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Cost share #: D-48-347  
Rev #: 4  
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Contract#: X 994566-94-0  
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Project unit:  
DEAN ARCH  
Unit code: 02.010.170  
Project director(s):  
ELLIOTT M L P  
DEAN ARCH  
(404)894-2350  

Sponsor/division names: ENVIRON PROTECTION AGENCY / EPA ATL - GA  
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Title: FOSTERING POLLUTION PREVENTION IN MID-SIZED FIRMS (EPA)  

PROJECT ADMINISTRATION DATA  

OCA contact: Anita D. Rowland  
894-4820  
Sponsor technical contact  
Sponsor issuing office  
CAROL MONELL  
(404)347-7109  
RALPH ROBINSON  
(404)347-2200  
U.S. ENVIRONMENTAL PROTECTION AGENCY  
345 COURTLAND STREET  
ATLANTA, GA 30365  
U.S. ENVIRONMENTAL PROTECTION AGENCY  
345 COURTLAND STREET  
ATLANTA, GA 30365  

Security class (U,C,S,TS) : U  
ONR resident rep. is ACO (Y/N): N  
Defense priority rating : supplemental sheet  
Equipment title vests with: Sponsor  
GIT X  

Administrative comments - 
UPDATE OF DELIVERABLE SCHEDULE PER SPONSOR'S 11/16/94 LETTER, COPY ATTACHED.
NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 11/08/95

Project No. D-48-A92

Center No. 10/24-6-R8223-0A0

Project Director ELLIOTT M L P

School/Lab DEAN ARCH

Sponsor ENVIRON PROTECTION AGENCY/EPA ATL - GA

Contract/Grant No. X 994566-94-0

Contract Entity GTRC

Prime Contract No.

Title FOSTERING POLLUTION PREVENTION IN MID-SIZED FIRMS (EPA)

Effective Completion Date 950531 (Performance) 950831 (Reports)

Closeout Actions Required: Y/N Submitted

Final Invoice or Copy of Final Invoice Y 950616

Final Report of Inventions and/or Subcontracts Y

Government Property Inventory & Related Certificate N

Classified Material Certificate N

Release and Assignment N

Other

Comments

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director Y

Administrative Network Representative Y

GTRI Accounting/Grants and Contracts Y

Procurement/Supply Services Y

Research Property Management Y

Research Security Services N

Reports Coordinator (OCA) Y

GTRC Y

Project File Y

Other N

NOTE: Final Patent Questionnaire sent to PDPI.
Project Title: Fostering Pollution Prevention in Mid-Sized Firms: Strategies for More Effective Pollution Prevention Assistance

Co-Principal Investigators: Michael Elliott, Associate Professor of Environmental Planning and Policy, Georgia Institute of Technology and Carol Foley, Research Scientist II, Environmental Science and Technology Laboratory, Georgia Tech Research Institute

Date of Report: April 1995 Status Report

Progress Report:
Summary of Progress to Date

Restatement of Goals and Objectives. A number of states have created technology transfer programs to promote pollution prevention. Most of these efforts are designed to assist small firms comply with environmental regulations. The importance of these efforts notwithstanding, technology transfer efforts aimed at mid-sized firms may yield significantly larger reductions in polluting wastes.

This project seeks to design environmental technology transfer strategies aimed at mid-sized firms. For these firms, the research project will examine 1) environmental decision making, 2) successful adoption of innovative pollution prevention technology and 3) the impact of public policy interventions to promote technology transfer. Based on this research, we will recommend strategies for promoting pollution prevention within these firms.

Progress to Date and Summary of Next Steps. The project consists of three types of research activities. These activities include statistical analysis of firm characteristics associated with pollution prevention behavior, in-depth case analyses and interviews, and explorations of state and federal programs.

Statistical analyses. First, the project is examining descriptive statistics on corporate decision making behavior. Specifically, information on corporate pollution prevention behavior is being correlated with detailed analyses of TRI data and financial characteristics of the 600 firms being studied. This information has been collected and entered into databases. These databases are now being analyzed to assess the significance of observed relationships on pollution prevention behavior. This segment of the research should be completed during the next reporting period.

Case analyses. The project is also examining several corporations in considerable detail. These detailed case analyses will complement the region-wide information developed through the survey by providing both a more focused examination of problems and opportunities associated with pollution prevention and an occasion to further examine the
linkage between public policy and corporate decision making. Four cases have been conducted, and interview data coded for analysis. These are now being examined for possible refinements in the case studies. Additional companies will soon be identified, based both on the survey responses and on the suggestions of state technical assistance agencies. Corporations will then be contacted to obtain corporate approval. Interviews will be conducted during the months of June through September.

*Government programs.* The assessment of state pollution prevention programs has not yet been initiated. This segment of the analysis will be initiated this summer, with data on state programs collected during this upcoming reporting period and completed in the fall.

**Estimated Completion Date.** The study is being conducted as part of a larger project with the Georgia Pollution Prevention Assistance Division. Completion date for the full project remains unchanged. The draft report for the full project should be available by December 30, 1995.

**Financial data.** To date, the project has been using matching funds to pay for project expenses. These funds must be expended over a shorter period of time. Matching funds are almost fully expended to date. At the same time, the project has not expended P2AD granted funds during this reporting period.

**Summary of Lessons Learned.** During this initial reporting period, analyses have not proceeded to the point of conclusions.
Fostering Pollution Prevention in Mid-Sized Firms: Strategies for More Effective Technology Transfer

Final Report

Presented to the
U.S. Environmental Protection Agency

by

Michael Elliott
Graduate City Planning Program
Georgia Institute of Technology

Carol Foley
Environmental Science and Technology Laboratory
Georgia Tech Research Institute

with the assistance of

Claudia Huff
Leigh McElvaney
Sene Sorrow

October 31, 1995
Summary

The Congressional Office of Technology Assessment concluded in a recent study that it is technologically and economically feasible to reduce hazardous waste generation by as much as 50%. Legislation mandating reductions in hazardous wastes or toxic chemical releases are now widespread. State agencies have adopted a variety of approaches to promote source reduction and recycling in industry, including fees on toxic releases or hazardous waste generation, tax incentives, facility waste reduction plans, numeric performance goals, on-site technical assistance, demonstration grants, and other forms of technology transfer.

Many of these non-regulatory programs, however, were designed to assist small businesses (with less than 100 employees) comply with environmental regulations as well as to reduce waste. The targeting strategies traditionally used by technology transfer programs, however, may be ineffective in reaching larger companies where management is more complex and environmental managers are less directly involved in decisions regarding product development, operating practices, input materials, or process technologies.

The problem is to develop programs for mid-sized industries which not only have more complex decision-making structures, but also collectively have a significant impact on the environment. A better understanding of how these companies make decisions for technological or operational changes, as well as regulatory compliance, is needed to identify the most effective methods for promoting corporate pollution prevention.
Based on 600 corporate respondents of a detailed survey and four in-depth case analyses, the paper explores how pollution prevention decisions are made in mid-sized corporations, who sets environmental policy (both formally and in fact), and what type of policy interventions (i.e., on-site technical assistance, seminars, incentives, or regulation) motivate corporate decision makers to adopt prevention strategies. For these firms, the paper examines 1) environmental decision making, 2) successful adoption of innovative pollution prevention technology and 3) the impact of public policy interventions to promote pollution prevention within corporations.

Problem to be Addressed

With the exception of Arkansas, all states in EPA Regions IV and VI have enacted legislation mandating reductions in hazardous wastes or toxic chemical releases. A variety of approaches have been adopted to promote source reduction and recycling in industry, including fees on toxic releases or hazardous waste generation, tax incentives, facility waste reduction plans, numeric performance goals, on-site technical assistance, demonstration grants, and other forms of technology transfer.

The National Toxic Release Inventory (TRI) Report data for Regions IV and VI illustrates the importance of developing effective technology transfer programs in the southern region of the United States. In 1988, industries in the thirteen states in these regions generated 54% of the toxic chemicals released and 24% of the toxic chemicals transferred in the United States. In the first year (1988 to 1989), these states accounted for only 5% of the reductions resulting from pollution prevention activities. While regional
differences in economic activity and other factors made this relatively small reduction difficult to interpret, clearly there was room for improvement.

Since 1989, the rate of pollution prevention has accelerated rapidly in the south. By 1992, the rate of reduction slightly exceeded the rate of reduction for the country as a whole. This reduction in total releases and transfers resulted from important shifts in state and federal policies as well as changes in corporate policy toward pollution prevention.

Many of the original non-regulatory technical assistance programs were designed to assist small businesses (with less than 100 employees) comply with environmental regulations as well as to reduce waste. The targeting strategies traditionally used by technology transfer programs, however, were largely ineffective in reaching larger companies where management is more complex and environmental managers are less directly involved in decisions regarding product development, operating practices, input materials, or process technologies.

While a focus on larger companies was needed, state technology transfer programs should not be aimed at major corporations (with more than 1,000 employees). These companies, such as 3M or Dow, have extensive in-house expertise for evaluating and correcting manufacturing inefficiencies. The public nature of the TRI data alone has motivated many of the largest emitters to voluntarily reduce their releases, with programs such as the EPA 33/50 Program seeking to formalize voluntary commitments. Much of the reduction in the south is a result of these changing dynamics.

The problem is to develop technology transfer programs for the mid-sized industries (100 to 1,000 employees per facility with three to 30 total facilities) which not only have
more complex decision-making structures than smaller companies, but also collectively have a significant impact on the environment. A better understanding of how these companies make decisions for technological or operational changes, as well as regulatory compliance, is needed to identify the most efficient and cost-effective methods for promoting decisions which prevent pollution. Information is needed on how decisions are made, who sets environmental policy (both formally and in fact), and what type of interventions (i.e., on-site technical assistance, seminars, incentives, or regulation) would motivate decision makers to adopt prevention strategies.

Focus of Study and Research Method

In designing this study, the research team conducted a literature search and examined specific cases of technology transfer to larger corporations. Three bodies of literature were examined: general reports and discussions, such as those compiled by the Waste Reduction Institute, on the effectiveness of environmental innovation in small firms; case-based reports, such as those compiled by MIT, on environmental decision making in large corporations; and a wide range of literature addressing corporate strategies for technological innovation in areas ranging from banking to factories. In addition, specific case experiences in which the co-principal investigators were active participants provide additional insight into the nature of the problem and its possible resolution.

This research and case experience suggests that in mid-sized firms, corporate environmental decision making is ill-structured to promote pollution prevention through
technological innovation. Such decision making requires a number of decision makers to interactively solve problems which lie outside the analytic expertise of any one of them and which appear to infringe on the interests of many of the stakeholders within the firm. Problems include incomplete data about waste production and its concomitant costs, lack of information about technologies for preventing pollution, fractionated decision making procedures with inadequate communications between divisions, misallocated analytic and financial resources, reward structures, and accounting systems, among others. Equally important, the research also suggests that many of these problems are resolvable with focused corporate and public policy interventions.

Programs designed to transfer technologies must target resources more effectively. To work effectively with mid-sized firms, managers of technology transfer programs must be able to identify opportunities with potentially large pay-offs and to design intervention strategies that are sensitive to the organizational and decision making constraints associated with specific firms.

The researchers hypothesized that the highest levels of pollution prevention activity will be found in those facilities:

- found in states with mandatory reduction goals, taxes or fees on pollution, or multimedia approaches (air, water, and hazardous),
- with a history of interaction with environmental officials and advocacy groups,
- with "policy entrepreneurs" and "eyes and ears" interested in innovation,
- with organizational structures that reinforce knowledge seeking and information flow,
located in states with programs that reinforce organizational imperatives associated with innovation and knowledge flow.

The study we conducted therefore had three major components: (1) to more effectively explain environmental decision making within mid-sized firms, (2) to identify opportunities and barriers to more effective decision making, and (3) to develop strategies for more efficient targeting of technology transfer programs.

Approach

The study focused on all mid-sized firms that are potentially eligible for the 33/50 program. The study also examined the pollution prevention policies and programs of the states in which these firms are located. Firms from six states were selected for review. These states, including Florida, Georgia, Louisiana, North Carolina, Tennessee and Texas, account for over 60% of all facilities in the 13 state region of the study. The research team conducted an intensive two-stage study of corporate and state decision making. In the first stage, the

Figure 1  Study Area
researchers surveyed the pollution prevention practices of all eligible firms located in the six states.

The mail surveys were conducted as follows. The surveys were designed to gather basic information on pollution prevention in the facility. This included:

✓ Current and past pollution prevention activity
✓ Type and number of personnel involved in projects
✓ How projects are identified
✓ Role of corporate headquarters in pollution prevention, environmental management, compliance and funding
✓ Interaction with regulatory and technical assistance programs
✓ Awareness of 33/50 Program
✓ TRI reporting levels
✓ Incentives
✓ Structure of company and number of employees
✓ Ranking of reasons for implementing pollution prevention projects, and
✓ Ranking of impediments to pollution prevention.

The sample included mid-sized corporations with between 2 and 30 facilities nationwide, AND who were eligible for the 33/50 Program (they report releases of any of the 17 toxics targeted by that Program), AND were identifiable and unique facilities still in existence at historically identified locations. The sample size was 1529 facilities.

The firms were surveyed using a mailed questionnaire. Pre-questionnaire introductory letters were sent to the firms. For non-respondents, two follow-up reminder
questionnaires were sent. The response rate was 40% overall. The survey is provided in Appendix A.

In the second phase, researchers conducted detailed case studies of four mid-sized firms. As a basis for designing more effective technology transfers, cases examined specific environmental decisions. Figure 2: Technology Transfer Strategies for Pollution Prevention

![Diagram](image)

To determine environmental decision paths, resource flows and processes of technological innovation, the researchers examined specific decisions made by the corporation. The decisions were examined from the perspectives of owners, managers, division directors, environmental specialists, personnel managers, quality assurance specialists, maintenance, accountants, and others. By linking this data to an examination
of technology transfer efforts associated with innovation, the researchers sought to
determine potential points of strategic intervention. These case studies included on-site
interviews, analysis of secondary data (company reports and documents, TRI data,
economic data, etc.). This phase is discussed in more detail later in this report.

State and Federal Policies Affecting Pollution Prevention

State federal policies were examined from the perspective of policies that would be
more likely to promote pollution prevention. Detailed conclusions about the effectiveness
of specific policies remains beyond the scope of this report. These policies, however,
provide important contextual variables to the decision making of corporations. This section
examines these potential impacts.

State policies around pollution prevention range across a spectrum of tools. Effectiveness of state policies vary by the policy options chosen by the state. In general,
we would expect direct regulations (such as facility audits and plans and mandatory
reduction goals) to influence corporate decision making most directly. Economic
incentives (such as taxes or fees on pollutants, investment tax credits, grants, low-interest
loans, and fines) will also have a pervasive, although lest direct effect. Finally, voluntary
compliance and education programs (such as research and development, technical
assistance programs, technology transfer, public recognition and awards), will provide the
least direct impacts.

At the same time, corporate freedom to design pollution prevention programs that
suit the company are likely to decrease as state policy moves from regulation, to incentives
to voluntary compliance. Thus, there is a tension in the policy making field: with more direct interventions requiring greater state involvement and resources and potentially reducing corporate flexibility and discretion.

The policies employed by the states in the survey are shown in the Table below.
<table>
<thead>
<tr>
<th>Policy Options</th>
<th>FL</th>
<th>GA</th>
<th>LA</th>
<th>NC</th>
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<tr>
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<td>☐</td>
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<tr>
<td>Taxes or fees on pollutants</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Investment tax credits</td>
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<tr>
<td>Grants</td>
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<tr>
<td>Low-interest loans</td>
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<tr>
<td>Fines</td>
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</table>

Voluntary Compliance and Education Programs

FL, GA, LA, NC, TN, TX
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<th>Policy Options</th>
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<th>GA</th>
<th>LA</th>
<th>NC</th>
<th>TN</th>
<th>TX</th>
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</thead>
<tbody>
<tr>
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<td>✓</td>
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<td>✓</td>
</tr>
<tr>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

SYMBOLS:
- ● Small Quantity Generators Only
- ▲ Large Quantity Generators Only
- □ Both Small and Large Generators
- ✩ Applies to Permitted Air Emissions
- ≈ Applies to Permitted Water Emissions
- ↑ Expansions Only
- ✓ Programs Exist
Federal activities also directly impact pollution prevention decisions of firms. A number of programs exist. While not the focus of this study, two bear discussion here because they form part of the data base of the study. This included the toxic release inventory and the 33/50 program.

The toxic release inventory (TRI) was created by Title III of the Superfund Amendments and Reauthorization Act (SARA) in 1986. The TRI is an annual accounting of toxics that are used and released during manufacturing activities. The TRI includes reports on releases to air, water, land and off-site transfers. The first reports were submitted July 1, 1988 for calendar year 1987. This initial year of reporting is generally ignored because of systematic bias in the patterns of reporting provided by the corporations in the start-up year. The data created by the TRI is public and available through the National Library of Medicine (TOXNET) or on CD-ROM. Data is currently available for calendar years 1987-92. Reports for CY 1993 (submitted July 1994) are now becoming available.

Toxic Release Inventory applies to all industries under SIC Codes 20-39 (manufacturing sector) with 10 or more full-time employees that exceed annual thresholds for manufacturing. These thresholds are: 25,000 lbs/yr for manufacturing or processing and 10,000 lbs/year for otherwise using the chemicals. The thresholds apply to any of approximately 300 substances on the TRI Toxic Chemical List.

The primary impact of this law comes from its requirement for a mass balance accounting of toxic materials used and released into the environment. This was the first federal law to require such accounting. The data created by the TRI raised awareness of
inefficiencies in manufacturing operations. In addition, public availability and use of the data has increased pressure on these companies to reduce releases.

During the mid 80's, the U.S. Environmental Protection Agency also created the 33/50 Program. The program encouraged corporations to voluntarily reduce release of 17 toxic chemicals listed by the EPA\textsuperscript{1}. The goals were a 33% reduction in releases in these chemicals by 1992 and a 50% reduction by 1995. These goals applied to the overall program. However, corporations largely committed to meet these reduction goals within their individual firms.

Over 700 companies made this commitment to EPA. As such, it provides a useful basis for sampling firms in the south. Firms that meet the requirements of the 33/50 program are likely to have more in common than manufacturing firms in general. Thus, comparisons will be facilitated. In addition, information is available on the characteristics of 33/50 firms that allow for some more general analyses. Finally, since the program is voluntary, corporate response to the initiative could be examined for companies that both volunteered and those that did not.

Before proceeding to a discussion of the results of the studies, it will be helpful to examine the relationship between pollution prevention technology transfer and concepts of organizational development. The next sections makes this examination, followed by a presentation of the results of the survey and the case studies.

\textsuperscript{1}The 17 chemicals included benzene, cadmium and compounds, carbon tetrachloride, chloroform, chromium and compounds, cyanides, dichloromethane, lead and compounds, mercury and compounds, methyl ethyl ketone, methyl isobutyl ketone, nickel and compounds, tetrachloroethylene, toluene, trichloroethane, trichlorethylene, and xylene (all isomers).
Systems Design for Promoting Pollution Prevention

As a concept, pollution prevention ($P^2$) holds considerable promise. In many corporations, $P^2$ programs reduce material, pollution abatement and regulatory compliance costs. These programs increase the efficiency of material and energy use, reduce demands on natural resources and minimize the production of waste. As such, pollution prevention appeals to both environmentalists and corporate leaders.

As a policy tool, however, $P^2$ is difficult to implement. Traditional policy tools lack flexibility. The two dominant environmental management systems -- environmental regulations and market-based incentives -- are rule-based systems that standardize treatment of firms. Neither allow policy makers to strategically promote pollution prevention.

Yet flexibility and strategic choice is an essential aspect of pollution prevention. $P^2$ works best when highly contextualized. To succeed, sustainable technologies and production processes must be adapted to the specifics of a particular facility. Operating procedures must evolve to maximize the benefits of these adaptations. Such changes are difficult to orchestrate from the outside.

A tension exists. Pollution prevention is essentially managerial. The strategies require detailed *intra-organizational* knowledge of the firm to succeed. At the same time, management will adopt such strategies only if they posses sufficient *knowledge* to understand the potential of $P^2$, *incentives* to utilize that knowledge, and *organizational capacity* to design and implement solutions. For many firms, such knowledge, incentives and organizational capacity does not exist.
One role of public policy, then, is to provide the \textit{extra-organizational} supports needed for firms to engage productively in pollution prevention. Knowledge-based, context-sensitive consultations are seen by many states as essential for effective diffusion of innovative P\textsuperscript{2} technology and managerial practices. Forty-nine states have instituted over 105 technical assistance programs aimed specifically at environmental compliance and pollution prevention.

This need for extra-organizational assistance to support intra-organizational capacity is particularly important for mid-sized firms. Small firms have relatively flat decision making structures, with few departmental differentiations. Mid-sized firms (firms with more than one facility, each of which employees more than 100 persons) are organizationally more complex. At the same time, many mid-sized firms lack the technological and organizational capacity to design and implement pollution prevention programs. Support by technology assistance programs (TAPs) can be particularly useful to these firms.

While recognizing the need for extra-organizational supports for pollution prevention, the objectives of many TAPs remain narrowly defined. Strategies to transform pollution prevention practice all too often focus on technological solutions, with little emphasis on the managerial and organizational capacity of the firm. Such strategies are problematic, particularly when applied to mid-sized firms.

This section contends that pollution prevention TAPs must increasingly build managerial capacity if they wish to effectively promote pollution prevention. Without such assistance, pollution prevention programs will fail to achieve their full potential. To show
this, we first examine the impact of a TAP on a hypothetical company. Building on this case, we examine the process of technological innovation as applied to pollution prevention, and the role that technology transfer plays in this process.

A Hypothetical Company

The environmental manager at Complete Coatings Inc. is concerned about the rising cost of hazardous waste disposal and is under pressure by the plant management to keep such costs to a minimum. The company's manufacturing processes include a coating step which generates hazardous waste from equipment cleaning and over spray in the paint booth. The environmental manager contacts the university-based technical assistance program (TAP) for help. She attends a technical training program conducted by the TAP and works with the TAP to analyze waste production within the plant. The TAP recommends a strategy to reduce the company's regulatory burden using pollution prevention techniques: less hazardous coatings, more efficient application equipment,

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2 The experience of the Complete Coatings Inc. is a composite of experiences with firms receiving assistance from the author's university-based technical assistance program.

3 Voluntary technical assistance and technology transfer between a government sponsored program and industry usually proceeds as follows: The technical assistance program (TAP) targets small-to-mid-sized companies through direct advertising or local chambers of commerce and other industry organizations. A company realizes that it has some urgent problem either with regulatory compliance or escalating costs of waste disposal. The company calls the TAP and sets up an appointment for an on-site assist or describes the problem over the telephone and receives information by mail. The TAP sends out a trained professional to collect information about the company's production and waste management processes by reviewing documents and interviewing managers and shop floor employees. Often, the shop floor employees provide valuable insight into the problem and potential solutions. The TAP professional returns to the office and writes a technical report which characterizes the problem and recommends actions to remedy it. The report is sent to the company manager for review and implementation. The TAP contacts the company six months later to discuss progress and evaluate the implementation rate of the recommendations.
scheduling changes which reduce cleaning steps and a production process change that eliminates the use of benzene from the plant. Six months later the TAP contacts the company and learns that the company changed the production schedule and instituted better operating procedures. The environmental manager explains that changes in the product and production equipment were beyond her power. The TAP chalks up a relatively successful technical assist.

A year later, Complete Coatings conducts its first Toxic Release Inventory. The firm discovers that it releases a surprising amount of volatile organic compound (VOC) emissions from the coating process and may need an air permit. The company also finds itself on a list compiled by the local newspaper of the 50 top toxic polluters in the region.

The environmental manager receives an agitated call from the plant manager and contacts the TAP for help. She attends a second training workshop. At her request, the TAP conducts further analysis of the plant. The TAP resubmits a report to the plant manager. The report once again recommends that the company install more efficient application equipment, substitute a less hazardous coating for the current one, and adjust the production process to adjust for this material substitution. If implemented, these changes would reduce Complete Coatings' VOC emissions sufficient to eliminate the need for an air permit.

4 The Toxic Release Inventory (TRI) is an annual submission of information on releases of over 300 toxic chemicals to the air, water, land, and in off-site transfers. Companies with 10-or-more full-time employees, in Standard Industrial Classification Codes 20-39, and which manufacture, process, or otherwise use the listed chemicals in excess of specified thresholds must complete the TRI forms for each chemical and submit them to the EPA by 1 July.
Six months later the TAP contacts the company and learns that the original environmental manager has left the company, that they now use better application equipment, and that the company obtained an air permit from the state which allows room for a planned plant expansion. The company is pleased that it is no longer on the list of top polluters. The production manager is not implementing the material substitution and process recommendations. "Our current system works fine," he notes.

The TAP staffers take pride in companies such as Complete Coatings. Compared to working with companies that ignore advice, working with Complete Coatings produces real satisfaction. Yet, the TAP managers remain uneasy.

TAP staffers refer to the Complete Coatings of the world as technical assistance "junkies." These are companies that rely on the TAP for assistance with every "new" problem. The reappearance of friendly and familiar faces at the TAP caused the staffers to wonder about the role of the TAP in the decision making processes in these companies and effectiveness of the types of assistance they provide.

Although the TAP gave away "a lot of fish," the staffers felt that they had not taught many companies "how to fish." All too often, environmental managers remained isolated, implementing changes in their sphere but having little impact on systems of production, operations and maintenance. If we were to design more effective technology transfer policies and programs, we needed to better understand the impact of a firm's organizational culture on the types of decisions required for pollution prevention.
Technology Transfer and Pollution Prevention

In broad terms, Dearing (1993) defines technology transfer as "the communication of information which is put to use." The technology can be anything from information which influences decision making to knowledge about how a particular technology works. Examples of technologies applicable for pollution prevention include planning processes (information for decision making) and performance characteristics for high-volume, low-pressure coating application equipment (knowledge about function).

The challenge for TAPs is the process by which the information is transmitted and received. Although transfer implies a unilateral movement of information from those conceiving it to those using it, more often the relationship between the participants is multi-lateral or bi-directional. Dearing (1993) concludes that "technology transfer is a complicated relational concept, which involves communication, information, use and time."

Most TAP professionals "tap" into the knowledge of the shop floor employees and the lower level managers for insight into possible solutions. The character of the technology

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5 The terms technical assistance program (TAP) and technology transfer program are used interchangeably.

6 The literature is packed with various definitions of technology transfer, however, most of the more complicated definitions boil down to the simple definition given by Dearing. Evans (1976) defined technology transfer as the movement of technical ideas and knowledge from a conceiving organization to a user organization. Staudt et al. (1994) state that technology transfer "designates a process whereby the specific know-how of a particular region and its reservoir of education and research institutions is transferred to companies in a maximally efficient way."
transfer relationship becomes more "bi-directional" or participatory as the focus of activities moves into the innovation phase of product development (Starbuck, 1994). The common strategy for improving the effectiveness of the technology transfer process is to reduce the differences (actual or perceived) between the programs and their clients. In our own TAP, we feel a significant boost in the company's receptiveness towards us when the engineers in the plant are graduates from Georgia Tech. One artifact of this strategy is the development of specialized TAPs designed to resemble the organization of the companies they serve. Often a state will have separate TAPs for environmental regulatory issues, pollution prevention, worker health and safety, productivity and quality enhancement, management and general business assistance,

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7 Starbuck (1994) proposes a biological model for the technology transfer process between the university and industry. Starbuck defines the transfer process as a cell (in this case the Engineering Research Center funded by the National Science Foundation) bounded by membranes which emit and receive signals (information). The cell membrane receptors (people) are classified into any or all of three functions: individuals to whom others often turn for information (gatekeepers), people who can change policies and procedures (boundary modifiers), and people who indirectly promote technical ideas and perpetrate change (transmitters).

8 Dearing (1993) discusses the relationship between research on communication networks and innovation. Citing Rogers et al. (1970), he uses the concepts of homophily (the degree to which people are alike) and heterophily (the degree to which people are different) and their relevance to communication networks to conclude that "the ultimate relationship for technology transfer to occur readily would be one in which participants are quite homophilous on all criteria [perceptual, relational, situational, organizational, social, and/or cultural] except for the technical expertise in question."

9 The Georgia Tech Research Institute and the Georgia Tech Economic Development Institute manage several separate industrial assistance programs. These programs are funded by both the state and federal government and address environmental regulatory compliance, pollution prevention, energy conservation, worker health and safety, ergonomics, productivity and quality, and industrial engineering and management. There also are numerous relevant research programs within the various academic units at Georgia Tech and the industry-sponsored Manufacturing Research Center.
energy conservation, among others. These TAPs conceptualize (or frame) the problems at a manufacturing site in the same manner as their industrial counterparts.

The goal of a pollution prevention TAP is to reduce pollutants at the source\(^\text{10}\) or, at the very least, to move a company along the waste management hierarchy from disposal to source reduction.\(^\text{11}\) The complexity of the task for the TAP (and the company) increases as the focus of activities moves from disposal to source reduction. As a company moves up the waste management hierarchy, the options require more integrated evaluation and decision making across functions in the plant. The organizational factors associated with "more advanced" options also include the capacity for the company to be innovative in the face of uncertain technologies and outcomes.\(^\text{12}\) For example, the decision at Complete

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\(^{10}\) The Pollution Prevention Act of 1990 defines source reduction as "any practice which (1) reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, and disposal; and (2) reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants. The term includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvement in housekeeping, maintenance, training, or inventory control." (42 U.S.C. 13102 (5)(A))

\(^{11}\) The Pollution Prevention Act of 1990 reinforced the waste management hierarchy established in the Hazardous and Solid Waste Amendments of 1984 (HSWA) to the Resource Conservation and Recovery Act of 1976 (RCRA) and expanded it to include discharges of pollutants in all environmental media. The Act states: "The Congress hereby declares it to be the national policy of the United states that pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner." (42 U.S.C. 13101(b))

\(^{12}\) Pearson (1991) identifies key characteristics for innovation: "the importance of observant people, the value of experience, the linking of different technologies to turn failure into success, the need for perseverance, the contribution of group problem solving techniques, the potential for opening up a wide range of opportunities and for changing, even destroying, existing organizational and market structures." The author presents a matrix of uncertainty about the output versus uncertainty about the process (ranging from low to high on both axes) and defines the four quadrants as exploratory research (high, high), development engineering (low, high), application engineering (high, low), and technical-market
Coatings Inc. to ship its paint-related wastes off-site for disposal could be made by the environmental manager alone, whereas the decision to substitute a less hazardous coating requires consideration by the top management, product designers and engineers, process technologists, the safety manager, and the environmental manager.

Pollution prevention TAPs\textsuperscript{13} strain against the boundaries of traditional technology transfer programs and the limited conceptual frameworks they (and their industrial counterparts) use to define issues at the manufacturing plant. The goal to change a company’s view from environmental management to pollution prevention represents a shift away from an atomistic view of the plant (or problem-oriented technical assistance) to a systemic view of the plant (or goal-oriented technical assistance).\textsuperscript{14} The strain is caused by the perception of pollution prevention as just an environmental issue and not as part of a larger system that includes product design, manufacture, distribution and use. The challenge is to design a technology transfer program (or policy) that promotes enduring, combination (low, low).

\textsuperscript{13} A recent U.S. General Accounting Office report (GAO, 1994) identified 105 state pollution prevention programs and classified them as regulatory and non-regulatory. Regulatory programs (20\%) incorporate pollution prevention concepts into the existing regulatory framework or implement new pollution prevention planning requirements. Non-regulatory programs (80\%) focus on voluntary technical assistance, education, and outreach.

\textsuperscript{14} This type of shift, from problem-orientation to goal-orientation, is discussed in several contexts in the corporate management literature. Senge (1990) explains the fundamental ideas of systems thinking, personal mastery, mental models, shared vision, and team learning in organizations and its importance to corporate survival. Richards, Allenby and Frosch (1994) provide an overview of the concept of an industrial ecosystem and the application of a systems approach. In his book on strategies for mid-sized corporations, Kuhn (1982) emphasizes the need for strategic planning (action guided by defined goals and objectives) rather than incremental planning (reaction to unexpected shocks to the system). de Bono (1992) makes a distinction between “achievement thinking” (the Japanese focus on continuous improvement) and “problem avoidance” (the western focus on faults).
widespread organizational changes that facilitate systemic evaluation and decision making for pollution prevention.\textsuperscript{15} The issue of TAP effectiveness becomes even more complex as the focus of their activities shifts to larger, systemic issues.\textsuperscript{16}

\section*{Systems Thinking and Pollution Prevention}

Ultimately we desire policies and programs that address pollution prevention systemically---and encourage industry to develop conceptually and organizationally to do the same. Roy (1988) suggests that policy (and, by extension, program) makers "view their task as one of creating heuristic devices both for the individual organizations involved in the pollution control debate, and for society in general." Systems thinking techniques allow us to conceptualize a model which links the decisions (or types of actions) necessary

\footnote{15 Thomas (1990) ranked the effectiveness of various policy and program approaches in promoting pollution prevention (direct regulation is high, economic incentives are moderate, and voluntary compliance and education programs are low). He predicted that the highest levels of pollution prevention activity will be found in those facilities located in states that have mandatory reduction goals, taxes or fees on pollutants, and/or use a multimedia approach. Foecke (1994) believes that seminars and training, grants and loans, TRI data reports, cross-media coordination, and incorporation of pollution prevention projects into notices of violation and settlements have the most potential to promote long-term organizational change. The statutory models developed by Sullivan and Floyd (1991) and Ryan and Schrader (1991) can be used for designing and evaluating the potential for implementation success of pollution prevention planning statutes.}

\footnote{16 TAPs measure their effectiveness qualitatively (did the customer value the service provided) and/or quantitatively (in terms of reductions in wastes generated or released). As cited in the GAO (1994) report, the National Roundtable of State Pollution Prevention Programs "asserts that effectiveness evaluations of state pollution prevention programs must consider the mission of the program or program activity and the need to use new measures of effectiveness, that pollution prevention is a long-term process, and that much of the pollution prevention process originates in the private sector." The authors of the GAO report conclude that "quantifiable amounts of reductions in wastes generated are required to ascertain the effectiveness of federal pollution prevention policy."}
for pollution prevention to the appropriate organizational and decision making characteristics in industry. Senge (1990) introduces systems thinking:

"Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots." It is a set of general principles---distilled over the course of the twentieth century, spanning fields as diverse as the physical and social sciences, engineering, and management. It is also a set of specific tools and techniques, originating in two threads: in "feedback" concepts of cybernetics and in "servo-mechanism" engineering theory dating back to the nineteenth century. During the last thirty years, these tools have been applied to understand a wide range of corporate, urban, regional, economic, political, ecological, and even physiological systems. And systems thinking is a sensibility---for the subtle interconnectedness that gives living systems their unique character."

Using Senge's systems archetypes for patterns of organizational behavior, we can group decisions into four categories: product mix and characteristics (conceptualization), product and process design to produce desired commodities (achievement), product and process design in response to inefficiency (prevention), and treatment and disposal of by-products (waste management). In the model, the corporation decides to manufacture goods or provide services with certain performance characteristics in response to customer demands and needs. The decision to offer certain products bounds the product and

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17 Rappaport and Dillon (1991) suggest nine types of decisions: the product mix and characteristics, materials used in the manufacturing process, natural resources used, handling of by-products, location of the company, facility design, accounting methods used, and company position regarding regulatory compliance. For additional information: on environmental management in corporations see Dillon and Fischer (1992); and on environmental management in small businesses see Dillon and Creighton (1993).

18 There are many interesting publications which summarize the activities in each of the four groups. For discussions related to conceptualization (the decision to make a product in the first place): see the excellent bibliography by Jamieson et al. (1993) on cultural barriers to behavioral change for pollution prevention; Bowman and Davis (1989) on CEO attitudes in which they report that nearly three-fourths of their respondents agreed that environmental issues should be taken into account even if the result is to slow the introduction of new products; Crosson and Toman (1994) on conceptual issues
surrounding economics and sustainable development; and Ray and Rinzler (1993) for a wide variety of essays on emerging views of business.

Information on programs, policies and approaches focusing on prevention can be found in many places: the Pollution Prevention Review, for practical information on programs, policies and case studies; U.S. GAO (1994) and Davis and Greer (1993) for issues associated with state programs; U.S. EPA (1994) for a summary of their activities to promote pollution prevention including internal organizational changes in the Office of Enforcement, and state and local, private sector, and federal partnerships; and Wilhelm et al. (1993) on using fuzzy logic to evaluate the qualitative attributes of pollution prevention strategies and improve strategic manufacturing decision making.

NACEPT (1993) comprehensively discusses the issues (legislative, permitting, inspections, enforcement, and organizational) associated with promoting pollution prevention through the regulatory process and EPA (1993) reviews efforts by state regulatory agencies and is organized by EPA region.

See the National Research Council (1991) which found the quality of U.S. engineering design to be generally poor and concluded that 70% or more of the costs of product development, manufacture, and use is determined during the initial design process; U.S. Congress Office of Technology Assessment (1992) which recommends integration of environmental concerns into policies to improve engineering design capabilities by requiring manufacturers to incorporate recycled materials into new products or take back discarded products from consumers and by harnessing market forces (taxes or fees) to encourage manufacturers to make environmentally sound decisions; Allenby (1994) for discussions about design for environment; and Mistree et al. (1990) for an interesting discussion about the emerging design theory called decision-based design which incorporates concepts from systems thinking and concurrent engineering.
During implementation, the plant management and shop floor employees make incremental production decisions to optimize the performance of the selected technologies. If management succeeds, these conceptualization and achievement decisions result in a product which the customer desires. The company finds itself in a reinforcing cycle of growth. This reinforcing cycle is shown in Figure 3.

The strength of this growth cycle, however, is limited by a counterbalancing cycle. The growth cycle increases the availability of desired commodities. At the same time, it also increases production of by-products and wastes. Inefficient use of raw materials and energy yields a decrease in production and work and an increase in the cost of managing the resultant wastes. These wastes must be managed according to an increasing complex set of environmental regulations. The growth cycle for a company today, therefore, is limited by efficiency. Thus, a limits to growth cycle dampens the growth cycle. The resources required for waste management slow down the growth cycle. This limits to growth cycle is shown in Figure 4.

Two decision pathways exist for the long-term management of inefficiency and waste materials. On the one
hand, managers can choose to continually treat and dispose of waste. This pathway externalizes the burden of residuals management to parties outside the firm. It treats the symptom of inefficiency (i.e., the production of waste) rather than reduce the inefficiency itself. This option exposes the firm to impacts that can reduce profit. These impacts, however, are delayed. Impacts include liability for toxic releases at disposal sites, community opposition to polluting production processes, increasingly stringent regulations, and decreased options for treating and disposing of wastes. Over time, these impacts can seriously threaten the profitability and viability of the firm. In the short run, however, they pose little threat.
On the other hand, managers can also chose to eliminate wastes by redesigning the products and processes. The solution for the problem is internalized within the firm.

Such redesign provides a fundamental solution by eliminating the waste and inefficiency from the production process. However, pollution prevention requires considerable expenditures and managerial supervision with little immediate payoff.
The system model, as shown in Figure 5, illustrates the interdependence of decision making for pollution prevention. The ability of a firm to prevent pollution is limited not only by technological factors (i.e., applications of the laws of thermodynamics), 20 but equally importantly by organizational factors. Simple waste management decisions can be made by environmental managers in isolation from other facility managers. However, as firms seek to reconceptualize waste management, decision making must become more integrated. The feedback loop located at the top of Figure 5 internalizes decision making and its consequences. Compare this to the feedback loop located at the bottom of Figure 5. The internalized (top) loop is organizationally more complex than the externalized (bottom) loop.

This can be further illustrated by reference to the Complete Coating example. The TAP advises that the company progresses up the waste management hierarchy 21 (from disposal of paint related wastes to product changes using alternative coatings). Decision making to support such progress requires integrated evaluation and decision making across functions in the plant (systemic approaches). Yet Complete Coating's organizational context and culture inhibits such integration. To understand the impact of organizational dynamics on pollution prevention, let us turn our attention to decision making in a corporation.

20 An example of systems analysis can be found in Chambers (1991). He uses a systems analysis framework for identifying options for technological substitution and change in the chemicals, fuels, and energy sector in Australia. His model includes influences from national interests, corporate goals, societal needs, and environmental requirements. The author points out the importance of net energy analysis and economic analysis in identifying optimal alternatives for change. Weinbert, Eyring, Raguso and Jensen (1994) also emphasize the need for systemic approaches to environmental policy making.

21 As codified in the Pollution Prevention Act of 1990.
Organizational Dynamics and Decision Making for Pollution Prevention

In general, decision making is limited by the bounded rationality of the decision maker who operates within both formal (hierarchical) and informal (lateral) channels of communication in the organization.\textsuperscript{22} One problem with organizations is coordination of decisions which are separable into components and where "the choice of an alternative can impose costs which are directly borne by other divisions or departments in the firm, and of which he [the decision maker] has imperfect knowledge." Deming (1993) illustrates this point quite well by showing how the components of a production flow diagram (a system) correspond to the typical organizational units in the company---corporate headquarters, departments for product and process design, research and development, production management, environmental management and worker health and safety, shipping and sales. The organizational units become competitive components of the system whose independent goals destroy the systemic functioning of the manufacturing plant. The role of management, Deming says, is "to recognize and manage the interdependence between components. Resolution of conflicts, and removal of barriers to cooperation, are responsibilities of management."

\textsuperscript{22} According to Cremer (1993), bounded rationality is a result of the following factors: humans are not perfect processors, acquirers, or transmitters of information (even when working with clearly stated objectives, a human cannot compute the best option); and humans are limited by the amount of knowledge they can acquire (ensuring that relevant, accessible information won't be used). He measures the cost of communication as the time spent transmitting and receiving information.
Cremer (1993) asserts that the presence of a strong corporate culture, which "coordinates the bounded rationality of the members of the organization," reduces the costs of making decisions and enables a firm to choose efficiently among alternatives. 23

Two significant factors which influence the ability of a company to make efficient and systemic decisions are its corporate culture and the characteristics of its communication and decision making style.

The influence of corporate culture in successful environmental management was observed by Rappaport and Dillon (1991). They found that in "progressive" corporations leadership from corporate headquarters most often provided the driving force for environmental management initiatives at facilities. These corporations also: (1) have environmental policies which express corporate intentions, implementing requirements, and management directives which cover all significant environmental, health, and safety risks, whether regulated or not; (2) use management controls (measures of performance for both the facility and the individual against goals and standards, and formal environmental reviews for capital expenditures, new products, new chemicals, new processes or modifications, property acquisition or operating budgets); and (3) use decision making tools (data collection and analysis systems and accounting methods).

Grant and Arnold (1993) propose a relationship between a company's communication and decision making style to its environmental performance. Companies

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23 On page 352, Cremer (1993) defines corporate culture as "the part of the stock of knowledge that is shared by a substantial portion of the employees of the firm, but not by the general population from which they are drawn." Roy (1988) addresses the role of organizational culture in the pollution-control related activities in companies. He believes that pollution control policies intervene in organizational cultures (described in terms of their norms, theories-in-action, symbolic languages, subgroup conflicts, and social network influences) and that organizations can learn from such interventions.
with a dictatorial management style, poor interaction with the customer, and low morale are likely to have a history of compliance problems. Companies can achieve compliance with a hierarchical management system that has departments operating independently. However, to reach beyond compliance, companies generally need some element of participatory management and customer feedback. Finally, an environmentally sustainable company uses a total quality management style, has multiple departments involved in decision making, is customer driven, drives responsibility and authority to the bottom of the organization, and is capable of problem definition and solving.24

Rappaport and Dillon concluded that successful companies recognize that decisions are made which impact the environment by business and production managers throughout the product life cycle. They also found that the "formal organizational structure of the environmental function within the company hierarchy seemed to have little bearing on the performance and quality of environmental management." The qualities of the environmental managers, their informal relationships and "their political and communication skills" were more important.

Note that the characteristics of successful environmental management are similar to the key characteristics for management of innovation mentioned by Pearson (1991): "the importance of observant people, the value of experience, the linking of different technologies to turn failure into success, the need for perseverance, the contribution of

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24 The President's Commission on Environmental Quality (1993) linked the use of quality management principles to significant pollution prevention and economic savings in a dozen diverse demonstration projects. Their report translates quality principles into an eight-step generic model to be used as a guide for identifying pollution prevention options.
group problem solving techniques, the potential for opening up a wide range of opportunities and for changing, even destroying, existing organizational and market structures."

Cremer (1993) makes one final comment on corporate culture. Corporate cultures are stable and resist selective intervention. Greater flexibility in communication structures and mobility of employees leads to greater integration of corporate culture. "Progressive reform by piecemeal improvement will be extremely difficult" if not impossible.

We can illustrate these interconnections through a transformation of the systems diagram shown in Figure 5. Consider the departments and individuals necessary to implement decisions made along each of the alternative waste management feedback loops. The top pollution prevention loop shown in Figure 5 requires integration of environmental management with R&D, process management, operations and maintenance divisions. Multi-unit, interdisciplinary teams are necessary. The bottom waste management loop, however, externalizes the waste disposal and requires relatively little internal coordination.
Decision Making for Pollution Prevention
in Mid-Sized Firms

Survey Findings

A summary of survey results is as follows:

*Pollution Prevention Activity.* The results show that nearly every facility is involved in pollution prevention. Ninety-five percent of all facilities report having implemented a pollution prevention project in the last five years. Facilities report that sixty percent of the time, their pollution prevention activities are part of company- or corporate-wide efforts. The remaining forty percent of the time, such activities are "bottom-up" and come from the facility itself. As research continues, it may benefit answering the question of which approach, top-down or bottom-up, produces the most emissions reductions and under what conditions.

Most facilities report having started pollution prevention activities in the late 1980's. On average, projects were initiated in 1989. Facilities reported having started so-called pollution prevention projects as early as 1963 and as recently as 1993. That the average firm started pollution prevention projects in 1989 signifies several things. One is a shift in emphasis from pollution control of the 1970s and 80s to pollution prevention. This represents both a shift in terminology and in thinking and acting. We can also understand that companies do indeed believe that projects they are doing now differ from those they were doing five to seven years ago.
The activities that companies did the most were in the areas of process modifications, good operating practices, and recycling. Least often done were activities in the areas of surface preparation and finishing, and inventory control. The most and the least implemented actions are as follows:

the most implemented actions...

1. Modification of equipment, layout, or piping
2. Substitution of less hazardous materials
3. Segregation of wastes for recycling
4. Instituting better controls on operating conditions
5. In-process recycling
6. Off-site recycling
7. Improved maintenance procedures.

the least implemented actions...

29. Increased purity of raw materials
30. Better labeling procedures
31. Testing of outdated materials and continued use if still adequate
32. Modification of containment procedures for cleaning units
33. Change to roller, powder, or dip coating systems
34. Redesign of parts racks to reduce dragout
35. Change product to eliminate coating.

We asked facilities to rank the most important reasons their company has for implementing pollution prevention initiatives. Of the choices that were given, facilities said that regulatory compliance, worker safety and health, and liability were the three most important reasons. The outcome of the ranking process was as follows:

1. Regulatory Compliance
2. Worker Safety and Health
3. Liability
4. Waste Management Costs
5. Costs for Regulatory Compliance
6. Process Cost Reductions
7. Community Relations
8. Permit Limits
9. Public Image
10. Mandatory Reductions.

The most common means of identifying pollution prevention options are through self-initiated assessments, employee recommendations, and published literature. This tends to reinforce two previous assertions: that pollution prevention is initiated at the facility level and that trained employees are crucial to this effort. Other methods of identification included consultants and non-profit organizations. Less frequently named were trade associations or quality circles.

Impediments to Pollution Prevention. In addition to asking respondents to rank their most important reasons for implementing pollution prevention projects, we also asked them about the most important reasons for not implementing such projects. Companies ranked the importance of impediments as follows:

1. Pollution prevention is not economically feasible: cost savings will not recover capital investment
2. Lack of capital to invest in improvements
3. Technical limitations of the process
4. Concern that product quality may decline as a result of changes
5. Lack of information on options
6. Changes would require modifications of existing permits
7. Changes would require new permits
8. Difficulty in initiating change in the corporation
9. Existing permit rules require investment in end-of-pipe pollution control technologies
10. Technical capabilities of staff to operate new equipment.

At the top of the list are financial concerns, followed closely by technology concerns. As this ranking appears, the toughest task for the states and EPA is to figure out how to
help companies to pay for or financially encourage companies to initiate pollution prevention projects. Companies then may need help to figure out what their options are and in not being discouraged by the re-permitting process.

**Incentives Needed.** In another part of our survey, we asked respondents to say, in their own words, what kinds of incentives they would need to voluntarily reduce releases. Financial considerations appear as the number one priority. The comments themselves address a wide range of financial concerns. Most basic is the need for investments in pollution prevention to have a financial payback. Without a return on investment, many companies seem in favor of tax breaks, fee reductions, low-interest loans, and outright financial assistance. Another important concern for several companies is the need to be assured that competitors will be regulated equally. For those companies not faced with the threat of survival, the cost of research and design as well as technological innovation appear to be barriers.

Surprisingly, the second most common response is that no incentives are needed. Some of these companies state that no incentives are needed because they don't want to be forced into additional reductions. Another group view current programs as being appropriately targeted. Finally there is a group who think no incentives are necessary because the environment or consumer demands provide sufficient incentive.

The comments on the government and regulation are the most strongly worded. Companies overall see a need for a change of direction and tone. Companies say that regulations are poorly worded, making compliance difficult. Further, government administration of the regulations tends to be inflexible, discouraging creative approaches.
to pollution prevention. Companies want the government to be more cooperative, rather than adversarial. Companies want the government to take the lead in several other areas: (1) assure that competitors will be equally regulated, (2) provide some guarantee that regulations will not be imposed after good faith efforts at pollution prevention, and (3) relax regulations on those companies or industries that demonstrate reductions. Companies noted that it would be especially helpful if regulations of recycling efforts were reduced. Finally, the paperwork and re-permitting process need to be refined.

Fourth in the line of requested incentives are science and technology support. Companies expressed a need for the following: (1) training, (2) assistance in finding substitute chemicals, (3) better information on available technology, (4) assistance in complying with current regulations, and (5) improvements to industry-government information exchange. On the other hand, a fair number of companies indicated that they would not initiate pollution prevention unless they could see some scientific proof showing either the dangers their chemicals posed to the public or showing industry specific examples and their paybacks. The first five comments say, "we want to do good if you show us how." The second group of comments say, "we don't think we're doing wrong and won't do anything until you can show us that we are." A final comment aimed at corporate offices were requests that the corporate office do more to make each facility aware of corporate commitments and technical requirements.

Fifth, many companies suggested that public relations would be a good incentive other than money. The logic goes like this: if costs can not be reduced, then some publicity and good-citizen awards might increase revenues by making consumers more
confident about a company's products. The desire for a pat on the back is generally acceptable. In some cases, however, it was apparent that some companies wanted certification of accomplishments as a means to make them immune from future regulations. If the EPA were to say that a company was doing "the best" then it could not be required to do more. Finally, in the interest of both the EPA and companies, some suggestions were made that both work together to promote the success of cooperation.

The last category of incentives requested was time. Companies want time to develop more alternatives. Companies want more time for returns on investments. Other companies just want more time to come up with the money needed for larger changes. Related to regulation, some companies requested a lag period for compliance with new regulations.

The "33/50 Program". While 65% know of the program, only about 33% participate. There are five main reasons companies give for participating. One is that their corporate office volunteered the whole corporation, including the facility surveyed. Second, some companies say they do it for the publicity. Third, companies volunteer because they were requested to participate or advised to participate by the EPA itself or by outside consultants. Fourth, some companies said they do it because its the "right thing to do", its for the environment, or it "just makes good sense". Closely related to this are responses that note that participating matches corporate goals, philosophy, or interests.

Companies give six general reasons for not participating. Slightly over a third of the companies are not familiar with or have never heard of 33/50. Second, companies say that their pollution levels are (already) too low, that they made major reductions recently,
or that their emissions are not among the seventeen 33/50 chemicals. (Note: all companies in the survey are eligible for the program). Third, companies resist additional regulation, government interference in their company and paperwork. They call all of these things "cumbersome". Fourth, technical problems such as a lack of currently available options make them leery of committing to such levels of reductions. Fifth, some respondents are pessimistic about the program. They don't have enough time, lack money, don't see the benefits, and say they have no incentive to join. Finally several companies said that they cannot make reductions because government contracts with other agencies (DOE and DOD) stipulate the chemicals they must use.

Case Studies

Methodology

The cases were drawn from the sample of firms receiving questionnaires in the first phase of this study. The selection was performance based; that is, we wanted to evaluate firms across several states and industrial sectors that had prevented a "significant" amount of pollution in the past four to five years. A "significant" amount of pollution prevention, however, is context specific. For that reason, we compiled a list of approximately 20 candidates with the guidance of state regulatory and technical assistance staff. The helped identify companies that had received public recognition for their pollution prevention activities or that were considered exceptional according to technical assistance evaluation criteria. We contacted the company environmental managers by telephone to discuss the study and, with their support, sent letters of invitation to the plant managers.
In the interviews, we hoped to learn about the corporate culture, values and attitudes, the internal organizational factors, the external factors, and decision making style of a variety of companies that had prevented pollution. Ideally, we wanted to interview as many participants in the decision making process as possible, from the shop floor to the plant manager. We requested interviews with the plant manager, production or operations manager, environmental manager, financial manager, human resources manager, and general workers. We reviewed background information on the case study companies from multiple information sources, including: chemical release data from the Toxic Release Inventory; financial data from published sources such as Dun and Bradstreet, Standard and Poors, and Moodys; and general corporate literature produced by the case companies. We developed a survey with open-ended questions (Please see Appendix B for a list of these specific questions), and we made further refinements by rehearsing the interview process with the team of three interviewers.

In order to establish a consistent method for data collection and compilation, the team of three interviewers conducted the first site visit as a group. The site visit included a plant tour—to familiarize the team with the plant layout and manufacturing processes—and interviews with individuals. We used the same survey instrument for all of the interviews and recorded data in note form and in tape recordings. Immediately following the site visit, the team members met to discuss and clarify the interview responses. Using two-person teams, we conducted the interviews for the remaining three cases over 1-2 day site visits depending on the number of interview participants (which varied from two to six).
One person, who had significant experience in pollution prevention and industrial process assessments, was a member of the interview team for all four cases.

With the exception of the first site visit (which was developed entirely by the group), the interview team members each selected one of the remaining three cases and became responsible for typing up the interview notes based on their own, as well as the other team member's, notes. Once the interview notes were compiled, the team reviewed the notes to verify and further clarify the responses. We developed three-letter codes that correspond to the topic categories of the survey instrument and responses (Please see Appendix C for a listing of these codes and their descriptors). Two members of the interview team discussed the application of each code in the context of the interview notes for one of the cases. For the remaining three cases, the two team members assigned codes to the notes independently and then met to compare the assignments to identify ambiguity in the codes and the need for additional codes. We revised the code list to add two additional codes (for decision making and technological processes) and then reassigned codes to all of the interview notes for all four cases.25

25 The interview comments were imported into a relational database system (Microsoft Access version 2.0 for Windows) designed for tracking and maintaining comments. Each comment has a unique comment identifier (ID) and resides in the Comments database file. The comment ID allows reports to be generated and files to be manipulated without the added length and redundancy of textual comments. The structure of the comment ID includes the initials of the corporation plus the initials of the interview participant plus a counter. This structure allows anyone viewing the file to be able to track pertinent information regarding the comment by simply knowing the initials of the corporation and the interview participant.

The first portion of the identifier is the same character sequence that becomes the interview participant ID. Each interview is a separate record in the Interviews
Findings

With regard to pollution prevention, one major theme emerged across companies and the majority of the interview participants. That theme was Total Quality Management (TQM). In these case studies, with the exception of one corporation who was starting to integrate the first phases of TQM, TQM provided the organizational infrastructure that allowed the firm to integrate environmental quality as an element of quality necessary to maintain the survival of the corporation in the marketplace.

Motivation for Improved Environmental Quality

TQM provides structural and operational concepts for maintaining a high level of product and service quality. Improving the quality of the product, among other improvements, requires that improvement of wastestreams generated during product

database file which maintains administrative information about the interview. The Comment Descriptors database file contains the full description of each descriptor code. This file is also structured to replicate the hierarchy of the codes, if needed, for report generation.

The database allows for flexibility in sorting and information hiding for research considerations. The database is designed to allow nested sorts based on pattern identification needs. For example, you can easily generate a report for comments that received any of the codes falling within the Culture and Politics (CUL) group of codes as sorted first by interview participant title and, second, by code in ascending order. Or, you may also reverse the sort order. Since the database is structured to eliminate all many-to-many data relationships and to divide the information into separate fields, information that should be hidden for improved research design, can easily be hidden. For instance, if you wanted a report that would not provide any information about the company or the person who made the comments, such a report could be easily generated. This information hiding feature allows the design of reports to eliminate biases that may occur while analyzing comments for pattern identification. On the other hand, all information is accessible and available for report generation if desired.
manufacturing. Improving environmental quality surrounding the manufacturing of the end product is perfectly in-line with improving the whole product.

In large corporations, management's daily decisions are not controlled directly by the shareholders and/or holding company. However, the main focus and bottom line is financial profitability. Environmental actions that are the most financially profitable are the ones most likely to receive management approval. When corporations are funding P2 projects, the trend will most always be to focus on the plants and processes that produce the largest amount whereby small changes can yield larger effects. Pollution prevention projects are either cost driven (profit driven) or regulatory (cost avoidance). One company stated that the major motivation for P2 projects is regulation and a proactive approach in anticipation of more regulations. For instance, if certain chemicals are problematic now, the risk of them becoming more problematic is great. The proactive company will start to investigate P2 projects to replace the chemicals altogether from the source.

Improving the quality of the whole product also includes improved employee satisfaction. Employees generally want to work for an environmentally-concerned corporation that also concerns itself with protecting the local community. It was noted that employees respected managers that had environmental concerns, and generally considered that manager to be "a good person." A company's desire to improve environmental quality becomes a moral statement that appeals to the employees. TQM not only enhances the importance of employee satisfaction, but it transcends the employees to include community involvement and good citizenry.
Likewise, improving the quality of the whole product requires a constant awareness of the market as determined by the needs of the customer. The value of the customer is often cited as a top priority for management. Therefore, customer environmental values become corporate values. Companies say that their customers are more concerned with purchasing the best product with the longest service life at the lowest cost than purchasing the cleanest processing techniques used to make the final product; however, these companies note that the two are not conflicting values. At the most basic operational level, it is important that the plant is running and producing timely products without down time due to environmental non-compliance. Additionally, customers are likely responding to their customers as well. Some corporations claim that customers' concerns about product labeling has forced the company to upgrade labels and attention to product. Most companies say their customers are very knowledgeable and informed about contamination and acceptable levels of contamination regarding the product.

Company experiences with spills, releases, or non-compliance issues also increases motivation to improve the environmental quality. The environmental activity usually increases if the corporation has had previous experiences with costly accidental releases or spills that received negative public attention. Previous experiences could include: warnings by a regulatory agency, citations for non-compliance, reportable incidence, neighbor or community complaints, permit excursions, penalties or fines, consent decrees, law suits, civil or criminal action filed by a regulatory agency. One plant manager believes that if a plant manager doesn't have significant experiences with an environmental issue, then the plant manager needs a mandate to be proactive.
Most corporations claim that their emphasis on environmental issues was driven by compliance to environmental regulations. Because the legislative procedure can have unintended consequences, one company has assumed an advocacy role with respect to educating the public and policy-makers on chemicals. The publicized reporting of toxic releases and Superfund listing has also increased incentives to reduce pollution within corporations.

**Ownership and Accountability of Environmental Quality**

TQM ideas of accountability and involvement also affect the corporate approach toward pollution releases. Where quality measures (and performance evaluations) are directly linked to safety and environmental health, managers and supervisors feel more responsible for departmental impacts. Suggestion programs and bright idea programs that provide cash awards also appear to promote awareness of environmental quality and opportunities for pollution prevention.

Ownership and accountability require that a corporation maintain a heightened awareness and knowledge of environmental issues. The main environmental information sources for corporations as cited in the interviews include in-house regulatory staff, journals, seminars, and vendors. Some corporations have legal teams at the corporate office that keep facilities updated on compliance procedures. In the facilities, the environmental engineer or manager is the main resource for environmental information. The presence of the environmental manager in the facility and corporation is therefore important. The current trend in corporations is to co-locate research, environmental and
safety services at the larger plants, with services provided to smaller facilities. For instance, the corporate headquarters would provide air modeling, hydrogeology, and toxicology services for producing environmental information available to its facilities.

Increasingly customer requirements, which may be guided by regulations, are driving pollution prevention. The importance on knowing and understanding environmental rules and regulations are becoming deeply ingrained in leadership. One company provides training to employees regarding environmental regulations and compliance.

Employees consistently recognize the need to measure releases, and are therefore more likely to produce accurate figures. Monitoring requirements for air and water made plant leaders more aware of pollution releases. Pollution measurement acts as an extension of a TQM concept, "what gets measured gets done."

While accountability for environmental quality is distributed differently among corporations, some commonalities emerge. The following represent some common statements concerning titles and responsibilities for environmental quality.

The plant manager is primarily motivated by efficiency and cost reduction. Thus, it becomes the plant manager's main focus to produce clean products because it is more cost-effective and profitable to do so. A plant manager's attitude about environmental protection greatly affects the degree to which other plant managers focus on the issue. One plant manager noted that the biggest changes for any manufacturing officer include: handling wastestreams, balancing economic and environmental requirements, increasing safety and health awareness, and establishing consistency in the handling of products.
To be successful, the environmental manager must have technical expertise, a business approach, and the ability to work with others. He can explain both why and how his ideas work and the risks and costs associated with them. One environmental manager perceives his responsibilities in three buckets: the "gotta do's", the "wanna do's", and the "like-to-do's." Hence, his work is always a balance of integrating different levels of the "wanna do's" and the "like-to-dos" while meeting the requirements of the "gotta do's."

The environmental engineers in the facilities studied are generally well-respected by upper management. Environmental engineers represent the critical balance between environmental compliance and profitability, since it is essentially the task of the environmental engineer to reduce pollution at the lowest cost. All process changes and additions including equipment changes and acquisitions must be approved by the environmental engineer.

The human resource manager is often directly involved with environmental decisions based on his/her responsibilities concerning employee health and safety. At larger plants in the corporation, the environmental and safety compliance functions are performed by a two managers.

In the firms studied, the shop floor workers often have a large responsibility associated with environmental decisions. They are usually the employee most affected by environmental quality and are most familiar with the hands-on production processes. Decisions are impeded when corporate management does not value their expertise. Often, the communication flow stops with the shop floor workers. In the studied companies, managers and supervisors are expected to discuss environmental concerns
directly with the hourly and other staff. This more direct communication facilitates the exchange of ideas more informally. Some plant and environmental engineers stated that the best ideas for process changes originate at the shop floor where problems arise.

The production engineers are evaluated according to performance on six measures: cost control, environmental compliance, production, quality, and safety compliance. Interaction with environmental managers frequently increased awareness of environmental impacts of process changes. However, barriers remain in the integration of production and environmental decisions.

Shared or participatory decision making is a main concept in TQM. Most corporations have established environmental teams. When the teams meet, they identify problems, set priorities, document their minutes and priorities, participate in nominal group techniques. For the meetings, they develop agenda topics and set the time allowable for each topic. The team members give assignments and due dates, choose leaders, and select focus teams for specific projects. The one problem that has been noted in team decision making is reaching closure.

Team players may consist of either inter-facility, intra-facility, or intra-industry engineers and operators from different areas of the plant to brainstorm and act as watchdogs for areas of non-compliance and general improvement. Teams that are composed of non-management employees whose missions are solely pollution reduction oriented are well-respected and trusted among employees; their intentions are more likely to be perceived as less tainted by profit motivations. One company is investigating the
behavioral sciences and behavioral modifications with the concepts of area teams where the whole process chain is represented and performance planning takes place.

Improved communication is a TQM edict for improving the whole product. Communications is imperative to generating employee commitment to corporate values as well as generating corporate values from collective employee values. Everyone is in agreement that communication leads to more accurate information. Environmental audits and corporate reporting provide preventative measures regarding compliance of regulatory issues. The reports are important communication tools for inter-facility information sharing.

Intra-corporate communication methods include satellite video, electron bulletin boards, e-mail, newsletters, and flyers and weekly safety meetings. For some companies, environmental concerns and actions have been posted using all of these methods. However, the question of access is important here. For instance, shop floor workers do not have access to all information streams. When one corporation received the Governor's award for reducing hazardous waste, the workers were not informed.

Site visits from competitors and to competitor facilities are not uncommon for the purpose of sharing cleaner technologies. However, for political reasons many times the visits are made by top management rather than engineers who would most likely benefit more directly by such site visits.

Communicating environmental impact decisions to the public requires careful assessment of the balance between a moral obligation and liability. For instance, a corporation may be less likely to publicize improvements in chemical substitutes, processing and equipment if the methods replaced and the information concerning those
methods may create liabilities for the corporation. One company reports that the requirement of public meetings for obtaining permits has forced an overall improvement with their community relationship and communication. Some companies now require media training and training in community dialogue for certain positions.

Long-term environmental planning

The corporate climate regarding the necessity of long-term planning and profitable sustaining operations is promoted by TQM. The emphasis on long-term planning and TQM has the residual effect of promoting regulation compliance due to the potential high costs of non-compliance. These high costs include not only fines, but also the cost of liabilities. Likewise, regulatory compliance can have a drastic effect on production. The importance of learning to work in a cooperative environment with State and Federal regulatory agencies has become a necessary corporate strategy for reducing the cost of compliance.

While corporations might engage in environmental compliance and other environmental activities, these corporations do not always have a formal environmental policy. In fact, most do not have a comprehensive environmental policy. Perhaps this is an off-shoot of being considered another aspect of TQM; that is, because there is a policy concerning TQM, then the environmental policy becomes "covered" by policies concerning quality. One corporate environmental policy was a simple, specific goal of a zero incident-rate of environmental non-compliance. One corporation had a general responsibility policy
that affects environmental action working towards a transformation from best-effort to no excuses.

Extensions of the Findings and Conclusions:

Implications for Technical Assistance Programs

According to Kuhn (1982), better performing mid-sized firms are flexible, entrepreneurial, and risk-taking in terms of their responsiveness to customer needs and making changes in their products. He concludes that they are more innovative than larger firms and distinctive in that they tightly define their products and markets and become dominant within them.\(^{26}\) They also have more financial and human resources constraints and are more dependent on external sources of information (Staudt et al., 1994).

\(^{26}\) Kuhn defines mid-sized firms as having total assets between $10 million and $500 million (indicating financial strength and capital size); total revenues between $10 million and $500 million (indicating gross sales and market strength); and total number of employees between 100 and 10,000 (indicating complexity of organizational structure and size).
All of these characteristics would provide us with hope concerning the ability of mid-sized firms to effectively integrate pollution prevention efforts into corporate decision making. While this appears to be true for many "better performing" mid-sized firms, as a class mid-sized firms appear to develop less integrated solutions to pollution than do larger corporations. As shown in Figure 6, facility managers and environmental specialists of mid-sized firms primarily plan pollution prevention programs. When compared with larger corporations, these firms show a distinct pattern of between 16 and 28 percent less involvement by process and production specialists, corporate office staff and production line employees, as well as by environmental specialists. At the same time, while relatively few owners directly involve themselves in the planning of pollution prevention projects, mid-sized firms nonetheless have significantly greater involvement of owners than do larger firms. These results are shown in Figure 7.

The description of mid-sized firms emerges from a study of 600 firms conducted by the authors. Firms located in six states and eligible for the U.S. Environmental Protection Agency's 33/50 program were sampled. The researchers sampled all firms with between 2 and 30 facilities and with greater than 100 and less than 1,000 employees per facility. These firms were identified using data from the toxic release inventory. A questionnaire was sent to each of the 1,600 firms that met these criteria. Forty percent responded. Finally, respondents were classified as to mid-sized and large firms using economic data from Standard and Poors.
Mid-sized firms also appear to be more dependent on outside information sources than are larger firms. Mid-sized firms identify options for pollution prevention from a wide array of information sources. When identifying the three most important methods for identifying pollution prevention options, over half of mid-sized firms identify the use of internal quality teams, self-initiated assessments, expressions of concern from state regulatory agencies and published literature (see Figure 8). Yet, when compared to larger firms, mid-sized firms show a clear dependence on externally generated methods for identifying pollution prevention options (published literature, trade associations, free outside assistance, and non-regulatory technical assistance programs) and an under-utilization of internally derived methods of identifying P2 projects (use of quality teams, self-initiated assessments and employee recommendations range between eight and 22 percent lower than for larger corporations). Consultants are also used less extensively by mid-sized firms. See Figure 9.

When compared to larger firms, then, organizational and technological capacity of mid-sized firms is lower. Yet mid-sized firms, on average, appear to reduce almost as
much pollution through pollution prevention programs as do larger firms. In the firms studied, mid-sized firms reduced an average of 4.2 million pounds of waste through these programs, or 92 percent of the average reduced by larger firms. Mid-sized firms, however, are highly variable. It would appear, then, that considerable opportunity for pollution prevention technical assistance exists amongst mid-sized firms.

Transforming Technology Transfer for Pollution Prevention

The implications for TAP interventions are equally important. Policies and programs designed to promote pollution prevention often neglect the relationship between the nature of the action and the capability of the organization to act. Decision making in firms is multi-dimensional, but for pollution prevention at least two dimensions appear to be significant. We suggest that technology transfer programs for pollution prevention need components that address the systemic nature of both the technological problem and the decision making structure, as illustrated in Figure 5.

Figure 9

Methods to Identify Pollution Prevention Options
Use by Mid-Sized Corporations as a Percent of Use by Large Corporations

- Published Literature
- Trade Associations
- Free Outside Assistance
- Non-Regulatory Technical Assistance Programs
- State Regulatory Agencies
- Consultants
- Quality Teams
- Self-Initiated Assessments
- Employee Recommendations

-30% -20% -10% 0% 10% 20% 30%
Options to reduce pollution that focus on root causes are more systemic in that they require concurrent adjustments in the design, production and waste management components of the production cycle (upper loop of the cycle, as shown in Figure 5). On the other hand, options focusing on waste management are less systemic, with impacts externalized outside the production system (lower loop of the cycle). As the options become more systemic, the corporate culture and its communication and decision making style must adjust accordingly.

For example, a company with a dictatorial or rigid hierarchical management structure can probably solve compliance issues (the environmental manager does it) and may be able to effect some minor changes in operating practices (dependent on the environmental manager's ability to convince the others of the importance of such changes), but is unlikely (on its own) to make significant modifications in its products and processes for environmental reasons alone. This company may be able to reach farther up into pollution prevention with the intervention of an external organization such as a TAP, vendor, or regulatory agency. As companies become more participatory in style, communication across departments is easier and more frequent, and problems can be framed more systemically.

Let us return to the hypothetical TAP case study discussed the beginning of this paper. What role does the TAP play in the decision making processes in the companies it serves? The focus of the report provided to the company manager is on a range of options from manage-and-treat to product redesign (the upper loop of Figure 5). The process by which the TAP professional canvasses for possible options (both in the
literature and on the shop floor) and communicates those options to the top management becomes either a surrogate for, or a part of, multi-departmental, participatory decision making in the plant (the horizontal axis). Technical assistance "junkies" may be companies whose decision making structures are not conducive to systemic problem solving. In terms of measuring effectiveness, the TAP may be effective at solving a particular problem, but ineffective at changing a company so that it may solve its own problems.

The findings of our study of mid-sized firms have several important implications for TAPs. First, mid-sized firms represent considerable opportunity for traditional TAPs. At the same time, these firms -- characterized by a combination of complex organizational structures, limited organizational and technological capacity, and potentially significant environmental impacts -- pose considerable challenge to traditional modes of technical assistance.

Second, a stronger relationship between the environmental TAPs and the industrial management TAPs may be in order.28 In order to improve the quality of technology transfer for pollution prevention, the TAPs may want to reorganize so that they can provide technologies (defined broadly) that: improve the organizational capability of the company to address problems systemically; and systemically reduce the environmental impact of their manufacturing practices. The technical assistance process could proceed as before, with the environmental TAP intervening in the decision making process to solve a particular problem, and a concurrent evaluation of the decision making capability of the firm to

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28 See comment supra note 4. Fortunately, our TAP is one of many programs which offer assistance to industry (and we happen to reside in the same building).
identify the need for possible interventions from the industrial management TAP. In the long term, the TAPs could become more interdisciplinary.

Third, TAPs will need an assessment methodology or diagnostic test (for example, benchmarking) to evaluate both the technological and organizational conditions in a company. The pollution prevention TAPs already have techniques for assessing the technological nature of the problems at the plant. One interesting possibility is the use of benchmarking. The TAP could facilitate benchmarking studies in an industry sector and use the information (and the political strength of the "buy in" associated with such an approach) to evaluate their organizational and technological needs.29

In the end, new measures -- for organizational as well as technological progress in the firm -- will be needed to evaluate the effectiveness of technical assistance programs as instruments for promoting pollution prevention.

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29 The Business Roundtable (1993) conducted an interesting benchmarking study of its pollution prevention practices. Dillon and Creighton (1993) found that in small businesses, certain types of changes were more likely to occur in one industrial sector than another. For example, process changes are more common in the chemical industry than the metals industry. These differences reflect important differences in technology and economics between industries. At the same time, they also reflect organizational responses to external and internal threats to the firms in these industries, and the efforts of the industries to coordinate responses to these threats.
References


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Foecke, Terry (1994) "Pollution Prevention Program Implementation: A Statement of Understanding", presentation notes from the *National Roundtable of State Pollution Prevention Programs Spring Meeting*, Seattle, WA.


Appendix A

Survey Questions
Pollution Prevention in the South: Learning from Your Experience

A 1992-93 region-wide effort to learn from industry's efforts to reduce pollution.
What has been attempted?
Why these particular initiatives?
What are the opportunities for and impediments to pollution prevention?

Please answer all the questions in the space provided.

"Pollution Prevention in the South" is sponsored by the U.S. Environmental Protection Agency.

Return this questionnaire to:
Pollution Prevention Project
Georgia Tech Research Institute
Environmental Science and Technology Lab
Georgia Institute of Technology
Atlanta GA 30332-0800
1. Has your company implemented pollution prevention, waste reduction, or waste minimization projects in the past 5 years?
   - Yes
   - No

2. Were the projects implemented:
   - At this facility only
   - As part of a company-wide or corporate program

3. Does your company plan to implement new pollution prevention, waste reduction, or waste minimization projects in the next 3 years?
   - Yes
   - No

If your company has not implemented pollution prevention initiatives and does not intend to do so in the future, please answer questions #5, 7b, 8, 9, 10, 12, and 13.

4. Who helps plan and initiate pollution prevention projects for this facility? (Check all that apply)

<table>
<thead>
<tr>
<th>Position</th>
<th>Location of Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At this Facility</td>
</tr>
<tr>
<td>Owner</td>
<td>0</td>
</tr>
<tr>
<td>Plant Manager</td>
<td>0</td>
</tr>
<tr>
<td>Environmental Specialist</td>
<td>0</td>
</tr>
<tr>
<td>Process/Production Specialist</td>
<td>0</td>
</tr>
<tr>
<td>Occupational Safety/Health</td>
<td>0</td>
</tr>
<tr>
<td>Corporate Office Staff</td>
<td>0</td>
</tr>
<tr>
<td>Production Line Employees</td>
<td>0</td>
</tr>
<tr>
<td>Marketing/Public Relations</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
</tr>
</tbody>
</table>

5. What is your position/title at this facility? (Use categories from Question #4)

6. Indicate the 3 most important methods used by your facility to identify pollution prevention options:

   In-House Activities
   - Published literature
   - Recommendations from employees
   - Reward programs
   - Self-initiated Assessments

   Trade Associations/Teaming Arrangements
   - Chemical Manufacturers Association
   - American Petroleum Institute
   - National Paint and Coatings Association
   - National Electrical Manufacturers Association
   - Other/Association:

   Quality Circles or Teams (select one)
   - Corporate staff only
   - Facility staff only
   - Teams composed of corporate and facility staff

   Other Outside Assistance
   - Non-profit, government funded assistance programs
   - Vendors
   - Consultants

   Other: ________________________________
Describe the role of corporate headquarters in:

a) Establishing pollution prevention goals, priorities, and projects:

b) Environmental management and compliance at this facility:

c) Approving expenditures and funding for pollution prevention projects:

9. Are you familiar with the U.S. Environmental Protection Agency's "33/50" Program?
   □ Yes
   □ No

   a) How did you find out about it?

   b) Does your company participate in the "33/50" Program?
      □ Yes
      □ No

   c) Why or why not?

8. Have you been encouraged to implement pollution prevention projects through:
   □ Interaction with state regulatory staff (compliance, etc.)
   □ Non-regulatory technical assistance programs

   Was the interaction with either the state regulatory staff or technical assistance program related to:
   □ Permit applications or renewals (explain):
   □ Issues associated with regulatory compliance (explain):

   d) What changes would you make to increase the effectiveness of the "33/50" Program?
10. For all of the chemicals that you reported on the Toxic Release Inventory, approximately how much was used in your facility in 1991? (Select a range)

Organic Solvents

- 10,000 lbs - 24,999 lbs
- 25,000 lbs - 49,999 lbs
- 50,000 lbs - 99,999 lbs
- 100,000 lbs - 249,999 lbs
- 250,000 lbs - 499,999 lbs
- 500,000 lbs - 999,999 lbs
- > 1,000,000 lbs

Inorganic Substances (Include Metals and Metal Compounds)

- 10,000 lbs - 24,999 lbs
- 25,000 lbs - 49,999 lbs
- 50,000 lbs - 99,999 lbs
- 100,000 lbs - 249,999 lbs
- 250,000 lbs - 499,999 lbs
- 500,000 lbs - 999,999 lbs
- > 1,000,000 lbs

11. List any pollution prevention initiatives currently being implemented at this facility and briefly describe them:

12. a. Is your company:

- Privately owned
- Publicly owned
- Employee owned

b. How many employees at this site? _____

c. How many employees in the corporation?

- <100
- 100 - 249
- 250 - 499
- 500 - 999
- 1,000 - 2,499
- > 2,500

d. What is your major product(s) or service(s)?

13. What types of incentives do companies like yours need to voluntarily reduce releases of chemicals to air, water, or as hazardous wastes?
14. On these 2 pages, describe the 3 most effective pollution prevention actions previously initiated by this facility:

<table>
<thead>
<tr>
<th>Most Effective Action</th>
<th>Next Most Effective Action</th>
<th>Third Most Effective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Describe the changes made.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Using the codes on page 11, indicate all actions taken.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>What problem/process did this address?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>What reduction is attributable to this action?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% lbs/yr</td>
<td>% lbs/yr</td>
<td>% lbs/yr</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>Year implemented:</td>
<td>Year implemented:</td>
</tr>
<tr>
<td>Cost: $</td>
<td>Cost: $</td>
<td>Cost: $</td>
</tr>
<tr>
<td><strong>What substances/wastes were reduced?</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Where will the reductions occur?</strong> (Air, water, hazardous waste, and/or solid waste)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
15. Rank order (by placing 1, 2, 3, etc.) the most important reasons your company has for implementing pollution-prevention initiatives:

<table>
<thead>
<tr>
<th>Community Relations</th>
<th>Costs for Regulatory Compliance</th>
<th>Liability</th>
<th>Mandatory Reductions</th>
<th>Permit Limits</th>
<th>Process Cost Reductions</th>
<th>Public Image</th>
<th>Quality Control</th>
<th>Regulatory Compliance</th>
<th>Waste Management Costs</th>
<th>Worker Safety and Health</th>
<th>Other:</th>
</tr>
</thead>
</table>

16. Rank order (by placing 1, 2, 3, etc.) the most important impediments to implementing pollution prevention initiatives:

| Changes would require modifications of existing permits | Changes would require new permits | Concern that product quality may decline as a result of changes | Difficulty in initiating change in the corporation | Existing permit rules require investment in end-of-pipe pollution control technologies | Labor issues | Lack of capital to invest in improvements | Lack of information on options | Pollution prevention is not economically feasible: cost savings will not recover capital investment | Technical capabilities of staff to operate new equipment | Technical limitations of the processes | Other: |

Please describe in more detail the most significant impediments listed above:

---

### Code list for Question #14

**Actions Taken to Implement Pollution Prevention**

<table>
<thead>
<tr>
<th>Code</th>
<th>Good Operating Practices</th>
<th>Code</th>
<th>Cleaning and Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>Management/personnel changes</td>
<td>CD1</td>
<td>Changed to mechanical stripping/cleaning devices</td>
</tr>
<tr>
<td>G2</td>
<td>Segregation of wastes for recycling</td>
<td>CD2</td>
<td>Changed to aqueous cleaners</td>
</tr>
<tr>
<td>G3</td>
<td>Improved maintenance procedures</td>
<td>CD3</td>
<td>Reduced the number of solvents used to increase recycling</td>
</tr>
<tr>
<td>G4</td>
<td>Production scheduling/reduce changeovers</td>
<td>CD4</td>
<td>Modified containment procedures for cleaning units</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CD5</td>
<td>Improved draining procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CD6</td>
<td>Redesigned parts racks to reduce dragout</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CD7</td>
<td>Modified or installed rinse systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CD8</td>
<td>Improved rinse drying/operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CD9</td>
<td>Changed product/process to eliminate cleaning step</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**Spill and Leak Prevention**

<table>
<thead>
<tr>
<th>Code</th>
<th>Good Operating Practices</th>
<th>Code</th>
<th>Cleaning and Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Improved storage procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>Improved transfer/loading operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td>Installed overflow alarms/shutoff valves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td>Installed secondary containment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S5</td>
<td>Installed vapor recovery systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S6</td>
<td>Inspection/monitoring program</td>
<td></td>
<td></td>
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</tbody>
</table>

**Raw Material Modifications**

<table>
<thead>
<tr>
<th>Code</th>
<th>Good Operating Practices</th>
<th>Code</th>
<th>Cleaning and Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Increased purity</td>
<td>X</td>
<td>In-process recycling</td>
</tr>
<tr>
<td>R2</td>
<td>Substituted less or non-hazardous materials</td>
<td>Y</td>
<td>On-site, outside of process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Z</td>
<td>Off-site</td>
</tr>
</tbody>
</table>

**Process Modifications**

<table>
<thead>
<tr>
<th>Code</th>
<th>Good Operating Practices</th>
<th>Code</th>
<th>Cleaning and Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Modified equipment, layout, or piping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>Instituted better controls on operating conditions (flow rate, temp, pressure, residence time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>Changed to bulk containers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

Case Study Interview Questions

The following sets of interview questions represents the set of possible questions that are dependent on the interview participant’s time allotment and consideration of proprietary information.

I. Background
   A. Corporate and facility history
      1. When was the company formed?
      2. Has the company incurred changes in ownership or management?
      3. Are published reports available?
   B. Products
      1. Is product literature with product descriptions available?
      2. Has product changes occurred recently? If so, why? and what was the impact?
   C. Customers
      1. Can you characterize a customer profile?
      2. Can you define the needs of your customer?
      3. Are your customers environmentally sensitive?
   D. Processes
      1. Are flow diagrams from raw materials receiving to final product shipping available?
      2. Has equipment or raw materials changes occurred recently? If so, why? and what was the impact?
   E. Commitments
      1. What are the top 3-4 values that underlie decisions made by management (customers, workers, community, industry, environment)?
      2. Has commitments changes occurred recently? If so, why?
   F. Community relations
      1. What types of environmental impacts are important to the company?
      2. Any problems such as controversial permits, accidental release, cleanups, law suits, picketing or community protests?
      3. What is the interaction between your company and external groups?
II. Decision Making Processes

A. How are decisions made in the corporation?
   1. Can you provide an org. chart for the facility / corporation?
   2. Describe decisions that can be made by:
      - you
      - the facility
      - the corporation

B. How are decisions made at the facility?
   1. Describe roles, responsibilities, and credentials for key positions.
   2. Are environmental issues integrated into production and product design decisions, purchasing, packaging, marketing?
   3. What is the decision-making influence from corporate HQ? Parent company? Other facilities?
   4. What is the decision-making influence from other external forces: economics, state agencies, and other programs?

C. What are the identifiable informal decision-making tendencies?
   1. Whose contribution/support is important which is not necessarily represented on the corporate diagram?
   2. How do those people exercise their influence?

III. Decisions: Culture and Politics

A. Leaders
   1. What are the common characteristics and values of the managers?
   2. What professional organizations, environmental groups, and/or community service activities are the managers associated with?
   3. What are the differences in perspective between the environmental manager and other managers?

B. Changes in and among leadership
   1. Have there been the substantial changes at this facility? corporate HQ?
   2. Are there notable differences in values / attitudes from site to site?

C. Planning
   1. What is the facility / corporate mission strategic plan?
   2. How are the goals for the corporation developed?
   3. What are the priorities for resource allocation and problem solving? How are these priorities set?
IV. Pollution Prevention: Initiation, Innovation, and Change

Note: P2 includes: source reduction, in-process recycling, out-of-process recycling, energy recovery on-site, energy recovery off-site, treatment, and disposal.

A. History of P2 activities
1. What was the impetus for the first P2 effort?
2. Did it have an impact on subsequent efforts?
3. Who led it and how?
4. What were the results?

B. Incentives
1. What are some of the external incentives for engaging in P2?
   External incentives include:
   - regulations
   - liability
   - events impacting or changes in other companies in your industry or region
   - community relations
   - direct incidents such as, spills, disasters, releases
   - changes in customer demands

2. What are some of the internal incentives for engaging in P2?
   Internal incentives include:
   - management/ownership changes
   - changes in mission, strategic direction, or market
   - quality programs, community care programs
   - reorganization
   - participation in professional, environmental, or service organizations

C. Ideas
1. From where or whom do ideas originate?
2. What is the relationship between ideas and the following players:
   - production/process management
   - finance and budgeting
   - product development/R&D
   - maintenance
   - external relations

D. Information Dissemination
1. How is information disseminated?
2. Whose responsibility is it?
3. Who provides expert advice on environmental / P2 issues inside the company? outside the company?

E. Champions
1. Who championed P2?
2. What was the basis for their success?
   e.g. position, power, moral authority, vision, force of personality, technical expertise, and negotiation skills
3. Where there any failures?

F. P2 and conflicts with other company values?
1. What, if any, opposition surfaced?
2. When and by whom did it surface?
3. How were the issues reconciled?

G. Planning and pollution prevention
1. What are the planning horizons?
2. What are the goals?
3. What percentage of the operation budget is dedicated to environmental management? to P2?

V. Pollution Prevention: Implementation

A. Barriers that make P2 implementation difficult?
1. Factors internal to the company?
2. Factors external to the company?

B. Implementation
1. What motivates people to implement it?
2. Are there differences across organizational boundaries?
3. How do you measure and monitor progress?
4. Does the corporation have environmental audits? at the facility level?
Appendix C
Comment Descriptor Codes

I. ACT (Actions)
   A. OUT (Outcomes and Implementation)
   B. DEV (Development and Planning)
   C. INI (Initiation)
   D. PRC (Processes)
      1. TEC (Technology)
      2. DEC (Decision Making)

II. CUL (Culture and Politics)
    A. COM (Communication)
    B. LEA (Leadership)
    C. INC (Incentives)
    D. ORG (Organizational Structure)
    E. ATT (Attitudes)

III. IMP (Impacts)
    A. EXT (External)
       1. INF (Information)
       2. PUB (Public)
       3. ECO (Economics)
       4. IND (Industry)
       5. CUS (Customers)
       6. REG (Regulation)
    B. COR (Corporation)
       1. HQ (Head Quarters)
          a. VIC (Vice-President)
          b. PRE (President)
       2. FAC (Facility)
          a. PRO (Production manager or super)
          b. FCM (Facilities Manager)
          c. ENV (Environmental Manager)
          d. HUM (Human Resources Manager)
          e. WOR (Shop Floor Workers)
          f. OPE (Operations Manager)
          g. GEN (General Manager)
          h. INV (Inventory Manager)
          i. ACC (Accounting)
          j. MAN (Manager in General)