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Business Motivations for Implementing Sustainability-Focused Projects: P3 Program - Lessons Learned

Ayna Kekilova
University of Nebraska-Lincoln, akekilova@mail.ru

BUSINESS MOTIVATIONS FOR IMPLEMENTING SUSTAINABILITY-FOCUSED PROJECTS: P3 PROGRAM – LESSONS LEARNED

by

Ayna Kekilova

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BUSINESS MOTIVATIONS FOR IMPLEMENTING SUSTAINABILITY-FOCUSED PROJECTS: P3 PROGRAM - LESSONS LEARNED

Ayna Kekilova, M.S.

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Adviser: Bruce I. Dvorak

The Partners in Pollution Prevention (P3) Program is an outreach assistance program, in which student interns provide clients with a business assessment reports and suggestions for waste minimization and resource conservation.

The goal of this study is to examine the motivations of business managers toward the implementation of P2 suggestions. This can influence education of the students and providers of the pollution prevention technical assistance. Methods used in this study included analysis of the reassessments and survey results. A group of 60 clients representing various sectors and reassessed in 2005-2011 was contacted, 43% returned the survey.

It was found that:

- A statistically significant relationship between a client's decision-makers for P2/Sustainability project and financial expectations was observed. When "other" than top and environmental managers were included in the decision making process, 80% of the respondents considered additional factors for P2/sustainability projects.
- Overall clients are focused and engaged in tangible and measurable benefits (e.g.,

cost saving, waste and toxins reduction, energy efficiency). GHG reductions currently are not highly valued even though they are realized from energy efficiency and waste reduction projects.

- The financial and risk-based factors are the most important for clients. Respondents from the manufacturing sector were more likely to give both risk-based and financial justifications, whereas the public institutions and "other" businesses were more likely to use social factors to justify P2/sustainability implementation.
- Preventative maintenance recommendations had the highest implementation rate (61%) and a high reoccurrence of benefits (77%); representing "low-hanging fruit" that often can be identified by student interns at the assessment of business operations. Preventative maintenance suggestions often can be easily implemented with limited cost; has safety, regulatory compliance and cost benefits.
- Off-site recycling suggestions had a relatively low reoccurrence rate (45%). This may be because most of the large quantity and common waste streams are already being recycled, thus recommendations are for smaller volume and harder to recycle materials. Only public institutions implemented off-site recycling longer than one year.

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CHAPTER 1 INTRODUCTION

1.1. Background

According to the Brundtland Report, "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (US EPA, 2013a). A sustainable future is important to the global economy, and pollution prevention is a measure that can help achieve sustainability. Pollution prevention (P2) is an environmental policy and a useful tool to reduce pollution generation (US EPA, 2012a).

To implement and promote pollution prevention and encourage sustainable business practices in Nebraska, the Partners in Pollution Prevention (P3) Program has operated at the University of Nebraska-Lincoln (UNL) since 1997. The program is funded by the USEPA Region 7, NDEQ, and business partners. P3 is an outreach assistance program, in which student interns provide P2 assistance to companies by performing waste assessments, waste reduction and resource conservation projects. As a result, each client receives a business assessment report with suggestions for waste minimization and resource conservation. Among the clients of the program are various enterprises including hospitals, hotels, large pharmaceutical and manufacturing plants, agriculture producers, dry cleaners and auto body shops.

The P3 program assisted a total of 621 clients from 1997 to 2012 in 80 different Nebraska communities. The estimated cost benefits achieved were $19.5 million dollars due to the waste reduction and resource conservation and more than 212 million pounds of solid wastes diverted from landfills. Follow-up reassessments with 143 past clients

showed that 42% of all recommendations made by the students were actually implemented. Each summer interns offer clients an original management report with P2 recommendations and potential expected benefits (Youngblood, 2008b). Besides its outreach component, the P3 Program is an important educational instrument and more than 200 interns have participated in the program since 1997 (UNL, P3, 2012).

Various methods of assessing the impact of this work have been developed; one is a reassessment of the clients one to three years later. Typically, P3 staff contacts past clients and those who agree to the follow up reassessment are revisited by interns. This study is based on analysis of 83 reassessment reports performed in 2005-2011 for 63 past clients and analysis of a survey results, conducted in 2012 for 60 of the same clients.

It was assumed that understanding of the driving forces to adopt and implement pollution prevention and sustainability practices by the business companies will help to improve training of students and technical assistance providers. This assumption led to a few hypotheses that were examined in this study.

Literature review of existing studies and theories shows that regulatory compliance, public image (Williams et al., 1993), behavioral changes (Diamond, 2013), and economic incentives (Sharfman et al., 2000) are important motivations for P2 and sustainability implementations. However, few studies and surveys researched the client type, and many papers are theoretical and do not provide survey data as a basis for their theories. Furthermore, no information in the available technical literature was found on the recurring benefits of implemented P2/sustainability suggestions.

1.2. Purpose for the Study

Understanding the motivations of business managers for implementation the P2 suggestions that enhance sustainability is highly important. Study of the types of the implemented suggestions and motivating factors for their implementation can improve design of the service-learning projects directed to help clients by training students and P2 technical assistance providers, and offering the best types of sustainability suggestions. The general goal of this study was to learn more about client motivations which led to the following hypotheses to examine:

- Decision makers for P2/sustainability implementation are important.
- Sector and size (number of employees on site) of the client affect P2/sustainability implementation.
- Not only financial benefits, but risk-based factors in addressing P2 implementation are important.
- Engagement in different types of P2/sustainability activities for P3 survey respondents will differ from results of national studies.
- Reoccurrence of benefits from implementation of P2/sustainability suggestions is longer for those with larger initial cost.

1.3.Objectives

Frameworks of this research used the seven-year reassessment dataset from 2005 to 2011. The scope of work included:

1. Analysis of the reassessment results based on metric data provided in the original and reassessment reports.

2. A survey of recently reassessed P3 clients to identify benefits and driving forces for implementation of P2 suggestions.
3. Identifying the key points helpful to educate students and P2 technical assistance providers for development of future technical assistance modes, based on the results of the survey and reassessments data.

Objectives of this study are to answer the following key questions by analyzing survey results:

- Who are the decision makers at various types of clients in terms of P2 and sustainability projects?
- What are the client motivations for P2implementation, both general and for specific suggestions?
- What extent and kind of sustainability and P2 activities are the clients engaged in?
- What is the reoccurrence and how long the different types of P2 suggestions provide a benefit?

1.4. Thesis Overview

This thesis includes six chapters and nine appendices. Chapter 1 provides background information for the research. Chapter 2 is a review of technical literature related to the research topic, including the policy overview. Chapter 3 describes methods used for reassessment of the companies and analysis of the available metric data, as well as survey methods. Chapter 4 presents the results from the reassessment and survey analyses. Chapter 5 presents the conclusions of the research and provides

recommendations for the future research. Chapter 6 includes list of references used throughout the thesis.

Appendices include supporting documents and tables that are not included in the discussion but would be useful as a source of additional information for those, who will use this research for future work or study.

CHAPTER 2 LITERATURE REVIEW

2.1. Introduction

Basic principles and concepts of sustainability are: balance of a growing economy, protection for the environment, and social responsibility. Together they lead to an improved quality of life for both ourselves and future generations (USEPA, 2013a). The three pillars of sustainability, indicated on the United Nations 2005 World Summit are: economic sustainability, social sustainability, and environmental sustainability. These three interdependent pillars also have been referred to as *the triple bottom line* and *people, profit, and planet*, among other terms (ASME, 2011). Each of these pillars has related topics, such as: green engineering and chemistry, air and water quality and resource integrity for environmental pillar; human health, resource security, environmental justice and education for social pillar; and jobs, incentives, supply and demand, cost and prices for economic pillar (USEPA, 2013b).

In 1990 the Congress of the United States adopted the Pollution Prevention Act and declared that prevention or reduction of pollution at the source of its generation whenever possible should be the national policy. If pollution cannot be prevented or recycled it should be treated in an environmentally safe manner whenever feasible. Disposal or other release, such as emission into atmosphere or discharge into surface or ground water, should be used only if other ways of treatment are impossible and should be conducted in an environmentally safe manner (Pollution Prevention Act, 1990).

The Pollution Prevention Act emphasized decreasing the amount of waste through the "three Rs" – reduce, reuse and recycle. Starting in 1991, the EPA coordinated federal

agencies' efforts to use recycled or recyclable products in their activity. For example, the federal government should buy the paper containing at least 30% recycled materials. Recycling level in the US also should be increased. EPA believed that 40% and more of municipal solid waste could be recycled. At the same time, densely populated Japan recycled 90% of solid waste (Daniels et al., 2003).

According to the Pollution Prevention Act, the United States produces millions of tons of pollution every year and spends billions of dollars per year to control this pollution. It also was found that significant suggestions for industry are possible to reduce or prevent pollution at its source. Cost-effective changes in production, operation, and raw materials use are the tools to achieve pollution reduction and prevention.

These changes could allow industry to achieve substantial savings due to the cost reduction for resources used, pollution control, and liability costs. They also can help protect the environment and reduce risks to the health and safety of workers. Regulations existing before the Pollution Prevention Act as well as all the industrial requirements were mainly focused on treatment and disposal, rather than source reduction. Thus, the suggestions for source reduction were not realized.

As a first step in preventing pollution through source reduction, the Environmental Protection Agency established a program to collect and disseminate information, provide financial assistance to states, and implement other activities related to the subject.

2.2 Terms and Definitions

Some terms were defined in the Pollution Prevention Act for better understanding by industry and all relevant agencies, to help in the adoption of source reduction practices. For this research the following basic definitions by US EPA are used:

Pollution Prevention is reducing or eliminating waste at the source by modifying production processes, promoting the use of non-toxic or less-toxic substances, implementing energy efficiency and resource conservation, and re-using materials rather than putting them into the waste stream.

Source Reduction is any practice to (i) reduce the amount of any hazardous waste or release into the environment; and (ii) reduce the hazards to public health and the environment associated with the release of such substances.

Multi-media. The "media" affected are land, water and air. Multi-media pollution prevention means that pollution is prevented in all media; it does not just move from one to another.

In-process recycling or "closed loop" recycling is one of the pollution prevention mechanisms when by-products generated during the industrial process are put back into the same process (US EPA, 1992).

2.3 Policy Overview

Besides the Pollution Prevention Act which mandated the EPA to develop and implement a strategy to promote source reduction and establish a database containing information on source reduction, the pollution prevention policy is mandated in federal statutes and acts, such as: Clean Air Act, Emergency Planning and Community Right to

Know Act, Resource Conservation and Recovery Act, Clean Water Act, Federal Insecticide, Fungicide and Rodenticide Act, and National Environmental Policy Act. A series of Executive Orders is related to waste prevention, recycling, and pollution prevention as key aspects to the environmental management system process include: the Executive Order "Strengthening Federal Environmental, Energy, and Transportation Management" (2007) and the Executive Order "Federal Leadership in Environmental, Energy, and Economic Performance" (2009).

A number of Partnership Programs and other EPA initiatives utilize pollution prevention approaches in their work. Since pollution prevention is a key policy in national environmental protection activities, the EPA has developed a 2010-2014 Pollution Prevention Program Strategic Plan which is focused on the work and results achieved by the Pollution Prevention Program. The P2 Program's strategy for 2010-2014 is to identify and promote pollution prevention suggestions for reduction of greenhouse gas emissions and use of hazardous materials and natural resources, while contributing to a greener and more sustainable economy. The P2 Program is a part of Goal 5 of the EPA's Strategic Plan which relates to compliance and environmental stewardship. The following are the goals of the P2 Program's Strategic Plan: reduce the generation of greenhouse gas (GHG) emissions; reduce the manufacture and use of hazardous materials; reduce the use of water and other natural resources; business efficiencies, and integration of pollution prevention practices through government services, policies, and initiatives (US EPA, 2010a).

At the state level, the Nebraska Department of Environmental Quality (NDEQ) is committed to assist Nebraskans in attaining and maintaining the quality of the air, land,

and water through the Pollution Prevention Plan, which provides elements and solutions for avoiding, elimination, or reduction of contamination of the air, land, and water. The goal set by NDEQ is to prevent pollution generation by eliminating or reducing pollution at the source.

2.4 UNL P3 Program

The UNL Partners in Pollution Prevention (P3) Program was designed to encourage implementation and promotion of pollution prevention and sustainable business practices in Nebraska. P3 is an outreach assistance program, in which student interns provide P2 assistance to the companies by performing waste assessments, and waste reduction and resource conservation projects since 1997 (UNL, P3, 2012).

After five years the impact of P3 technical assistance was evaluated by using a close-ended survey. A total of 145 clients responded, which is 65% of all contacted. Besides the survey, reassessment interviews were conducted by student-interns with 75 clients between 2001 and 2004 (Dvorak et al., 2007). It was found that it is important for providers of environmental technical assistance to document the impact of their program by both quantitative and qualitative evaluation.

Quantifying and comparing the P3 program's benefits (Youngblood et al., 2008b) based on reassessment interviews allowed the following conclusions to be made: in-depth complex technical assistance projects resulted in highest implementation rate and largest monetary savings, whereas simple projects and short-term assistance for clients with little knowledge of P2 resulted in the lowest savings and lowest waste reductions. It was also found that when implementation cost is more than $1000, other factors were often more

important to the client when considering P2 implementation.

To estimate difficult-to-quantify indirect benefits of the P3 program, 20 business clients were studied (Youngblood et al., 2008a). The results of this study illustrated that indirect savings, such as time and labor savings, reduced operating cost and cost of future liability quantified using fuzzy set theory, may have substantial additional financial savings.

Another survey of P3 program was conducted in 2010 to determine and evaluate long-term impacts of the program on workplace behavior of former P3 interns (Dvorak et al., 2011). Student interns who had completed an intensive sustainability course, were compared with a control group of students who studied sustainability concepts only in the classroom. It was found that theoretical and implementation components of the P3 program have enhanced student's capacity to address industry challenges. These results are consistent with the hypothesis that an intensive, multicomponent course may impact students and result in long-term changes in workplace behavior.

2.5 Measuring the Pollution Prevention

Pollution prevention approaches can be applied to all pollution-generating activity, including energy, agriculture, and industrial sectors as well as federal and consumer activities. Pollution prevention practices may be essential for preserving wetlands, groundwater sources, and other critical resources. These practices may include conservation techniques and changes in management practices to prevent potential harmful effects on sensitive ecosystems. It is imperative that pollution prevention does not include practices that might create new risks.

According to the 2005-2011 P3 reassessment reports, past P3 projects included waste assessment and waste reduction (recycling, waste exchange programs, composting, switch to reusable glassware, biodegradable solvents etc.); water use reduction (replacement of water valves, sprinklers, flushes); energy use reduction (switch to energy efficiency lighting system and energy consuming appliances, insulation of facilities; replacement of old pumps and air compressors); resource conservation, material substitution, risk reduction (spill prevention, trainings on handling of hazardous materials) and others.

Measuring results is an essential component of any successful P2 program. It allows the success of technical assistance provided to be determined. Not all types of P2 recommendations and activities have the same results. Some of the results have their metrics, but others cannot be quantified despite their benefits. For the recommendations that are hard to measure, the information, tools and examples to identify appropriate measures and data collection methods for P2 program activities are provided by the USEPA (EPA, 2013). Using USEPA equations Youngblood et al. (2008a) estimated and quantified four categories of indirect savings: time savings from research conducted by interns, operating cost reductions, labor savings and future liability reductions. It was found that quantifying indirect savings may result in significant monetary savings, and if indirect savings beyond the four studied were included, the ratio of indirect to direct savings would be larger.

The following tools were used to quantify some of the reassessment results:

1. P2 Greenhouse Gas Calculator was used to calculate GHG emission reduced as a result of electricity conservation, green energy, fuel and chemical substitutions,

water conservation, and improved materials and process management in the chemical manufacturing sector. This tool demonstrates the unique multi-media perspective that P2 brings to reduce metric tons of carbon dioxide equivalent (MTCO2e) (US EPA, 2012a).

2. P2 Cost Calculator was used to assess cost savings associated with reduced costs for hazardous inputs in a facility process, reduced costs for handling hazardous waste, reductions in annual air permitting fees that are based on actual emissions, reduced water discharge treatment costs based on gallons discharged, reduced charges for water usage, reduced fuel costs, and reduced costs for electricity. Understanding potential cost savings presents a big incentive for action and collaboration to program beneficiaries (US EPA, 2012b).

Besides the direct financial benefits, like payback periods and cost savings related to energy and water use reduction, there are certain intangible benefits that should be considered by the companies, including:

- Risk reduction (reduced spills, liability etc.)
- Regulatory compliance
- Safety and health benefits (better working conditions, etc.)
- Employee environmental awareness
- Improved brand reputation/Public image
- Customer's demand
- Enhanced stakeholders/investor relations
- Increased employee productivity

- Less environmental impact and resource conservation
- Better efficiency/ Better innovation of business models and processes
- Equipment replacement due to reach of end of useful life.

2.6 Important Findings

2.6.1 Introduction

In this section a review of technical literature concerning the analysis of approaches and motivations to implement sustainable development and pollution prevention measures and increase energy efficiency, as well as their direct and intangible benefits is provided.

One of the important issues, facilitating pollution prevention, is an understanding of motivations that drive the companies to implement the P2 recommendations. It is obvious that short payback periods, low initial costs and high potential cost savings are important for decision making in favor of implementing the opportunity. However, as was mentioned earlier, there are intangible benefits, that also should be taken into consideration.

In frame of this study the survey of the 60 companies, former participants in the P3 program, was conducted. The survey questions were generated so that its results could be compared with those reported in technical literature or other surveys, such as Second Annual Sustainability and Innovation survey of global corporate leaders (MIT Review, 2011), Green Technologies and Practices Survey (USDL, 2012), and Impact Assessment Survey (UNL P3, 2001). The survey questions primarily related to such areas as: decision making, financial expectations, sustainability reporting, motivations and benefits, (both

direct and intangible), reoccurrence, and engagement into the P2 and sustainability activities.

2.6.2 Decision Making

Decision making is a process that is important for implementation of the pollution prevention practices and depends on the personal awareness of the managers responsible for environmental management in the organization. Thus, it is directly related to the person's awareness and the existing corporate or industrial policy.

Many decision tools for evaluation of the economic performance were developed, whereas limited research has been done on evaluating environmental and social impacts of manufacturing processes. To control impacts on the environment, reduce the risk of pollution incidents, ensure environmental regulatory compliance, manufacturers mainly use an Environmental Management System. When making decisions with regard to sustainable manufacturing, factors such as time, quality, resources, and costs have to be considered along with environmental performance (ASME, 2011).

Integration of science with decision-making represents one of the most difficult challenges of environmental management. Arguably, enhancing the credibility, legitimacy, and saliency of information being produced can lead to more effective and proper use of science products and thus, better informed decision making (Liu et al., 2008).

Analysis of the various studies and surveys related to the energy-efficient investments conducted by DeCanio (1993) identified the barriers to profitable

investments into energy saving technologies. These findings might explain the barriers existing in implementation of pollution prevention practices, which include:

- Managerial compensation is tied to recent performance due to rotation policy, what explains why managers prefer the projects with short payback periods.
- Difficulties in monitoring the savings due to lack of historical data for comparison.
- More positive examples and information (particularly about long-term and intangible benefits) increase motivation.
- High costs for expanding the management teams.
- Projects with higher anticipated rates of return will be more likely selected. Some projects will also be selected because their actual returns have been overestimated.

Prakash (2001) identified two types of intra-firm processes that affect the adoption of "beyond-compliance" policies, based on existing literature related to institutional theory, corporate social perspective and stakeholder theory, as well as efficiency-based theories. These processes are power based and leadership based. Beyond-compliance policies specifically intended to exceed the law requirements. Key managers – policy-supporters – champion these policies. Among four policy types identified, Type 2 was characterized by the profitability that cannot be assessed and demonstrated to meet the expected profit criteria. Multiple motivations identified in literature for firms to adopt Type 2 policy were:

- Response to the expectations of and pressures from external institutions. Perhaps, firms in pollution intensive industries or industries with bad reputations are more likely to adopt them.
- Normatively appropriate: "the right thing to do".
- Strategic reasons geared towards potential long-term benefits. Firms could pre-empt and/or shape environmental regulations and reap first-mover advantages.

The survey conducted among 21 SME manufacturing facilities of Toronto Region (Granek et al., 2006) identified motivating factors that affected the company leader's decision to participate in the program. According to the survey results, the top three drivers to participate in a program were: the "mandatory P2 requirements", "50% funding support", and "Environmental Stewardship". No obvious correlations between size and sector of a company and the reason for participation in the Program were found. It was also found that economics in terms of cost savings and return on investment were important, but it was not the primary consideration for implementing P2 projects.

45% of respondents of the survey, conducted by MIT Sloan Management Group in collaboration with Boston Consulting Group said that top management, who determines strategy of organization as a whole, factored sustainability consideration into decision making. In 21% of cases the decision-makers were managers in sustainability-dedicated roles (MIT Report, 2011).

2.6.3 Financial Expectations

It is expected that any investment should result in financial benefit. However, implementation of P2 suggestions not always relates to direct benefits, as was discussed

in Section 2.4, and intangible benefits are as much important and profitable, as direct benefits, though sometimes it is hard to determine the exact amount of return.

Lyon et al. (2002) reviewed the existing literature to draw out the major findings and to summarize the areas of agreement and disagreement among the papers. The literature reviewed mostly related to toxic emissions in the United States. Empirical findings of the extent to which firms undertake voluntary efforts in the environmental area said that it was determined by the willingness and ability of firms (Lyon et al., 2002). Even if direct profitability, such as adoption of a greener and less costly production process, was a consideration, the indirect effects associated with the action eventually determined whether it was profitable. The empirical literature suggests that large firms implement voluntary corporate environmental actions for solid economic reasons. However, the mechanism linking environmental and financial performance is still unclear.

Financial expectations from the sustainability-related investments, according to the respondents of the MIT Survey, were the same as any investments in 21% of all responses. 19% of respondents indicated that intangible factors were considered and influenced decision. And 10% of respondents reported allowable timetable for longer expected returns (MIT Report, 2011).

2.6.4 Motivations and Benefits

Understanding of driving forces to adopt and implement pollution prevention practices by the business companies is a foundation stone for further successful development of P3 Program and maximizing its value. It is obvious that direct benefits

play important role in the decision making; however analysis of the P3 reassessments reports (UNL, 2013) showed that there were other reasons, not related to financial benefits. Thus, it seems important to review existing studies and theories described in literature in different time and places to understand and make comparative analysis of justifications for sustainable and environmentally friendly developments of industrial and other businesses through the years, along with development of environmental awareness and regulatory basis.

The early study of characters of environmental pressures and their potential impacts on business were discussed by Williams et al. (1993). The study based on the results of surveys undertaken by ECOTEC: (i) survey of the expenditures made by 117 firms in the United Kingdom in 1988; and (ii) survey of future development of the 25 firms of the West Midlands of the United Kingdom in 1991. The following pressures were identified: governmental pressure, consumer and supplier pressure, investor pressure, community pressure and workforce pressure (Williams, 1993). These pressures impacted on pollution control, especially effluent control and disposal. Companies had adopted technical responses to comply with environmental standards, reacting to the legislation change. The general motivations for industry to adopt more sustainable strategies had two models: first was the "normative" model, in which best-practice management was conducted together with social responsibilities of companies; and second was the model, built around the environmental standards and market mechanism with the use of economic instruments, such as effluent charges and taxes. Large multinational companies adopted normative model due to their wider exposure to pressures. That also may be explained by corporate cultures of these companies, which

were more likely to respond formally to social or community responsibility issues and to integrate quality management, part of which is environmental control (Williams et al., 1993).

The forces that lead firms to innovate in green, environmentally friendly way were studied and analyzed on example of four case studies (Sharfman et al., 2000). Based on these case studies undertaken as part of a larger US EPA-funded study that described environmentally conscious product and process innovations in high and low regulation environments authors concluded, that:

- Economics incentives have always been the motivators for innovation. The same would hold true for environmental innovations. However, regulation provided not only economic incentives but also institutional pressure; i.e. federal purchase guidelines helped to create market for postconsumer recycle product.
- Participative regulatory relationships were helpful for industry to develop new products.
- Autonomy and flexibility of operations was a major motivating factor in two cases, when firms used innovation to be able to pursue its business operations the way they chose.
- The market began to view environmental factors as increasingly important business factors (market demanded to change the product; market saw the product as an answer to future problems; market perceived the product over competing products) (Sharfman et al., 2000).

Stead and Stead (2000) developed the theoretical model of eco-enterprise strategy, which reflects the moral view of Aldo Leopold's "land ethic" (1949), and represents the idea that the Earth is an ultimate stakeholder in the organization's strategic thinking. A value system based on sustainability can provide a sound ethical basis to develop ecologically sensitive strategic management systems. Sustainable strategic management focused on the formulation and implementation of strategies by using ecological responsibility as a way to cost reduction. Thus, organization must focus its efforts on the entire ecological life cycle, including among others, reducing resource and energy use, pollutions and wastes (Stead and Stead, 2000).

King and Lenox (2002) used statistical methods to examine the importance of relationship between the various means of pollution reduction and profitability. They hypothesized that managers underexploit waste prevention and overexploit waste treatment. There were two hypotheses used by authors that stated:

1) The more a firm prevents waste, the higher its financial performance.
2) The less a firm treats waste onsite, the higher its financial performance.

For the analysis the sample consisting 2,837 firm-year observations for the years 1991-1996, was drawn from publicly traded US manufacturing firms that were listed in the Compustat database and had at least one facility that met the requirements of the USEPA Toxic Release Inventory. As a result of modeling, the evidence that waste prevention is underused and engagement in waste prevention can improve the financial performance of the companies was found.

Survey for 145 clients participating in the UNL P3 Program in 1997-2001 was conducted in 2001 (Dvorak, 2008). The results of the survey found that the most

beneficial aspects of the participating in the program were assistance in waste reduction (81% of Industrial and 61% of Small Business mode clients) and time saved for the waste-related issues (88% of Industrial clients and 63% of Small Business clients). Direct cost savings were more important for business clients, and improved working conditions for small business clients. To the question on clients change in "awareness of P2 as another consideration when making business decisions" as a result of the assistance, more Industrial Placement and Small Business client respondents acknowledged increased awareness of P2 when making business decisions than Industrial Assessment clients. Of clients who stated an increase in awareness, most (95%) stated that the assistance increased their existing knowledge of P2.

Direct and indirect savings were estimated by the survey of P3 clients participated in the program in 1997-2003 (Youngblood et al., 2008a). The study consisted of 20 in-person reassessment interviews with clients. It was found that 37% of implemented P2 suggestions had health, safety and preventative components and likely resulted in indirect savings, which were possibly, had significant monetary value. The authors concluded that: (i) technical assistance involved simple projects, short-term assistance and little knowledge of P2 resulted in a lowest monetary savings and waste reductions; (ii) at the equipment costs less than $ 1000, other factors (cost saving, environmental and safety benefits, etc.) were often more important to client; and (iii) the types of technical assistance with complex projects and clients interested in P2 changes resulted in the highest rate of implementation, as well as largest monetary savings and waste reductions.

Hughey and Chittock (2011) conducted a research of voluntary approaches to pollution prevention program based on nine programs in five regional and district

councils of New Zealand. The questionnaire structured around five key areas: program evolution; type of program; policy and regulation; program structure; and performance measures, as well as personal interviews and discussions were used as part of approaches, used by the study. Program evaluation compared to the "best practice" design features found that all five councils reported some participant benefit mainly via indirect benefits related to the reduced potential fines or environmental actions (clean-up cost etc.).

Respondents of the MIT Survey indicated the improved brand reputation (49%) as a greatest benefit in addressing to sustainability (MIT Report, 2011). Reduced cost due to energy efficiency was the second common benefit (28%).

Eight principles of behavioral change leading to energy efficiency changes and savings are presented on a public site of the Institutional Change for Sustainability working group (Diamond, 2013). These principles can help in efforts toward sustainability and might be used to understand the driving forces to implementation of pollution prevention program. The principles were culled from the literature in social, organizational, and behavioral sciences that addresses the circumstances that affect how people make choices and alter their behaviors. Some of these studies focused on energy and sustainability-related topics, but others centered on other kinds of behaviors and choices. The principles include:

- Social network and communications principles: institutions and people change because they see or hear of others behaving differently.
- Leadership principles: institutions and people change because the workplace rules change and visible leadership communicated management commitment.

- Commitment principle: when they have made definite commitments to change, especially when those commitments related to future conditions. For example, fulfilling a previous corporate commitment to reduce waste/energy use.
- Information and feedback: receive actionable information and feedback.
- Infrastructure: changed infrastructure makes new behaviors easy and/or desirable (new tools, equipment, contracts, etc.).
- Social empowerment principle: those who feel they can reach desirable social goals often do. Involved in program design and processes.
- Multiple motivations principles.
- Continuous change: cultural change takes time.

2.6.5 Engagement in P2 and Sustainability Activities

Many companies understand that resource efficiency benefits the bottom line. According to the MIT survey results (MIT Review, 2011), waste reduction and energy efficiency were named top priority activities, in which respondent's organizations engaged more frequently. For many companies these were the entry points to sustainability. For example, Johnson&Johnson completed more than 60 energy-reduction projects between 2005 and 2009 for $187 million in capital investments, generating about 247,000 megawatt hours of energy savings (MIT Report, 2011).

Among the sustainability activities were listed: building awareness of pollution prevention in the organization; building culture of innovation by pursuing sustainability/P2 strategies; analyzing risks associated with P2 and sustainability issues; reducing greenhouse gas emissions; generating electricity, heat, or fuel from renewable

sources; improving energy efficiency; conserving natural resources; reducing or eliminating the creation of waste materials; reducing the creation or release of pollutants or toxic compounds.

According to MIT survey, to the question "To what extent is your organization engaged in each of the following activities?" rated on a scale from 1 to 5 with 5 being the highest and 1 being the lowest; the highest average response rate (3.69) have received the "Improving efficiencies and reducing wastes activity", and the lowest (2.39) "Revising compensation approaches and management incentives to promote sustainability-related strategies" (MIT Report, 2011). Among the most common activities were also listed:

- Identifying suggestions to enhance or differentiate brand image through sustainability strategies
- Building awareness of sustainability in the organization, and
- Identifying potential new revenue streams through sustainability-related products, services, or business models.

"Green Technologies and Practices Survey" (GTP) was conducted for the Bureau of Labor Statistics, part of the U.S. Department of Labor, by the Washington State Employment Security Department and also may be used for comparison of the results. The GTP survey is a special survey of business establishments designed to collect data on establishments' use of green technologies and practices and the occupations of workers who spend more than half of their time involved in green technologies and practices. 75% of business establishments reported the use of at least one green technology or practice during the August 2011. The two most frequently reported types were those that improve

energy efficiency (57 %), and those that reduce the creation of waste materials as a result of operations (55%). The least commonly used green technology or practice was generating electricity, heat, or fuel from renewable sources primarily for use within the establishment (about 2 %) (USDL, 2012).

2.7 Summary

Sustainable development and sustainability are the basis for future development and economic growth, and they define most of the environmental movements. Pollution prevention is a core part of sustainable development and long term planning. Combining these two movements can make both more successful in solving environmental problems. P2 approaches and technologies can assist business and communities in implementing sustainability.

Though the Pollution Prevention Policy has been highly developed since the Pollution Prevention Act was adopted in 1990, there is still a potential for development and research. One of the important issues is an understanding of benefits, barriers and motivations for implementing of P2 suggestions, for further development of recommendations and educational components, as well as technical assistance modules. Though there were many research studies conducted in various countries, discussing direct and indirect benefits, barriers, approaches and value of P2 Program and sustainable environmental management, still there are very few studies, discussing motivations and justifications for implementing of certain P2 suggestions. With this study and survey of the companies-participants of the P2 Program we plan to investigate the driving forces leading companies not only participate in P3 Program, but to make decision on

implementing of the proposed P2 suggestions. This study should help P3 and sustainability assistance providers in development of the future modules for business clients and might be used for development of recommendations of the P3 approaches not only in the State of Nebraska.

CHAPTER 3 METHODS

3.1 Introduction

It is important to understand the justifications and motivations of the decision-making toward the implementing pollution prevention suggestions. The goal of this study is to examine the reasons that drive business managers to implementation of P2 suggestions which should help educators and service providers to design technical assistance programs to the client needs. Methods used in this study include: (i) analysis of the reassessment results based on P3 original and reassessment reports; (ii) survey to identify benefits and driving forces for implementation of P2 suggestions. Data used for this study include reassessment results of the Partners in Pollution Prevention Program at the University of Nebraska-Lincoln from 2005 to 2011.

The P3 Program has offered P2 technical assistance to the businesses of Nebraska since 1997 using summer student interns. During 1997-2012 the program assisted 621 business clients. At the end of a summer interns submit to clients management reports with P2 recommendations and potential benefits, both direct and intangible (Youngblood, 2008b). During the past decade, various methods of assessing the impact of this program have been developed, some of which were used for this study and further described in more details.

3.2 Reassessment of Past Clients

P3 program has performed follow-up reassessments to 143 past clients. This section provides an overview of the reassessment objectives and approaches. Follow-up reassessments help to learn the achieved success and improve the technical assistance for

future assessments and clients. Reassessments were generally conducted once in one to three years after the original assessment. The P3 staff contacted past clients and those who agreed to the follow-up reassessment were revisited by interns. If the time between the original assessment and reassessment was too short and client implemented only some part of suggestions and willing to be reassessed next year, then student interns visited this client again. The reassessments were conducted by student interns according to the Standard Operation Procedure, developed by staff of the P3 Program (Appendix A) and included the following steps:

- Review of the original technical assistance report and preparation of its copy and a list of suggestions
- Interview and site tour with client for identification of the implementation rate and estimation of the waste and resource reduction and cost savings
- Reassessment report for client and P3 program
- Reassessment forms for P3 program.

Reassessment form includes a table with general information of suggestions proposed during the original assessment, as shown in Table 3.1.

Table 3.1 Example of the reassessment form

P2 Opportunity (Brief Description)	Implemented			Not Implemented			Doing Before Assessment
	As Suggested	With Modification	Similar Idea	Investigated	Not Investigated	Don't Know	

Using the original report and list of P2 suggestions intern discusses with the client the status of their implementation and fills the forms for reassessment report. A site tour may be also conducted for better understanding. The reassessment metric information on reduction/saving outcomes is provided by client. If the suggestions were not implemented, the reasons should be also discussed. Often clients do not record the benefits and savings resulted from the implemented P2 suggestion, then intern asks client to consult purchase orders, waste disposal manifests and other available records to accurately quantify savings. If these records are not available, client asked to conduct rough estimation of outcomes based on other methods (UNL P3 program, SOP, 2012). Based on resource saving information intern calculates greenhouse gas reduction using tools, such as WARM (USEPA, 2012c) and EIO-LCA Models (Carnegie-Mellon, 2013).

This information included in the Metric reassessment form for internal use by P3 program. Template of the reassessment form is provided in Appendix B. Intern prepares the reassessment report both for the client and P3 Program and completes the reassessment forms for internal use (UNL P3 program, SOP, 2012). Reassessment results for 1997-2012 show that 42% of all recommendations made by students were actually implemented though some with modifications (UNL P3 program, 2013).

3.2.1 Parameters Reassessed

The parameters reassessed during the reassessment include:

- Initial cost
- Cost saving: potential and actual
- Payback period
- Recurring years of benefit, and

Quantified benefits:

- Amount of solid wastes diverted from landfill
- Amount of hazardous wastes diverted from landfill
- Amount of reduced hazardous materials use
- Amount of reduced water use
- Amount of reduced electricity/natural gas use.

The table below provides information on parameters reassessed based on the standard reassessment form.

Table 3.2 Parameters assessed during the reassessment

General information	Savings information	Unit	Notes
Opportunity #	Cost Savings		
Description	Savings	$/year	
Recurring years of benefit	Initial Cost	$	
Releases Prevented	Energy Savings		
Material Prevented from release	Electricity Reduced	kWh/year	
Additional Indirect/ Intangible Benefits	Other Energy		Nat Gas=Therms/yr; Diesel=Gal/yr; Coal=Tons/yr
	Hazardous Materials Reduced	lbs/year	
	Hazardous Waste Reduced	lbs/year	
	Water Use Reduced	Gal/year	
	Water Pollutant Reduced		BOD, toxics, nutrients, stormwater contaminants, TSS
	Solid Waste Reduced	lbs/year	
	Air Emissions Reduced		CO2, NOx, VOC, SOx, PM

3.3 Reassessment Data Management

This section discusses methods used for analysis of the reassessed data and provides information on processing of analyzed data.

3.3.1 Reassessment Database Generation

As it was said, only companies reassessed in 2005-2011 and implemented at least one suggestion were included into this dataset. The goal of a study is to analyze the motivations for implementation of P2 suggestions by type, client sector, size and decision making. Thus, eight reports with no implemented suggestions were not considered as relevant and not included in this research, but used for calculation of the implementation rate.

A database was generated based on the reassessments reports from 2005 to 2011. The database contains information on implemented and not implemented suggestions and their main parameters, such as initial costs for the implementation, potential cost savings and actual cost savings. When the reassessment data was not available, an estimated initial costs and potential cost savings from the original assessment reports were used. The database contains information on the following parameters reported in the reassessment reports:

- Initial cost
- Cost saving
- Payback period
- Amount of solid wastes diverted from landfill
- Amount of hazardous wastes diverted from landfill
- Amount of reduced hazardous materials use
- Amount of reduced water use
- Amount of reduced electricity/natural gas use.

Since not all implemented suggestions were quantified during the reassessment, due to the very short period of time to be quantified or were hard to measure, several assumptions and tools were used.

Simple payback period was calculated using the following equation:

PAYBACK PERIOD = INITIAL COST/POTENTIAL COST SAVING

Though payback period method is a limited approach, it is commonly used by business for rough evaluation of investment projects. Thus, this approach was applied for the analysis of the reassessments results. When potential cost savings were not available, the actual cost savings were used to calculate the simple payback periods. The same equation was used for the calculation of the initial costs and potential cost savings where available. In a few cases when no cost information was provided in reports, the approximate equipment cost was found on the producers or suppliers websites and the average cost was assumed. The same approach was used for the analysis of not-implemented suggestions.

To extend data as much as possible, the EPA P2 cost calculator was used to quantify the potential cost savings, associated with reduction of used water, gas and electricity; landfill of solid wastes; reduction of hazardous wastes and hazardous materials (US EPA, Pollution Prevention Division, 2013). P2 cost calculator is a spreadsheet designed to help measure the environmental and economic performance results of P2 activities. This calculator can demonstrate the multi-media perspective that P2 brings to reduce cost savings. P2 Cost Calculator assesses cost savings associated with

reduced costs for hazardous inputs in a facility process, reduced costs for handling hazardous waste, reductions in annual air permitting fees that are based on actual emissions, reduced water discharge treatment costs based on gallons discharged, reduced charges for water usage, reduced fuel costs, and reduced costs for electricity.

The Pacific Northwest Pollution Prevention Research Center (PPRC) developed an early P2 cost savings calculator (accessible through the Pollution Prevention (P2) National Results Database <http://www.p2rx.org/services/measurement.cfm> last updated in 2004). EPA's Pollution Prevention Program in the Office of Pollution Prevention and Toxics (OPPT) worked with PPRC and other partners to revise and update this calculator.

P2 Cost Calculator includes references and justifications for methodologies and data sources, updated cost savings values, illustrated examples for users, and the ability to aggregate cost savings that can be derived from adopting pollution prevention practices.

P2 Cost Calculator is a tool to help the Pollution Prevention program, its partners, and grantees calculate the financial dollar savings from implementing P2 activities. This tool is designed to track annual savings or conservation. The P2 Cost Calculator is organized along the following tabs:

- Hazardous Inputs and Wastes: Cost savings from reduced hazardous materials used or generated
- Air Emissions: Cost savings from reduced emissions of air pollutants
- Water Pollution: Cost savings from reduced water pollutant and/or nutrient discharges
- Water Use: Cost savings from reduced water usage

- Energy Use: Cost savings from reduced fossil fuel use or reduced activities which use fuel (e.g. air or vehicle travel)
- Electricity Use: Cost savings from reduced purchases of electricity
- Non-hazardous Inputs and Solid Waste: Cost savings from reduced solid waste or other non-hazardous inputs (US EPA, 2012b).

3.3.2 Implementation Rate

Implementation rate was calculated by dividing the number of implemented suggestions by the total amount of the recommended P2 suggestions. 63 companies implemented at least one suggested P2 opportunity, have been reassessed in 2005 - 2011. Reassessment information of the clients with not implemented suggestions (8 reports) was not included in this research, but used for calculation of the implementation rate which was found as 46%, considering that some suggestions had several alternate options and clients chose the best one. It should be noted that some of the suggestions were under consideration or in a process at the time of reassessment, thus eventual rate of implementation may be higher. Total implementation rate reported by Youngblood et al. (2008b) for reassessments performed on original assistance in the 1997-2004 was 42%.

3.4 Survey

This section discusses the survey of the past P3 clients conducted for this study. Analysis of the available reassessment information and metric data found that information is not enough for logical argumentation of the motivations for implementation of some suggestions and declining others. Thus, it was decided to conduct a survey of the P3 clients implemented at least one suggestion. The survey

objective is to get the information related to the approaches and justifications to the P2 implementation.

To conduct a survey the project proposal was submitted to the Institutional Research Board (IRB) and an approval of the Human Research Protection Program at the UNL Office of Research and Economic Development has been received in late November 2012.

3.4.1 Survey Goal and Methods

The goal of the project was to prepare and distribute by mail individual survey forms among the P3 clients reassessed in 2005-2011 and implemented at least one P2 suggestion. The total number of clients to be surveyed was 60 and included industrial and service sectors and governmental organizations. Clients with no implementation were not included in a survey because they would not be able to discuss justifications and reoccurrence of specific P2 implementations.

To compare the P3 survey results, survey questions were modeled using the questions of two previous national surveys: Second Annual Sustainability and Innovation survey of global corporate leaders (MIT, 2011), and Green Technologies and Practices (GTP) Survey (USDL, 2012). MIT survey respondents included more than 3,107 managers and executives, representing every major industry and region of the world. Green Technology and Practices survey (GTP) was conducted for the U.S. Department of Labor with statistical sample size of 35,000 establishments and designed to collect data on use of green technologies and practices.

In Table 3.3 the survey questions for this study and reference questions as they appeared in the source are shown with answer options. To compare the results of these surveys, the questions and response options for this study were designed as close to the source as possible, however responses to this survey were modified in accordance with the study goals and client's profile. Draft survey was sent to past participants of P3 program for review and comments to assure that questions are easy to understand and answer. One of the reasons to simplification of the survey responses is the increase of the response rate. Specific questions 6 and 7 of the survey were related to the justifications of implemented P2 suggestions and their reoccurrence. These questions were generated according to the potential general motivations and number of recurring years of benefit, based on P3 experience and reassessment reports.

In the first column of Table 3.3 is the number of the question as it appears in this study. Column 3 shows reference source for the question. Columns 2 and 4 present the wording of the survey questions with responses as they appeared in this study and reference source. For Question 5 responses of both MIT and GTP surveys have been used and shown accordingly in Column 4.

To increase the response rate, the follow-up phone calls were anticipated and phone script has been prepared (Appendix C). Surveys along with cover letter, consent form and enclosed envelope were sent early January 2013. Two weeks later the follow-up phone calls were made to the companies that did not respond.

Table 3.3 Comparison of the survey questions with the reference source

This study	Reference	Wording Used by reference
Question 1		
Who in your organization typically factors P2 considerations into decision making? (Check all that are appropriate.) • Top management, who determine a strategy of organization as a whole • Managers in environmentally-dedicated roles • Managers in other functions or units • Our organization does not factor P2 considerations into decision making • Do not know	MIT survey (MIT, 2011)	Which of the following describes who in your organization typically factors sustainability considerations into decision making? (Choose all that apply) • Top management, who determine a strategy of organization as a whole • Managers in sustainability-dedicated roles (chief sustainability officer or equivalent; managers in dedicated sustainability units) • Managers in certain non- sustainability functions or units (e.g. supply chain functions, or units focused on particular offerings or customers) • Our organization does not factor sustainability considerations into decision making • Do not know • Sustainability is not typically considered anywhere, but it is factored into decision making occasionally by managers
Question 2		
When deciding P2-related investments, which financial expectations does your organization have? (Check one.) • Expectations are the same as any other investments • Do not know • Other factors allow P2/environmental projects to have longer or negative payback periods	MIT survey (MIT, 2011)	When deciding on sustainability-related investments, which financial standards does your organization apply? (Check all that apply) • No different standards at all; expectations are same as any other investments • Do not know • Allowable timetable for realizing expected returns is longer • Intangible/qualitative factors are formally considered, and influence decision • ROI or IRR expectations hurdles are lower • Our organization does not factor sustainability considerations into decision making

Table 3.3 (continued)

This study	Reference	Wording Used by reference
Question 3		
If you answered "YES" to "Other factors" what are the benefits to your organization in addressing P2? (Check up to 3) • Improved brand reputation/Public image • Regulatory compliance • Increased employee productivity • Enhanced stakeholder/investor relations • Risk reduction (reduced spills, liability etc.) • Customer demand • Better efficiency/productivity * • Less environmental impact, resource conservation • Safety and worker health (better conditions, etc.) • Equipment replacement at end of useful life • Other	MIT survey (MIT, 2011)	What are the greatest benefits to your organization in addressing sustainability? (Select up to three benefits) • Improved brand reputation • Improved regulatory compliance • Increased employee productivity • Enhanced stakeholder/investor relations • Reduced risk • Increased competitive advantage Access to new market • Reduced cost due to materials or waste efficiencies • Reduced cost due to energy efficiency • Increased margins of market share due to sustainability positioning • Improved perception of how well company is managed • Better innovation of product/service offerings • Better innovation of business models and processes • Improved ability to attract and retain top talent • There are no benefits

* These response options were reported as important benefits by P3 clients in past reassessments.

Table 3.3 (continued)

This study	Reference	Wording Used by reference
Question 5		
To what extent is your organization engaged in each of the following activities? (Rate on a scale of 1 to 5, with the following assumptions: 1 – not considered; 2- under consideration; 3 –sometimes applied; 4 – frequently applied; 5 – always applied.) • Improving energy efficiency • Building awareness of pollution prevention in the organization • Analyzing risks associated with P2 and sustainability issues (environmental, legal, competitive, reputational, resource access, political risk etc.) • Building culture of innovation by pursuing sustainability/P2 strategies • Reducing greenhouse gas emissions • Reducing or eliminating the creation of waste materials	MIT survey (MIT, 2011)	To what extent is your organization engaged in each of the following activities? (Rate on a scale of 1 to 5, with 1 being lowest) • Improving energy efficiency • Building awareness of sustainability in the organization • Analyzing risks associated with not fully addressing sustainability issues (e.g., environmental, legal, competitive, reputational, resource access, or political risk) • Identifying suggestions to build a culture of innovation by pursuing sustainability strategies • Reducing or eliminating carbon dioxide or other greenhouse gas emissions • Improving efficiencies and reducing waste • Identifying suggestions to enhance or differentiate brand image through sustainability strategies • Identifying potential new revenue streams through sustainability-related products, services, or business models • Including sustainability in scenario planning or strategic analysis • Analyzing potential regulations (e.g. carbon prices, etc.) and preparing response • Analyzing investor and stakeholder expectations related to sustainability • Benchmarking sustainability practices of competitors and sustainability leaders • Highlighting sustainability in the recruitment of employees • Revising compensation approaches and management incentives to promote sustainability-related strategies

Table 3.3 (continued)

This study	Reference	Wording Used by reference
Question 5		
• Generating electricity, heat, or fuel from renewable sources • Improving energy efficiency • Reducing the creation or release of pollutants or toxic compounds • Reducing or eliminating the creation of waste materials • Conserving natural resources (storm water management, soil conservation, sustainable forestry, etc.)	GTP survey (USDL, 2012)	Did your location use any of the following green technologies or practices? • Generate electricity, heat, or fuel from renewable sources primarily for use within your establishment? • Use technologies or practices to improve energy efficiency within your establishment? • Use technologies or practices to either reduce the creation or release of pollutants or toxic compounds as a result of operations, or to remove pollutants or hazardous waste from the environment? • Use technologies or practices to reduce or eliminate the creation of waste materials as a result of your operations? • Use technologies or practices in your operations to conserve natural resources? Please do not include using recycled inputs in your production processes.

3.4.2 Survey Structure

Each survey consisted of three parts:

- Summary with brief information on the original assessment and further reassessment of the business and implemented suggestions with benefits information, when available.
- Second part included definition of the Pollution Prevention used for the survey, and five general questions that are common for all clients.
- Third part of the survey included two questions, individual for each company depending on the implemented suggestions.

Survey forms were prepared by A. Kekilova and Dr. B. Dvorak at the support of Dr. R. Yoder. An example of the survey form is provided in Appendix D.

The general questions of the survey included:

1. Who in your organization typically factors P2 considerations into decision making?
2. When deciding P2-related investments, which financial expectations does your organization have?
3. If you answered "YES" to "Other factors" what are the benefits to your organization in addressing P2?
4. Does your organization prepare some type of annual Sustainability Reporting (GRI, annual water, solid waste, electricity usage benchmarking, etc.)?
5. To what extent is your organization engaged in each of the following activities? Rate on a scale of 1 to 5, with the following assumptions: 1 – not considered; 2- under consideration; 3 –sometimes applied; 4 – frequently applied; 5 – always applied.

Questions 1 and 2 were designed to understand the process of decision-making for P2 implementation. The received results were compared with results of MIT sustainability survey. Question 3 followed the Question 2, if clients answered "Other factors allow P2/environmental projects to have longer or negative payback periods". This question had ten response options with motivations for implementing suggestions with no obvious benefits; the clients could chose three. Questions 4 and 5 should help to estimate if organization is environmentally/sustainably oriented.

The answers to general questions allowed picturing the average client profile for further development of P3 program. Specific questions were individual for each company and directly related to the implemented suggestions:

6. For each P2 suggestion, what benefits were important to your organization in justifying the implementation?
7. Approximately how many sequential years were financial and non-financial benefits gained from each implemented opportunity?

Questions 6 and 7 were helpful to understand the motivations for implementing of specific suggestions and their benefits, and for estimating the future design of P3 program.

3.4.3 Survey Response Rate

Of 60 past clients contacted, 26 (43%) returned the survey. After receiving all expected responses, the survey results were analyzed. It was found that six of the clients contacted were out of business or changed the business (10% of contacted), six of the clients responded that there is no person to answer or that they do not retain information for long periods (10% of contacted). Some clients responded that they had no time to answer. It should be noted, that some respondents were new and not familiar with previous pollution prevention implementations.

CHAPTER 4 RESULTS AND DISCUSSIONS

4.1 Introduction

This study is focused on analyzing the results of the reassessments and survey of past P3 clients that received technical assistance between 2005 and 2011. These clients had been reassessed to determine the degree of implementation of the original suggestions. This chapter presents the analyses of the reassessment results and survey responses. The findings were compared with the results of previous research and surveys when possible.

4.2 Analysis of the Reassessments Results

As it was mentioned in Chapter 3, follow-up reassessments of past P3 clients were conducted by student interns to learn the implementation results of the original assistance recommendations. Based on the reassessment reports the client's database was generated and results were analyzed from various aspects, including analysis of the implementation rate, analyses based on initial costs, payback periods, type and size of the business, type of implemented suggestions etc.

The reassessments results were from past P3 clients that had implemented at least one P2 opportunity. Reassessments occurred between 2005 and 2011. Overall 63 companies were provided a total of 91 business management reports, included in the database. Various businesses across Nebraska are represented, (e.g. manufacturing, hotels, hospitals, retail service, banking, pharmaceutical etc.), and are further defined as manufacturing (M), not-for profit/governmental (N) and other (O) businesses as shown on Figure 4.1. Detail information listed in Table E.1 of Appendix E.

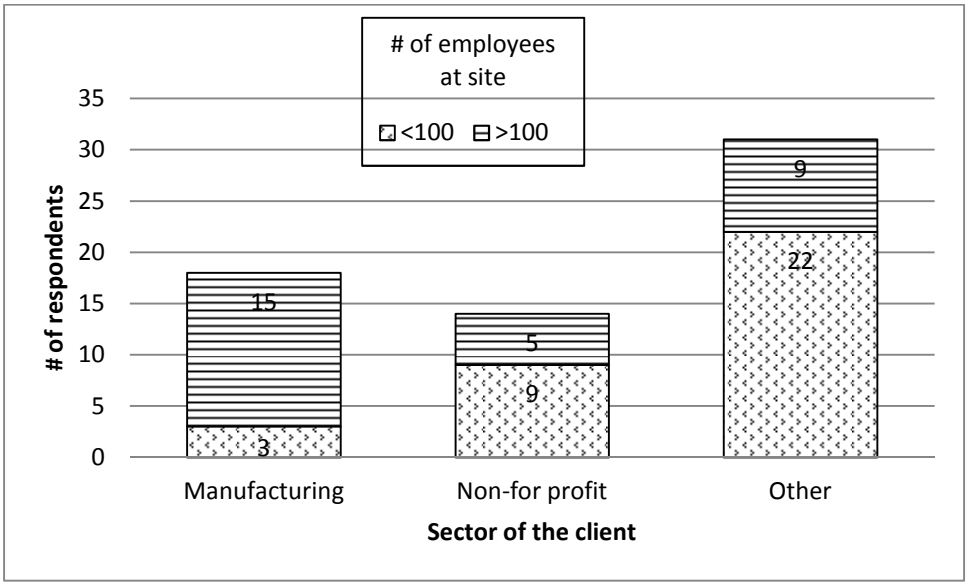

Figure 4.1 Profile of clients reassessed between 2005 and 2011.

4.2.1 Implementation Rate

In Table 4.1, the general information by the year of reassessment is presented. Reassessments reports for clients with no implementation of original suggestions (8 reports) were not included in this research, but considered at determination of the implementation rate. Column 2 of the table shows the total number of companies reassessed each year that were analyzed in this study. Columns 3 and 4 list the percentage of implemented and not implemented suggestions for a given year with the original number of P2/sustainability suggestions in parentheses.

As listed in Table 4.1, 91 reassessment reports were analyzed. Implementation rate is 46%, considering that in some cases there were several alternate options for one process and clients accepted one best option. It also should be noted that some of the suggestions were under consideration or in-process at the time of reassessment, thus the eventual rate of implementation may be higher. Total implementation rate reported by

Youngblood et al. (2008b) for data from original UNL P3 assistance provided between 1997 and 2001 was 42%.

Table 4.1 Implementation rate of P2 suggestions by year (2005-2011)

Year	Number of companies reassessed	%/Number of implemented	%/Number of not implemented
2005	14	44% (87)	56% (111)
2006	13	46% (46)	54% (55)
2007	15	46% (38)	54% (44)
2008	18	58% (58)	42% (42)
2009	14	41% (28)	59% (41)
2010	10	45% (40)	55% (48)
2011	7	35% (21)	65% (39)
Total	91	46% (318)	54% (380)

4.2.2 Data Comparison

For further analysis the data with available information for both, implemented and non-implemented suggestions was analyzed. All data was sorted into the groups according to payback periods and initial costs (Appendix E, Table E.2). It was identified that most of the implemented suggestions (69%) had initial costs less than $1000 and payback periods less than 1 year.

Figure 4.2 illustrates the implementation rate versus projected payback periods in years based on direct costs. General trend of higher implementation rate for shorter payback periods and lower implementation costs is obvious, but it is clear that other factors were important for clients who considered implementing P2 suggestions, which is consistent with previous studies of Granek et al. (2006), Youngblood et al. (2008a) and MIT Survey (2011). Thus, given the fact that other factors beyond payback periods and

initial costs are important to clients in the decision making for implementation of P2 and sustainability concepts, there is a need to further investigate the range of motivations for implementation of P2 and sustainability ideas.

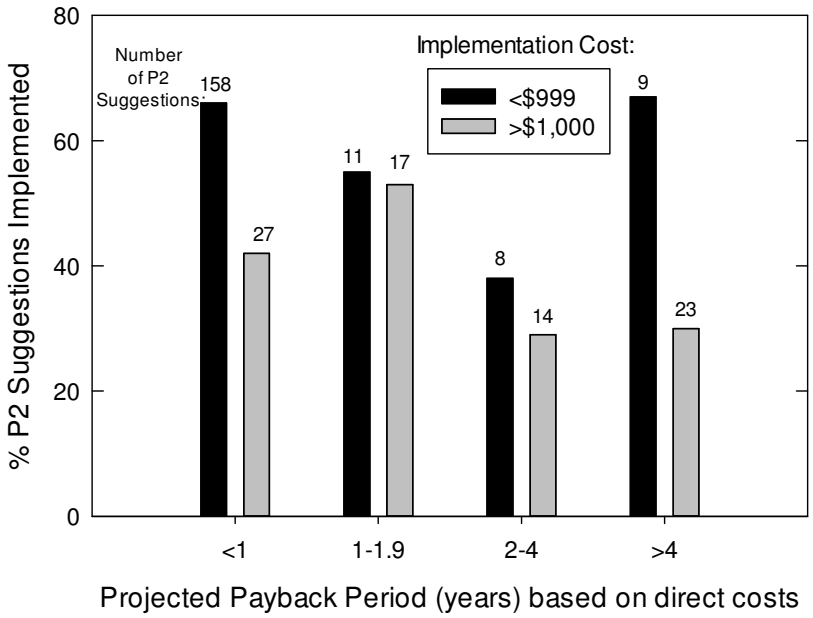

Figure 4.2 Implementation rate versus projected payback periods and reported implementation costs

4.2.3 Analysis Based on Initial Costs

Considering that most of the implemented suggestions had initial costs less than $1000; the implemented data was sorted by initial costs (Appendix E, Table E.3). Figure 4.3 illustrates the percent of implemented suggestions based on the initial implementation costs.

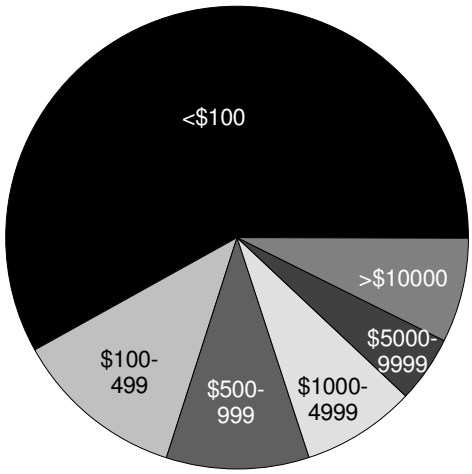

Figure 4.3 Percent of implemented suggestions for each initial cost category

It is obvious that the number of implemented suggestions is significantly lower with the increase of the initial costs:

- 58% of the total implemented suggestions had initial costs of less than $100. Most of them (99%) had calculated payback periods of less than 1 year.
- 20% of all implemented suggestions had initial costs of greater than $1000; 57% of them had estimated payback periods greater than 2 years.

In Table 4.2 the implementation rates based on initial costs are listed.

Table 4.2 Implementation rates based on initial costs

Initial cost	**Implemented**		**Not implemented**	
	#	**%**	**#**	**%**
<100	87	67%	43	33%
100-500	18	46%	21	54%
>500-1000	15	88%	2	12%
>1000-5000	12	40%	18	60%
>5000	7	41%	10	59%
>10000	11	34%	21	66%

Initial cost	Implemented		Not implemented	
	#	%	#	%
Total	**150**	**57%**	**115**	**43%**

Based on the data shown in Table 4.2 it may be concluded:

- The less the initial costs of the opportunity, the greater the implementation rate.
- The implementation rate of the suggestions with initial costs higher than $1000 is 38%.
- Other factors beyond payback periods and initial costs were also important to clients in deciding the implementation.

4.2.4 Analysis Based on Estimated Payback Period

Implementation rates based on payback periods are shown in Table 4.3.

Table 4.3 Implementation rate based on payback periods

Payback, year	Number of implemented (total)	Implementation rate
<1	119 (193)	62%
1-2	11 (22)	50%
>2-4	7 (19)	37%
>4	13 (32)	41%
Total	**150 (266)**	**56%**

It may be concluded that:

- The implementation rate based on payback periods is 56%.
- The implementation rate of the suggestions with potential payback periods of less than 2 years is 60%.

- The implementation rate of the suggestions with payback periods longer than 2 years is 31%.
- Potential short payback periods (<2 years) resulted in higher implementation rate.
- Payback period was not the only factor considered by clients.

4.2.5 Analysis Based on Type of Business

Potentially, different types of clients made decisions on implementation of P2 and sustainability suggestions differently. Thus, all clients of the P3 program, which are various by sector and business functions, were divided by sector of operations as manufacturing (M), not-for profit (N) and "other business" (O).

Manufacturing clients (M) were typically larger in number of employees at the site than the other clients. Manufacturing companies were represented by businesses involved in producing of equipment, machinery, and other engineered devices for various industrial purposes. The not-for profit (N) organizations were represented by hospitals, utilities (i.e. water and wastewater, electricity), schools and government-owned vehicle maintenance facilities. "Other" businesses included retail outlets, distribution warehouses and other service providers (e.g., vehicles, aircrafts, furniture, farm implement, hotels and banks).

The data on implemented suggestions was analyzed by payback periods and initial costs (less or greater than $1000). It was found that 50% of all suggestions with initial costs of greater than $1000 were implemented by manufacturing companies, and 77% of implemented suggestions were related to energy efficiency and technological

improvement projects. Analysis found that payback periods of the 32% of the implemented suggestions by "other" business clients and 27% by not-for profit clients, were longer than 2 years. In general, these numbers do not differ greatly and probably cannot be used as representative of a relationship between type of business and payback period.

In Table 4.4 implementation rate by the type of business, payback periods and initial costs is presented. Column 2 lists the implementation rate of P2/sustainability suggestions with payback periods longer than 2 years by type of business. Column 3 lists the implementation rates of P2/sustainability suggestions with initial costs more than $1000 by type of business.

Table 4.4 Implemented suggestions by the type of business

Type of business	Implementation rate, % (#)	
	Payback > 2yr	Initial cost >$1000
Manufacturing	35% (9)/26	41% (16)/39
Not-for profit	55% (6)/11	45% (10)/22
Other business	44% (7)/16	33% (6)/18
Total	**42% (22)/53**	**41% (32)/79**

It can be concluded that:

- Implementation rate for P2 suggestions with longer payback periods and higher initial costs was slightly lower than the overall implementation rate previously noted (47%).
- Implementation rate for P2 suggestions with larger initial costs (>$1000) is greater than the implementation rate of P2 suggestions with longer payback periods (>2 years) for manufacturing sector. This may be explained that,

potentially manufacturers have more capital to invest in new technologies than not-for-profit and the "other" sectors.

- Not-for-profit clients were more likely to implement suggestions with longer payback periods.

4.2.6 Analysis Based on Type of the Implemented Opportunity

To understand differences between various types of P2/sustainability suggestions, implemented suggestions were analyzed by categories. The seven P2 categories used for the analysis were the following: Practices and procedures (including Preventative maintenance as one of the methods), Equipment modification, Energy efficiency, Material substitution, Product reformulation, Process modification, and In-process recycling (Appendix F). Categories "Energy efficiency" and "Equipment modification" were combined due to their similarity. Categories "Material substitution", "Process modification" and "In-process recycling" were combined and shown as "Other" due to their small sample size. The frequency in each category of implemented P2 suggestions with initial costs of greater than $1000 is illustrated in Figure 4.4.

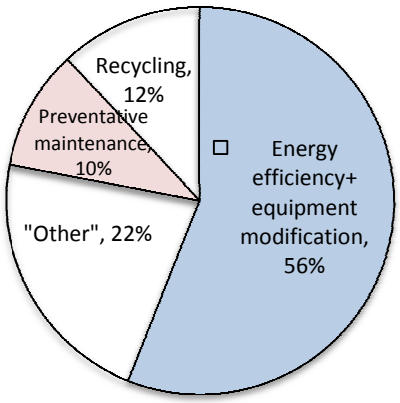

Figure 4.4 Implemented P2 suggestions with initial costs >$1000 according to the P2 category.

It was found that:

- 56% of the implemented suggestions were related to energy efficiency and equipment modification (mainly replacement of lighting systems and old equipment).
- 22% of the implemented suggestions were related to area of technological improvements and resource/water conservation and shown as "Other".
- 10% of the implemented suggestions were related to health, safety and risk reduction: spills prevention, replacement of hazardous materials and regulatory compliance. Implementation of these suggestions resulted in reduced liability, increased safety and health and less impact on the environment.
- 12% of all suggestions were related to recycling.

4.2.7 Conclusions

- Implementation rates for the suggestions with initial costs more than $1000 and payback periods more than 2 years were 38-39%. Thus, payback period and initial cost were not only criteria considered by clients for implementation. Most of these suggestions were implemented by manufacturing business companies.
- Energy efficiency suggestions had the greatest number (56%) of implemented suggestions with initial cost greater than $1,000. It may be explained by the longevity and years of reoccurrence of these suggestions. Equipment usually is being replaced in case it is worn out or old fashioned, thus replaced equipment

will be used to the time new equipment is needed, or in case of changes in technological process. Thus, implementation of the suggestions related to replacement of equipment may be considered as a long-term investment.

- Reasons provided by clients for not implementing P2 suggestions were primarily: financial problems; long payback period; the suggestions "[did] not meet the needs" of the client; would affect "quality of the final product" or "working conditions"; were "not cost effective", "not needed", "not/less effective", "not a priority"; or "[violated] Safety Code/legislation" (P3, UNL, 2012).
- Benefits and motivations for implementation provided in the narrative of the reassessment reports were mostly related to cost savings and resource savings. But in some cases clients reported non-quantified benefits such as risk reduction, spill prevention, safety benefits, reduced liability, and employee awareness; however this information couldn't be analyzed due to lack of data.

4.3 Analysis of the Survey Results

The analysis of data reassessments indicated that although financial considerations such as payback period and initial cost were important, other factors were also considered by clients in making decisions toward the implementation of P2 and sustainability suggestions. To further understand these factors, a survey of past P3 clients that had been reassessed between 2005 and 2011 was performed.

4.3.1 Profile of Surveyed Clients

A group of 60 past P3 clients reassessed in 2005-2011 was selected to be surveyed. These clients all had been provided the original assistance in 1999 - 2010 and

received an on-site reassessment one to three years after the initial assistance in order to determine what initial recommendations had been implemented. According to Youngblood et al. (2008a) the best data in terms of implementation quantifications occurred with reassessments of past clients 2 to 3 years after the original assistance. Of 60 past clients contacted, 26 (43%) returned the survey. It was found that 10% of clients contacted are out of business or changed the business; 10% responded that there is no person to answer or they do not retain information for long periods, and another 10% responded that they have no time to answer.

Participating companies differed by size and sector (e.g., manufacturing companies, governmental or not-for-profit agencies, and others private companies). Manufacturing companies were typically larger in number of employees at the site. An analysis of the respondents' profile found that 12 of all clients were in the manufacturing sector, five were not-for profit or public utilities (called not-for profit hereto), and the rest were a group of companies of small businesses, retail, and service companies classified hereafter as "Other". Manufacturing companies were represented by those involved in producing of equipment, machinery, and other engineered devises for industrial purposes. Most of the manufacturing companies had more than 100 employees on site. The not-for profit organizations were mainly represented by hospitals, utilities (i.e. water, wastewater and electricity), schools and government-owned vehicle maintenance facilities. "Other" businesses included retail outlets, distribution warehouses and other service providers (e.g., vehicles, aircrafts, furniture, farm implement).

A profile of the survey respondents is provided on Figure 4.5. It was observed that the largest number of respondents had between 100 and 1000 employees at the work site.

An analysis by the years since the original assessment shows that for most of the companies (16), original assessment was conducted four through eight years previous to this survey; for nine of them it was more than eight years previous. Thus, it may be assumed that the person responsible for environmental issues in the organization has changed. An analysis of persons who completed P3 survey forms showed that 14 of them were involved in original assessments, and 10 were new and didn't participate in initial assessments, thus they might not be aware of implemented suggestions in detail. This also affected the responses: new persons often didn't cover specific implementation questions due to their unfamiliarity, but provided responses to general questions only. More detailed information of client profile is provided in Appendix G Table G.1 and on Figure 4.5.

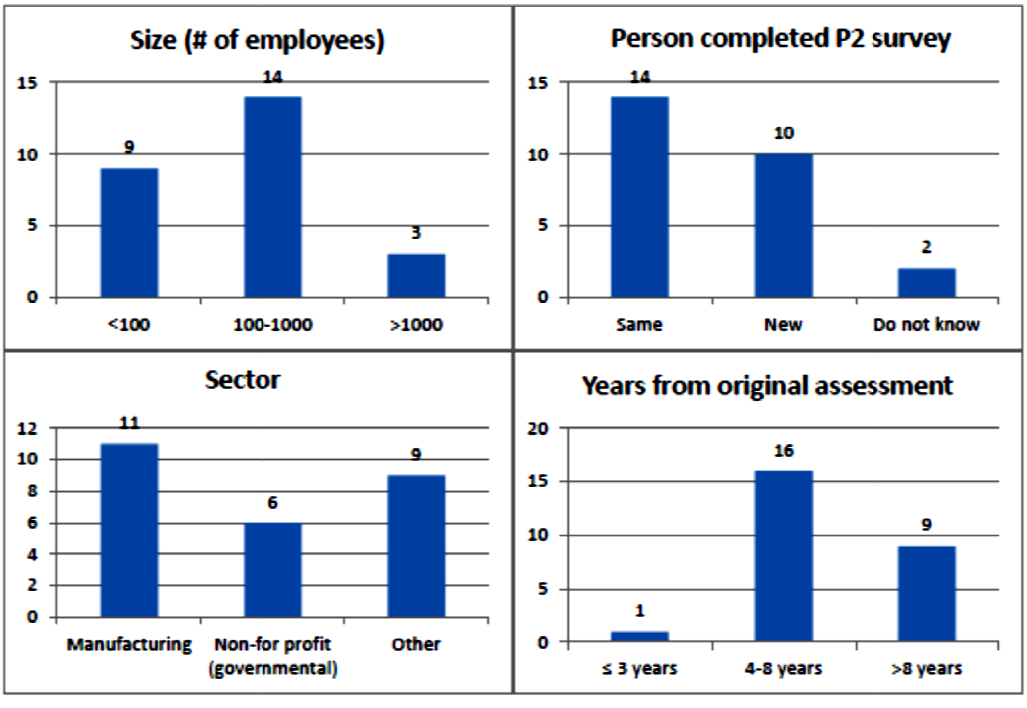

Figure 4.5 Profile of survey respondents.

On Figure 4.6 the sector and size of clients are shown. It can be seen that "other" business clients mostly have less than 100 employees on site, whereas manufacturing clients have mostly more than 100 employees on site.

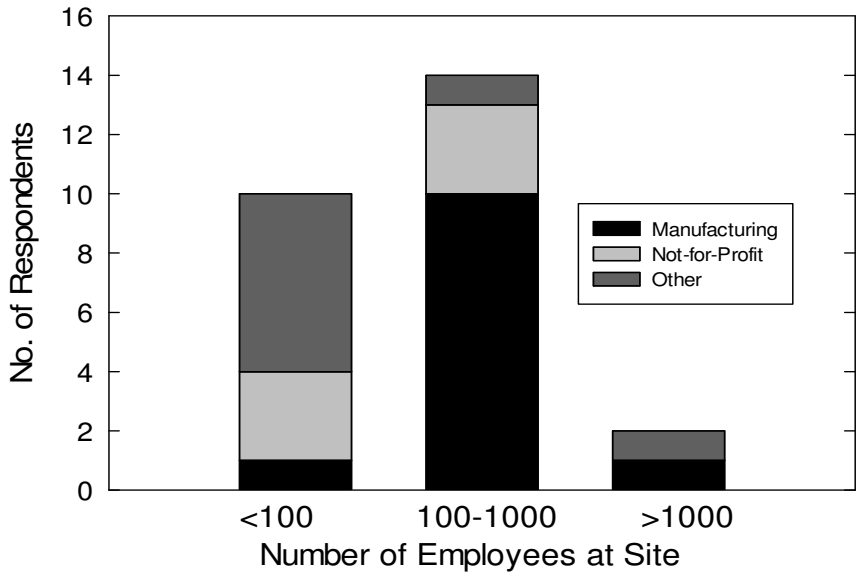

Figure 4.6 Survey respondents by sector and size.

These 26 clients had been provided with 311 original source reduction recommendations by the original interns, and reassessment's analysis found that 39% of the initial recommendations had been implemented. (Appendix G, Table G.2). Implementation rate reported by Youngblood et al. (2008b) is 42%, and implementation rate based on the reassessment analysis of 63 clients in this study is 47%.

4.3.2. Survey Information

Detailed analysis of all responses was conducted. There were seven questions asked in a survey:

1) Who in your organization typically factors P2 considerations into decision making?
2) When deciding P2-related investments, which financial expectations does your organization have?
3) If you answered "YES" to "Other factors" what are the benefits to your organization in addressing P2?
4) Does your organization prepare some type of annual Sustainability Reporting (GRI, annual water, solid waste, electricity usage benchmarking, etc.)?
5) To what extent is your organization engaged in each of the following activities?
6) For each P2 suggestion, what benefits were important to your organization in justifying the implementation?
7) Approximately how many sequential years were financial and non-financial benefits gained from each implemented opportunity?

Questions 1 and 2 were intended to examine the process of decision-making in P2 implementation and financial expectations from implementing. Question 3 investigated general motivations for the implementation of suggestions with no obvious benefits. Question 5 evaluated the degree of environmental/sustainability orientation of a company. Questions 6 and 7 were related to specific implemented P2 suggestions, justifications for their implementation and reoccurrence. Responses to the survey questions are provided in Appendix H. Discussion of the analysis of the survey results are given in the following sections.

The responses to this survey were compared with results of two large national studies. One study was focused on more than 3100 business executives and top corporate managers from organizations located around the world ranging from less than 500 employees to the more than 500,000 employees. This survey was conducted by MIT Sloan Management Group in collaboration with Boston Consulting Group (MIT Review, 2011). Another study is a Green Technology and Practices survey (GTP) which was conducted for the Bureau of Labor Statistics, part of the U.S. Department of Labor by the Washington State Employment Security Department. The GTP survey is a special survey of business establishments designed to collect data on establishments' use of green technologies and practices (USDL, 2012). The GTP total sample size is about 6.7 million establishments, from which a statistical sample of 35,000 establishments was selected.

It was found that responses from the Clients of this survey for Question 1 were similar to results of the MIT survey (Appendix H, Table H.1); and survey responses for Question 5 were very close to both MIT and GTP surveys (Table 4.5).

Table 4.5 Comparison of engagement into P2 activities based on responses to P3, MIT and GTP surveys

Activity	Average Response		
	This study	MIT[1]	GTP[2]
Reducing or eliminating the creation of waste materials	3.8	3.69	55%
Improving energy efficiency	3.7	3.69	57%
Reducing the creation or release of pollutants or toxic compounds	3.6	n/a	13%
Conserving natural resources	3.3	n/a	19%
Analyzing risks associated with P2 and sustainability issues	3.2	3.1	n/a
Building awareness of pollution prevention in the organization	3.1	3.22	n/a
Building culture of innovation by pursuing sustainability/P2 strategies	2.8	3.06	n/a
Reducing greenhouse gas emissions	2.8	2.83	13%
Generating electricity, heat, or fuel from renewable sources	2.0	n/a	2%

[1] - MIT Sloan Management Group in collaboration with Boston Consulting Group Review, 2011

[2] - Green Technology and Practices surveys, Washington State Employment Security Department, 2012.

In Question 5 clients were asked to report on nine sustainability-related activities listed in the first column. Since not all of these options were listed in MIT and GTP surveys, "n/a" in response columns indicates that this answer was not available for those surveys. The obvious similarity was noted in responses for P3 and MIT surveys. Despite the difference in measurements (responses for P3 and MIT surveys provided in a scale from 1 to 5, with 1 – not considered, and 5 – always applied; and responses for the GTP survey provided in percentage of total establishments participated), GTP survey results showed similar trends to the P3 survey in engagement to many activities, such as low involvement in generating energy from renewable sources, and high engagement in energy efficiency and waste reduction projects. Assuming that the survey respondents of this study were relatively similar to those in the MIT and GTP, this similarity may indicate the general trend of the businesses despite the size and sector of operations. Granek et al. (2006) didn't find size and sector correlations with sustainability orientation of small and medium manufacturing clients though not-for profit and other businesses were not a part of his research.

It was also observed that Annual sustainability reporting mainly was performed by larger companies (59%) (Appendix G, Table G.3). Most of smaller-size clients do not have such requirements, whereas manufacturing and governmental sector have to prepare annual sustainability reports due to their more often application of toxin compounds and greater amount of wastes produced.

4.3.3. Analysis of the Decision Making Process

One of the important factors in achieving implementation of sustainability solutions is obtaining the support of the key decision makers. The first survey question was "Who in your organization typically factors P2 considerations into decision making?" Three choices were allowed: top management (TM), environmental managers (EM), and other managers (OM); and respondents could chose all that applied. Other managers included safety, facilities, emergency preparedness, process and quality improvement, worker's compensation managers, etc. Responses received for this question were analyzed by client size and sector and its correlation with responses to other questions. It was found that for 32% of respondents decision making was performed by top management only; however most of the clients (64%) reported that not only top managers but all managerial levels (top, environmental and other managers) are involved in decision making process (16 clients of 26). A detailed distribution of responses is presented in Appendix G, Table G.4.

For further analysis of the decision making, all respondents were divided into two groups according to their responses and referred hereafter as:

(i) TM/EM - clients who reported TM and EM either alone or in combination (15 clients); and

(ii) OM - clients who answered OM alone or in combination with TM and EM (10 clients).

In Table 4.6 the relationship between decision making and size, sector of client's operation and financial expectations is listed. As it was previously mentioned, all clients were divided by sector of operations as "manufacturing", "not-for profit" and "other

businesses". These sectors are listed in columns four through six. A profile of the respondents by the financial expectations from the implementation of P2 and sustainability recommendations was reported by clients in response to Question 2 and listed in columns seven through nine of a table.

Decision making performed by only top and environmental managers comprised 58% of responses; and in 38% decisions were made by other managers in conjunction with top and environmental managers. It was observed that "other managers" were involved in the decision making process only in manufacturing and not-for profit sectors and mainly in organizations that had more than 100 employee's.

Table 4.6 Distribution of decision makers by financial expectations, size, and sector

Decision makers	Total responses % of total (#)	Size (# of employees on site) <100/ >100	Sector of operation			Financial Expectations		
			Manufacturing	Not-for-profit	Other Businesses	Same	Other factors	Do not know
TM/EM[1]	58% (15)	6/9	50% (6)	33% (2)	88% (7)	73% (11)	27% (4)	-
OM[2]	38% (10)	3/7	50% (6)	67% (4)	-	10% (1)	80% (8)	10% (1)
Do not know	4% (1)	1/0	-	-	12% (1)	-	-	100% (1)
Total	26	10/16	12	6	8	12	12	2

[1] - Top management only and/or Environment managers
[2] - Other managers along with Top and Environment managers

As shown in Table 4.6, OM clients were more likely to report willingness to consider other factors beyond simple paybacks and cost savings in determining P2 implementation. It should be noted that more P2 suggestions were given to OM clients

(average of 17/client) than TM/EM clients (average of 11/client) as listed in Appendix G, Table G.5. OM clients implemented the suggestions at a lower rate but still implemented more P2 suggestions than TM/EM clients (average of 5.9 vs. 5.0/client). There was a difference in the breadth of suggestion given to the clients, with more tendencies to give OM clients multiple suggestions for the same problem and long-term suggestions that one would not anticipate being implemented in the next few years (e.g., recommending alternative wood preservation technologies). However, no notable difference was found in terms of reoccurrence, positive cost benefits and other motivations for implementation of P2 suggestions relative to the decision making responses.

Analysis of a relationship between decision making and general benefits (Table 4.7) found that among the clients who expect other factors allowing longer or negative payback periods beyond the financial benefits (Question 3), clients with "Other managers" in decision making overall have provided more responses to all general benefits. Is also was noticed that these clients mostly reported on Health and safety (78%) and Regulatory compliance (75%) benefits. It can be concluded that there is a "notable" difference in higher considering of risk-based factors if "other managers" are involved in decision making.

More responses for specific justifications of P2/sustainability implementation were received from clients with Top management and Environmental managers in decision making, with main focus on Regulatory compliance (84%), Increased employee productivity (76%) and Reduced environmental and health risk (62%). If "other managers" (environmental, health and safety) were involved in decision making, then Easier to implement due to changed infrastructure (59%), Safety and health benefits

(52%), and Improved public image (55%) were the factors considered beyond the payback period (Table 4.8). These findings are consistent with Prakash (2001), who identified two types of processes affecting "beyond-compliance" policies. According to Prakash, key managers – policy-supporters champion these policies. Thus, it is important to know who the decision makers in the company provided with the assistance are.

Table 4.7 General benefits in addressing P2 suggestions by financial expectations and decision making

General benefits in addressing P2	Other expectations % (#)	Decision makers	
		TM/EM (5 /15)	OM (8 /10)
Resource conservation	21%(10)	40% (4)	60% (6)
Health and safety	19% (9)	22% (2)	78% (7)
Regulatory compliance	17% (8)	25% (2)	75% (6)
Risk reduction	15% (7)	29% (2)	71% (5)
Public image	11% (5)	40% (2)	60% (3)
Better efficiency	6% (3)	33% (1)	67% (2)
Customer demand	6% (3)	100%(3)	0
Enhanced stakeholder relations	4% (2)	50% (1)	50% (1)
Increased employee productivity	-	-	-
Total	47	37%(18)	63%(30)

First column of Table 4.7 lists the general benefits given as a response options for Question 3. Second column shows the percentage (number) of responses. Total number of responses received is 47. Columns 3 and 4 show the percentage (number) of responses given by decision makers, where TM/EM are the top and environmental managers alone or in combination, and OM are the "other managers" alone or in combination with top and environmental managers. Five of fifteen clients responded that the decision-making at their organizations is performed by top and/or environmental managers which are

shown as 5/15; and 8 of 10 have responded that the decision making is performed by "other" managers.

4.3.4. Analysis of Financial Expectations and Benefits in Addressing P2

As noted in Section 4.2, many P2/sustainability suggestions did not have a short (e.g. <2 years) payback periods, however many of these suggestions had important indirect or intangible benefits. Youngblood et al. (2008a) estimated and quantified four categories of indirect savings: time savings from research conducted by intern, operating cost reductions, labor savings and future liability reductions. It was found that quantifying indirect savings may result in significant monetary savings and including the indirect savings beyond the four studied, will increase the ratio of indirect to direct savings substantially.

Question 2 of the survey asked "When deciding P2-related investments, which financial expectations does your organization have?" Clients could choose one of three offered responses, but the most valuable for the P3 program was response: "Other factors allow having longer or negative payback period". This question shed the light on the type of clients willing to consider other factors beyond straight cost savings and payback periods. Figure 4.7 shows the distribution of responses to Question 2.

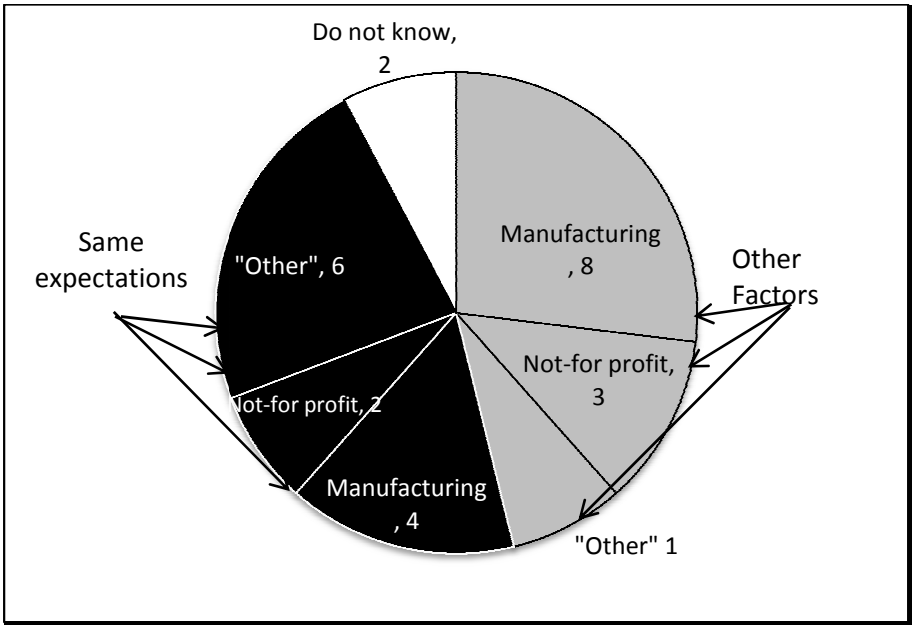

Figure 4.7 Financial expectations from P2 projects by sector

46% of all clients (12) responded that they consider other factors allowing longer or negative payback periods for implemented P2 projects. Most of these clients (7) were represented by manufacturing sector; three were not-for profit facilities. These clients were asked then to indicate general benefits they expect in addressing P2 (Question 3).

Analysis of responses received to the survey questions shows that:

1. Very small companies (6 of all respondents had less than 25 employees according to the reassessments reports), mostly expected the same financial benefits as from other investments, whereas larger clients allow longer or negative payback periods.
2. If “other managers” were involved in decision making, clients more often considered other factors beyond financial benefits (80%). Other managers included safety, facilities, emergency preparedness managers and others.

4.3.5 General and Specific Benefits and Motivations in Addressing P2

Since understanding of the motivations driving companies to implement P2/sustainability suggestions is important for P3 technical assistance providers, in this section the general and specific benefits reported by survey respondents are discussed.

Questions 3 and 6 of the survey were related to the general and specific motivations in addressing to implemented P2 suggestions and some response options were similar for both questions. It was found that responses were generally consistent, thus they are discussed together.

Question 3 followed the second question of the survey and provided nine answer options of general benefits (Table 4.7). Those clients who responded that they consider other factors beyond financial benefits (Question 2), were asked to indicate the important general benefits (clients could mark more than one response option). Based on 47 responses received from 12 clients it was concluded that most of the clients who considered other factors, have expected benefits in resource conservation. Health and safety, and regulatory compliance were considered mainly by respondents with "other managers" in a decision-making. It should be noted, that six of eight clients reported regulatory compliance benefits were from manufacturing sector with more than 100 employees on site.

Besides general benefits, clients were asked to report on motivations and justifications in addressing to specific P2 suggestions in Question 6. In Table 4.8 the relationship of justifications for implemented specific P2 suggestions and financial expectations ("same" and "others") is presented.

The most common justification for P2 implementation, based on 433 responses to implemented suggestions (Appendix H, Table H.6) was "Reduced operating cost" (62). Five other justifications also commonly provided were:

- Reduced environmental and health risk (44)
- Acceptable payback period (42)
- Health and safety benefits (40)
- Regulatory compliance (39), and
- Energy efficiency (38).

Thus, the top priorities for the respondents were financial and risk-based factors. Table 4.8 presents the relationships between justifications for implementation of specific P2 suggestions and financial expectations. The first column of the table lists the justifications given by respondents to each implemented suggestion, and the second column lists the total number of responses for each justification shown in parentheses with the percentage of the total. Since this question was multiple choices, the respondents could provide more than one justification to each implemented P2 suggestion. The last row of the table lists the total number of responses by column.

Responses in columns 3 and 4 are sub-divided as if respondents applied "same" or "other" financial expectations to P2/sustainability recommendations. The justifications in Column 1 are listed in descending order by "other" expectations (Column 4) from 100% for "Other" to 59% for "Improved public image". There were total 405 responses for justifications to implemented P2 suggestions reported by clients who indicated their financial expectations. Analysis of expectations shows that 70% (282) of responses were

reported by clients who had “other expectations” beyond direct financial benefits in justifying the implemented P2 projects. A higher than average number of responses for reduced business risk (91%), energy efficiency (79%), and environmental and health risk reduction and safety benefits (76% each) was provided by respondents with “other expectations”.

Table 4.8 Justifications for implementation of the specific P2 recommendations and financial expectations distributed by sector, decision making and size

Justifications	Total	Financial expectations		Sector (clients)						Decision makers		Size (employees)	
				Manufacturing (12)		Not-for profit (5)		Others (8)					
		Same	Other	Same (4)	Other (7)	Same (2)	Other (3)	Same (6)	Other (2)	OM (9)	TM/EM (15)	<100 (9)	>100 (16)
Other	0% (1)	0	100% (1)	-	-	-	100% (1)	-	-	100% (1)	-	-	100% (1)
Reduced business risk	5% (22)	9% (2)	91% (20)	-	100% (15)	-	100% (5)	100% (2)	-	41% (9)	59% (13)	45% (10)	55% (12)
Energy efficiency	9% (38)	21% (8)	79% (30)	-	100% (19)	25% (3)	75% (9)	86% (6)	14% (1)	50% (19)	50% (19)	39% (15)	61% (23)
Reduced environmental and health risk	9% (37)	24% (9)	76% (28)	27% (4)	83% (20)	-	100% (6)	71% (5)	29% (2)	38% (14)	62% (23)	32% (18)	68% (19)
Health and safety benefits	8% (33)	24% (8)	76% (25)	5% (1)	95% (18)	-	100% (7)	100% (7)	-	42% (14)	58% (19)	36% (12)	64% (21)
Payback period	10% (42)	27% (11)	73% (31)	11% (3)	89% (25)	25% (2)	75% (6)	100% (6)	-	52% (22)	48% (20)	29% (12)	71% (30)
Environmental awareness	9% (37)	30% (11)	70% (26)	7% (1)	93% (14)	31% (5)	69% (11)	83% (5)	11% (1)	41% (15)	59% (22)	49% (12)	51% (25)
Reduced operating cost	15% (62)	34% (21)	66% (41)	14% (5)	86% (32)	47% (8)	53% (9)	100% (7)	-	48% (30)	52% (32)	29% (18)	71% (44)
Regulatory compliance	8% (32)	34% (11)	66% (21)	9% (2)	91% (20)	50% (1)	50% (1)	100% (8)	-	16% (5)	84% (27)	16% (5)	84% (27)

Table 4.8 (Continued)

Justifications	Total	Financial expectations		Sector (clients)						Decision makers		Size (employees)	
				Manufacturing (12)		Not-for profit (5)		Others (8)					
		Same	Other	Same (4)	Other (7)	Same (2)	Other (3)	Same (6)	Other (2)	OM (9)	TM/EM (15)	<100 (9)	>100 (16)
Corporate commitment	8% (34)	35% (12)	65% (22)	6% (1)	94% (17)	40% (4)	60% (6)	100% (7)		43% (15)	57% (20)	32% (11)	68% (23)
Increased productivity	5% (21)	38% (8)	62% (13)	-	100% (13)	100% (2)	-	100% (6)		24% (5)	76% (16)	24% (5)	76% (16)
Easier to implement	4% (18)	39% (7)	61% (11)	-	100% (4)	25% (2)	75% (6)	83% (5)	17% (1)	59% (10)	41% (7)	56% (10)	44% (8)
Improved public image	5% (22)	41% (9)	59% (13)	67% (2)	33% (1)	-	100% (11)	88% (7)	13% (1)	55% (12)	45% (10)	50% (11)	50% (11)
Other companies also implemented	1% (6)	100% (6)	-	-	-	100% (2)	-	100% (4)	-	-	100% (6)	50% (3)	50% (3)
Total	405	30% (123)	70% (282)	9% (20)	91% (199)	27% (29)	73% (78)	94% (74)	6% (5)	42% (170)	58% (235)	35% (141)	65% (264)

Columns 5 through 10 present the data sub-divided by both respondent sector and financial expectations ("same" and "other"), where number in parentheses shows the number of clients responded. From the total number of responses listed in last row it can be observed that manufacturing (199 of 219) and not-for profit (78 of 107) clients mainly had "other" financial expectations (91% and 73% accordingly), but "Other" clients (74 of 79) tended to have the "same" financial expectations (94%) from implemented P2 suggestions. This can be explained that manufacturing and not-for profit sectors had more various expectations from each implemented P2 suggestion in general. Comparison of the responses to the total average by column showed that manufacturers (67%) and "other" (88%) clients mostly had the "same" expectations from "Improved public image", whereas all not-for profit clients had "other" expectations. "Reduced environmental and health risk" and "Health and safety benefits" were mostly reported by clients with "other" financial expectations.

In Columns 11 and 12 the data was sub-divided by decision makers (following the approach used in Section 4.3.3). An analysis of justifications by decision makers and size shows that "Regulatory compliance" was mostly driven by top and environmental managers and clients with more than 100 employees on site (84% each). "Improved public image" vice versa was driven mainly by "other managers" in decision making (55%) and clients who had less than 100 employees on the site (50%).

In Columns 13 and 14 the justification data was sub-divided by respondent's number of employees at work site. It was noted that larger clients (>100 employees) reported more expectations (65%) in general. Clients with less than 100 employees on site more often reported "Easier to implement" (56%), "Improved public image" (50%),

and “Environmental awareness” (49%). However, there is no clear relationship between higher number of responses and clients size and sector. A similar trend was noticed when “same” and “other” expectations were analyzed by number of employees on the site (size). Despite the size clients mostly had “other” expectations from the P2 implementation, but 73% of clients with more than 100 employees on site had the “same” expectations from “Improved public image” as from any other investments (Appendix G, Table G.6).

Summarizing, the respondents were consistent in reporting general benefits and justifications for implemented P2 suggestions. All clients regardless the sector have reported “Reduced operating cost” and “Payback period” as most important justifications. Some reported parameters vary by sector. These findings are coherent with early findings of DeCanio (1993), that projects with higher anticipated rates of return will be more likely selected. “Other” business clients reported Increased productivity as most common justification. Justifications most commonly named by manufacturers (all clients have more than 100 employees on site) included:

- Regulatory compliance, and
- Reduced environmental and health risk

Respondents from the not-for profit sector most commonly valued:

- Improved public image
- Easier to implement due to the changed infrastructure, and
- Environmental awareness.

Then all reported justifications (433) for P2 implementation regardless the client’s financial expectations were analyzed. Most common justifications were broken into 4

groups of motivating factors as shown in Table 4.9. The financial factors are the most common group of responses (59%), which includes direct (24%) and indirect or risk-based factors (35%). Thus, responses to justifications for implementing of specific P2 suggestions are very close to the responses on expected general benefits.

Table 4.9 Most common motivating factors

Factors	Total (433)	Components	% of responses to # of implemented suggestions (120)
Financial	59% (256)		
Indirect/ Risk based	35% (152)	Reduced environmental and health risk (spills, vapors etc.)	37% (44)
		Health and safety benefits/improvements	33% (40)
		Regulatory compliance	33% (39)
		Reduced business risk	24% (29)
Direct	24% (104)	Reduced operating cost	52% (62)
		Payback period	35% (42)
Social	21% (93)	Environmental awareness	31% (37)
		Corporate commitment	28% (34)
		Improved public image	18% (22)
Efficiency	14% (59)	Energy efficiency	32% (38)
		Increased productivity	18% (21)
Other	6% (25)	Easier to implement	15% (18)
		Other implemented similar	5% (6)
		Other	(1)

Since more than one justification for each implemented P2/sustainability recommendation could be selected, an analysis was performed to identify their cross-correlation (Appendix G, Table G.7). For the simplicity group of efficiency factors was combined with other factors. For example, reduced environmental and health risk was provided as a justification for 44 implemented P2/sustainability suggestions, health and

safety benefits were also provided as a justification for 31 of those. Thus 70% of the reduced environmental and health risk was indicated as a justification, health and safety benefits were also indicated. At the same time, health and safety benefits were provided as a justification for 40 implemented P2/sustainability suggestions, and reduced environmental and health risk was also provided as a justification for 31 of those. Thus 78% of the health and safety benefits were indicated as a justification, the reduced environmental and health risk was also indicated.

Further analysis of these factors by sector found that risk-based factors are the most important for all clients: from 30% for "other" clients to 37% for manufacturers (Table 4.10). First column of Table 4.10 lists client's sector. Next column presents the total number of responses by sector. Columns 3 to 5 list percentage and number of responses in parentheses, reported by clients for each group of motivating factors.

Table 4.10 Motivating factors by sector of a client

Sector	Total	Factors				
		Financial		Social	Efficiency	Other
		Indirect/ Risk based	Direct			
Manufacturing	217	37% (80)	30% (65)	16% (36)	15% (32)	2% (4)
Not-for profit	135	36% (48)	19% (25)	27% (37)	10% (14)	8% (11)
Other	81	30% (24)	17% (14)	25% (20)	16% (13)	12% (10)

It is noted that manufacturers had a highest percentage of responses reported on financial direct (30%) and indirect (risk based) factors (36%), and lowest on other factors (2%). Responses to social factors are similar for not-for profit (27%) and "other" clients (25%), but low for manufacturing sector (16%). Therefore, it can be concluded that

regardless the expectations and clients sector, the risk-based factors are the most important for the clients of this survey. These data are consistent with results of a survey conducted in Toronto Region (Granek et al. 2006), that showed cost savings and return on investment as important, but not primary consideration for implementing P2 projects, and findings of Lyon et al. (2002), stating that large firms implement voluntary environmental actions for solid economic reasons, however, the mechanism linking environmental and financial performance is still unclear. Williams et al. (1993) also identified governmental pressure, consumer and supplier pressure, investor pressure, community pressure and workforce pressure that impacted pollution control at businesses, which are consistence with regulatory compliance, public image, stakeholders/investors relations discussed and researched in this study.

Some evidence of the behavioral change was noted when clients responded to the following justifications for P2 implementation: Corporate commitment (34 responses), Easier to implement (18), Improved public image (22), and Other companies also implemented the same (6). These findings show an importance of awareness of principles of behavioral changes leading to sustainability changes (Diamond, 2013).

4.3.6 Analysis of Engagement in Sustainability Activity

The generation of wastes directly relates to the living standards in industrialized countries, which does not support sustainable lifestyle (Khan and Islam, 2012). According to the study of MIT Sloan Management School (MIT, 2011), waste reduction and energy efficiency emerged as top priorities for international respondents reported these as the activities their companies engaged in more frequently. In this study the

correspondence of the sustainability activities to the local businesses on example of companies operating in Nebraska was investigated. Responses to Question 5 of the survey "To what extent is your organization engaged in each of the following activities?" provide several options in scale from 1 to 5, with 1 – not considered, and 5 – always applied, that are common to MIT and Green Technologies and Practices (GTP) surveys. This question should help to identify in which activities companies tend to be involved the most.

The obvious similarity was noted in responses for P3 and MIT surveys. A comparison of engagement in P2/ sustainability activities based on responses to P3, MIT and Green Technologies and Practices (GTP) surveys was briefly discussed previously and presented in Table 4.5. The difference between the results of P3 and GTP surveys was noted in responses to "Natural resources conservation" and "Toxic compounds reduction". This might be explained that P3 clients think beyond traditional recycling, and more actively involved in hazardous waste and material management, storm water management and spills prevention.

Responses received for Question 5 were averaged for each sustainability activity and then analyzed by client size and sector. The relationship between engagement in sustainability activities, size and sector of clients is presented in Table 4.11. Nine types of activities are provided in descending order from the most to the least practicing according to the total average shown in Column 2. This column shows the average response to each question from the 26 respondents of the survey and the standard deviation of these responses. Analysis of responses shows that most activities survey respondents engaged

in are: waste reduction, improving energy efficiency, and reducing of pollutants or toxic compounds, which supports the findings of MIT survey.

Columns 3 through 7 of the Table 4.11 list the average responses to each question by size and sector of the clients. Analysis by size and sector of the company showed that clients with less than 100 employees on site tended to be less engaged in sustainability activities in general (2.6), and in such activities as "reducing greenhouse gas emissions" (2.0) and "analysis of risks associated with P2/sustainability issues" (2.6). This can be explained that these clients produce or use less toxic compounds, or greenhouse gas (GHG) emissions, while manufacturers (typically larger in size) in general, use and create more toxic compounds, wastes and GHG, thus are more regulated.

Table 4.11 Engagement in P2 activity based on size and sector

Activity	Total Ave. /Std. dev	Size (# of employees)		Sector (clients)		
		<100 (9)	>100 (17)	Manufacturing (12)	Not-for profit (6)	Others (8)
Reducing or eliminating the creation of waste materials	3.8/1.1	3.2	3.9	4.3	3.2	3.4
Improving energy efficiency	3.7/1.2	2.8	4.1	4.2	4.3	2.5
Reducing the creation or release of pollutants or toxic compounds	3.6/1.4	2.7	4.1	4.3	3.2	2.9
Conserving natural resources	3.3/1.3	2.7	3.6	3.8	3.0	2.6
Analyzing risks associated with P2 and sustainability issues	3.2/1.2	2.6	3.5	3.7	3.5	2.4
Building awareness of pollution prevention in the organization	3.1/0.9	3.0	3.1	3.2	3.7	2.6
Building culture of innovation by pursuing sustainability/P2 strategies	2.8/0.9	2.8	3.0	2.6	3.3	2.8
Reducing greenhouse gas emissions	2.8/1.3	2.0	3.3	3.4	2.7	2.1
Generating electricity, heat, or fuel from renewable sources	2.0/1.1	1.9	2.2	2.0	2.2	1.9
Total average (26)	3.1/0.6	2.6	3.4	3.5	3.2	2.6

For most of the activities the responses reported by "Other" clients were notably below the average. "Not-for profit" clients reported higher engagement in "building awareness in the organization" and "building culture of innovation by pursuing P2 strategies", which may be explained by more developed environmental management system in governmental organizations.

Table 4.12 presents the relationship between general benefits in addressing P2 implementation and client engagement in P2 activities. 47 responses on general benefits (some respondents listed more than one) were analyzed based on responses to Question 5, when clients rated their engagement in P2/sustainability activities on a scale from 1 to 5. The first column lists the general benefits (responses to Question 3 of the survey). Heading row lists the P2/sustainability engagement activities. Second column shows total average engagement data, the number of responses is given in parentheses.

Columns 3 through 11 show average engagement rate, received by averaging the responses of clients, who also responded to general benefits: i.e., 7 clients indicated "Risk reduction" as a general benefit (first row) in addressing P2/sustainability suggestions. Average engagement rate of those clients in "Toxins reduction" is 4.6. Last row shows total average for engagement in P2/sustainability. Standard deviations for each column are shown in parentheses and used for comparison of the average rates of engagement rated above or below than 0.5 standard deviation from a mean (shaded cells).

Table 4.12 Engagement in P2/sustainability activities and general benefits in addressing P2 implementation

General Benefits	Total ave. (# of responses)	Engagement (average)[1]								
		Toxins reduction	Waste reduction	Energy efficiency	Resource conservation	Analyzing risks	Building awareness	GHG reduction	Culture of innovation	Renewable sources
Risk reduction	3.8 (7)	4.6[2]	4.3	4.3	4.1	3.9	3.4	3.6	3.4	2.4
Enhanced stakeholder relations	3.6 (2)	4.5	4.5	4.0	4.5	3.5	3.0	3.5	3.0	2.0
Regulatory compliance	3.5 (8)	4.4	4.1	4.1	3.6	3.8	3.4	3.0	2.9	1.9
Health and safety	3.4 (9)	4.1	3.9	4.0	3.4	3.4	3.6	2.9	3.0	2.2
Resource conservation	3.3(10)	3.9	3.8	3.7	3.6	3.4	3.3	2.8	3.0	1.8
Better efficiency	3.3 (3)	4.3	4.7	4.0	3.7	3.3	3.3	3.0	2.3	1.3
Customer demand	3.3 (3)	3.3	3.7	3.7	4.3	3.0	3.0	3.0	3.3	2.3
Public image	2.9 (5)	2.8	3.0	3.4	3.0	2.8	3.0	2.6	3.4	1.8
Total Average / Std. Deviation	47	3.6 (1.4)	3.8 (1.1)	3.9 (1.2)	3.3 (1.3)	3.2 (1.2)	3.2 (0.9)	2.8 (1.4)	2.8 (0.9)	1.9 (1.0)

[1] - Responses in the table are average rating.

[2] - Shaded areas show the general benefits with average engagement rated above or below than 0.5 standard deviation from mean.

A relationship between the engagement in P2 activities and general benefits shows that respondents who see general benefits in risk reduction, regulatory compliance and enhanced stakeholder relations, are more engaged in toxins and wastes reduction, and energy efficiency. The average rates of engagement for these general benefits is higher than total average by column, and for most activities is higher than 0.5 standard deviation from mean (shaded cells). Only clients who considered Public image as a general benefit, were less engaged in toxins (2.8) and waste reduction (3.0), and for these activities average rate is lower than 0.5 standard deviation from mean (shaded cells). Those who

used Risk reduction as a primary motivator for implementation were more engaged in a wide range of sustainability activities, and mainly were represented by manufacturers. These findings support results of Sharfman et al. (2000) that economic benefits are important but not the main driving force for corporate environmental innovations.

4.3.7 Reoccurrence of Implemented P2 Suggestions

In addition to considering the percentage of a specific type of the implemented P2/sustainability suggestions, the "reoccurrence" of the benefits from the implementation helps define the degree of impact of the suggestion. "Reoccurrence" for this study was defined as number of sequential years that financial and non-financial benefits were realized from an implemented suggestion. No similar analysis has been found in the available technical literature, related to the longevity of the P2/sustainability implementation benefits. The survey respondents provided reoccurrence data for 110 out of 120 implemented P2/sustainability suggestions reported by the clients in the reassessment reports. Respondents were asked "Approximately how many sequential years were financial and non-financial benefits gained from each implemented opportunity?", with answer options including no or negative benefit, number of years from one to five, and that an implemented suggestion still provides benefit.

Most implemented P2/sustainability suggestions had a reported reoccurrence of either one year or less or a negative benefit (25%) or were still providing benefits (70%) (Appendix H, Table H.7). Only 5% (5) of implemented suggestions discontinued providing benefits after 1 year. Note that average period between the initial assessment

and the survey was 7.5 years, with an average of 7.9 years for P2/sustainability suggestions where the benefits were reported as still occurring; 97% of the suggestions where benefits were reported as still occurring had been suggested 5 or more years prior to the survey. Past research (Youngblood et al, 2008b) found that most suggestions were implemented in the first two years after the initial assessment. Thus, it is anticipated that few of the P2/sustainability suggestions reported as still providing benefits have a "life" less than 5 years. A detailed distribution of reoccurrence and years since original assessment and survey is presented in Table G.8, Appendix G. Thus, the reoccurrence data was simplified to report if an implemented suggestion continued to provide benefits longer than one year.

In order to examine implementation and reoccurrence trends, the P2/sustainability suggestions were divided into categories. One group of categories relates to "practices and procedures" which often were "low hanging fruit" requiring little implementation cost (70% of all implemented suggestions with implementation cost less than $100):

- Preventative Maintenance and Improved Housekeeping, including operating practices to minimize leaks, spills, and overflows (e.g., leak detection and repair for compressed air and water, spill prevention, routine inspection and maintenance of equipment, and spill prevention programs).
- Off-site recycling, which for these clients typically focuses on more challenging materials such as batteries, solvents, used oil, oil filters, plastics, wood, and pallets, since many other materials were already being recycled.

- Purchasing and Inventory control, including replacement hazardous materials by alternative products, purchasing of recycled products, and inventory tracking and control system integrated with purchasing.
- Training and Policy including spills prevention practices; a P2 and Environmental Management System policies and plans, formation of P2/Sustainability teams, and educational posters / materials.

Another group of categories were suggestions that often required more initial investment of capital (80% of all implemented suggestions with implementation cost more than $100):

- Equipment and Process Modification, including replacement of old or inefficient equipment, upgrading capability of existing equipment, process optimization, and changes to improve efficiency (e.g. alternative testing for wastewater contamination, reducing operating pressure, replacement of water cutting system).
- Energy Efficiency, including lighting improvements, more efficient equipment/motors, insulation, and control systems/sensors.
- Material Substitution, which is the substitution of an input with less hazardous or non-hazardous materials or more environmentally friendly product (e.g., use of aqueous parts cleaner).
- In-process recycling includes on-site reuse of waste materials (e.g., solvent still, burning used oil for heat).

An analysis of the P2/sustainability implementation rates and reoccurrence periods is provided in Table 4.13. The first column of the table lists the categories of implemented P2 suggestions. Second column of the Table 4.13 lists the implementation

rates of the original P2/sustainability suggestions based on the reassessment results of the surveyed clients. Suggestions related to the practices and procedures categories were generally implemented at a higher rate than the other categories, likely due to the lower implementation cost. The other columns list the reoccurrence period for each P2/sustainability category. The actual number of implemented suggestions is provided in parentheses.

Table 4.13 Reoccurrence of the implemented P2 suggestions by P2 category

P2 Category (# of implemented suggestions)	Implementation rate	Reoccurrence % (#)		
		<1 year	>1 year	No answer
Practices and Procedures Preventative maintenance (30)	61%	10% (3)	77% (23)	13% (4)
Training and Policy (14)	39%	14% (2)	71%(10)	14% (2)
Off-site recycling (22)	52%	45% (10)	45% (10)	9% (2)
Purchasing and Inventory Control (7)	30%	57% (4)	43% (3)	
Energy efficiency (17)	38%	6% (1)	88%(15)	6% (1)
Equipment modifications, Process Modification, Material Substitution, In-process Recycling (30)	26%	27% (8)	70% (21)	3% (1)
Total (120)	39%	23%(28)	69%(82)	8% (10)

Preventative maintenance/ housekeeping suggestions had the highest reported implementation rate (61%) and a high reoccurrence of benefits beyond one year (77%) comparing to other categories. This combination of high implementation and reoccurrence is believed to be due to being easily implemented suggestions with limited cost that result in safety, regulatory compliance, and/or cost benefits, and are often not recognized by clients until student intern provides documented business management report with costs and environmental impact.

The implementation rate for off-site recycling recommendations was 52% with low reoccurrence of benefits (45%) beyond one year. Note that for these clients most of the large quantity and common waste streams were already being recycled, thus these recommendations were focusing on smaller volume and harder to recycle materials such as batteries, wood pallets, etc. It was identified in the reassessment data that in many cases the recycling service providers were transient (often discontinuing recycling one of these materials) and the economics of these materials varied significantly year-to-year. This finding highlights the need to focus on source reduction and overall sustainability and move beyond recycling. All off-site recycling suggestions with reoccurrence less than one year were implemented in private sector, which highlights the differences between sectors.

Purchasing and inventory control recommendations also had a relatively low implementation rate (30%) and reoccurrence (43%). Reassessment data suggest that important contributing factors include cross-departmental barriers within the client organization (e.g., technical groups and purchasing), internal resistance to changing existing client-vendor relationships, and post-implementation changes in vendor cost structure that eliminated the prior financial benefits.

Energy efficiency recommendations had the higher reoccurrence (88%) beyond one year. This is believed to be due to the recommendations primarily being in installation of equipment (e.g., new lights, motors, sensors) that was only rarely removed (typically due to a subsequent change in a given building or process line).

Because of the relatively small sample sizes, similar implementation rates, and reoccurrence, data from equipment and process modification, material substitution, and

in-process recycling were combined in Table 4.13. Detail information of reoccurrence by P2 method is presented in Appendix G, Table G.9. This combined category had a relatively high reoccurrence (70%) since it primarily involved the purchase and installation of new equipment. In 27% of cases where reoccurrence was less than one year, a process line or portion of the facility was renovated making the modification obsolete.

Analysis of reoccurrence based on P2 recommendation method showed that this is the area for further improvement of the P3 program to make students aware of the types of suggestions that have certain challenges as: cross-departmental and institutional barriers, internal resistance, not beneficial recommendations etc. But at the same time, students shouldn't ignore small easy things that do not require big start-up costs, such as practices and procedures recommendations.

Analysis of P2/sustainability implementation for each category by initial costs showed similar trend for implementation of suggestions as was found for reassessment data. Initial cost was defined as less and greater than $100 for 94 implemented suggestions, where cost data was available. The majority of implemented suggestions had initial cost less than $100 (46%), except the suggestions related to energy efficiency and equipment modifications. 47% of these had initial cost higher than $100. Analysis of the relationship between reoccurrence and initial costs of implemented P2/sustainability suggestions (Appendix G, Table G.10) showed that 92% of P2 suggestions (23/25) with initial cost more than $100 provided benefit during 4 years and longer. Almost 60% of P2 suggestions (15/25) with no available initial costs had

reoccurrence less than one year or didn't provide benefit. No notable trends by sector, decision-making and client size were observed.

4.3.8 Summary

- It was found that in general the number of employees at the site (size) of a client does not affect decision making and reoccurrence of implemented P2 suggestions.
- Clients with less employees on site (<100) are less engaged in P2 activities. Most common types of activities for these clients are waste reduction and building awareness. The most important general benefits for these clients are Enhanced environmental awareness and Reduces business risk.
- For larger clients, with more than 100 employees on site, most common general benefits are: reduced operating cost and payback period. These clients more involved in toxins and waste reduction, and energy efficiency projects.
- Analysis of decision makers by two basic groups: (i) top managers and environmental managers either alone or together; and (ii) "other managers" alone or in combination with top and environmental managers found that different benefits and motivations were considered when different types of managers were involved. Thus, it might be important to know the decision makers in the company assessed by P3 interns since this might affect the factors likely to be considered by client.
- Most common general benefits reported by most of the clients are: i) resource conservation, ii) health and safety, and iii) regulatory compliance.

- Sustainability oriented activities in which clients more often engaged in, are: i) reducing or eliminating the creation of waste materials, ii) reducing the creation or release of pollutants or toxic compounds, and iii) improving energy efficiency.
- Clients considered risk-based factors as a primary motivation for implementation of the P2 suggestions were more engaged in sustainability activities. These clients more involved in toxins and waste reduction, energy efficiency and building awareness.
- Only not-for profit organizations implemented off-site recycling longer than one year.

CHAPTER 5 CONCLUSIONS

5.1 Introduction

Although this research is based on a small sample size and should be considered as a pilot study, the findings are consistent with technical literature and national surveys conducted among large international companies. These findings can help students and technical assistance providers working with clients, to improve the sustainability of client operations and use key motivating factors and client information as factors for further improvement of P3 program approaches. As it was mentioned in section 4.3.7 no other studies of reoccurrence of the P2/sustainability implemented suggestions have been found in the available technical literature. This study provides guidance to the potential longevity of implemented suggestions based on their type and method.

5.2 Conclusions

This study used two different methods: analysis of the reassessments reports prepared by student interns, and analysis of survey results conducted in January 2012. Methods and results were discussed in Chapters 3 and 4 correspondingly. Conclusions below are presented in two sub-sections according to these methods.

5.2.1 Reassessment Results Summary

- Payback periods and initial costs were important but not the only criteria considered by clients for implementation of P2/sustainability suggestions.
- The highest implementation rate had P2/sustainability suggestions related to energy efficiency and equipment modification.

- Financial problems, quality of the final product, working conditions, regulatory restrictions, not or less effectiveness, were the most common motivations for not implementing of some P2 suggestions.

5.2.2 Survey Results Summary

Based on the analysis of a survey results the following it was found:

Decision Making

- Similar results to MIT study were observed.
- When all levels of decision makers (top, environmental, and other managers) were involved, a higher number of P2/sustainability suggestions were implemented 5.9 (OM) versus 5.0 (TM/TM).
- Clients with other managers in decision making implemented higher number of P2 suggestions and more often considered other factors beyond payback period.

Justifications and benefits for P2 implementation

- Reduced operating cost (52%) and acceptable payback period (35%) were important for justification of the most of the implemented suggestions.
- Other most common motivations provided by clients were risk-based factors including: i) reduced environmental and health risk (35%), ii) health and safety (33%), iii) regulatory compliance (33%), and iv) reduces business risk (24%).

Financial Expectations in Addressing P2

- Many manufacturing companies considered factors allowing longer or negative payback period for P2/sustainability projects.

- Most "other business" clients had the same expectations from implementing P2 suggestions as from any other investments.

Engagement in sustainability activities

- Similar results received in P3 survey as national surveys.
- The three most common sustainability activities were: i) reducing or eliminating the creation of waste materials, ii) reducing the creation or release of pollutants or toxic compounds, and iii) improving energy efficiency.
- Manufacturing clients were more engaged in sustainability activities and more likely used risk-based factors as a primary motivation for implementation.
- Smaller clients (<100 employees on site) were more engaged in waste reduction and building awareness of pollution prevention in the organization, but less engaged in sustainability activities in general.

Reoccurrence of implemented P2 suggestions

- Clients more often implemented P2 projects with anticipated longer reoccurrence, especially if initial cost is high. 92% of P2 projects (23/25) with initial cost more than $100 provided benefits during 4 years and more (Appendix G, Table G.8).
- P2 suggestions related to Improved Housekeeping/Preventative Maintenance had the highest implementation rate and longest reoccurrence: more than 88% still provide benefit. Reoccurrence of Energy efficiency and Equipment modification suggestions found to be 84%.
- Only non-for profit organizations implemented off-site recycling longer than one year. New off-site recycling suggestions had a relatively low reoccurrence rate (50%).

5.3 Future Work

The P3 program is an important tool in equipping future environmental engineers and scientists with extensive knowledge of sustainability concept and its achieving. Reassessments of implementation status provided data and information for further research and improvements of the technical assistance modes. Surveys conducted in different years also brought an understanding of long-term impact of P3 program on both business clients and P3/sustainability interns and service providers.

Though this study is based on a small sample size, the results are consistent with national surveys and technical literature. The following points should be considered for future research:

- Regular follow-up and reassessments are important for collecting metric data and information of implemented P2 suggestions.
- Regular surveys provide additional information for further research and analysis of effectiveness of intensive sustainability program.
- Modified survey form should be used in future surveys, based on lessons learned. Specific suggestions for modification of the survey questions to better response rate were developed. Revised survey form with justification of suggestions is provided in Appendix I.
- Improvement of the reassessment forms to collect additional data, such as: client sector, size (number of employees), reoccurrence of implemented suggestions, etc.
- Since almost no reoccurrence information for implemented P2/sustainability suggestions available in technical literature, it may be a key point for future research.

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Appendix A. Reassessment Instructions (Standard Operating Procedure), UNL Partners in Pollution Prevention

Reassessments: Method of helping UNL P3 program learn about successes from past implementation of P2 suggestions, and learn to improve the assistance provided clients. Also valuable for helping interns learn about assessment process and encouraging businesses to renew efforts to implement suggestions.

1. Arrange for reassessment visit and discuss what a reassessment is with client (via phone or in person).
   Confirm that the client has a copy of the original technical assistance report. If the client has lost or does not remember the report, be sure to arrange to get the client a copy.
2. Review the original technical assistance report submitted to the client:
   - Check out the original report from UNL P3 Final Report Library (2nd floor Chase Hall). Make photocopies of the original report if needed.
   - List the original recommendations/suggestions made to the client on the reassessment form. Prepare a list of questions based on what is needed to complete the reassessment form.
     - Identify waste reduction and cost savings estimates, and understand how the original intern made each of these estimates.
     - Review the original report's "impact" form.
     - Note the reduction / savings for each recommendation in the original report, possibly to be used in the "high/low game".
     - Consider how to help the client make estimates of potential savings, if none are presented in the original report.
     - Note the media (solid waste, water, hazardous materials/waste, energy, etc.) involved in each original recommendation.
   - Include in your list, questions that will help you complete the questions on the last page of the reassessment form (e.g., Other P2 suggestions the client implemented since first assessment, "P2 policy", "P2 team" and "EMS", did the previous P2 intern assessment have an impact on the business, etc.).
3. Visit client and discuss the status of each original P2 suggestion.
   Visits may last anywhere from 20 minutes to an hour. The client may include a site tour or you may ask for one.
   Obtain the client's description (and perception) of the actual outcome of implementing suggestions. Stress that you want the reduction/savings outcomes to be as accurate as possible.
   If a suggestion WAS implemented, determine reductions/savings by:

- Ask clients to consult purchasing orders and waste disposal manifests or other existing records to accurately quantify savings.
- If the purchasing and disposal records are not available, ask client to estimate the outcomes based on any other methods routinely used by the client.
- Only if the client asks for help in making an estimate, can the potential cost savings and waste reduction estimated during the original assistance be provided as a starting point.

Determine the number of reoccurring years using the instructions discussed in class. If the benefits from implementing a suggestion will occur for an indeterminate period into the future, enter ">5 years".

If a suggestion was NOT implemented, learn why by asking follow-up questions.

Ask the client questions from the last page of the reassessment form (e.g., additional P2 implementation, "P2 policy", "P2 team", "EMS", etc.).

4. Prepare a narrative feedback report for the client (and the P3 program). In this report, start with a background paragraph. Then for each original P2 recommendation, state what the recommendation was and the metrics expected from implementation, what was learned about the implementation status and any direct benefits realized, and then discuss any additional indirect benefits realized. At the end of the report, explain what else you learned from the reassessment, in terms of other overall indirect benefits of the assistance, and how to improve future assistance to enhance the likelihood of P2 implementation.

   As part of the discussion of additional or indirect benefits, consider factors like liability reduction or employee exposure reduction from the implementation of a suggestion. Also consider if you can quantify the life cycle benefits in terms of energy savings and greenhouse gas emission reductions. Include these life cycle benefits in the discussion of additional benefits.
5. Offer to provide additional assistance to the client on new or unresolved P2 issues. In most cases this means providing an additional report to the client.
6. Complete the reassessment forms using the information you have gathered. Typically you do not share the "reassessment form" with the client. The P3 staff will review your reassessment report and form, and may ask you to respond to specific questions. In some cases you may need to contact the client to gather additional information to complete the reassessment.
7. Deliver the completed feedback report to the client explaining your findings.
8. Submit your report and completed reassessment forms to the P3 program as part of your mid-summer and final reports.

Appendix B. Reassessment Form Template

Pollution Prevention Reassessment Form (use one reassessment form for each management report/business reassessed)
Intern:
Business: _____
This is a reassessment of the _____project completed by _____. Placement mode of initial intern: insert IP, IA, or SB

P2 Opportunity (Brief Description)	Implemented			Not Implemented			Doing Before Assessment	Comments
	As Suggested	With Modification	Similar Idea	Investigated	Not Investigated	Don't Know		
								Source:
								Source:
								Source:
								Source:
								Source:
								Source:
								Source:
								Source:
								Source:

Note for Comments Column: Be sure to indicate what source was reduced for each opportunity implemented above (solid waste, hazardous material or waste, water use or water pollution, electricity, natural gas, diesel, coal, air emissions) Add any other comments which clarify status or future plans, particularly for those not implemented.
How many of the P2 suggestions that you checked in NOT Implemented categories did client say he/she was still interested in?_____
How many of the P2 suggestions that you checked in NOT Implemented categories did client ask you to investigate further?

_____

As you reassessed the business, did you make any other P2 suggestions? (yes or no) yes

Instructions and Additional Information

Fill out the following sections for each of the P2 suggestions that you checked in the Implemented categories above. Copy and insert as many additional opportunity sections as you need, numbering sequentially to coincide with the accompanying management report wherein you provide a brief discussion of all P2 suggestions. Explain why each is in its category in the above table. Include discussion of metrics with proper units for each opportunity in the table.

Try to obtain metrics for all implemented suggestions—they are very important for program analysis. If an opportunity was implemented but no savings metrics were obtained, still list the opportunity and give a brief reason why. Reasons may include: promoting good practices in others, health/safety benefits, not enough time has passed to quantify, still working on, or other reasons.

Definitions:
Hazardous Material – Process input supplies and feedstocks that are toxic or hazardous. Examples include chemicals, solvents, pesticides, etc.
Hazardous Waste – State and/or federally listed hazardous or toxic wastes or waste meeting the criteria for ignitability, toxicity, corrosivity, or reactivity.
Initial Cost – Expense of implementing pollution prevention opportunity.
Use local NE costs if you do not have client specific information to determine waste and energy cost reductions (e.g., landfill disposal fees per ton of waste, electricity cost per kWh and wastewater charges per 1,000 gallons).

Opportunity # Description: _____

Quantification Possible? (yes or no) _____ If no, why not?_____
Recurring years of benefit: ___years If benefit is greater than 5 years, write >5

Cost Savings:

Savings: _____ $/year

Initial Cost: _____ dollars

Energy:

Electricity Reduced: _____ kWh/year

Other Energy: _____ (Natural Gas, Diesel, Coal, Other)

_____ Quantity _____ Units

Units: (Nat Gas=Therms/yr; Diesel=Gal/yr; Coal=Tons/yr)

Hazardous Materials:

Pounds Reduced: _____ lbs/year

Water Use:

Gallons Reduced: _____ gallons/year

Hazardous Waste:

Pounds Reduced: _____ lbs/year

Water Pollutions:

Pollutant Reduced: _____ lbs/year of _____

(COD, BOD, toxics, nutrients, stormwater contaminants, TSS)

Solid Waste:

Pounds Reduced: _____ lbs/year

Air Emissions:

Emissions Reduced: _____ lbs/year of _____ (toxics, CO2, NOx, VOC, SOx, PM)

Releases: Releases Prevented: _____ average number per year

Material Prevented from release: _____

How much will be prevented from release? _____ lbs/year Where would release have gone? _____

Additional Indirect/Intangible Benefits: _____

Additional Questions:

Other P2 suggestions the client implemented since first assessment:

Burn waste oil to heat the bus bay, metal recycling

Did your business contact report that the previous P2 intern assessment had an impact on the business? (yes or no)
If yes, what impact?

Implemented more P2 opportunities, increased environmental awareness

If the client could speak with the intern who first assessed this business, what suggestions would they give him/her to improve the rate of implementation of suggestions or acceptance of P2 by the business?

n/a

Did the client report implementing a P2 policy within the last three years? (yes or no)
Did the client report establishing a P2 team within the last three years? (yes or no)
Did the client report establishing an EMS within the last three years? (yes or no)

Additional comments about initial assessment, the reassessment, interest in having a P3 intern in the future, etc:

New technical assistance from the P3 Program will be received in near future. It is reccomended to establish P2 Team and EMS

Appendix C

Phone Script for Follow-Up Calls

- Hi, my name is Ayna Kekilova. I'm a graduate student of the Environmental Engineering Program at the Department of Civil Engineering, UNL. I am affiliated with the Partners in Pollution Prevention Program (P3), in assessing impact from past P3 intern projects. This information will help assess how to maximize the value of such intern projects.
- May I talk to someone who is appropriate in making the decision to participate in the survey as a company? Typically this isan environmental manager, production manager, or owner, or person in charge for environmental issues? Our contact for our last reassessment was Mr./Ms. _____, who's title was _____ (Environmental Manager, etc.).
- Your company has participated in Pollution Prevention Program (P3) in _____ year. Currently we are conducting a survey to identify the motivations for implementation of certain types of P3 suggestions.
- Few weeks ago we send a survey along with the cover letter and Informed Consent Form addressed to the person in charge for environmental issues and I would like to follow-up this.
- Did you receive this survey?

  Option 1. If not:

    - Do you want us to re-send it?
    - Do you want to receive it by e-mail?
        - If yes – Could you spell your e-mail address?

Option 2. If yes:

- Did you already fill the survey up?

Option 3. In both cases:

- Would you mind to be interviewed by phone? The interview will not take more than fifteen (15) minutes. There are 7 general questions and 3 specific for your company. I will read the questions to you and write down your

responses. After the completion of the survey form, I will e-mail it to you for you could check if the answers are written correctly.

*If client's representative decides first to receive the documents, send the documents and informed consent form by e-mail or fax, and then call back to interview them.

*If client's representative agreed to be interviewed by phone, read the consent form first, then start reading the questions.

Thank you very much for your cooperation. I will e-mail you the survey with answers in 5 minutes.

Appendix D Example of Survey Form

SUMMARY

The P2 assessment of _____ was conducted in 200_ by P3 intern _____. According to the reassessment, conducted in 200_ by intern _____ five (5) of nine suggested suggestions were implemented; however metric information was not available for all suggestions at the time of the reassessment. Brief description of the suggestions and their direct benefits is summarized in Table 1.

Table E.1 Implemented P2 Suggestions Summary

#	P2 Opportunity	Direct Benefits
1	Repair leaks in air compressor	Cost savings $5,000/year Reduced amount of electricity used 100,000 kWh/yr

GENERAL QUESTIONS

Definition of Pollution Prevention for this survey - "Pollution prevention (P2) is reducing or eliminating waste at the source by modifying production processes, promoting the use of non-toxic or less-toxic substances, implementing energy efficiency and resource conservation, and re-using materials rather than putting them into the waste stream."

1. Who in your organization typically factors P2 considerations into decision making? Check all that are appropriate.
   - ☐ Top management, who determine a strategy of organization as a whole
   - ☐ Managers in environmentally-dedicated roles
   - ☐ Managers in other functions or units
   - ☐ Our organization does not factor P2 considerations into decision making
   - ☐ Do not know
2. When deciding P2-related investments, which financial expectations does your organization have? Check one.
   - ☐ Expectations are the same as any other investments
   - ☐ Other factors allow P2/environmental projects to have longer or negative payback periods
   - ☐ Do not know

3. If you answered "YES" to "Other factors" what are the benefits to your organization in addressing P2? Check up to 3.
   - ☐ Customer demand
   - ☐ Enhanced stakeholder/investor relations
   - ☐ Improved brand reputation/Public image
   - ☐ Increased employee productivity
   - ☐ Better efficiency/productivity
   - ☐ Equipment replacement at end of useful life
   - ☐ Less environmental impact, resource conservation
   - ☐ Regulatory compliance
   - ☐ Risk reduction (reduced spills, liability etc.)
   - ☐ Safety and worker health (better conditions, etc.)
4. Does your organization prepare some type of annual Sustainability Reporting (GRI, annual water, solid waste, electricity usage benchmarking, etc.)?
   - ☐ Yes
   - ☐ No
   - ☐ Not sure
5. To what extent is your organization engaged in each of the following activities? Rate on a scale of 1 to 5, with the following assumptions: 1 – not considered; 2- under consideration; 3 –sometimes applied; 4 – frequently applied; 5 – always applied.

____ Building awareness of pollution prevention in the organization
____ Building culture of innovation by pursuing sustainability/P2 strategies
____ Analyzing risks associated with P2 and sustainability issues (environmental, legal, competitive, reputational, resource access, political risk etc.)
____ Reducing greenhouse gas emissions
____ Generating electricity, heat, or fuel from renewable sources
____ Improving energy efficiency
____ Conserving natural resources (storm water management, soil conservation, sustainable forestry, etc.)
____ Reducing or eliminating the creation of waste materials
____ Reducing the creation or release of pollutants or toxic compounds

SPECIFIC QUESTIONS

1. For each P2 suggestion, what benefits were important to your organization in justifying the implementation? Please check all that are appropriate in the Table below.

Justification	Implemented P2 suggestions		
	a	b	c
Acceptable payback period			
Energy efficiency			
Reduced operating cost			
Health and safety benefits			
Regulatory compliance			
Reduced environmental and health risk (spills, vapors, liability etc.)			
Reduced business risk (impact of changes in regulation, input costs etc.)			
Increased employee productivity			
Enhanced environmental awareness/ new ideas/knowledge			
Improved public image			
Other companies also implemented the same or similar solution			
Corporate commitment to resource use/waste reduction			
Easier to implement due to the changed infrastructure (better equipment or conditions)			

2. Approximately how many sequential years were financial and non-financial benefits gained from each implemented opportunity? Please check the appropriate cell in the Table below.

Years of benefit	Implemented P2 suggestions		
	a	b	c
No or negative benefit			
One year or less			
Two years			
Three years			
Four years			
Five years			
Still provides benefit			

Appendix E Supporting Tables for Reassessment Analysis

Table E.1 Profile of clients reassessed between 2005 and 2011.

Size	# of clients
<100 employees	34
>100 employees	29
Sector	
Manufacturing	18
Non-for profit (governmental)	14
Other	31

Table E.2 Distribution of data by initial cost and payback period

Zone	Payback, year	Initial cost, $	Implemented	Not implemented	% of Implemented
A	<1	<1000	104	54	66
B	<1	>1000	11	15	42
C	1-2	<1000	6	5	55
D	1-2	>1000	9	8	53
E	2-4	<1000	3	5	38
F	2-4	>1000	4	10	29
G	>4	<1000	6	3	67
H	>4	>1000	7	16	30
Total			150	116	

Table E.3 Percent of implemented suggestions based on initial implementation cost

Initial cost	Implemented	%
<100	87	58%
100-499	18	12%
>500-999	15	10%
>1000-4999	12	8%
>5000-9999	7	5%
>10000	11	7%
	150	100%

Appendix F P2 Approaches and Methods

Categories of Pollution Prevention Suggestions:

1) Practices and Procedures

a) Purchasing

- purchase only the amount of raw materials needed for a production run or a set period of time
- develop review procedures for all materials purchased
- replace hazardous materials if possible

b) Inventory Control

- buy only what you know you will use
- rotate inventory so older material is used first
- store material to prevent spills and leaks
- set up an inventory tracking system
- label all containers with contents and date
- don't accept free samples unless you know you will use them
- stockless production
- customer/supplier networking
- pull system
- JIT transportation

c) Improved Housekeeping/ Preventative maintenance. The use of improved operating practices can reduce spills, overflows, leaks and other inefficiencies. These practices will often increase profits with little or no capital outlay:

- inspect and maintain equipment routinely
- replace seals and gaskets on a regular basis
- repair leaks immediately
- use tight-fitting lids to prevent evaporation
- wipe up spills whenever possible rather than hosing them down
- use spigots and pumps instead of pouring
- label all containers with contents and date
- have a spill prevention program
- use drip pans

d) Training

- Explain the environmental, health and safety consequences of spills or poor management practices.

- provide employee incentives (bonuses, awards, other recognition)
- train employees on proper waste handling, equipment use, etc.

e) Waste Segregation

- In most cases, it is easier to reuse/treat/dispose a waste that contains only one contaminant than a waste containing many different contaminants.
- When hazardous wastes are mixed with non-hazardous wastes, the resulting waste is hazardous waste.

2) Equipment Modifications. Old or inefficient processes and equipment often account for excess use of toxic substances and unnecessary generation of (hazardous) waste.

- change equipment operating conditions, such as flow rates, temperatures, pressures, etc.
- use more efficient equipment
- modify photocopiers so they use a refillable toner cartridge
- replace incandescent lighting with energy-efficient compact fluorescent lighting

3) Material Substitution. Hazardous materials used either in the formation of a product or in a production process may be replaced with less hazardous or non-hazardous materials.

4) Product Reformulation. Product reformulation is a more difficult waste reduction technique, yet reformulation can be very effective. Examples of product reformulation include:

- using double sided photocopies instead of single sided copies.
- reusing envelopes (e.g., intra-company mail).
- reducing the aluminum thickness in a soda can.
- elimination of pigments that contain heavy metals from ink, dyes and paint formulations development of new paint, ink and adhesive formulations based on water rather than organic solvents.

5) Process Modification. Changing the processes or operations used to create the same end product while minimizing waste or increasing efficiency.

Examples:

- use different equipment (using a different technology)
- incineration oven instead of (hazardous) solvent to test bitumen content in asphalt
- shape metal parts by dry grinding and milling instead of using a grinding and milling using a cutting fluid.
- keep food warm by better insulating it instead of using a heating lamp

- performing the COD test using non-hazardous Manganese instead hazardous Dichromate (equipment used also changes).

6) In-Process Recycling. Use and reuse of waste materials to reduce the amount of waste generated. Examples:

- recycling a waste back into the production process as a raw material
- purchasing distillation or recovery units (for fluids and solvents)
- reduce salt consumption of industrial (ion exchange) water softeners by capture and reusing brine.
- joining a waste exchange

7) Energy Efficiency (E2)

- reduce thermostat setting
- turn lights off
- change lighting type
- use fume hood only when needed
- insulate ovens / pipes
- insulate buildings
- add time to energy using devices
- use energy star appliances
- eliminate compressed air leaks (or inappropriate uses of compressed air)
- replace old motors / compressors

Appendix G Supporting Tables for Survey Analysis

Table G.1 Profile of survey respondents

Clients profile (26)			
Size	#	Person completed P2 survey	#
<100 employees	9	Same	14
100-1000 employees	14	New	10
>1000 employees	3	Do not know	2
Sector	#	Years from original assessment	#
Manufacturing	12	≤ 3 years	1
Non-for profit (governmental)	6	4-8 years	16
Other	8	>8 years	9

Table G.2 Implementation rate according to P2 method

Method	Implemented	Not implemented
Training	67% (2)	33% (1)
Preventative maintenance	55% (38)	45% (31)
Waste segregation	53% (20)	47% (18)
Energy efficiency	47% (20)	53% (23)
Inventory Control	44% (4)	56% (5)
Equipment modification	36% (14)	64% (25)
Purchasing	33% (3)	67% (6)
Material Substitution	24% (5)	76% (16)
In-process Recycling	23% (5)	77% (17)
Process modification	16% (9)	84% (49)
Total	39% (120)	61% (191)

Table G.3 Annual sustainability reporting, size, sector and decision making

Parameter		Reporting (total # responses)		
		Yes (11)	No (14)	Not sure (1)
Size	<100	11% (1)	78% (7)	10% (1)
	>100	59% (10)	41% (7)	
Sector	M	50 % (6)	50 % (6)	
	N	50 % (3)	33 % (2)	17 % (1)
	O	25 % (2)	75 % (6)	
Decision making	TM/EM	40% (6)	60% (9)	
	OM/TM/EM	50% (5)	40% (4)	10% (1)
	Do not know		100% (1)	

Table G.4 Detailed distribution of decision making responses

Decision making option	Total	# of responses to				
		Checked alone	TM/EM	TM/EM /OM	TM/OM	EM/OM
Top management	20	8	5	5	2	2
Environment managers	14	2				
Other managers	10	1				
Not factor P2 into decision making	0	0				
Do not know	1	1				
Total	45					

Table G.5 Decision makers vs Implementation rate (based on reassessment reports)

Decision makers	Total	Implementation rate per client	Not Implemented	Implemented
TM/EM (15)	100% (159)	5.0	52% (83)	48% (76)
OM (10)	100% (173)	5.9	66% (114)	34% (59)
Total (25)	100% (332)	5.4	59% (197)	41% (135)

Table G.6 Justifications for implementation of specific P2 recommendations and financial expectations by size

Justifications	Size			
	<100 employees		>100 employees	
	same	other	same	other
Acceptable payback period	18% (2)	82% (9)	30% (9)	70% (21)
Energy efficiency	13% (2)	87% (13)	30% (7)	70% (16)
Reduced operating cost	29% (5)	71% (12)	35%(15)	65% (28)
Health and safety benefits	17% (2)	83% (10)	29% (6)	71%(15)
Regulatory compliance	20% (1)	80% (4)	37%(10)	63% (17)
Reduced environmental and health risk	8% (1)	92% (11)	32% (8)	68% (17)
Reduced business risk	10% (1)	90% (9)	8% (1)	92%(11)
Increased employee productivity	20% (1)	80% (4)	44%(7)	56% (9)
Enhanced environmental awareness	22% (4)	78% (14)	37% (7)	63%(12)
Improved public image	9% (1)	91% (10)	73% (8)	27%(3)
Other companies also implemented	100%(3)	-	100%(3)	-
Corporate commitment	18% (2)	82% (9)	39% (9)	61% (14)
Easier to implement due to the changed infrastructure	30% (3)	70% (7)	50% (4)	50% (4)
Other	-	-		100% (1)
402	20%(28)	80%(112)	36%(94)	64%(168)

Table G.7 Specific justifications for P2 implemented recommendations by motivating factors reported by P3 respondents

Specific justifications by motivating factors	Total (433)	Specific justifications by motivating factors (# responses)											
		Financial						Social			Other		
		Risk-based				Direct							
		Reduced environmental and health risk	Health and safety benefits	Regulatory compliance	Reduced business risk	Reduced operating cost	Acceptable payback period	Enhanced environmental awareness	Corporate commitment	Improved public image	Energy efficiency	Increased employee productivity	Other
Reduced environmental and health risk (spills, vapors, liability etc.)	44		70%	57%	64%	43%	41%	41%	39%	27%	36%	34%	30%
Health and safety benefits	40	78%		63%	60%	55%	48%	50%	45%	30%	45%	38%	35%
Regulatory compliance	39	64%	64%		51%	33%	28%	38%	33%	26%	26%	44%	18%
Reduced business risk (impact of changes in regulation, input costs etc.)	29	97%	83%	69%		55%	52%	48%	52%	28%	48%	38%	24%
Reduced operating cost	62	31%	35%	21%	26%		56%	42%	45%	21%	56%	26%	34%
Acceptable payback period	42	43%	45%	26%	36%	83%		33%	60%	24%	67%	29%	33%
Enhanced environmental awareness/ new ideas/ knowledge	37	49%	54%	41%	38%	70%	38%		54%	49%	62%	27%	43%
Corporate commitment to resource use/ waste reduction	34	50%	53%	38%	44%	82%	74%	59%		29%	56%	32%	44%
Improved public image	22	55%	55%	45%	36%	59%	45%	82%	45%		55%	23%	68%
Energy efficiency	38	42%	47%	26%	37%	92%	74%	61%	50%	32%		32%	39%
Increased employee productivity	21	71%	71%	81%	52%	76%	57%	48%	52%	24%	57%		43%
Other	18	52%	56%	28%	28%	84%	56%	64%	60%	60%	60%	36%	

Table G.8 Relationship between reoccurrence and years since original assessment

Years of benefit	Implemented P2 # (%)	Years between original assessment and survey, # responses							
		3	5	6	7	8	9	10	≥12
No or negative benefit	17 (15%)			8		5	1	2	1
One year or less	11(10%)		2		2	1	4		2
Two years	2 (2%)				1				1
Three years	2 (2%)			1					1
Four years	1 (1%)			1					
Five years	-								
Still provides benefit	77 (70%)	2	10	12	4		15	23	11
Total	110	2	12	22	7	6	20	25	16

Table G.9 Reoccurrence of the implemented P2 suggestions by detailed P2 category

P2 Category	% implemented	Reoccurrence % (#)		
		<1 year	>1 year	No answer
Practices and procedures				
Preventative maintenance (30)	61%	10% (3)	77% (23)	13% (4)
Off-site recycling (22)	52%	45% (10)	45% (10)	9% (2)
Training and Policy (14)	39%	14% (2)	72% (10)	14% (2)
Purchasing and Inventory Control (7)	30%	57% (4)	43% (3)	
Energy efficiency (17)	38%	6% (1)	88%(14)	6% (1)
Equipment modifications (13)	45%	23% (3)	69% (9)	8% (1)
Process Modification (7)	16%	29% (2)	71% (5)	
Material Substitution (5)	22%	30% (2)	60%(3)	
In-process Recycling (5)	29%	20% (1)	80% (4)	
Total (119)	39%	23%(26)	69%(83)	8% (10)

Table G.10 Relationship between reoccurrence and initial cost

Reoccurrence (years)	Total	Initial cost, $		
		n/a	<100	100>
<1	31% (29)	60% (15)	25% (11)	8% (2)
>1	69% (65)	40% (10)	75% (33)	92% (23)
Total	94	27% (25)	46% (44)	27% (25)

Appendix H Survey Responses

GENERAL QUESTIONS

1. Who in your organization typically factors P2 considerations into decision making? Check all that are appropriate.

Table H.1 Responses to survey Question 1

##	Response	P3	P3 %	MIT %
1	Top management, who determine a strategy of organization as a whole	20	44	45
2	Managers in environmentally-dedicated roles	14	31	21
3	Managers in other functions or units	10	22	18
4	Our organization does not factor P2 considerations into decision making	0	0	5
5	Do not know	1	2	2
6	Sustainability is not typically considered anywhere, but it is factored into decision making occasionally by managers	n/a	n/a	10
	Total	45		

2. When deciding P2-related investments, which financial expectations does your organization have? Check one.

Table H.2 Responses to survey Question 2

	Response	P3 #	P3 %	MIT[1] %
1	Expectations are the same as any other investments	12	46	21
2	Other factors allow P2/environmental projects to have longer or negative payback periods	12	46	10
3	Do not know	2	8	9
	Intangible/qualitative factors are considered	n/a		19
	Risk scenarios are considered	n/a		18
	ROI or IRR expectation hurdles are lower	n/a		15
	Our organization does not factor sustainability considerations into decision making	n/a		8
	Total	26		

[1] Due to MIT survey mostly covered broad sustainability questions, for similar question they have more response options what might affect the distribution of responses.

3. If you answered "YES" to "Other factors" what are the benefits to your organization in addressing P2? Check up to 3.

Table H.3 Responses to survey Question 3

Response	P3 #	P3 %	MIT %
Less environmental impact, resource conservation	10	21	-
Safety and worker health (better conditions, etc.)	9	19	-
Regulatory compliance	8	17	18
Risk reduction (reduced spills, liability etc.)	7	15	14
Improved brand reputation/Public image	5	11	49
Customer demand	3	6	-
Better efficiency/productivity	3	6	17
Enhanced stakeholder/investor relations	2	4	10
Equipment replacement at end of useful life	-	-	-
Increased employee productivity	-	-	5
Other	-	-	-
Total	47		

4. Does your organization prepare some type of annual Sustainability Reporting (GRI, annual water, solid waste, electricity usage benchmarking, etc.)?

Table H.4 Responses to survey Question 4

	Response	#	%
1	Yes	11	44
2	No	14	52
3	Not sure	1	4
	Total	26	

To what extent is your organization engaged in each of the following activities? Rate on a scale of 1 to 5, with the following assumptions: 1 – not considered; 2- under consideration; 3 –sometimes applied; 4 – frequently applied; 5 – always applied.

Table H.5 Responses to survey Question 5

	Activity	P3	MIT
1	Building awareness of pollution prevention in the organization	3.1	3.22
2	Building culture of innovation by pursuing sustainability/P2 strategies	2.8	3.06
3	Analyzing risks associated with P2 and sustainability issues (environmental, legal, competitive, reputational, resource access, political risk etc.)	3.2	3.1
4	Reducing greenhouse gas emissions	2.8	2.83
5	Generating electricity, heat, or fuel from renewable sources	2.0	n/a
6	Improving energy efficiency	3.7	3.69
7	Conserving natural resources (storm water management, soil conservation, sustainable forestry, etc.)	3.3	n/a
8	Reducing or eliminating the creation of waste materials	3.8	3.69
9	Reducing the creation or release of pollutants or toxic compounds	3.6	n/a

SPECIFIC QUESTIONS

1. For each P2 suggestion, what benefits were important to your organization in justifying the implementation? Please check all that are appropriate in the Table below.

Table H.6 Responses to survey Question 6

Justification	P3 #	P3 %
Reduced operating cost	62	14%
Reduced environmental and health risk (spills, vapors, liability etc.)	44	10%
Acceptable payback period	42	10%
Health and safety benefits	40	9%
Regulatory compliance	39	9%
Energy efficiency	38	9%
Enhanced environmental awareness/ new ideas/knowledge	37	9%
Corporate commitment to resource use/waste reduction	34	8%
Reduced business risk (impact of changes in regulation, input costs etc.)	29	7%
Improved public image	22	5%
Increased employee productivity	21	5%
Easier to implement due to the changed infrastructure (better equipment or conditions)	18	4%
Other companies also implemented the same or similar solution	6	1%
Other	1	0%
Total	433	100%

2. Approximately how many sequential years were financial and non-financial benefits gained from each implemented opportunity? Please check the appropriate cell.

Table H.7 Responses to survey Question 7

##	Years of benefit	Implemented P2 suggestions	
		# of responses	%
1.	No or negative benefit	17	15%
2.	One year or less	11	10%
3.	Two years	2	2%
4.	Three years	2	2%
5.	Four years	1	1%
6.	Five years	-	-
7.	Still provides benefit	77	70%
8.	Total	110	100%

Appendix I. Suggestions for Modification of the Survey.

Suggested Revisions:

- Items suggested for addition are shadow and underlined
- Items suggested for deletion are ~~strike through~~.

SUMMARY

Results of initial assessment and reassessments with metric information in table.

Table 1. Implemented P2 Suggestions Summary

##	P2 Opportunity	Direct Benefits
2003		
1	Recycle bulbs and batteries	Reduced amount of solid waste 180 lbs/yr

GENERAL QUESTIONS

Definition of Pollution Prevention for this survey - "Pollution prevention (P2) is reducing or eliminating waste at the source by modifying production processes, promoting the use of non-toxic or less-toxic substances, implementing energy efficiency and resource conservation, and re-using materials rather than putting them into the waste stream."

Suggested Revisions to Question 1:

- *Add "(indicate: _____)" to help explain title of individual and*
- *Remove question "Our organization does not factor P2 considerations into decision making" because none of the 26 respondents selected this option.*

1. Who in your organization typically factors P2 considerations into decision making? Check all that are appropriate.

☐ Top management, who determine a strategy of organization as a whole
☐ Managers in environmentally-dedicated roles
☐ Managers in other functions or units (indicate _____)
☐ ~~Our organization does not factor P2 considerations into decision making~~
☐ Do not know

Suggested Revisions to Question 2: No modifications.

2. When deciding P2-related investments, which financial expectations does your organization have? Check one.

☐ Expectations are the same as any other investments
☐ Other factors allow P2/environmental projects to have longer or negative payback periods
☐ Do not know

Suggested Revisions to Question 3:

- *Remove from the question phrase "If you answered "YES" to "Other factors"…" To get more responses it is better if all the clients will ask all the questions. Even if they reported the same expectations for Question 2, they still should consider some other benefits.*
- *Combine questions "Increased employee productivity" and "Better efficiency" due to their similarity and few responses (3) for "Better efficiency" and no responses for "Increased employee productivity".*
- *Remove question "Equipment replacement at end of useful life" because none of the 26 respondents selected this option.*
- *Remove question "Other (please indicate)", because none of the respondents indicated any.*

3. ~~If you answered "YES" to "Other factors"~~ What are the benefits to your organization in addressing P2? Check up to 3.

☐ Customer demand
☐ Enhanced stakeholder/investor relations
☐ Improved brand reputation/Public image
☐ ~~Increased employee productivity~~
☐ Better efficiency/ Increased productivity
☐ ~~Equipment replacement at end of useful life~~
☐ Less environmental impact, resource conservation
☐ Regulatory compliance
☐ Risk reduction (reduced spills, liability etc.)
☐ Safety and worker health (better conditions, etc.)
☐ ~~Other (please indicate)~~ _____

Suggested Revisions to Question 4:

- *Remove this question for the simplicity of the survey. Results were not very helpful for analysis and mainly predictable.*

~~**4.** Does your organization prepare some type of annual Sustainability Reporting (GRI, annual water, solid waste, electricity usage benchmarking, etc.)?~~

~~☐ Yes~~
~~☐ No~~
~~☐ Not sure~~

Suggested Revisions to Question 5: *No modifications.*

5. To what extent is your organization engaged in each of the following activities? Rate on a scale of 1 to 5, with the following assumptions: 1 – not considered; 2- under consideration; 3 –sometimes applied; 4 – frequently applied; 5 – always applied.

____ Building awareness of pollution prevention in the organization
____ Building culture of innovation by pursuing sustainability/P2 strategies
____ Analyzing risks associated with P2 and sustainability issues (environmental, legal,
competitive, reputational, resource access, political risk etc.)
____ Reducing greenhouse gas emissions
____ Generating electricity, heat, or fuel from renewable sources
____ Improving energy efficiency
____ Conserving natural resources (storm water management, soil conservation, sustainable
forestry, etc.)
____ Reducing or eliminating the creation of waste materials
____ Reducing the creation or release of pollutants or toxic compounds

SPECIFIC QUESTIONS

Suggested Revisions to Question 6:

- *Remove from the question "…new ideas/knowledge" to simplify the question.*
- *Remove question "Easier to implement due to the changed infrastructure (better equipment or conditions)" because few respondents selected this option and it was not useful for analysis.*
- *Remove question "Other" because none of 26 respondents selected this option.*
- *Remove question "If your answer is "Other", please specify____" due to few (1) responses.*

6. For each P2 suggestion, what benefits were important to your organization in justifying the implementation? Please check all that are appropriate in the Table 2 below.

Table 2. Suggestions suggested in 200__

Justification	Implemented P2 suggestions		
Acceptable payback period	a	b	c
Energy efficiency			
Reduced operating cost			
Increased employee productivity			
Health and safety benefits			
Regulatory compliance			
Reduced environmental and health risk (spills, vapors, liability etc.)			
Reduced business risk (impact of changes in regulation, input costs etc.)			
Enhanced environmental awareness ~~/new ideas/knowledge~~			
Improved public image			
Other companies also implemented the same or similar solution			
Corporate commitment to resource use/waste reduction			
~~Easier to implement due to the changed infrastructure (better equipment or conditions)~~			
Other			

~~If your answer is "Other", please specify~~

_____

Suggested Revisions to Question 7:

- *Simplify question based on responses received (Table 3). Only five (5) responses received for questions "Two" through "Five" years (less than 5%).*
- *Add question "More than one year or still provides benefit".*
- *Remove the following questions due to the low response rate:*
  - *Two years*
  - *Three years*
  - *Four years*
  - *Five years*
  - *Still provides benefit*
- *Suggested version of this question is given in Table 4.*

Approximately how many sequential years were financial and non-financial benefits gained from each implemented opportunity? Please check the appropriate cell in the Table below.

Table 3. Responses to survey Question 7

Years of benefit	# of responses
No or negative benefit	17
One year or less	11
Two years	2
Three years	2
Four years	1
Five years	-
Still provides benefit	77
Total	110

Table 3.

Years of benefit	Implemented P2 suggestions		
	a	b	c
No or negative benefit			
One year or less			
More than one year or still provides benefit			
~~Two years~~			
~~Three years~~			
~~Four years~~			
~~Five years~~			
~~Still provides benefit~~			