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Strengthening Corporate Commitment to Pollution Prevention in Illinois: Concepts & Case Studies of Total Cost Assessment

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Strengthening Corporate Commitment to Pollution Prevention in Illinois: Concepts & Case Studies of Total Cost Assessment

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Tellus staff for this project included Edward Reiskin, David Miller, Karen Shapiro, Angela Dierks, Diana Zinkl, Allen White, and Deborah Savage (project manager). The analysis findings and interpretation, as well as any remaining errors, are the sole responsibility of the authors.

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ABSTRACT

Since the late 1980s, both regulatory and market forces have been moving firms to rethink their pollution management practices. Despite these trends, however, the pace of conversion to a more preventive mode of environmental management has been slow, and many seemingly profitable pollution prevention (P2) opportunities remain unexploited.

If many P2 investments in fact are in the best interests of a profit-driven firm, why does such underinvestment in prevention persist? The answer is arguably two-fold: (1) organizational characteristics of the firm; and (2) economic/financial barriers. This report focuses primarily on the latter explanation, i.e., that P2 investments may be unable to compete with other potential uses of limited capital because they are disadvantaged by standard project financial evaluation techniques.

Environmental accounting (EA) is a broad term that is used in three areas: national income accounting, financial accounting and management accounting. In managerial accounting, the focus of this study, EA comprises the identification, compilation, analysis, use, and reporting of environmental cost information, primarily for internal purposes, i.e., for use within the company. It is in the last context that EA has enormous potential to help business strengthen its pollution prevention practices and, in turn, its long-term competitiveness. One EA method, Total Cost Assessment (TCA), is an approach to removing potentially unwarranted and misleading financial barriers to environmental investment.

For this project eight firms in the Illinois printing and chemicals industries were selected for collaboration on Phase I case studies. These firms of widely varying size were chosen to represent a cross-section whose current capital budgeting and project evaluation practices capture the spectrum of those found in Illinois. The collaborating firms' views and practices were evaluated using the responses to written questionnaires on a variety of topics and the results of on-site interviews and follow-up conversations. While the sample, of course, is not statistically significant, the field data revealed different company views and practices concerning:

- explicit commitment to environmental policy and objectives
- environmental management approach
- types of environmental projects and investments considered and implemented
- financial analysis procedures
- receptivity to TCA
- the types and relative importance of internal and external barriers and incentives to adoption of TCA approaches.

From the larger sample of firms, a subset of three firms was selected for a further in-depth case study based on a pending or recently completed environmental project. For two of these Phase II case study projects, we assembled cost to perform two different financial analyses for each project, one using the company's standard financial analysis methods and one using a Total Cost Assessment (TCA) approach. The goal was to compare the data collection and analysis process as well as the final results for the TCA approach vs. the conventional approach. Data were analyzed using Tellus Institute's P2/FINANCE software system.

The third case study focused on using EA and TCA cost inventory and allocation principles for the assessment of the case study firm's current methodology for calculating a "cost of waste" for it's various product lines. In coordination with an ongoing facility effort to perform a comprehensive, P2-focused technical and cost evaluation of a particular product line, we performed a constructive critique of the existing allocation methods by estimating several representative costs with a different approach, for comparison to the firm's original estimates.

As the Phase I and Phase II case studies were performed, a parallel task took place: the assessment of internal and external barriers and incentives to adoption of TCA methods in industry. The case study results, a review of existing literature and previous related research all contributed to this evaluation.

1. INTRODUCTION

1.1 Background

Since the late 1980s, both regulatory and market forces have been moving firms to rethink their pollution management practices. U.S. EPA and many state environmental agencies have attempted to move away from traditional command and control end-of-pipe regulation and focus on encouraging upstream pollution prevention (P2). Regulatory pressures in the form of pollution disclosure requirements, bans on land disposal of many hazardous wastes, escalating waste disposal costs, bans or limitations on the use of certain hazardous materials, and other federal and state mandates act as strong inducements to prevent rather than control pollution. Reinforcing these pressures are market incentives, some created by government – e.g., tradable permits and taxes on hazardous waste – and others by public and consumer demand for clean technologies and "green" products. When these factors are taken together, the prevention path should look increasingly attractive to companies from the standpoint of both compliance and market competitiveness.

Despite these trends, however, the pace of conversion to a more preventive mode of environmental management is viewed as slow, and many seemingly profitable pollution prevention opportunities likely remain unexploited. If such investments in fact are in the best interests of a profit-driven firm, why does such underinvestment in prevention persist? The answer is arguably two-fold: (1) organizational characteristics of the firm; and (2) economic/financial. Relevant organizational characteristics of the firm may include weak signals from top management; failure to assign environmental managers adequate authority over capital investments; and insufficient information flow to product design and operations staff to build a broad constituency for prevention projects. An economic/financial explanation may be the inability of pollution prevention investments to compete with other potential uses of limited capital because they are disadvantaged by standard project financial evaluation techniques.

The objective of this project is to investigate and clarify the approach of a sample of Illinois firms to the calculation of the potential profitability of pollution prevention and other environmental investments. Continuing a line of study we began in the early 1990s, we seek to demonstrate how better environmental accounting may help Illinois firms to achieve competitive advantage through the capital budgeting process.

1.2 Environmental Accounting (EA) and Total Cost Assessment (TCA)

Environmental accounting (EA) is a broad term that is used in three areas: national income accounting, financial accounting and management accounting. In terms of national income accounting, EA refers to the consumption, quality, and valuation of a nation's natural resources. In financial accounting, EA refers to legally mandated estimation and public reporting by a company of environmental liabilities and financially material environmental costs for external audiences using Generally Accepted Accounting Principles (GAAP) and Securities and Exchange Commission (SEC) guidelines. In managerial accounting, the focus of this study, EA comprises the identification, compilation, analysis, use, and reporting of environmental cost information, primarily for internal purposes, i.e., for use within the company. It is in the last context that EA has enormous potential to help business strengthen its pollution prevention practices and, in turn, its long-term competitiveness.

Environmental costs and performance deserve management attention for several reasons (U.S. EPA, 1995). Often, environmental costs are obscured in overhead accounts or otherwise overlooked. Identification and proper allocation of these costs enhances a firm's understanding of the environmental costs it faces and clarifies the opportunities to significantly reduce or eliminate them through operational changes, investment in 'greener' process technology, and redesign of processes or products. Alternatively, many companies have found ways to turn environmental costs into revenue by selling waste by-products, remaking by-products into marketable goods, selling transferable pollution allowances that are no longer needed in the wake of process changes, or licensing clean technologies to other businesses.

By including more environmental costs in business decision-making, EA also allows more accurate product costing and pricing. EA may reveal that product lines are systematically under- or over-priced. That is, when all costs associated with environmental regulation and liability are added into the total cost of manufacturing a product, the product is sometimes more or less profitable at its current price than the company believes.

EA also aids in the design of environmentally preferable processes, products, and services that engender a competitive advantage with consumers. In addition, accounting for environmental costs and performance supports the development of an overall environmental management system that, in turn, provides a basis for future cost management innovations and benchmarking. In general, better management of environmental costs and performance leads to better corporate performance simply because "what gets measured, gets managed."

Unlike financial accounting, which is standardized for external reporting, there is little uniformity among managerial accounting practices. This inconsistency hampers the incorporation of environmental considerations into managerial accounting activities, since there are no pre-existing guidelines or organization to encourage and enforce the adoption of EA. To compensate for the lack of consistent legal or professional standards, a number of different methods have been developed to assist businesses in the evaluation of environmental impacts and incorporation of environmental factors into business decisions. One such method, Total Cost Assessment (TCA), is an approach to removing potentially misleading financial barriers to environmental investment. TCA differs from conventional practices in four key ways:

- TCA expands inventory of costs, savings, and revenues to include indirect, less tangible items typically omitted from project analyses.
- It encourages the accurate allocation of costs and savings to specific process and product lines rather than combining them as overhead costs.
- It extends the time horizon of the analysis to account for longer-term costs and savings typical of environmental investments.
- It uses profitability indicators capable of incorporating longer-term costs and savings and the time value of money.

1.3 Study Methodology

This project continues a sequence of studies begun in the early 1990s for the U.S. EPA and the New Jersey Department of Environmental Protection. These two studies provided theoretical foundations of TCA and developed a number of case studies of capital budgeting.

For this project, Tellus selected eight firms in the Illinois printing and chemicals industries for collaboration on Phase I case studies. These firms of widely varying size represent a cross-section whose current capital budgeting and project evaluation practices represent the spectrum of those found in Illinois. Contacts at the Illinois Waste Management and Research Center (IL WMRC), the Illinois Environmental Protection Agency (IEPA), the Center for Neighborhood Technology (CNT), the Screenprinting and Graphic Imaging Association International (SGIA), and Printing Industry of Illinois/Indiana assisted in the identification of the collaborating firms.

In recruiting firms to take part in this study, Tellus discussed with each firm its general purpose, the firm-specific topics we would want to address, the necessary time commitment, the potential benefits of collaboration, and the guarantee of confidentiality. By far, the most significant barrier to participation in the project was the time commitment necessary for participation. A number of firms contacted were quite interested in the project topic but unable to participate due to time constraints of knowledgeable personnel.

The collaborating firms' views and practices were evaluated using the responses to written questionnaires on a variety of topics (see Appendix A) and the results of on-site interviews and follow-up conversations. While the sample, of course, is not statistically significant, the field data revealed different company views and practices concerning:

- explicit commitment to environmental policy and objectives
- environmental management approach
- types of environmental projects/investments considered and implemented
- financial analysis procedures
- receptivity to TCA approaches
- the types and relative importance of internal and external barriers and incentives to adoption of TCA approaches.

Each firm reviewed the Phase I case study summary for accuracy prior to inclusion in the final report. Six of the eight firms chose to be identified in the final report; two chose to remain anonymous.

From the larger sample of firms, Tellus selected a subset of three firms for further in-depth case studies based on pending or recently completed environmental projects. For two of these Phase II case study projects, cost data were assembled to perform two different financial analyses for each project, one using the company's standard financial analysis methods and one using a Total Cost Assessment (TCA) approach. Once initial data were gathered, both analyses were performed using assumptions and input parameters mutually agreed upon by Tellus and the firm. The goal was to compare the data collection and analysis process as well as the final results for the TCA approach vs. the conventional approach. Data were analyzed using Tellus Institute's P2/FINANCE software system.

The third Phase II case study evaluates the facility's cost allocation methodology for a single product line. For this case study, we evaluated the effectiveness of the facility's current allocation practices at capturing the true costs of the product line by looking at three cost item examples—operating labor, waste disposal, and environmental management labor. This case study differs from the other Phase II case studies in that it does not focus on improving the financial analysis methodology for a particular investment using TCA. However, as accurate allocation is a critical foundation for a TCA approach, the findings from this product costing case study assist in the advancement of TCA and environmental accounting strategies.

As the Phase I and Phase II case studies were performed, a parallel task took place: the assessment of internal and external barriers and incentives to adoption of TCA methods in industry. The case study results, a review of existing literature and previous related research all informed this evaluation.

A third significant component of this project was training in Environmental Accounting (EA), Total Cost Assessment (TCA), and the use of Tellus Institute's P2/FINANCE software. We conducted two training sessions mid-way through the project, one for WMRC and other state agency staff, and one for technical assistance staff and industry representatives. The training sessions were co-sponsored by WMRC, The Chicago Manufacturing Center, and the Illinois Institute of Technology Rice Campus.

We turn now to Chapter 2, Phase I Case Studies. This is followed by Chapter 3, Phase II Case Studies, in which we take an in-depth look at TCA applications in three firms. Chapter 4, Barriers and Incentives, examines organizational and regulatory impediments and opportunities to advance TCA. Finally, Chapter 5 offers a number of conclusions and recommendations on approaches to expanding EA and TCA practices in Illinois industry.

2. PHASE I CASE STUDIES

2.1 Company and Facility Profile

The firms selected are profiled in Table 1. Four of the firms are from the printing industry and four are from the chemical manufacturing industry. The diversity of the group is reflected by the size of the firms based on the number of facility employees. Two of the facilities have fewer than 20 employees, two employ approximately 650. Sales range from less than $1 million annually to $300 million. A local printing shop, an incorporated cooperative serving community groups, works out of a small urban facility; a large petrochemical manufacturing plant makes industrial products at its 890-acre rural complex. Ranging from single-facility sole proprietorships to multi-billion dollar international industrial corporations, each firm has a unique perspective on its business and regulatory climates and thus the need for and relevance of pollution prevention P2 initiatives. The diversity of these facilities manifests itself not only in the physical characteristics of each, but in how they manage environmental affairs and capital budgeting, as described below.

All eight of the firms volunteered to participate in this portion of the study; two chose to remain anonymous (SLP and RM). Each committed to completing a comprehensive questionnaire and participating in on-sites interviews and follow-up conversations via telephone and fax. The information they provided touched on general company background and organization, facility history and configuration, materials used in and environmental impacts of manufacturing processes, environmental management, financial analysis and description of environmental projects, and the firm's perspective on TCA. The process entailed candid discussions that were organized into individual case studies. These studies provide insight into how each facility approaches the selection of P2 and other environmental projects.

Table 1. Profile of Participating Facilities

Firm	Processes	Products	Revenues	Employees
Small Lithographic Printer (SLP)	lithographic printing	posters, brochures, booklets, cards	$ 900,000	15
Meto Graphics (Meto)	screen printing, metal fabrication	printed panels, signs, decals, nameplates	$950,000	18
Bema Film Systems (Bema)	plastic extrusion, flexographic printing	plastic bags and rollstock, printed packaging	N/A	40
Bulk Molding Compounds (BMC)	batch chemical processing, extrusion	fiberglass-reinforced polyester molding compounds	N/A	60
Resins Manufacturer (RM)	batch chemical synthesis	resin products for paint and coatings	$300,000,000 (corporate)	220
D. A. Stuart (Stuart)	chemical blending and synthesis	cleaning solutions, lubricants, specialty chemicals	$90,000,000 (corporate)	320 (corporate in U.S.)
Quantum Chemical (Quantum)	polymer production	ethylene, polyethylene, polypropylene	$714,000,000 (corporate)	650
Quebecor Printing (Quebecor)	lithographic and rotogravure printing	magazines, catalogs, newspaper inserts	$9,500,000	650

Note: Statistics apply to the facility only unless otherwise indicated. N/A indicates that the information was withheld by the firm.

2.2 Phase I Case Study Observations/Results

For the sake of simplicity, the eight case study firms were ranked in order of increasing number of employees at the case study facility; all references to firm or facility size follow this convention.

Environmental Policy and Objectives

Corporate philosophy drives corporate practice. Those firms with a more progressive, comprehensive attitude about the facility's roles and responsibilities are likely to take a more proactive approach to environmental management. These kinds of firms see P2 as integral to economically-sound business practice.

Six of the eight firms have explicit, written environmental policies of some kind, either as part of a general company mission statement or in one or more specific environmental policy statements. The two firms with no written environmental policy statement are two of the smallest firms; in contrast, the smallest firm of all has a very explicit focus on environmentally-sound practices, a situation attributable to employee ownership and an environmentally-conscious customer base.

Only the three largest firms have policies or goals that explicitly mention P2 and waste minimization. For example, these firms mentioned support for or participation in environmental strategies or programs proposed by outside organizations: U.S. EPA's Waste Management Hierarchy and the Chemical Manufacturers' Association's Responsible Care program. Only one of these firms mentioned quantitative goals, in the form of specified reductions in total air emissions, airborne carcinogen releases, and hazardous waste generation per unit of production. The firm achieved all of these goals ahead of schedule.

Environmental Management Approach

All of the case study firms were able to identify one or two individuals with the primary responsibility for handling environmental issues at the case study facility. Only two of the largest facilities, each with over 200 employees, have individuals whose only responsibility is environmental issues. At each of the remaining firms, the person responsible for environmental issues also has non-environmental responsibilities. At two firms, for example, the VP of Manufacturing or the Production Manager is responsible for environmental issues. At one facility, the Plant Manager is responsible. One of the largest firms has a single individual functioning as the Building Superintendent and Maintenance Superintendent as well as the Environmental Coordinator.

Conflicting opinions were voiced as to the potential pros and cons of having a single individual be responsible for both environmental and non-environmental issues at a facility. For example, one individual felt quite strongly that his position and knowledge as the VP of Manufacturing gives him a real-world connection to the manufacturing processes that benefits his efforts as the facility's de facto environmental manager. On the other hand, the Environmental Manager at another firm feels that his additional duties as Building Superintendent and Maintenance Superintendent prevent him from devoting more time to important environmental projects at the facility.

The individuals primarily responsible for environmental issues at these facilities have a variety of mechanisms for obtaining both guidance on environmental policy and assistance with day-to-day implementation. Seven of the eight firms have in place some sort of a management group that participates in or directs environmental decisions or policy, which is then carried out by the de facto "environmental manager." The management decision-making groups range from two individuals (the President and Head of Sales and Product Development) at one small firm to small groups of senior facility managers to corporate committees. All of the companies with multiple facilities or subsidiary status to a parent company receive significant input on environmental issues from the corporate level.

Several of the smaller firms (with no access to "corporate" guidance) reported alternate mechanisms for obtaining assistance with environmental issues. Sources mentioned were outside consultants retained for tasks related to environmental and safety compliance, auditing, and training; and an active company Safety Committee made up of employees who perform weekly facility audits.

Even with the proper foundation in place, the realities and constraints of day-to-day operations limit the extent to which the ideal of proactive environmental management can be attained. Several of the participating managers are eager but unable to implement environmental projects and improve processes on a more rigorous schedule than they currently are able to do. Constraints of time, personnel, and cash flow combine with competitive and sometimes regulatory considerations to temper even the most progressive managers and facilities.

Types of Environmental Projects/Investments

The written questionnaire provided to the firms requested information on recently completed, ongoing, and pending "environmental" projects, i.e., "pollution reduction initiatives". The questionnaire specifically listed "material substitutions, process and product modifications, and on-site recycling" as project types of interest. In other words, this section of the questionnaire had a P2 focus, even though the phrase "pollution prevention" was not used in that particular question. We did not ask the firms to list all related projects; the questionnaire given to each firm had space for written summaries of four projects, two completed and two ongoing or pending.

The environmental projects listed by the firms in response to this question can be broadly classified into three fairly distinct categories: pollution prevention, pollution control, and recycling (some of which also could be viewed as prevention). No remediation/cleanup projects were listed. Of the 32 environmental projects discussed, 19 fit into the P2 category; only seven were traditional end-of-pipe pollution control. The six remaining projects fell into the recycling category. This strong P2 showing is not surprising, considering the focus of the questionnaire. It is possible that the listing of pollution control projects in response to this P2-focused question indicates some confusion on the part of firms as to the distinction between control and prevention, but this issue was not further discussed, due to a lack of interview time.

The P2 projects listed by the firms can be further subdivided into three groups: materials substitution, logistical modifications, and wholesale process changes. Almost 80% of the P2 projects were either in-progress or were completed, compared to less than 45% of the pollution control projects. Most of the pollution control projects that were not completed at the time of the interviews had been found to be prohibitively expensive.

Interestingly, none of the facilities tend to undertake only certain classes of projects. The range of recycling, pollution control, and pollution reduction projects demonstrates the diversity of ways in which firms make environmental investments (despite the P2 focus of the questionnaire), even using traditional financial analysis methods. It also suggests that some combination of approaches, rather than a single overriding one, provides manageable and effective system of environmental management for many firms.

Pollution Prevention (P2) Projects

Materials substitution, one key type of P2 activity, was discussed by each of the small firms in the study – 7 projects in total - but by none of the larger firms. Most of the materials substitution projects were at printing firms, and involved switches to non-toxic inks or to cleaners that are water-, soy-, or citrus-based. In a few of these cases, the non-toxic substitute costed more on a per volume basis, but required less material to perform the desired function. There were several cases, however, where there was a net cost of making the switch (using a conventional financial analysis) but the change nonetheless was implemented for worker safety and/or environmental reasons. The fact that these materials substitutions were completed suggests an acknowledgment of some of the less tangible, traditionally unquantified costs of business-as-usual practices.

One potential explanation for the stronger emphasis on materials substitution efforts at the smaller firms may be that the technologies at the smaller firms are relatively simple compared to those at the larger firms. The larger firms tended to operate more specialized equipment with highly engineered processes that may not easily lend themselves to substitution. For example, specifications for ink drying times for high-speed, mass-production printing presses are more stringent than specifications for slower presses. Therefore, a small print shop with slower presses may be able to use soy-based inks that do not dry as quickly, whereas a larger facility may not be able to make that switch without affecting product quality. Another potential explanation may be differences in organizational barriers, e.g., fewer layers of management decision-making at smaller firms.

It should be noted once again that the case study firms were not prompted to describe all relevant projects in the questionnaires or during the interviews, but a maximum of four projects per firm. Therefore, it also possible that materials substitutions projects undertaken by the larger firms were not described to us simply because the larger firms had other projects they viewed as more interesting or significant. However, considering the language of the written questionnaire, which asked for descriptions of "material substitutions" projects, it is surprising that none of the large firms described a project of this type.

A class of P2 that is often overlooked is logistical modifications, which represented six of the projects discussed by the firms. Half of these projects did not require any substantial investment and therefore are not considered to be capital investments. Nonetheless, these projects provided substantial cost reductions by improving the efficiency of existing processes. For example, one facility began using dedicated process tanks to manufacture each chemical product rather than having multi-process tanks. By making adjustments in scheduling, production of the chemicals proceeded without the necessity of cleaning tanks between production runs. The seemingly simple change saved thousands of dollars in treatment and disposal costs and avoided solvent purchase costs. A similar change in drumming logistics at another firm, involving the assignment of dedicated drum-filling lines and a scheduling change, reaped large savings from scrap reduction and reduced waste disposal costs, all with minimal up-front investment. With one exception, a small printing firm that instituted specific housekeeping practices to reduce waste, the three large chemical firms described these logistical changes.

The third P2 category comprises investments to make wholesale manufacturing process changes. Again, with one exception, these types of projects were undertaken by the large firms. Two of the projects entailed looking systematically at processes, measuring waste streams, identifying inefficiencies, and implementing corrective changes. Other projects involved complete process changes, such as switching from incineration to wastewater treatment and replacing a darkroom and an off-site service bureau with digital printing equipment. The process change projects were evenly split between the chemical and printing firms.

Pollution Control Projects

Traditional pollution control projects remain a part of many firms' pollution management strategies. The collaborating firms identified a total of seven end-of-pipe projects, but only three of these projects had been implemented. Six of the seven projects were described by chemicals firms. Only two of these projects were described by smaller firms, and neither of those projects had been completed. All of the pollution control projects except one – an ultrafiltration system to clean an aqueous water stream – were targeted at capturing and controlling fugitive air emissions. Control methods ranged from scrubbers to thermal oxidizers to vapor equalization systems, and many of these projects were under consideration to ensure compliance with existing or anticipated regulations, although two projects had expected cost savings as well.

Recycling Projects

Six recycling projects enabled firms to increase process efficiencies by recapturing non-product outputs and reusing them as manufacturing inputs either directly or via off-site recyclers. Two of the projects involved recovering solvent; one from fugitive air ink emissions captured and sent to a recycler, another from spent paint thinner that is now redistilled on site. Two other projects involved water recycling to reduce both water input requirements and the amount of water discharged to sewer systems. Although recycling generally does not reduce the overall throughput of materials in a particular manufacturing system, these projects were profitable because they reduced raw material purchase requirements for the facility. Therefore, five of the six projects were either underway or completed.

Motivating Factors

As shown in Figure 1, there were various motivations for the environmental projects discussed. Respondents indicated multiple motivations for many projects, whereas in other areas the motivation was not entirely clear.

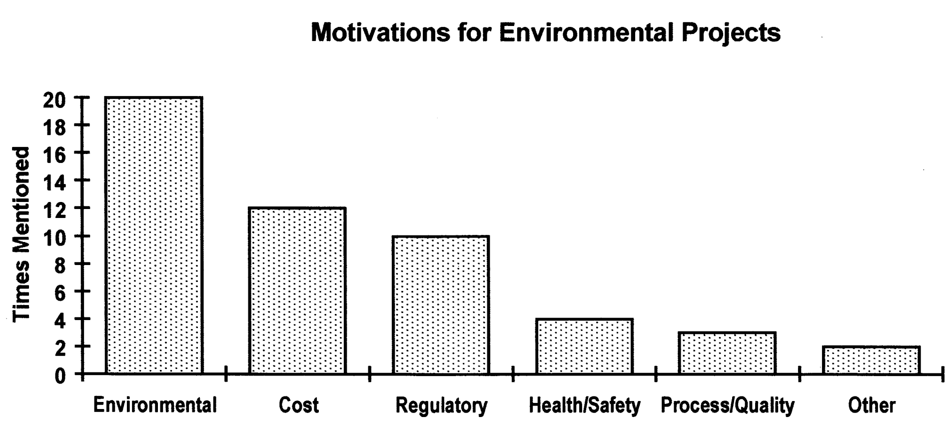

Figure 1. Motivations for Environmental Projects

Of the 32 projects, 20 were motivated by environmental concerns. Of those, six had a regulatory component as well. In total, ten projects were motivated either directly or indirectly by regulatory issues. Significantly, more than a third of the projects were driven by cost reduction. This suggests that even without a Total Cost Assessment (TCA) approach, environmental projects sometimes are viewed as profitable. Three-quarters of the cost reduction projects were underway or completed. In addition, we found that many projects are motivated by a less tangible feeling of unease with the use and generation of large amounts of chemical waste.

Financial Analysis Procedures

Degree of Formality

We found that methods of capital budgeting span the spectrum from informal, ad-hoc decision-making to rigorous, formalized processes. The four larger firms all have standardized annual budgeting processes, while the smaller firms use a less formal method. At the smaller firms, it apparently is more difficult to conduct reliable long-range planning due to marketplace volatility. As a result, investment needs and decisions are determined and evaluated as they arise, rather than on a set schedule.

All but one of the firms establish an initial annual budget, but two of the smaller firms who do this consider the budget to be rough and often do not strictly adhere to it. Annual capital spending budgets ranged from $6,000 to $18 million, correlating roughly to facility size. Only five firms could make estimates regarding what portion of total expenditures could be considered to be environmental. Of those, one suggested 30-60% of capital spending was for environmental projects, three put the number at 10-20%, and one guessed a scant 1% of capital spending was environmental. This extremely wide range is probably partly due to differences in defining the term "environmental." None of the firms establish a separate pool of funds expressly for environmental projects.

Analysis Elements

We found considerable variation in the extent of cost items considered by the eight firms when performing the financial analysis of a project. Surprisingly, the three smallest firms seem to consider the broadest array of costs relevant to a project. These firms, all printers, try to take a comprehensive look at indirect operating costs and even less tangible costs that may be affected by projects under consideration. Two of these firms, however, consider many of these costs only in a qualitative manner

The inventories of cost items included by the larger firms may tend to be somewhat less comprehensive than the inventories considered by the smaller firms, but the costs that are included seem to be handled in a more quantitative fashion. For larger firms, the scope of costs may be narrower because their cost structures are more complex and diffuse, thereby making data gathering a costly exercise. Nevertheless, because the costs that a large firm includes generally are quantified in a formal analysis, the cost estimates tend to be more rigorous. One of the largest firms expands the inventory of costs it considers only for very big projects, but opts not to quantify indirect costs for small projects. Two firms – one large and one small – consider corporate image, at least qualitatively, in project assessment. On the whole, most of the firms make some effort to consider at least a few less conventional costs qualitatively in their analyses.

Few firms have rigorous methods of allocating indirect costs – including environmental management, waste disposal, and effluent treatment – to their product lines. In total, five of the eight facilities do attempt to allocate overhead costs and include them in project analyses. But, with one exception, these costs are often pooled together with other administrative costs and broadly allocated with a single cost driver, making allocation rather imprecise. This type of overhead allocation system obscures the true environmental cost of a production process.

The elements of an investment analysis can be viewed as multidimensional. In addition to the cost inventory and allocation dimensions discussed above, there is yet another element - the time horizon over which the investment will be evaluated. Just as is the case with inventory and allocation, analysis time horizon is handled in various ways by the eight firms. Only half of the firms specified time horizons for project evaluation, and these varied from two to ten years. The firm that uses a ten-year horizon uses it only for projects *a priori* considered to be long-term investments.

Project Evaluation

Once the financial analysis of a project is complete, the project is typically subject to prioritization or competition with other projects. However, all of the collaborating firms, to a greater or lesser extent, consider environmental projects separately from other projects although their funding comes from the same capital pool. All of the facilities give compliance projects automatic approval, and in many cases, these projects are not subject to rigorous financial analysis. Three of the firms do generally group all projects (except for compliance projects), but give strong consideration to qualitative environmental issues, effectively giving such projects a potential advantage.

To prioritize projects, three firms calculate simple payback while the other five use some form of return on investment (ROI); neither of these indicators accounts for the time value of money. Some of the firms actually consider multiple indicators of profitability, but payback and ROI seem to be dominant. Almost all of the firms consider qualitative factors to some degree in their analyses, which can be mitigating factors that influence the ultimate prioritization. As a means of selecting projects, however, six of the eight firms do use some sort of financial hurdle that projects (other than compliance projects) must clear. Of the facilities that disclosed hurdle rates: three firms seek paybacks of 1½, 2, and 3 years; and two seek returns of 15% and 20%. Only the two smallest firms look at each project independently and do not use any predetermined financial hurdle rate.

For the smaller firms, cash flow is the ultimate constraint for any spending decision; it is therefore sensible for them to assess the value of a project based on its effect on future cash flows. Quite often, investment decisions essentially are based on current cash flow at these facilities. In these cases, the firms allocate their limited investment funds based on a qualitative appraisal of imminent, perceived need.

Only two firms made explicit reference to accounting for the time value of money through discounting in their analyses. The others base calculations on current dollars, which is a reasonable approach when short time horizons are used. However, as time horizons are expanded to better reflect the nature of environmental costs, it become more inaccurate to rely on profitability indicators that do account for the time value of money.

Perspectives on TCA

Although it appears that all of these firms are far from systematically incorporating TCA into their decision making systems, all but one were receptive to the idea of and the need for TCA and are making small steps toward that end. Acknowledging the value of proper cost allocation is an important step towards integrating these costs, even qualitatively, into financial assessment systems. All of the managers interviewed recognize this value and would like to make strides towards a more comprehensive means of accounting for environmental costs.

3. PHASE II CASE STUDIES

3.1 Introduction

Three of the eight collaborating firms were selected for Phase II case studies based on a pending or recently completed environmental project or initiative. Appendix C contains detailed descriptions and analyses of these projects. For the Small Lithographic Printing (SLP) firm and Quebecor Printing Mount Morris, Inc. (Quebecor), we assembled cost data to perform two different financial analyses for each project, one using the company's standard financial analysis methods and one using a Total Cost Assessment (TCA) approach. Once initial data were gathered, both analyses were performed using assumptions and input parameters mutually agreed upon by Tellus and the firm. The goal was to compare the data collection scope as well as the final results for the TCA approach vs. the conventional approach. Data were analyzed using Tellus' P2/FINANCE software system.

For the Resins Manufacturer (RM), we evaluated the facility's cost allocation methodology for a single product line. For this case study, we identified the facility's current allocation practices and evaluated the effectiveness of these practices in capturing the true costs of the product line by looking at three cost item examples—operating labor, waste disposal, and environmental management labor. This case study differs from the other Phase II case studies in that it does not compare the company's financial analysis methodology for a particular investment to a TCA approach. Accurate cost allocation, however, is a critical foundation for TCA; the findings of this product costing case study will inform the continued evolution of TCA and environmental accounting methods.

3.2 Small Lithographic Printer (SLP)

This company is a small lithographic printer, printing one- to four-color posters, cards, and booklets. The facility recently purchased a computer pre-press system that is able to directly process jobs that customers submit on computer disk; jobs submitted as camera-ready art can be scanned and then processed. Previously, artwork on digital media was sent out to an external service bureau for pre-press processing, and camera-ready art was processed in the facility's darkroom using an open-tray developing system. The film processor that is part of the new system produces film that can be used in platemaking, thus bypassing the darkroom entirely. The investment was motivated by a desire to reduce costs, improve customer satisfaction, and reduce darkroom chemical use. A flow diagram for the older pre-press operation and the new computer pre-press system are provided in the full case study in Appendix C.

The company estimated the direct, quantifiable costs (purchased equipment) and savings (reduced service bureau and courier charges) of the investment, and considered less tangible benefits (production flexibility, improved product quality) qualitatively, and made a conservative but somewhat intuitive decision to proceed. It did not consider the potential effects of taxes, depreciation, inflation, and discounting.

In contrast, the TCA for the project included a much broader inventory of costs and savings to more accurately reflect the economic impact of the investment on the facility. Costs associated with the system's installation were included, as were annual operating costs of materials and allocation of labor. In addition, the TCA included the expected increase in product revenues from the facility's enhanced flexibility and quality and reduced turnaround time. In total, the TCA cost inventory contained 15 quantified cost items, whereas the inventory for the company's analysis had three. In addition to the additional costs and benefits included via the TCA approach, the impact of taxes, the equipment depreciation tax break, and the time value of money were included to better characterize the project's profitability.

Although the more thorough characterization showed the initial investment to be more than $2,500 above the estimate used in the company analysis, and annual labor allocation and film costs associated with the new system represented an overall increase, the overall project is more profitable than originally envisioned. This is due to the savings from decreased chemical cost and increased product revenues. The net effect of the operating cost items included in the TCA is an annual savings of close to $10,000. The company did not use a discount rate in its original analysis, but for comparison purposes in this report, both the company analysis and TCA were run using the same 12% discount rate. The TCA yielded a five-year net present value (NPV) of $188,000 compared to $58,000 from the company's analysis, and the discounted payback for the TCA was under ten months compared with two-plus years in the company analysis.

The inclusion of estimated increased revenues in the TCA was a key assumption in the analysis. This assessment of potential revenue increase is complicated by the fact that revenues are currently increasing for reasons not related to the new system. Separating out the commingled effects would be difficult, if possible at all. The sensitivity of the analysis was tested against varying assumptions on the magnitude of the revenue increase. From this analysis, if revenues increase by only 5% instead of by 10%, the discounted payback calculated via the TCA climbs to 1.4 years and the five-year NPV falls to $94,000. Thus, the analysis is quite sensitive to changes in this assumption. However, even these more conservative assumptions produce a decidedly more profitable investment than SLP originally estimated. Thus, TCA strengthens the intuitive assessment of the project's value to the firm and helps the company to understand where it can expect cost increases and where the savings are likely to originate.

It should also be noted that the neglected costs and savings uncovered by TCA in this case study were not primarily environmental costs/benefits but were related to increased production and revenues. This illustrates that TCA is useful approach for many types of investment projects, not just environmental projects.

3.3 Quebecor Printing Mount Morris, Inc. (QPMMI)

QPMMI provides pre-press, printing, post-press, and distribution services for high-volume customers using both direct-to-plate (for web offset) and direct-to-cylinder (for rotogravure) processes. The rotogravure cylinder aqueous waste streams – about 1 million gallons per year – are contaminated with copper, chromium, and other metals, and are sent to the on-site wastewater treatment system. These waste streams are highly acidic (pH between 2 and 3) and, in addition to high levels metals, contains some dissolved VOCs and oily waste.

QPMMI has been considering a project to improve its wastewater treatment system. The improvements would replace the current batch system with a continuous membrane filtration system that would precipitate and remove dissolved metals. The new system would use a smaller volume of treatment chemicals than the existing system and would be considerably less labor intensive as well, because it is highly automated. Instead of generating sludge, the new system would generate a metal concentrate that QPMMI hoped to sell to a metal recycler instead of sending it off-site for treatment as a hazardous waste. The market for the concentrate, upon further investigation, is not strong; the value of the product would be just enough to have it picked up from the facility. A flow diagram for the current wastewater treatment system and the proposed system upgrade are given in the full case study in Appendix C.

The wastewater treatment upgrade project proposal has been submitted to corporate headquarters as part of the facility's annual list of potential investments for each of the last several years. However, it is always one of the first projects rejected because it is perceived as an unnecessary money-loser – it is not required by regulation and it is not clearly profitable. Projects from the annual list that are accepted after the preliminary review are subject to a more comprehensive financial analysis in which a broader inventory of costs, taxes, depreciation, and discounting are included. The wastewater treatment upgrade project has never passed the initial screening, and therefore, no comprehensive analysis has been conducted.

The preliminary analysis completed by the facility's Environmental Coordinator included the costs of the purchased equipment and its installation (both from vendor quotes) and an estimation of savings due to reduced direct labor and waste disposal costs. From these costs, he calculated a simple payback of five-plus years.

In the TCA of the proposed investment, we included a more comprehensive cost inventory, more precise allocation of costs, the impact of income taxes, the equipment depreciation tax break, and the time value of money. In addition to the cost items included in the company analysis, the TCA added initial investment costs associated with supervision, training, and start-up, and operating cost savings associated with treatment chemicals and indirect labor allocations. Financial parameters used in the TCA were those that would have been used by the company had the more comprehensive analysis been performed.

The inclusion of a broader inventory of relevant cost items and the addition of considerations such as taxes, depreciation, and the time value of money led to an increase in the estimate of both costs and savings that would result from implementation of the project. The initial investment costs shown by the TCA were almost $19,000 higher than in the company analysis, and the annual operating savings were close to $19,000 higher as well. Since the investment represents a one-time cost and operating savings accrue each year, the TCA does show the project to be more profitable than the company analysis.

The original company analysis calculated only a simple payback. However, in order to make a direct comparison of the company and TCA analyses, net present values and discounted paybacks were calculated for both using the company's 8.5% discount rate. (The company uses a real discount rate, as opposed to a nominal one, i.e., it does not discount for inflation.) The TCA provided a ten-year NPV of $81,152 compared with $51,887 from the company analysis. The discounted payback from the TCA was 5.7 years, a little over one year lower than the 6.94 years generated by the company analysis.

While the preliminary company analysis neglected some large investment costs and operating cost savings, the project appears only moderately more profitable after the TCA is performed. The project is profitable in the medium-term, but in the facility's tight competition for capital funds, a five-plus year payback is unlikely to garner management enthusiasm. Nevertheless, the TCA provides useful information by demonstrating more of the actual costs associated with both the current system and the proposed one. As wastewater treatment technology improves, equipment costs may fall. Similarly, improved recycling technology and the development of better recycled material markets may make metal concentrate more valuable. These advances may render the investment more profitable in the future.

3.4 Resins Manufacturer (RM)

The RM firm manufactures a family of resin products used in paints, coatings, and reinforced fiberglass. Products are manufactured in batch reactor vessels by heating raw materials—mostly derivatives of petroleum or vegetable oils—until they polymerize. After the reaction, most resins are mixed with solvent to allow pumping and provide lower viscosity for the paint products. The facility uses a combination of treatment technologies and pollution prevention techniques to manage wastes generated during production.

In early 1996, RM began a collaborative P2 project with the Illinois Waste Management and Research Center (WMRC). This Life-Cycle Project examines one of the facility's products, Resin A, from a life-cycle[1] perspective. The Life-Cycle Project contains two components: 1) a technical evaluation of the manufacturing process and 2) a financial analysis of the product line. Tellus assisted the facility in conducting the financial component of the project. We focused on characterizing the current allocation practices at the facility and making suggestions for improvement. This case study differs from the other Phase II case studies in that it does not focus on improving the financial analysis methodology for a particular investment using Total Cost Assessment (TCA). However, as accurate allocation is a critical foundation for a TCA approach, the findings from this product costing case study will assist in the advancement of TCA and environmental accounting strategies.

To allocate annual operating costs (with the exception of raw material costs, which are directly charged to the appropriate product lines), the facility calculates prospective *conversion costs* on a per pound basis. To allocate costs, RM divides costs into three categories, applying a different allocation basis for each category. The facility labels these three categories *direct costs*, *overhead costs*, and *fixed costs*. Direct costs such as operating labor, non-waste disposal utilities, and equipment depreciation are allocated on the basis of kettle hours (i.e., the amount of reaction time required for the product). Overhead costs such as waste disposal and treatment costs and administrative costs are allocated on the basis of the number of batches. Fixed costs such as safety materials and shipping/handling labor are allocated on the basis of product volume. When a particular product's manufacturing process differs greatly from the other products in the family, the facility adds a surcharge above the conversion cost to incorporate these additional costs.

[1] For the facility, life cycle focuses on the product from the point where it enters the doors of the facility as raw material inventory to the point at which it leaves the facility either as waste or product.

For example, products that have been identified as requiring additional filtration, cleaning, or rework are candidates for a surcharge.

We conducted two modified analyses, the results of which we then compared to the Facility Analysis. First, we revisited the facility's conversion cost estimate with particular attention to any surcharges required by the product, entitled the *Surcharge Analysis*. Second, we selected three priority cost items—operating labor, waste disposal, and environmental management labor—and applied alternative allocation methods to conduct a cost comparison, entitled the *Allocation Analysis*.

In developing its conversion costs, the facility uses surcharges to penalize those products that require additional production effort before they can be shipped. For the *Surcharge Analysis*, we reviewed the Resin A production process to identify any potential surcharges required for this product. Resin A does require a non-typical filtration step to eliminate a haze generated as a by-product during manufacturing but despite this extra filtration step, the accounting staff did not identify Resin A as a product line that merits a surcharge when calculating the conversion cost for the product. We measured the financial impact of Resin A's failure to receive an appropriate surcharge, including filtration labor, filtration raw materials (filter powder and filter paper), and waste disposal from the filtration process. Our estimate added 18% to the original conversion cost estimate for Resin A. This analysis indicates that effective implementation of the facility's conversion cost methodology is critical to its accuracy. Enhanced communication between accounting and production departments likely would lead to improvements in the implementation of the current system.

For the *Allocation Analysis*, we evaluated the accuracy of the conversion cost allocation methodology for operating labor, waste disposal costs, and environmental management labor. For operating labor, we compared the conversion cost approach with a bottom-up cost estimation method that relies on production employee self-reporting of work activities. The conversion cost estimate is an order of magnitude higher than the bottom-up cost estimates. However, the reasons for this significant difference are unclear. The major discrepancy between the way that production employees think they spend their time and the way that the conversion cost methodology allocates their time suggests the need for further assessment.

For waste disposal costs, we compared the conversion cost estimate, which uses the number of batches as its allocation basis with measured waste generation rates for Resin A gathered during bench-scale experiments. The alternative approach calculates a cost that is 75% more than the waste disposal cost calculated using the conversion cost method. This difference is not surprising given that the significant filtration waste costs were neglected in the Facility Analysis. The alternative allocation method reflects the significance of the filtration waste disposal cost; the Facility Analysis's failure to capture such filtration costs through a surcharge reduces its accuracy significantly.

For environmental management labor costs, we compared the conversion cost estimate, which uses product volume as its allocation basis, to activity-based estimates of time by the facility's environmental engineer. The conversion cost method calculates an allocation of 3.8% of environmental management labor to Resin A. However, the environmental engineer estimates that 12.9% of her time is spent on work related to Resin A. The discrepancy is due to the fact that waste minimization activities (including the Life-Cycle project itself) are often targeted to specific product lines; this was not accounted for via the conversion cost method. However, it is not clear whether the costs of those waste minimization activities should be borne solely by the product lines they target when such waste minimization activities will have broader implications and lead to improvements in other product lines.

These analyses demonstrate the importance of accurate implementation of the company's conversion cost method. The conversion cost method balances resource constraints with accuracy, yet the method's failure to identify Resin A as a surcharge candidate significantly compromises its accuracy. In general, the method succeeds in capturing the costs associated with different product lines with minimal tracking and effort. Resin A, however, serves as an example of a product that fell through the cracks. Because an extra filtration step was never identified for this product, the ability of the conversion cost method to reflect the real costs of the product was limited from the start. In theory, the conversion cost method succeeds at meeting this balance. In practice, however, improvements can be made.

4. BARRIERS AND INCENTIVES TO TCA

Despite the benefits of environmental accounting and, specifically, Total Cost Assessment (TCA), business generally has been slow to embrace these concepts. In this chapter we explore why TCA approaches are not more widely used, what changes must be instituted within firms in order to advance TCA practices, and what government can do to facilitate this process. We use the Illinois cases to illustrate many points in this assessment.

4.1 Internal Issues

Capital Budgeting Practices

Capital budgeting is the process by which organizations plan and finance capital outlays to purchase new equipment, to introduce new product lines, and to modernize facilities (Garrison and Noreen, 1994). Capital budgeting processes vary widely. Many small firms use simple, informal methods owing to lack of resources or in-house expertise. Among our case studies, two small firms expressed interest in using more sophisticated capital budgeting processes, including TCA methods, but did not feel their companies have the financial and manpower resources to do so on their own. The same is often true of mid-sized firms; proposed projects pass through more hands, but the review process is no more rigorous. At one mid-sized firm there is no formal appropriations process, but potential projects are discussed by all four partners. Large firms more often employ capital budgeting techniques, but these techniques may be applied to only certain types of projects. One large firm, for instance, does not conduct financial analyses of 'necessary' projects, and any financial benefits of these projects are considered 'indirect'.

Large firms normally classify investments in some fashion, e.g., market expansion projects; profit adding/cost reducing projects; or profit sustaining projects, which include compliance and maintenance (White, et al., 1991; White, 1993). Market expansion projects are those that contribute most directly to the growth of a company by introducing a new product or opening a new market. They usually represent a significant investment and risk for the company and are subject to a rigorous review process. Profit-adding projects enhance the firm's performance by improving efficiency and reducing costs. Equipment upgrades that reduce annual labor or materials inputs are included in this category. The investments improve the market position of products the firm already sells, but do not add to the firm's growth. They are preferred by managers at the plant level, but less so by managers at higher levels in the corporation because they add little to growth of the firm. Profit-adding projects often are subject to less stringent review than market expansion projects. Profit-sustaining projects sustain production at current levels through maintenance or replacement of old equipment, or improvements necessary to meet regulatory standards. These projects normally are viewed as "must-do," not discretionary, and as such, they are normally not subject to systematic financial review. Historically, most environmental investments were placed in this category, thereby leaving the economic rewards to such projects largely or entirely unrecognized. In reality, these projects may not only add profit by reducing costs, but also result in lower compliance costs and production of more environmentally-friendly, profitable products. An in-depth financial analysis may demonstrate these benefits, but such an analysis is rarely performed because these environmental projects are so often preconceived as net financial losers.

In today's marketplace, it is possible to view environmental projects as market-expanding. Consumers demand of environmentally-friendly products made by environmentally responsible firms is a documented, though still minor, determinant of purchasing behavior. Nonetheless, even a 2-3 percent market share advantage can make a difference in highly-competitive product lines such as automobiles and computers. TCA enables managers to quantify these and other revenue streams that may result from green practices and processes.

Organizational Issues

Attitudes of top management toward environmental issues play a key role in the implementation of environmental programs. In a recent survey of corporate environmental strategies, Epstein (1996) found that, in most companies, major environmental accounting programs do not begin until the CEO commits to improved environmental management. Commitment to the environment can be declared through an environmental mission statement or the development of corporate environmental strategy. The form of an environmental mission statement and the types of programs implemented in its wake depend upon the knowledge and experience of those involved in its planning. As a result, whether or not TCA is integrated into corporate environmental programs depends on management's awareness of the utility of TCA.

When designing corporate environmental strategy, assigning authority and responsibility for environmental policy is the first step to confronting environmental issues. Historically, because companies took a reactive approach to environmental issues, corporate environmental policy was in the hands of lawyers (Epstein, 1996). Lawyers look for legal solutions to problems; they are not intrinsically concerned with resource efficiency, waste disposal costs, or improved managerial accounting. Of course, legal counsel has a place in firms faced with environmental liabilities. However, for a company to take a more proactive stance on environmental issues – including utilization of TCA methods – aimed at preventing future liability, a multi-functional team must design and oversee policy and program development.

A recent survey of corporations found that the most environmentally forward looking companies now employ individuals with more diverse professional backgrounds in their corporate environmental health and safety (EH&S) departments (Surma, 1992). Engineers and scientists bring a fresh and valuable perspective to EH&S issues, but their expertise normally does not extend to managerial accounting (Karam et al., 1989), especially accounting expertise that would enable them to ferret out the hidden and contingent costs associated with environmental projects.

When planning corporate environmental strategy, including EH&S personnel in planning is the best way to ensure that innovative, technical and proactive strategies such as TCA are incorporated into environmental policies and practices (Epstein, 1996). At the Resins Manufacturer (RM) in our study, for instance, most suggestions for improving the company's environmental performance come from EH&S staff and from EH&S facility audits. EH&S staff have the experience with environmental issues to see the opportunities for improved performance that may reduce a company's future exposure in the form of Superfund, natural resource damages, and personal injury liability.

Once TCA is endorsed by top management and made an integral component of corporate environmental policy, the responsibility for implementation passes to personnel at the division and facility level. Methods of disseminating information to EH&S, accounting, production and other staff via formal training seminars, informal information sessions, and/or newsletters and memos are vehicles for turning policy into action. Managers and workers also need to know that TCA has the full endorsement and support of senior management, and that divisions and facilities are expected to use the tool in their respective capital budgeting processes.

Six of the eight firms studied in Illinois have written environmental policies of some kind. Each of these firms is able to identify the key individual(s) with primary responsibility for handling environmental issues. They also can identify the variety of other personnel (e.g., corporate, facility managers, external consultants) who help make or implement environmental decisions. In our sample, the environmental commitment and diversity of personnel involved in environmental decisions vary widely. The range of investment decision-making practices similarly varies, but TCA is not practiced systematically by any of the study's firms. Thus, we see ample opportunity, and need, to inform top management of TCA's benefits and to translate this understanding to division and facility staff in ways that make business sense.

Implementing TCA

In addition to awareness and education, many firms may find that there are a number of procedural changes that must take place in order to smoothly integrate TCA into corporate structure. TCA requires firms to include new information in their financial analyses. Gathering this information often requires modified or new information management approaches such as materials tracking systems.

Consider the first element of TCA (first discussed on page 2 of this report), an expanded inventory of costs and saving relevant to a project. Traditional project evaluation methods often exclude cost items such as regulatory compliance, insurance, on-site waste management, operation of on-site pollution control equipment, and liability. These costs may be neglected for a variety of reasons: they may be hidden in overhead accounts, viewed as insignificant, or viewed as too difficult or uncertain to quantify. Yet incorporating such costs into project evaluations may make the difference between success or failure in the capital budgeting process.

The second element of TCA, accurate cost allocation, goes hand in hand with the first. Moving hidden, or indirect, costs out of overhead accounts and linking them to processes where they occur results in a more comprehensive cost inventory. For example, the SLP firm does not allocate labor costs from overhead accounts to specific processes because it feels there are too many different production jobs to make cost allocation practical. Therefore, if SLP proposed a process change to eliminate the use of toxic substance which, in turn, decreases the time workers spend managing wastes, exclusion of these labor savings in an evaluation of the project would underestimate its true profitability. SLP realizes this and, moreover, feels that allocating labor costs to production jobs would have the added benefit of informing its pricing process.

Similarly, when hidden costs are assigned to projects and processes via some generic cost driver that does not accurately reflect costs that actually are incurred, project profitability will be distorted. For example, one Illinois firm assigns overhead costs on a per-pound-of-product basis. Using this method, a product line that produces large amounts of product, but is relatively resource efficient, may bear an unfairly large share of waste management costs. Under these conditions, both process improvement and pricing decisions will fail to account for differential waste generation costs across product lines.

Both improved cost allocation and expanded cost inventories require procedural changes within companies. Costs that previously were assigned to overhead accounts must be tracked and assigned to processes or products according to how they are incurred. Viewing costs in new ways requires a new view of cost structures that some managers may resist due either to resource requirements or to the unwelcome news that a process or product is more costly than previously thought. Improved tracking of costs may require a simple, one-time procedure, such as surveying supervisors about how they spend their time managing individual processes or procedures, and then allocating the labor cost accordingly. Such one-time costs might be absorbed or cost-shared by corporate management in order to protect facility managers from such burdens. Similarly, rewards, not penalties, should be put in place to motivate managers to sharpen their allocation practices, notwithstanding their implications for process and product pricing.

Improved materials and cost tracking and allocation can require more concrete and costly changes. Implementation of a computerized waste management system would be a capital investment in and of itself, but might be necessary to track and allocate costs and revenues associated with materials use and waste treatment. One Illinois firm considers the manpower involved in tracking and allocating costs in order to implement TCA to be simply too expensive, a reminder that improved allocation practices inevitably face tough questions regarding costs and benefits.

Expanding project time horizons is the third component of TCA. By lengthening time horizons, project evaluations can capture long-term financial benefits, such as avoided liability and waste management costs that short time horizons (e.g., 1-3 years) may miss. Because environmental investments often result in the permanent reduction or elimination of an expense such as waste management or insurance, they may yield a recurrent financial benefit. Since most companies, particularly smaller firms, require that investments show a profit in a relatively short period of time, environmental investments are systematically disadvantaged. One Illinois firm requires a payback of 18 months or less. Another requires a payback of less than two years. Both companies acknowledge that environmental investments often do not meet this criterion.

Extending time horizons, however, may meet with resistance. Small companies often are unable to afford a long-term investment if access to capital or cash flow is limited. They may be reluctant to tie up limited capital, especially if the business is relatively new and the landscape dynamic. More generally, firms may be reluctant to invest long term due to economic uncertainty. Changes in interest rates, market share, and general economic health might adversely affect the profitability of an investment. Committing scarce capital to long-term investments might result in a missed lucrative future opportunity. Similarly, subsequent technological and regulatory changes might offset the financial benefits of an investment. However, one approach that some companies, including two Illinois firms, have taken in order to account for long-term benefits of environmental investments is to use longer time frames in the evaluation of these investments.

The last component of TCA, using better financial indicators to evaluate investments, requires a firm to look at indicators such as Net Present Value, Internal Rate of Return, and Discounted Payback, all of which incorporate the time value of money. In large firms, the primary barrier likely is project classification, discussed earlier; large firms often do not perform sophisticated financial analyses on 'profit-sustaining' projects which usually encompass environmental investments. In small and medium sized firms there may simply be a lack of financial analysis sophistication. Personnel at SLP, for example, expressed an interest in using more sophisticated financial indicators, but admitted they did not have the financial background to do so.

Common to all four components of TCA is the perceived risk involved in changing any current business practice. The implementation of TCA itself requires an investment of time and money. A business might need to hire consultants or devote internal resources to educate personnel on TCA methodology. Implementing TCA would also require labor resources for gathering information and performing assessments, and possibly financial resources in the form of capital investments in accounting systems, materials tracking systems, or other management information systems. Investing in TCA, of course, does not in itself guarantee that TCA will save money. Empirical evidence may support the case for such an investment, but a firm may still feel that the costs involved outweigh the potential benefits. Moreover, many small firms cannot easily divert resources from day-to-day operations in order to make the changes necessary for TCA implementation. Nonetheless, despite the potential risks involved, several of the case study firms expressed a desire to adopt TCA methods.

Epstein (1996) found that reluctance to innovate on environmental issues may be symptomatic of a general laggard character in some firms. He refers to such firms as crisis prone firms that do not approach problems in a proactive or innovative manner. Their lack of response to environmental issues is not the result of a failure to appreciate environmental responsibility. Rather, the company generally does not take a preventive approach to problem-solving, in its environmental management or otherwise.

Liability

TCA encourages the consideration of environmental liability costs, since liability represents a contingent cost for companies that use or generate hazardous materials. Many companies are reluctant to quantify liability costs for a variety of reasons. Because liability results when something goes wrong – e.g., an accident or injury – it is not possible to determine exactly when a firm might incur liability expenses or how much those expenses would be. Two of our case study firms consider liability in a qualitative manner, but many others do not consider liability costs at all in capital budgeting. Confronted with litigious stakeholders and apprehensive investors, firms may be reluctant to quantify liability for fear that doing so could be viewed as tantamount to an admission of responsibility for any adverse environmental or public health impacts.

Current liability must be reported by publicly-held corporations to the Securities and Exchange Commission (SEC). However, it may not be possible to allocate current liability for past misdeeds to the culpable segment of the company since it may no longer exist (Epstein, 1996). When liability costs cannot be allocated to the products or processes that were the source of the liability, for whatever reason, companies must recognize that lumping these costs into overhead accounts or distributing them evenly across products or processes obscures the true costs of such products and processes.

Considering current and potential liability costs in project evaluations is increasingly relevant, now that lenders are considered PRPs (Potentially Responsible Parties) under Superfund legislation. Also, banks do not want to foreclose on properties that are current or potential Superfund sites, since this would make the bank liable for the clean up costs. A comprehensive project evaluation including liability estimates may therefore convince a bank that an investment evaluation is more realistic, and that the firm acknowledges the real possibility of future liability associated with its current practices.

Rewards and Recognition

TCA methods can benefit a company by improving morale among workers. Accurate cost allocation removes the burden of improperly assigned costs from managers whose areas generate less pollution and run more efficiently. TCA also creates an opportunity for employee recognition. Two case study firms, for example, have awards for employees who make suggestions that improve the companies' environmental performance. TCA might involve accountants and other personnel in environmental awards programs who would not otherwise participate. Managers whose process lines run most efficiently in terms of materials use, emissions and energy use, or whose process lines show considerable improvement can be rewarded for saving money, thus creating an incentive for others to do likewise

4.2 The External Perspective

Competing with Compliance

In addition to internal barriers to TCA, organizations also face external, primarily regulatory, barriers to the implementation of TCA. A number of Illinois firms mentioned regulatory inflexibility as a barrier to innovative, pollution-prevention-oriented environmental improvements. It is still the case that the weight of regulations continues to emphasize end-of-pipe controls rather than materials and waste reduction. As such, they shift the focus of EH&S away from process improvement to compliance, absorbing resources that otherwise might be used for investments in upstream process efficiency or an enhanced material tracking system. Capital is always limited; a firm facing the choice of compliance mandates versus TCA or other P2 initiatives will almost always choose the former. In addition, investments made for regulatory compliance tend to reinforce accounting deficiencies because they are rarely subject to rigorous cost analysis.

Regulations associated with the Resource Conservation and Recovery Act (RCRA), Superfund Amendments Reauthorization Act (SARA), and the Toxics Release Inventory (TRI), require accounting of releases of substances at facilities that fall under certain SIC codes and use threshold amounts of toxic chemicals. However, these programs do not require comprehensive materials accounting systems, the foundation for effective application of TCA approaches. The release (emissions) focus of these regulations diverts attention from materials inputs into processes. Firms typically are reluctant to invest in a more comprehensive materials tracking system, or feel they do not need one, since they are not required by regulation. Furthermore, TRI and RCRA are facility-focused, not process-focused, regulations, a situation which again directs attention to facility-level materials and cost information.

Uncertainty

The uncertain nature of government regulation, such as the periodic additions and deletions of chemicals from the Toxics Release Inventory (TRI), may make companies reluctant to invest in process changes with lengthy time horizons and considerable returns in later years. New regulations might render the improvements outdated or inadequate, or existing regulations may be repealed, thereby devaluing a previous investment. This type of uncertainty reinforces businesses', especially small businesses', reluctance to extend investment horizons beyond the 2-3 year range, one of the key elements of TCA. The prospect of allocating capital for elimination of a material or waste that may be 'delisted' is an unwelcome scenario for any business manager. Of course, getting away from ever-changing regulatory requirements altogether (sometimes called the regulatory 'treadmill') is a powerful counterpoint to this perspective.

Regulatory Incentives

Many states and federal agencies are experimenting with new, innovative regulations that may directly encourage TCA. Flexible regulations can give companies the freedom to try creative approaches to environmental accounting that achieve the desired ends of the regulation more efficiently than is possible under current command-and-control approaches.

At the federal level, the U.S. Environmental Protection Agency (EPA) encourages the integration of pollution prevention and waste minimization activities (called Supplemental Environmental Projects, or SEPs) into enforcement settlements in exchange for penalty reductions. The seven categories of SEPs identified by EPA include:

- public health;
- pollution prevention;
- pollution reduction;
- environmental restoration and protection;
- assessments and audits;
- environmental compliance and promotion;
- emergency planning and preparedness.

A firm could propose a new materials and waste tracking system under the assessments and audits category. The extent to which penalty mitigation is used depends upon the benefits to the public and the environment at large; innovation; environmental justice; and multi-media impact and pollution prevention. The penalty reduction can amount to 80 percent of the cost of the SEP as a general guideline, and as much as 100 percent if the respondent is a small business, government agency or nonprofit organization. This program encourages companies to try new and different types of projects since SEPs cannot simply take the place of compliance that otherwise is legally required, and innovation is one criterion for determining penalty mitigation. Because these programs target companies that face enforcement action for environmental violations, they offer motivation to the environmental laggards who likely need the most assistance in initiating environmental projects. Giving environmental laggards the opportunity to try projects such as implementing TCA systems would be a creative application of the SEP concept. Many states, including Massachusetts, Washington, California, Indiana, Illinois, Texas, Florida, and

Ohio, have followed EPA's example and have developed or are developing similar programs (Ohio EPA, 1995).

EPA is also working with the management accounting community to develop means for institutionalizing environmental accounting, including TCA methods. One outcome may be guidelines for environmental accounting for large government contractors. This effort would create a foothold for TCA within a segment of the business community that is familiar with advanced management accounting practices and has the financial resources implement programs necessary to track costs. In addition, there has been some discussion with EPA of a voluntary program such as 'Green Lights' and the 33/50 program to encourage the dissemination of Environmental Accounting methods.

At the state level, Technical Assistance Programs initiated by state governments and containing environmental accounting components are excellent resources for businesses of all sizes. TCA-type programs in the form of training, demonstration and technical assistance have been launched by Illinois (to train Certified Public Accountants and demonstrate TCA methods), New Jersey (demonstration), and Massachusetts and Washington (training and technical assistance). These programs primarily focus on small firms, the segment of the business community that is most in need of financial and technical assistance, least likely to be aware of TCA, and least likely to have the resources to implement it. Integrating TCA into the mainstream of environmental assistance programs will go a long way toward making TCA standard practice.

5. CONCLUSIONS

There are numerous advantages to Environmental Accounting strategies, especially TCA. With respect to capital budgeting decisions, it is clear from this study and preceding work that TCA helps make costs/savings more complete, more consistent, and more comparable in comparing current and alternative manufacturing practices. In addition to improving the scope and accuracy of investment decision-making, TCA also can facilitate integration of environmental improvement with broader objectives of competitiveness through cost management, production flexibility, and stronger market position.

Two of the in-depth case studies performed as part of this project illustrate the use of TCA as an investment decision-making tool. As illustrated in the SLP case study, TCA may sometimes provide a financial foundation for what is often sound intuition on the part of facility management. TCA does this by providing a consistent framework for dealing with less tangible items such as the potential for increased revenues, which, from a business strategy standpoint, may be decisive in justifying capital outlays. On the other hand, TCA does *not* ensure that environmental projects will be profitable, or surpass a company's hurdle rate, as is illustrated by the Quebecor case study.

Regardless of the outcome of a particular analysis, TCA *does* help ensure that the limited capital resources are rationally allocated in that it often more accurately characterizes the potential profitability of a project than a more conventional analysis. The inclusion of 13 cost items in the Quebecor TCA (vs. the 3-4 cost items in the original analysis) changed the project IRR by only a few percent because both neglected costs and savings were uncovered by the TCA. The neglected costs almost balanced out the hidden savings in the end. However, the inclusion of 15 cost items in the SLP TCA (vs. the 3 items in the original analysis) illustrated that the project profitability was more than double the original estimate. This is valuable information for the firm in the short-run, and will hopefully encourage a closer look at profitabilities for projects considered in the future. The SLP case study also illustrates that non-environmental costs, savings, or revenues can be the key determinants of profitability for projects that contribute to environmental improvement.

The value of accurate and consistent cost allocation is illustrated by the RM case study. The existence and necessary treatment of an undesirable product haze led to the selection of that product line for a focused P2 effort at the facility. However, the cost implications of the hazardous waste stream were not allocated and captured by the accounting system used as a basis for product costing and pricing. Discrepancies in labor cost allocations were also identified, one of them potentially quite significant. The Life-Cycle project being undertaken by this firm provides a timely opportunity to revisit the existing cost allocation procedures to improve the quality of the data gathered and allocated for a variety of decision-making purposes.

The in-depth TCA case studies described in this report are fairly comprehensive, and included data collection and/or allocation on numerous cost items to provide as accurate a characterization of profitability as possible. Investment costs were generally easy to obtain, but operating costs were more difficult to assess accurately. Operating cost data collection included manually leafing through purchasing invoices at one firm. In addition to comprehensive data collection, the actual data entry and analysis of each case study was done for a number of sensitivity analyses, particularly in the case of SLP, where many relevant variables, such as sales volumes, were changing with time. We estimate that a company employee somewhat familiar with the facility's processes and the project at hand could perform a comprehensive TCA of this sort in 2 to 3 days. The necessary time commitment greatly depends on the specific project under consideration, the ready availability of data, e.g., computerized purchasing records, and partly on the desired format and detail for the final project report.

Unfortunately, there are a number of internal and external barriers to the implementation of TCA and other environmental accounting practices. Internally, many companies are unwilling to change their business-as-usual practices, or do not have the financial or information resources necessary to implement TCA on their own. One important barrier may be a perception that TCA requires an overhaul of existing managerial accounting systems; it does *not*. . Incremental, piecemeal progress towards TCA and better EA practices can be easy and affordable, even for the smallest and busiest of firms. For example, a simple expansion of the typical cost/savings inventory for project analysis would be a step in the right direction for many firms. Even if a small firm is unwilling or unable to generate or use a "complete" cost/savings inventory, simply adding a few of the potentially more significant items to the list will lead to more accurate analysis.

Tailoring the inventory to specific industry sectors or industrial processes can also be quite useful. The expanded, tailored inventory can be used as a simple checklist during project analysis, to ensure more consistent analysis for potentially competing projects, for comparison of investment trends over time, and for tracking the post-implementation financial success of projects. Financial analysis software can make the mathematical calculations less of a burden and enable easy sensitivity analyses. TCA should be geared to the needs and resources of individual firms, and its implementation will vary widely from firm to firm. Similarly, the necessary resources for data collection and analysis will vary.

With respect to data collection, there may not be an easy way to speed up manual extraction of relevant data from written records when a facility does not routinely enter and store this information on a computer system, as is the case for many smaller firms. Even for firms that do track purchasing, inventory, production, and product shipments via computer, many data items such as process specific labor and energy costs are not allocated and readily available in written records or on computer. Our experience, and that of others who have performed TCA case studies, is that many labor cost and savings estimates can best and most easily be estimated by the individual responsible for the labor activity. Energy costs can similarly be obtained via approximate engineering estimates. In sum, the goal should be to make reasonable estimates of potentially significant costs and savings without expending an inordinate amount of time on the data collection effort. Uncertainty in cost estimates can better be handled via sensitivity analysis than by a search for more accurate data that might not be available at all.

Externally, regulation may create a barrier to TCA by diverting limited capital to compliance projects, by preventing companies from trying new ideas or technologies because they do not conform to narrowly-written regulations, or by failing to create incentives for facilities to improve environmental performance beyond the minimum required compliance.

None of these barriers are insurmountable, and all need not be removed before progress toward TCA approaches can occur. Federal and state agencies can facilitate the spread of environmental accounting and TCA methods by creating flexibility within regulations to encourage innovative ideas and technologies, and by providing educational and financial opportunities for firms interested in improving their financial analysis methods, their environmental performance, and their competitiveness. In addition, by creating standards for EA and liability, the government can create a model of TCA methods that can guide companies seeking to adopt TCA approaches.

The Illinois firms interviewed in the Phase I and II case studies represent two different industry sectors and a range in firm size. Although the explicit commitment to environment and the specific activities to improve environment, P2 or otherwise, vary widely among these firms, all acknowledge the reality and legitimacy of environmental issues in their day to day business operations. All want to make improvements within the context of running a successful business subject to both internal and external constraints. Given the right incentives, along with minimization of potential barriers, Environmental Accounting and Total Cost Assessment can move these and other firms along a continuum towards the improved environmental performance and business performance that will help them to be good corporate citizens with long-term, competitive future.

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Appendix A - Facility Questionnaire

TOTAL COST ASSESSMENT:

Catalyzing Corporate Commitment to Pollution Prevention in Illinois

Facility Questionnaire

Sponsor
Illinois Hazardous Waste Research and Information Center (IL HWRIC)

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Part I - Facility Profile: General and Environmental

Please review the questionnaire and fill out as much information as possible prior to our visit. Use extra sheets and attachments as needed. We will elaborate on these questions during our visit, and also address some other items relevant to the financial analysis of environmental projects, such as issues of cost inclusion and allocation, the potential benefits of a Total Cost Assessment (TCA) approach, and potential barriers to TCA adoption.

The first set of questions covers general management, product lines and processes, and environmental emissions.

1. Background Information

   a. Name and address of facility:
   ____
   ____
   ____

   b. SIC code(s) ____________
   c. Number of employees ____________
   d. Average Sales ($/year) ____________
   e. Age of facility ____________
   f. Does the company have other facilities? ____________

2. Respondent Information

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

   ____
   ____
   ____
   ____
   ____
   ____

3. Briefly describe the major processes that are used to manufacture principal products, or to provide principal services. Please list in order of significance (based on 1994 sales).

Product/service	Process
______________ ______________	______________ ______________ ______________ ______________
______________ ______________	______________ ______________ ______________ ______________
______________ ______________	______________ ______________ ______________ ______________
______________ ______________	______________ ______________ ______________ ______________

4. Briefly describe the major waste streams generated by the products/processes described above or by other activities on-site (e.g., power generation). Waste stream types include air emissions (e.g., VOCs, SO_2), hazardous wastes (e.g., spent solvents, waste oil), and water-based effluents (e.g., BOD, metals). Management/disposal methods include both on-site methods (e.g., on-site wastewater treatment, use of an air stream scrubber) and off-site methods (e.g., shipment of hazardous waste to landfill, use of POTW for sewered waste).

Product/Process/Activity	Waste Stream (type, volume, management/disposal method)
____________________	____
____________________	____
	____
	____
____________________	____
____________________	____
	____
	____
____________________	____
____________________	____
	____
	____
____________________	____
____________________	____
	____
	____

5. Management structure

   a. Briefly describe the management structure of the firm and/or facility as it relates to environmental decision-making.

   ____
   ____
   ____
   ____
   ____

b. List the individuals in the firm and/or facility normally involved in decisions on environmental matters?

Name	Title and Responsibility
____________________	____
____________________	____
____________________	____
____________________	____

c. Does the firm and/or facility 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 second set of question covers recent, ongoing, and pending environmental projects at your facility.

6. Recent hazardous waste, air and water pollution reduction initiatives.

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

   Project 1:

   Description: ____
   ____
   ____
   ____

   (e.g. installed silver recovery unit)

   Motivation: ____
   ____
   ____
   ____

Effects on Hazardous Waste Generation, Air Emissions, and Water Effluent:
(e.g. reduced silver emissions by 95%)

____
____
____
____

Approximate Capital Outlay: __________________
Year Completed: __________________

Project 2:
Description: ____
____
____
____

(e.g. switched fountain solution)

Motivation: ____
____
____
____

Effects on Hazardous Waste Generation, Air Emissions, and Water Effluent:
(e.g. reduced VOC emissions by 50%)

____
____
____
____

Approximate Capital Outlay: __________________
Year Completed: __________________

7. Ongoing and pending hazardous waste, air and water pollution reduction initiatives.

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

Project 1:
Description: ____
____
____
____

Motivation: ____

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

Approximate Capital Outlay: ____________________

Status: ____________________

Project 2:

Description: ____________________

Motivation: ____________________

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

Approximate Capital Outlay: ____________________

Status: ____________________

Part II - Financial Analysis of Environmental Projects

The first set of questions covers general capital budgeting procedures at your firm.

1. Please describe the capital budgeting procedure at your facility. Is it formal or informal? Annual vs. ad-hoc? Is there an annual limit on capital spending? If your firm has more than one facility, at what level does capital budgeting occur - at the corporate level, division level, plant level, or some combination?

____
____
____
____
____
____
____
____
____

2. What has been the average total capital expenditure at your facility over the last 5 years?

____

The second set of questions covers capital budgeting for environmental projects at your firm.

3. Is there a single budget pool for all capital projects, or do environmental projects (compliance and non-compliance) have a separate pool?

____
____

4. On average, during the last five years, approximately what percentage of the facility's total capital and operations/maintenance budget has been spent on environmental projects?

	$/year	%
capital	____________	______
O&M	____________	______

5. Have your capital budgeting practices for environmental projects changed in any significant way within the last 5 years?

____
____
____

Appendix B - Phase I Case Studies

SMALL LITHOGRAPHIC PRINTER (SLP)

Company and Facility Background

This company is a small lithographic printer, printing 2-color and 4-color posters, cards, and booklets. Many of the company's customers are community groups, political groups, or national non-profit organizations, but the company also serves commercial clients.

There are a large number of small print shops in the area which compete on price, quality, and service. The company tries to differentiate itself based on its customer service by developing close relationships with customers. The company also works hard to keep costs and prices low to remain competitive. Sales in 1995 were approximately $900,000.

The company, started in the late 1960s at an Illinois university, later moved to its present location and became a non-profit organization. In the mid-1980s, the company became incorporated as a for-profit cooperative in order to gain access to financing through avenues that are unavailable to non-profit organizations. There are eight partners who make business decisions collectively, plus seven other employees.

The company moved to its current location in late 1994. The building, which the company owns, is about 40 years old and is located in an urban area.

Materials, Processes, and Environmental Impacts

This printer provides traditional lithographic printing, including pre-press, printing, and some post-press processing. The company's current computing abilities are limited, so disk-based jobs requiring computer pre-press operations are sent to a service bureau to produce film for platemaking. These jobs represent about 40 percent of the company's total jobs, a percentage that is rapidly increasing.

The company runs two 2-color sheetfed presses. The company uses about 98 percent soy inks (instead of petroleum-based inks) and about 65 percent recycled paper. Lithographic presses additionally require a fountain solution and a blanket wash solvent. Fountain solutions that contain isopropyl alcohol (IPA) are standard in the industry, but the company uses a less volatile glycol ether fountain solution. The company also uses a citrus-based blanket wash instead of the traditional organic solvent-based blanket washes that generate volatile organic compounds (VOCs). This citrus-based cleaner is also used for most press clean-up operations. An aqueous detergent is used for cleaning press rollers. For platemaking, the company uses an aqueous plate processor. The company also has a darkroom for silver film tray developing. Post-press capabilities include machine folding, stapling, and saddle stitching, and hand collating up to about thirty thousand sheets.

The company believes that it produces very few air emissions, because it uses non-heatset lithography, mostly soy-based inks, a non-volatile fountain solution, and a low-VOC blanket wash and press cleaner. The major waste streams are darkroom chemicals, platemaking solutions, and printing waste.

Film developing in the darkroom produces spent fixer and spent film developer. Spent fixer, about 6 gallons per year, is poured through a small silver recovery unit. The Production Manager suspects that the recovery unit may be too old to recover very much silver from the fixer. The spent developer, about 24 gallons per year, is washed down the drain.

Platemaking produces about 9 gallons per year of spent plate developer, which is also washed down the drain. The Production Manager is concerned about the plate developer and the film developer. Both are aqueous, and the vendors assure him that it is safe to pour them down the drain, but he is not sure about the regulations or the possible environmental effects.

Printing waste includes spent fountain solution, dirty solvents and cleaning rags, and dried-up ink. Spent glycol ether fountain solution, about 260 gallons per year, is poured down the drain. Dried ink, about 130 pounds per year, is skimmed off and thrown in the trash. A rag service collects dirty rags and provides clean ones. The rag service also collects the company's dirty citrus-based solvents. The Production Manager does not know what the rag service does with the rags or the solvent waste.

Environmental Management

The company's mission statement "demand[s] respect for ourselves... and our workplace.... This means building a workplace... that nurtures our concern for others and our environment." The Financial Manager emphasized that the company's owners are also the company's employees, and that they are concerned about their own health. They also are motivated by a desire to protect the environment and to be early adopters of environmentally preferable materials and technologies. Furthermore, the company serves a customer base that is environmentally conscious, so it is important for the company to project a green image.

As a small waste generator, the company faces neither reporting requirements nor strict enforcement. The company does face OSHA enforcement for workplace safety.

Responsibility for environmental management rests primarily with the Production Manager. He negotiates with chemical suppliers and waste disposal vendors, and oversees the day-to-day operations that use chemicals and produce waste.

In late 1994 or early 1995 the Great Printers Project (GPP) approached the company about becoming a "Great Printer." GPP is a Great Lakes Basin initiative aimed at establishing pollution prevention (P2) as a standard practice in lithographic printing. Unfortunately, at the time, the company was overwhelmed with its move to the new building and was unable to participate. However, the company would consider participating in the future.

Recent and Pending Environmental Initiatives

Soy inks

Over the course of several years, from 1993 to 1995, the company switched from traditional petroleum-based inks to mostly soy-based inks. Now the company uses soy inks for almost all of its work—only metallic colored inks still lack satisfactory soy-based substitutes. Soy inks may be somewhat more expensive, but the company is committed to the switch and has not priced solvent inks in several years. In order to use soy inks, the company purchased some inexpensive metering equipment to maintain a proper fountain solution to ink ratio.

Petroleum-based inks are problematic because they emit VOC's as they dry. Soy inks—which contain lower levels of petroleum oils—at one time were a poor substitute because they dried slowly and did not provide high quality color. But in the past several years soy inks have improved dramatically and have become less expensive. The company's Production Manager wanted to switch to soy inks early and began testing them regularly in the mid-1980's. He began using them in 1993 when he found acceptable performance.

The primary motivation for switching to soy inks was to reduce pollution and worker health hazards. The partners decided that they were willing to spend more for soy inks as long as the printing quality was acceptable. Thus they subjected the soy inks to rigorous performance testing, but not to rigorous financial analysis.

Citrus-based solvents

In 1994 and 1995, the company stopped using organic solvent-based blanket washes and switched to a citrus-based blanket wash that is also used for press clean-up. (The company uses an aqueous detergent for cleaning press rollers.) The citrus-based solvent evaporates much less than traditional solvents, and its odor is strong but not objectionable. Also, unlike traditional solvents, it is non-toxic and is not classified as hazardous waste after use.

The citrus-based solvent costs about $300 more per year to purchase. There is no savings on disposal costs because, although the citrus-based solvent is non-hazardous, the disposal vendor still charges the same rate.

As with soy inks, the primary motivation for switching to the citrus-based solvent was to reduce worker health hazards and pollution. The partners are willing to pay more for the citrus-based solvent because it provides a safer and more pleasant work environment and is safer for the natural environment as well.

Computer pre-press system

The company is presently considering the purchase of a computer pre-press system. A typical system consists of a scanner, a computer, and a film processor. The system will be able to directly process jobs that customers submit on computer disk; jobs submitted as camera-ready art can be scanned and then processed. The film processor will produce film that can be used in platemaking, thus bypassing the darkroom entirely. Some systems use thermally processed film that eliminates the use of chemicals altogether.

The company wants to purchase an integrated turn-key system from a single vendor to avoid product incompatibilities and facilitate maintenance and technical support. A typical system includes two high-end computers, a scanner, an imagesetter, and a film processor. The cost of these systems ranges from $35,000 to $60,000, depending on speed and features.

A computer pre-press system will allow the company to bring disk-based jobs—which are currently sent to a local service bureau for processing—back in-house. The company would save $3,000–4,000 per month in avoided service bureau and courier expenses. Conducting all pre-press operations in-house will reduce job turnaround time by about 24 hours on disk-based jobs. In-house processing will also provide more control over pre-press decisions, and will avoid darkroom costs on most jobs. The Production Manager expects to continue using the darkroom for jobs that involve halftones because most scanners cannot reproduce halftones faithfully.

The primary motivations for this project are to streamline pre-press operations, avoid service bureau costs, and provide new capabilities that will increase product quality and attract new business. Avoiding darkroom use is a significant secondary motivation.

Financial Analysis of Environmental Projects

Capital budgeting at the company is ad-hoc and informal. The eight partners develop a wish list of ideas to be funded when money becomes available. For most capital expenditures, a subgroup scopes out possibilities and makes a recommendation back to the group of eight, who then make a collective decision. Projects under $500 can be approved by just one partner.

The company does not have the expertise to use financial indicators beyond simple payback, and does not collect the data necessary to conduct rigorous financial analyses. When evaluating capital expenditures, the partners estimate costs, savings, and intangibles and make an intuitive judgment. Time horizons vary depending on the project. Because the company is located in an economic development zone, it is allowed to use accelerated depreciation schedules on capital equipment.

When considering a capital expenditure, the company's partners try to look at all aspects of the project. Most issues are not quantified, but are taken into account through the collective decision-making process—which brings many opinions to the table. Because the partners are not profit-oriented and are all workers as well as partners, they tend to take greater notice of environmental, health, safety, and other non-traditional costs.

Capital expenditures in the past five years have been unusually large because the company purchased a new building and replaced most of its equipment. During this time total capital expenditures averaged between $120,000 and $140,000 per year, but expenditures will be much less over the next five years. The Production Manager estimates that about one percent of capital expenditures and one percent of operating costs are environmental.

The company does not allocate the costs of press operation or waste disposal to their products. The Production Manager explains that allocating these costs would be very difficult due to the large number and variety of jobs. Instead, an overhead charge is included in the hourly rates used to compute job prices. The company does track costs at the department level (Office, Pre-press, Press, and Bindery) in order to flag unusual costs.

Perspectives on TCA

The Production Manager sees a need for TCA at the company. Although collecting cost data would require some expenditures of both time and money, it would streamline the capital budgeting process and help the partners make better decisions. If implementation costs were not too great, the benefits would be worth the effort. He feels that two prerequisites for instituting TCA are (1) a computer system that would automate the TCA calculations (and handle other financial and office chores as well) and (2) a method for tracking or sampling labor costs for different types of jobs. These would not only enable TCA, but would also improve the process of job pricing. The company does plan to begin using a computer job-cost estimator.

The company does not perceive any significant external barriers to TCA. The Financial Manager and the Production Manager feel that the greatest internal barrier to TCA at the company is lack of knowledge. First of all, they are unsure about the hazard characteristics and handling requirements of their chemicals and about the quantitative relationship between wastes and different types of jobs. Second, they lack the expertise to conduct rigorous financial analyses. Technical assistance would be helpful in this regard.

METO GRAFICS, INC. (METO)

Company and Facility Background

Meto produces instrument panels, nameplates, overlays, decals, dials, scales, and signs using a wide variety of materials, including aluminum, stainless steel, acrylic, polycarbonate, plastic/metal laminates, and paper. Its customers are primarily producers of industrial equipment and some architectural products. Most customers are domestic, but Meto has some international sales. Meto's official SIC codes are 3596 (scales and balances), 3625 (relays and industrial controls), 3643 (current-carrying wiring devices), 3825 (instruments for measuring and testing of electricity), and 3993 (signs and advertising specialties), although, in Meto's opinion, these do not accurately reflect its operations.

Meto prides itself on flexibility and customer service and is committed to continuous improvement. Meto is working toward ISO 9000 certification for its quality management systems and has had MIL-I-45208 quality certification since 1989. Its competition varies widely due to the diverse nature of Meto's product offerings. The market for engraving, for example, is large and has many competitors, while the etching market has just a few main players. Generally, in terms of volume, with annual sales of $950 thousand, Meto is on the small end of the competitive spectrum.

Meto was founded by the current President's father just after World War II. Initially he made signs for the Greyhound bus company in his own garage. In 1961 Meto moved to its current location, and upon the founder's death two years later, ownership was passed on to his wife. The current President took over operations in 1972 and became the sole owner of the corporation's stock in 1986. There are currently about eighteen employees, although there have been as many as twenty-four in the past. Management works to involve employees in decision-making, with monthly company meetings and with employee committees such as the safety committee. If Meto exceeds its weekly shipping goal, the President cooks a barbecue lunch for the employees. The company's mission statement includes the phrase "...and have fun doing it."

Meto's facility is 47 years old. Offices are on the second floor of the company's single building, and most production is on the first floor. There is some production equipment on the second floor, which requires employees to carry project materials up and down the stairs. Meto is planning to build an addition to its current facility for future expansion, but will rent out most of the new space until it is needed.

Materials, Processes, and Environmental Impacts

Meto has such a wide variety of products that some processes are not in use full-time. The main exceptions are screen printing and fabrication, as almost every substrate is machined and screen printed at some point.

Aluminum Anodizing

Many of Meto's products involve screen printing on anodized aluminum sheets. For low quantity jobs and rush jobs Meto purchases pre-anodized sheets, but for most jobs the sheets are anodized on site. Anodizing opens the pores of the aluminum, making it receptive to dye suspended in the ink vehicle. The anodizing equipment, one of two process located on the second floor, consists of a 200-gallon tank of sulfuric acid in deionized water and a caustic etch tank. Prior to anodization, a sheet of aluminum is cleaned in the 25-gallon caustic etch tank. The sheet is then immersed in the sulfuric acid solution and is oxidized for 45 minutes using an electric current. The waste sulfuric acid solution is neutralized with waste caustic solution and additional caustic powder and then is released to the plant's septic system.

Darkroom

Meto obtains most of its film for printing from a service bureau. The second-floor darkroom at Meto is small and used only in special situations, about two or three times per week. There is a process camera for enlargements and reductions, and trays for traditional film development. There is also an exposure unit and an autoprocessor that handles both developer and fixer. Spent darkroom chemicals, less than 20 gallons per year, are poured down the drain. Due to the small volume of darkroom fixer used, Meto does not attempt any silver recovery.

Metal Etching

Some of Meto's products involve etching and inking of metal plates. The conveyor etching machine, located on the first floor, uses ferric chloride (and sometimes hydrochloric acid) for etching and water for the two rinsing steps. After the plate is etched, it is filled with ink by hand. Typically, several jobs per week involve etching.

The etching chemicals are completely contained within the etching machine. Operators need to periodically recharge the chemical supply and fill out shipping manifests prior to etching chemical waste pickup by a vendor. Meto generates enough waste chemicals to fill a 55-gallon drum every three weeks. The waste vendor is called once three barrels have accumulated, so that Meto can avoid being designated a Treatment, Storage, and Disposal facility (TSDF) under the Resource Conservation and Recovery Act (RCRA). Because these chemicals are considered a RCRA hazardous waste, they are more expensive to dispose of than to purchase, so Meto periodically solicits waste vendor bids to be sure that it is using the most economical service. Currently, this waste is picked up by the same company that supplies the fresh chemicals.

Metal Shop

Meto has a wide variety of tools for cutting, engraving, punching, and polishing metal and plastic. Scrap aluminum and stainless steel are sold to a metal recycler, and scrap polycarbonate is sold to a plastics recycler.

Screen Printing

Meto has two automated screen presses. They use six types of inks, depending on the printing substrate and the intended use. (1) Epoxy inks are used on brass, stainless steel, aluminum, and phenolic plastics. (2) Polyester inks are used on polyethylene and aluminum. (3) Alkyd enamels are used on aluminum and stainless steel. (4) Ultraviolet-curable inks are used on paper, polycarbonate, print-treated polyester, vinyl, and stainless steel. (5) Vinyl inks are used on vinyl, polycarbonate, polyester, and styrene. (6) Water-based inks are used on polycarbonate. Scrap ink is saved and disposed of through waste treatment companies.

In screen printing, porous screen material is processed in an exposing unit so that only the desired areas will allow ink to pass through. The screen is applied to the substrate, and ink is forced through the porous areas. Before printing, stainless steel substrates are cleaned by hand, using household cleaners, and aluminum is cleaned in a caustic solution. After printing, some substrates are processed in a 56-gallon sealing tank of boiling water and sealing salts to close pores. Waste from the sealing process is transferred to the septic system.

After printing, waste ink is cleaned manually from the screens using a low-toxicity spray cleaner, putty knives, and rags. The screens are then sent to the screen reclamation area for final cleaning with biodegradable screen-cleaning chemicals that are poured down the drain after use.

Spray Booth

Some of Meto's products need to be painted with a solid overcoat before printing. This process is done in a well-ventilated paint spray booth. The vapors from this process are channeled through woven filters and then exhausted. The filters, which collect paint particles from the air, are disposed of as a special waste. Previously, the Illinois Environmental Protection Agency (IEPA) required that the filters be treated as hazardous waste due to high solvent content. Meto found that the process of cleaning the paint guns, and not the painting itself, was responsible for the solvent accumulation in the filters. By changing its process so that the guns are cleaned in a waste solvent solution that is then distilled and recycled, Meto is no longer required to treat the filters as hazardous waste.

Several types of paints are used, particularly epoxies and solvent-based paints. These materials are handled and stored very carefully; e.g., paint cans are always kept closed, there are strict inventory controls, and partially used paint containers are disposed of after one year. Meto manages its inventory such that only about ten gallons of paint are disposed of in this manner each year. This waste is collected in a sludge barrel and is disposed of as hazardous waste.

Environmental Management

The Vice President of Administration at Meto is also the Environmental Manager. He is responsible for compliance and waste disposal, and reports directly to the President. He works closely with an environmental and safety consultant, who helps make sure that Meto files all regulatory forms correctly and on time. The consultant also conducts a monthly facility audit for compliance with environmental and workplace safety regulations, helps with staff safety training, and attends quarterly staff meetings.

The Environmental Manager also chairs the Safety Committee, which is made up of Meto employees. The Safety Committee inspects the facility on a weekly basis, and reports to management if something needs remediation. The Safety Committee meets monthly with the environmental and safety consultant to review any incidents and to make sure that safety logs are up to date. According to the Environmental Manager, spills are infrequent and injuries are very rare.

Incidents of solvent exposure have happened only a few times in the company's history and have never required medical attention.

As a way to motivate a continuous improvement process, Meto has a "Meto Money Makers" incentive plan. The plan provides bonuses to employees for suggestions that save money. Environmental projects are included in this plan. The VP estimates that over a third of the projects in this program are environmental or OSHA-related. These projects do not typically reap huge savings; $400-500 is probably saved each year.

There is a weekly management meeting, including the President, the Environmental Manager, the Quality Assurance Manager, and the Production Manager, at which safety and environmental issues such as concerns raised by the Safety Committee may be reviewed.

Meto has no specific environmental mission statement, and the overall mission statement does not currently mention environmental or safety issues. However, it is being revised, and the President and the Environmental Manager state that environmental and safety issues are very important to the company and becoming more so. They acknowledge the need for further environmental improvements.

Recent and Pending Environmental Initiatives

Solvent Recycling

In the first quarter of 1995, Meto had 23 drums of spent paint thinner solvent on site. Instead of hiring a waste vendor to dispose of the solvent, Meto decided to purchase a solvent distillation system. Currently, the system processes about 16 gallons of solvent and produces 8–10 ounces of still bottoms per day of operation. A waste vendor periodically comes to pick up the still bottoms, which are a RCRA hazardous waste.

The capital cost of the project was $2,300. The project provided the potential for a one-time savings of $9–10 thousand from avoided costs of purchasing new solvent. The project was motivated primarily from a desire to avoid a large one-time waste disposal charge and to avoid future solvent purchase and disposal costs. These latter cost avoidances save Meto an estimated $6–7 thousand each year. Reducing pollution was also an important secondary motivation.

The project would have been more profitable had IEPA not required that Meto hire a waste vendor to collect the 23 drums of solvent instead of recycling them. Meto was forced to make a major one-time purchase of new solvent despite having in-house recycling capabilities. The Environmental Manager believes that if Meto had known about this problem ahead of time, he still would have gone ahead with the still project.

Alternative Screen Reclamation Chemicals

Meto tested alternative cleaners for reclamation of printing screens in order to reduce worker exposure to the previously used solvent, methyl ethyl ketone (MEK). Meto began to use a non-toxic cleaner for the first phase of screen reclamation late in 1995. The cleaner Meto is now using is three times more expensive by volume than MEK, but less is needed per screen because operators can spray it where it is needed instead of soaking the whole screen.

Meto had received information on a series of alternative screen cleaners from a report published by US EPA's Design for the Environment Program, but, to avoid product endorsements, EPA withheld the trade names of the cleaners from the document. Thus Meto had to individually test each alternative even though EPA had already tested them. This was frustrating to the Environmental Manager.

Another challenge was to convince employees to accept a new cleaner, particularly one that required changing established practices. In the case of the cleaner finally selected, employees reacted to the change positively because they found it easier to spray cleaner where it is needed than to immerse the entire screen.

The primary motivation for this project was to reduce or eliminate worker exposure to hazardous solvents, possibly at a net cost to the company.

Alternative Inks and Paints

Meto also recently began examining alternatives to solvent-based inks and paints. Meto already uses aqueous and ultraviolet curable inks on some substrates, but hopes to further reduce its reliance on solvent-based inks for other surfaces. Meto will conduct extensive testing to find inks and paints that will not compromise quality but will be environmentally preferable. The problem is more difficult for Meto than for most printers because solvent-based ink prints effectively on such a wide variety of materials.

Financial Analysis of Environmental Projects

The President and the Vice President for Administration are involved with all environmental and non-environmental capital budgeting decisions, and all projects must be approved by the President. Capital budgeting is mostly informal and ad-hoc. Management tries to set a capital budget at the beginning of the year, but project ideas and investment needs often arise later. Typically, the President and Vice President together will decide whether to make an unbudgeted capital outlay.

Over the past five years, Meto's capital expenditures have varied from $0 to $35,000 per year. The Vice President estimates that about 15 percent of capital costs and 8–10 percent of the operating costs during that time have been for environmental expenditures.

Meto uses return on investment, considering costs and savings over a two year time horizon, as the profitability indicator for evaluating projects. Meto does not use a strict hurdle rate; the real criteria is the effect on cash flow. Because of longer-term changes in the industry, such as substitution of plastics for metal and the increase in the use of computers for pre-press operations, Meto does plan strategically over a longer time horizon.

Meto considers a fairly extensive inventory of potential costs and savings; whether these are quantified, however, depends on the scope of projects. For example, more costs and savings will be quantified for more expensive projects or for projects that have major effects on the workplace or the environment. Meto's costs of compliance and costs of potential future liability are perceived as small, so these costs are usually considered qualitatively. Meto has begun to place stronger emphasis on taking environmental costs into consideration, even for non-environmental projects.

Costs not easily traceable to products are assigned to overhead and are not reallocated to products. It would be difficult to reallocate these costs because Meto produces such a large variety of custom-made products.

Perspectives on TCA

The Vice President recognizes the value of a more comprehensive method of financial analysis of environmental projects at Meto. He feels that environmental costs are important to understand and include in order to improve the environmental integrity of Meto's products and processes. Implementing TCA would require changes in Meto's accounting system to reallocate costs from overhead to processes, but it would provide a much clearer picture of the cost drivers in Meto's operations.

Meto has found that regulatory inflexibility can be a barrier to P2. A prime example was the IEPA's insistence that Meto dispose of its 23 drums of spent solvent instead of recycling them on site. In the Environmental Manager's opinion, US EPA's "common sense" approach has not filtered down to IEPA.

Meto also is faced with a lack of data. The Environmental Manager would like to know the true costs associated with wastes, such as the environmental damage that they cause after they are hauled away by waste vendors. He would also like to know how much of Meto's waste could be avoided by increasing process efficiency.

Meto is aware of Small Business Administration programs through which it could pursue loans for its environmental projects, but the burdensome paperwork requirements make it simpler to self-finance or seek commercial bank loans. In general, Meto tries to exploit all available resources to advance its pollution prevention initiatives.

BEMA FILM SYSTEMS, INC. (BEMA)

Company and Facility Background

Bema Film Systems is a small flexographic printer and producer of plastic bags and plastic rollstock. Half of Bema's sales are directly to customers and half go through print brokers. Bema products are primarily used for packaging. The bags are printed by Bema and used as-is by customers; the rollstock is processed by customers in their own packaging processes. Both rollstock and bag products are offered in a variety of colors, properties, and configurations which serve numerous end purposes.

Bema was founded by two brothers as the Shaw Paper Company in 1957. It now has 40 employees and has operated out of one 30-year-old facility since 1969. Located in the Chicago metro area, the facility is in a one-story building, one quarter of which is used for office space, cylinder storage, and maintenance equipment.

Bema has a sole proprietor, a brother of the founders, who runs the company as President and Chief Executive Officer. His management team includes the Sales Manager, the Office Manager, the Controller, the Plant Manager, and the Plant Engineer.

Competition in the flexographic printing business in the area is intense. Complicating the situation is the fact that some competitors operate in regions that are in attainment with the National Ambient Air Quality Standards (NAAQS) for ozone while the Chicago area is in non-attainment. Companies such as Bema that operate in ozone non-attainment areas face more stringent volatile organic compound (VOC) emission regulations, because VOCs are precursors to ozone. Thus Bema is subject to stricter emission standards which it feels limits its potential profitability.

Materials, Processes, and Environmental Impacts

Bema has a diverse line of operations because it both produces plastic film to make bags and it does flexographic printing. The processes are very distinct as characterized by different inputs, different required expertise, and different waste attributes.

Polyethylene Film

Bema has five extrusion machines for blow film extruding polyethylene film. Plastic pellets are melted and mixed and then formed into a bubble with a blown film extrusion process. The bubble is cooled in order to induce crystallization of the molten material. The now tube-shaped material is flattened, trimmed, and separated into sheeting in preparation for printing and bag making. Bema collects all of the trimmings – 9% of the material used – and recycles it directly back into the process. Operating conditions are controlled to alter the properties of the sheeting depending on its intended end use. The process uses different grades of polyethylene resin, including low density polyethylene, linear low density polyethylene, and various copolymers.

Printing

Bema uses a flexographic printing process to print on the polyethylene film. Using two central impression, wide web six-color presses, Bema prints bags for commercial packaging. An ink metering roller, known as an anilox roller, transfers ink from an ink pan to the printing plate. The ink is then transferred directly from the plate to the substrate, in this case, plastic film. Bema does not have in-house capabilities for producing plates. Bema's customers provide camera-ready art that is then sent off site to a plate maker.

A central impression press uses a single impression cylinder around which the substrate travels. Multiple printing stations surround the central cylinder, with each station applying a separate color to the substrate. An in-line hot air dryer dries the ink between stations. Residual hot air containing fugitive solvent VOCs is vented out of the top of the building. The process is complicated by the fact that the plastic film is sensitive to the heat and it tends to stretch, which limits the extent to which the film can be tensioned. Each press line is run by an operator who is responsible for all of the stages of the printing process and who reports to the press room supervisor.

Flexographic printing uses transparent dyes rather than inks containing heavy metals. The use of isopropanol and n-propanol solvents in these dyes produces 33½ tons of VOCs each year. These alcohol-based solvents are used for their fast-drying properties, their ability to evenly adhere to the polyethylene surface, and their ability to dissolve the pigment-carrying resins. As part of a previous pollution prevention (P2) effort, water-based cleaners are used for roller and floor washing. Waste ink is considered a hazardous waste and is picked up by a licensed disposal firm. Old cans with dried ink residue are not hazardous waste and are sent to a landfill for disposal. Dirty cleaning cloths that contain solvent, ink, oil, dust, and dirt are stored in closed containers, sent out to be cleaned, and then returned for reuse.

Bag Making

Printed film is converted to bags on one of 11 bag-making machines. These machines make bottom seal, side seal, reclosable, soft header, and reinforced header bags. The scrap, generated at a rate of about 5%, is collected into bailers and sent to a recycler who remelts and pelletizes it. These dark gray "repro" or reprocessed pellets are shipped back to Bema and made into trash bag liners that are sold to janitorial supply houses.

Environmental Management

Although Bema does not have any sort of environmental mission statement or formal corporate environmental commitment, the company considers itself to be environmentally proactive. Environmental decision-making is done by the President in consultation with the head of Sales and Product Development. Bema has worked with the Illinois Environmental Protection Agency (IEPA) often in the past, including hosting an intern as part of the Partners in Pollution Prevention program offered by the Office of Pollution Prevention. In addition, Bema has participated in the IEPA's small business task force.

Bema's primary pollution concern is air emissions that are subject to provisions of the Clean Air Act. Bema's facility lies in a non-attainment zone for ozone where the threshold for compliance is 25 tons/year (in attainment zones the threshold is 100 tons/year) based on potential to emit. Bema is currently above this threshold. Facilities in Illinois not in compliance with the existing State Implementation Plan were required to submit a compliance plan with their Title V applications, delineating the steps they would take to achieve compliance. The IEPA currently is working with various industries, including flexographic printers, to finalize requirements for emission controls. Bema is in the process of documenting for the IEPA difficulties it foresees with Title V implementation for flexographic printers. Bema's own Title V application was submitted last year and was accepted for completeness. It included a two-year compliance plan that allows time for the development of usable, low-VOC inks and installation of capture and control equipment.

Recent and Pending Environmental Initiatives

Water-Based Inks

In 1994, motivated by its high output of VOCs, Bema hosted a summer intern to conduct trials of water-based inks. During a trial with the water-based inks, VOC emissions were reduced by as much as 60%. The inks, which cost about the same as the solvent inks, could not be used on shrink and stretch bags, freezer bags, or products that require heat resistance because the inks did not adhere well enough and their coefficient of thermal expansion was different than that of the substrates'.

Nevertheless, these inks were used with some initial success in certain applications. There was a quality control problem with the water-based inks wherein plastic bags were sticking together after printing. Because this problem was not immediately identified and some of these bags went out to customers, this problem was quite costly for Bema. In addition, water-based ink residue is highly toxic and Bema has had trouble in the past finding local haulers to dispose of it because it cannot be incinerated and therefore requires more expensive disposal technology. Due to these problems and uncertainty regarding the pending regulations on emission control systems discussed below, Bema has suspended the use of water-based inks.

Water-Based Cleaners

Prior to 1995, Bema used solvents to clean print rollers and the press room floor. In addition to generating VOCs, use of these solvents rendered a hazardous waste – shop towels. A water-based cleaner was substituted for these solvents for use on the floor, cutting usage by 30 gallons per week, saving Bema approximately $300 annually, and reducing VOC emissions by an estimated one to two tons. While the new cleaner was slightly more expensive and required more labor to clean the press area, cost savings resulted from avoided solvent costs and reduced waste disposal costs. Bema is currently working with suppliers to find water-based cleaners to remove solvent ink residue from the print rollers.

Emission Control System

The Illinois Administrative Code requires installation of a VOC emission capture and control system when inks having a VOC content greater than 40% by volume (excluding water) are used by firms operating inside the ozone non-attainment area. The solvent inks Bema has traditionally used, after dilution for printing, have close to 80% VOC by volume. Although the control equipment would be quite expensive, it could capture 70% of the VOC emissions and destroy 90% of what it captures. For Bema, it would mean an annual reduction of over 21 tons of VOC emissions.

The equipment to capture fugitive emissions alone for the system would cost $300,000 plus another $150,000 for enclosure of the press room and installation. With the additional $50,000 estimated for mandatory system testing, the full project cost was estimated to be half a million dollars. Based on a 10% interest rate on borrowing, Bema estimates the total monthly bill for this system will be over $10,000. Bema's President feels that these additional costs could not be passed onto customers because competitors in Illinois outside of the non-attainment area and competitors out of state will not face such costs. He has therefore petitioned the Illinois EPA to provide relief from the regulation for flexographic printers.

While the use of water-based inks would bring Bema below the compliance threshold, these inks cannot be used for all applications and, as previously mentioned, Bema has not been able to achieve acceptable quality with them. If Bema were to install the emission control system, it would be unable to use water-based inks in the future as emissions from these inks poison the catalyst used by the control system. In addition, Bema is concerned about anecdotal evidence it has heard from Wisconsin suggesting that switching to water-based inks in order to avoid the need for a capture and control system is not economically viable.

Housekeeping Practices

To ensure environmental responsibility in day-to-day operations, Bema has established a number of pollution prevention housekeeping practices. The theory behind this initiative is that improvements in the plant's housekeeping are often the easiest and least expensive means of achieving waste reduction goals. Some specific procedures are to:

- minimize ink use in fountains and return unused ink to storage;
- centralize responsibility for storing and distributing solvents;
- use a first-in first-out inventory system and systematically track raw materials;
- purchase raw materials according to specific production needs; and
- keep storage areas neat and clean.

Generally, these practices are geared towards maintaining good inventory control and efficient operations.

Financial Analysis of Environmental Projects

As a small company, Bema does not have a formal capital budget planning process. The level of analysis detail depends on the nature of the project. A long term investment considered to be necessary for Bema's operations is assessed in consideration of the impact on the entire business. Other capital expenditures are considered secondary investments and are evaluated using a simple payback method or an ROI calculation. The overall budget for capital spending is ultimately constrained by cash flow. All projects, environmental and other, are considered together and funded out of the same budget.

Bema compiles a fairly comprehensive inventory of costs when considering a project. In addition to initial costs of purchase and installation, a range of operating costs including regulatory compliance, insurance, legal costs, and potential Superfund liability are taken into account. Using purchasing data, operation logs, and shipment reports, overhead costs are also assigned to individual projects and processes.

All of the analysis for each project is essentially done by the President, who requires an 18-month payback for capital expenditures. He does calculate ROI (for short-term investments) or IRR (for long term investments) in order to prioritize the projects. The time horizon for environmental projects is generally longer than that for other capital spending – 3+ years versus 18 months. Non-compliance projects are subject to a shorter payback period.

Perspectives on TCA

Bema's President does believe there is a need for a more comprehensive, systematic method of financial analysis for environmental projects both in his company and in the industry in general. A better analysis method would enable Bema to consider true costs and produce more meaningful results when performing capital investment analyses. He feels that in order to implement some sort of TCA process, he would need more personnel resources for the analysis.

Bema has found some mandated regulations to be unworkable, and gets frustrated with the by-the-book mentality of the regional office of the US EPA. And although the Illinois EPA has generally been helpful, the uncertainty regarding the implementation of many regulations leaves Bema very cautious and somewhat reluctant to undertake environmental capital projects.

BULK MOLDING COMPOUNDS, INC. (BMC)

Company and Facility Background

BMC produces thermoset fiberglass-reinforced polyester molding compounds in bulk, unset form. Customers then mold the compound into the necessary shape by applying pressure and heat. BMC's customers include companies that supply headlamp backings and valve covers to automakers, produce dental chair components, or supply airline food service trays. Other customers make consumer products, such as waffle irons and hot plates, which take advantage of the heat-resistant properties of BMC's compound. The customer base is concentrated in the Midwest and eastern United States. BMC's SIC code is 3087.

BMC's competitors include smaller independent producers and several vertically integrated companies who produce molding compounds for their own use as well as for external sale. BMC considers itself the quality leader in the market and is confident that it can charge a higher price than its competitors because its proprietary processes produce a product with greater purity and superior performance. In fact, BMC's revenues have been growing steadily at 25-35% annually in recent years.

BMC was founded in 1979 and sold to its present owners in 1989. It has since been wholly owned by four partners: the President & Chief Executive Officer, the VP for Manufacturing, the Senior VP for Research & Development, and the Sales Manager. Thus BMC is an S-Corporation, which pays taxes at the personal income rate. In addition to the four partners, there are sixty employees, fifteen of whom are temporary.

BMC had been located in a single, leased facility in a suburban industrial area. In the past few years, a sizable residential community had developed nearby the 16-year-old facility. BMC had already expanded its operations to the limits of that facility, so BMC is purchased a new, larger facility to which it is currently relocating. The new facility was built in the late 1950s, and was previously owned by a Fortune 500 company. It is also in a suburban industrial area, but is not located near private residences.

Materials, Processes, and Environmental Impacts

BMC's thermoset polyester molding compounds are made from unsaturated polyester resins, fiberglass, organic peroxides, and mineral fillers—primarily lime. Pigments and other additives are used to produce the specific appearance and performance characteristics desired by the customer. These inputs are blended and compounded in batch processing units, and then extruded into appropriate shapes for shipping, depending on the customer. In addition to the batch processors, BMC has a small laboratory and a molding press for product testing.

In the processes of compounding and extruding product, BMC annually emits 26,000 pounds of fugitive volatile organic compounds (VOCs), mostly styrene monomer. The odor of styrene is detectable at very low concentrations, and thus, although it is not a health hazard at these levels (less than one percent of EPA's legal limit), it is a nuisance to BMC's neighbors. The pending thermal oxidizer project, described below, will address the handling of these emissions.

BMC also produces 70,000 pounds of solid scrap compound and 10,000 pounds of waste liquid resins annually. If sent to a landfill, the solid waste is considered an Illinois Special Waste due to the solvent residues it contains. The liquid waste is considered a Resource Conservation and Recovery Act (RCRA) Hazardous Waste, and can be shipped off-site for fuel blending due to its high energy content. The shipping container project, described below, addressed the handling of these waste streams. Other waste streams include office trash, rags and solvents from equipment cleaning, waste packaging from BMC's raw materials, and miscellaneous manufacturing waste such as worn-out latex gloves and corroded conveyor belts. The solvent substitution, recycling, and housekeeping projects described below addressed the handling of these waste streams.

Environmental Management

Although BMC does not have an explicit environmental mission statement, the company's mission statement includes commitment to environmentally friendly production. Environmental decision-making rests primarily with the VP for Manufacturing, who is responsible for all compliance issues, waste management, and pollution prevention. He believes that pollution is closely related to cost and quality issues, and that environmental management is an issue that he should approach proactively. Because he works closely with the production staff on a daily basis, he is well positioned to identify pollution prevention (P2) opportunities. And as the only person in production with an engineering degree, he is also responsible for designing and implementing P2 projects.

He contrasts his experience at BMC with the environmental management at a multinational, high technology conglomerate for which he worked as an engineer for eighteen years prior to joining BMC. There, the engineers were disconnected from production, and instead of working to improve the production process, they spent their time on strategic planning and filling out appropriation requests, all of which contributed little to product or process improvements. He sees one distinct advantage for small companies in the area of environmental management—the ability of proactive managers to act quickly for the benefit of the company without having to wallow in bureaucracy and company politics.

Due to pressures on his time and the limits of his knowledge, the VP for Manufacturing, in the past few years, has begun to retain external consultants to help with time-consuming compliance issues and specialized engineering tasks. Mostly due to this outsourcing, identifiable environmental operating costs have increased from $1,500 per month five years ago to about $6,000 per month in 1995. Nevertheless, these costs are less than three percent of total operating costs.

Recent and Pending Environmental Initiatives

BMC has five primary concerns with regard to the environment: (1) maximizing productive use of inputs, i.e. minimizing process waste; (2) minimizing costs due to waste handling and environmental reporting; (3) overcoming regulatory barriers to expansion; (4) improving worker health and safety; and (5) maintaining a positive environmental image. In addition to several small process changes to reduce evaporation, a variety of larger recent and pending projects address these concerns.

Thermal Oxidizer

When BMC completes its move to the new facility, a thermal oxidizer for control of fugitive air emissions will be installed. Total enclosures under negative pressure for the production lines will collect evaporative losses, and blowers will provide the steady airflow required by the oxidizer. The project was initially budgeted to cost $300,000, including contractors for engineering, permitting, and construction, but the final cost may be as much as 50% higher. It will be the largest investment BMC has ever made and will be financed with term notes from the company's bank. Operating costs are expected to be $40,000–60,000 per year. In preparation for this project, BMC spent more than $40,000 testing its stacks to gain an accurate picture of its air emissions. This expense is not included in the project's estimated capital cost.

The principal benefit of the project to BMC is that it removes a regulatory barrier to expansion. Currently, BMC can manufacture up to about 27 million pounds of product before exceeding its permitted level of air emissions. Although there is still some room under that ceiling; at BMC's current rate of growth, it will reach this limit before long. The thermal oxidizer will reduce the air emissions enough to allow BMC to continue to increase production substantially before approaching the permitted limit.

There are several other benefits of the project. It will reduce air emissions well below the 20,000 pounds per year threshold for Clean Air Act Title V reporting, saving on reporting costs and negating a factor that could tarnish BMC's environmental image. The oxidizer will also allow BMC to avoid $30,000–50,000 annually in Title V monitoring costs. Finally, it will eliminate the styrene odor problem and reduce worker headaches.

Because BMC viewed the thermal oxidizer project as necessary for business expansion, the project was not subjected to rigorous cost-benefit analysis.

Solvent Substitution

In 1990–1991, BMC substituted high-molecular-weight glycol ethers for the toluene and methyl ethyl ketone (MEK) used for cleaning production equipment. The initial capital outlay was about $2,000 for miscellaneous handling equipment, including a centrifuge to extract reusable solvent from the cleaning rags.

BMC was able to reduce its annual solvent use from 60,000 pounds of toluene and MEK to 6,000 pounds of glycol ethers. Thus, although glycol ethers are more expensive per unit volume, BMC realized a net annual savings estimated at over $30,000 on solvent purchases. The difference is due in part to the higher flash point of the glycol ethers, which causes them to evaporate much more slowly, and to the centrifuge recovery system. Also, BMC instituted a housekeeping change—workers no longer have free access to cleaning solvents; instead the glycol ethers are ladled out in small quantities to minimize use.

The primary motivations for the solvent substitution project were to reduce operating costs and to improve worker health and safety. In addition to the direct solvent savings, BMC saves an additional $5,000–6,000 annually on protective equipment and equipment maintenance because the glycol ethers are not corrosive; they can be handled with inexpensive latex gloves, whereas toluene and MEK corroded even expensive heavy gloves. With regard to worker health, glycol ethers do not cause skin rashes, as did toluene and MEK, nor do they have noxious vapors.

In conjunction with solvent substitution was an effort to eliminate the use of solvents wherever feasible. For example, solvents were used to clean BMC's polyvinyl chloride (PVC) plastic conveyor belts, which had to be replaced every three or four months due to corrosion. Now the belts are wrapped with packing tape which has eliminated the need for solvents, greatly extended the life of the belts, and reduced the time required for maintenance and cleaning.

There were several other benefits of the project. The substitution allowed BMC to avoid Toxic Release Inventory (TRI) reporting under SARA Title III because, although it is using a reportable chemical, the quantity is below the reporting threshold. BMC not only saves on reporting costs, but the firm also qualifies for recognition under EPA's 33/50 program for eliminating the use of a priority pollutant.

The project was so obviously profitable that it was not subjected to rigorous cost-benefit analysis.

Shipping Containers

Prior to the implementation of this project, BMC shipped product to its customers in cardboard boxes. Meanwhile, scrap compound from its production process, which was 6% styrene, was disposed of as Illinois Special Waste, meaning that it was not considered hazardous but still had to go to a special landfill. Similarly, liquid resin wastes from the production process were being disposed of as hazardous waste.

In 1991, one customer requested returnable shipping containers. BMC investigated several commercially available alternatives, but instead hit upon the idea of using the scrap compound and liquid resin waste to make the shipping containers. Using the same process as its customers, BMC now uses a molding press to make appropriately sized shipping containers that are durable, stackable, and reusable.

The initial capital outlay was $50,000–65,000 for a molding press and a mold. BMC received a P2 loan through the Illinois EPA for $40,000–$50,000 at 5% interest, plus a $4,000 contribution from the customer that requested returnable containers in the first place. BMC paid the remaining expenses with short-term credit. Another customer sold BMC one of its used molding presses at a substantial discount, and a third customer built the actual mold for the process also at a substantial discount. To encourage the reuse of the containers, BMC gives its customers a 1¢ per pound discount for returning the containers if they pay the freight costs.

The initial motivation for this project was non-environmental—satisfying a major customer. But BMC was also motivated by the prospect of reducing the costs associated with the purchase of the cardboard boxes and disposal of both the scrap compound and the liquid resin. In addition, the new containers have superior packaging properties, and contribute to positively to BMC's environmental image.

Since this project addressed so many issues for BMC, no rigorous economic analysis was done to justify it. The VP of Manufacturing is fairly confident that even a narrow cost-benefit analysis, exclusive of the benefits of customer satisfaction and environmental goodwill, would show the project to have been profitable.

Trash Compacting and Recycling

In 1993 BMC began working with a recycling company. The recycling company leases BMC two large compactors and a waste trailer for $650 per month. BMC compacts and bales all its raw materials packaging, including cardboard, empty lime bags, and other waste. Cardboard, plastic, and paper (including office paper and magazines) are recycled; lime bags and other trash are incinerated. By compacting and recycling its trash, BMC reduced its average monthly trash bill from $3,500 to $1,200. No capital costs were associated with the project because the equipment is leased.

The major motivation for this project was to reduce waste disposal costs. But the project also contributes to BMC's environmental image because it exceeds local recycling standards that have not yet even gone into effect. The project was subjected to rigorous cost-benefit analysis, and proved to be highly cost-effective.

Financial Analysis of Environmental Projects

Project ideas usually originate with the VP for Manufacturing. He authorizes small projects (under $4,000) himself on an ad-hoc basis. For larger projects he goes to the President & CEO and the Senior VP for Research & Development for approval. There are no appropriation request forms or formal appropriation procedures.

At the beginning of the fiscal year the four partners try to set a realistic budget. But actual implementation of projects during the year is based on cash flow, which is BMC's primary constraint. For this reason the partners often prioritize capital projects in the budget based on immediacy of need rather than on profitability. BMC aims for a simple payback of two years or less for most investments.

The VP for Manufacturing characterizes BMC's capital investment strategy as "conservative." In recent years, capital spending has averaged about $5,000–7,000 per year, but two years were exceptional—one over $20,000 and another over $100,000. This year will also be exceptional, because of the new facility and its thermal oxidizer.

Projects are not systematically classified or prioritized. Because BMC is a small company and there is not a large list of pending projects, each project is considered on a case-by-case basis. The range of costs and benefits that BMC's partners consider in evaluating investment decisions is fairly broad. For example, they consider, but do not quantify, the effects of environmental responsibility on corporate image and the benefits of reducing future liabilities. They do quantify the costs of environmental reporting, waste disposal, and permitting. Among the costs that they do not consider are insurance, utilities, in-house training, and inspections and audits. Generally, they like to consider the factors that are driving the proposed projects as well as the strict economics. Many projects are undertaken as a matter of survival for continued growth and customer satisfaction. Currently there are no environmental projects pending approval.

Due to the dynamic nature of its production and the job-shop type manufacturing operation, BMC does not attempt to allocate overhead costs to particular products. Overhead is simply allocated broadly and evenly across all manufacturing accounts.

Perspectives on TCA

The VP for Manufacturing does not see a need for TCA in a company the size of BMC. He feels that rigorously quantifying and summing up all the costs and benefits of each project would be a waste of time, because he is close enough to the process to understand the various costs intuitively. However, he does want to improve the allocation of overhead, labor, and materials costs in order to better understand their behavior. A more sophisticated accounting system is BMC's major need in this area.

He cites time pressure as the primary barrier to getting things done. There are only two layers of authority below him in manufacturing: the foremen and the line workers. He must oversee all manufacturing operations in person, plus conduct all of the in-house engineering work. Thus, certain aspects of TCA—such as considering all relevant costs—are useful, but formal TCA is not cost-effective because it is time consuming.

BMC faces some external barriers to P2 as well, but they are not insurmountable. One is the sometimes frustrating nature of state and federal regulatory processes and requirements. Another is the threshold effect built into many regulations. Thresholds are meant to define acceptable performance, but they are always arbitrary. Due to the structure of business costs, exceeding the threshold can in some cases be much more expensive than approaching it, with little corresponding environmental benefit.

BMC always tries to take advantage of incentives for P2, such as low-cost financing, technical assistance, and public recognition and award programs. Such programs can reduce investment costs and contribute to BMC's environmental image.

RESINS MANUFACTURER (RM)

Company and Facility Background

This company (SIC 2821) makes a variety of resin products that are used in paints, coatings, and reinforced fiberglass. The paint and coatings industry to which the company sells its products includes over eight hundred firms. The resin products industry comprises a few dominant large firms, along with a wide variety of smaller manufacturing facilities. Some of these competitors are vertically integrated divisions of paint firms.

The company was once part of a vertically integrated paint firm, but recently became independent, and has expanded by acquiring other resin producers. In 1995, the company's gross sales approximated $300 million. The new management is committed to growth, and hopes to become a $1 billion company by 2000—primarily through acquisitions.

The company employs approximately 570 workers at eight facilities in the U.S., including the case study facility in Illinois. The case study facility employs 220 workers and is responsible for on average 40 percent of the company's production. The facility is actually two adjacent facilities, each of which has nine reactor vessels. The research and development laboratory for latex products is housed on the west side; research and development for other products occurs in a laboratory at another facility.

Materials, Processes, and Environmental Impacts

The firm's resin products are manufactured in batch reactor vessels. Typical batch processing time is 15 hours and typical batch size is about 3,500 gallons. The inputs—mostly derivatives of petroleum or vegetable oils—undergo polymerization reactions when the reactor vessel is heated to between 400° and 500°F. Most resins are mixed with 40% solvent to allow pumping at 110°F to provide thinner viscosity for the paint.

Alkyd Resins, which comprise the company's largest product line, are made on both sides of the facility. They are used in the manufacture of oil-based paints and coatings for consumer, industrial, and special purpose use. Alkyd resins are made from polyols and organic acids reacted at 500°F. They can be modified by the subsequent addition of silicone (for heat resistance), vinyl toluene (for quicker drying), or acrylics (for durability) at 200°F. The waste stream from alkyd resin production is 90 percent water, 9 percent aldehydes, and 1 percent solvent. The reactor vessel must be cleaned with a caustic solution when consecutive batches are incompatible, but the company uses compatibility scheduling and dedicated lines to minimize cleaning frequency.

Polyester Resins are made on the east side of the facility. Unsaturated polyester resins are used in reinforced fiberglass, such as for boat hulls, bathtubs, and imitation marble. Saturated polyester resins are used in industrial coatings to provide specific properties such as gloss and color retention, resistance to corrosion, and flexibility. Polyester resins are produced from glycols and organic acids at 500°F, in a process similar to the alkyd resins. The resulting waste stream is 90 percent water, 4 percent glycols, and 6 percent others, including traces of phenol.

Powder Resins are similar in composition and waste characteristics to polyester resins. They are used in industrial powder coatings, a market segment with significant growth potential. Powder coatings emit no solvents and have high transfer efficiency. Powder resins are made only on the east side of the facility.

Acrylic and Vinyl Emulsion Resins, made only on the west side, are low-solvent resins used in consumer latex paints and industrial coatings. They are produced from the reaction of acrylic and vinyl monomers with water at 200°F. Because the reactions involved are exothermic, the reactor vessel must be cooled instead of heated. The only wastes—aside from fugitive air emissions—consist of the caustic solution used to clean the reactor vessel after every fourth batch and some filtration wastes.

Urea Formaldehyde, manufactured on the east side, is used as a cross-link ingredient for resins. The waste stream from urea formaldehyde production is 85 percent isobutanol and 15 percent water. In addition, the reactor vessel must be cleaned after every tenth batch with an acid rinse.

Waste Management Processes

Both sides of the facility have water-cooled condensers on each reactor vessel to collect and liquefy solvent fumes. Condensed solvents are decanted and returned to the reactor during processing for reuse. On the east side, solvent fumes that escape condensation are piped into a fume incinerator. On the west side, solvent fumes that escape condensation are released as fugitive emissions. Total fugitive emissions, from this and other sources, equal approximately 28,000 pounds annually.

The east side of the facility has a RCRA Part B permit to incinerate much of its liquid waste on site. The west side does not have an incinerator permit, and must ship its waste to off-site vendors. Although off-site disposal is more expensive than on-site incineration, the company would have to obtain expensive and time-consuming permit modifications to incinerate waste from the west side in the east side incinerator. At this time, the company is not pursuing a permit modification. Incinerator ash from the east side incinerator is disposed of as hazardous waste; one 55-gallon drum is generated every 12 to 18 months.

Water is a byproduct of the polymerization reactions in most of the company's production processes—approximately 7 percent of each batch. The water is removed from the reactor vessels through xylene addition. The water-xylene condensate is piped from the reactor to a decanter tank, where xylene and other entrained solvents are allowed to rise to the surface and are skimmed off. On the west side, these solvents are recycled and reused on site; on the east side they are sent off site for fuel blending (about 600,000 pounds per year). On the west side some of the used process water is reused and some is sent for off-site disposal. On the east side, the used process water cannot be reused due to hazardous levels of alcohol and xylene contaminants and is incinerated on site. Also due to these contaminants, caustic cleanup water from the east side is classified as a hazardous waste. Caustic cleanup water from the west side is considered an Illinois "special waste," subject to state regulation that is similar to Resource Conservation and Recovery Act (RCRA) regulation. Both caustic streams (about 3.5 million pounds per year) are sent for off-site treatment.

Other liquid and solid wastes, such as scrap product (about 3 million pounds per year), scrap inputs (about 90 thousand pounds per year), and scrap solvents (about 900 thousand pounds per year), are sent off-site for fuel blending. Most of these wastes have very high energy content, and are ideal for fuel blending. Even solids that collect on filters (about 200 thousand pounds per year) can be homogenized into the liquids and sent for fuel blending, but this is much more expensive to manage than the liquid waste streams.

Disposal costs for 1995 totaled $1.3 million. The company tracks waste volume and disposal costs (including transport and disposal fees) for a variety of waste streams. Scrap inputs ($1.76 per pound) and hazardous filter solids ($0.79 per pound) are particularly expensive to dispose.

Environmental Management

The company's new management is supportive of a more "aggressive P2 [pollution prevention] and waste minimization program." For example, when the company was owned by the vertically integrated paint firm, suggestions for environmental projects historically came directly from regulatory or permit requirements. The new corporate Environment Health & Safety (EHS) staff, in contrast, performs proactive facility audits to generate ideas for environmental projects.

The company's Environmental Policy states that "Environmental protection is the responsibility of every [company] employee." It also calls for programs to "prevent or minimize the generation and subsequent disposal of all waste materials," and to protect "the health, environment and safety of our employees and the public." A separate Pollution Prevention/Waste Minimization Policy incorporates the U.S. EPA's P2 hierarchy, beginning with source reduction. The 1994 annual reports states that "environmental responsibility is at the core of what we do—for all our constituents."

The company uses cross-functional process improvement teams to address high priority issues within the firm. These groups, called High Impact Teams (HITs), are convened annually from among the corporate staff. Typically, a HIT convenes for 9–12 months with a meeting each month, and disbands after completing its task. Previous tasks have included revamping inventory management and developing a methodology for scaling up product lines from R&D. HITs focus comprehensively on existing processes first, and then move on to analyze alternatives. Clearly, only a limited number of large issues can be addressed in any given year due to personnel limitations.

After the company became independent, corporate EHS brought together representatives from each facility to develop a waste tracking system and hired a consultant to develop the software. The Windows-based database program tracks both quantity and disposal cost data for all wastes, but not general material flows or inputs. This ongoing project is coordinated by the company's environmental coordinator, who is located at a facility on the East Coast. Waste minimization teams at each plant send information to the coordinator via modem; the coordinator then produces monthly reports for each facility and for the corporation as a whole. The coordinator monitors progress at individual facilities and offers advice based on a review of the reports he generates. The wastes are summarized by type, not by product or process, although each product produces somewhat different waste streams.

Not every facility has an environmental engineer. Instead, the need for an environmental engineer depends on the size of the plant and the regulatory environment at the plant location. For example, one smaller facility on the West Coast, due to strict regulations, does have an environmental engineer. The larger plants, such as the case study facility, also have environmental engineers at the facility. Where there is not a full-time engineer, an operations engineer has part-time responsibility for environmental issues such as permitting and manifesting.

Most of corporate EHS functions are handled at the case study facility; with the exception of product stewardship and Toxic Substances Control Act compliance which are handled in the research and development laboratory at another facility. Both the EHS Director and the Director of Operations report to the VP of Operations. P2 and waste minimization efforts focus on the case study facility, because every product (except oil-modified urethane resins) is manufactured there and what is learned can be transferred to the other facilities. Also, the case study facility is very large, thus environmental efforts at this facility provide the "biggest bang for the buck."

Recent and Pending Environmental Initiatives

Improved Drumming Procedures

A student intern from the Illinois Environmental Protection Agency Graduate Internship Program helped the company improve its drumming procedures in 1995. Previously, it was difficult to move drums off the drumming line during line flushes. Operators had to flush the lines into partially filled drums, which then had to be scrapped. The generation of scrap resin was due to the development of drumming procedures designed exclusively to maintain product quality and efficient materials handling. The intern advised several modifications to the drumming procedure to reduce the generation of scrap resin: 1) all partial drums of in-spec resin are stored until manufacture of that product re-occurs at which time they are topped off with new product; 2) installation of six dedicated filling lines; 3) reduction in the amount of solvent used to flush the lines; and 4) schedule with compatibility of product lines in mind to minimize flushing.

Several small investments (under $5,000 total) enabled the company to reduce scrap by approximately 750 thousand pounds and to save a projected $250,000 annually—half from improved drumming procedures and half from reduced line flushing. The savings account for projected savings from both raw materials purchasing and waste disposal.

Process Automation

Converting to computer process control is an ongoing project, which began in 1989. At present, computers control many of the valves and switches related to batch processing with operators manually programming the parameters for each batch.

Currently, operators have some limited ability to bring a substandard batch back on spec. The company eventually would like to identify a threshold beyond which the batch can no longer be saved early in the manufacturing process while the batch volume is still small. Alternatively, the company is considering programming the computer to indicate the steps needed to get a batch back on spec, reducing its reliance on operator intuition. With computer process control, the company hopes to be able to produce a consistently high quality product and reduce off-spec scrap. In the appropriations request (AR) for this project, these benefits—reduced losses from human error, improved quality, and marketing advantage—were presented in a qualitative discussion, but were not quantified.

Long-oil Alkyd Life Cycle Pollution Prevention Program

In early 1996, the company began a collaborative project with the Illinois Waste Management and Research Center (WMRC - formerly called the Illinois Hazardous Waste Research and Information Center, HWRIC) to examine the long-oil alkyd resin manufacturing process from a life cycle perspective. The analysis will examine all aspects of the process from the purchase of raw materials to the use of the product by customers. Each step in the process will be scrutinized so that operating parameters can be optimized, including raw material selection, how raw materials are added, process temperature, mixing rates, and cooling time. Manufacturing support functions will be analyzed as well: shipping/receiving, purchasing, inventory, maintenance, waste handling/storage, laboratories, powerhouses/boilers, and cooling towers.

This project is envisioned as a launching pad for a broad-based corporate P2 effort. The company's responsibilities under the cooperative agreement are specific, and include developing a P2 plan, instituting a cost allocation system, conducting periodic P2 audits, and tracking material flows. The long-oil alkyd process was selected as the starting point for this project because it has intermittently been plagued by a haze of unknown origin that necessitates an additional process filtration step that creates filter waste. Thus the long-oil alkyd is the "worst case" product. Every company facility produces the long-oil alkyd, and the long-term goal of the project is to transfer learning to other company facilities and processes.

In the short-term, the company expects the long-oil alkyd life cycle exercise to generate a variety of capital investment and other process change ideas. One possibility is that raw materials selection may present a P2 opportunity. The corporate EHS department could encourage the purchasing department to consider product quality and price when making purchasing decisions. Low quality of raw materials may contribute to off-spec batches, increase the quantity of precipitation solids, or cause the mysterious haze in the long-oil alkyd production line.

The company hopes that this collaborative project with WMRC will help reduce off-spec batches. An off-spec batch represents both a cost, because it must be disposed of as hazardous waste, and a forgone revenue, because the wasted time and materials could have been used to produce salable product. The project may also improve the quality and consistency of salable batches, and reduce waste. Thus the motivations for the project include reducing costs, improving quality, and increasing knowledge of the process.

Switch from Incineration to Water Treatment

In 1994, permit issues at a West Coast facility led the company to investigate a switch from incineration to water treatment for the aqueous waste streams. The waste streams from many of the company's processes contain close to 90 percent water, and are thus relatively inefficient to incinerate. The West Coast facility decided to install a water treatment system to enable it to eliminate its incinerator. This installation is slated to begin in early 1997.

The decision remains as to whether the same switch should be made at the company's other facilities. The company investigated transferring the technology to other facilities to see if this would reduce treatment costs. Financial analysis of the project indicates that incineration is at present the less expensive option. Water treatment could become preferable as regulations on incineration grow more restrictive; however, the case study facility abuts a scenic waterway, so it may be difficult to gain approval for water treatment at this particular location.

Chiller/Condenser for Fume Capture

The company is considering installing a chiller/condenser system on the west side of the case study facility to increase the capture efficiency of solvent fumes from the reactor vessels. The existing condensers—one per reactor vessel—are cooled by city water pumped through a cooling tower such that the water maintains a temperature between 60–90°F. A secondary, central chiller/condenser would cool remaining uncaptured fumes from all seven reactor vessels to below 0°F. The total capital cost for a chiller/condenser system is estimated at $1 million. A financial analysis is currently being conducted.

The motivation for this project is to reduce fugitive emissions. The portion of the solvent fumes that is cooled to the liquid state can be decanted and reused. Solvent fumes that remain gaseous, however, escape as fugitive emissions. On the east side of the facility, a chiller/condenser system is unnecessary because both liquid and gaseous fumes are piped directly into an on-site incinerator.

Financial Analysis of Environmental Projects

Capital budgeting at the company is a formal, annual process. At the beginning of the fiscal year, each facility puts together a capital plan with the assistance of the Corporate Engineering Director. Some suggestions for environmental projects do come from the facilities, but the majority of initiatives come from corporate engineering and environmental staff upon review of facility audit information. These capital plans go to a management committee for approval, and approved projects are incorporated into the annual operating budgets for the facilities. At the budgeting stage the company aims for 25 percent accuracy in cost forecasting. All projects compete for funds from a single budget pool, but competition is not strictly based on payback when projects have unquantified benefits. In addition to the funds budgeted for approved projects, each facility is allotted $6,000 to $10,000 per year in discretionary capital funds.

When the facility is ready to implement a budgeted project, the project engineer fills out an appropriations request (AR) and documents expected project costs in more detail by attaching vendor bids and engineering estimates. The AR form presents information on expected changes in future cash flow from increased sales and reduced operating costs, as well as the initial cost of the project and the value of old capital being traded in or sold. The company has a spreadsheet to organize the data and calculate the payback period. Each AR also must be accompanied by an environmental impact statement, a Management of Change checklist, and a project safety review to ensure that the project complies with EPA, OSHA, and other regulations.

Most ARs are approved by the Corporate EHS Director, the Controller, and the VP of Operations, as well as by the Management Committee. Projects over $250,000 also require the approval of the CEO and CFO.

The Corporate EHS Director indicates that there is wide variability in the quality of ARs. Some engineers do a very thorough job, while others do no more than the minimum necessary. The company does not have a formal cost inventory, but there is a guidance document with department guidelines on how to prepare an AR. Costs that are difficult to quantify, such as potential future liability, are usually considered qualitatively. The Corporate Engineering Director has authority to send back substandard ARs for revision.

The company uses standard lifetimes of 5 years for equipment and 20 years for buildings and land. The typical project time horizon is five years, and the payback hurdle is three years. The engineer completing the AR is responsible for collecting cost information from vendors, accounting records, and engineering estimates.

All of the facilities use a standard set of accounting codes. Costs are aggregated according to product group. The Liquid Coatings group includes alkyd, saturated polyester, and emulsion resins; the Powder Coatings group includes the powder resins; the Composites group includes the unsaturated polyester resins. Capital costs are allocated to product groups based on engineering estimates of equipment usage. Facility overhead, including waste disposal, is allocated based on production volume. There is a separate corporate overhead charge, which is allocated on the basis of personnel count. (As part of the Long-Oil Alkyd Life Cycle P2 Program, described above, the company will reexamine some of its overhead allocation policies.)

In 1995 the company's total capital investment expenditure was about $6.5 million, of which approximately 60 percent was for environmental projects—including recycling, pollution control, and site remediation. Annual capital expenditures vary widely from year to year, however. In 1994 capital expenditures were $4.7 million, of which about 28 percent was for environmental projects. The company's estimated 1996 expenditures on environmental projects are $2.4 million.

Whereas capital investment expenditures are classified as environmental or non-environmental on ARs, operational environmental costs are not classified formally into such categories by the company. Therefore, the company has not estimated the percent of its total operating budget directly related to environmental activities. However, the company is involved as a potentially responsible party in thirteen remediation sites, and estimates its net liability at about $1.5 million.

Perspectives on TCA

Representatives from the corporate EHS department see the need for more comprehensive, systematic financial analysis of environmental projects in industry. The firm is already convinced of the value of full and accurate costing, as illustrated by the detailed waste cost estimation and allocation efforts being undertaken as part of the Long Oil Alkyd Life Cycle P2 Program.

Pending the results of the ongoing cost estimation and allocation work, the firm likely will see some changes in costing practices. One environmental engineer doubted that the company would change the accounting system itself, but envisioned making better use of the data collection and analysis capabilities within the existing system. In addition, he expects the company to promulgate formal written guidelines on financial analysis of process design and production scale-up decisions. The corporate EHS department also hopes to expand utilization of the Corporate Waste Reporting System by integrating it more closely with other data systems and reorganizing responsibility for data entry.

D.A. STUART, INC. (STUART)

Company and Facility Background

D.A. Stuart produces cleaning solutions, hydraulic fluids, lubricants, and other specialty chemicals for industries involved in metals processing and metalworking, including mining, automotive, steel, aluminum, and aerospace. Stuart's product line includes environmentally preferable alternative solvents and aqueous cleaning systems. Stuart positions itself as a high quality, high margin supplier in this market, based on technological advantage and working closely with customers. Stuart offers a "Chemical Management Program" in which it provides complete chemical management services, including equipment, training, assistance with environmental compliance, and performance monitoring. Stuart's quality management systems at its Illinois, Philadelphia, and Toronto facilities are certified under ISO 9001 and QS9000.

Stuart was founded in 1865, and is currently owned by a German company. In the U.S., Stuart employs about 120 people at two facilities in Illinois plus another 200 at three more facilities on the East and West coasts. Stuart also has facilities in Canada, England, and Germany. Average annual sales are in the range of $90 million, a third of which is international. Stuart's sales volume places it at or near the top of the aluminum, steel, and metalworking markets. Its competition consists of a few large firms and a variety of small, regional companies.

One of its Illinois facilities is a research and development center located in a suburban area. Its production facility, the subject of this case study, is located in an urban area. The site was constructed in the 1940s by Standard Oil and was acquired by Stuart in 1977.

Materials, Processes, and Environmental Impact

Raw materials for Stuart's production processes can be classified into the following broad categories: mineral oils, animal fats (e.g., tallow), fatty acids, and emulsifiers. Most of the plant's operations (85%) consist of chemical blending; the remainder involve chemical synthesis. The blending operations occur at temperatures up to 200°F; synthesis takes place in four reactors at temperatures reaching 500°F. All of Stuart's products are recyclable; a partner company collects used product from customers. Although the recycled products are not returned directly to Stuart, reprocessed and rerefined oils are used in Stuart's processes.

Stuart's major non-air waste streams can generally be placed in one of three categories. The first is non-hazardous aqueous solutions that have 10-15% oil content, which is generated at about 26,000 gallons per year and is directly discharged to the sewer. The second is solid wastes such as filtration media and spill absorbents, amounting to 6,000 pounds per year. Non-hazardous solid wastes are sent to a landfill, and hazardous wastes are either encapsulated or incinerated. The third waste category is hazardous laboratory residues (from the R&D facility), such as spent reagents, at roughly 1–2 drums per year. Stuart has contracted with Safety-Kleen to dispose of all laboratory waste.

Since the completion of a major capital improvement (discussed below), fugitive hydrogen sulfide (H_2S) emissions have been lowered to about 400 pounds per year, according to mass balance calculations. Other annual emissions include two tons of carbon monoxide (both fugitive and stack), 11 tons of nitrogen-compounds, and 11½ tons of volatile organic compounds (VOCs).

Environmental Management

Stuart has a variety of environmental policy statements, mostly written by the Vice President for Manufacturing. These include risk management (spills, industrial hygiene, safety, worker Right-to-Know) and EH&S (emergency response, etc.). There is no environmental "mission statement" and there are no special incentives for environmental performance. Instead, such concerns are built into the job descriptions, which include phrases such as "waste control and minimization" and "environmental integrity and compliance."

The VP for Manufacturing sits on the Executive Committee, which formulates environmental policy. He is then responsible for its administration. Environmental compliance at the facility level is the responsibility of the Plant Manager. Together, the VP and each facility's Plant Managers identify environmental and all other capital improvements.

Recent and Pending Environmental Initiatives

Scrubbing system

Stuart's Illinois production facility recently completed the installation and calibration of an air scrubbing system. A piping complex was installed to collect evaporative H_2S emissions from storage and process tanks in the plant and channel them to a central location where they are scrubbed prior to release. The capital outlay was $527,000 and yearly operating costs are estimated to be $20,000. Stuart projects H_2S emission reductions of 99%, which will improve the working environment and exempt Stuart from Clean Air Act (CAA) Title V reporting requirements.

Dedicated process tanks

In late 1994, Stuart began using a dedicated process tank for each product to replace the old system in which tanks were used for multiple processes. The conversion to the use of dedicated tanks eliminated the need for cleaning tanks between each production run. The reduced waste treatment and disposal costs contributed to a savings of $50,000 per year, not including labor and raw material savings, and required no capital outlay. This project also reduced aqueous oil waste by 35%. Reducing costs was the motivating factor for this project, with production streamlining and waste reduction as ancillary benefits. A project cost analysis found this project to be economically justifiable.

Ultrafiltration

In 1995, Stuart completed a $100,000 installation of an ultrafilter, a process tank, and a recirculating pump. The purpose of this ultrafiltration system was to clean the facility's aqueous waste stream, which allowed for subsequent discharge directly to the sewer. Disposal costs were reduced 15%, saving about $18-20,000 per year. The project was estimated to, and subsequently did, provide a good return on investment. This project was undertaken expressly to reduce costs, and from the initial cost analysis and subsequent operating data it is expected to pay for itself within four years.

Containment system

In early 1996 Stuart completed a project to build containment systems for stationary tanks and rail cars. These systems reduce the risk of spills arising from tank car filling. Although Stuart has never had a rail spill, management recognized the possibility of a spill and thus the opportunity to minimize the risk, associated liability, and potential cleanup costs. The project required a one-time outlay of $250,000. Since this project was viewed as an environmental priority, no cost analysis was done.

Cooling Tower

A cooling tower was installed in 1993 to cool process water for reuse. The system allows Stuart to avoid 100,000 gallons of daily sewer discharge. The tower installation cost $750,000 and reduced both water bills and sewer discharge costs. This project was subject to a cost analysis that found it to be economically justifiable.

Financial Analysis of Environmental Projects

Capital budgeting at Stuart is performed annually. The Plant Manager recommends environmental projects, which are reviewed by the EH&S Manager. The Vice President of Manufacturing performs the final internal review. The VP of Manufacturing and the Plant Managers propose a budget first to the top Stuart management. Once approved, the budget goes through Stuart's Board of Directors to the parent company in Germany. Any project over $1,000 must get approval from the parent company. Projects under $1,000 can be undertaken at the plant level with the approval of the Vice President. Stuart endeavors to keep capital costs at around 5% of sales per annum, but this limit is flexible. Average capital expenditure has been $3-4 million per year over the last five years. The proportion of that figure which is environmental is unknown.

There is a single pool of funds for all projects, but projects are classified into four priority groups: EH&S, Quality Improvement, Productivity Improvement, and New Process Development. In order to be considered, most projects must demonstrate a ROI of 15%. Environmental and safety projects are automatically assigned top priority regardless of whether they are mandatory or not. No financial calculation is required for these projects. All other projects are prioritized based on their ROI. This prioritization scheme of separating EH&S projects from the rest was initiated three years ago because these projects were not competitive on a strict ROI basis and therefore were not being approved.

Stuart does consider disposal costs when evaluating projects (in fact, this has been a motivating factor for several of the projects they have undertaken), as well as licensing and permitting fees. It does not consider reporting costs, emissions trading, future regulatory compliance costs, employee safety/health compensation claims, and infrequently considers salvage value. Stuart qualitatively considers corporate image effects and green product sales, the latter of which is relevant to its marketing (e.g. Stuart markets chlorine-free cleaning systems). Because environmental projects are given top priority, there is not much emphasis on detailing costs and savings resulting from those projects.

Overhead costs are pooled and then allocated to products on a per pound of product basis. This method is not likely to change, due to the complex structure of Stuart's accounting system. There are no managerial accounting services provided by the accounting department; instead, managers must watch their own expenses.

Perspectives on TCA

The VP of Manufacturing thinks that Total Cost Assessment could be useful to make voluntary environmental projects more palatable to the parent company and to provide better information for evaluating projects. However, the costs would outweigh the benefits if the cost of collecting additional data was greater than its return. Few, if any of the mechanisms necessary for TCA are already in place at Stuart. Many systematic changes would be necessary to implement a TCA process, including changes in job responsibilities and accounting systems. The constraints of time and resources are thus the main barriers to TCA.

The end-of-pipe regulatory approach is the reason Stuart assigns environmental projects top priority. Regulatory uncertainty has an effect on capital budgeting, but it has worked both ways: uncertainty can either "spur" or "delay" investments depending on the nature of the regulation. Stuart does not concern itself with avoiding future regulation because it consumes considerable resources simply keeping up with existing regulations. Stuart has been frustrated by regulatory inflexibility, which has thwarted its efforts to devise innovative solutions to environmental problems.

The availability of grants, loan support, and recognition programs have not influenced Stuart's capital budgeting decisions. Similarly, Stuart does not consider possible SEC disclosure issues, hazardous waste reduction incentives, or the possibility of accelerating the depreciation of environmental capital expenditures. Technical assistance for pollution prevention projects and problems is always available from both internal and external sources.

Stuart does not perceive any risk from Superfund liability. In the past, plant shutdowns have been cleaned up properly to avoid Superfund problems. One customer did dispose of some Stuart product at a Superfund site, but Stuart does not expect to be held liable for that incident. In any case, the VP of Manufacturing feels that the barriers to quantifying Superfund liability are many. Estimating the probability of a claim and the likely magnitude of the settlement, let alone legal costs, is practically impossible. Complicating any estimation is the fact that liability costs can be dramatically affected by media attention and politics. For these reasons, Stuart does not plan to incorporate potential liability costs, or reductions thereof, into its capital project analyses.

QUANTUM CHEMICAL CORPORATION - MORRIS PLANT (Quantum)

Company and Facility Background

Quantum is the United States' largest producer of polyethylene. Quantum also produces ethyl alcohol and polyolefin powders, and is a major producer of specialty polymers and industrial chemicals. Its roots trace back to the US Industrial Alcohol Company in 1906, and the corporation has since undergone numerous mergers and acquisitions, culminating in the establishment of Quantum Chemical Corporation in 1987. A subsidiary of Millennium Chemicals Inc., since October 1, 1996, Quantum is headquartered in Cincinnati and has eleven manufacturing facilities throughout the US.

Built in 1969 among the Illinois corn fields, the 890-acre Morris plant originally produced ethylene glycol and ethylene oxide. It has since expanded into the production of ethylene, polypropylene, and low density and linear low density polyethylene. The Morris facility has a utility plant to provide steam and water, a wastewater treatment unit, a nitrogen supply system, and a major research and development center that focuses on improving and optimizing production methods company-wide. The Morris facility has about 650 employees.

Quantum reported an operating profit of $714 million on sales of $2.2 billion in 1995. It is a vital part of Millennium Chemicals Inc., accounting for two-thirds of Millennium's total annual revenue.

Materials, Processes, and Environmental Impacts

The Morris plant predominantly produces intermediate plastic products starting with liquefied petroleum gases (LPG) as raw materials. Pelletized polymers are shipped by road and rail. Liquid and gaseous by-products are transported via pipeline, rail, and barge. The plant is organized into four units, one to process the LPG, and three to manufacture the polymers. The manufacturing technology is mature and capital-intensive, which potentially limits both the technological and economic feasibility of major process changes.

Input Unit (Olefins)

The first step in the Morris production process is the olefins unit. Liquefied petroleum gases – ethane, propane, and butane – arrive by pipeline and are vaporized and mixed with steam. The mixture enters high-temperature cracking furnaces which creates a gaseous mixture that includes ethylene, propylene, and butylene. After the gases cool, a compression and cryogenic distillation process recovers purified ethylene and propylene. Some of the ethylene produced is shipped out at this stage by truck, rail, or pipeline to other Quantum plants, but most is used as feedstock for other Morris processes. Annual waste generated by the olefins unit includes roughly 800,000 pounds of oils and 620,000 pounds of oily sludge that are sent to a recycler for fuel blending.

Low Density Polyethylene

The low density polyethylene (LDPE) unit receives and compresses the ethylene gas from the olefins unit. With very high pressure, careful temperature control, and a catalyst, the gas polymerizes in a tubular reactor to form polyethylene. Unreacted ethylene gas is separated from the liquid polymer and is recycled back through the process. The liquid, a molten plastic, is solidified via underwater extrusion and then cut into small pellets. The LDPE pellets produced are sent by truck or rail to manufacturers who convert them into products such as trash bags and paper coatings.

The LDPE unit annually generates 550,000 pounds of spent vinyl acetate that is either sent to another Quantum facility as a raw material or is sent to a recycler for redistillation. The LDPE unit also generates roughly two million pounds of waste lubricating oils that are sent to a recycler for recovery.

Linear Low Density Polyethylene

Distinct from the LDPE process, the reaction of ethylene in the linear low density polyethylene (LLDPE) process takes place at relatively low pressure in one of two Unipol® gas-phase reactors. This procedure creates polyethylene in a granular solid form rather than a molten plastic. The solid is extruded and cut into small pellets. The purpose of this pelletizing process in polymer manufacture is to facilitate more efficient handling. LLDPE is a stronger plastic than LDPE and is used for applications such as heavy duty sacks and truck bed liners.

The primary waste streams from the LLDPE unit are pyrophoric materials generated from the reactor catalyst. The 10,000 pounds of this waste material produced each year are shipped off site to an incinerator.

Polypropylene

Morris's polypropylene unit was the first in the country to use gas-phase technology. Gas-phase technology produces a higher quality polymer while using less energy than previously used methods. Propylene from the olefins unit is fed into the gas-phase operation where it reacts with a catalyst. The resulting polymer is a fine powder that is blended with additives, then extruded and pelletized. Polypropylene is used to make a diverse range of products, including bottle caps, housewares, and automobile battery cases.

Like the LLDPE unit, the polypropylene unit annually generates approximately 5,000 pounds of pyrophoric catalyst waste. Also in this unit, oligomers, short-chain polymers which fail to form polypropylene, come out of the process as an oily, waxy waste. Almost 10,000 pounds of this waste is shipped out for fuel blending every year. Polymer scrap from the polyethylene and polypropylene units – one million pounds per year – is sold as a byproduct for use in other plastic making processes.

On-site Utilities and Wastewater Treatment

Morris has its own utilities unit that supplies the plant with compressed air, superheated steam, and water that is modified to meet all of the plant's various needs. Wastewater from the production operations is treated in a state-of-the-art, computer controlled treatment plant and then collected in a two million gallon storage tank, which serves as a secondary source of water for use in case of fire. Water from the tank is gravity fed through a National Pollution Discharge Elimination System (NPDES) permitted outfall to the Illinois River. The wastewater treatment unit annually generates about 300,000 pounds of oily sludges that are sent to a recycler for fuel blending. Activated sludge from the wastewater plant is sent off site to a landfill. For one additional utility, Morris has contracted with Air Products to generate purified nitrogen on site due to its heavy use of this gas throughout the plant.

Environmental Management

The Environmental Manager for four Quantum plants (the Northern Region), including Morris, is based at Morris and is largely responsible for environmental affairs at the plant. He reports to a regional Health, Safety, and Environment (HSE) Manager who, in turn, reports to the site general manager. As part of Quantum's matrix management structure, he also has responsibilities to the corporate HSE staff.

At Morris, the Environmental Manager has a staff of five environmental professionals and an annual budget ranging from $750,000 to $3.5 million depending on specific needs. His group is responsible for reviewing regulations to identify relevant requirements; devising action plans for compliance; maintaining an inventory of emissions throughout the manufacturing processes and finding opportunities for reduction; identifying pollution prevention (P2) capital projects and preparing Capital Expenditure Authorization requests; and reviewing engineering projects to determine regulatory effects and contributions to pollution prevention.

There is also a corporate Environmental Management Committee to establish policy, standardize activities among plants, and review environmental capital projects. In reviewing projects, the Committee classifies projects as government-required (mandatory) or Responsible Care® (voluntary) to facilitate prioritization. As the main environmental governing body, the Committee ultimately serves as a source of information and guidance for plant-level environmental affairs.

Generally, Quantum has taken an active posture concerning company-wide environmental management. There is an explicit HSE policy "to operate its facilities in an environmentally responsible manner and to assure that the utmost care is taken in the manufacture and storage of its products." In order to achieve the policy goals, Quantum has committed:

- to meet or exceed applicable requirements of laws, regulations, and standards relating to environmental protection;
- to make protection of the environment the direct responsibility of line management;
- to consider environmental matters in the design and development, maintenance and operation of manufacturing processes;
- to conserve natural resources through energy and raw material conservation and recovery;
- to minimize the quantity of internally generated waste via source reduction, recycling, and treatment.

Specific pollution prevention goals to be achieved by the year 1999 are to reduce:

- total air emissions 50% from 1987 levels;
- airborne carcinogen releases 90% from 1987 levels;
- and hazardous waste generation per unit of production 40% from 1990 levels.

The Morris plant recently announced that these pollution prevention goals have been met well ahead of schedule. By the end of 1995, the Morris plant had reduced total air emissions by 81%, airborne carcinogen releases by 93%, and hazardous waste generation per unit of production by 55%.

Beyond these internal initiatives, Quantum has adopted the Chemical Manufacturers Association (CMA) Responsible Care initiatives to further demonstrate and strengthen its commitment to environmental protection. Within this framework, Quantum is committed to the Pollution Prevention Code of Responsible Care, which specifies 14 detailed management practices to minimize waste generation. In addition, Morris' Community Advisory Panel involves the plant and its neighbors in environmental education and protection initiatives.

Quantum has also launched a next generation Responsible Care program called Vision 2000. This innovative program is unique to Quantum and will "raise the bar" beyond the requirements of the existing Pollution Prevention code and other Codes of Management Practice defined by Responsible Care.

Recent and Pending Environmental Initiatives

Because the manufacturing technology at the Morris plant is rather mature and the process feedstocks do not change, the Environmental Manager believes that there are limited opportunities for substantial additional pollution prevention (P2) progress. Any major change that is identified would likely be prohibitively expensive. Nevertheless, the environmental group recognizes the difference between pollution prevention and pollution control and is committed to implementing emission reduction projects wherever practical.

Vapor Equalization System

Until recently, the Morris plant was a large producer of ethylene oxide (EO). After the EO was produced in the plant, it was either converted to ethylene glycol or transferred to a storage tank pending transport via rail. Stored as a cryogenic liquid, EO can be a considerable emission source of airborne carcinogens. Each time the liquid is transferred from one tank to another, it generates vapors. Quantum installed a vapor equalization system to control the fugitive emissions from EO, which is listed under the Superfund Amendments and Reauthorization Act (SARA) Title 313. Once installed, the system reduced annual emissions by 130,000 pounds. The primary motivation for this project was to reduce emissions of airborne carcinogens as part of Quantum's Responsible Care commitment. Therefore, it was not subjected to any rigorous cost-benefit analysis. The EO production unit was recently shut down and removed from the Morris plant site.

LDPE Process Redesign

The reactor in the LDPE unit operates under very high pressure. This older-technology reactor/compressor system is sensitive to temperature, vibration, and displacement, and is therefore monitored by an extensive instrumentation system that can initiate a shutdown when necessary. When the shutdown process begins, the reaction, which is highly exothermic, has to be quenched. Quenching was previously accomplished by venting the reactor to the atmosphere which relieved the pressure, but created significant air emissions of primarily ethylene – 8,000 pounds per shutdown.

This problem was overcome largely through logistical changes requiring little capital expenditure. With the new system, the initial quenching drops the pressure by approximately 60% which sufficiently slows the reaction but does not require that a large volume be vented. Then the system is depressurized further by sending ethylene back to the olefins unit where it can be purified and returned. At that point, if there is a problem that requires a process or equipment adjustment or repair, some further venting would be necessary, but this is often not the case. Otherwise, the reaction can be resumed. The new system allows most of the hydrocarbons to be recycled rather than released to the atmosphere; in many cases, the reaction is quickly restarted with minimal venting. These changes have reduced air emissions by two million pounds per year.

In another part of the LDPE process, some of the low molecular weight residual waxes are separated from the process stream and temporarily collected in receiving vessels. When these vessels are emptied into disposal containers, there is a significant release of ethylene vapor, estimated at 500,000 pounds each year. The environmental group initiated a process change whereby the receiving vessels are depressurized back to the process prior to being emptied and then injected with nitrogen which displaces the ethylene gas in the vessels, leaving only nitrogen to escape to the atmosphere. Again, by a fairly simple process change, emissions were reduced substantially.

Further along in the same manufacturing process, dissolved ethylene remains in the final polymer product because of its slow mass transfer rate out of the pellets. In order to make the pellets safe for handling, they are placed in a blending silo and the ethylene gas is removed by forcing air through them. This process emits roughly 200 tons of ethylene gas each year. There are filters that capture the particulate matter in the vapor, but because it is a low-pressure, high-volume, dilute, moist mixture, it is very difficult to extract the remaining ethylene gas. An outside consultant studied the process and proposed the installation of a thermal regenerative incinerator. The estimated cost of emissions reduction was calculated to be $7,900 per ton. Quantum was granted an adjusted standard by the Illinois Pollution Control Board on the grounds that the improvement was not economically viable and reasonably available control technology requirements would have been exceeded.

Vinyl Acetate Source Reduction

The environmental group at Quantum has developed an extensive waste stream identification system in which each stream generated is assigned a number. This system facilitates tracking and analysis to create a means for identifying and assessing pollution prevention opportunities throughout the plant. One source of hazardous waste generated on a continuous basis is spent vinyl acetate. Vinyl acetate is injected into the LDPE to form a copolymer that has the special characteristic of high clarity, which is desirable for certain applications. Following the reaction, the spent vinyl acetate is removed from the unreacted portion of the process stream.

The spent vinyl acetate contains trace amounts of moisture. Some of the vinyl acetate reacts with this moisture to form acetic acid. Reinjecting this slightly acidic mix back into the process would create production problems, so it is treated as waste. Previously, this waste was sent to other Quantum plants to be used as feedstock for other processes. More recently, however, the environmental group turned to a chemical waste management company, which was able to redistill the spent material and return it for reuse. This approach was more cost effective and caused no problems in the production process. Unfortunately, because of the manner in which the relevant regulations are written, this approach to recycle the vinyl acetate does not count toward reduction of a Resource Conservation and Recovery Act (RCRA) hazardous waste.

Quantum has considered installing redistillation capacity on site; but because it is economically marginal does not officially reduce hazardous waste generation according to the regulations, the project provides less incentive for Quantum and therefore has not received capital approval. Only by incorporating redistillation into the production process as a closed system with no storage would the waste be RCRA exempt, and the cost of such a system is prohibitive.

Barge Loading Vapor Controls

In addition to ethylene and propylene, the olefins unit produces an aromatic gasoline product. This product goes from the plant directly onto barges that take it to market. When the barge tanks are being filled with the liquid product, there is vapor displacement that emits benzene. Morris has considered installing vapor controls to capture these fugitive emissions, but recently enacted Coast Guard regulations have made that prospect more complicated. The regulations require the installation of safety interlocks at any barge terminal where there is a vapor control system. Further complicating the matter, the Coast Guard authorized only four consultants in the country to approve proposed designs. As a result, the cost of the project has tripled. Nevertheless, as opportunities to achieve the company's P2 goals decrease (because of the significant progress already made), this project has been placed in the 1997 capital budget.

Financial Analysis of Environmental Projects

The plant's environmental group identifies projects as part of a five-year capital plan which encompasses projects to implement pollution prevention improvements, projects to adjust processes in anticipation of regulations, and other engineering projects that have environmental ramifications. The environmental plan is then sent to the Environmental Management Committee where projects are screened and prioritized. Since all plant projects are administered by the engineering group, the sanctioned environmental projects are routed back through engineering to be budgeted and then are integrated into a five-year capital plan.

Projects within this plan are then submitted into an annual corporate capital budgeting process within which the total capital budget is reviewed. After filtering out financially marginal and strategically misaligned projects, the plan is sent to the parent company, Millennium Chemicals, for approval. All corporate borrowing is done through Millennium due to the more favorable interest rates accessible to the larger firm. Except for regulatory compliance projects, Millennium requires a demonstrable return on investment for capital projects. The return is calculated based on a discounted cash flow model. After Millennium's approval, Quantum assigns a capital budget to each facility and requires local management to proceed with the approved projects. On average, the Morris facility works with an annual capital budget of $18 million, of which approximately 11% is spent on environmental projects.

The specific rules for capital projects are delineated in the company's Capital Budget Policy. This policy requires the creation of a Capital Expenditure Approval (CEA) for each project. Projects classified in the CEA as 'cost reduction,' 'expand manufacturing capacity,' 'new product,' or 'yield improvement' require a calculation of simple payback based on pre-tax operating profits after depreciation. Projects in the remaining categories – 'necessary replacement,' 'major repair,' 'safety,' 'government required,' 'general purpose,' and 'quality control' – do not require financial justification. Economic benefits, if any, from these latter project types are included as "indirect effects" of the project.

The analysis of large projects includes elements of a total cost inventory, such as insurance and wastewater costs. Small projects, which represent most of the projects analyzed, are not budgeted with operating, secondary, or other nontraditional costs. Because the nature of polymer production is so capital intensive with very high relative fixed costs, it is felt that the effects of these other costs would generally be negligible, even for smaller projects.

Plant overhead comes from four cost centers: environmental, safety, accounting, and administration. These costs are initially allocated to the polymer units based on a quantitative calculation based on process size, capacity, and production rate. However, a qualitative analysis by each cost center is used to adjust the allocation based on expected proportion of effort that will be required for each process. Specific time spent by environmental personnel on a particular process is not charged back to that process. Doing so would require too much paperwork for a relatively small impact. The cost of environmental personnel is generally small compared to monthly maintenance costs.

Besides the formal capital budgeting process, there are sometimes funds available for discretionary spending, depending on recent profitability and cash flow. These funds, around $500,000 per year, are available for small projects to help meet emission reduction goals and are expensed rather than capitalized.

Perspectives on TCA

There is a growing need for a more comprehensive method of analysis for capital projects, especially environmental ones. Environmental projects deemed as necessary from a safety or regulatory standpoint are assigned the highest priority and are completed regardless of economic justification. In these cases, the financial analysis is rarely done. However, the recent evolution towards performance driven regulation has somewhat obscured the threshold above which projects are considered to be mandatory. As a result, it is becoming increasingly necessary for the environmental group to address the financial aspects of these projects.

Some significant barriers stand in the way of Quantum's implementation of TCA methodology for capital budgeting. The first is somewhat of a structural barrier in Quantum's organization. Currently, as projects are identified, a rough estimate of cost is assigned and the projects are prioritized and sometimes eliminated. Typically, those with a payback period greater than three years are eliminated at this stage. This rough cut is meant to expedite the process and ensure that significant engineering resources – which are typically capitalized into the project – are not spent on a project that ultimately will not be approved. More detailed engineering effort is only invested after this first pass review is complete.

The Environmental Manager would like to see a phased engineering study for proposed projects, with certain hurdles at each stage. This system would allow for enough detail in the early phases such that nontraditional costs could be included. Finally, once all costs, including operating costs, were included, an IRR for each project would be calculated and the projects ranked by that indicator. Under this process, engineering time would be expensed rather than capitalized to ensure that an adequate project analysis is completed before a project is eliminated.

A related barrier to implementing TCA is the limited resources of the environmental staff. Because the staff does not have time to perform its own project analyses, this task is farmed out to the engineering department. However, the engineering department does not always have the knowledge necessary to consider the best available technology or the potential savings from a project. As a result, environmental projects are often characterized as providing sub-optimal improvements that are economically understated.

Another barrier to TCA is the difficulty of costing certain elements of a project. Unlike safety projects, where insurance companies' actuarial data on workers' compensation can be used to determine probabilistic costs, environmental projects do not lend themselves to simple assessment of future liability. Because of its commitment to environmental improvement, Quantum rarely receives fines or penalties, and other intangible costs are practically impossible to quantify. Nevertheless, the Environmental Manager is eager for means to employ more rigor in the cost assessment process for capital environmental projects because he feels that doing so will enhance their chance of being approved.

QUEBECOR PRINTING MOUNT MORRIS, INC. (QPMMI)

Company and Facility Background

QPMMI is a large commercial printing facility, SIC 2721 (periodicals publishing and printing), 2752 (commercial printing, lithographic), and 2754 (commercial printing, gravure) that prints catalogs, magazines, and advertisement inserts for national distribution. QPMMI is a subsidiary of Quebecor Printing, Inc. (QPI), a $2.1 billion Canadian corporation with 84 printing facilities—35 in the United States, 38 in Canada, and 11 others worldwide—employing over 22,000 workers. QPI is one of the dominant competitors in a variety of print service markets, ranging from banknotes to books. QPI considers its strengths to be close integration between sales and manufacturing, value-added services such as mailing list management and demographic research for mass marketing, a large variety of printing options, and the latest high-speed printing technology.

QPI has been growing quickly over the past several years, primarily through acquisitions but also through expansion and increased capacity utilization at existing facilities. Operations management is decentralized, but sales and capital budgeting are closely controlled at the corporate level. QPI is a wholly owned subsidiary of Quebecor, Inc., a multinational holding company.

QPMMI is one of QPI's higher volume facilities, with revenues of about $95 million and 650 employees. The facility is physically very large, almost 5 acres under one roof, and is located in a rural area. It was first established as a family-owned business in 1898. In 1990, QPI purchased the facility from Maxwell Communications, Inc., to become the fourth corporate owner.

Materials, Processes, and Environmental Impacts

QPMMI provides pre-press, printing, post-press, and distribution services for high-volume customers. Customers can select from a variety of paper types and print qualities. Many customers require national or international distribution, so QPMMI must often coordinate with other QPI facilities to meet the strict delivery schedules for weekly magazines and advertising inserts.

Pre-press

QPMMI processes mostly computer-based art. Camera-ready art is usually scanned to create computer art that can then be manipulated. Proofing is done on color printers to avoid wasting time and materials by proofing on the presses. QPMMI has direct-to-plate (for web offset) and direct-to-cylinder (for roto-gravure) capabilities.

The plates for web offset printing are aluminum, and are etched in a series of closed plate processors containing first developer, then etch solution, and then stencil remover. Photopolymers are used as the coating material. The etch solution contains low-volatility glycol ethers, instead of the traditional and highly volatile isopropanol. About 500 gallons per year of spent etch solution is recycled via the supplier and then returned for reuse at Quebecor. The purchase price of the returned etch solution includes the cost of the recycling loop. Spent stencil remover, which is non-hazardous, is also recycled by the supplier. The aluminum plates are recycled after use.

Cooling water and rinse water from plate prep is tested in batches by the firm's Environmental Coordinator, and most of the time it is clean enough to discharge directly to the municipal sewer. If any constituent in the effluent exceeds its maximum allowable concentration set by the local publicly owned treatment works (POTW), the water is sent to the on-site wastewater treatment facility.

The roto-gravure cylinders are steel, electroplated with copper. They are electro-mechanically engraved; then the image area is coated with a five-micron layer of chromium for wear-resistance. Gravure cylinder prep is much slower than the offset plate prep. Cylinders are reused indefinitely (i.e., they are physical capital), while the scrap copper is sold back to the vendor for recycling. There are total enclosures for the various baths in the cylinder prep process to prevent fugitive emissions. The various wastewater streams from cylinder prep—about 1 million gallons per year—are contaminated with copper, chromium, and other metals, and are sent to the on-site wastewater treatment system.

Web Offset Printing

QPMMI has three four-color web offset presses, which are used for about 35 percent of the facility's production. Web offset printing provides a higher quality and higher priced product than roto-gravure, and is typically used for glossy magazines and retail catalogs.

In web offset printing, oil-based ink is applied to the plate, but adheres only to the parts of the plate that have been rendered hydrophobic by the platemaking process. The ink is then transferred from the plate to a roller, which then prints it onto the web of paper passing by. Web offset presses are heatset presses, which means they use heat to dry the ink. QPMMI uses petroleum-based and soy-based inks. The etch water (fountain solution) is a highly dilute solution of glycol ethers.

Vapors from the inks are piped directly into 1300°F thermal oxidizers for incineration. However, there are many opportunities for fugitive emissions to bypass the thermal oxidizers, particularly from the inks, but also from the mineral spirit solvents used in press cleaning. Etch water that has become contaminated with ink, about 14,000 gallons per year, is disposed of off site (see etch water filtration project, below) as an Illinois Special non-hazardous waste. There are also waste oils and other lubricants from the machinery—these are nonhazardous, but are disposed as hazardous waste along with the more flammable wastes.

Roto-gravure Printing

QPMMI has five four-color roto-gravure presses that account for about 65 percent of facility production. This makes QPMMI one of the largest gravure printing facilities in the United States. Initial investment costs for roto-gravure are much higher than for web offset, but operating costs are lower. Roto-gravure is used for lower quality, lower priced jobs, such as entertainment weeklies and advertisement inserts.

In roto-gravure printing, the ink is spread into the depressions engraved in the copper-coated steel cylinder, which then transfers the ink to the web of paper as it goes by. The inks are toluene-based because they must dry very quickly. QPMMI has tested a variety of aqueous inks, but none come close to the necessary drying times. Roughly 20,000 gallons per year of waste toluene are sent off-site for fuel blending. The cylinders are cleaned with solvents from the solvent recovery system—mostly toluene. Roto-gravure produces a large volume of fugitive emissions, close to 900,000 pounds annually, mostly from ink drying.

Post-press and Distribution

Pages are cut from the web and collated at the press. All other post-press operations are conducted separately from the press. These activities include folding, stitching, and labeling. Labeling is performed by ink jet printers using methyl alcohol-based inks, which emit some fugitive volatile organic compounds (VOCs). Pallets of printed material ready for shipping are shrink-wrapped; scrap wrapping is returned to the vendor for recycling.

QPMMI generates an enormous amount of waste paper—over 12,000 tons each year. Waste paper is shredded, baled, and sent to paper mills for recycling. The cardboard cores from paper rolls are returned to the paper mills for reuse.

On-site Solvent Recovery

Plant air is ventilated into a vapor recovery system to reclaim ink solvent vapors and prevent fugitive emissions outside the facility. Three enormous blowers collect a total of 180,000 cubic feet of air per minute and force it into four carbon adsorption towers. Based on the volume of solvents (mostly toluene) used upstream in the inks, the solvent recovery rate is 89 percent, which amounts to 14.5 million pounds of recovered solvent each year. Recovered solvents are mostly sold back to the ink vendors for recycling.

The carbon towers must be steam ventilated every 4 hours for 50 minutes. The steam is generated by two natural gas-powered boilers. The steam system is automated to vent the towers in sequence, so that at any given time three towers are active and one is being ventilated. The Environmental Coordinator checks the towers annually to make sure that the carbon has not settled to create gaps through which solvent vapors might escape; this ensures that the carbon will function well over its 8–10 year lifetime.

On-site Wastewater Treatment

QPMMI's water treatment system processes about one million gallons of highly acidic (pH between 2 and 3) wastewater per year from gravure cylinder operations. The wastewater contains high levels of chromium along with other metals, some dissolved VOCs, and oily waste. The treatment system consists of a 750 gallon chromium reduction tank, two 5,000 gallon batch settling tanks, an oily waste separation tank, a 1,320 gallon sludge storage tank, and a filter press. The system removes about 99 percent of the dissolved metals and oily waste, and raises the pH to between 6 and 9.

Overflow rinse water from the chromium plating tanks are fed to the chromium reduction tank, in which the wastewater is pretreated with sodium bisulfate and sulfuric acid to reduce hexavalent chromium to trivalent chromium. The reduced chromium, along with all other plating wastewater from the gravure cylinder preparation, is transferred to the settling tanks where ferric chloride, caustic soda, and flocculent are added. Once the iron, chromium, and other solids have been precipitated and the pH has risen, the water is sent to the oil separation tank where the oil is skimmed and returned to the settling tanks. The precipitate is transferred to the sludge storage tank, to await dewatering. The dewatered sludge, about 12,000 gallons per year, is sent through the filter press to be compressed and dried. Water from this stage is returned to the settling tanks, and a small amount of oil is collected and disposed of as hazardous waste. The resulting solid filter "cake" is bagged and sent off-site as hazardous waste. Although the waste leaves the plant as hazardous waste; due to a recent change in Illinois hazardous waste regulation, once the waste has been fixated at a treatment facility, it is no longer considered to be hazardous.

Ferric chloride solution (19,000 pounds) and caustic soda (3,000 gallons) together cost about $11,500 per year; the other wastewater treatment chemicals are used in relatively minute amounts. The Environmental Coordinator estimates that the labor costs involved in water treatment are close to $60,000 per year, for 2,000 person-hours. The cost of the off-site sludge treatment is over $11,000 per year.

Environmental Management

The Environmental Coordinator is responsible for all waste handling, recycling, and treatment at QPMMI. He also is the Maintenance Superintendent and the Building Superintendent, which leaves him little time to spend on proactive pollution prevention (P2) activities. He regrets that he has not had time to devote to several environmental projects he considers important. He has worked hard to reduce and recycle as many waste streams as possible, however, and was awarded second place in the 1993 QPI Enviro-Awards contest. An Environmental Council that he established in 1993 has been closely involved in facility recycling efforts. The Environmental Council consists of representatives from different departments who serve as an advisory and brainstorming group on environmental issues.

The Environmental Coordinator reports to the Plant Controller, who is the second-ranking executive at the facility. The top QPMMI executive is the Vice President and General Manager, who reports to the corporate staff of Quebecor Printing USA, Inc.

Upstream P2, such as input substitution and source reduction, is primarily under the authority of operations management since these types of activities are integral to process operations and therefore beyond the immediate purview of the Environmental Coordinator. Input substitution is difficult in high-volume, high-quality printing because of the strict requirements with regard to ink drying time. QPMMI has switched to glycol ether etch water and soy inks in web offset printing, and uses recycled paper for much of its production.

The QPI environmental policy centers on its trademarked "Enviro-Printer" program. The policy statement associated with the Enviro-Printer program lists eight objectives:

1) use processes that reduce pollution, material use, and energy use
2) use recycled materials

3) use non-hazardous products and processes
4) promote environmental awareness and service among employees and other stakeholders
5) reduce and recycle waste
6) comply with environmental regulations
7) construct, renovate, and maintain facilities with consideration for the environment
8) use renewable energy

The policy statement stresses five priority areas to focus on within these objectives:

1) solid waste reduction beyond regulatory requirements
2) hazardous waste reduction beyond regulatory requirements
3) air pollution control in accordance with regulations
4) water conservation and water pollution control beyond regulatory requirements
5) an annual "Earth Day Every Day" service campaign

The statement describes six mechanisms for accomplishing these objectives:

1) fostering technology transfer among facilities
2) establishing concrete waste reduction goals
3) working with vendors and suppliers toward input substitution
4) choosing vendors and suppliers that are willing to take back materials for recycling
5) evaluating progress annually
6) participating in trade association environmental initiatives

Facility Environmental Coordinators receive a binder containing details of QPI's Waste Minimization and Pollution Prevention Plan. The binder also contains descriptions of waste minimization and pollution prevention projects undertaken at various QPI facilities.

The Environmental Coordinator says that QPMMI has a good relationship with the US Environmental Protection Agency and the Illinois Environmental Protection Agency (IEPA). QPMMI is a charter member of the Illinois Partners in Pollution Prevention program. QPMMI is also beginning to get involved with community environmental efforts, such as tree planting and recycling collection.

Recent and Pending Environmental Initiatives

Both the Environmental Coordinator and the Plant Controller stress that the primary motivations for environmental initiatives are to stay in compliance and save money. Within the larger corporate goals of rapidly increasing revenues and building a reputation for quality and customer service, these motivations have led QPMMI to search for ways to reduce both its regulated waste streams and its non-regulated waste streams.

Solvent Recovery System Expansion

QPMMI plans to add a second solvent recovery system that will add 120,000 cubic feet per minute capacity. The new system will be similar to the existing system, except that it will use three horizontal carbon adsorption beds instead of vertical towers. QPMMI will also build total enclosures for the press room to achieve greater fugitive emissions capture efficiency.

The project has been approved and is nearly completed. The cost is $4.2 million, which includes $600 thousand for the total enclosures.

The new system is necessary to accommodate a sixth gravure press that is being added at the facility. Without a vapor recovery system expansion, the new press would put QPMMI over its permitted levels of VOC emissions. The two recovery systems will be used in parallel. According to the Environmental Coordinator, this configuration will provide both production flexibility and risk reduction by allowing the facility to run two or three presses even when only one solvent recovery system is working. He can conduct inspections during off-peak hours when just one system is needed. Moreover, emergency repairs will not force the whole plant to shut down. The total enclosures combined with the additional capacity will also allow QPMMI to relax restrictions on solvent use during peak production periods and still stay within its air emissions permit. (QPMMI exceeded its permit briefly in 1992 when one of the blowers in the existing recovery system failed.)

The solvent recovery expansion was not strictly analyzed as an independent project because it is an integral part of the new gravure press installation project. It represents an additional $4.2 million capital cost for that project, but it also provides production flexibility and reduced down time benefits.

Pre-treatment of Cylinder Plating Solution

As part of the Illinois Partners in Pollution Prevention program, a graduate engineering intern studied QPMMI's wastewater treatment system. The intern recommended pre-treatment to remove most of the copper from the water before it is sent to the treatment system for removal of chromium and oily wastes. This project allowed QPMMI to skip the copper treatment step in the wastewater treatment process, eliminating the copper sulfate precipitate that used to be part of the sludge. Instead, the recovered copper is replated onto the cylinders.

The main motivations for this project were to reduce costs and eliminate a waste stream. The initial outlay was $8,000 for the copper recovery system. The system recovers over 99% of the copper and sends it directly back to the plating operation. Because the recovered copper is not segregated from the raw copper and because the previous copper use volume is unknown, no savings have been quantified from this project.

Etch Water Ultrafiltration

The same graduate intern also investigated ultrafiltration of the etch water waste stream from offset printing. In principle, etch water is reusable indefinitely, but in practice it becomes contaminated with ink and needs to be scrapped periodically. Although the contaminated etch water waste is non-hazardous and costs little to dispose, reusing it would reduce purchases of new etch water solution. A pilot project to filter out ink and solids produced etch water clean enough to be reused endlessly, but the equipment had reliability problems.

The graduate intern has left, and the Environmental Coordinator does not have time to troubleshoot the recycling equipment. The Environmental Coordinator suspects that the project would be profitable for three reasons: (1) the capital investment would be small, (2) some of the preliminary engineering work has already been done by the intern, and (3) the project would enable QPMMI to reduce its etch water purchases.

Wastewater Treatment System Improvements

The Environmental Coordinator has been considering a project to improve QPMMI's wastewater treatment system. The improvements would replace the current batch system for chromium reduction with a continuous membrane filtration system that would precipitate and remove dissolved metals. The membrane system under consideration can filter up to 5 gallons per minute. Wastewater from the chromium reduction tank and other gravure cylinder wastewater would be transferred to one of the existing 5000 gallon settling tanks, which would be used simply as a holding tank to equalize the flow into the proposed membrane filtration system. In the chemical reaction section of the proposed system, the pH would be adjusted and metal hydroxide precipitates formed. In the crossflow micro-filtration section of the system the particulates would be removed using membrane filters. The particulates would then be concentrated and dewatered. The clean water would be pumped to the second existing settling tank, which would also be used just as a holding tank so that the outgoing water could be tested before release to the POTW.

The direct capital cost of the proposed system is $120,000 for the equipment from the vendor plus the cost of accessory equipment and installation, roughly $60,000. The new system would use a smaller volume of treatment chemicals than the existing system and would be considerably less labor intensive as well. Instead of generating sludge, the new system would generate a metal concentrate that QPMMI could sell to a metal recycler instead of sending it off-site for treatment as a hazardous waste.

Due to constraints on his time, the Environmental Coordinator has not performed the necessary analysis to determine if the project would be profitable, although he is confident that it would be. He has submitted the project several times as part of the annual list of potential projects for the facility. However, it is always one of the first removed from the list because it is perceived as an unnecessary money-loser—it is not required by regulation and it does not appear to be profitable.

Financial Analysis of Environmental Projects

Capital budgeting has been a very formal and tightly controlled process since 1990, when QPI purchased the Mount Morris facility. Individual facilities cannot approve any project without corporate approval. In other words, there is no discretionary capital spending. The capital budgeting process is the same for all projects, although customer-requested projects and compliance projects are not required to meet financial hurdle rates.

Project ideas originate at the facility level. According to a QPMMI guidance document, capital needs arise from customer requests, common equipment replacement, cost avoidance opportunities, business expansion plans, environmental regulations, or safety and quality opportunities. Based on this guidance, managers submit project ideas with simple costs/savings figures for an initial screening. Based on this preliminary list, and before detailed financial analysis is done, projects that appear to be unprofitable are removed from further consideration. Each facility then submits its narrowed list of projects to QPI in the annual capital budgeting process. After reviewing these lists, QPI determines how much capital spending each facility will be allowed. Facilities must decide for themselves which projects to cancel in order to meet their spending limits.

Perhaps even before a project has been included in the capital budget but after it has passed the initial facility screening, the relevant operating department personnel (such as a technical supervisor or superintendent, engineer, or maintenance staff person) prepares a Project Authorization Request (PAR) in detail. The project originator must adhere strictly to the PAR guidelines, which call for: (1) a PAR form; (2) a one to two page written explanation that lists assumptions, alternatives, and motivations for the project; (3) an estimate of the project cost; (4) a financial justification showing the internal rate of return (IRR); (5) commitments from customers or a letter from the Sales Department, if relevant; (6) equipment quotes from vendors; and (7) Gantt schedule charts on time-critical projects. The Plant Controller and the Engineering Superintendent provide technical support in the preparation of PARs.

The completed PAR must be approved by the relevant Department Superintendent, the Engineering Superintendent, the Manufacturing Manager, the Plant Technical Manager, and the Plant Vice President/General Manager. Once these facility personnel have approved the PAR, it is passed on to QPI corporate managers. Depending on the magnitude of the project, final approval authority may rest with the Senior Vice President of Operations for the relevant product group ($0–150,000); the President and Chief Operating Officer, QPI USA ($150,000–250,000); the President and Chief Operating Officer, QPI ($250,000–350,000); the QPI Executive Committee ($350,000–2,000,000); or the QPI Board of Directors (more than $2 million). Unbudgeted PARs, usually less than 10 per year at QPMMI, are subject to stricter review. The PAR approval process takes 60–90 days.

QPI uses payback period, internal rate of return (IRR), and net present value (NPV) as indicators of profitability. The NPV currently a discount rate of 8.5%, which represents QPI's cost of borrowing but does not include inflationary effects. Projects must return a minimum of 15% to be considered. The maximum time horizon allowed is ten years.

The Plant Vice President/General Manager and the Plant Controller must submit an accomplishment report and an economic report for all projects over $500,000. The accomplishment report is required at the end of construction and installation, and it summarizes actual expenditures compared to the original PAR. The economic report is required one year after the accomplishment report, and it details the "global economic impact of the project in light of the revenues generated, expenses, cash flow, impact on other segments of the business, etc.," compared to the original PAR.

Competition among facilities for capital funds from QPI is "fierce," with a typical payback within 2–3 years and IRR over 20 percent. QPMMI's strategy in this highly competitive environment is to have all PARs ready for submission as soon as the capital budget is approved, a strategy that requires a lot of advance preparation and coordination among facility personnel.

Capital expenditures at QPMMI have averaged about $10 million over the past five years, but the capital budget for 1996 was about $30 million. This is higher than the average QPI facility because the Mount Morris plant bought a new press. Identifiable environmental expenditures have not been more than $7 million total over the past five years, but according to the Environmental Coordinator, environmental considerations are incorporated into all plant renewal and plant expansion projects.

A QPMMI checklist for filling out PARs asks for (1) definition of need, (2) discussion of options, and (3) recommendation. Under the first section, "definition of need," the subsection for environmental PARs asks "what's violated? what's the risk? what does America say? what does Canada say?" The third section, "recommendation," in one subsection entitled "basis of recommendation" lists a variety of criteria to consider, including cost, cost per unit, specific customer need, quality, unique fit with other equipment, reputation of the manufacturer or vendor, technical support of vendor, and environmental considerations. The other subsections prompt for outside recommendations, such as from customers or other QPI facilities; consideration of future needs such as expandability, upgradability, and adaptability to other customer needs; and consideration of other issues such as environmental regulation, new technology, and "ability to enhance customer dependence."

This checklist indicates that some environmental issues are considered qualitatively along with other important but unquantified issues. However, the checklist does not break the environmental category into its component cost items (such as staff time for permitting and manifesting, compliance training, insurance, liability, etc.), nor does it ask for quantitative cost estimates for the environmental aspects of a project. Only readily quantifiable, incremental cash flow effects are included.

Departments are responsible for the costs of disposing their own waste. Overhead costs, such as building, grounds, and energy, are not reallocated to operating departments.

Perspectives on TCA

The Environmental Coordinators thinks there is a need for a more systematic and comprehensive approach to the financial analysis of environmental projects. Most pollution prevention projects are done in anticipation of future regulations and/or to reduce waste, but without a regulatory mandate, QPMMI is reluctant to invest scarce funds in such proactive projects without an assurance of reasonable profitability. In that respect, TCA, which would show many of these projects to be profitable, would lead to increased investment in environmental projects. Without TCA, it is very difficult to get funding.

The main obstacle to the implementation of TCA is scarcity of time. Due to downsizing in recent years, the Environmental Coordinator does all of the work that used to be done by four people. With limited time, detailed financial analysis of potential environmental capital projects is a low priority. When he submits a list of capital projects each year, only a simple analysis supports each project. Only after the project has cleared the first internal screen would he go through the time-consuming PAR process. Therefore, most projects do not clear that first screen.

The "stick" approach of end-of-pipe regulation is currently the only driver for committing capital funds to environmental projects at the facility. At the same time, regulatory inflexibility can impede or retard such investment. For example, QPMMI is required by the National Emissions Standards for Hazardous Air Pollutants (NESHAP) to install the best available control technology (BACT) on its chromium plating tanks. Although there are already control devices on the tanks and the BACT installation would therefore be an upgrade, IEPA requires a new construction permit. This long process has kept the new control technology from going on line. This type of inflexibility is frustrating to QPMMI and can affect investment decisions.

An incentive for capital investments is a long-standing Illinois law that exempts equipment used in printing production from state tax. Since almost any system upgrade to prevent pollution affects production machinery, most capital costs are state-tax exempt. Nevertheless, QPMMI will generally not undertake a voluntary capital environmental project unless there is sufficient return, and the state tax exemption rarely enables a project to provide that return.

Appendix C - Phase II Case Studies

COMPUTER PRE-PRESS SYSTEM PURCHASE - SMALL LITHOGRAPHIC PRINTER (SLP)

Company and Facility Background

This company is a small lithographic printer, printing one- to four-color posters, cards, and booklets. Many of the company's customers are community groups, political groups, or national non-profit organizations, but the company also serves commercial clients.

The company, started in the late 1960s at an Illinois university, later moved to a Chicago location and became a non-profit organization. In the mid-1980s, the company became incorporated as a for-profit cooperative in order to gain access to financing through avenues that are unavailable to non-profit organizations. There are eight partners who make business decisions collectively, plus seven other employees. The company moved to its current location in late 1994. The building, which the company owns, is about 40 years old.

Project Background

This printer provides traditional lithographic printing, including pre-press, printing, and some post-press processing. The company's current computing abilities are limited, so disk-based jobs requiring computer pre-press operations are sent to a service bureau to produce film for platemaking. (See Figure 1 for a schematic of the pre-press operation.) These jobs currently represent about two-thirds of the company's total jobs, a percentage that is rapidly increasing. The costs of using the service bureau are increasing even faster, from under $1,500 in 1994 to a projected $48,000 in 1996.

The remaining third of the business comes in on conventional media. This original art is photographed and the film is sent to an in-house darkroom for silver film open tray developing. Film developing produces spent fixer and spent film developer. Spent fixer, about 6 gallons per year, is poured through a small silver recovery unit. The Production Manager suspects that the recovery unit may be too old to recover very much silver from the fixer. The spent developer, about 24 gallons per year, is washed down the drain. As this darkroom process is an open tray developing process, it produces fugitive vapor emissions of unknown quantity and composition.

The Production Manager is concerned about the fate of the spent film developer. Although it is aqueous, and the vendor assures him that it is safe to pour down the drain, he is not sure about the regulations or the possible environmental effects.

From the darkroom, the prints are laid out on a stripping table where manual adjustment and formatting is done. Scrap material from this process is thrown in the garbage. A rag service collects dirty rags and provides clean ones. The rag service also collects the company's dirty citrus-based solvents. The Production Manager does not know what the rag service does with the rags or the solvent waste.

Figure 1. Schematic of Former Pre-Press System

Project Description

The company recently purchased a computer pre-press system. The system is able to directly process jobs that customers submit on computer disk; jobs submitted as camera-ready art can be scanned and then processed. The film processor that is part of the system produces film that can be used in platemaking, thus bypassing the darkroom entirely (see Figure 2).

The company sought purchase an integrated turnkey system from a single vendor to avoid product incompatibilities and to facilitate maintenance and technical support. After soliciting equipment bids from a number of vendors and considering the processing speed and features required, the company purchased a nearly complete system for approximately $46,000. This price included a PowerMacintosh for digital artwork and publishing, a Pentium PC for image processing, various software packages, accessories (scanner, modem, zip drive, etc.), installation, and configuration. Separately, the company purchased a used film processor from the company's primary film vendor for $3,000. Finally, some miscellaneous electrical and plumbing work was done to accommodate the new system.

The computer pre-press system allows the company to bring disk-based jobs – which were previously all sent to a local service bureau for processing – back in-house. Savings from avoided service bureau and courier expenses could potentially reach $3,000–4,000 per month. In addition to these direct savings from avoided costs, there are other benefits that are expected to indirectly contribute savings as well.

Conducting pre-press operations in-house reduces job turnaround time by a minimum of 24 hours on disk-based jobs. As printing operations generally become more electronic, customer expectations and demands increase, and lead times that used to be acceptable are now considered too long. Thus any reduction in the time it takes to turn around a job for a customer creates a competitive advantage.

In-house processing also provides more control over pre-press decisions and facilitates easier rework. Maintaining control over this critical aspect of the printing process gives the facility the means to greatly enhance customer satisfaction via production of quality work. Furthermore, the new system eliminates the use of the darkroom on most jobs. The new film processor allows camera-ready jobs to be processed without use of open-tray developing in the darkroom.

The primary motivations for this project were to streamline pre-press operations, reduce service bureau costs, and provide new capabilities and flexibility that would increase product quality and services offered and attract new business. Avoiding darkroom use and minimizing chemical use in the pre-press process for both environmental and worker safety reasons were significant secondary motivations.

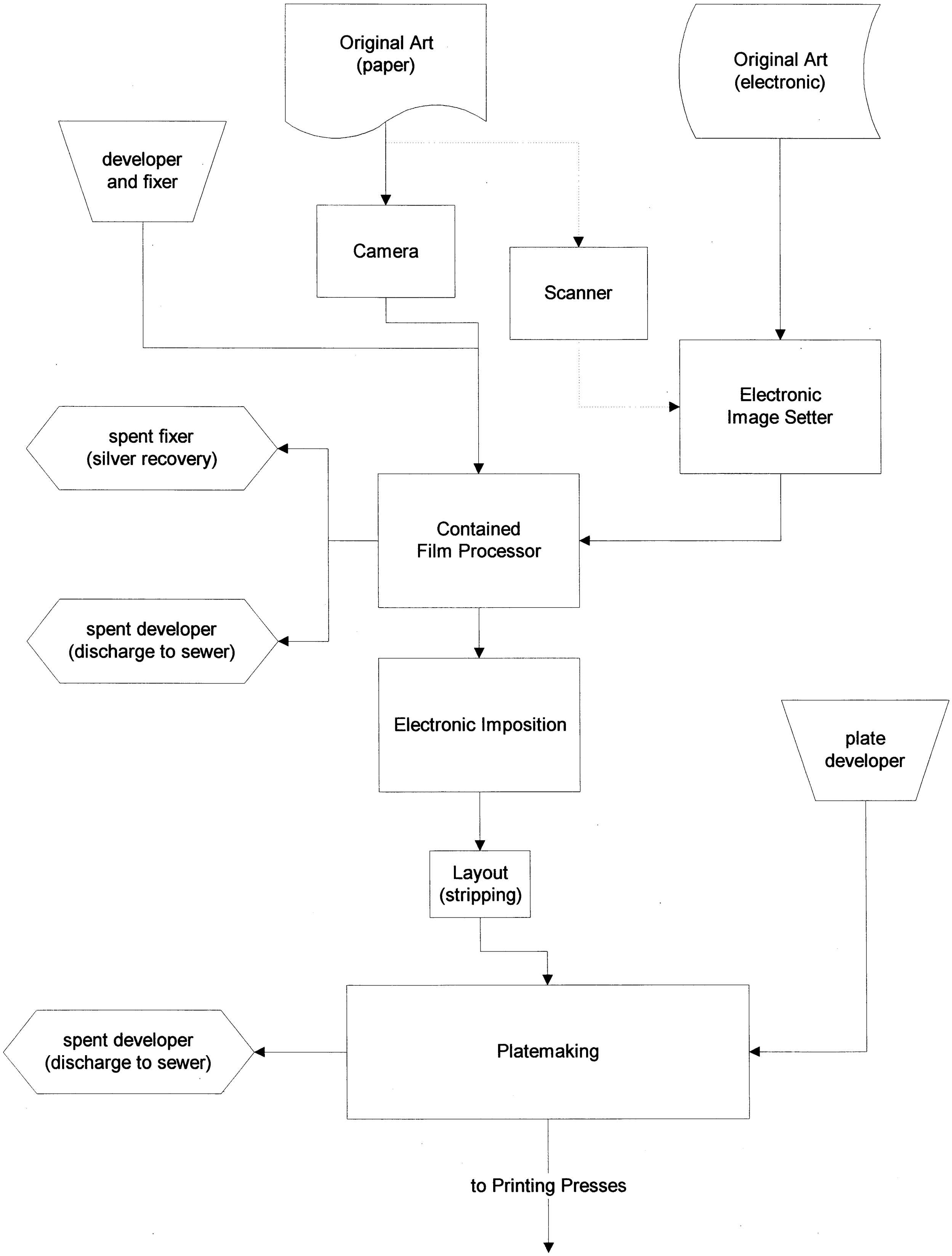


Figure 2. Schematic of New Computer Pre-Press System

The Company's Financial Analysis of the Project

The company does not use financial indicators beyond simple payback, and does not collect the data necessary to conduct rigorous financial analyses. When evaluating capital expenditures, the partners estimate the direct quantifiable costs and savings, consider less tangible benefits, and make a conservative but somewhat intuitive decision. The evaluation of the computerized pre-press system was done in this fashion. The potential effects of taxes, depreciation, inflation, and discounting were not considered.

For this project, the company made a quick analysis of its expenditures to the service bureau. It was estimated that upwards of two-thirds of current service bureau costs could be eliminated with the installation of the new pre-press system. The Production Manager assumed that, at first, that fraction might be lower as the facility moved along the learning curve of the new equipment. He further estimated that roughly one-third of the work that currently comes in electronically would still be beyond the capabilities of the new system either for technical or logistical reasons. One such reason is that the processor that is in the facility's price range is too small for large posters. Also, the more complex four-color work would be, in the near term, beyond the technical capabilities of the staff. Similarly, some of the work may remain in the darkroom due to limitations of electronic processing and specific customer needs. The final constraint of the new system would be one of resources; during very busy periods, one operator working on one processor will not be enough. This constraint will relax in time as operators move along the learning curve and require less time per job.

Because of the anticipated learning curve with the high-tech equipment in the otherwise traditional printing environment, the effects of the project on labor costs were not considered. The Production Manager felt they would be too difficult to quantify and would change over time. Other costs, such as raw materials, utilities, and waste disposal also were not considered.

In summary, the costs considered by the company were:

- Initial purchased equipment costs, as specified in vendor quotes ($49,310)
- Annual savings from a reduction in service bureau charges ($22,500)
- Annual savings from reduced courier charges ($1,500)

Total Cost Assessment (TCA) of the Project

A Total Cost Assessment (TCA) was performed in order to provide a more accurate economic picture of the project. An essential element of a TCA in analyzing the true costs of a project is an enhanced cost inventory. Direct project investment costs and operating cost savings are typically included in a standard project analysis, but many other relevant costs may be omitted because they are less apparent. Indirect labor, compliance, and waste disposal are examples of actual costs that can materially affect the potential profitability of a project. In this case, the TCA includes many other cost and savings relevant to the purchase and operation of the computerized pre-press (see Table 1).

This broader inventory of costs and cost savings also encompasses another element of TCA; more precise allocation of costs to specific projects or processes. Facilities incur many costs – including many environmental costs – that are placed in overhead accounts and then broadly allocated across the facility. Misallocation distorts the costing of individual processes, rendering some seemingly more profitable than they are and others less. By correcting this imprecise allocation, TCA more realistically reflects the costs of a process. For this project, the Production Manager's managerial time was allocated to the pre-press in proportion to the relative share of time demanded by that process.

The TCA included the following costs and cost savings that the company's analysis did not.

Initial Investment Costs

1. The Production Manager and others at the facility spent time to carefully consider the purchase of this system. After the group decided to seek vendor quotes, time was spent working with the vendors, selecting the system to purchase, and coordinating the installation. All of this time was estimated to have taken, in total, the equivalent of one person's time for one week, costing roughly $650.

2. Since the system was not purchased as an entirely turnkey package, there were contractor costs associated with the installation. Wiring and piping to accommodate the new system cost $1,400 and plumbing to accommodate the film processor cost an additional $275.

3. The new system, unlike any equipment currently in-house at the facility, required some training time. Training required roughly 14 hours each for the Production Manager and the operator, costing $190. (This figure includes only direct wages and does not try to account for lower productivity due to lost time.)

Annual Operating Costs and Savings

1. Reduced labor for pre-press darkroom and stripping operations. The new system virtually eliminates the need for darkroom work and reduces the overall workload on stripping operations. As shown in Table 2, the darkroom previously required approximately 16 hours per week of labor costing $10,103. These darkroom costs essentially were reduced to $2,799 for the new digital pre-press system.

   Similarly, pre-press stripping operations previously required two workers for three-quarters of their time plus half of the Production Manager's time. Total stripping costs previously were $54,369 per year and have dropped to an estimated $49,890 due to the increase in digitally processed art.

2. New computer pre-press labor. The electronic imposition work, previously done by the service bureau, requires almost a full-time employee in-house, costing $19,672 per year. As shown in Table 2, an employee who previously spent 85% of his time on pre-press stripping operations and 15% of his time on darkroom operations was shifted almost full-time to this electronic imposition work.

3. Reduced supervision cost. With the previous system, the Production Manager spent half of his time performing pre-press stripping operations and half performing managerial duties at the facility. As shown in Table 2, one-third (17%) of the Production Manger's managerial time has been allocated to the pre-press process since it accounts for roughly one-third of the facility's labor cost.

   With the new digital pre-press system, the Production Manager needs to spend 75% of his performing pre-press stripping operations. The remaining 25% of his time is available for managerial duties at the facility, and one-third of this (8%) again is allocated to pre-press operations. The end result is a decrease in supervision time for the facility's pre-press operations (from 17% to 8% of the Manager's time). This corresponds to a cost reduction from $5,260 to $2,630.

4. Increased film costs. Film for the new processor is considerably more expensive on a unit basis than the darkroom film, but it is still less than film processed by the service bureau. Annual film costs, currently $2,100 per year, are expected to increase to $14,700. This figure does not account for the reduction of service bureau film, since this cost is bundled into the total service bureau cost.

5. Reduced use and disposal of darkroom fixer and developer. Moving film developing from the darkroom to the enclosed processing unit is expected to reduce chemical cost by 60% from its current cost of $2,500 per year. This reduction is achieved because less volume is required for a given quantity of film, and chemical life is increased by a water filtration system inside the processor. With open-tray developing, chemicals exposed to the atmosphere lose their integrity after four or five hours and must be disposed of. (Since the chemicals are currently disposed of without direct cost, no savings from avoided disposal cost was included.)

6. Lower costs of service bureau charges and of ferrying disks between the facility and the service bureau. Service bureau and shipping costs, previously projected at $45,000 and $3,000 respectively for 1996, are expected to drop by a half to two-thirds. The initial drop is assumed to be by one half with costs continuing to decline by 10% per year as the facility moves along the learning curve.

7. Lower typesetting costs from vendor. Much of the work previously sent out for typesetting (e.g., business cards, letterhead) can now be done with the digital imaging software. The expected 60% drop in this service will save $1,710 annually.

8. Improved customer response by eliminating the service bureau's 24-hour turnaround time. This improvement is one of the more difficult to quantify. Even without this project, the company's revenues have been growing rapidly. The Production manager estimates that digital capabilities will enable an additional 10-15% sales increase over 1996 projected revenues of $1,130,000. This incremental revenue stream is assumed to decline at 10% per year to conservatively reflect diminishing returns from the system and aggressive competition. Because the facility is not currently at capacity, it is expected that this increase in business can be handled with existing resources. Before long, however, additional staff will be required as the business continues to grow.

Table 1. Comparison of Cost Items Included

		Company	TCA
Initial Investment Costs			
Purchased Equipment		✓	✓
Planning			✓
Electrical Work			✓
Plumbing			✓
Training			✓
Annual Operating Costs			
Materials:	film		✓
	chemicals		✓
Labor:	darkroom		✓
	stripping		✓
	computer		✓
	supervision		✓
Service Bureau work		✓	✓
Typesetting			✓
Courier		✓	✓
Revenues			✓

Table 2. Changes in Allocation of Labor for Pre-Press Operations

		Service Bureau Pre-Press			Digital Pre-Press			
	wage	stripping	darkroom	supervision	stripping	darkroom	computer	supervision
Prod. Mgr.	$16.28	50%		17%	75%			8%
Operator 1	$12.20	75%	25%		90%	10%		
Operator 2	$ 9.75	85%	15%		5%		95%	
		$ 54,369	$ 10,103	$ 5,260	$ 49,890	$ 2,799	$ 19,672	$ 2,630

Note: The balance of the Production Manager's time is spent managing the press and post-press operations. Pre-press labor represents approximately one-third of the facility's total labor. Using this labor figure as an allocation base, one-third of the Production Manager's supervision time is allocated to pre-press. In total, labor costs for pre-press operations at the facility have increased with the new system because, although the operators already spent all of their time in pre-press, the Production Manager now devotes more of his time (83%, up from 67%) to pre-press operations.

In addition to these costs and benefits uncovered by the TCA approach, the impact of taxes, the equipment depreciation tax break, and the time value of money were included to better characterize the project's profitability. Physical investment items were depreciated using a double declining balance method to take advantage of the tax effects of accelerated depreciation. All of these items, except the film processor, were assumed to be in the five-year class of goods that includes computer equipment. The film processor was placed in the seven-year that includes assets used for lithographic printing, and was assumed to have an equipment lifetime of five years with a salvage value of roughly half its cost. This relatively high salvage value estimate was used because the processor was purchased as used equipment, therefore its initial devaluation had already occurred. The two computers were assumed to have equipment lifetimes of four years and salvage values of roughly 20% of their purchase price.

Inflation for the analysis was set at 3%, and income taxes were 37.94% for federal (this number is an effective rate based on 15% tax on the first $50,000 and 39% on the balance) and 7.3% for the state of Illinois. The projected cash flows were discounted at 12% for the analysis. This rate was chosen as a conservative estimate of the facility's cost of capital. The relatively short 5-year project lifetime reflects the rapidly changing technology of lithographic pre-press operations. Advances in direct-to-plate processes and imaging software may shorten the lifetime of any current capital purchase.

Summary of Results

The more comprehensive cost analysis highlighted a number of costs and some savings that resulted from the purchase of the computerized pre-press system. Table 3 compares results of the company's analysis with those of the TCA. In order to make a direct comparison of net present values and discounted paybacks, both analyses were run using a 12% discount rate. Although the more thorough treatment showed the initial investment to be more than $2,500 above the estimate used in the company analysis, and the labor and film costs associated with the new system represented an increase; the overall project is more profitable due to the savings from decreased chemical cost and increased product revenues.

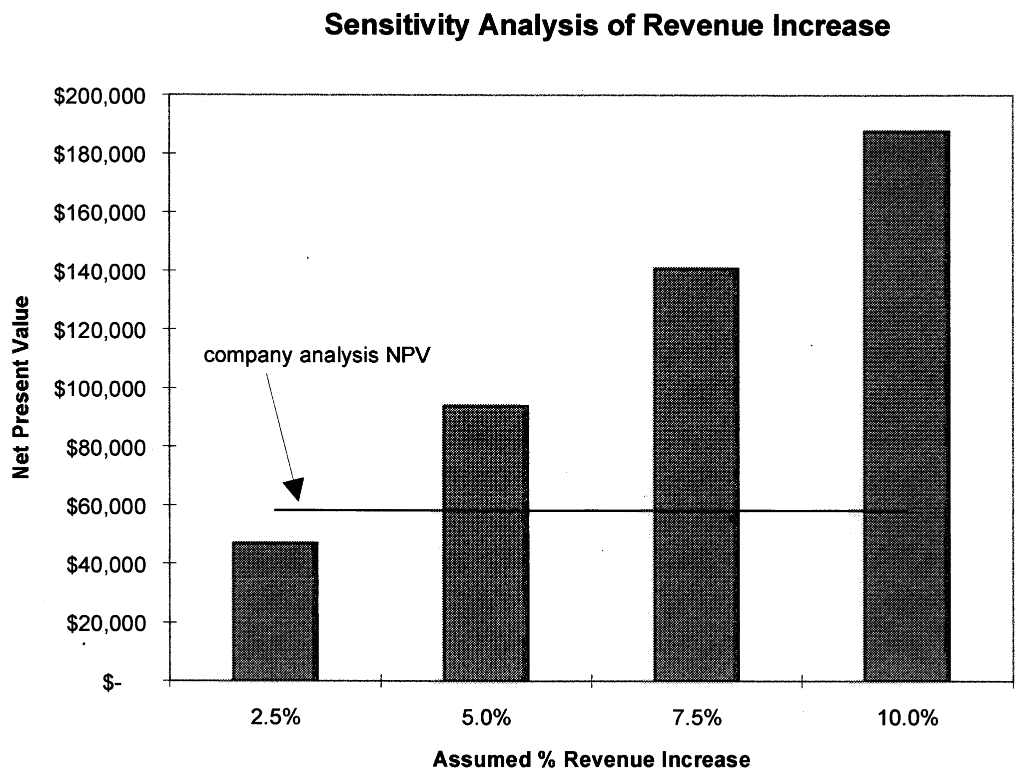
Table 3. Comparative Summary of Cost Data and Profitability

	Company	TCA
Initial Investment Costs	$ 49,385	$ 51,900
Annual Operating Savings - Year 1	$ 26,400	$ 90,165
Net Present Value - Years 0-5	$ 58,358	$ 187,701
Internal Rate of Return - Years 0-5	51%	132%
Discounted Payback	2.14	0.82

The new annual operating costs identified by the TCA, comprising the increase in film costs and labor, total $17,860. Meanwhile, the cost savings, from reduced chemical purchases, reduced service bureau and courier costs, and reduced typesetting costs, total $27,210. Therefore the net effect of the operating items in the TCA is an annual savings of close to $10,000. Inflation notwithstanding, this incremental savings grows over the life of the project as the operators become more adept and efficient in using the computer pre-press.

The main assumption in the analysis concerned the increase in revenues that would result from the investment. Since the system has been on-line for just a short time, no data were yet available to support the assumption that revenues would increase by 10%. This assessment is further complicated by the fact that revenues are currently increasing for reasons not related to the new system, and that cost increases necessary to generate the increased revenues are unknown. Separating out the commingling effects would be difficult if possible at all. The sensitivity of the analysis was tested against varying assumptions on the magnitude of the revenue increase. As shown in the chart on the next page, if revenues increase by only 5%, the discounted payback calculated via the TCA climbs to 1.43 years and the five-year NPV falls to $93,963. Thus, the analysis is quite sensitive to changes in this assumption.

The analysis endeavored to account for and allocate all relevant costs relating to both the former process and the new one in order to perform a more precise Total Cost Assessment. However, allocations of labor within the larger framework of a fixed labor pool (there was no change in overall headcount as a result of this process change) can be misleading if the analysis opts not to consider the opportunity costs of labor. In other words, reassigning people to make better use of their time can yield significant benefits, but absent this consideration, overall, bottom-line costs are not changing. The TCA analysis was re-run without the inclusion of initial investment or annual operating internal labor costs. In this analysis, the five-year NPV climbs to $200,074, dropping the discounted payback slightly to 0.77 years. The labor allocation, in this case, made the project appear less profitable because it accounted for labor that was drawn from other facility activities. A more complete labor allocation would have accounted for the fact that the Production Manager's time in non–pre-press operations changed as well.



In both the company analysis and the TCA, the project is quite profitable for the facility. The TCA, in this study, strengthens the intuitive assessment of the project's value to the firm and helps the company to understand where it can expect cost increases and where the savings should come from.

Costing and Financial Analysis Documentation

Table 4. Initial Investment Costs

COST ITEM	DESCRIPTION	COST
Purchased Equipment	from vendor invoice for Power Macintosh, image-setter, software, and associated hardware.	$ 46,310
	from vendor invoice for film processor	$ 3,075
Planning	preliminary system design and vendor selection, 40 hours at $16.28/hour	$ 650
Electrical Work	from electrician invoice for materials and labor to wire the new system	$ 1,400
Plumbing	from plumber invoice to relocate drain & water supply & install shut-off valves to accommodate the film processor	$ 275
Training	equipment training for the Production Manager and the operator, 7 hours each at an equivalent $12.74/hour	$ 190
Total		**$ 51,900**

Table 5. Annual Operating Costs/Savings

COST CATEGORY ITEM	PREVIOUS-SERVICE BUREAU	COMPUTER PRE-PRESS	ANNUAL SAVINGS (COSTS)
Materials			
Chemicals	$2,500/year	$1,000/year	$ 1,500
	current cost	reduction of developer and fixer use, expected to decrease 60% based on preliminary use data	
Film	$2,100/year	$14,700/year	($ 12,600)
	current cost	increase in film costs based on assumption that one third of business comes on conventional media, so one-third of film usage will be at current costs, two-thirds will be ten times that figure	

Cost Category Item	Previous-Service Bureau	Computer Pre-Press	Annual Savings (Costs)
Labor (see Table 2)			
Computer	$0	$19,672/year addition of 40 hours/week labor at $10.75/hour for computer processing	($ 19,672)
Darkroom	$10,103/year current cost	$2,799/year change in darkroom labor from 16 hours to 4 per week	$ 7,304
Stripping/Layout	$54,369/year current cost	$49,890/year change in stripping labor from 2 people to 1¾	$ 4,479
Supervision	$5,260/year	$2,630/year reduction by half of supervision and management time, was 29 hrs/month	$ 2,630
Service Bureau			
Service bureau	$45,000/year current cost	$22,500/year reduction by half of current costs of service bureau - this cost estimated to fall by 10%/year as in-house proficiency increases	$ 22,500
Courier	$3,000/year current cost	$1,500/year reduction by half of current costs of courier corresponding to service bureau use - this cost also estimated to fall by 10%/year	$ 1,500
Typesetting	$2,820/year current cost	$1,110/year reduction by 60% of vendor typesetting costs	$ 1,710
Revenues	$1,100,000/year current projected revenues	$1,210,000/year increase in total revenues by roughly 10% resulting from increased capabilities, faster turnaround, and better process control	$ 110,000
Net Revenues	**$974,848**	**$1,094,199**	**$ 119,351**

Note: Current costs of materials and Service Bureau based on invoices from the first seven months of 1996, before the new system was installed.

Case Study Appendix - P2/FINANCE Reports

Company Analysis

Directory: WMRCCASE OPERATING COSTS SUMMARY 02/16/1997
ALT - Reference Project Page 1
ALT: Computer Pre-Press - Comp
Reference: Current Operations - Comp

OPERATING COST	Year 1	Year 2	Year 3	Year 4	Year 5
Pre-Press					
Service Bureau Costs					
Service bureau charges	-24,750	-26,775	-28,597	-30,238	-31,714
Transportation	-1,650	-1,785	-1,906	-2,016	-2,114
TOTAL OPERATING COST	-26,400	-28,560	-30,503	-32,254	-33,828

* Annual inflation rate of 0.00% applied to all costs, as well as item-specific esc. rates

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ALT - Reference Project
ALT: Computer Pre-Press - Comp
Reference: Current Operations - Comp

		Year 1	Year 2	Year 3	Year 4	Year 5
Pre-Press						
Purchased Equipment						
Delivery (Expensed)	Cost/Book Value					
	Expense	250				
Densitometer (Expensed)	Cost/Book Value					
	Expense	1,378				
Film processing equipment (Expensed)	Cost/Book Value					
	Expense	3,075				
Image processing software (Expensed)	Cost/Book Value					
	Expense	4,347				
Imagesetter & software (Expensed)	Cost/Book Value					
	Expense	25,233				
Insurance (Expensed)	Cost/Book Value					
	Expense	250				
Pentium PC (Expensed)	Cost/Book Value					
	Expense	3,277				
Power Macintosh & Printer (Expensed)	Cost/Book Value					
	Expense	8,982				
Scanner & software (Expensed)	Cost/Book Value					
	Expense	2,593				
TAX DEDUCTION SUMMARY	Depreciation					
	+ Expenses	49,385				
	- Taxable Gain					
	= Tax Deduction	49,385				

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ALT - Reference Project
ALT: Computer Pre-Press - Comp
Reference: Current Operations - Comp

TAX CALCULATION	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues					
- Operating Costs (Savings)	-26,400	-28,560	-30,503	-32,254	-33,828
- Initial Expensed Costs	49,385				
- Depreciation					
+ Taxable Gain (Loss)					
= Taxable Income	-22,985	28,560	30,503	32,254	33,828
Income Tax					

CASH FLOW CALCULATION	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues					
- Operating Costs (Savings)	-26,400	-28,560	-30,503	-32,254	-33,828
- Income Tax					
- Initial Investment Costs					
+ Working Capital Recovery					
+ Salvage Value					
= After-Tax Cash Flow	26,400	28,560	30,503	32,254	33,828
Discounted Cash Flow @ 12.00%	23,571	22,768	21,711	20,498	19,195

Directory: WMRCCASE — PROFITABILITY ANALYSIS SUMMARY — 02/16/1997, Page 1

ALT - Reference Project
ALT: Computer Pre-Press - Comp
Reference: Current Operations - Comp

	Cumulative to:				
	Year 1	Year 2	Year 3	Year 4	Year 5
Net Present Value @ 12.00%	-25,814	-3,046	18,665	39,163	58,358
Internal Rate of Return (%)	-46.54	7.34	32.39	44.60	50.99
Discounted Payback @ 12.00%	2.14 years				

Total Cost Assessment (TCA) Analysis

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ALT - Reference Project — Page 1
ALT: Computer Pre-Press - TCA
Reference: Current Operations - TCA

OPERATING COST	Year 1	Year 2	Year 3	Year 4	Year 5
Pre-Press					
Materials					
Chemicals	-1,545	-1,591	-1,639	-1,688	-1,739
Film	12,875	13,261	13,659	14,068	14,491
Labor					
Computer operator	20,262	20,870	21,496	22,141	22,805
Darkroom operator	-7,523	-7,749	-7,981	-8,221	-8,467
Layout/Stripping	-4,613	-4,752	-4,894	-5,041	-5,193
Supervision	-2,709	-2,790	-2,874	-2,960	-3,049
Service Bureau Costs					
Service bureau charges	-25,425	-28,281	-31,075	-33,817	-36,514
Transportation	-1,695	-1,886	-2,071	-2,255	-2,434
Typesetting	-1,762	-1,814	-1,868	-1,925	-1,982
TOTAL OPERATING COST	-12,135	-14,732	-17,247	-19,698	-22,082

REVENUE	Year 1	Year 2	Year 3	Year 4	Year 5
Non-process/Other					
Revenues					
Sale of product	102,300	95,139	88,479	82,286	76,526
TOTAL REVENUE	102,300	95,139	88,479	82,286	76,526

* Annual inflation rate of 3.00% applied to all costs, as well as item-specific esc. rates

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ALT - Reference Project — Page 1
ALT: Computer Pre-Press - TCA
Reference: Current Operations - TCA

		Year 1	Year 2	Year 3	Year 4	Year 5
Pre-Press						
Purchased Equipment						
Delivery (Expensed)						
	Cost/Book Value					
	Expense	250				
Densitometer (Depreciated)						
	Cost/Book Value	1,102	661	397	238	79
	Depreciation	276	441	264	159	159
	Salvage Value					
	Gain (Loss)					
Film processing equipment (Depreciated)						
	Cost/Book Value	2,636	1,883	1,345	961	824
	Depreciation	439	753	538	384	137
	Salvage Value					1,739
	Gain (Loss)					915
Image processing software (Depreciated)						
	Cost/Book Value	3,478	2,087	1,252	751	250
	Depreciation	869	1,391	835	501	501
	Salvage Value					
	Gain (Loss)					
Imagesetter & software (Depreciated)						
	Cost/Book Value	20,186	12,112	7,267	4,360	1,453
	Depreciation	5,047	8,074	4,845	2,907	2,907
	Salvage Value					
	Gain (Loss)					
Insurance (Expensed)						
	Cost/Book Value					
	Expense	250				
Pentium PC (Depreciated)						
	Cost/Book Value	2,622	1,573	944	755	
	Depreciation	655	1,049	629	189	
	Salvage Value				732	
	Gain (Loss)				-23	
Power Macintosh & Printer (Depreciated)						
	Cost/Book Value	7,186	4,312	2,587	2,070	
	Depreciation	1,796	2,874	1,725	517	
	Salvage Value				2,026	
	Gain (Loss)				-44	
Scanner & software (Depreciated)						
	Cost/Book Value	2,074	1,244	746	448	149
	Depreciation	519	830	498	298	299
	Salvage Value					
	Gain (Loss)					

Directory: WMRCCASE
ALT - Reference Project
ALT: Computer Pre-Press - TCA
Reference: Current Operations - TCA

TAX DEDUCTION SCHEDULE

02/16/1997
Page 2

		Year 1	Year 2	Year 3	Year 4	Year 5
Pre-Press						
Utility Systems and Connection						
Electricity (Expensed)						
	Cost/Book Value					
	Expense	1,400				
General plumbing (Expensed)						
	Cost/Book Value					
	Expense	275				
Planning/Engineering						
In-house planning/engineering (Expensed)						
	Cost/Book Value					
	Expense	650				
Start-up/Training						
Training (Expensed)						
	Cost/Book Value					
	Expense	190				
TAX DEDUCTION SUMMARY	Depreciation	9,601	15,412	9,334	4,955	4,003
	+ Expenses	3,015				
	- Taxable Gain				-67	915
	= Tax Deduction	12,616	15,412	9,334	5,022	3,088

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ALT - Reference Project
ALT: Computer Pre-Press - TCA
Reference: Current Operations - TCA

TAX CALCULATION	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	102,300	95,139	88,479	82,286	76,526
- Operating Costs (Savings)	-12,135	-14,732	-17,247	-19,698	-22,082
- Initial Expensed Costs	3,015				
- Depreciation	9,601	15,412	9,334	4,955	4,003
+ Taxable Gain (Loss)				-67	915
= Taxable Income	101,819	94,459	96,392	96,962	95,520
Income Tax	43,243	40,117	40,938	41,180	40,568

CASH FLOW CALCULATION	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	102,300	95,139	88,479	82,286	76,526
- Operating Costs (Savings)	-12,135	-14,732	-17,247	-19,698	-22,082
- Income Tax	43,243	40,117	40,938	41,180	40,568
- Initial Investment Costs					
+ Working Capital Recovery					
+ Salvage Value				2,758	1,739
= After-Tax Cash Flow	71,192	69,754	64,788	63,562	59,779
Discounted Cash Flow @ 12.00%	63,564	55,607	46,115	40,395	33,920

Directory: WMRCCASE — PROFITABILITY ANALYSIS SUMMARY — 02/16/1997 Page 1

ALT - Reference Project
ALT: Computer Pre-Press - TCA
Reference: Current Operations - TCA

	Cumulative to:				
	Year 1	Year 2	Year 3	Year 4	Year 5
Net Present Value @ 12.00%	11,664	67,271	113,386	153,781	187,701
Internal Rate of Return (%)	37.17	103.29	122.70	129.54	132.06
Discounted Payback @ 12.00%	0.82 years				

WASTEWATER FACILITY UPGRADE - QUEBECOR PRINTING MOUNT MORRIS, INC. (QPMMI)

Company and Facility Background

QPMMI is a large commercial printing facility that prints catalogs, magazines, and advertisement inserts for national distribution. The facility's SIC codes are 2721 (periodicals publishing and printing), 2752 (commercial printing, lithographic), and 2754 (commercial printing, gravure). QPMMI is a subsidiary of Quebecor Printing, Inc. (QPI), a $2.1 billion Canadian corporation with 84 printing facilities—35 in the United States, 38 in Canada, and 11 others worldwide—employing over 22,000 workers. QPI is one of the dominant competitors in a variety of print service markets, ranging from banknotes to books. It considers its strengths to be close integration between sales and manufacturing, value-added services such as mailing list management and demographic research for mass marketing, a large variety of printing options, and the latest high-speed printing technology.

QPI has been growing quickly over the past several years, primarily through acquisitions but also through expansion and increased capacity utilization at existing facilities. Operations management is decentralized, but sales and capital budgeting are closely controlled at the corporate level. QPI is a wholly owned subsidiary of Quebecor, Inc., a multinational holding company.

QPMMI is one of QPI's higher volume facilities, with annual revenues of about $95 million and 650 employees. The facility is physically very large, almost 5 acres under one roof, and is located in a rural area. It was first established as a family-owned business in 1898. In 1990, QPI purchased the facility from Maxwell Communications, Inc., to become the fourth corporate owner.

Project Background

QPMMI provides pre-press, printing, post-press, and distribution services for high-volume customers. Customers can select from a variety of paper types and print qualities. Many customers require national or international distribution, so QPMMI must often coordinate with other QPI facilities to meet the strict delivery schedules for weekly magazines and advertising inserts.

QPMMI processes mostly computer-based art. Camera-ready art is usually scanned to create computer art that can then be manipulated. Proofing is done on color printers to avoid wasting time and materials by proofing on the presses. QPMMI has direct-to-plate (for web offset) and direct-to-cylinder (for roto-gravure) capabilities.

The roto-gravure cylinders are steel, electroplated with copper. They are electromechanically engraved; the image area then is coated with a five-micron layer of chromium for wear-resistance. Cylinders are reused indefinitely (i.e., they are physical capital), while the scrap copper is sold back to the vendor for recycling. There are total enclosures for the various baths in the cylinder prep process to prevent fugitive emissions.

The gravure cylinder waste streams – about 1 million gallons per year – are contaminated with copper, chromium, and other metals, and are sent to the on-site wastewater treatment system. These waste streams are highly acidic (pH between 2 and 3) and, in addition to high levels of metals, contain some dissolved VOCs and oily waste. The treatment system consists of a 750 gallon chromium reduction tank, two 5,000 gallon batch settling tanks, an oily waste separation tank, a 1,320 gallon sludge storage tank, and a filter press (see Figure 1). The system removes about 99 percent of the dissolved metals and oily waste, and raises the pH to between 6 and 9.

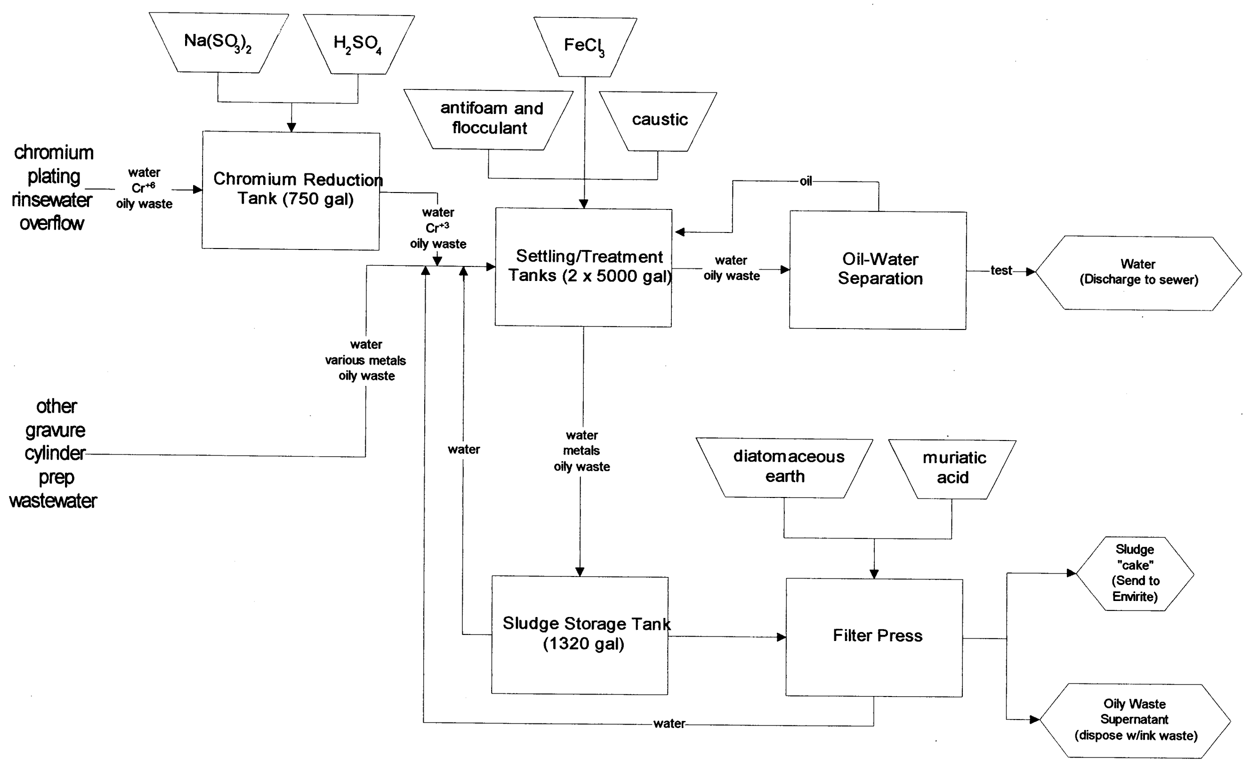

Figure 1. Schematic of Existing Wastewater Treatment System

Overflow rinse water from the chromium plating tanks are fed to the chromium reduction tank, which pre-treats the wastewater with sodium bisulfate and sulfuric acid to reduce hexavalent chromium to trivalent chromium. The reduced chromium, along with all other plating wastewater from the gravure cylinder preparation, is transferred to the settling tanks where ferric chloride, caustic soda, and flocculent are added. Once the iron, chromium, and other solids have been precipitated and the pH has risen, the water is sent to the oil separation tank where the oil is skimmed and returned to the settling tanks. The precipitate from the settling tanks is transferred to the sludge storage tank where it begins to dewater by further settling. The sludge, about 12,000 gallons per year, then is sent through the filter press to be compressed and dried. Water from this stage is returned to the settling tanks, and a small amount of oil is collected and disposed of as hazardous waste. The solid sludge "cake" is bagged and sent off-site as hazardous waste. Due to a recent change in Illinois hazardous waste regulation, once the waste has been fixated at a treatment facility, it is no longer considered hazardous waste.

Ferric chloride solution (19,000 pounds) and caustic soda (3,000 gallons) together cost about $11,500 per year; the other chemicals are used in relatively minute amounts. QPMMI's Environmental Coordinator estimates that the labor costs involved in water treatment are close to $60,000 per year, for 2,000 person-hours. These costs include the equivalent of one full-time employee to perform the actual treatment, do all testing and paperwork, and do any required maintenance or cleaning. The cleaning is not done by the regular cleaning staff because the treatment area is restricted due to the hazardous nature of the chemicals. The cost of the off-site waste disposal from this operation is over $11,000 per year.

Project Description

The Environmental Coordinator has been considering a project to improve QPMMI's wastewater treatment system. The improvements would replace the current batch system with a continuous membrane filtration system that would precipitate and remove dissolved metals (see Figure 2). Wastewater from the chromium reduction tank and other gravure cylinder wastewater would be transferred to one of the existing 5000 gallon settling tanks. This tank would be used simply as a holding tank to equalize the flow into the new membrane filtration system, which can filter at a rate of up to 5 gallons per minute. This tank would feed into the new system, which performs two distinct functions: chemical precipitation followed by micro-filtration. First, the pH is adjusted and metal hydroxide precipitates are formed. In the crossflow micro-filtration section of the system, the metal precipitates are removed using membrane filters. The precipitates would then be concentrated and dewatered in the existing filter press. The clean water would be pumped to the second existing settling tank, which would be used as a holding tank so that the outgoing water could be tested before release to the sewer.

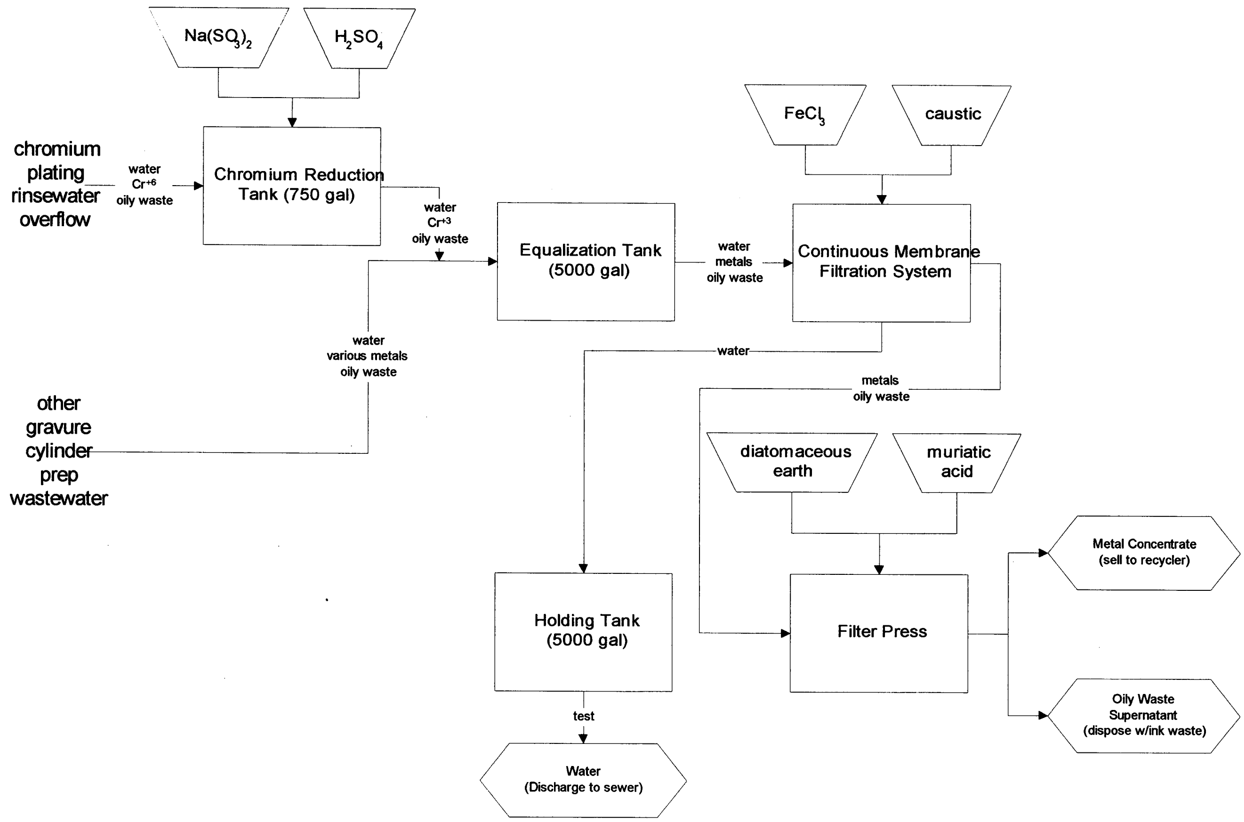

Figure 2. Schematic of Proposed Wastewater Treatment System

The direct capital cost of the proposed system is $120,000 for the equipment, plus the cost of accessory equipment and installation, approximately $60,000. The new system would use a smaller volume of treatment chemicals than the existing system and would be considerably less labor intensive as well, because it is highly automated. Instead of generating sludge, the new system would generate a metal concentrate that QPMMI hopes to sell to a metal recycler instead of sending it off-site for treatment as a hazardous waste.

The current batch system is labor intensive because each time one of the settling tanks fills up, a technician manually treats the mixture to precipitate the solids and raise the pH. The subsequent process of transferring the water and sludge out of the settling tank requires constant oversight to ensure that the water is sufficiently pure and the sludge is the right consistency. The new system, in contrast, essentially runs unattended. As a continuous, automatically regulated system that actively forces the solids from the mixture rather than waiting for them to settle, there is little need for oversight.

The Company's Financial Analysis of the Project

Each year, QPMMI's facility managers submit a list of proposed capital projects for their departments to corporate management. This list includes the reason for each project and an approximate estimate of the implementation costs and any expected annual savings. Based on a number of considerations, the primary of which is the availability of capital funds, projects are approved for more in-depth analysis or are rejected. The Environmental Coordinator has submitted the wastewater treatment upgrade project for consideration over the last several years, but it is always one of the first projects rejected because it is perceived as an unnecessary money-loser – it is not required by regulation and it is not clearly profitable.

Because the Environmental Coordinator is not only responsible for facility environmental issues but also acts as the Maintenance Superintendent and the Building Superintendent, he has little time to devote to activities other than those required to keep his day to day operations running properly. He has not had the time to perform a rigorous financial analysis of the proposed treatment system upgrades, although he is confident that the project would be profitable. Therefore, the costs/savings figures that he has submitted for the wastewater treatment project each year have been very roughly estimated.

Projects from the annual list that are accepted after the preliminary review are subject to a more comprehensive financial analysis in which a broader inventory of costs, taxes, depreciation, and discounting are included. The wastewater treatment upgrade project has never passed the initial screening, and therefore, no comprehensive analysis has been done.

The preliminary financial analysis performed by the company's Environmental Coordinator included the following cost items:

- Initial purchased equipment costs, as specified in vendor quotes ($119,590)
- Initial system installation costs, as specified in vendor quotes ($58,700)
- Annual savings from a reduction in direct operating labor ($24,328)
- Annual savings from avoided hazardous waste disposal ($10,753)

Without considering depreciation, inflation, or a discount rate, the Environmental Coordinator calculated a simple payback of just over five years. While there is no explicit hurdle rate for the facility initial screening of capital projects, five years is considerably above the payback for approved projects. Facility management did not wish to devote resources to pursuing this project any further due to its unlikelihood of being approved.

Total Cost Assessment (TCA) of the Project

A Total Cost Assessment (TCA) was performed in order to provide a more accurate economic picture of the project. There are four elements of a TCA that are essential in analyzing the true costs of a project. The first is an enhanced cost inventory. Direct project investment costs and operating cost savings are typically included in a standard project analysis, but many other relevant costs may be omitted because they are less apparent. Indirect labor, compliance, and waste disposal are examples of actual costs that can materially affect the potential profitability of a project. In this case, the TCA includes many other cost and savings relevant to the purchase and operation of the proposed wastewater treatment system (see Table 1).

This broader inventory of costs and cost savings also encompasses the second element of TCA; more precise allocation of costs to specific projects or processes. Facilities incur many costs – including many environmental costs – that are placed in overhead accounts and then broadly allocated across the facility. Misallocation distorts the costing of individual processes, rendering some seemingly more profitable than they are and others less. By correcting this imprecise allocation, TCA more realistically reflects the costs of a process. For this project, the Environmental Coordinator's time was allocated to the wastewater treatment system in accordance with his actual work schedule.

The TCA included the following costs and cost savings that the company's analysis did not.

Initial Investment Costs

1. The Environmental Coordinator has already spent some time to conceptualize the system, determine the necessary specifications, and arrange vendor visits. If the capital appropriation is accepted, more time would be needed to finalize arrangements with the selected vendor. The total time for this planning is estimated at 40 hours, costing $2,100.
2. The new wastewater system will require a new state operating permit. The total time required to gather the materials for and submit the permit application is expected to cost roughly $3,000.
3. Installation of the new system and integration with existing components will be done by the vendor, but the Environmental Coordinator will have to devote some of his own time to facilitate the vendor work and ensure the process is smooth. This supervision will take an estimated 50 hours, costing $2,625.
4. Once the system has been installed and the operators trained in its use, there will be start-up costs associated with the time it takes for operators to become comfortable with the new equipment and use it most efficiently. The Environmental Coordinator estimates this time at 30 hours each for three people, costing $7,278
5. As with any piece of new operating equipment, this new system will require training. Equipment training on the basic operation will take one day for each of the seven people at the plant who will need to know how to use the new system. This training will cost $1,456. In addition, those seven people will have to undergo environmental training by the state EPA to become certified to use the new system. At one week per person, which includes transportation time off-site, this state-mandated environmental training will cost $7,278.

Annual Operating Costs and Savings

1. A major environmental benefit of this project is the reduction in the volume of chemicals that will be required to treat the wastewater. The chromium will still have to be reduced, but treatment of the bulk of the wastewater will be more chemical-efficient. Annual chemical purchase costs are expected to decline by $12,800.
2. Mirroring the anticipated 50% drop in direct operating labor costs will be commensurate declines in indirect labor costs. The current system operators spend a few hours each week filling out activity logs, test reports for the local POTW, and various other documents. Also, since there are hazardous chemicals in the treatment area, it is a restricted area that the plant's regular maintenance crews may not enter. The treatment system operators therefore currently spend a few hours each week performing maintenance functions in the area. Finally, the Environmental Coordinator dedicates a modest portion of

his time to direct supervision of the system and its operators. Because of the highly automated nature of the proposed system, these indirect labor costs are expected to drop by approximately 50%, saving $5,853 each year.

A critical economic and environmental aspect of the new system is the potential for revenues from the sale of the metal concentrate. Unfortunately, investigation into recycling found that the value of this concentrate would be sufficient only to cover the costs of removing it from the site. Additionally, reduced liability from the elimination of a waste stream was considered for inclusion in the TCA. However, since most of the facility's hazardous waste – and associated liability – is generated elsewhere in the plant, the plant's overall waste would not be reduced significantly and its hazardous waste generator status would not change, therefore liability reduction was not included.

Table 1. Comparison of Cost Items Included

(✓ = included ✗ = partially included)

		Company	TCA
Initial Investment Costs			
Purchased Equipment		✓	✓
Installation		✗	✓
Permitting			✓
Planning			✓
Start-Up			✓
Equipment Training			✓
Environmental Training			✓
Annual Operating Costs			
Chemicals			✓
Labor:	operating	✓	✓
	maintenance		✓
	paperwork		✓
	supervision		✓
Waste Disposal		✓	✓

For this project, the impact of income taxes, the equipment depreciation tax break, and the time value of money (via discounting) were included in the evaluation of project profitability. This part of the TCA exercise is similar to the analysis that would have been done by the company if the project had passed the preliminary screening test; the parameters used here are the parameters the company would have used. The physical assets purchased were capitalized as seven-year assets using the double-declining balance method for depreciation. Other investment costs were expensed. Since these systems are plant specific and would be used for a relatively long time, no salvage value or equipment lifetime was specified. The federal and state income tax rates used for company analyses are 35% and 3%, respectively.

In addition to a more comprehensive cost inventory and allocation, time-inclusive profitability indicators and a longer time horizon are essential elements of a TCA. Had the project passed the initial screening, the company analysis would have incorporated both of these elements. The company does not inflate prices over the life of the project, and correspondingly uses a relatively low discount rate of 8% for its payback calculation. (In this case, the discount rate reflects the real, rather than the nominal, cost of capital.) Finally, the company uses a progressive 10-year project lifetime to analyze its longer-term investments.

Summary of Results

The TCA significantly changed the appearance of the project both in terms of initial investment and annual operating costs. The inclusion of a broader inventory of relevant cost items and the addition of considerations such as taxes, depreciation, and the time value of money led to an increase in the estimate of both costs and savings that would result from the project. The initial investment costs used in the TCA – including planning, permitting, training, and start-up – were almost $19,000 higher than they were in the company analysis, and the annual operating savings – from lower chemical and indirect labor costs – were close to $19,000 higher as well. Since the investment represents a one-time cost and operating savings accrue each year, the TCA does show the project to be more profitable than the company analysis does.

Although the original company analysis calculated only a simple payback, in order to make a direct comparison of the analyses, net present values and discounted paybacks were calculated for both analyses using the company's 8.5% discount rate. (The company uses a real discount rate, as opposed to a nominal one, i.e., it does not discount for inflation.) Table 2 summarizes the financial data resulting from the two analyses. While the TCA shows the investment to be more profitable, both analyses yield a negative five-year NPV indicating a discounted payback greater than five years.

Table 2. Comparative Summary of Cost Data and Profitability

	Company	TCA
Initial Investment Costs	$ 178,290	$ 197,087
Annual Operating Savings - Year 1	$ 35,081	$ 53,735
Net Present Value - Years 0-5	($ 40,049)	($ 16,216)
Net Present Value - Years 0-10	$ 51,887	$ 81,152
Internal Rate of Return - Years 0-5	-0.5%	5.2%
Internal Rate of Return - Years 0-10	14.7%	17.8%
Discounted Payback	6.94	5.66

While the company analysis neglected some large investment costs and operating cost savings, the project does not appear significantly more profitable under the TCA lens. The project is profitable in the long term, but in an environment of tight competition for scarce capital funds, a five-plus year payback is unlikely to garner management enthusiasm. Nevertheless, the TCA provides useful information by demonstrating more of the actual costs associated with both the current system and the proposed one. As wastewater treatment technology improves, equipment costs may fall. Similarly, improved recycling technology and the development of better recycled material markets may make metal concentrate more valuable. These advances may render the investment more profitable in the future.

Documentation of Cost Items Included in the TCA

The following tables list the investment and operating cost data used in the TCA.

Table 3. Initial Investment Costs

COST ITEM	DESCRIPTION	COST
Purchased Equipment	from vendor quote for continuous membrane filtration system	$ 119,590
Planning	preliminary system design and vendor selection, 40 hours at $35/hour plus 50% burden rate	$ 2,100
Installation	from vendor quote for installation and integration with existing components	$ 58,700
	in-house supervision of installation, 50 hours at $35/hour plus 50% burden rate	$ 2,625
Permitting	in-house preparation of new environmental operating permit	$ 3,000
Training	equipment training for 7 people, 8 hours each at $17.33/hour plus 50% burden rate	$ 1,456
	environmental training by EPA for 7 people, 40 hours each at $17.33/hour plus 50% burden rate	$ 2,339
Start-Up	labor time to become familiar with system for 3 people, 30 hours each at $17.33/hour plus 50% burden rate	$ 7,278
Total		$ 197,087

Operating Cost Savings

Table 4. Annual Operating Costs/Savings

COST CATEGORY ITEM	CURRENT SYSTEM	PROPOSED MEMBRANE FILTRATION SYSTEM	ANNUAL SAVINGS
Materials			
Chemicals	$18,500/year current cost	$5,700/year reduction of wastewater treatment chemical use	$12,800

Cost Category Item	Current System	Proposed Membrane Filtration System	Annual Savings
Labor			
Operating	$48,656/year current cost 36 hours/week	$24,328/year reduction to 18 hours/week at $17.33/hour plus 50% burden rate	$24,328
Supervision	$6,300/year current cost 10 hours/month	$3,150/year reduction to 5 hours/month at $35/hour plus 50% burden rate	$3,150
Paperwork	$2,703/year current cost 2 hours/week	$1,352/year reduction to 1 hour/week at $17.33/hour plus 50% burden rate	$1,352
Maintenance	$2,703/year current cost 2 hours/week	$1,352/year reduction to 1 hour/week at $17.33/hour plus 50% burden rate	$1,352
Waste Disposal	$10,753/year 50 bags per year in 4 pick-ups at $181/bag and $425/pick-up	$0	$10,753
Net Revenues	**($89,615)**	**($35,882)**	**$53,735**

Case Study Appendix - P2/FINANCE Reports

Company Analysis

SCENARIO SUMMARY - Base Scenario

Base Scenario: Current Operations 11/18/96 Summm-Base-pg1

INITIAL INVESTMENT COSTS	Cost	Salvage Value	Inv. Year	Lifetime	Depreciation Period	Depreciation Method
Purchased Equipment (Purchase, Tax, Delivery)	$0	$0	0	10	0	EXP
Utility Connections/Systems	0	0	0	10	0	EXP
Planning/Engineering (Labor, Materials)	0	0	0	10	0	EXP
Site Preparation (Labor, Materials)	0	0	0	10	0	EXP
Construction/Installation (Labor, Materials)	0	0	0	10	0	EXP
Start-up/Training (Labor, Materials)	0	0	0	10	0	EXP
Permitting	0	0	0	10	0	EXP
Buildings & Land	0	0	0	10	0	EXP
Working Capital	0	0	0	10	0	EXP
Contingency	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP

ANNUAL OPERATING COSTS	Cost	Start Year	End Year	Escalation
Direct Materials (Purchase, Delivery, Storage)	$0	1	10	0.0%
Utilities	0	1	10	0.0%
Direct Labor (Wage/Salary, Benefits)	48,656	1	10	0.0%
Waste Management (Labor, Materials)	10,753	1	10	0.0%
Regulatory Compliance (Labor, Materials) #1	0	1	10	0.0%
Regulatory Compliance (Labor, Materials) #2	0	1	10	0.0%
Product Quality (Labor, Materials)	0	1	10	0.0%
Revenues - Product	0	1	10	0.0%
Revenues - By-product	0	1	10	0.0%
Insurance	0	1	10	0.0%
Future Liability	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%

GLOBAL PARAMETERS		SCENARIO PARAMETERS	
Project Title: Quebecor Wastewater Treatment			
Inflation Rate	0.0%	Default Investment Year	0
Discount Rate	8.5%	Default Lifetime	10
Aggregate Income Tax Rate	0.0%	Default Start Year	1
Default Depreciation Method	EXP	Default End Year	10
Default Depreciation Period	0		

SCENARIO SUMMARY - Alternative Scenario 1

Alternative Scenario 1: Wastewater Treatment Systei 11/18/96 Summm-Alt1-pg1

INITIAL INVESTMENT COSTS	Cost	Salvage Value	Inv. Year	Lifetime	Depreciation Period	Depreciation Method
Purchased Equipment (Purchase, Tax, Delivery)	$119,590	$0	0	10	0	EXP
Utility Connections/Systems	0	0	0	10	0	EXP
Planning/Engineering (Labor, Materials)	0	0	0	10	0	EXP
Site Preparation (Labor, Materials)	0	0	0	10	0	EXP
Construction/Installation (Labor, Materials)	58,700	0	0	10	0	EXP
Start-up/Training (Labor, Materials)	0	0	0	10	0	EXP
Permitting	0	0	0	10	0	EXP
Buildings & Land	0	0	0	10	0	EXP
Working Capital	0	0	0	10	0	EXP
Contingency	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP
Other	0	0	0	10	0	EXP

ANNUAL OPERATING COSTS	Cost	Start Year	End Year	Escalation
Direct Materials (Purchase, Delivery, Storage)	$0	1	10	0.0%
Utilities	0	1	10	0.0%
Direct Labor (Wage/Salary, Benefits)	24,328	1	10	0.0%
Waste Management (Labor, Materials)	0	1	10	0.0%
Regulatory Compliance (Labor, Materials) #1	0	1	10	0.0%
Regulatory Compliance (Labor, Materials) #2	0	1	10	0.0%
Product Quality (Labor, Materials)	0	1	10	0.0%
Revenues - Product	0	1	10	0.0%
Revenues - By-product	0	1	10	0.0%
Insurance	0	1	10	0.0%
Future Liability	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%

GLOBAL PARAMETERS		SCENARIO PARAMETERS	
Project Title: Quebecor Wastewater Treatment			
Inflation Rate	0.0%	Default Investment Year	0
Discount Rate	8.5%	Default Lifetime	10
Aggregate Income Tax Rate	0.0%	Default Start Year	1
Default Depreciation Method	EXP	Default End Year	10
Default Depreciation Period	0		

TAX DEDUCTION SCHEDULE
Alternative Scenario 1

Alternative Scenario 1: Wastewater Treatment System Improvement 11/18/96 Tax-Alt1-pg1

Operating Year	0	1	2	3	4	5	6	7
Depreciable Initial Investment Costs	0	0	0	0	0	0	0	0
Expensed Initial Investment Costs	178,290	0	0	0	0	0	0	0
Working Capital Initial InvestmentCosts	0	0	0	0	0	0	0	0
Total Initial Investment Costs	178,290	0	0	0	0	0	0	0

For each category, the top line indicates the tax deduction taken in that year, including expensed items and depreciation. The bottom line tracks the Initial Investment Costs for all categories, plus the Remaining Book Value for depreciable categories.

	0	1	2	3	4	5	6	7
Purchased Equipment (Purchase, Tax, Delivery) (EXP)		119,590	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	119,590	0	0	0	0	0	0	0
Utility Connections/Systems (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Planning/Engineering (Labor, Materials) (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Site Preparation (Labor, Materials) (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Construction/Installation (Labor, Materials) (EXP)		58,700	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	58,700	0	0	0	0	0	0	0
Start-up/Training (Labor, Materials) (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Permitting (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Buildings & Land (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Working Capital (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Contingency (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Other (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Other (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Other (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0
Other (EXP)		0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7
Total Depreciation		0	0	0	0	0	0	0
Expensed Initial Investment Costs		178,290	0	0	0	0	0	0
- Taxable Gain (Loss) on Salvaged Equipment		0	0	0	0	0	0	0
Total Tax Deductions		178,290	0	0	0	0	0	0

INCREMENTAL CASH FLOW ANALYSIS

Alternative Scenario 1 vs. Base Scenario

Analysis Name: Quebecor Wastewater Treatment — 11/18/96 — Cash Flow-Alt1 v. Base-pg.1

Operating Year	0	1	2	3	4	5	6	7
INCREMENTAL INITIAL INVESTMENT COSTS								
Purchased Equipment (Purchase, Tax, Delivery)	119,590	0	0	0	0	0	0	0
Utility Connections/Systems	0	0	0	0	0	0	0	0
Planning/Engineering (Labor, Materials)	0	0	0	0	0	0	0	0
Site Preparation (Labor, Materials)	0	0	0	0	0	0	0	0
Construction/Installation (Labor, Materials)	58,700	0	0	0	0	0	0	0
Start-up/Training (Labor, Materials)	0	0	0	0	0	0	0	0
Permitting	0	0	0	0	0	0	0	0
Buildings & Land	0	0	0	0	0	0	0	0
Working Capital	0	0	0	0	0	0	0	0
Contingency	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Initial Investment Costs	178,290	0	0	0	0	0	0	0
INCREMENTAL ANNUAL OPERATING (COSTS)/SAVINGS								
Direct Materials (Purchase, Delivery, Storage)		0	0	0	0	0	0	0
Utilities		0	0	0	0	0	0	0
Direct Labor (Wage/Salary, Benefits)		24,328	24,328	24,328	24,328	24,328	24,328	24,328
Waste Management (Labor, Materials)		10,753	10,753	10,753	10,753	10,753	10,753	10,753
Regulatory Compliance (Labor, Materials) #1		0	0	0	0	0	0	0
Regulatory Compliance (Labor, Materials) #2		0	0	0	0	0	0	0
Product Quality (Labor, Materials)		0	0	0	0	0	0	0
Revenues - Product		0	0	0	0	0	0	0
Revenues - By-product		0	0	0	0	0	0	0
Insurance		0	0	0	0	0	0	0
Future Liability		0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0
Total Annual Operating (Costs)/Savings		35,081	35,081	35,081	35,081	35,081	35,081	35,081
INCREMENTAL TAX CALCULATION								
Annual Operating (Costs)/Savings		35,081	35,081	35,081	35,081	35,081	35,081	35,081
- Depreciation		0	0	0	0	0	0	0
- Expensed Initial Investment Costs		178,290	0	0	0	0	0	0
+ Taxable Gain (Loss) on Salvaged Equipment		0	0	0	0	0	0	0
Taxable Income		(143,209)	35,081	35,081	35,081	35,081	35,081	35,081
Income Tax at 0.0%		0	0	0	0	0	0	0
INCREMENTAL CASH FLOW CALCULATION								
Annual Operating (Costs)/Savings		35,081	35,081	35,081	35,081	35,081	35,081	35,081
- Income Tax		0	0	0	0	0	0	0
- Initial Investment Costs	178,290	0	0	0	0	0	0	0
+ Recovery of Working Capital		0	0	0	0	0	0	0
+ Salvage Value		0	0	0	0	0	0	0
After-Tax Cash Flow	(178,290)	35,081	35,081	35,081	35,081	35,081	35,081	35,081
Cumulative Cash Flow	(178,290)	(143,209)	(108,128)	(73,048)	(37,967)	(2,886)	32,195	67,276
Discounted Cash Flow	(178,290)	32,333	29,800	27,465	25,313	23,330	21,503	19,818

INCREMENTAL CASH FLOW ANALYSIS

Alternative Scenario 1 vs. Base Scenario

Analysis Name: Quebecor Wastewater Treatment

Cash Flow-Alt1 v. Base-pg.2

Operating Year	8	9	10	11	12	13	14	15
INCREMENTAL INITIAL INVESTMENT COSTS								
Purchased Equipment (Purchase, Tax, Delivery)	0	0	0	0	0	0	0	0
Utility Connections/Systems	0	0	0	0	0	0	0	0
Planning/Engineering (Labor, Materials)	0	0	0	0	0	0	0	0
Site Preparation (Labor, Materials)	0	0	0	0	0	0	0	0
Construction/Installation (Labor, Materials)	0	0	0	0	0	0	0	0
Start-up/Training (Labor, Materials)	0	0	0	0	0	0	0	0
Permitting	0	0	0	0	0	0	0	0
Buildings & Land	0	0	0	0	0	0	0	0
Working Capital	0	0	0	0	0	0	0	0
Contingency	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Initial Investment Costs	0	0	0	0	0	0	0	0
INCREMENTAL ANNUAL OPERATING (COSTS)/SAVINGS								
Direct Materials (Purchase, Delivery, Storage)	0	0	0	0	0	0	0	0
Utilities	0	0	0	0	0	0	0	0
Direct Labor (Wage/Salary, Benefits)	24,328	24,328	24,328	0	0	0	0	0
Waste Management (Labor, Materials)	10,753	10,753	10,753	0	0	0	0	0
Regulatory Compliance (Labor, Materials) #1	0	0	0	0	0	0	0	0
Regulatory Compliance (Labor, Materials) #2	0	0	0	0	0	0	0	0
Product Quality (Labor, Materials)	0	0	0	0	0	0	0	0
Revenues - Product	0	0	0	0	0	0	0	0
Revenues - By-product	0	0	0	0	0	0	0	0
Insurance	0	0	0	0	0	0	0	0
Future Liability	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Annual Operating (Costs)/Savings	35,081	35,081	35,081	0	0	0	0	0
INCREMENTAL TAX CALCULATION								
Annual Operating (Costs)/Savings	35,081	35,081	35,081	0	0	0	0	0
- Depreciation	0	0	0	0	0	0	0	0
- Expensed Initial Investment Costs	0	0	0	0	0	0	0	0
+ Taxable Gain (Loss) on Salvaged Equipment	0	0	0	0	0	0	0	0
Taxable Income	35,081	35,081	35,081	0	0	0	0	0
Income Tax at 0.0%	0	0	0	0	0	0	0	0
INCREMENTAL CASH FLOW CALCULATION								
Annual Operating (Costs)/Savings	35,081	35,081	35,081	0	0	0	0	0
- Income Tax	0	0	0	0	0	0	0	0
- Initial Investment Costs	0	0	0	0	0	0	0	0
+ Recovery of Working Capital	0	0	0	0	0	0	0	0
+ Salvage Value	0	0	0	0	0	0	0	0
After-Tax Cash Flow	35,081	35,081	35,081	0	0	0	0	0
Cumulative Cash Flow	102,356	137,437	172,518	172,518	172,518	172,518	172,518	172,518
Discounted Cash Flow	18,266	16,835	15,516	0	0	0	0	0

INCREMENTAL PROFITABILITY ANALYSIS

Analysis Name: Quebecor Wastewater Treatment 11/18/96 Profit-pg1

P2/FINANCE calculates three indicators of profitability. (See on-line help for more detailed descriptions.)

Net Present Value (NPV), the most reliable indicator, is the value in today's dollars of the discounted future savings of a project. A positive NPV indicates a profitable project. When considering multiple projects, the most profitable project has the highest NPV.

Internal Rate of Return (IRR) is the Discount Rate for which the NPV of a project would equal zero. An IRR greater than the Discount Rate indicates a profitable project. When considering multiple projects, the most profitable project usually, but not always, has the highest IRR. IRR cannot be calculated for some projects with irregular cash flows.

Discounted Payback is the time period within which the discounted future savings of a project repay the Initial Investment Costs. A shorter payback period often, but not always, indicates a more profitable project because Discounted Payback does not account for cash flows that occur after the payback period. Discounted Payback cannot be calculated for some projects.

P2/FINANCE provides four time horizons for calculating Net Present Value and Internal Rate of Return. P2/FINANCE automatically calculates the profitability over 5, 10, and 15 years. You may choose an optional fourth time horizon between 1 and 15 years.

Optional Time Horizon 13

This analysis calculates the incremental profitability of each Alternative Scenario relative to the Base Scenario.
Base Scenario: Current Operations

Net Present Value ($)

Scenario	Name	Years 0-5	Years 0-10	Years 0-15	Years 0- 13
Alternative Scenario 1	Wastewater Treatment System	(40,049)	51,887	51,887	51,887
Alternative Scenario 2	Alternative Scenario 2 Name	#N/A	#N/A	#N/A	#N/A

Internal Rate of Return (%)

Scenario	Name	Years 0-5	Years 0-10	Years 0-15	Years 0- 13
Alternative Scenario 1	Wastewater Treatment System	-0.5%	14.7%	#N/A	#N/A
Alternative Scenario 2	Alternative Scenario 2 Name	#N/A	#N/A	#N/A	#N/A

Discounted Payback (years)

Scenario	Name	Payback
Alternative Scenario 1	Wastewater Treatment System	6.94
Alternative Scenario 2	Alternative Scenario 2 Name	#N/A

TCA Analysis

SCENARIO SUMMARY - Base Scenario

Base Scenario: Current Operations 11/18/96 Summ-Base-pg1

INITIAL INVESTMENT COSTS	Cost	Salvage Value	Inv. Year	Lifetime	Depreciation Period	Depreciation Method
Purchased Equipment (Purchase, Tax, Delivery)	$0	$0	0	10	7	DDB
Utility Connections/Systems	0	0	0	10	7	DDB
Planning/Engineering (Labor, Materials)	0	0	0	10	7	DDB
Site Preparation (Labor, Materials)	0	0	0	10	7	DDB
Construction/Installation (Labor, Materials)	0	0	0	10	7	DDB
Start-up/Training (Labor, Materials)	0	0	0	10	7	DDB
Permitting	0	0	0	10	7	DDB
Buildings & Land	0	0	0	10	7	DDB
Working Capital	0	0	0	10	7	DDB
Contingency	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB

ANNUAL OPERATING COSTS	Cost	Start Year	End Year	Escalation
Direct Materials (Purchase, Delivery, Storage)	$18,500	1	10	0.0%
Utilities	0	1	10	0.0%
Direct Labor (Wage/Salary, Benefits)	60,362	1	10	0.0%
Waste Management (Labor, Materials)	11,248	1	10	0.0%
Regulatory Compliance (Labor, Materials) #1	0	1	10	0.0%
Regulatory Compliance (Labor, Materials) #2	0	1	10	0.0%
Product Quality (Labor, Materials)	0	1	10	0.0%
Revenues - Product	0	1	10	0.0%
Revenues - By-product	0	1	10	0.0%
Insurance	0	1	10	0.0%
Future Liability	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%

GLOBAL PARAMETERS		SCENARIO PARAMETERS	
Project Title: Quebecor Wastewater Treatment			
Inflation Rate	0.0%	Default Investment Year	0
Discount Rate	8.5%	Default Lifetime	10
Aggregate Income Tax Rate	37.0%	Default Start Year	1
Default Depreciation Method	DDB	Default End Year	10
Default Depreciation Period	7		

SCENARIO SUMMARY - Alternative Scenario 1

Alternative Scenario 1: Wastewater Treatment Systei 11/18/96 Summ-Alt1-pg1

INITIAL INVESTMENT COSTS	Cost	Salvage Value	Inv. Year	Lifetime	Depreciation Period	Depreciation Method
Purchased Equipment (Purchase, Tax, Delivery)	$119,590	$0	0	10	7	DDB
Utility Connections/Systems	0	0	0	10	7	DDB
Planning/Engineering (Labor, Materials)	2,100	0	0	10	7	EXP
Site Preparation (Labor, Materials)	0	0	0	10	7	DDB
Construction/Installation (Labor, Materials)	61,325	0	0	10	7	DDB
Start-up/Training (Labor, Materials)	11,072	0	0	10	7	EXP
Permitting	3,000	0	0	10	7	EXP
Buildings & Land	0	0	0	10	7	DDB
Working Capital	0	0	0	10	7	DDB
Contingency	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB
Other	0	0	0	10	7	DDB

ANNUAL OPERATING COSTS	Cost	Start Year	End Year	Escalation
Direct Materials (Purchase, Delivery, Storage)	$5,700	1	10	0.0%
Utilities	0	1	10	0.0%
Direct Labor (Wage/Salary, Benefits)	30,181	1	10	0.0%
Waste Management (Labor, Materials)	495	1	10	0.0%
Regulatory Compliance (Labor, Materials) #1	0	1	10	0.0%
Regulatory Compliance (Labor, Materials) #2	0	1	10	0.0%
Product Quality (Labor, Materials)	0	1	10	0.0%
Revenues - Product	0	1	10	0.0%
Revenues - By-product	0	1	10	0.0%
Insurance	0	1	10	0.0%
Future Liability	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%
Other	0	1	10	0.0%

GLOBAL PARAMETERS		SCENARIO PARAMETERS	
Project Title: Quebecor Wastewater Treatment			
Inflation Rate	0.0%	Default Investment Year	0
Discount Rate	8.5%	Default Lifetime	10
Aggregate Income Tax Rate	37.0%	Default Start Year	1
Default Depreciation Method	DDB	Default End Year	10
Default Depreciation Period	7		

TAX DEDUCTION SCHEDULE
Alternative Scenario 1

Alternative Scenario 1: Wastewater Treatment System Improvement 11/18/96 Tax-Alt1-pg1

Operating Year	0	1	2	3	4	5	6	7	8
Depreciable Initial Investment Costs	180,915	0	0	0	0	0	0	0	0
Expensed Initial Investment Costs	16,172	0	0	0	0	0	0	0	0
Working Capital Initial InvestmentCosts	0	0	0	0	0	0	0	0	0
Total Initial Investment Costs	197,087	0	0	0	0	0	0	0	0

For each category, the top line indicates the tax deduction taken in that year, including expensed items and depreciation. The bottom line tracks the Initial Investment Costs for all categories, plus the Remaining Book Value for depreciable categories.

	0	1	2	3	4	5	6	7	8
Purchased Equipment (Purchase, Tax, Delivery) (DDB)		17,084	29,287	20,919	14,942	10,673	10,673	10,673	5,337
Initial Investment Cost and Remaining Book Value	119,590	102,505	73,218	52,299	37,356	26,683	16,010	5,337	0
Utility Connections/Systems (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Planning/Engineering (Labor, Materials) (EXP)		2,100	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	2,100	0	0	0	0	0	0	0	0
Site Preparation (Labor, Materials) (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Construction/Installation (Labor, Materials) (DDB)		8,761	15,018	10,727	7,662	5,473	5,473	5,473	2,737
Initial Investment Cost and Remaining Book Value	61,325	52,565	37,546	26,819	19,156	13,683	8,210	2,737	0
Start-up/Training (Labor, Materials) (EXP)		11,072	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	11,072	0	0	0	0	0	0	0	0
Permitting (EXP)		3,000	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	3,000	0	0	0	0	0	0	0	0
Buildings & Land (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Working Capital (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Contingency (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Other (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Other (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Other (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0
Other (DDB)		0	0	0	0	0	0	0	0
Initial Investment Cost and Remaining Book Value	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8
Total Depreciation		25,845	44,306	31,647	22,605	16,146	16,146	16,146	8,073
Expensed Initial Investment Costs		16,172	0	0	0	0	0	0	0
- Taxable Gain (Loss) on Salvaged Equipment		0	0	0	0	0	0	0	0
Total Tax Deductions		42,017	44,306	31,647	22,605	16,146	16,146	16,146	8,073

INCREMENTAL CASH FLOW ANALYSIS

Alternative Scenario 1 vs. Base Scenario

Analysis Name: Quebecor Wastewater Treatment

Operating Year	8	9	10	11	12	13	14	15
INCREMENTAL INITIAL INVESTMENT COSTS								
Purchased Equipment (Purchase, Tax, Delivery)	0	0	0	0	0	0	0	0
Utility Connections/Systems	0	0	0	0	0	0	0	0
Planning/Engineering (Labor, Materials)	0	0	0	0	0	0	0	0
Site Preparation (Labor, Materials)	0	0	0	0	0	0	0	0
Construction/Installation (Labor, Materials)	0	0	0	0	0	0	0	0
Start-up/Training (Labor, Materials)	0	0	0	0	0	0	0	0
Permitting	0	0	0	0	0	0	0	0
Buildings & Land	0	0	0	0	0	0	0	0
Working Capital	0	0	0	0	0	0	0	0
Contingency	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Initial Investment Costs	0	0	0	0	0	0	0	0
INCREMENTAL ANNUAL OPERATING (COSTS)/SAVINGS								
Direct Materials (Purchase, Delivery, Storage)	12,800	12,800	12,800	0	0	0	0	0
Utilities	0	0	0	0	0	0	0	0
Direct Labor (Wage/Salary, Benefits)	30,181	30,181	30,181	0	0	0	0	0
Waste Management (Labor, Materials)	10,753	10,753	10,753	0	0	0	0	0
Regulatory Compliance (Labor, Materials) #1	0	0	0	0	0	0	0	0
Regulatory Compliance (Labor, Materials) #2	0	0	0	0	0	0	0	0
Product Quality (Labor, Materials)	0	0	0	0	0	0	0	0
Revenues - Product	0	0	0	0	0	0	0	0
Revenues - By-product	0	0	0	0	0	0	0	0
Insurance	0	0	0	0	0	0	0	0
Future Liability	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total Annual Operating (Costs)/Savings	53,734	53,734	53,734	0	0	0	0	0
INCREMENTAL TAX CALCULATION								
Annual Operating (Costs)/Savings	53,734	53,734	53,734	0	0	0	0	0
- Depreciation	8,073	0	0	0	0	0	0	0
- Expensed Initial Investment Costs	0	0	0	0	0	0	0	0
+ Taxable Gain (Loss) on Salvaged Equipment	0	0	0	0	0	0	0	0
Taxable Income	45,661	53,734	53,734	0	0	0	0	0
Income Tax at 37.0%	16,872	19,855	19,855	0	0	0	0	0
INCREMENTAL CASH FLOW CALCULATION								
Annual Operating (Costs)/Savings	53,734	53,734	53,734	0	0	0	0	0
- Income Tax	16,872	19,855	19,855	0	0	0	0	0
- Initial Investment Costs	0	0	0	0	0	0	0	0
+ Recovery of Working Capital	0	0	0	0	0	0	0	0
+ Salvage Value	0	0	0	0	0	0	0	0
After-Tax Cash Flow	36,862	33,879	33,879	0	0	0	0	0
Cumulative Cash Flow	146,770	180,649	214,529	214,529	214,529	214,529	214,529	214,529
Discounted Cash Flow	19,193	16,258	14,984	0	0	0	0	0

INCREMENTAL PROFITABILITY ANALYSIS

Analysis Name: Quebecor Wastewater Treatmen11/18/96 Profit-pg1

P2/FINANCE calculates three indicators of profitability. (See on-line help for more detailed descriptions.)

Net Present Value (NPV), the most reliable indicator, is the value in today's dollars of the discounted future savings of a project. A positive NPV indicates a profitable project. When considering multiple projects, the most profitable project has the highest NPV.

Internal Rate of Return (IRR) is the Discount Rate for which the NPV of a project would equal zero. An IRR greater than the Discount Rate indicates a profitable project. When considering multiple projects, the most profitable project usually, but not always, has the highest IRR. IRR cannot be calculated for some projects with irregular cash flows.

Discounted Payback is the time period within which the discounted future savings of a project repay the Initial Investment Costs. A shorter payback period often, but not always, indicates a more profitable project because Discounted Payback does not account for cash flows that occur after the payback period. Discounted Payback cannot be calculated for some projects.

P2/FINANCE provides four time horizons for calculating Net Present Value and Internal Rate of Return. P2/FINANCE automatically calculates the profitability over 5, 10, and 15 years. You may choose an optional fourth time horizon between 1 and 15 years.

Optional Time Horizon 13

This analysis calculates the incremental profitability of each Alternative Scenario relative to the Base Scenario.
Base Scenario: Current Operations

Net Present Value ($)

Scenario	Name	Years 0-5	Years 0-10	Years 0-15	Years 0- 13
Alternative Scenario 1	Wastewater Treatment System	(16,216)	81,152	81,152	81,152
Alternative Scenario 2	Alternative Scenario 2 Name	#N/A	#N/A	#N/A	#N/A

Internal Rate of Return (%)

Scenario	Name	Years 0-5	Years 0-10	Years 0-15	Years 0- 13
Alternative Scenario 1	Wastewater Treatment System	5.2%	17.8%	#N/A	#N/A
Alternative Scenario 2	Alternative Scenario 2 Name	#N/A	#N/A	#N/A	#N/A

Discounted Payback (years)

Scenario	Name	Payback
Alternative Scenario 1	Wastewater Treatment System	5.66
Alternative Scenario 2	Alternative Scenario 2 Name	#N/A

PROCESS COSTING EVALUATION - RESINS MANUFACTURER (RM)

Company and Facility Background

The parent company (SIC 2821) manufactures resin products used in paints, coatings, and reinforced fiberglass and employs approximately 570 workers at eight U.S. facilities. The case study facility, which employs 220 workers, manufactures approximately 40 percent of all product volume for the company.

The parent company was once part of a vertically integrated paint firm, but recently became independent, and has expanded through the acquisition of other resin producers. In 1995, the parent company's gross sales approximated $300 million. The new management is committed to growth, and hopes to reach $1 billion in sales by 2000—primarily through acquisitions.

Project Background

The company's new management supports an "aggressive P2 and waste minimization program." In early 1996, the case study facility began a collaborative P2 project with the Illinois Waste Management and Research Center (WMRC - formerly called the Illinois Hazardous Waste Research and Information Center, HWRIC). The project, known from this point as the Life-Cycle Project, examines one of the facility's products, Resin A, from a life-cycle[2] perspective. The Life-Cycle Project contains two components: 1) a technical evaluation of the manufacturing process (e.g., review of raw material quality, adjustment of operating parameters) and 2) a financial analysis of the product line, focused on calculating the "cost of waste." This case study focuses on the financial analysis portion of the Life-Cycle project.

Life-Cycle project activities include developing a P2 plan, tracking material flows, identifying P2 opportunities, and instituting a cost allocation system. In the short-term, the facility expects the project to generate opportunities to improve the chosen product via the purchase of capital equipment or the optimization of operating parameters. In the long term, the facility views the Life-Cycle Project as a launching pad for a broad-based corporate P2 effort.

The Life-Cycle project focuses on the east side of the facility described in the Phase I case study. The east side of the facility manufactures four distinct types of resin products:

- Alkyd Resins
- Polyester Resins
- Powder Resins
- Urea Formaldehyde

A single product within the Alkyd Resin family was selected for in-depth evaluation for the Life-Cycle project itself as well as for this case study. A brief background on resins and the selected product, Resin A, follows.

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[2] For the facility, life-cycle focuses on the product from the point where it enters the doors of the facility as raw material inventory to the point at which it leaves the facility either as waste or product.

Resin Background

In general, the company manufactures a family of resin products in batch reactor vessels by heating the raw materials—mostly derivatives of petroleum or vegetable oils—until they polymerize. A typical batch requires 15 hours of reaction time and produces approximately 3,500 gallons of product. After the reaction, most resins are mixed with 40% solvent to allow pumping at 110°F and to provide lower viscosity for the paint products. The manufacturing process can be modified by the subsequent addition of silicone (for heat resistance), vinyl toluene (for quicker drying), or acrylics (for durability). Upon completion of the reaction, the product is transferred to a mixing tank and then drummed for shipping.

Production generates waste during reaction, mixing, transfer, and cleaning processes. The facility uses a combination of treatment technologies and pollution prevention techniques to manage wastes generated during production. For example, the reactor vessel must be cleaned with a caustic solution when consecutive batches are incompatible, but the company uses compatibility scheduling and dedicated lines to minimize cleaning frequency.

To control fugitive emissions, the facility uses water-cooled condensers on each reactor vessel to collect and liquefy solvent fumes. Condensed solvents are decanted and returned to the reactor during processing for reuse. Solvent fumes that escape condensation are piped into a fume incinerator. Incinerator ash from the east side incinerator is disposed of as hazardous waste; one 55-gallon drum is generated every 12 to 18 months.

Water is a byproduct of the polymerization reaction in most of the company's production processes—approximately 7% by weight of each batch. The water is removed from the reactor vessels through xylene addition. The water-xylene condensate is piped from the reactor to a decanter tank, where xylene and other trapped solvents are allowed to rise to the surface and are skimmed off. The process water cannot be reused due to hazardous levels of alcohol and xylene contaminants and is incinerated on site.

Other hazardous and non-hazardous wastes are sent off-site for disposal. In general, the composition of the waste stream from alkyd resin production comprises 90% water, 9% aldehydes, and 1% solvent. Caustic cleanup water is classified as a hazardous waste and sent for off-site treatment. Other liquid and solid wastes such as scrap product, scrap inputs, and scrap solvents are sent off-site for fuel blending. Most of these wastes have very high energy content, and are ideal for fuel blending. Even solids that collect on filters can be homogenized into the liquids and sent for fuel blending, but this is much more expensive to manage than the liquid waste streams.

Resin A Background

Resin A, the focus of the company's Life-Cycle project and of this case study, is an intermediate product used in the manufacture of oil-based paints and coatings for consumer, industrial, and special purpose uses. Inputs to the process—polyols and organic acids—are reacted at 475°F for 17 hours before transfer to a mixing tank. Resin A was selected as the focus of this project because it has been plagued intermittently by a haze of unknown origin that necessitates an additional process filtration step, creating filter waste. Other company facilities also produce alkyd resins, enabling the transfer of both the short term and the long term successes of the Life-Cycle project to other facilities.

Project Description

Tellus assisted the facility in conducting the financial component of the Life-Cycle project. In particular, we focused on characterizing the current allocation practices at the facility and making suggestions for improvement. This case study differs from the other Phase II case studies in that it does not focus on improving the financial analysis methodology for a particular investment using Total Cost Assessment (TCA). However, as accurate allocation is a critical foundation for a TCA approach, the findings from this product costing case study will inform the advancement of TCA and environmental accounting strategies.

Because Tellus became involved in the Life-Cycle project after its initiation, three approaches to product costing and allocation are relevant for this case study. The first approach comprises the facility's traditional method of allocating operating costs to product lines (i.e., the Facility Analysis). The second approach comprises evaluation of and modifications to the Facility Analysis (i.e., the Modified Analysis). The third approach comprises the allocation method and scope defined by the facility under the Life-Cycle Project (i.e., the Life-Cycle Analysis). A description of each approach follows.

Facility Analysis

The facility currently tracks two different sets of cost data that are relevant to the case study: cost of waste and conversion costs.

Cost of Waste

Prior to the Life-Cycle Project, the company had defined the "cost of waste" as either the disposal and transportation fees for off-site waste disposal activities or the utility costs for on-site waste disposal activities. The facility recently developed a computerized waste tracking system that tracks disposal quantity and per unit cost data for all wastes. According to this database, the annual "cost of waste" for the facility is $1,305,658. The report summarizes the waste by type, not by product or process, although each product generates different waste streams. The report classifies waste by the following categories:

- Process Water
- Organic Water of Reaction
- Caustic Water
- Storm Water
- Final Product Scrap
- Raw Material Scrap
- Solvent Scrap
- Hazardous Filter Waste
- Non-hazardous Filter Waste
- Other RCRA Hazardous Waste

- •Other Specific/Industrial Waste
- •Other Non-hazardous Waste

Because the facility does not track waste generation for specific products or families of products, it does not explicitly calculate a cost of waste for each product line. However, the facility does incorporate the cost of waste disposal and treatment into its calculation of the conversion cost for each product line, as described below.

Conversion Costs

As a surrogate for indirect operating costs,[3] the facility calculates prospective *conversion costs*, using sales forecasts as a guide to estimate product volume for the upcoming year. Conversion costs include all manufacturing expenses except for raw materials, calculated on a per pound basis. Calculation begins with each facility allocating its manufacturing expenses to different business groups (or product families). The facility then allocates the costs within each business group to different individual products. Each facility calculates a conversion cost that is then incorporated into a company-wide conversion cost for the product using a weighted average technique.

To allocate costs, the case study facility divides costs into three categories, applying a different allocation basis for each category. The facility labels these three categories *direct costs*, *overhead costs*, and *fixed costs*. Direct costs such as operating labor, non-waste disposal utilities, and equipment depreciation are allocated on the basis of kettle hours (i.e., the amount of reaction time required for the product). Overhead costs such as waste disposal and treatment costs and administrative costs are allocated on the basis of the number of batches. Fixed costs such as safety materials and shipping/handling labor are allocated on the basis of product volume. When a particular product's manufacturing process differs greatly from the other products in the family, the facility adds a surcharge above the conversion cost to incorporate these additional costs. For example, products that have been identified as requiring additional filtration, cleaning, or rework are candidates for a surcharge.

Using these techniques, the facility calculated a conversion cost for Resin A of $0.063 per pound, which was averaged into a company-wide cost for Resin A of $0.077. This lower conversion cost at the facility largely stems from the availability of large scale reaction equipment that allows manufacture of larger batches. Resin A was not identified by accounting as a product that requires additional effort and thus, its conversion cost does not include any surcharges. We can calculate the estimated annual operating costs (less raw material costs) for Resin A by multiplying the facility conversion cost by the total Resin A volume of 4,094,055 pounds, giving an annual operating cost (less raw material costs) of $257,925.

From the conversion cost, we can re-create the cost of waste for Resin A. The facility classifies waste disposal and treatment costs as overhead, which it allocates on the basis of the number of batches. Applying this rationale, we can estimate the Resin A cost of waste using the Facility Analysis framework. We start by calculating the percentage of batches at the facility that

[3] The conversion cost includes all operating costs except for raw materials, which are directly charged to individual product lines.

manufacture Resin A and then allocate the total waste cost using that percentage. For this facility, Resin A comprises 2.3% of all batches and the total cost of waste for the facility equals $1,305,658. We then estimate a cost of waste for Resin A equal to $29,814.

Modified Analysis

We reviewed the facility's current approach to cost allocation (i.e., the Facility Analysis) with an eye to building on its strengths rather than starting from scratch. Discussions with accounting staff who calculated the conversion cost for Resin A defined the three-tiered allocation process described in detail above. The goal of this approach is to balance the accuracy derived through the use of multiple cost drivers with the reality of limited resources to perform the allocation, resulting in a system that is both manageable and flexible. In particular, the use of surcharges to penalize resource-intensive products provides maximum flexibility. Knowledge of the facility's current allocation method outside the accounting department, however, was limited, preventing environmental personnel from leveraging available data to guide its P2 prioritization.

Keeping in mind the original motivation for the financial component of the Life-Cycle Project (i.e., use of cost data to motivate P2), we conducted two analyses, the results of which we then compared to the Facility Analysis. First, we revisited the facility's conversion cost estimate with particular attention to any surcharges required by the target product, entitled the *Surcharge Analysis*. Second, we selected three priority cost items—operating labor, waste disposal, and environmental management labor—and applied alternative allocation methods to conduct a cost comparison, entitled the *Allocation Analysis*. In both analyses, we build from the facility's current allocation system, suggesting modifications that more accurately track the cost of the product. Our methodology and findings appear below.

Surcharge Analysis

In developing its conversion costs, the facility uses surcharges to penalize those products that require non-typical production effort before they can be shipped. Examples of surcharges include fees for extra re-work and filtration. The accounting staff identifies the products that merit a surcharge by asking the site manager for feedback. The site manager works with production staff to identify surcharge candidates. For the Surcharge Analysis, we reviewed the Resin A production process to identify any potential surcharges required for this product.

Unlike other products at the facility, Resin A requires minimal rework, which would require placement of an off-spec product batch back in a reactor for further reaction. Process operators generally can keep this product within major product specifications during manufacture. However, Resin A does require an extra filtration step to eliminate a haze generated as a by-product during manufacturing. Despite this additional filtration step, accounting staff did not identify Resin A as a product line that merits a surcharge when calculating the conversion cost for the product. This oversight may reflect a communication breakdown between accounting and production personnel, as opposed to a flaw in the conversion cost methodology.

We estimated the financial impact of Resin A's failure to receive an appropriate surcharge, by estimating the true filtration cost for the product. We included the filtration labor, filtration raw materials (filter powder and filter paper), and waste disposal from the filtration process. To estimate the costs of each item, we spoke with environmental and operating personnel at the facility. We also accessed information on waste disposal costs from the corporate-wide waste database.

Using these sources, we calculated the following costs for each batch:

Cost Item	**Cost per Batch**
Filtration Labor	$99
Filtration Materials	$16
Waste Disposal from Filtration	$552
Total Filtration Cost	**$667**

Assuming an average batch size for Resin A of 60,735 pounds raw materials and 58,823 pounds of product, we estimate a filtration cost of $0.011 per pound, which adds 18% to the original conversion cost estimate for Resin A at this facility.[4] This analysis indicates that effective implementation of the facility's conversion cost methodology is critical to its accuracy. Failure to identify Resin A as a surcharge candidate significantly compromises the accuracy of the conversion cost approach. Enhanced communication between accounting and production departments likely would lead to improvements in the implementation of the current system.

Allocation Analysis

The facility's cost allocation system uses three different allocation bases—kettle hours, number of batches, and product volume—to calculate the conversion (or manufacturing) cost of the product. This conversion cost serves as the baseline for pricing and product mix decisions. We evaluated the company's allocation methodology by revisiting the cost estimates for three cost categories—operating labor, waste disposal, and regulatory compliance labor—each of which uses a different allocation basis in the company's methodology. For each of these categories, we applied an alternative cost estimation approach and then compared these estimates to costs developed through the company's conversion cost approach.

Operating Labor

In the conversion cost approach, the company currently allocates operating labor to products using the basis of kettle hours. In calculating the conversion cost, the company first allocates labor costs to product families (e.g., alkyd resins) and then within each family allocates operating labor to each product line. For our analysis, we focus on the second allocation—from the product family to the product. We estimate the annual operating labor cost for Resin A using both the company and alternative methodologies and conduct a comparison.

Currently, the facility develops prospective operating labor budgets for each product family. The annual operating labor budget for alkyd resins equals $2,460,906. On average, the

[4]The original conversion cost estimate spreads this filtration cost evenly over all products in the family, including Resin A. Therefore, adding the filtration cost to the original conversion cost would result in some double-counting, though in our estimates very minor.

facility manufactures 1,054 batches of alkyd resins with each batch requiring 19 hours of kettle time, giving a total number of 20,026 kettle hours for alkyd resins. In 1996, the facility manufactured an estimated 70 batches of Resin A, each requiring 17 hours of kettle time for a total of 1,183 kettle hours per year. Using kettle hours as the allocation basis, Resin A is responsible for 5.9% of the operating labor cost for alkyd resins. Using these data, the company's conversion cost method would estimate an operating labor cost for Resin A of $145,398, or $2,089 per batch. These calculations appear in detail below.

	Alkyd Resins	**Resin A**
Average kettle hours/batch	19	17
# batches/yr.	1,054	70
# kettle hours/yr.	20,026	1183
Allocation %	100%	5.9%
Total operating labor cost	$2,460,906	$145,398
Operating labor/batch	NA	**$2,089**

We compared the above facility approach with a bottom-up estimate of operating labor for Resin A production based on the activities of operating personnel. The following table contains our estimating assumptions and calculations, based on averaged salaries of multiple personnel in each labor category. The labor hours per batch are lower than the processing hours per batch because multiple batches run simultaneously.

	Worker/shift	**Batches**	**Processing hrs/batch**	**Labor hrs/batch**	**Labor $/batch**
Operators	4	9	19	7.6	$79
Supervisors	1	9	19	1.9	$26
Laborers	3	9	19	5.7	$77
Filter person	1	1	3	3.0	$32
Powder helper	2	1	3	6.0	$68
TOTAL					**$280**

Using the alternative allocation approach, we estimate an operating labor cost per batch equal to $280. Multiplying that cost by the number of Resin A batches in a year, 70, we estimate an annual operating labor cost for Resin A of $19,448.

These two methodologies generate significantly different estimates. The conversion cost estimate is an order of magnitude higher than the bottom-up estimate. However, the reasons for this significant difference are unclear. The bottom-up method assumes that production employees are 100% productive, not even accounting for legal breaks, but this alone could not explain the full difference. The bottom-up estimates are based on employee identification of their own activities and thus, may differ from their actual allocation of time. To truly compare the conversion cost allocation of operating labor with the actual labor spent on an individual product would likely require some direct tracking of the activities of different labor classes, a task that fell outside the scope of this analysis. Our analysis shows, however, that there is a major discrepancy between the way that production employees think they spend their time and the way that the conversion cost methodology allocates their time, suggesting the need for further assessment.

Waste Disposal Cost Estimation

The company currently allocates waste disposal costs to products using the number of batches as the allocation basis. The facility produces an average of 254 batches per month with approximately 5.8 of those batches Resin A, or 2.3% of all batches. With this in mind, we can use the facility's conversion cost approach to calculate the waste disposal cost associated with Resin A. In FY95, the facility spent $1,305,658 for off-site disposal of hazardous and non-hazardous waste and on-site operation of treatment processes.[5] Allocating 2.3% of that cost to Resin A gives $29,814.

Taking a closer look at the waste disposal cost associated with Resin A, the environmental engineer at the facility performed bench-scale analysis to calculate the quantity of waste generated during Resin A production, measured as a percentage of the raw material volume for the batch. This information is reported in the following table:

Waste Category	**Percent of Raw Material Volume**
Organic Water of Reaction	2.0%
Scrap - Solvent Waste	0.6%
Filter - Hazardous Waste	1.2%
Other - RCRA Hazardous Waste	0.5%

Using an average Resin A batch size of 60,735 pounds and the per pound waste costs from the corporate waste database, we can translate the results from the bench scale experiment into a per batch cost as shown below:

Waste Category	**% Raw Material**	**# / batch**	**$ / batch**
Organic Water of Reaction	2.0%	1,215	$55
Scrap - Solvent Waste	0.6%	364	$22
Filter - Hazardous Waste	1.2%	698	$552
Other - RCRA Hazardous Waste	0.5%	273	$120
Total	**4.2%**	**2,551**	**$741**

Multiplying this per batch cost by approximately 70 batches per year equals $52,099, 75% over the waste disposal cost calculated using the company method. This difference is not surprising, given that hazardous waste from filtering the product haze, which was neglected in the Facility Analysis, accounts for 74% of the total waste cost for Resin A. The alternative allocation method reflects the significance of the filtration waste disposal cost; the Facility Analysis's failure to capture such filtration costs reduces its accuracy significantly.

[5]This treatment cost includes the cost of utilities to operate on-site treatment equipment and any associated waste disposal fees and transportation costs.

Environmental Management Labor Cost Estimation

Among the environmental management labor costs, we focus on the labor allocation of the facility's environmental engineer. The company currently allocates the labor for its environmental engineer to individual product lines using the allocation basis of product volume. Resin A contributes to 3.8% of the total product volume at the facility.

Taking a closer look at environmental management costs for Resin A, the environmental engineer estimated the percentage of her time spent on different activities, including the Life-Cycle Project that focuses on Resin A. She then estimated the portion of each activity that focused on Resin A to allocate her labor cost.

	Percent of Time	**Percent for Resin A**	**Total Resin A %**
Life-Cycle Project	10%	100%	10%
Permits	15%	3.8%	0.6%
Reporting	35%	3.8%	1.3%
Waste Disposal	25%	3.8%	1.0%
Other Waste Min.	15%	0%	0%
Total			**12.9%**

Note that the environmental engineer's estimates agree with the Facility Analysis allocation scheme (3.8%, based on product volume) for most compliance-related activities. The waste minimization activities, however, require a different allocation basis because they are targeted at specific product lines. The end result is that the environmental engineer estimates that she spends 12.9% of her time focusing on Resin A, not 3.8% as estimated through the company allocation method. The discrepancy in these estimates was not converted to dollars in order to maintain confidentiality on the annual salary figure.

The labor requirements of some product lines targeted for waste minimization was not apparent through the conversion cost method. However, it is not clear whether the costs of those waste minimization activities should be borne solely by the product lines they target. Ideally, such waste minimization activities would have broader implications and lead to improvements in other product lines.

Life-Cycle Analysis

In any environmental planning activity, cost data can point to sources of waste and inefficiency (i.e., areas ripe for P2 attention) and, in conjunction with waste generation data, can assist the facility in prioritizing environmental projects. Cost considerations are a major component of the Life-Cycle Project conducted jointly by the case study facility and WMRC staff. One of the major tasks outlined in the Life-Cycle proposal is the calculation of the *cost of waste* for Resin A. The current cost of waste for Resin A will then serve as a benchmark against which the facility can compare the operating costs of P2 opportunities to calculate the expected savings.

In its definition of cost of waste for the Life-Cycle project, the facility moves beyond a more conventional and narrow definition and focuses instead on the broader *environmental* costs associated with the product. Table 1 contains the list of costs identified in the Life-Cycle Project under the cost of waste.

Table 1. Costs to Consider in Life-Cycle Project

Hazardous Substance Use	
Purchasing	Taxes on hazardous products
	Safety training
	MSDS filing
	Safety equipment
	Extra insurance premiums
	Labor
Storage and Inventory	Special storage facilities
	Safety equipment
	Storage area inspection and monitoring
	Storage container labeling
	Safety training
	Emergency response planning
	Spill containment equipment
	Lost product from spills, evaporation, etc.
	Labor
	SARA Title III reporting
In-Process Use	Safety training
	Safety equipment
	Containment facilities and equipment
	Clean up supplies
	Labor
Lost Raw Materials	Labor for handling
	Equipment for clean up
	Reporting
Waste Generation	
Air and Water Emissions	Air emission permits and controls
	TRI measurements/estimates
	TRI reporting
	TRI fees
	Worker health monitoring
	Sewer discharge fees
	NPDES permits
	Water quality monitoring
	Sampling training
	Pretreatment equipment
	Pretreatment system operation
Solid Waste Collection	Safety training
	Safety equipment

	Collection supplies
	Container labels
	Container labeling
	Recordkeeping
	Truck maintenance (for in-house fleet)
Waste Storage	Storage permits
	Special storage facilities
	Spill containment equipment
	Emergency response planning
	Safety training
	Storage area inspection and monitoring
On-Site Treatment or Recycling	Capital and operating costs
	Depreciation
	Utilities
	Operator training
	Safety equipment
	Emergency response planning
	Permits
	Inspection and monitoring
	Insurance
Disposal	Sewer fees
	Container manifesting
	Disposal vendor fees
	Preparation for transportation
	Transportation
	Insurance and liability
	Disposal site monitoring

The Table 1 list is quite comprehensive and will lead to a clearer consideration of environmental costs within the firm. However, Tellus has suggested that the facility and WMRC not limit the analysis to environmental costs. Instead, we suggest that the facility broaden the net to incorporate all of the costs associated with the product line—environmental and non-environmental. Our experience indicates that the profitability of P2 projects often hinges on non-environmental cost savings, some of which were not included in Table 1. An example is utility costs in general, not just those associated with treatment/recycling.

In developing cost data for these items, the facility should keep in mind the limitations and strengths of the Facility Analysis and make modifications where necessary. For example, the facility can prioritize the cost items based on significance and develop detailed cost estimates for some portion of the cost items, using the Facility Analysis approach for the remaining cost items.

Conclusion

In sum, these analyses demonstrate the importance of careful implementation of the company's conversion cost method. Although the facility's conversion cost method balances resource constraints with accuracy, its failure to identify Resin A as a surcharge candidate significantly compromises its accuracy for that product line. In general, the method succeeds in capturing the costs associated with different product lines with minimal tracking and effort. Resin A, however, serves as an example of a product that fell through the cracks. Because an extra filtration step was never identified for this product, the ability of the conversion cost method to reflect the real cost of the product was limited from the start. In theory, the conversion cost method succeeds at meeting this balance. In practice, however, improvements can be made.

We suggest improved communication between accounting staff that develop the conversion costs and environmental staff who coordinate the P2 program. Each group can learn much from the other. Those products that merit a surcharge because they require additional production effort also serve as probable candidates for a P2 assessment. A product that generates extra filtration waste or requires additional rework may indicate a need for process optimization. By working together, the environmental and accounting groups can create a system of metrics that meet their joint needs. In doing so, the facility can move forward to strengthening the connection between its environmental and economic performance. Such progress is within reach, using the facility's current data systems.