1 Comparison of Cost Items in Company and TCA Cost Analyses

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

	Company	TCA
Capital Costs		
Purchased Equipment	X	X
Materials (e.g., Piping, Elec.)	X	X
Utility Systems	X	X
Site Preparation	X	X
Installation (labor)	X	X
Engineering/Contractor	X	X
Contingency	X	X
Operating Costs		
Direct Costs:*		
Raw Materials/Supplies	P	X
Labor	X	X
Indirect Costs:*		
Utilities:		
Energy	P	X
Water		X
Sewerage (POTW)	X	X

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

Table A-1.2. Summary of Financial Data for the White Water and Fiber Reuse Project[4]

	Company Analysis	TCA
Total Capital Costs	$1,743,820	$1,743,820
Annual Savings (BIT)*	$ 116,245	$ 658,415
Financial Indicators		
Net Present Value - Years 1-10	($ 702,855)	$1,242,536
Net Present Value - Years 1-15	($ 587,346)	$1,808,384
Internal Rate of Return - Years 1-10	0%	36%
Internal Rate of Return - Years 1-15	6%	36%
Simple Payback (years)	11.4	2.0

* Annual operating cash flow before interest and taxes

The improvement shown in annual savings and financial indicators for the TCA stems from the inclusion of energy savings in the TCA, but not in the Company Analysis. Specifically, reduced energy consumption for pumping and treating fresh and wastewater, and freshwater heating are included only in the TCA. These savings, which would typically not be included in the mill's calculation of profitability, bring the project in line with the mill's 2 year payback rule-of-thumb. By excluding these savings in the Company Analysis, the project looks highly "unprofitable".

[4] This table contains preliminary results, subject to change upon receipt of complete cost data.

Some uncertainty exists in the wastewater treatment cost estimate. As discussed above, the subject mill will be renewing its contract with the neighboring mill in 1992, and it is possible that treatment fees will increase. To test the sensitivity of the project analysis to these potential changes, we recalculated the TCA twice, doubling and tripling the wastewater treatment costs. In both cases, the financial indicators changed slightly: 40% IRR (years 1-10) and 1.8 payback for double the cost, and 44% (years 1-10) IRR and 1.7 payback for triple the treatment cost. While we do not see a dramatic change in projected profitability, a tripling of wastewater treatment costs, may make this project somewhat more competitive with other projects competing for capital in a particular budget year. This may be especially true if the firm applied its rule-of-thumb, 2 year payback criteria as a screening test for the project.

Detailed reports of the Company Analysis, TCA, and associated cost calculation documentation follows.

APPENDIX A-1
COATED FINE PAPER COMPANY

Project 1 - Company Analysis

WHITE WATER AND FIBER REUSE PROJECT

Project: Whitewater/Fiber Reuse Project	CAPITAL COSTS			page 1 Date: 11/4/91
Capital Costs	**Cost**	**Totals**	**Ref.**	**Notes:**
Purchased Equipment				
Equipment - Phase I	$330,853			Saveall and associated pumps and tanks
Equipment - Phase II	$15,132			White water pump
Sales tax				
Price for Initial Spare Parts		$345,985		
Materials				
Piping	$183,690			
Electrical	$67,721			
Instruments	$68,465			
Structural	$54,946			
Insulation/Piping		$374,822		
Utility Connections and New Utility Systems				
Electricity				
Steam				
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$0		
Site Preparation				
Demolition, Clearing, etc.		$0		
Installation				
Vendor				
Contractor	$397,148			
In-house Staff		$397,148		
Engineering/Contractor (In-house & Outside)				
Planning				
Engineering	$166,946			15% of materials and labor
Procurement				
Consultants	$44,100	$211,046		Consultant feasibility study, 1989

Project: *Whitewater/Fiber Reuse Project*

Date:

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances				
Training		$0		
Contingency				
	$140,403	$0		10% of materials, labor, and engineering
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

Project: Whitewater/Fiber Reuse Project

Operating Costs

Costs are positive
Savings and revenues are negative

Date: 11/4/91

CURRENT PROCESS Item	Annual Cost ($/year)	Total	Ref	ALTERNATIVE PROCESS Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				Raw Materials/Supplies				
Fiber loss (includes transport)	$457,000		1a	Fiber loss (includes transport)	$91,500		1b	
Filler loss (includes transport)	$79,700		1a	Filler loss (includes transport)	$16,000		1b	
				Flocculating agents for saveall	$275,200		1c	
		$536,700				$382,700		$154,000
Waste Management *(disposal, hauling, insurance, storage, etc.)*				Waste Management *(disposal, hauling, insurance, storage, etc.)*				
		$0				$0		$0
Utilities (elec., steam, water, sewerage)				Utilities (elec., steam, water, sewerage)				
Freshwater Pump. and Treat.			2a	Freshwater Pump. and Treat.			2b	
Freshwater Heating			2c	Freshwater Heating			2d	
Wastewater Pumping			2e	Wastewater Pumping			2f	
Wastewater Treatment	$273,000		2g	Wastewater Treatment	$204,765		2h	
		$273,000		Elec. for Equipment Operation	$102,870	$307,635	2i	($34,635)
Labor				Labor				
				Equipment Operation	$3,120		3a	
		$0				$3,120		($3,120)
Other				Other				
		$0				$0		$0
Regulatory Compliance *(manifesting, reporting, monitoring, testing, labeling, etc.)*				Regulatory Compliance *(manifesting, reporting, monitoring, testing, labeling, etc.)*				
		$0				$0		$0
Insurance				Insurance				
		$0				$0		$0
Revenues				Revenues				
		$0				$0		$0
Revenues - Marketable By-products				Revenues - Marketable By-products				
		$0				$0		$0
Total		$809,700				$693,455		$116,245

Project: Whitewater/Fiber Reuse Project

Date: 11/4/91

CAPITAL AND OPERATING COST SUMMARY

Capital Costs	$
Equipment	$345,985
Materials	$374,822
Utility Connections	$0
Site Preparation	$0
Installation	$397,148
Engineering/Contractor	$211,046
Start-up/Training	$0
Contingency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$1,329,001
Working Capital	$0
Subtotal	$1,329,001
Interest on Debt	$0
Total Capital Requirement	$1,329,001
Salvage Value	$0
% Equity	100%
% Debt	0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$1,329,001
Debt Principal	$0
Interest on Debt	$0
Total Financing	$1,329,001
Depreciation period	15
Income Tax Rate, %	40%
Escalation Rates, %	5.0%
Cost of Capital (for NPV)	16.00%

Operating Costs		Current	Alternative	Difference (Cur. - Alt.)
Raw Materials/Supplies		$536,700	$382,700	$154,000
Waste Management		$0	$0	$0
Utilities		$273,000	$307,635	($34,635)
Labor		$0	$3,120	($3,120)
Other		$0	$0	$0
Regulatory Compliance		$0	$0	$0
Insurance		$0	$0	$0
Maintenance - % of Capital				
Labor	0%		$0	$0
Materials	0%		$0	$0
Overhead - (% of Labor)	0%	$0	$0	$0
Labor Burden	0%	$0	$0	$0
Revenues		$0	$0	$0
Revenues - Marketable By-products		$0	$0	$0
TOTAL		$809,700	$693,455	$116,245

Future Liability	Ref.	Year Expected	Cost (Curr. - Alter.)
(Year expected = 1,2,3, etc.)			

Project: Whitewater/Fiber Reuse Project

page 5

Date: 11/4/91

Profitability Analysis

	0	1	2	3	4	5	6	7	8
Operating Year	0	1	2	3	4	5	6	7	8
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	1.478
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS									
Raw Materials/Supplies		$154,000	$169,862	$178,332	$187,264	$196,658	$206,514	$216,832	$227,612
Waste Management		$0	$0	$0	$0	$0	$0	$0	$0
Utilities		($34,635)	($38,202)	($40,107)	($42,116)	($44,229)	($46,446)	($48,766)	($51,191)
Labor		($3,120)	($3,441)	($3,613)	($3,794)	($3,984)	($4,184)	($4,393)	($4,611)
Other		$0	$0	$0	$0	$0	$0	$0	$0
Regulatory Compliance		$0	$0	$0	$0	$0	$0	$0	$0
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings		$116,245	$128,219	$134,612	$141,354	$148,445	$155,884	$163,673	$171,810
CAPITAL COSTS									
Investment	$1,329,001								
Book Value	$1,329,001	$1,240,401	$1,075,014	$931,679	$807,455	$699,794	$606,488	$542,647	$478,806
Tax Depreciation (by Straight-line, 1/2 yr)		$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	$88,600
Tax Depreciation (by Double DB, 1/2 yr)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$80,865	$72,353
Tax Depreciation (by DDB switching to SL)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at: 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$116,245	$128,219	$134,612	$141,354	$148,445	$155,884	$163,673	$171,810
Operating Cash Flow (BIT)		$116,245	$128,219	$134,612	$141,354	$148,445	$155,884	$163,673	$171,810
- Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$27,645	($37,168)	($8,723)	$17,130	$40,784	$62,578	$99,832	$107,969
- Income Tax at: 40.0%		$11,058	($14,867)	($3,489)	$6,852	$16,314	$25,031	$39,933	$43,188
Net Income		$16,587	($22,301)	($5,234)	$10,278	$24,470	$37,547	$59,899	$64,781
+ Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt Princ	($1,329,001)								
- Working Capital	$0								
+ Salvage Value									
After-Tax Cashflow	($1,329,001)	$105,187	$143,086	$138,101	$134,502	$132,131	$130,853	$123,740	$128,622
Cumulative Cashflow	($1,329,001)	($1,223,814)	($1,080,728)	($942,627)	($808,125)	($675,994)	($545,141)	($421,401)	($292,779)
Discounted Cashflow	($1,329,001)	$90,678	$106,336	$88,475	$74,284	$62,909	$53,708	$43,783	$39,233

	Years 1 - 10	Years 1- 15
Net Present Value	($702,855)	($587,346)
Internal Rate of Return	0%	6%
Payback	11.4 years	

Profitability Analysis (continued)

Operating Year Number	9	10	11	12	13	14	15
Escalation Factor	1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES							
Revenue (production rate or value)	$0	$0	$0	$0	$0	$0	$0
Marketable By-products	$0	$0	$0	$0	$0	$0	$0
Annual Revenue	$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS							
Raw Materials/Supplies	$239,008	$251,020	$263,648	$276,892	$290,752	$305,228	$320,474
Waste Management	$0	$0	$0	$0	$0	$0	$0
Utilities	($53,754)	($56,455)	($59,295)	($62,274)	($65,391)	($68,647)	($72,075)
Labor	($4,842)	($5,086)	($5,341)	($5,610)	($5,891)	($6,184)	($6,493)
Other	$0	$0	$0	$0	$0	$0	$0
Regulatory Compliance	$0	$0	$0	$0	$0	$0	$0
Insurance	$0	$0	$0	$0	$0	$0	$0
Maintenance	$0	$0	$0	$0	$0	$0	$0
Overhead	$0	$0	$0	$0	$0	$0	$0
Labor Burden	$0	$0	$0	$0	$0	$0	$0
Liability	$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings	$180,412	$189,479	$199,012	$209,008	$219,470	$230,397	$241,906
CAPITAL COSTS							
Investment							
Book Value	$414,965	$351,124	$287,283	$223,442	$159,601	$95,761	$31,920
Tax Depreciation (by Straight-line, 1/2 yr)	$88,600	$88,600	$82,693	$82,693	$82,693	$82,693	$82,693
Tax Depreciation (by Double DB, 1/2 yr)	$63,841	$55,329	$46,817	$38,304	$29,792	$21,280	$12,768
Tax Depreciation (by DDB switching to SL	$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
Debt Balance	$0	$0	$0	$0	$0	$0	$0
Interest Payment at : 12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment	$0	$0	$0	$0	$0	$0	$0
CASHFLOW							
Revenues	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings	$180,412	$189,479	$199,012	$209,008	$219,470	$230,397	$241,906
Operating Cash Flow (BIT)	$180,412	$189,479	$199,012	$209,008	$219,470	$230,397	$241,906
- Depreciation	$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Interest on Debt	$0	$0	$0	$0	$0	$0	$0
Taxable Income	$116,571	$125,638	$135,171	$145,167	$155,629	$166,557	$178,065
- Income Tax at: 40.0%	$46,628	$50,255	$54,068	$58,067	$62,252	$66,623	$71,226
Net Income	$69,943	$75,383	$81,103	$87,100	$93,377	$99,934	$106,839
+ Depreciation	$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Debt Repayment	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt Princ.)							
- Working Capital							
+ Salvage Value							$0
After-Tax Cashflow	$133,784	$139,224	$144,944	$150,941	$157,218	$163,774	$170,680
Cumulative Cashflow	($158,995)	($19,771)	$125,173	$276,114	$433,332	$597,106	$767,786
Discounted Cashflow	$35,179	$31,560	$28,325	$25,428	$22,832	$20,504	$18,421

APPENDIX A-1
COATED FINE PAPER COMPANY

<u>Project 1 - TCA</u>

WHITE WATER AND FIBER REUSE PROJECT

Project: Whitewater/Fiber Reuse Project

CAPITAL COSTS

Date: 11/4/91

Capital Costs	Cost	Totals	Ref.	Notes:
Purchased Equipment				
Equipment - Phase I	$330,853			Saveall and associated pumps and tanks
Equipment - Phase II	$15,132			White water pump
Sales tax				
Price for Initial Spare Parts		$345,985		
Materials				
Piping	$183,690			
Electrical	$67,721			
Instruments	$68,465			
Structural	$54,946			
Insulation/Piping		$374,822		
Utility Connections and New Utility Systems				
Electricity				
Steam				
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$0		
Site Preparation				
Demolition, Clearing, etc.		$0		
Installation				
Vendor				
Contractor	$397,148			
In-house Staff		$397,148		
Engineering/Contractor (In-house & Outside)				
Planning				
Engineering	$166,946			15% of materials and labor
Procurement				
Consultants	$44,100	$211,046		Consultant feasibility study, 1989

Project: Whitewater/Fiber Reuse Project

page 2

Date:

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances				
Training		$0		
Contingency				
	$140,403	$0		10% of materials, labor, and engineering
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

Project: Whitewater/Fiber Reuse Project

Costs are positive
Savings and revenues are negative

Operating Costs

Date: 11/4/91

CURRENT PROCESS Item	Annual Cost ($/year)	Total	Ref	ALTERNATIVE PROCESS Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				Raw Materials/Supplies				
Fiber loss (includes transport)	$457,000		1a	Fiber loss (includes transport)	$91,500		1b	
Filler loss (includes transport)	$79,700		1a	Filler loss (includes transport)	$16,000		1b	
				Flocculating agents for saveall	$275,200		1c	
		$536,700				$382,700		$154,000
Waste Management *(disposal, hauling, insurance, storage, etc.)*				Waste Management *(disposal, hauling, insurance, storage, etc.)*				
		$0				$0		$0
Utilities (elec., steam, water, sewerage)				Utilities (elec., steam, water, sewerage)				
Freshwater Pump. and Treat.	$168,630		2a	Freshwater Pump. and Treat.	$56,210		2b	
Freshwater Heating	$565,850		2c	Freshwater Heating	$188,600		2d	
Wastewater Pumping	$210,000		2e	Wastewater Pumping	$157,500		2f	
Wastewater Treatment	$273,000		2g	Wastewater Treatment	$204,765		2h	
		$1,217,480		Elec. for Equipment Operation	$102,870	$709,945	2i	$507,535
Labor				Labor				
				Equipment Operation	$3,120		3a	
		$0				$3,120		($3,120)
Other				Other				
		$0				$0		$0
Regulatory Compliance *(manifesting, reporting, monitoring, testing, labeling, etc.)*				Regulatory Compliance *(manifesting, reporting, monitoring, testing, labeling, etc.)*				
		$0				$0		$0
Insurance				Insurance				
		$0				$0		$0
Revenues				Revenues				
		$0				$0		$0
Revenues - Marketable By-products				Revenues - Marketable By-products				
		$0				$0		$0
Total		$1,754,180				$1,095,765		$658,415

Project: Whitewater/Fiber Reuse Project

Date: 11/4/91

CAPITAL AND OPERATING COST SUMMARY

Capital Costs	$
Equipment	$345,985
Materials	$374,822
Utility Connections	$0
Site Preparation	$0
Installation	$397,148
Engineering/Contractor	$211,046
Start-up/Training	$0
Contingency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$1,329,001
Working Capital	$0
Subtotal	$1,329,001
Interest on Debt	$0
Total Capital Requirement	$1,329,001
Salvage Value	$0
% Equity	100%
% Debt	0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$1,329,001
Debt Principal	$0
Interest on Debt	$0
Total Financing	$1,329,001
Depreciation period	15
Income Tax Rate, %	40%
Escalation Rates, %	5.0%
Cost of Capital (for NPV)	16.00%

Operating Costs		Current	Alternative	Difference (Cur. - Alt.)
Raw Materials/Supplies		$536,700	$382,700	$154,000
Waste Management		$0	$0	$0
Utilities		$1,217,480	$709,945	$507,535
Labor		$0	$3,120	($3,120)
Other		$0	$0	$0
Regulatory Compliance		$0	$0	$0
Insurance		$0	$0	$0
Maintenance - % of Capital				
Labor	0%		$0	$0
Materials	0%		$0	$0
Overhead - (% of Labor)	0%	$0	$0	$0
Labor Burden	0%	$0	$0	$0
Revenues		$0	$0	$0
Revenues - Marketable By-products		$0	$0	$0
TOTAL		$1,754,180	$1,095,765	$658,415

Future Liability	Ref.	Year Expected	Cost (Curr. - Alter.)
(Year expected = 1,2,3, etc.)			

Project: Whitewater/Fiber Reuse Project

Date: 11/4/91

Profitability Analysis

Operating Year	0	1	2	3	4	5	6	7	8
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	1.478
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS									
Raw Materials/Supplies		$154,000	$169,862	$178,332	$187,264	$196,658	$206,514	$216,832	$227,612
Waste Management		$0	$0	$0	$0	$0	$0	$0	$0
Utilities		$507,535	$559,811	$587,726	$617,163	$648,122	$680,604	$714,609	$750,137
Labor		($3,120)	($3,441)	($3,613)	($3,794)	($3,984)	($4,184)	($4,393)	($4,611)
Other		$0	$0	$0	$0	$0	$0	$0	$0
Regulatory Compliance		$0	$0	$0	$0	$0	$0	$0	$0
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings		$658,415	$726,232	$762,445	$800,633	$840,796	$882,934	$927,048	$973,138
CAPITAL COSTS									
Investment	$1,329,001								
Book Value	$1,329,001	$1,240,401	$1,075,014	$931,679	$807,455	$699,794	$606,488	$542,647	$478,806
Tax Depreciation (by Straight-line, 1/2 yr)		$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	$88,600
Tax Depreciation (by Double DB, 1/2 yr)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$80,865	$72,353
Tax Depreciation (by DDB switching to SL)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at: 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$658,415	$726,232	$762,445	$800,633	$840,796	$882,934	$927,048	$973,138
Operating Cash Flow (BIT)		$658,415	$726,232	$762,445	$800,633	$840,796	$882,934	$927,048	$973,138
- Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$569,815	$560,845	$619,110	$676,409	$733,135	$789,628	$863,207	$909,297
- Income Tax at: 40.0%		$227,926	$224,338	$247,644	$270,564	$293,254	$315,851	$345,283	$363,719
Net Income		$341,889	$336,507	$371,466	$405,845	$439,881	$473,777	$517,924	$545,578
+ Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt Princ	($1,329,001)								
- Working Capital	$0								
+ Salvage Value									
After-Tax Cashflow	($1,329,001)	$430,489	$501,894	$514,801	$530,069	$547,542	$567,083	$581,765	$609,419
Cumulative Cashflow	($1,329,001)	($898,512)	($396,618)	$118,183	$648,252	$1,195,794	$1,762,877	$2,344,642	$2,954,061
Discounted Cashflow	($1,329,001)	$371,111	$372,989	$329,811	$292,752	$260,692	$232,755	$205,846	$185,888

	Years 1 - 10	Years 1- 15
Net Present Value	$1,242,536	$1,808,384
Internal Rate of Return	36%	38%
Payback	2.0 years	

Project: Whitewater/Fiber Reuse Project

Date: 11/4/91

Profitability Analysis (continued)

Operating Year Number		9	10	11	12	13	14	15
Escalation Factor		1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES								
Revenue (production rate or value)		$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS								
Raw Materials/Supplies		$239,008	$251,020	$263,648	$276,892	$290,752	$305,228	$320,474
Waste Management		$0	$0	$0	$0	$0	$0	$0
Utilities		$787,694	$827,282	$868,900	$912,548	$958,226	$1,005,934	$1,056,180
Labor		($4,842)	($5,086)	($5,341)	($5,610)	($5,891)	($6,184)	($6,493)
Other		$0	$0	$0	$0	$0	$0	$0
Regulatory Compliance		$0	$0	$0	$0	$0	$0	$0
Insurance		$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings		$1,021,860	$1,073,216	$1,127,207	$1,183,830	$1,243,087	$1,304,978	$1,370,161
CAPITAL COSTS								
Investment								
Book Value		$414,965	$351,124	$287,283	$223,442	$159,601	$95,761	$31,920
Tax Depreciation (by Straight-line, 1/2 yr)		$88,600	$88,600	$82,693	$82,693	$82,693	$82,693	$82,693
Tax Depreciation (by Double DB, 1/2 yr)		$63,841	$55,329	$46,817	$38,304	$29,792	$21,280	$12,768
Tax Depreciation (by DDB switching to SL		$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
Debt Balance		$0	$0	$0	$0	$0	$0	$0
Interest Payment at :	12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0
CASHFLOW								
Revenues		$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$1,021,860	$1,073,216	$1,127,207	$1,183,830	$1,243,087	$1,304,978	$1,370,161
Operating Cash Flow (BIT)		$1,021,860	$1,073,216	$1,127,207	$1,183,830	$1,243,087	$1,304,978	$1,370,161
- Depreciation		$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0
Taxable Income		$958,019	$1,009,375	$1,063,366	$1,119,989	$1,179,246	$1,241,138	$1,306,320
- Income Tax at:	40.0%	$383,208	$403,750	$425,346	$447,996	$471,698	$496,455	$522,528
Net Income		$574,811	$605,625	$638,020	$671,993	$707,548	$744,683	$783,792
+ Depreciation		$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt Princ.)								
- Working Capital								
+ Salvage Value								$0
After-Tax Cashflow		$638,652	$669,466	$701,861	$735,834	$771,389	$808,523	$847,633
Cumulative Cashflow		$3,592,713	$4,262,179	$4,964,040	$5,699,874	$6,471,263	$7,279,786	$8,127,419
Discounted Cashflow		$167,935	$151,757	$137,156	$123,961	$112,026	$101,223	$91,482

APPENDIX A-1 - COATED FINE PAPER MILL

Project 1 - Whitewater Recycling Project for:

Costing and Financial Analysis Documentation

Phase I - Installation of Saveall, and
Phase II - Separation of Paper Machine No 9 and 11 White Water Systems

A. Capital Costs

Note: All costs, originally reported in 1989 dollars, have been inflated by 5% per year, and marked-up by 12.5% (engineering design estimates were +/- 25%.

See Page 1 of Financial Analysis Report.

B. Operating Costs

Key: M - thousand
MM - million
GD - gallons/day

Current Process

1. Raw Materials

1.a. Fiber and Filler Loss (includes freight)

Estimated solids loss - 1,500 tons/yr
Whitewater solids = 67% fiber and 33% filler

Fiber loss:
1,500 tons/yr x 0.67 = 1005 tons/yr
Fiber cost = $445/ton
Cost of lost fiber = 1005 tons/yr x $455/ton = $457,275/yr

Filler loss:
1,500 tons/yr x 0.33 = 495 tons/yr
Filler cost = $161/ton
Cost of lost filler = 495 tons/yr x $161/yr = $79,695/yr

White Water and Fiber Reuse

1.b. Fiber and Filler Loss (includes freight)

Estimated recoverable solids by Phases I & II - 1,200 tons/yr
Estimated solids loss - 1,500 - 1,200 tons/yr = 300 tons/yr

Fiber loss:
300 tons/yr x 0.67 = 201 tons/yr
Cost of lost fiber = 201 tons/yr x $455/ton = $91,455/yr

Filler loss:
300 tons/yr x 0.33 = 99 tons/yr
Cost of lost filler = 99 tons/yr x $161/ton = $15,939/yr

1c. Flocculating Agents for Saveall

Avg. whitewater flow through saveall - 600 GPM (864 MGD)

Chemical Costs:
Cationic polymer cost - $0.056/Mgal
Anionic polymer cost - $0.035/Mgal
total $0.91/Mgal

864 MGD x $0.91/Mgal x 350 days/yr = $275,200/yr

Current	Whitewater and Fiber Reuse

2. Utilities

2.a. Freshwater Pumping and Treatment

Average annualized freshwater use - 1.5MMGD

Chemicals Costs:

	$/MGD
Alum	0.025
Sodium aluminate	0.009
Polymer	0.034
Sodium hypochorite	0.003
Total $	0.071

Energy Costs:

	$/period*	$/MGD
Variable freshwater pumping	$133,098	$0.234
Misc.	1,479	0.0026
Total	$134,577	$0.237

*period = 8 months, 1990
total use freshwater - 566,460MGD

Chemicals + Energy costs = $0.308/MMGD

1.5MMGD x 365 days/yr x ($0.308x1000)/MMGD = $168,630

2.b. Freshwater Pumping and Treatment

Estimated freshwater use - 0.5MMGD

0.5MMGD x 365days/yr x ($0.308 x 1000)/MMGD = $56,210/yr

2.c. Freshwater Heating

1.5MMGD freshwater comes in at 57°, must be raised to 95°

1.5MMGD x 1 Btu/lb-°F x 8.4 lb/gal x (95 - 57°F) = 4.788×10^8 Btu/day

Fuel cost (No. 6) = $0.39/gal
Estimated boiler efficiency = 82.5%

4.788×10^8 Btu/day x 1 gal No.6 fuel/1.4×10^5 Btu x $0.39/gal x 1/0.825 x 350 days/yr = $565,850/yr

2.d. Freshwater Heating

0.5MMGD freshwater ------> $188,600/yr

2.e. Wastewater Pumping

4MMGD x 350 days/yr x $150/MMGD = $210,000/yr

2.f. Wastewater Pumping

3MMGD ------> = $157,500/yr

Current	Whitewater and Fiber Reuse
2.g. Wastewater Treatment	2.h. Wastewater Treatment
- Average, annualized wastewater discharge rate - 4.0 MMGD - Wastewater treatment cost - $187/MMGD	-Average, annualized wastewater discharge rate - 3.0MMGD
4.0MMGD x 365 days/yr x $187/MMGD = $273,000/yr.	3.0MMGD x 365 days/yr x $187/MMGD = $204,765/yr

2.i. Energy for Equipment Operation

Electricity cost = $0.08/kWh

Phase I - New Equipment:	HP
Drive Pump	1 HP
Scoop Pump	1
Pressure Pump	40
Feed Pump	20
Recovered Stock Chest Agitator Motor	5
Recovered Stock Chest Pump	25
Clear White Water Chest Pump	125
Phase II - New Equipment:	
White Water Surge Pump	125
Total	342 HP

342 HP x 0.6 x 0.746 kW/HP x 8,400 hr/yr x $0.08/kWh = $102,870/yr

3. Labor

3.a. Equipment Operation - Saveall

4 hours/week labor
$15/hour - fully loaded wage rate

4 hrs/wk x 52 wk/yr x $15/hr = $3,120/yr

APPENDIX A-2

PAPER COATING MILL

Company Background

This mill employs approximately 900 people in its research center, corporate office, and manufacturing plants. The mill has extensive facilities for coating, laminating and converting a variety of (purchased) film, paper and foil substrates. Products made at this facility find use in a variety of industries, including electronics, graphic arts, publishing, engineering, and instant photography.

Before March 1991, this mill was a division of a publicly held, large multinational corporation. The division was further divided into three sub-divisions that reflected product lines: photographic and specialty coated materials used in imaging, electronics, graphic arts and other applications; paper and films for use in pen and electrostatic plotters, diazo printing and xerographic copying; and plastic-coated, non woven materials used for book coverings, diaries, albums, menus and other products.

Today, the mill is held privately by a group of investors who also own several other mills that were formerly part of the same corporation. Approximately 50% of the companies volume comes from coated film production and the remainder from coated papers.

As of March 1991, the mill had not yet changed hands, and the effect of the change on the financial and environmental practices of the firm were largely unknown. Therefore, this case study primarily reflects the procedures used under the former ownership, though we do refer to several changes in capital budgeting anticipated by management.

Environmental Management

Environmental affairs in the paper coating business are managed by an Environmental, Safety, and Health Manager (ES&H) who reports to the site manager who, in turn, reports to the president of the business. A manager of safety, a manager of health, and several environmental engineers report to the ES&H. Manager, including a senior environmental engineer, responsible for regulatory compliance and environmental community and public relations. The primary person responsible for environmental affairs in the film coating business is the Manager of Research and Development and Environmental. This manager relies on staff resources within the paper coating business for support on environmental projects.

Environmental management characterized the mill as "operationally driven--faster, better, cheaper, aiming to maximize revenue dollars per machine hour; while at the same time seeking to maximize environmental protection". Though they consider waste reduction projects to be an important component of their environmental strategy, the companies operational goals are seen as driving environmental protection strategies toward end-of-pipe solutions. The business generally considers an end-of-pipe approach as less threatening to product quality and production rates. Several other barriers to implementation of such projects: high cost; inability to find the technology--equipment and materials--to implement certain measures; difficulty in recognizing and focusing on the "right" project; insufficient staff resources to identify and justify prevention projects; and an inability to justify long-term projects.

The last barrier was illustrated by a description of a long-considered end-of-pipe wastewater filtration project designed to remove coating solids from wastewater prior to discharge to the POTW. Though the mills wastewater is in compliance with the current, POTW discharge standards, the sewering of unfiltered wastewater to the POTW has, on occasion caused discoloration of POTW's discharge to the river. While there was a recognition that relations with the POTW and the town would be improved by implementing the filtration project, the company began to seriously pursue the project when they made the decision to begin the conversion to aqueous coating.

Two and a half years ago, the mill made a pledge to the surrounding community to reduce VOC emissions by 50%. Since that time, the mill has invested several million dollars to cut VOC emissions from its solvent-based coating operations through a combination of VOC incinerator and solvent recovery system improvements, and source reduction measures (including conversion of some coating to aqueous).[5] Despite these reductions, the mill remains a significant VOC emitter in the region.

Capital Budgeting and Project Financial Analysis

Capital projects fall into three categories: profit sustaining--must do maintenance and regulatory compliance projects; profit adding--cost reduction projects; and expansion projects--projects that increase market share. Profit adding projects generally have to pass a 50% Return on Assets Employed (ROAE)[6] hurdle rate. Projects that fall into the profit sustaining category (e.g. the majority of environmental projects), are not subjected to the ROAE hurdle rate.[7] Since there are often many projects within this category competing for capital, environmental management would like to shift environmental projects into the profit adding category by showing a return for the project. They often try to represent these projects as "operational projects" rather than environmental projects.

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[5] The mill estimates that VOC emissions have been reduced from 1,200 tons/yr in 1989, to 635 tons/year in 1991. A small percentage of the reduction is a result of a decline in production.

[6] This firm calculates **ROAE** as follows:

(income after depreciation x 100)/(fixed + working capital)

and

ROI as follows:

(income after tax and depreciation x 100)/(fixed capital)

[7] For the next year or two, as a result of the change in ownership, the mill will make investment decisions on the basis of cash flow from the investment, rather than ROAE.

However, they generally find it difficult to develop profit adding justifications for environmental projects that can pass the 50% ROAE hurdle.

Project ideas are typically initiated by middle level managers within the mill. Once initiated, the project is assigned to an engineer who will prepare an Appropriations Request (A.R.) containing: a discussion of the need for the project; a description of the proposed technical approach and rationale for approach; proposed process outline and schematics; and project cost estimate. Based on the cost estimate, an accountant within the appropriate operations group develops the project financial analysis. Mill engineers do not include non-disposal waste management costs, pollution control costs, or regulatory compliance costs in project cost estimates. Raw material and energy costs are typically included. Potential liability costs associated with waste disposal and penalties and fines are commonly considered in a qualitative fashion in the A.R.

Perspectives on TCA

We encountered a great deal of enthusiasm, within the environmental department, for the objectives of, and approaches to TCA. This enthusiasm was demonstrated by their eagerness to subject one of their projects to an in-depth TCA study. Several possible barriers, however, to TCA adoption within the company were cited: difficulty in changing the practices of the company as a whole when the need for more and better environmental investments is not uniformly understood; difficulty in modifying the A.R. format and procedure to include less-obvious environmental costs; difficulty in obtaining the necessary technical and cost data for a TCA; and extra time involved in preparing a more thorough TCA project analysis (one Environmental Manager stated at the conclusion of the in-depth project analysis, that he could only justify the time necessary to develop a TCA for projects with a capital cost of $2 million or more).

Of particular interest to the company was the inclusion of developmental and start-up costs in project analyses. They would like to be able to better predict, and include in a project analysis, the costs associated with laboratory testing (this mill must match coating colors to color standards), and lost productivity due to pilot tests and the "learning curve" associated with virtually all process changes.

As we learned in the in-depth project analysis described below, the Company's procedure for allocating certain costs to product lines may work against the objectives of a TCA approach. The company allocates solvent recovery costs to the paper and film coating businesses on the basis of quantity of coating prepared. While the paper coating prevention project analyzed will reduce solvent use and therefore the solvent flow to the recovery system, the current allocation system will not be sensitive to this effect. Management speculated that even if a decision is made to change the allocation system, for various business reasons this coated paper line may still be required to subsidize the recovery system in excess of its proportional share.

Project Background

The paper coating business produces a line of coated paper that is used for book publishing, binders, labels, menus and other related applications. The business purchases the paper, applies a pigmented base coat and clear top coat, embosses, cuts and ships the paper to its customers. While coating used to produce colored grades contains solvent and a small amount of heavy metal-based pigment, white grades have been made with an aqueous-based coating for the last several years. The mill has long considered converting colored grades to aqueous, and more recently to an aqueous/heavy metal-free coating, for several reasons (as cited in a recent memo): "develop manufacturing flexibility"--to position themselves to respond to solvent-free/heavy metal-free market demand[8]; "reduce environmental impacts"--by reducing VOC emissions, and "improve health and safety"--by reducing worker exposure to fugitive solvent emissions and hazards associated with nitrocellulose (a solvent coating ingredient) handling and storage.

After expending $222,000 in capital in 1988 to begin the conversion to aqueous, the mill halted the project for two reasons: possible relocation of the plant and difficulty in meeting product specifications during aqueous trial runs. In September of 1990, the business resumed the process of converting the base coat mixture for colored grades to aqueous/heavy metal-free[9], and plans to continue until 80% of its production is converted. While their goal is 80% conversion by mid 1993, progress is slower than planned. Reasons cited are: capital constraints (exacerbated by the change in ownership), concern over higher raw material costs for aqueous versus solvent coating; concerns over increased aqueous wastewater; slower than expected manufacturing rates (i.e. tons per machine-hour) for aqueous; and labor resource constraints.

With a TCA for the aqueous project, Environmental Management hoped to improve the financial picture of the conversion project to overcome the economic barriers and shorten the conversion timeline.

Project Description

Currently, the majority of colored, coated papers are produced in two steps, as illustrated in Figure A-2.1. First the paper is coated with a pigmented base coat, consisting of a variety of solvents, nitrocellulose, clay, calcium carbonate, and in approximately 50% of colored grades contain a small amount of lead, chromium, and cadmium-based pigments. The base-coated paper is run through a dryer where most of the solvent is driven off and the remaining materials set on the paper. In the second step, the paper is coated again with a top coat of solvent and nitrocellulose. The paper is dried again and rolled onto a reel; ready for converting. The vaporized solvent from the first and second dryers is collected and sent to a solvent recovery system. In the recovery process, vaporized solvent is adsorbed onto a carbon filter bed, distilled to separate and purify the different types of solvent, and drummed for reuse in the base and top coat mix, and for washing operations (off-specification solvents are also reused for washing). Waste solvents generated in equipment washing are sent directly to the distillation system for recovery. The distillation system bottoms (or "still bottoms"), consist of residual solvent, coating pigments, and other impurities carried into the recovery system. Approximately 2,220 drums per year of hazardous still bottom waste are generated and incinerated off-site.

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[8] The European Economic Committee is expected to set a lead-free packaging standard which would apply to the products manufactured at this plant.

[9] The term "aqueous/heavy metal-free" base coat is used functionally, not absolutely. The new aqueous coating contains small amount of solvent--4%--and, some barium, but does not contain lead, chromium, and cadmium found in the solvent-based coating.

VOC emissions are generated at three points in the process. VOCs not recovered in the solvent recovery system are sent through 3 high efficiency tail gas combusters, and residual VOCs are emitted into the atmosphere. Fugitive VOCs from base coat mixing and from the coating operation are emitted into the plant and then ultimately to the atmosphere.

The aqueous coating process, pictured in Figure A-2.2, involves the basic steps described for solvent coating, with several modifications. The base coat consists of water, acrylic latex resin, and a small amount of ammonia and solvent; pigments are heavy-metal free (with the exception of barium). Currently, the wash water waste generated in the base coating section is treated (i.e. flocculated and settled) in holding tanks prior to discharge to the POTW. If a recently submitted A.R is approved, the waste water will be sent to a new ultrafiltration system before discharge. Under this system the water fraction will be sewered, and the solid fraction will either be reused in the coating process or landfilled as a non-hazardous waste. Vaporized solvent and wash solvent from the second dryer and top coater, respectively, will be sent to the solvent recovery system.

Water-based coating has a shorter shelf-life than solvent-based coating (3 months compared to 5 years) since it is vulnerable to microbiological contamination. The mill expects approximately 100 drums of aqueous coating each year to spoil. The mill will lose the raw material value of this product and will pay for its management and disposal. In addition, unlike solvent coating, aqueous coating can freeze in cold weather. Therefore, the mill must install a new steam heating system in the coating storage area.

Under the aqueous system, emissions of VOCs from the coating process will be reduced by 209 tons/year, but not completely eliminated. Solvent will still be used in the top coat, and a small amount of solvent (4%) will be used in the pigmented coating mixture. Fugitive emissions of ammonia from the base coat mix process and from coating will be emitted into the plant and then to the atmosphere. Approximately 810 fewer drums of hazardous still bottoms will be generated and disposed.

To convert this coating system to aqueous will have to make several capital investments that total to approximately $654,000 (1991 dollars). They are summarized below:

1. Waste water treatment system - ultrafiltration;
2. Coater upgrade (to increase drying capability);
3. Drum shed heating system; and
4. Mix room and coating machine modifications (implemented 1987 to 1990).

Figure A-2.1 SOLVENT/HEAVY METAL PAPER COATING

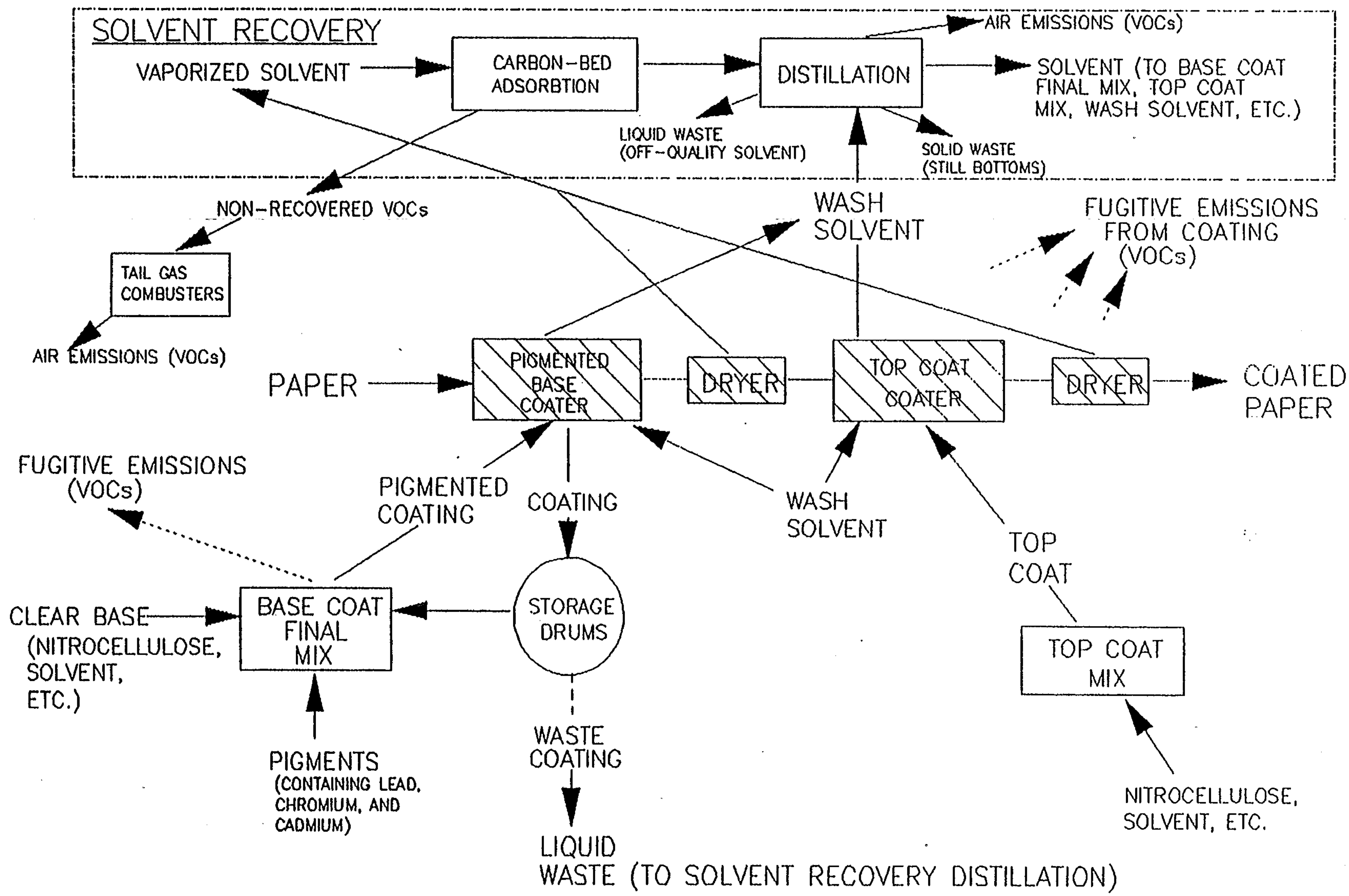
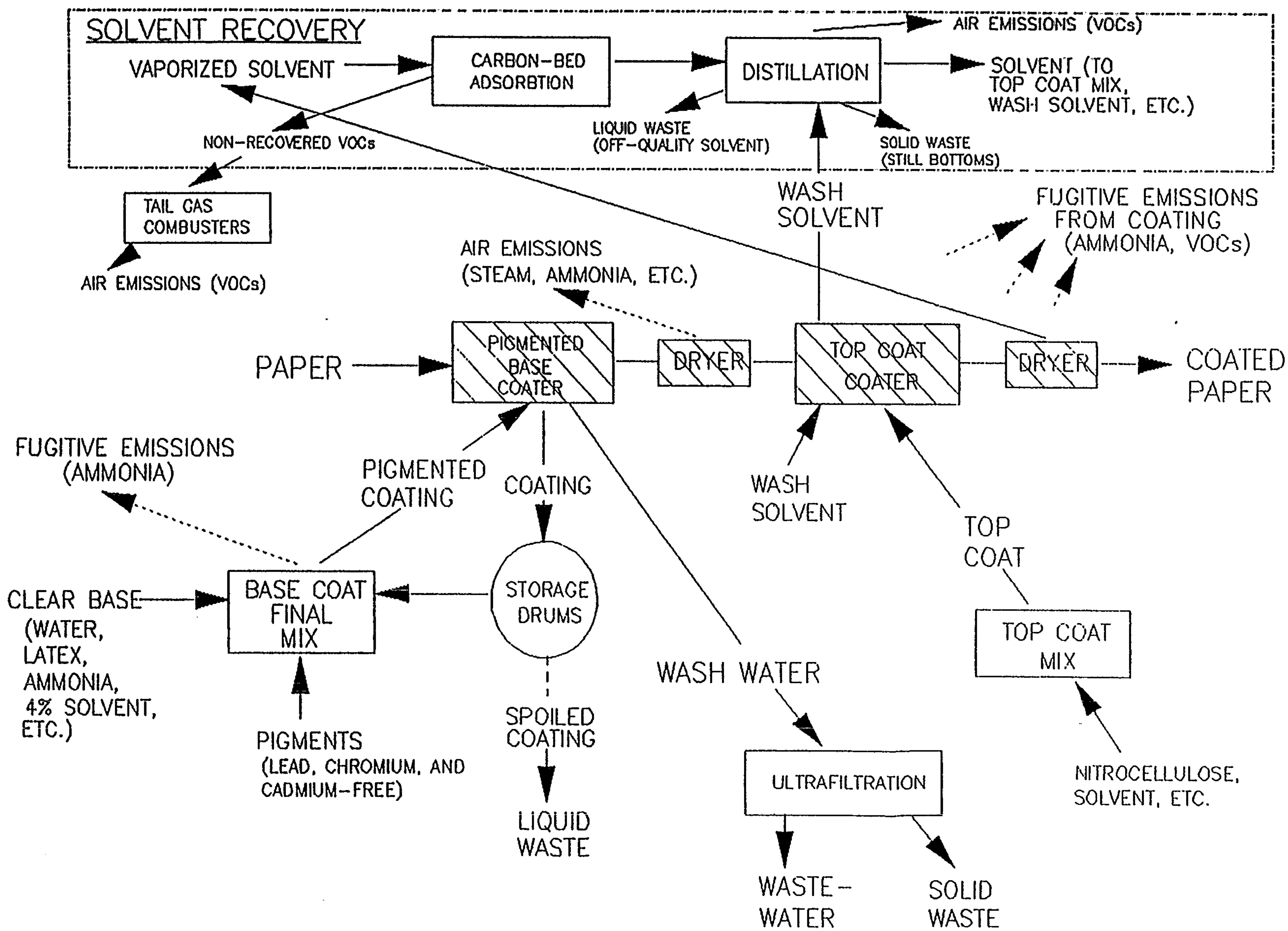


Figure A-2.2 AQUEOUS/HEAVY METAL-FREE PAPER COATING



The conversion will reduce costs related to waste management, solvent recovery, and regulatory compliance; increase utility costs; and have a mixed effect on raw material costs. These are described below:

Waste Management. Under the aqueous coating system, fewer drums of hazardous still bottom waste will be generated each year. In addition to lowering waste disposal costs, the mill expects costs associated with drum handling, storage, transportation, and state hazardous waste-end fees to be reduced. Two new waste streams will be created by the change -- spoiled coating, and concentrated waste from the wastewater ultrafiltration system -- offsetting the gains made at the solvent recovery plant.

Regulatory Compliance. Fewer drums mean fewer manifests to fill out and manage, and fewer drums to label and inspect that translates into a labor cost savings to the mill. The mill also expects to reduce laboratory analysis costs owing to an expected cut in waste generation. However, a new wastewater sampling and analysis regimen will be required for the ultrafiltration system, adding a new cost to the aqueous process.

Despite anticipated reductions in VOC emissions and waste generation, the mill does not expect to realize a reduction in RCRA, TRI and state TUR reporting costs.

Solvent Recovery. Solvent from this product line constitutes 60% of the flow of solvent to the recovery system; the balance coming from plastic film coating. It is estimated that this line will send only 10% of its current solvent stream to the recovery system (top coat solvent) when the aqueous conversion is made. While this effect will result in a reduction in variable costs for the recovery system, fixed costs will be unchanged. However, since the mill currently runs two recovery units, they are considering either using the freed-up recovery capacity to capture fugitive VOC emissions or completely shutting down of one units.

Raw Materials. The higher solid content of aqueous coating requires fewer wet pounds of base coating, but the cost of heavy-metal free pigments drives the base coat cost up over that for solvent/heavy-metal. To achieve adequate protection of an aqueous base-coated sheet, greater coat weight of clear top coat is needed, driving up the top coat cost for the aqueous system. Controlled and fugitive solvent emission losses for the solvent system base and top coat constitute a loss of valuable raw material. These losses, i.e. costs will be reduced through aqueous conversion. Anticipated aqueous coating spoilage will result in the loss of the value of spoiled material. The net result of these financial effects on raw material costs is a somewhat higher cost for the aqueous system.

Utilities. Aqueous coating requires more energy for drying than solvent-based coating. The mill estimated that it will spend more each year for steam. Steam and electricity consumption will increase further for drum storage heating and for the ultrafiltration system.

Project Financial Analysis

In 1987, the mill developed an A.R. for the conversion of basecoat for color grades to aqueous. At that time, the mill was not considering a switch from heavy metal-based to non-heavy metal pigments. The A.R. cost estimate included the following items:

1. **Capital Costs**

   a. Various mix room modifications
   b. Various coating machine modifications
   c. Wash water waste dilution system

2. **Operating Costs**

   a. coating materials
   b. wash solvents
   c. hazardous waste disposal - wash still sludge
   d. controlled and fugitive solvent emission losses

The A.R. reported the results of financial calculations as follows:[10]

Fixed Capital Required		$ 340,000
" "	Return	$1,016,000
" "	R.O.I.*	153.3%
" Payback*		0.61 Years

* R.O.I. and payback include tax effects

The A.R. contained an untitled section that stated:

> "In addition to the cost savings associated with the aqueous conversion, the major reductions in levels of fugitive emissions, and amounts of solid hazardous waste going to landfill, is very positive from a regulatory and community standpoint."

This section also mentioned several other possible financial benefits (which were not monetized in the financial analysis), including possible shutdown of the solvent recovery process thereby eliminating energy costs.

Another section, titled "Safety/Health Impact of Converting From solvent to Aqueous Coatings" listed several improvements in plant "safety/industrial hygiene" that will result from the conversion, including:

I. Safety
   A. Flammability
      1. Minimize need for static control devices and procedures to maintain static free work environment.
      2. Reduce risk of fire in chemical storage, mixing and coating areas.
      3. Minimize need for explosion proof electrical systems in lacquer handling areas.

[10] This analysis was done prior to consideration of conversion from heavy metal to heavy metal-free pigments.

B. Material Handling

1. Nitrocellulose
    a. Minimize special storage requirements in the drum lot.
    b. Minimize special handling procedures for fire safety control.
    c. Minimize employee physical activity and fire risk when loosening and removing nitrocellulose from drums.
    d. Minimize special clean up activities to reduce threat of dried nitrocellulose.

C. Industrial Hygiene

1. Minimize employee exposure to organic vapors reducing health risks and need for IH monitoring and record keeping.
2. Minimize odor complaints in mill and the administration building when retained solvents are released during converting or solvents are used to clean converting equipment.

The last section, called "Product Quality Impact" cited several product quality improvements that the mill expected from the conversion.

An A.R. was recently developed for the waste water ultrafiltration system. Consistent with our earlier discussion of the capital budgeting/financial analysis protocol used at the mill, this investment analysis did not include a calculation of financial indices since it is considered a profit sustaining investment. Rather, it contained only a capital and operating cost estimate.

Company Analysis Versus TCA[11]

Because the mill has already started to convert this product line to aqueous, and has already purchased and installed some of the required equipment, it was necessary to establish a baseline scenario in order to test the effect of a TCA approach on the bottom-line of the project. In conjunction with the company, we decided that the "current process" analyzed will be a 100% solvent base coat system, and the "alternative process" analyzed will be a 100% aqueous base coat system; setting 1992 as the year in which the conversion (hypothetically) would be made, and then bringing all capital costs already expended up to 1991 dollars.

1. Company Analysis

The cost items contained in the Company Analysis come from the 1987 A.R., the 1990 A.R. for the waste water ultrafiltration system, and several internal memos generated by the company. Since the 1987 A.R. dealt only with the conversion to aqueous, but not the conversion to heavy metal-free coating, the Company Analysis developed in this study is not comparable to the financial analysis in the A.R..

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[11] Certain cost data for raw materials and utilities have been modified to protect confidential business information. However, annual savings and financial indicators for the Company and TCA presented in this report are identical to those for analyses developed with true raw material and utility cost data.

2. TCA Analysis

The TCA contains many costs omitted from the Company Analysis, including costs for non-disposal waste management, water, sewerage, solvent recovery, regulatory compliance, and future liability. The documentation attached to the financial analyses provides detail of cost calculations. The estimation of future liability cost deserves further discussion here.

Future Liability. The conversion to aqueous coating will significantly reduce the amount of hazardous waste generated in the solvent recovery distillation system. Using General Electric's TCA method "Financial Analysis of Waste Management Alternative", we have developed an estimate of potential, avoided future liability associated with a reduction in this waste stream. This cost is incorporated into the TCA as a one time cost in year 13.

The methodology for estimating future liability using the GE method is described in Appendix B. The mill sends its waste to a hazardous waste incinerator. On a rating scale of 3 to 9, 9 meaning the highest risk facility, this incinerator scored 3.5 based on surrounding population, water supply proximity, and leak history. As directed by the method, this risk score was adjusted according to the type of TSDF. Since the multiplier for incinerators is 0.15, we end up with a score of 0.175 for this incinerator.[12] Future liability per ton for this waste stream is estimated as follows:

$/ton = 0.175 x $350/6
10.2

where $350 is an average liability cost/ton for a landfill with an average score of 6

To estimate the projected year that liability costs may be incurred, we used the GE method that makes a prediction based on waste toxicity and mobility. We averaged the projected years for three major components of the still bottom waste stream, as follows:

		Year Predicted
acetone		16
toluene		12
MEK		12
	avg.	13

Finally, we calculated total liability cost for year 13 as follows:

Total tons avoided = 810 drums/year reduced x 55 gallon/drum x 12 lb/gal x 1 ton/2,000lb x 13 year

3432

(assuming an average waste density of 12 lb/gallon)

[12] As a point of reference, the multiplier for a landfill is 1.0, 2.0 for an injection well, 0.8 for a surface impoundment, and 0.1 for stabilization/solidification.

and **Total avoided liability** = 3432 tons x $10.20/ton

$35,000

In Tables A-2.1,A-2.2, and A-2.3, we present a comparison of cost items included, financial indicators, and operating cost categories for the Company Analysis and the TCA, respectively. Following these tables are the detailed results of the Company Analysis, TCA and associated cost calculation documentation.

Table A-2.1 Comparison of Cost Items in Company and TCA Cost Analyses

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

	Company	TCA
Capital Costs		
Purchased Equipment	X	X
Utility Systems		X
Engineering/Contractor	X	X
Start-up/Training	X	X
Operating Costs		
Direct Costs:*		
Raw Materials/Supplies	P	X
Waste Disposal	P	X
Labor	X	X
Indirect Costs:*		
Waste Management:		
Hauling		X
Storage		X
Handling		X
Waste-end Fees/Taxes		X
Utilities:		
Energy		X
Water		X
Sewerage (POTW)		X
Pollution Control/ Solvent Recovery		X
Regulatory Compliance		X
Future Liability		X

* 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. "Indirect costs" here mean costs that are typically charged to an overhead account and typically not included in project financial analysis.

Table A-2.2. Summary of Financial Data for the Aqueous Conversion Project

	Company Analysis	TCA
Total Capital Costs	$623,809	$653,809
Annual Savings (BIT)*	$118,112	$216,874
Financial Indicator		
Net Present Value - Years 1-10	($98,829)	$232,817
Net Present Value - Years 1-15	$13,932	$428,040
Internal Rate of Return - Years 1-10	12%	24%
Internal Rate of Return - Years 1-15	16%	27%
Simple Payback (years)	5.3	3.0

* Annual operating cash flow before interest and taxes

Table A-2.3. Summary of Cost Categories and Differences for the Company Analysis and TCA

	Company Analysis	TCA	Difference
Capital Costs	$623,809	$653,809	($30,000)
Net Operating Savings/(Costs):[1]			
a) Raw Material (Spoiled Coating)	$18,112	($27,488)	($45,600)
b) Waste Management	$121,500	$243,871	$122,371
c) Utilities	($5,000)	($87,029)	($82,029)
d) Labor	($8,000)	($8,000)	0
e) Other	($3,500)[2]	$84,520[3]	$88,020
f) Regulatory Compliance	($5,000)	$11,000	$16,000
Total	**$118,112**	**$216,874**	**$98,762**
g) Future Liability[4]	0	$35,000	$35,000

1. Before interest and taxes
2. Filters for wastewater ultrafiltration
3. Filters for wastewater ultrafiltration and solvent recovery
4. Not included in Annual Savings

APPENDIX A-2
PAPER COATING MILL

Project 2 - Company Analysis

AQUEOUS/HEAVY METAL-FREE COATING PROJECT

Project: Aqueous/Heavy Metal-Free Conversion

CAPITAL COSTS

page 1

Date: 7/24/91

Capital Costs	Cost	Totals	Ref.	Notes:
Purchased Equipment				
Mix Room and Coater Modifications	$269,640		1	1987-88 expenditure of $177,620 adjusted
Process Equipment	$91,740		2	to 1991 dollars
Waste Water Treatment System	$163,000		3	
Coater Upgrade	$150,000		4	
Taxes				
Delivery				
Price for Initial Spare Parts		$404,740		
Materials				
Piping				
Electrical				
Instruments				
Structural				
Insulation/Piping		$0		
Utility Connections and New Utility Systems				
Electricity				
Steam			5	For drum storage shed
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$0		
Site Preparation				
Demolition, Clearing, etc.		$0		
Installation				
Vendor				
Contractor				
In-house Staff		$0		
Engineering/Contractor (In-house & Outside)				
Planning	$110,500		6	Technical and manufacturing
Engineering	$85,410		7	1987-88 costs (adjusted) and 1991 costs
Procurement				
Consultants		$195,910		

Project: Aqueous/Heavy Metal-Free Conversion

Date: 7/24/91

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances	$23,159		8	
Training		$23,159		
Contigency				
		$0		
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

Project: Aqueous/Heavy Metal-Free Conversion

OPERATING COSTS

Costs are positive
Savings and revenues are negative

Date: 7/24/91

Current Process Item	Annual Cost ($/year)	Total	Ref	Alternative Process Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				Raw Materials/Supplies				
Coating and Wash Solvents	$4,317,300		2a	Coating and Wash Solvents	$4,404,920		2b	
Solvent emission losses:				Solvent emission losses (from top coat)				
a. controlled	$48,276		2c	a. controlled	$21,168		2d	
b. fugitive	$84,672		2c	b. fugitive	$6,048		2d	
				Coating spoilage (value of material)			2e	
		$4,450,248				$4,432,136		$18,112
Waste Management				Waste Management				
(disposal, hauling, insurance, storage, etc.)				(disposal, hauling, insurance, storage, etc.)				
Wash still sludge disposal	$180,000		3a	Wash still sludge disposal	$58,500		3b	
Drum handling			3c	Drum handling			3d	
Drum storage			3e	Drum storage			3f	
Drum transportation			3g	Drum transportation			3h	
State waste-end fees			3i	State waste-end fees			14b	
				Spoiled coating disposal			3k	
		$180,000		Conc. waste disposal - ultrafiltration		$58,500	3l	$121,500
Utilities (electricity, steam, water, sewerage)				Utilities (electricity, steam, water, sewerage)				
Steam for coater			4a	Steam for coater			4b	
				Water - aqueous base coat			4c	
				Steam heat for drum shed			4d	
				Electricity - ultrafiltration	$5,000	$0	4e	
				Water - base coat wash-up			4f	
		$0		Wastewater treatment (POTW)		$5,000	4g	($5,000)
Labor				Labor				
				Operator - ultrafiltration	$8,000		5a	
		$0				$8,000		($8,000)
Other				Other				
Solvent Recovery			6a	Solvent Recovery - top coat			6b	
				Filters - ultrafiltration	$3,500		6c	
		$0				$3,500		($3,500)
Regulatory Compliance				Regulatory Compliance				
(manifesting, reporting, monitoring, testing, labeling, etc.)				(manifesting, reporting, monitoring, testing, labeling, etc.)				
Managing manifests			7a	Managing manifests			7b	
Drum labeling			7c	Drum labeling			7d	
RCRA, TRI and TURA reporting			7e	RCRA, TRI and TURA reporting			7f	
Inspections			7g	Inspections			7h	
Lab analysis - haz. waste			7i	Lab analysis - haz. waste			7j	
				Lab analysis - ultrafiltration	$5,000		7k	
		$0				$5,000		($5,000)
Insurance				Insurance				
		$0				$0		$0
Revenues				Revenues				
		$0				$0		$0
Revenues - Marketable By-products				Revenues - Marketable By-products				
		$0				$0		$0
Total		$4,630,248				$4,512,136		$118,112

Project: Aqueous/Heavy Metal-Free Conversion

Date: 7/24/91

CAPITAL AND OPERATING COST SUMMARY

Capital Costs	Year 0 $
Equipment	$404,740
Materials	$0
Utility Connections	$0
Site Preparation	$0
Installation	$0
Engineering/Contractor	$195,910
Start-up/Training	$23,159
Contigency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$623,809
Working Capital	$0
Subtotal	$623,809
Interest on Debt	$0
Total Capital Requirement	$623,809
Salvage Value	$0
% Equity	100.0%
% Debt	0.0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$623,809
Debt Principal	$0
Interest on Debt	$0
Total Financing	$623,809
Depreciation period	15
Income Tax Rate, %	40.0%
Escalation Rate, %	5.0%
Cost of Capital (for NPV)	16.0%

Operating Costs		Current	Alternative	Difference (Cur. - Alt.)
Raw Materials/Supplies		$4,450,248	$4,432,136	$18,112
Waste Management		$180,000	$58,500	$121,500
Utilities		$0	$5,000	($5,000)
Labor		$0	$8,000	($8,000)
Other		$0	$3,500	($3,500)
Regulatory Compliance		$0	$5,000	($5,000)
Insurance		$0	$0	$0
Maintenance - % of Capital				
Labor	0%		$0	$0
Materials	0%		$0	$0
Overhead - (% of Labor)	0%	$0	$0	$0
Labor Burden	0%	$0	$0	$0
Revenues		$0	$0	$0
Revenues - Marketable By-products		$0	$0	$0
TOTAL		$4,630,248	$4,512,136	$118,112

Future Liability	Ref.	Year Expected	Cost (Curr.-Alter.)
(Year expected = 1,2,3, etc.)			

Project: Aqueous/Heavy Metal-Free Conversion

Date: 7/24/91

Profitability Analysis

Operating Year	0	1	2	3	4	5	6	7	8
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	1.478
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS									
Raw Materials/Supplies		$19,018	$19,978	$20,974	$22,024	$23,129	$24,288	$25,502	$26,770
Waste Management		$127,575	$134,015	$140,697	$147,744	$155,156	$162,932	$171,072	$179,577
Utilities		($5,250)	($5,515)	($5,790)	($6,080)	($6,385)	($6,705)	($7,040)	($7,390)
Labor		($8,400)	($8,824)	($9,264)	($9,728)	($10,216)	($10,728)	($11,264)	($11,824)
Other		($3,675)	($3,861)	($4,053)	($4,256)	($4,470)	($4,694)	($4,928)	($5,173)
Regulatory Compliance		($5,250)	($5,515)	($5,790)	($6,080)	($6,385)	($6,705)	($7,040)	($7,390)
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Costs		$124,018	$130,278	$136,774	$143,624	$150,829	$158,388	$166,302	$174,570
CAPITAL COSTS									
Investment	$623,809								
Book Value	$623,809	$582,222	$504,592	$437,313	$379,005	$328,471	$284,675	$254,709	$224,743
Tax Depreciation (by Straight-line, 1/2 yr)		$41,587	$41,587	$41,587	$41,587	$41,587	$41,587	$41,587	$41,587
Tax Depreciation (by Double DB, 1/2 yr)		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$37,957	$33,961
Tax Depreciation (by DDB switching to SL)		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$29,966	$29,966
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at : 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$124,018	$130,278	$136,774	$143,624	$150,829	$158,388	$166,302	$174,570
Operating Cash Flow (BIT)		$124,018	$130,278	$136,774	$143,624	$150,829	$158,388	$166,302	$174,570
- Depreciation		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$29,966	$29,966
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$82,431	$52,648	$69,495	$85,316	$100,295	$114,592	$136,336	$144,604
- Income Tax at: 40.0%		$32,972	$21,059	$27,798	$34,126	$40,118	$45,837	$54,534	$57,842
Net Income		$49,459	$31,589	$41,697	$51,190	$60,177	$68,755	$81,802	$86,762
+ Depreciation		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$29,966	$29,966
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)	$623,809								
- Working Capital	$0								
+ Salvage Value									
After-Tax Cashflow	($623,809)	$91,046	$109,219	$108,976	$109,498	$110,711	$112,551	$111,768	$116,728
Cummulative Cashflow	($623,809)	($532,763)	($423,544)	($314,568)	($205,070)	($94,359)	$18,192	$129,960	$246,688
Discounted Cashflow	($623,809)	$78,488	$81,168	$69,816	$60,475	$52,711	$46,196	$39,547	$35,605

	Years 1 - 10	Years 1 - 15
Net Present Value	($98,829)	$13,932
Internal Rate of Return	12%	16%
Payback	5.3 years	

Profitability Analysis (continued)

Operating Year		9	10	11	12	13	14	15
		1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES								
Revenue (production rate or value)		$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS								
Raw Materials/Supplies		$28,110	$29,523	$31,008	$32,565	$34,195	$35,898	$37,691
Disposal		$188,568	$198,045	$208,008	$218,457	$229,392	$240,813	$252,842
Utilities		($7,760)	($8,150)	($8,560)	($8,990)	($9,440)	($9,910)	($10,405)
Labor		($12,416)	($13,040)	($13,696)	($14,384)	($15,104)	($15,856)	($16,648)
Supplies		($5,432)	($5,705)	($5,992)	($6,293)	($6,608)	($6,937)	($7,284)
Regulatory Compliance		($7,760)	($8,150)	($8,560)	($8,990)	($9,440)	($9,910)	($10,405)
Insurance/Liability		$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0
Total Operating Costs		$183,310	$192,523	$202,208	$212,365	$222,995	$234,098	$245,791
CAPITAL COSTS								
Investment								
Book Value		$194,777	$164,811	$134,845	$104,879	$74,914	$44,948	$14,983
Tax Depreciation (by Straight-line, 1/2 yr)		$41,587	$41,587	$41,587	$41,587	$41,587	$41,587	$41,587
Tax Depreciation (by Double DB, 1/2 yr)		$29,966	$25,970	$21,975	$17,979	$13,984	$9,989	$5,993
Tax Depreciation (by DDB switching to SL)		$29,966	$29,966	$29,966	$29,966	$29,965	$29,966	$29,965
Debt Balance		$0	$0	$0	$0	$0	$0	$0
Interest Payment at:	12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0
CASHFLOW								
Revenues		$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$183,310	$192,523	$202,208	$212,365	$222,995	$234,098	$245,791
Operating Cash Flow (BIT)		$183,310	$192,523	$202,208	$212,365	$222,995	$234,098	$245,791
- Depreciation		$29,966	$29,966	$29,966	$29,966	$29,965	$29,966	$29,965
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0
Taxable Income		$153,344	$162,557	$172,242	$182,399	$193,030	$204,132	$215,826
- Income Tax at:	40.0%	$61,338	$65,023	$68,897	$72,960	$77,212	$81,653	$86,330
Net Income		$92,006	$97,534	$103,345	$109,439	$115,818	$122,479	$129,496
+ Depreciation		$29,966	$29,966	$29,966	$29,966	$29,965	$29,966	$29,965
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)								
- Working Capital								
+ Salvage Value								
After-Tax Cashflow		$121,972	$127,500	$133,311	$139,405	$145,783	$152,445	$159,461
Cummulative Cashflow		$368,660	$496,160	$629,471	$768,876	$914,659	######	######
Discounted Cashflow		$32,073	$28,902	$26,051	$23,485	$21,172	$19,085	$17,210

APPENDIX A-2
PAPER COATING MILL

Project 2 - TCA

AQUEOUS/HEAVY METAL-FREE COATING PROJECT

Project: Aqueous/Heavy Metal-Free Conversion		CAPITAL COSTS		page 1 Date: 7/24/91
Capital Costs	**Cost**	**Totals**	**Ref.**	**Notes:**
Purchased Equipment				
Mix Room and Coater Modifications	$269,640		1	1987-88 expenditure of $177,620 adjusted
Process Equipment	$91,740		2	to 1991 dollars
Waste Water Treatment System	$163,000		3	
Coater Upgrade	$150,000		4	
Taxes				
Delivery				
Price for Initial Spare Parts		$404,740		
Materials				
Piping				
Electrical				
Instruments				
Structural				
Insulation/Piping		$0		
Utility Connections and New Utility Systems				
Electricity				
Steam	$30,000		5	For drum storage shed
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$30,000		
Site Preparation				
Demolition, Clearing, etc.		$0		
Installation				
Vendor				
Contractor				
In-house Staff		$0		
Engineering/Contractor (In-house & Outside)				
Planning	$110,500		6	Technical and manufacturing
Engineering	$85,410		7	1987-88 costs (adjusted) and 1991 costs
Procurement				
Consultants		$195,910		

Project: Aqueous/Heavy Metal-Free Conversion

page 2
Date: 7/24/91

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances	$23,159		8	
Training		$23,159		
Contigency				
		$0		
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

Project: Aqueous/Heavy Metal-Free Conversion

OPERATING COSTS

Costs are positive
Savings and revenues are negative

Date: 7/24/91

Current Process Item	Annual Cost ($/year)	Total	Ref	Alternative Process Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				**Raw Materials/Supplies**				
Coating and Wash Solvents	$4,317,300		2a	Coating and Wash Solvents	$4,404,920		2b	
Solvent emission losses:				Solvent emission losses (from top coat)				
a. controlled	$48,276		2c	a. controlled	$21,168		2d	
b. fugitive	$84,672		2c	b. fugitive	$6,048		2d	
				Coating spoilage (value of material)	$45,600		2e	
		$4,450,248				$4,477,736		($27,488)
Waste Management				**Waste Management**				
(disposal, hauling, insurance, storage, etc.)				(disposal, hauling, insurance, storage, etc.)				
Wash still sludge disposal	$180,000		3a	Wash still sludge disposal	$58,500		3b	
Drum handling	$100,000		3c	Drum handling	$50,000		3d	
Drum storage	$10,000		3e	Drum storage	$2,000		3f	
Drum transportation	$90,000		3g	Drum transportation	$15,000		3h	
State waste-end fees	$10,920		3i	State waste-end fees	$3,549		14b	
				Spoiled coating disposal	$18,000		3k	
		$390,920		Conc. waste disposal - ultrafiltration	$20,000	$147,049	3l	$243,871
Utilities (electricity, steam, water, sewerage)				**Utilities (electricity, steam, water, sewerage)**				
Steam for coater	$189,000		4a	Steam for coater	$226,800		4b	
				Water - aqueous base coat	$24,458		4c	
				Steam heat for drum shed	$5,500		4d	
				Electricity - ultrafiltration	$5,000	$0	4e	
				Water - base coat wash-up	$13,083		4f	
		$189,000		Wastewater treatment (POTW)	$1,188	$276,029	4g	($87,029)
Labor				**Labor**				
				Operator - ultrafiltration	$8,000		5a	
		$0				$8,000		($8,000)
Other				**Other**				
Solvent Recovery	$97,800		6a	Solvent Recovery - top coat	$9,780		6b	
				Filters - ultrafiltration	$3,500		6c	
		$97,800				$13,280		$84,520
Regulatory Compliance				**Regulatory Compliance**				
(manifesting, reporting, monitoring, testing, labeling, etc.)				(manifesting, reporting, monitoring, testing, labeling, etc.)				
Managing manifests	$2,500		7a	Managing manifests	$500		7b	
Drum labeling	$2,500		7c	Drum labeling	$500		7d	
RCRA, TRI and TURA reportin	$15,000		7e	RCRA, TRI and TURA reporting	$15,000		7f	
Inspections	$2,500		7g	Inspections	$500		7h	
Lab Analysis - Haz. Waste	$20,000		7i	Lab analysis - haz. waste	$10,000		7j	
				Lab analysis - ultrafiltration	$5,000		7k	
		$42,500				$31,500		$11,000
Insurance				**Insurance**				
		$0				$0		$0
Revenues				**Revenues**				
		$0				$0		$0
Revenues - Marketable By-products				**Revenues - Marketable By-products**				
		$0				$0		$0
Total		$5,170,468				$4,953,594		$216,874

Project: Aqueous/Heavy Metal-Free Conversion

page 4

Date: 7/24/91

CAPITAL AND OPERATING COST SUMMARY

Capital Costs	Year 0 $
Equipment	$404,740
Materials	$0
Utility Connections	$30,000
Site Preparation	$0
Installation	$0
Engineering/Contractor	$195,910
Start-up/Training	$23,159
Contigency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$653,809
Working Capital	$0
Subtotal	$653,809
Interest on Debt	$0
Total Capital Requirement	$653,809
Salvage Value	$0
% Equity	100.0%
% Debt	0.0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$653,809
Debt Principal	$0
Interest on Debt	$0
Total Financing	$653,809
Depreciation period	15
Income Tax Rate, %	40.0%
Escalation Rate, %	5.0%
Cost of Capital (for NPV)	16.0%

Operating Costs		Current	Alternative	Difference (Cur. - Alt.)
Raw Materials/Supplies		$4,450,248	$4,477,736	($27,488)
Waste Management		$390,920	$147,049	$243,871
Utilities		$189,000	$276,029	($87,029)
Labor		$0	$8,000	($8,000)
Other		$97,800	$13,280	$84,520
Regulatory Compliance		$42,500	$31,500	$11,000
Insurance		$0	$0	$0
Maintenance - % of Capital				
Labor	0%		$0	$0
Materials	0%		$0	$0
Overhead - (% of Labor)	0%	$0	$0	$0
Labor Burden	0%	$0	$0	$0
Revenues		$0	$0	$0
Revenues - Marketable By-products		$0	$0	$0
TOTAL		$5,170,468	$4,953,594	$216,874

Future Liability	Ref.	Year Expected	Cost (Curr.-Alter.)
(Year expected = 1,2,3, etc.)	8	13	$35,000

Project: Aqueous/Heavy Metal-Free Conversion

Date: 7/24/91

Profitability Analysis

Operating Year	0	1	2	3	4	5	6	7	8
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	1.478
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS									
Raw Materials/Supplies		($28,862)	($30,319)	($31,831)	($33,425)	($35,102)	($36,861)	($38,703)	($40,627)
Waste Management		$256,065	$268,990	$282,403	$296,547	$311,423	$327,031	$343,370	$360,441
Utilities		($91,380)	($95,993)	($100,780)	($105,827)	($111,136)	($116,706)	($122,537)	($128,629)
Labor		($8,400)	($8,824)	($9,264)	($9,728)	($10,216)	($10,728)	($11,264)	($11,824)
Other		$88,746	$93,226	$97,874	$102,776	$107,932	$113,341	$119,004	$124,921
Regulatory Compliance		$11,550	$12,133	$12,738	$13,376	$14,047	$14,751	$15,488	$16,258
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Costs		$227,719	$239,213	$251,140	$263,719	$276,948	$290,828	$305,358	$320,540
CAPITAL COSTS									
Investment	$653,809								
Book Value	$653,809	$610,222	$528,859	$458,344	$397,231	$344,267	$298,365	$266,958	$235,551
Tax Depreciation (by Straight-line, 1/2 yr)		$43,587	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587
Tax Depreciation (by Double DB, 1/2 yr)		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$39,782	$35,594
Tax Depreciation (by DDB switching to SL)		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$31,407	$31,407
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at: 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$227,719	$239,213	$251,140	$263,719	$276,948	$290,828	$305,358	$320,540
Operating Cash Flow (BIT)		$227,719	$239,213	$251,140	$263,719	$276,948	$290,828	$305,358	$320,540
- Depreciation		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$31,407	$31,407
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$184,132	$157,850	$180,625	$202,606	$223,984	$244,926	$273,951	$289,133
- Income Tax at: 40.0%		$73,653	$63,140	$72,250	$81,042	$89,594	$97,970	$109,580	$115,653
Net Income		$110,479	$94,710	$108,375	$121,564	$134,390	$146,956	$164,371	$173,480
+ Depreciation		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$31,407	$31,407
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)	$653,809								
- Working Capital	$0								
+ Salvage Value									
After-Tax Cashflow	($653,809)	$154,066	$176,073	$178,890	$182,677	$187,354	$192,858	$195,778	$204,887
Cummulative Cashflow	($653,809)	($499,743)	($323,670)	($144,780)	$37,897	$225,251	$418,109	$613,887	$818,774
Discounted Cashflow	($653,809)	$132,816	$130,851	$114,607	$100,891	$89,202	$79,157	$69,272	$62,496

	Years 1 - 10	Years 1- 15
Net Present Value	$232,817	$428,040
Internal Rate of Return	24%	27%
Payback	3.0 years	

Project: Aqueous/Heavy Metal-Free Conversion

Date: 7/24/91

Profitability Analysis (continued)

Operating Year	9	10	11	12	13	14	15
	1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES							
Revenue (production rate or value)	$0	$0	$0	$0	$0	$0	$0
Marketable By-products	$0	$0	$0	$0	$0	$0	$0
Annual Revenue	$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS							
Raw Materials/Supplies	($42,661)	($44,805)	($47,059)	($49,423)	($51,897)	($54,481)	($57,203)
Disposal	$378,488	$397,510	$417,507	$438,480	$460,428	$483,352	$507,496
Utilities	($135,069)	($141,857)	($148,994)	($156,478)	($164,311)	($172,491)	($181,107)
Labor	($12,416)	($13,040)	($13,696)	($14,384)	($15,104)	($15,856)	($16,648)
Supplies	$131,175	$137,768	$144,698	$151,967	$159,574	$167,519	$175,886
Regulatory Compliance	$17,072	$17,930	$18,832	$19,778	$20,768	$21,802	$22,891
Insurance/Liability	$0	$0	$0	$0	$0	$0	$0
Maintenance	$0	$0	$0	$0	$0	$0	$0
Overhead	$0	$0	$0	$0	$0	$0	$0
Labor Burden	$0	$0	$0	$0	$0	$0	$0
Liability	$0	$0	$0	$0	$66,080	$0	$0
Total Operating Costs	$336,589	$353,506	$371,288	$389,940	$475,538	$429,845	$451,315
CAPITAL COSTS							
Investment							
Book Value	$204,144	$172,737	$141,330	$109,923	$78,516	$47,110	$15,703
Tax Depreciation (by Straight-line, 1/2 yr)	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587
Tax Depreciation (by Double DB, 1/2 yr)	$31,407	$27,219	$23,032	$18,844	$14,656	$10,469	$6,281
Tax Depreciation (by DDB switching to SL)	$31,407	$31,407	$31,407	$31,407	$31,407	$31,406	$31,407
Debt Balance	$0	$0	$0	$0	$0	$0	$0
Interest Payment at : 12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment	$0	$0	$0	$0	$0	$0	$0
CASHFLOW							
Revenues	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings	$336,589	$353,506	$371,288	$389,940	$475,538	$429,845	$451,315
Operating Cash Flow (BIT)	$336,589	$353,506	$371,288	$389,940	$475,538	$429,845	$451,315
- Depreciation	$31,407	$31,407	$31,407	$31,407	$31,407	$31,406	$31,407
- Interest on Debt	$0	$0	$0	$0	$0	$0	$0
Taxable Income	$305,182	$322,099	$339,881	$358,533	$444,131	$398,439	$419,908
- Income Tax at: 40.0%	$122,073	$128,840	$135,952	$143,413	$177,652	$159,376	$167,963
Net Income	$183,109	$193,259	$203,929	$215,120	$266,479	$239,063	$251,945
+ Depreciation	$31,407	$31,407	$31,407	$31,407	$31,407	$31,406	$31,407
- Debt Repayment	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)							
- Working Capital							
+ Salvage Value							
After-Tax Cashflow	$214,516	$224,666	$235,336	$246,527	$297,886	$270,469	$283,352
Cummulative Cashflow	$1,033,290	$1,257,956	$1,493,292	$1,739,819	$2,037,705	$2,308,174	$2,591,526
Discounted Cashflow	$56,408	$50,928	$45,989	$41,531	$43,261	$33,861	$30,581

APPENDIX A-2 - PAPER COATING MILL
Project 2 - Aqueous/Heavy Metal-Free Coating Project

Costing and Financial Analysis Documentation

A. Capital Costs

1. 1987-88 capital expenditure - $222,025 on mix room and coating machine modifications
   80% of $222,025 - equipment ———> $177,620
   20% of $222,025 - engineering

   Adjust 1987-1988 expenditure to 1991 dollars:

   $$\$177,620 \times (1+0.11^*)^4 = \$269,640$$

   * 11% nominal discount rate

2.

Various Mix Room	$30,000	
#14 Web Temperature	11,000	
Mix Room Drum Handling	11,000	
Bulk Resin	21,240	
In-line Mixing	18,500	
	$91,740	(Expended)

3. Wastewater Treatment System - $163,000
   estimate includes: engineering and design, installation and contingency

4. Coater Upgrade - $150,000

5. Installation of Drum Shed heating system to prevent freezing of aqueous coating - $30,000

6. Labor - Technical and Manufacturing - $110,500 (Expended)
   - Equivalent 2 Man/years + 30% fringe

7. Engineering

a. 1987-1988 Engineering on Capital Projects

$$\$222,025 \times 0.2 = \$44,405$$

Adjust 1987-88 expenditure to 1991 dollars:

$$\$44,405 \times (1+0.11)^4 = \$67,410$$

b. Ultrafiltration System - $18,000

8. Trials and Manufacturing Variances (5/90 - 4/91)

a.	Average Productivity Loss	$17,302
b.	Yield Loss	5,857
		$23,159

B. Operating Costs

Solvent

1. Raw Materials and Supplies

1a. Coating and Wash Solvents

$4,317,300/yr

1c. Solvent emission losses

Controlled:
96 tons/yr x $0.21/lb x 2000 lb/ton = $40,320/yr
Fugitive:
(97+71)tons/yr x $0.21/lb x 2000 lb/ton = $70,560/yr

2. Waste Management

2a. Wash still sludge disposal - from base coat and bottom coat

Disposal Cost - $150/drum

2,200 drums/yr x $150/drum = $180,000/yr

2c. Drum Handling:

2 man yr @ $50,000/yr (including benefits) = $100,000/yr

Aqueous

1b. Coating and Wash Solvents

$4,404,920/yr

1d. Solvent emission losses:

Controlled:
42 tons/yr x $0.21/lb x 2000 lb/ton = $17,640/yr
Fugitive:
12 tons/yr x $0.21/lb x 2000 lb/ton = $ 5,040/yr

1e. Coating Spoilage - value of lost raw material:

Spoilage of stored aqueous coating from micro-bacteriological build-up.

100 drums/yr at a cost of $45,600/year

- estimate 100 drums/yr spoiled

2b. Wash still sludge disposal - from top coat only

390 drums/yr x $150/drums - $58,500/yr

2d. Drum Handling:

1 man yr @ $50,000/yr

Solvent

2e. Drum Storage:

$10,000/yr
estimate, based on calculated cost of $4/sq. ft./year for heating, lighting, and fire protection

2g. Waste Transportation

$90,000/yr - estimate,
based on waste disposal invoices

2i. Massachusetts waste-end fees

1,200 drums wash still sludge/yr x 50 gal./drum x $0.182/gal = $10,920/yr

Tellus estimate based on state waste transportation fee - $0.182/gal

Aqueous

2f. Drum Storage

$2,000/yr

(See 2e)

2h. Waste Transportation

$15,000 - estimate

2j. Massachusetts waste-end fees

390 drums/yr x 50 gal/drum x $0.182/gal - $3,549/yr

(See 2i)

2k. Spoiled coating disposal

Disposal Cost - $18/drum

100 drums/yr x $18/drum = $18,000/yr

(See 2i)

2l. Disposal of concentrated waste from waste water ultrafiltration

Disposal Cost - $0.50/gal

150 gal/day x $0.50/gal x 267 days/yr = $20,000/yr

Solvent	Aqueous
3. Utilities	
3a. Steam for coater	**3a. Steam for coater**
$27/hr x 7,000 hrs/yr = $189,000/yr	1.2($27/hr x 7,000 hrs/yr) = $226,800/yr - Based on an estimated 20% increase in steam needed to dry aqueous coating
	3c. Water for Aqueous Coating Based on 60% water content of coating 1,450,000 lb water/yr x gallon/8.3 lb x $0.14/gal = $24,458/yr
	3d. Steam Heat for Drum Shed Drum shed steam heating will be needed to prevent freezing of aqueous coating Annual Steam Costs = $5,500/yr
	3e. Electricity for Ultrafiltration System $5,000/yr Based on $0.105/kwh
	3f. Water Use for Base Coat Wash-up 3,500 gal/day x 267 day/yr x $0.14/gallon = $13,083/yr

Solvent

4. **Labor**

5. **Other**

5a. **Solvent Recovery (S.R.)**

	Total	Product Line(60%)
S.R. Ann. Oper. Cost	$1,468,000	$880,800
Fair Market Value of Solvent Produced	1,323,000	783,000
Net Cost	$145,000	$ 97,800

S.R. Annual Cost includes:

- utilities
- labor
- engineering (in-house and consultants)
- supplies
- maintenance

Cost allocated to Product Line based on 60% solvent contribution from Product Line coating. Costs are based on 3 year average.

Aqueous

3g. **Wastewater Treatment (POTW) of Washwater**

Treatment of wastewater discharge from ultrafiltration system

2,850 gal/day x 267 days/yr x $0.00156/gallon = $1,188/yr

4a. **Operator - Ultrafiltration**

$8,000/yr

5b. **Solvent Recovery**

$97,800/yr x 0.1 = $9,780

Solvent recovery of top coat solvents only. Cost based on an estimated 10% of solvents in solvent coating attributed to top coat.

5c. **Filters - Ultrafiltration**

$3,500/yr

	Solvent	Aqueous
6. Regulatory Compliance*		
Managing Hazardous Waste Manifests	6a. $2,500/yr	6b. $500/yr
Waste Drum Labeling	6c. $2,500/yr	6d. $500/yr
RCRA, TRI and Mass. TURA Reporting	6e. $15,000/yr	6f. $15,000/yr
Inspections	6g. $2,500/yr	6h. $500/yr
Laboratory Analysis-Hazardous Waste	6i. $20,000/yr	6j. $10,000/yr
Lab Analysis - Ultrafiltration		6k. $5,000/yr

*All costs are estimates based on current expenses.

7. Future Liability

$35,000 in year 13 (see project write-up)

APPENDIX A-3

SPECIALTY PAPER COMPANY

Company Background

This Division of a large U.S. corporation operates four small mills on nearby sites. The mills produce 160 tons per day of bond (some cotton-content), writing, vellum, wedding, and drawing papers and other high quality grades from purchased pulp and pre-consumer wastepaper.[13] The Division currently markets several (pre-consumer) recycled grades of paper, and expects to increase their recycled line -- including two post-consumer grades. The four mills generate approximately $120,000,000 in annual sales.

Two mills treat and discharge their own wastewater; the third mill discharges all wastewater to a POTW; and the fourth runs a primary treatment system--discharging the liquid phase under permit to a river, and pumping the solid phase to a POTW for additional treatment.

One mill utilizes a two-phase bleaching/color stripping system--a hypochlorite stage followed by a hydrosulfite stage--to process both incoming market pulp, purchased pre-consumer colored wastepaper, and recycled broke (i.e. in-house scrap). Colored grades are produced with dyes containing copper, phenolic and biphenolic compounds.[14]

Environmental Management

The Division's Technical Manager has primary responsibility for environmental projects at all four sites. He is assisted by an Environmental Coordinator who spends approximately 50% of his time on compliance work. The focus of environmental projects is wastewater treatment. The Division recently completed a NPDES permit renewal for one mill that uses primary treatment only. It requested, and received, an increase in the BOD discharge limit. The permitting process involved a series of toxicity tests, which the mill will be required to perform regularly under the new permit. In the next few months, the Division expects to enter into negotiations with the state permitting authority for a new permit at another site.

A POTW used by one mill is facing a shortage of landfill capacity for its wastewater sludge. The town is considering a study of alternative sludge disposal methods, and since the mill is a significant contributor of solids to this treatment plant it will likely participate in and fund the study.

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[13] Pre-consumer waste consists of trimmings or off-specification paper which is purchased from another mill or on the open-market, but has not been used or discarded by a consumer. Post-consumer waste includes those materials which have reached the final end-user and have served their useful life.

[14] These chemical can react with chlorine to form toxic chlorophenolic compounds.

A primary objective of environmental management is to minimize use of town-owned and operated POTWs by treating wastewater on-site, where appropriate. Management expressed frustration with lack of control over the operation of town-owned plants, and the cost that they are required to pay for treatment services. For example, they would like to have discretion over the types and levels of chemical flocculants and the choice of sludge disposal locations as well as the ability to optimize the operating conditions at the plant in accordance with the changing nature of the mill's wastewater stream.

To meet this objective, environmental management is evaluating two technical options. The first is a new secondary treatment plant for one site that currently discharges wastewater to a POTW. This plan is synergistic with the company's desire to utilize higher levels of wastepaper at this site. Unlike market pulp, wastepaper contains starch. When wastepaper is repulped, much of the starch ends up in wastewater, increasing wastewater BOD levels. It is possible that the mill will exceed the BOD limit set by the POTW if it increases its use of wastepaper. Environmental management sees an opportunity to justify the construction of a new secondary treatment plant on the basis of the company's goal to expand their line of recycled paper products.

The second option under evaluation is a new plant that would process wastewater sludge from all sites by separating reusable fiber and filler from non-reusable solids. The mill would recycle the recovered fiber and filler and landfill the residual material. This technology is still in its infancy and the potential technical and economic feasibility for this mill is still under investigation.

The mill is in the process of implementing a saveall system (a screening device used for in-plant recycling of fiber, filler, and water, and reduction of solids and BOD in wastewater) for one papermachine. This project was proposed several years ago on the basis of an estimated 0.9 year payback. The attractive financial outlook for the project is primarily attributable to recovery of high-value, purchased fiber.

Capital Budgeting and Project Analysis

The Environmental Department, in conjunction with Division Management develops a capital plan for the coming year. A recent plan included a feasibility study for the use of mill sludge as daily cover for a landfill. Corporate Management recently required the Department to develop a five year environmental capital plan as part of an overall five year plan for the Division. After researching proposed regulations for air emissions, water effluent, and storm water runoff, the Department developed capital needs projections for wastewater treatment, plant maintenance projects, permitting costs, waste disposal fee increases, and other projects needed in anticipation of new or changed regulations and permit renewals.

Any capital improvement project above $5,000 must be justified on a Capital Improvement form (CI form). For environmental projects, the Technical Director or Environmental Coordinator completes most of the form alone or with the help of the plant engineers. They prepare the:

- problem statement
- solutions

- alternative solutions
- scope of work
- cost/savings summary.

The form is sent to the Finance Comptroller (for calculation of the various financial indices) the Vice President of Manufacturing and President of the Division. As in most corporations, large projects must receive additional analysis and approval from corporate management. The time horizon used in the corporate financial analysis is 17 years.

The CI for the saveall project mentioned above was prepared by the Environmental Coordinator. The costs and savings included in the cost/savings analysis included:

- replacement value of the recovered fiber
- savings from reduced polymer usage in primary treatment
- reduction in sludge transportation costs.

Though the Coordinator mentioned that the project will save costs associated with energy use and labor at the treatment plant (they could potentially shut down the belt press for a day and put the treatment plant operator to work elsewhere), these costs were not included in the financial justification. Typical project analysis considers waste hauling and disposal costs, but not wastewater treatment costs. Potential impacts on revenue are handled qualitatively.

The Technical Manager has been working with the Comptroller to disaggregate environmental expenses within the internal cost accounting system used by the Division, into sub-categories--labor, operations, maintenance, engineering, fees/fines/penalties. While the Manager's initial efforts are focused on wastewater treatment and sludge disposal costs, he will likely include compliance costs. Though this is currently done for budgeting purposes, the Manager hopes that this accounting framework will help him do a better job of financial justification for environmental projects

The Technical Manager acknowledged that he often has difficulty gaining approval for environmental projects because these projects have to compete with other non-environmental uses of capital that management views as priority, profit-expanding or market expanding investments. He looks for project opportunities that will result in direct and measurable financial benefits, such as reduced waste disposal costs. This was the case for a project designed to collect sludge from one of their primary treatment plants for transport to a boxboard mill that will use the waste as a raw material. If possible, the Director will link environmental projects with non-environmental, strategic projects, as coupling secondary treatment with the recycled fiber use strategy, thereby making the environmental project more competitive than it would otherwise be.

Perspectives on TCA

The Technical Director and Environmental Coordinator were interested in estimating potential future liability. However, their primary interest in applying such a methodology is to evaluate "remediation" options (e.g. PCB-contaminated transformer and asbestos removal options) and waste disposal alternatives (e.g. for wastewater treatment sludge), not to quantify the avoided liability cost associated with a pollution prevention investment. By breaking out a category of costs in their cost accounting system --"fees, fines, and penalties"--the firm is beginning to bring these costs to the attention of management.

APPENDIX A-4

INTEGRATED BLEACHED KRAFT MILL

Company Background

This mill is a subsidiary of a large U.S. pulp and paper corporation. The facility operates as an integrated bleached kraft mill comprising kraft pulping, pulping chemical recovery, bleaching, drying of market pulp and papermaking. Average daily production is approximately 600 tons.

Environmental Management

Environmental management is handled by an Environmental Manager with overall responsibility for environmental compliance. The Manager also develops investment recommendations in conjunction with a management team comprising the mill manager and the managers of all operating units at the facility. Environmental initiatives are evaluated according to regulatory requirements, environmental benefits, and compatibility with other non-environmental objectives for the mill. Emphasis is placed, first, on projects aimed at compliance with applicable state and federal standards and, second, on discretionary (i.e. non-compliance-driven) environmental projects that are considered to be in the best interest of the mill. If a proposed, discretionary environmental project will result in reduced operating costs, it is re-classified as a "profit-adding project with an environmental benefit". In other words, its identity as an environmental project is downplayed in favor of a designation that enhances the project's prospects within the capital budgeting process.

Approximately one-third of all capital expenditures at the mill are allocated to environmental projects, a figure that is expected to rise to 50% by 1995. Overall environmental investments at the mill in 1990 were in the range of 3-4 times the projected before tax profits for that period, a reflection of the heavy demands on capital budgets stemming from environmental compliance.

The mill attempts to anticipate and remain ahead of state standards that often exceed those promulgated by EPA. This posture is evident in recent capital expenditures aimed at reducing dioxin emissions prior to either a state or federal regulatory mandate. Other recent investments include a combination of cost-reducing measures plus "good-will" projects (e.g. odor control, boiler upgrades, dust control) to enhance relations with its residential community.

Capital Budgeting and Project Analysis

The firm operates within the overall framework of the parent corporation's capital budgeting process. A management committee at the facility assembles capital projects from the various units at the plant.

As environmental projects are developed, those that are compliance-driven (profit-sustaining) and defined by a single technological option are subject to minimal financial analysis. These are viewed as "must-do" and likely to rely on proven, least-cost solutions. At the other extreme, projects of greater technological complexity that are profit-adding (through reduced costs or market expansion) are typically analyzed over a 3-5 year time horizon using standard financial indicators typical of large firms.

Financial analyses include conventional operating and capital costs. Where liability can be reasonably estimated using actuarial data to estimate risks from comparable projects, such estimates may form part of the project financial analysis. In instances where such data is non-existent or unacceptably soft, estimates do not appear as part of the quantitative assessment but, instead, are subject to qualitative assessment in the request for funding.

Once investments are assembled and ranked, the package is submitted for review to a division of the parent corporation. Those projects that are necessary to achieve compliance receive priority, with the remaining projects reconciled with the parent corporation's overall capital investment plan. The more discretionary the investment, the more comprehensive the financial analysis must be to secure funding. In all cases, requests that exceed a prescribed threshold must be approved by the Corporation's Board of Directors.

Perspectives on TCA

Utilization of TCA raises some serious concerns for this firm due to the inclusion of less tangible benefits that in large measure distinguish TCA from conventional analysis. Liability avoidance benefits are quantitatively included in project financial analyses only where reliable estimates are possible, a situation present in only a small fraction of all projects submitted for capital funding. However, liability is addressed qualitatively in the narrative section of most written project justifications. Other intangible benefits such as corporate or product image are viewed as non-quantifiable. Environmental investments made in anticipation of new regulations or made on the basis of "good-will" have, in certain cases, brought on public criticism of the mill by highlighting the prior existence of a problem or remaining pollution. In this firm's view, the better role for TCA is its use in refining financial analysis of compliance investments where more than one technology option is available.

APPENDIX B

DETAILED DESCRIPTIONS OF THREE TCA METHODS

APPENDIX B-I

FINANCIAL ANALYSIS OF WASTE MANAGEMENT ALTERNATIVES (GE METHOD)

Prepared for:	General Electric, Corporate Environmental Programs Richard W. MacLean, Manager
Prepared by:	General Electric, and ICF Technology
Publication date:	1987

The purpose of the GE method is "...to aid plant professionals in selecting and justifying waste management investment decisions which are both environmentally sound and reduce GE's long-term liabilities." It was developed as a tool to help the user identify possible options for waste minimization and focus on the most profitable projects.[1]
The method is designed to be used at the plant level by process and environmental engineers working with financial professionals. **Direct** and **potential liability costs** associated with current and alternative waste management practices are identified, quantified and compared to evaluate the economic viability of waste minimization investments.

The method divides waste management costs into two categories:

1. **Direct costs** - operation, maintenance and capital, including the out-of-pocket cash costs routinely associated with waste management and disposal. These costs include:
   - Waste-end taxes
   - Investment in waste management equipment
   - Engineering
   - Waste collection and transportation services
   - On-site raw material and labor costs sampling, monitoring, and record-keeping
   - Production costs affected by waste management decisions (e.g. raw material consumption, energy or productivity penalties)
   - Insurance

2. **Future liabilities** - include potential environmental liabilities for remedial action costs, as well as related costs for personal injury and property damage. These costs include:

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[1]The Manual provides the following definition of waste minimization "Waste Minimization generally applies in a regulatory context to include reduction or elimination, of the amount of waste requiring ultimate disposal, through treatment steps, recycling steps, and/or waste source reduction". Waste source reduction is further defined as "any method which will reduce or eliminate the amount of hazardous waste before it is generated within the process". While the focus of the Manual is on waste minimization, it can be helpful in evaluating other pollution prevention investments.

- Cost recovery actions, administrative orders, or negotiated settlements under CERCLA
- Corrective action costs under RCRA at company-owned (on-site) treatment, storage, or disposal facilities
- Site remediation costs at third-party (off-site) treatment, storage, or disposal facilities for which the waste generator becomes liable under CERCLA
- Liabilities arising out of third-party lawsuits seeking compensation for bodily injury and/or property damage
- Liabilities arising out of claims seeking compensation for natural resource damages

This system can be used to analyze an entire plant or a single process. The manual recommends an assessment of an entire plant to encourage the consideration of a wide array of waste management alternatives that might otherwise be overlooked.

The following is a brief, step-by-step description of the method:

Step 1: Describe current waste generation and management practices, and alternative projects designed to minimize waste

In this step, the user must develop a waste flow diagram that describes the relevant waste generation and management activities in a format which allows subsequent cost analysis. The workbook employs a flow diagram format which uses different shapes to represent wastes and waste management techniques for the current and alternative process.

The user is instructed to diagram and describe:

a) **Waste generation activities** (in the plant or in one area of the plant) including volume, rate of generation, physical form of waste, and RCRA regulatory status.

b) **Subsequent on-site waste management steps.** Detailed checklists are provided to help the user identify all relevant wastes and management steps.

c) **Any alternative projects which might reduce waste generation or reduce the volume and toxicity of wastes handled.** The manual includes a checklist of suggestions for quantity and toxicity reduction, and a table of treatment technologies for specific types of industrial wastes to help the user identify alternative waste management practices.

Step 2: Describe current and alternative waste management practices involved in final disposition of the waste streams identified in Step 1

In this step the user characterizes final disposition of wastes under current and alternative scenarios, using the flow diagram format described in Step 1.

The user is instructed to diagram and characterize:

a) **Current waste management practices involved in final waste disposition.** A checklist of common on-site disposal or discharge, and off-site transportation, treatment, storage and disposal activities is provided to assist the user.

b) **Alternative waste management practices involved in final waste disposition.** The manual provides a checklist containing examples of the kinds of information that must be gathered to evaluate a waste management facility and a discussion of risks associated with the most commonly used facilities used for final disposal.

Step 3: Identify and analyze costs associated with current and alternative waste generation and management practices

a) **Identify capital, operating, future liability costs associated with each current and alternative waste management activity addressed in Steps 1 and 2.** Some guidance is provided to help identify relevant costs.

Since only the changes in cash flow for the alternative practice relative to the current practice are of concern, it is not necessary to include the costs of activities that remain the same under the alternative practice.

b) **Estimate potential total future liabilities, and time when they are likely to be incurred.**

The method presents a procedure for estimating the magnitude and timing of future liability costs associated with the current and alternative waste management practices. The method is based on the premise that environmental and technological factors affect the size and frequency of future liability claims, while the characteristics of the waste affect their likely onset.

The user first develops a score for the TSDF based on the technology that it employs, and on the location of the facility (i.e. surrounding population density, proximity to water supply, etc.). This score is then used to adjust--up or down--a per ton cost estimate for corrective actions and claims developed for a base-case, generic hazardous waste landfill. The base case cost estimate was developed in a study comparing the long term liabilities associated with landfilling or incinerating wastes, conducted for the Department of Defense in 1984.[2] The estimate, expressed as total cost and $/ton of waste landfilled, includes costs of surface sealing, fluid removal and treatment, personal injury, real property claims, economic losses, and natural resource damage claims.

The modification of the estimate is based on a score developed for the disposal facility, which consists of: a) a combined rating of three environmental and technological parameters: population, proximity to water supply and record of

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[2]ICF Technology, "A Comparison of the True Costs of Landfill Disposal and Incineration of DOD Hazardous Wastes," Prepared for Environmental Policy Directorate, Office of Secretary of Defense, Defense Environmental Leadership Project Office, Washington, D.C., September 21, 1984.

leaks, and b) a relative weighting factor based on GE risk assessments (no description of the weighing protocol is provided).

The workbook contains a procedure which helps the user to estimate the year in which a liability claim may occur. The determination is based on the toxicity and mobility of the hazardous waste constituents.

Note: This method assumes that there are no liability costs for on-site waste reduction and/or minimization processes described in Step 1. If the user thinks that this assumption is inappropriate, s/he can use this framework to factor in these liability costs.

c) **Enter cost estimates and other input parameters (inflation rate, discount rate, etc.) into financial analysis worksheets**

The cost calculations can be done either with or without software. The Financial Calculation Software which accompanies the manual, was developed with Lotus 1-2-3 version 2.01 and can be run on an IBM-PC, XT, AT or compatible microcomputer. The software limits the number of waste management activities to nine, so the user must aggregate several activities into one if more than nine activities are to be analyzed.
For each activity, the user enters estimates of capital costs, operating expenses, and future liabilities expected for each year up until the year that capital costs are recovered.

d) **Calculate streams of after-tax incremental annual cash flows**

Based on cost estimates and input parameter values, the software will calculate the streams of after-tax incremental annual cash flows. The manual contains a step-by-step procedure for calculating cash flows for users who do not use the software.

e) **Calculate key financial indices -- net present value (NPV), break-even point, return on investment (ROI), discounted cash flow rate of return (DCRR)**

The workbook provides step-by-step instructions for entering cost data into the software spreadsheets or worksheets provided in the workbook (Step 3). The software automatically calculates streams of after-tax incremental cash flow, the net present value (NPV) for the current and alternative practice; and the following financial parameters: a) break-even point, b) return on investment (ROI), and c) discounted cash flow rate of return. Recommendations are given to assist in the identification and ranking of alternative practices which may be preferable to the current practice.

f) **Using the financial indices to identify "good" projects**

The financial indices can be used to identify and rank alternative waste generation and management practices which may be preferable to the current practice. The manual states that GE Corporate Financial Management recommends NPV as the key financial index with which to compare alternative practices. A rule-of-thumb is given for each financial index to guide the user's investment decision. For example, the rule given for ROI is: "Accept an alternative waste generation and management practice if the ROI based on incremental cash flows is greater than the cost of money (or discount rate)."

APPENDIX B-II

POLLUTION PREVENTION BENEFITS MANUAL (EPA METHOD)

Prepared for:	Office of Solid Waste and Office of Policy, Planning and Evaluation U.S. Environmental Protection Agency Dr. Ron McHugh, Project Manager
Prepared by:	ICF Incorporated
Publication date:	October 1989 (available to the public, but not officially released in final form)

The stated purpose of the EPA method "...is to promote a complete objective analysis of the economic benefits of PP projects." The manual further states "This manual enables you to calculate the true cost of the current materials and waste management practice and then evaluate the financial payback of the PP alternative."

The method sets up a hierarchy of costs as follows:

Tier 0 - Usual Costs:	i.e. equipment, labor, and materials
Tier 1 - Hidden Costs:	i.e. compliance, and permits
Tier 2 - Liability Costs:	i.e. penalties/fines and future liabilities
Tier 3 - Less Tangible Costs:	i.e. consumer responses and employee relations

They are arranged in order of increasing uncertainty, and uncertainty of estimation. At each tier, the user calculates all costs associated with the current and alternative PP project and then estimates key financial indicators of the economic viability of the PP project based on the costs associated with the tier.

The results of the financial calculations for each tier are added a tier at a time, until either the result concludes that the PP alternative is economically feasible, or all tiers have been completed. For example, if the results of the Tier 0 financial calculation indicates that the alternative strategy is economically feasible, the user can end the analysis. If, however, the result does not show economic feasibility, then the user proceeds to calculate and add the Tier 1 results to the Tier 0 results and so on.

The method assists the user in calculating three key financial indicators: annualized savings, internal rate of return, and net present value. The manual does not come with software, however it does contain worksheets which assist in organizing and presenting results from the cost calculations.

A brief discussion of the methodology used to calculate each Tier follows:

TIER 0 COST PROTOCOL: USUAL COSTS

Assessing current facility operations, developing options, and estimating direct expenses of the options are the activities included in the Tier 0 protocol.

The EPA method does not provide a detailed framework for the calculation of usual costs. Rather, it contains a discussion of the recommended steps and describes the cost elements that should be considered in this tier. The user is referred to other information sources, such as the EPA Waste Minimization Opportunity Assessment Manual[3], engineering handbooks and manuals, trade associations, and professional auditing firms for information on pollution prevention alternatives, equipment and operating costs.

The recommended steps for calculating usual costs are:

Step 1: Identify pollution prevention alternatives

The manual suggests the following four steps for identifying pollution prevention alternatives:

1) Create a team of in-house and outside experts who can provide experience and expertise on current and alternative practices;
2) Collect facility operations data to identify the types and quantities of wastes and pollutants generated;
3) Develop pollution prevention alternatives; and
4) Determine the technical feasibility of the alternatives.

Step 2: Estimate the usual costs of current and alternative practices

Usual costs are broken down into two categories: **depreciable capital expenditures** that must be depreciated for tax purposes, and other **expenses** that can be deducted from taxes in a single year. Depreciable capital expenditures include equipment, materials, engineering and procurement; and expenses include start-up, permitting, raw materials, and labor costs.

Step 3: Complete the Tier 0 cost worksheet

The last step, is the completion of the worksheet for the Tier 0 costs. For this and other tiers, the cost calculations may be performed a) one time for the alternative relative to current practice (i.e. an incremental calculation), or b) two times -- once for the current practice and once for the alternative practice. If the second approach is chosen, the user will be instructed to subtract the annualized cash flows for the current process from the cash flows for the alternative process in the financial protocol section of the workbook. The escalation rate (or inflation rate), first year of cash flow, lifetime of expenditure/revenue from the process, and cash flow estimate (from Step 2) must be supplied by the user. The worksheet provides a place for entering changes in operating revenues, such as changes in the production rate, or production of marketable by-products which may result from the adoption of the alternative practice.

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[3]U.S. EPA, Hazardous Waste Engineering Research Laboratory, "Waste Minimization Opportunity Assessment Manual (EPA/625/7-88/003)," Prepared by Jacobs Engineering Group, July 1988.

The manual instructs the user to proceed to the financial protocol, after the second column of the Tier 0 worksheet has been completed. The financial protocol provides guidance for calculating annualized cash flow and financial indicators for the investment. The financial protocol will be described later in this appendix.

TIER 1 COSTS PROTOCOL: HIDDEN COSTS

The Tier 1 Cost Protocol assists the user in estimating hidden regulatory costs for monitoring, paperwork, and permitting activities associated with the current and alternative practices. The following steps are presented for estimating these costs:

Step 1: Establish your facility's regulatory status

The manual contains a *Regulatory Status Questionnaire* and a summary of relevant regulatory programs to help the user determine the regulatory status of the facility for the purpose of this analysis.

Step 2: Estimate hidden capital expenditures

The manual provides guidelines for identifying technology-forcing regulatory requirements which may require a capital expenditure in the near future. The user is instructed to estimate the capital outlay necessary to satisfy these requirements, and report them in the worksheets. The manual suggests that the user consult the regulations (or the summary provided), specialized literature, or experts in the field to obtain information needed to quantify these future costs.

Step 3: Estimate hidden expenses

In this step, the user is directed to estimate costs associated with regulatory compliance activities. The procedure is outlined below:

1. *Identify applicable regulatory requirements.* The manual contains a series of tables designed to assist the user in identifying the specific compliance activities required under each regulatory program applicable to the facility. These compliance activities include: notification, reporting, monitoring/testing, and recordkeeping.

2. *Estimate the cost of each applicable regulatory requirement.* To calculate costs associated with each compliance activity, the user can estimate these costs by one of three methods:

   a) use actual, total annual costs for your facility;

   b) use cost equations provided in the manual, with parameter values specific to the facility; and

   c) use the cost equations with the default values (adjusted if necessary) provided in the manual.

3. *Sum all costs*

Cost estimates from item 2 are entered into the Tier 1 worksheet and summed.

Note: Steps 2 and 3 focus on a the compliance costs for a facility, rather than a practice or process. The protocol does not address attaching these costs to a specific process. Therefore, if the user is assessing a process within the facility, s/he will have to use judgement in determining which costs are specifically related to the process being evaluated.

Step 4: Complete the Tier 1 cost worksheet

Similar to the Tier 0 worksheet, Worksheet 1, Tier 1-*Hidden Costs* segregates compliance costs that are depreciable capital expenditures from those that are considered expenses.

The user is again instructed to proceed to the financial protocol to calculate financial indicators of Tier 0 through 1 costs.

TIER 2 COST PROTOCOL: LIABILITY COSTS

This section discusses the method proposed to estimate two types of potential liability costs: penalties and fines associated with regulatory non-compliance, and other liabilities associated with waste management and disposal practices.

Penalties and Fines

The procedure used to first identify, then estimate the expected costs is outlined below:

Step 1: Identify regulatory programs under which penalties and/or fines could be incurred

The method contains an exhibit titled, Summary of Penalties and Fines Under EPA Federal Programs (Fiscal Year 1987), which shows a) the major EPA programs and requirements which prescribe penalties and fines, and b) the range of penalties and fines which can be assessed under the program. The user is instructed to check off the regulatory programs involving possible penalties or fines for non-compliance. Since this list contains only federal programs, supplemental information regarding state and local programs must be furnished by the user.

Step 2: Estimate the expected annual penalties and fines associated with each program/requirement

The user is instructed to select a dollar value of the penalty or fine, for each program or requirement, from the exhibit described in Step 1 above. This value is then multiplied by a probability number, from 0 to 1, assigned by the user based on the likelihood of occurrence. The results of these calculations are summed to calculate the total potential liability from penalties and/or fines.

Step 3: Identify waste management components to which liabilities can be attached

In this step, future liabilities associated with current and alternative waste management practices are identified. The manual recommends focusing on activities involving: treatment or storage of waste in tanks, waste transportation, and land disposal of waste (on-site, or off-site). No other guidelines are provided in this step.

Step 4: Estimate total expected liabilities

Liability costs are disaggregated into seven categories:

- Soil and waste removal and treatment
- Ground-water removal and treatment
- Surface sealing
- Personal injury
- Economic loss
- Real property damage, and
- Natural resource damage.

Two methods are suggested for estimating total expected liabilities, as follows:

1. Estimate the magnitude of liabilities by comparing the current and alternative practices to other known, similar activities where actual claims, awards, or settlements have occurred and have been documented.

2. Use the conceptual framework contained in the manual for estimating these costs. This framework consists of seven cost equations and management-specific parameters which are used to estimate the seven types of future liability listed above. For example, a cost equation is provided for **Soil and Waste Removal and Treatment** for a hazardous waste storage tank, as follows:

   FL1 = 8.92 x a x b x Q, where:

   FL1 = cost ($000) of soil and waste removal and treatment
   a = correction factor
   2 if underground, 1 if above ground
   b = fraction of the total annual quantity expected to be released
   Q = total quantity of waste managed (kgal/yr).

   Suggested values are given for tanks, transportation, and disposal (landfill) so that costs associated with soil and waste removal and treatment for each waste management activity can be calculated separately.

   The manual does not explain the methodologies used to develop the cost equations or the recommended variable values.

Step 5: Estimate year when liabilities are expected to be incurred

Since penalties and fines are calculated on an expected annual basis, these liability costs are calculated annually starting from the first year (year 1), through the end of the PP project.

For future liabilities, the method includes an equation and recommended parameters for tanks, transportation and disposal, that is used to estimate the expected year that these costs will be incurred.

Step 6: Estimate your share of total future liabilities

Generally, the future liability costs calculated in Step 4 are *total costs* of, for example, sealing the surface of a landfill which receives waste from a number of different companies. Since one firm may not be liable for all these costs, the user must calculate a fraction which represents a share of the liability. This fraction, called alpha, is approximated in the manual as:

$$\text{alpha} = Q / Q_t$$

where: Q = waste quantity contributed by the current or alternative practice, and

Q_t = total quantity of waste managed.

Alpha is calculated for each management activity - treatment of storage tanks, transportation, and disposal in landfills, as needed. Finally, the user must sum up the seven types of liability cost for each waste management practice and then multiply them by their corresponding alpha value.

The user is instructed to proceed to the financial protocol to calculate the financial indicators for Tier 0 through 2 costs.

TIER 3 COST PROTOCOL: LESS TANGIBLE COSTS

This tier is designed to help the user identify certain less obvious financial benefits that may be realized through the implementation of pollution prevention.

Step 1: Qualify less tangible benefits of pollution prevention

The user is asked to describe the benefits of pollution prevention from, for example, increased sales through publicity of pollution prevention efforts; and improvements in employee/union relations, reduced health benefits costs and fewer accident related injuries from reductions or elimination of waste managed in the workplace.

Step 2: Quantify less tangible benefits of pollution prevention

No guidance is given for the quantification of less tangible benefits. If these costs can be estimated, they are factored into the analysis through an adjustment of the estimates calculated in previous tiers. If, for example, the pollution prevention alternative will result in a two percent increase in sales, the cash flow estimate for operating revenues is adjusted by an amount corresponding to the increase.

After completing this tier, the user proceeds to the financial protocol to calculate financial indices of Tier 0 through 3 costs. We now turn to a discussion of the financial protocol.

FINANCIAL PROTOCOL

The method contains a financial protocol that is used to evaluate the economic viability of the pollution prevention alternative. The user is instructed to conduct the financial analysis, as outlined in the Protocol, after completion of the cost calculations in each tier has been completed. Financial indicators are calculated for an individual tier, **and** through the tier just completed (i.e. calculated for Tiers 0, 1, 2, and 3; **and** Tiers 0 through 1 after Tier 1 has been completed, 0 through 2 after Tier 2 has been completed, and so on).

The protocol provides equations and instructions for the calculation of three financial indicators:

- total annualized savings (TAS)
- net present value (NPV)
- internal rate of return (IRR)

APPENDIX B-III

PRECOSIS[4]

Prepared by: George Beetle Company
George R. Beetle

Publication date: August 1990

PRECOSIS, consists of a set of programs and a user's manual which is designed to "support analysis of financial advantage in waste reduction schemes:. The software was designed to support participants at a series of U.S. Environmental Protection Agency-sponsored seminars on waste minimization in 1989. The method has since been enhanced and placed in general distribution under license by the George Beetle Company. The software is a menu-driven program consisting of ten data input tables and two output reports containing financial calculations. The programs can be used on any IBM-compatible microcomputer having 512 kilobytes or more of base memory. The software is programmed in BASIC.

Economic data is grouped into three categories, as follows:

1. **Resource effects**
   - labor costs
   - material costs
   - facility costs

2. **Revenue or value effects**
   - changes in output quantity
   - changes in quality of output
   - secondary products/services

3. **Waste management effects**
   - storage, handling, hauling, disposal
   - monitoring and reporting
   - insurance - workers
   - insurance - third party
   - litigation

Economic costs and gains associated with the alternative waste minimization process are calculated as incremental costs or values from the base case.

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[4]Originally prepared for the U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, Ohio.

PRECOSIS uses the technique of initiating new files from a template file which contains sample data. The system is designed this way to familiarize the user with the types of values that are needed for a particular table.

The financial assessment of alternative waste reduction strategies is conducted in four basic steps, as follows:

Step 1: Enter Data Describing Baseline Plant or Process

The user's first task is to enter descriptive, qualitative information about the project. This information is used to identify and manage the project file.

Both narrative and quantitative information regarding the existing process, is entered into the "Process Characteristics Data" table. The numerical data entered in this table, such as *processing detention minutes, and feedstock user per output unit* are used to characterize the current process. Labor, material and facility costs of the current and alternative manufacturing processes are entered in unit cost rather than total cost form. For example, an hourly wage is entered for each class of labor employed either in the current process or for the proposed alternative. Again the file template contains data which the user can use directly or modify.

To calculate costs associated with the current process, the user must enter the number of units of each category of labor, materials and facilities in concert with the unit cost entries. The system calculates the real costs of the current process by multiplying the unit cost of each resource by the corresponding number of units of that resource used.

Unlike the GE method and EPA method, PRECOSIS explicitly includes revenue from sale of product and secondary products (e.g. recovered metals) in the analysis.

Step 2: Enter Effects Data for the Alternative Strategy

To calculate costs associated with the alternative process, the user must enter an expected increase or decrease in the number of units of real resources that will result from the process change. For example, if one fork-lift truck operator is used for the current system, and two will be needed for the alternative system, then the expected increase in the units of fork-lift truck operators is one. Revenue and waste management costs for the current system, and expected changes in revenue, product value, and waste management costs for the alternative process are calculated in a similar manner.

Step 3: Run Financial Calculations

The system generates two financial calculation output reports. The first called "Consolidated Financial Evaluation Results", reports the following information for the current process, and for the incremental affect of process change considered:

- Annual production
- Revenue/value effects
- Indirect recurring costs
- Waste management costs
- Total annual recurring costs
- Net operating value (costs)

- Investment annual equivalent costs
- Total fixed & variable annual costs
- Net value (cost) after fixed charges
- Net value per output unit after fixed charges.

Taxes and depreciation are not included in the analysis and must be separately calculated by the user.

The second report, titled "Comparative Economic Evaluation Results" reports the results of additional constant and current dollar calculations for the base case, and for up to five alternative projects (for comparison among alternatives), including:

Constant Dollar Evaluation:

- Estimated payback years (at the user-entered interest rate)
- Internal return on investment

Current Dollar Evaluation:

- 5-year average net operating value
- 10-year average net operating value
- Dollar difference relative to worst alternative
- Estimated payback years
- Restated internal return on investment

Step 4: Repeat Steps 2 and 3 for Additional Alternative Strategies

The user can repeat Steps 2 and 3 to compare financial differences among alternative waste minimization strategies. Up to five alternatives can be compared.

APPENDIX C

BIBLIOGRAPHY

TOTAL COST ASSESSMENT FOR POLLUTION PREVENTION

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APPENDIX D

SURVEY QUESTIONAIRE

TELLUS INSTITUTE
for Resource and Environmental Strategies

TOTAL COST ASSESSMENT SURVEY

Contacts: Monica Becker
Allen White

Part I - Company Profile: General and Environmental

Please fill out Part I of the survey and return it to us prior to our visit. Use extra sheets and attachments as needed. Part II comprises open-ended questions we would like to cover during our interview. You need not answer these in writing, but we suggest you review them prior to our visit.

The first set of questions cover general management, product lines and processes

1. a. Name and address of company:

   ____
   ____
   ____

   b. Name(s), title(s), and telephone number(s) of respondent(s):

   ____
   ____
   ____

2. SIC code(s) ____________

3. Briefly describe the major products which are manufactured at your mill. Please list in order of significance (based on 1990 sales).

   Product

   ____
   ____
   ____
   ____

4. Size of mill

   a. number of employees ______
   b. sales ($/year) __________

89 Broad Street, Boston, MA 02110-3542 • Tel: 617-426-5844 • Fax: (617) 426-7692

5. History of mill

   a. When was mill opened? __________

   b. What major changes in product lines and/or processes have occurred in the last 10 years.

   ____
   ____
   ____
   ____
   ____

6. Management structure

   a. List the individuals in the mill/corporate office normally involved in decisions on environmental matters?

Name	Title	Responsibility

   b. Briefly describe the management structure of the mill/corporate office as it relates to environmental management.

   ____
   ____
   ____

   c. Does the company have an environmental quality mission statement or corporate commitment, a waste or pollution reduction goal, or an incentive structure for environmental initiatives and/or performance? If so, describe

   ____
   ____
   ____

The next set of questions concern your and solid waste, air pollution and water pollution management practices.

7. **Waste generation and management profile**

a. What principal types of waste are generated and how are they disposed?

Waste Type (e.g. wastewater sludge, coating wastes, waste oil)	Annual Volume	On-Site Mgmt./ Disposal (e.g. recycling, incineration)	Off-Site Mgmt./ Disposal (e.g. recovery, landfill)
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

b. On average, during the last five years, approximately how much, and what percentage of the mill's total capital and operations/maintenance budget was spent on waste management and disposal?

	$/year	%
capital	________	____
O&M	________	____

c. How are waste management costs allocated, or charged to specific processes or product lines?

capital costs: ____
____

O&M costs: ____
____

d. Do you anticipate any significant increases or decreases in waste management costs in the next few years? If so describe.

____
____

8. **Air pollution control profile**

a. List principal air pollutants generated at the plant and control measures used for each.

Air Pollutant (e.g. chlorine, SO_2)	Pollution Control Device (e.g. scrubber, ESP)
______________	______________________
______________	______________________
______________	______________________
______________	______________________

b. On average, during the last five years, approximately how much, and what percentage of the mill's total capital and operations/maintenance budget was spent on air pollution control?

	$/year	%
capital	________	___
O&M	________	___

c. How are air pollution control costs allocated, or charged to specific processes or product lines?

capital costs: ______________________________
____

O&M costs: ______________________________
____

d. Do you anticipate any significant increases or decreases in air pollution costs in the next few years? If so describe.

____
____

9. **Water pollution control profile**

a. List principal water pollutants generated at the plant and control measures used for each

Water Pollutant (e.g. BOD, sulfuric acid)	Pollution Control Device (e.g. on-site secondary treatment, discharge to POTW)
______________	______________________
______________	______________________
______________	______________________
______________	______________________
______________	______________________

b. On average, during the last five years, approximately how much, and what percentage of the mill's total capital and operations/maintenance budget is spent on water pollution control?

	$/year	%
capital	________	____
O&M	________	____

c. How are water pollution control costs allocated, or charged to specific processes or product lines?

capital costs: ____________________
____

O&M costs: ____________________
____

d. Do you anticipate any significant increases or decreases in water pollution costs in the next few years? If so describe.

____
____

10. **Waste, air and water pollution reduction initiatives**

a. How, and to what extent, has the mill reduced the generation of waste, air pollution, water effluent? Include material substitutions, process and product modifications, and on-site recycling projects.

Project 1:

Description: ____________________
____

(e.g. installed saveall to recover solids)

Impetus: ____________________
____

Effects on Waste Generation, Air Emissions, and Water Effluent: ____________________
____

(e.g. reduced solids load to treatment plant by 20%)

Approximate Capital Outlay: ____________

Year Completed: ______

Project 2:

Description: ______________________________

Impetus: ______________________________

Effects on Waste Generation, Air Emissions, and Water Effluent:

____

Approximate Capital Outlay: ____________

Year Completed: ______

b. Is your mill currently considering, or have you recently considered materials substitution, process modifications, or on-site recycling aimed at reducing waste generation, air emissions, or water effluent? If so, describe

Project 1:

Description: ______________________________

Impetus: ______________________________

Projected Effects on Waste Generation, Air Emissions, and Water Effluent: ______________________________

Approximate capital outlay: ____________

Status: ______________________________

Project 2:

Description: ____
____

Impetus: ____
____

Projected Effects on Waste Generation, Air Emissions, and Water Effluent: ____
____

Approximate capital outlay: ____________

Status: ____
____

Part II - Financial Analysis of Environmental Projects

The following questions were developed to provide a preview of questions that we will be asking during our visit. It is not necessary for you to answer them now, however, we request that you review them in preparation for our meeting.

1. **Decision-making processes regarding <u>environmental management</u>**

   a. How are pollution control investments and waste management options assessed, selected, and justified?

   b. Does your mill have a standard procedure for conducting financial analysis of these projects? If so, describe.

      i. what types of costs are calculated?

      ii. what financial criteria is/are decisions based upon (e.g. total capital outlay, NPV)?

   c. Are assessments and justification of environmental projects similar or dissimilar to non-environmental projects? If so, describe.

2. **Views and practices regarding waste and pollution reduction (ie. operational, process, material, and product modifications designed to reduce the quantity and/or hazardous nature of waste, air emissions and water effluent)**

   a. How important are waste and pollution reduction projects in your business?

   b. What are the barriers to implementation of these projects?

   c. If waste and pollution reduction projects are commonly considered?

      (1) How and by whom are they generally initiated?

      (2) Is a financial evaluation always conducted prior to implementation?

      (3) Is the financial evaluation critical to the decision to implement the project?

      (4) What types of costs and savings are calculated?

      (5) What financial criteria is/are decisions based upon? (e.g. payback period, return on investment, net present value)

      (6) Are assessments and justification of these projects similar or dissimilar to non-environmental projects? If so, describe.

c. Do pollution prevention projects have to compete with more conventional investments that are expected to yield comparable or superior returns?

d. Are financial or technical risks associated with pollution prevention investments considered higher, lower or the same as risks of other investments, including those for pollution control?

3. **Views on Total Cost Assessment (TCA)**

a. Based on what you have heard/read about TCA (sometimes referred to as "full-cost accounting"), is there a need or value for more comprehensive, systematic financial analysis of waste reduction and pollution prevention projects in your mill?

b. What potential benefits do you see in using TCA in project evaluation?

c. What barriers do you see to the implementation of TCA?

d. How persuasive would a positive result (ie. meets or surpasses the mill's/corporation's investment criterion) from a TCA be in deciding to proceed with a pollution prevention investment?

e. Among the following, which costs components are (1) currently not incorporated in the mill's/corporation's project analysis procedure, and (2) if not, should be?

	Incorporated Yes	No	If no, should be
• waste management costs			
•• storage			
•• treatment			
•• hauling			
•• disposal			
• compliance costs			
•• permitting			
•• reporting, monitoring, and recordkeeping			
•• manifesting			
•• training			
• liability insurance costs			
• future liability costs			
•• penalties and fines			
•• personal injury and property damage			
• effects on raw material and energy inputs			
• revenue (or cash flow) effects from changes in product quality, or the creation of marketable by-products			
• worker health/safety effects			
• corporate and product image effects			
• assessing costs over a longer time horizon (e.g. 10 or 20 years)			
• other			

f. What kinds of changes would have to take place in order to modify the way project financial analysis is conducted at your mill (e.g. change in accounting system, different personnel responsible for project financial analysis)?

How feasible are these changes?

4. Views on existing TCA methods

a. Do these methods appear to be useful to your mill?

b. Are they structured in a manner that is consistent with the way project financial analysis is currently conducted?

c. Would these methods be usable considering the personnel who currently perform project financial analysis?

5. Perspectives on existing and potential government incentives/disincentives regarding generation of waste, air emissions, and water effluent

a. Rank the following proposed or actual incentives in order of how effective each would be in influencing your mill to make waste and pollution reduction investments.

1) grant programs for pollution reduction feasibility studies or equipment;

2) loan programs (e.g. low interest loans) and loan guarantee programs;

3) waste reduction tax incentives (including tax exempt financing for waste reduction investments);

4) accelerated depreciation of capital expenditures for pollution prevention;

5) technical assistance, such as free audits and technical recommendations; and

6) local, state or federal recognition programs for good citizenship

b. Are there other pollution prevention incentives to which your mill/corporation would respond positively?

APPENDIX E

TECHNICAL ADVISORY GROUP

Technical Advisory Group

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APPENDIX F

GLOSSARY OF FINANCIAL TERMS

Annual Cash Flow	For an investment, the sum of cash inflows and outflows for a given year (see cash flow).
Break-Even-Point	The point at which cumulative incremental annual cash flows of an investment aggregate to 0. The Break-Even-Point designates the end of a project's investment Pay Back Period (see Incremental Cash Flows and Pay Back Period).
Capital budget	A statement of the firm's planned investments, generally based upon estimates of future sales, costs, production and research and development (R&D) needs, and availability of capital
Cash flow (from an investment)	The dollars coming to the firm (cash inflow) or paid out by the firm (cash outflow) resulting from a given investment.
Cost Accounting System	The internal procedure used to track and allocate production cost and revenues to a product or process. Defines specific cost/profit centers, overhead vs. allocated costs, degree of cost disaggregation.
Cost Allocation	A process within an internal cost accounting system of assigning costs and revenues to cost and profit centers for purposes of product pricing, cost tracking, and performance evaluation.
Discount Rate	The discount rate is either the interest rate at which money can be invested or borrowed. In profitability analysis, the discount rate is used in Net Present Value (NPV) calculations to express the value of a future expenditure in the present year. The discount rate is expressed as a percentage.
Discounted Cash Flow Rate of Return (DCRR)	See Internal Rate of Return.
Financial Accounting	The process that culminates in the preparation of financial reports relative to the enterprise as a whole for use by parties both internal and external to the enterprise.
Financial Reporting	Required by authoritative pronouncement, regulatory rule or custom, including: corporate annual reports, prospectuses, annual reports filed with government agencies, descriptions of an enterprise's social or environmental impact.
Financial Statements	The principal means through which financial information is communicated to those outside an enterprise. Statements include the **balance sheet, income statement,** and **statement of cash flows.**

Full Cost Accounting

A method of managerial accounting which accounts for both the direct and indirect costs of an item. Full cost accounting uses historical data to assign all costs to a process, product or product line, most often for purposes of pricing.

Hurdle Rate

The internally defined threshold, or minimum acceptable rate of return, required for project approval, e.g. 15% ROI, or 2 year payback

Incremental Cash Flow (of an investment)

The cash flow of an alternative practice (e.g. after a pollution prevention investment has been implemented) relative to the current practice. Incremental cash flow is calculated by taking the difference between the cash flow for the current practice and the alternative practice.

Internal Rate of Return (IRR)

The discount rate at which the net savings (or NPV) on a project are equal to zero. The computed IRR of an investment is compared to a company's desired rate of return.

Managerial Accounting

The process of identification, measurement, accumulation, analysis, preparation, interpretation, and communication of financial information used by management to plan, evaluate, and control all activities within an organization to ensure appropriate use, and accountability for its resources. Capital budgeting is one component of managerial accounting.

Measure of Profitability

An index that helps to answer the question: are the future savings/revenue of a project likely to justify a current expenditure? Synonyms: "decision rule", or "financial index", or "profitability index", or "capital budgeting technique". Includes: NPV, IRR, payback, ROI.

Net Present Value (NPV)

The present value of the future cash flows of an investment less the investment's current cost.

$$NPV = \frac{CF_1}{1+k} + \frac{CF_2}{(1+k)^2} + \ldots\ldots \frac{CF_n}{(1+k)^n} - I$$

where: CF_1 is cash flow in period 1

CF_2 is cash flow in period 2, etc.

I is initial outlay or investment cost

k is cost of capital or discount rate

An investment is profitable if the NPV of the cash flow it generates in the future exceeds its cost, that is if the NPV is positive.

Payback Period

The amount of time required for an investment to generate enough cash flow to just cover the initial capital outlay for that investment.

Payback = Investment/Annual Net Income

Project Financial Analysis

Costing (i.e. calculating the costs and savings) and calculating cash flow and/or profitability measures of a project.

Project Justification Process

A generic term for a series of steps which are necessary to get approval for a project.

Project Justification

A document prepared in the project justification process which comprising a written description of the project, a project financial analysis, and a discussion of benefits and risks which are not quantified in the financial analysis.

Return on Investment (ROI)

A measurement of investment performance, calculated as the ratio of annual net income (minus depreciation) over the initial investment amount.

ROI = Annual Net Income/Investment

Total Cost Assessment (TCA)

A comprehensive financial analysis of the lifecycle costs and savings of a pollution prevention project. A TCA approach includes:

a) internal allocation of environmental costs to product lines or processes through full cost accounting;
b) inclusion in a project financial analysis of direct and indirect costs, short and long term costs; liability costs, and less tangible benefits of an investment;
c) evaluation of project costs and savings over a long time horizon, e.g. 10-15 years;
d) use measures of profitability which capture the long-term profitability of the project, e.g. NPV and IRR.