

**Construction of a Decision Analysis Tool for Choosing Corporate  
Environmental Management Systems**

By: Mary Pat Bomher

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Advisor: Dr. Lynn Maguire

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## **ABSTRACT**

Environmental managers are continually faced with new challenges to improve stakeholder relationships, save money and reduce the organization's environmental footprint. Many of these challenges can be efficiently addressed by implementation of an environmental management system (EMS). However, there are a number of different environmental management systems which are available, from industry specific standards such as the Recycling Industry Operating Standard (RIOS) to international standards such as ISO14001. Selecting the system that is the best fit for an organization is a challenge, especially for smaller organizations with limited resources.

Fortunately, multicriteria decision analysis is well-suited to this type of decision problem. The objective of this project was to construct a decision analysis tool to differentiate among various environmental management systems based on organizations' preferences. The project focused on three environmental management systems: ISO14001, Eco-Management and Audit Scheme (EMAS) and The Natural Step (TNS). The tool was built using the expertise of environmental management system practitioners to evaluate the systems on criteria representing financial, logistical and environmental goals. I tested the tool using the preferences of environmental managers at four facilities: one small chemical facility, one large chemical facility, one small manufacturing facility and one large manufacturing facility, to show that the tool is useful. I then improved the tool's accuracy and user-friendliness based on comments from a typical user.

The results showed that the Eco-Management and Audit Scheme system scored best on the majority of attributes, and thus was the preferred alternative for three out of four sample cases. Additionally, the most important attributes amongst all respondents in the overall evaluation were verification reliability and environmental stewardship. Organizations want to know that their system is verifiable and that it will help prepare them for future environmental challenges. Slight similarities in the importance rating of attributes were seen between the facilities of equivalent size, especially with respect to those attributes which helped to improve shareholder return.

Overall, the process demonstrated that how an EMS is implemented at an organization will be based on the preferences of the organization and what they are hoping to accomplish with their system. While some organizations want to focus on saving money, others choose to focus on a reduction in emissions. The decision analysis tool I developed is flexible enough to accommodate such differences in priorities.

Finally, this research showed that none of these three systems scored perfectly on all company objectives. It is possible to identify the single system that best matches a facility's preferences, but the best environmental management system may be a hybrid among the three.

## Table of Contents

ABSTRACT	ii
Table of Contents	iv
List of Tables	vi
List of Figures	vii
INTRODUCTION	1
Environmental Management Systems	4
ISO14001	6
Eco-Management and Audit Scheme (EMAS)	7
The Natural Step	8
OBJECTIVES	11
METHODS	11
Multicriteria Decision Analysis	11
Research Design	14
Surveys and Interviews	15
Sensitivity Analysis	18
APPLICATION OF METHODS	18
Determination of Decision Objective	19
Determination of Subobjectives and Attributes	19
Scoring of Attributes	21
Utility Determination	24
Determination of Weights	32
Calculation of Overall Utility	35
Sensitivity Analysis	36
Sensitivity to Changes in Attribute Weights	37
Performance Assessments	41
Final Interview with Decision System Reviewer	42
DISCUSSION	47
CONCLUSIONS AND RECOMMENDATIONS	51

ACKNOWLEDGMENTS	52
LITERATURE CITED	54
APPENDICES	56
Appendix A: Recruitment letter for project participants	57
Appendix B: Performance assessment survey	58
Appendix C: Utility assessment survey	63
Appendix D: Weight assessment survey	68

## List of Tables

Table 1. A summary of the differences among ISO14001, EMAS and The Natural Step. ....	12
Table 2. Research instruments used for groups of research subjects. ....	16
Table 3. Attribute measurement scales for attributes related to increasing shareholder return. ....	22
Table 4. Attribute measurement scales for attributes related to reducing environmental impact. ....	23
Table 5. Attribute measurement scales for attributes related to improving stakeholder ....	24
Table 6. Performance ratings for ISO14001, EMAS and The Natural Step from three experts in consulting, industry and regulatory compliance for maximizing shareholder return. Boldface type denotes performance ratings which were used in the decision analysis. ....	25
Table 7. Performance ratings for ISO14001, EMAS and The Natural Step from three experts in consulting, industry and regulatory compliance for reducing environmental impact. Boldface type denotes performance ratings used in the decision analysis. ....	26
Table 8. Performance ratings for ISO14001, EMAS and The Natural Step from three experts in consulting, industry and regulatory compliance for improving stakeholder relationships. Boldface type denotes performance assessments used in the decision analysis. ....	27
Table 9. Normalized weighting of attributes determined through surveys from two manufacturing industry environmental managers and two chemical industry managers.. Italicized numbers in parentheses are totals of associated attribute weights. ....	34
Table 10. Weight assigned to three objectives and 11 attribute measures by environmental managers from five industry sectors. Italicized numbers in parentheses represent the total of associated attribute weights. ....	35
Table 11. Overall utility of the three EMSs based on expert ratings of performance (Tables 6 through 8) and preferences of four industry representatives (Fig. 4-14 and Table 9). ....	36
Table 12. Sensitivity of overall utilities of EMSs to changes in performance ratings (i.e., using the lower scores assigned by the experts, where high and low scores are those denoted in Tables 6-8) for the preferences of environmental managers from four types of facilities. Boldface font indicates the most preferred alternative for each scenario. Large boldface font indicates the preferred alternative is different than the base case. ....	43
Table 13. Sensitivity of overall utilities of EMSs to changes in performance ratings (i.e., using the lower scores assigned by the experts, where high and low scores are those denoted in Tables 6-8) for the preferences of the decision system reviewer. Boldface font indicates the most preferred alternative for each scenario. Large boldface font indicates the preferred alternative is different than the base case. ....	48

## List of Figures

Figure 1. Plan-Do-Check-Act cycle for environmental management systems (adapted from Environmental Management Systems, Gallagher 2008). .....	5
Figure 2. The Natural Step sustainability funnel. ....	10
Figure 3. Environmental management system decision objective hierarchy.....	20
Figure 4. Utilities for competitive advantage from each of the four respondents. ....	28
Figure 5. Utilities for risk reduction from each of the four respondents. ....	28
Figure 6. Utilities for cost savings from each of the four respondents. ....	28
Figure 7. Utilities for verification reliability from each of the four respondents. ....	29
Figure 8. Utilities for reduced consumption from each of the four respondents. ....	29
Figure 9. Utilities for reduced emissions from each of the four respondents. ....	29
Figure 10. Utilities for environmental stewardship from each of the four respondents. ....	30
Figure 11. Utilities for agency relationship from each of the four respondents. ....	30
Figure 12. Utilities for employee satisfaction from each of the four respondents.....	30
Figure 13. Utilities for community reputation from each of the four respondents.....	31
Figure 14. Utilities for customer reputation from each of the four respondents. ....	31
Figure 15. Sensitivity of overall utility to changes in the weight on verification reliability for the preferences of the large chemical facility. ....	38
Figure 16. Sensitivity of overall utility to changes in the weight on reduced outputs for the preferences of the large chemical facility. ....	38
Figure 17 Sensitivity of overall utility to changes in the weight on cost savings for the preferences of the large manufacturing facility.....	39
Figure 18. Sensitivity of overall utility to changes in the weight on competitive advantage for the preferences of the small manufacturing facility.....	40
Figure 19. Sensitivity of overall utility to changes in the weight on environmental stewardship for the preferences of the small chemical facility.....	41
Figure 20. Sensitivity of overall utility to changes in the weight on competitive advantage for the preferences of the decision system reviewer.....	45
Figure 21. Sensitivity of overall utility to changes in the weight on environmental stewardship for the preferences of the decision system reviewer.....	46
Figure 22. Sensitivity of overall utility to changes in the weight on reduced outputs for the preferences of the decision system reviewer. ....	46



## INTRODUCTION

Ever since the industrial revolution, humans have been consuming the earth's resources and discharging wastes at a rate faster than they can be renewed. They have been living under the impression that hopes and dreams can only be reached with unlimited economic growth. Increased production and consumption are viewed as "good," with little regard for the effects in the environmental and social sphere. If this trend continues, the world that humans leave to future generations will likely be one with a reduced quality of life. To prevent the detriment of environment and people, humans need to set a new paradigm based on an interconnected world functioning in harmony with one another and with nature (Stead et al. 2004, 9).

While all people in some way contribute to environmental degradation, corporations, by their nature, also create a significant environmental footprint. In alignment with humanity's natural tendency toward progress, many of these types of organizations pursue profit without regard to their effects on their external environment or community. With large market chains which include manufacturing, shipping, distribution and sales, corporations greatly impact the environment and communities worldwide. By setting a new paradigm in how they operate, these organizations can "prevent the detriment of environment and people" (Stead et al. 2004, 9).

There are some corporations that have already begun to change their thinking, values and thus their operations, such that they are more environmentally and socially benign. However, the majority of corporations still have significant progress to make. As public awareness of highly publicized topics such as global warming, water shortages and oil shortages increases, corporations are and will be held to a higher standard in how they operate. They will face increased scrutiny into the transparency of their operations and pressures to adopt sustainable practices. According to Renato Orsato, "Consumers are increasingly expressing the value they attribute to environmental protection through shopping behavior. As ecological and social responsibility become increasingly important issues for society, consumers value

the way organizations manage their production processes and supporting activities” (Orsato 2006, 130). Thus, consumer demand will likely dictate a behavior change for corporations with regard to environmental management. To remain competitive amidst this increased scrutiny, corporations will have to adjust their values, paradigms and practices.

Many managers are beginning to see the importance of transparency in their operations and reporting. However, they are overwhelmed by the possibilities for creating transparent data. Orsato said, “Managers are increasingly being requested to base corporate environmental strategies on more solid justifications. In the past few years, they have also been bombarded with ‘stage models,’ tools, techniques, schemes, standards and demonstration cases of best environmental practices. Although awareness of environmental issues in business has certainly risen, managers have been left wondering what they should do first and why” (Orsato 2006, 140). Without specific knowledge of what solutions are available and whether they are the best fit for their corporations, managers can spin their wheels trying to do a little bit of everything (Orsato 2006, 140).

One of the most efficient ways for corporations to transform their operations to include sustainable practices is the implementation of an environmental and/or sustainability management system. Environmental/sustainability management systems provide a framework from which an organization can structure its business practices in a sustainable manner with regard to economics, social welfare and the environment (United States Environmental Protection Agency 2008).

An environmental management system (EMS) focuses on environmental impacts. It integrates environmental management with normal operation and overall management practices. According to the Environmental Protection Agency (USEPA 2001, 18), the significant parts of an EMS include:

- environmental policy defined by upper management;
- assessment of operations environmental impact;
- assignment of authorities, responsibilities and resources;
- framework for regular review of environmental performance and other results; and,

- guidelines for continual improvement, including timelines, monitoring systems and corrective action tracking.

For consideration as an EMS, all of the listed elements must be present; however, they do not have to fit into a specific structure, although most systems do have specific rules and strategies. The variations in these rules and strategies among EMSs are what determine the “fitness” of an environmental management system for a given corporation.

Management systems vary greatly in approach, requirements and goals, so choosing the right system for an organization can be difficult. For example, the ISO14001 management system focuses primarily on evaluating current environmental impacts, finding ways to reduce them and setting targets for improving performance (International Organization for Standardization 2008). The Natural Step focuses on predicting a desired future state and then “backcasting,” plotting a path to get from the present state to the future state (The Natural Step 2008). The variety in the nature and framework of environmental management systems parallels the variety of needs of various corporations. Corporations vary widely in their missions, cultures, resources and views of the environment and of sustainability, all of which affect the choice of an environmental management system. The success of the environmental management system will depend on how well it fits the needs, operations and culture of an organization.

Since there are significant differences among management systems and significant differences among corporations that are using these systems, managers need a tool that will help them differentiate among various systems. The ideal tool would incorporate the values of the corporation and match them to the characteristics of management systems to find the best fit.

In this masters project, I constructed a decision analysis tool for choosing among environmental management systems. I developed it using a combination of literature reviews, surveys and interviews. The management systems I compared are: ISO14001(International Organization for Standardization 2008), the Natural Step (The Natural Step 2008), and Eco-Management and Audit Scheme (EMAS) (European Commission on Environment 2008).

## **Environmental Management Systems**

Environmental management systems differ widely on the elements included and the relative significance of each element. However, there is a general consensus on the basic elements which are required (Stead et al. 2004):

- strong commitment to improved environmental/sustainability performance from management;
- development of clear goals with related objectives and targets;
- development of core competencies required for implementation of strategies for achievement of goals and objectives;
- assessments of performance toward meeting environmental/sustainability goals and against previous performance and regulatory requirements;
- establishment of information and reporting systems; and,
- alignment of human resource processes with environmental/sustainability performance goals.

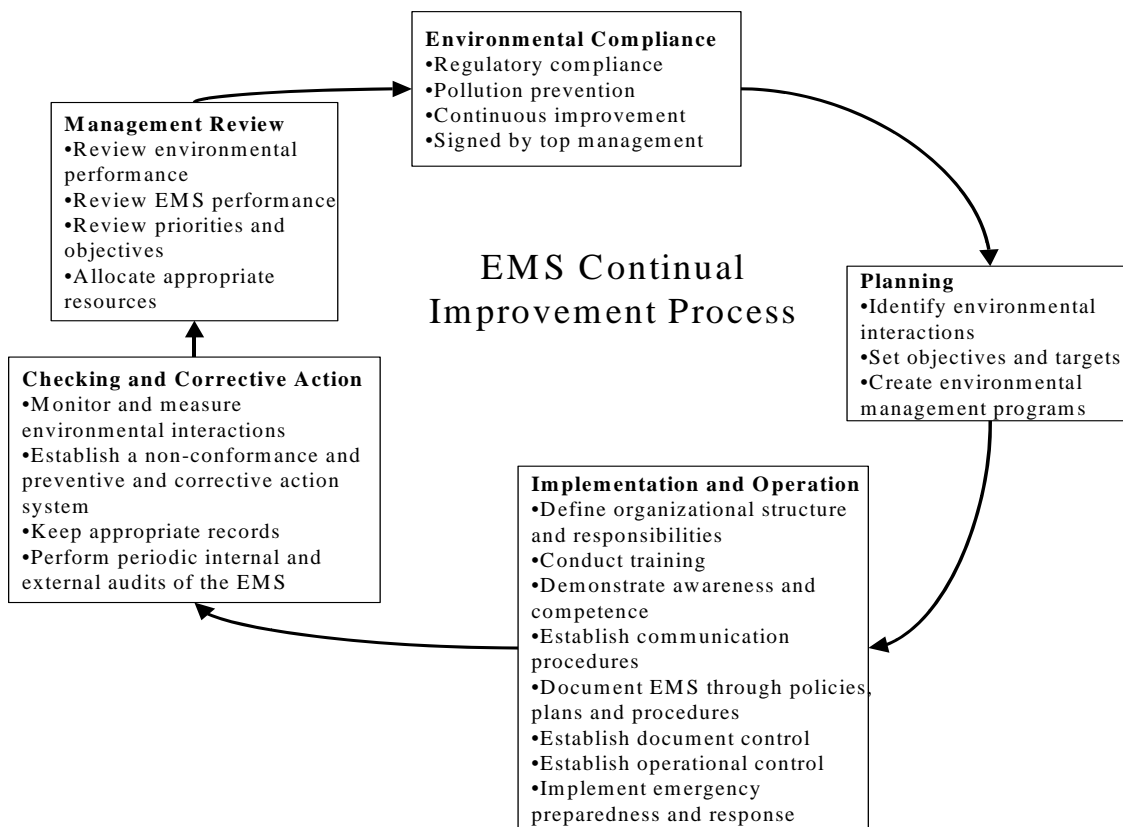
To implement these elements, facilities must enact a “Plan, Do, Check, Act” continuous improvement loop (Gallagher 2008) (Fig. 1), which is the foundation of all quality management systems. The EMS should comprise five steps (Gallagher 2008):

- (1) environmental policy: considers pollution prevention, environmental compliance, continual improvement and is signed by management;
- (2) environmental plan: identifies environmental interactions, sets objectives and targets and creates environmental management programs;
- (3) implementation: defines organizational structure and activities, conducts training, demonstrates awareness and competence, establishes communication procedures, documents EMS through

policies, plans and procedures, establishes document control, establishes operational control, implements emergency preparedness and response;

(4) monitoring and corrective action system: monitors and measures environmental interactions, establishes a non-conformance and corrective and preventive action system, keeps appropriate records, performs periodic internal and external audits of the EMS; and

(5) management review: reviews environmental performance, reviews EMS performance, reviews priorities and objectives, allocates appropriate resources.



**Figure 1.** Plan-Do-Check-Act cycle for environmental management systems (adapted from Environmental Management Systems, Gallagher 2008).

The way in which organizations incorporate these elements into their operations will be determined by the management system selected and the operations, processes and structure of the

organization. Factors such as organization size, location, profitability, and financial structure can all drive an organization's desire to become environmentally proactive with implementation of a management system (Bracke et al. 2008). Other incentives for EMS implementation include economic benefits, public recognition, market pressure, and risk reduction (Esquer-Paralta 2008). Those criteria which are most important to an organization should determine which management system they choose to implement. Each of the systems is briefly described below.

### **ISO14001**

ISO14001 is one of the most recognized environmental management system frameworks in the world (Gavronski et al. 2008). It was developed in 1996 and updated in 2004 by the International Organization for Standardization in response to the development of the Eco-Management and Audit System developed by the European Union in 1992. The standard was created as framework to help organizations more effectively manage their environmental footprints and demonstrate their standing as environmentally proactive organizations (Gavronski et al. 2008).

ISO14001 is a voluntary certification program; there is no legal obligation that mandates certification. It is structured around the Plan-Do-Check-Act cycle (Martin 1998). There are 16 basic requirements for certification; highlights include (Martin 1998):

- definition of environmental policy;
- identification of environmental aspects;
- setting of objectives and targets;
- development of program/procedures for auditing;
- development of procedures for non-conformances and corrective action; and,
- conduct of management review of performance.

Organizations seeking to verify conformity with the standard can pursue one of four courses (International Organization for Standardization 2008):

- make a self-determination;
- seek confirmation of conformance by stakeholders in the organization;
- seek confirmation by a party outside the organization; or,
- seek certification by an external organization.

ISO14001 does not specify required levels of environmental performance. This flexibility allows for ISO14001 to be implemented at a wide variety of organizations, no matter what the level of environmental activity. The focus is then on a commitment to compliance with local, state and federal regulations and a commitment to continual improvement in environmental performance (International Organization for Standardization 2008).

Although ISO does not advertise that 14001 will improve environmental performance or increase competitive advantage, empirical studies have shown that both of these are confirmed results of 14001 implementation (Gonzalez-Benito 2005). ISO does state that implementation will provide assurance to employees and management that the organization is in control of its operations and processes and that it is an environmentally progressive organization. ISO also states that implementation will improve the confidence of external stakeholders, ensure compliance with regulations and demonstrate that the organization's claims about its environmental performance are accurate (International Organization for Standardization 2008).

### **Eco-Management and Audit Scheme (EMAS)**

EMAS was made available to organizations in the industrial sector starting in 1995, and updated in 2001 so that it could be applied to a wider variety of organizations. EMAS was developed with the aim of recognizing and rewarding organizations whose actions go beyond minimum compliance and who commit to continuous improvement (Institute of Environmental Management & Assessment 2009). By requiring verification of environmental performance results by an approved, independent party, EMAS

provides enhanced credibility to organizations for their environmental efforts (Institute of Environmental Management and Assessment 2009).

EMAS is governed and enforced by the European Union Commission on Environment, a public entity (Bracke et al. 2008). The system defines environmental performance in terms of best available technology with specific performance requirements. It also requires the publishing of environmental performance results on an annual basis to demonstrate compliance (Gonzalez et al. 2008).

EMAS can be considered a standard of environmental excellence (Bracke et al. 2007). EMAS requires continuous evaluation of performance, objectives and targets for improvement. As a standard of excellence, it focuses on legal compliance, environmental performance, external communication and employee involvement (Bracke et al. 2008). Because the certification is more stringent than ISO14001, the process tends to be more costly. Therefore, there are significantly fewer EMAS-certified organizations than ISO14001 organizations. Because of the significant cost and level of effort required for initial implementation and annual recertification, EMAS certification must be approached with more forethought (Bracket et al. 2008).

While EMAS implementation requires a significant investment of both time and money, it also reaps significant benefits for organizations which make the investment. These benefits include: reduced costs on inputs due to efficiency improvements, risk minimization, continuous efficiency improvements, competitive advantage, enhanced business management, improved compliance, improved external relationships and increased employee involvement (European Commission on Environment 2008). Bracke et al. (2008) also cite regulatory relief, easier access to funds, increased customer goodwill and increased regulator goodwill as some intangible benefits.

### **The Natural Step**

The Natural Step is a Sustainability Management System developed by Karl-Henrik Robert with the assistance of many groups of scientists and consultants (Reichert 1998). A sustainability management

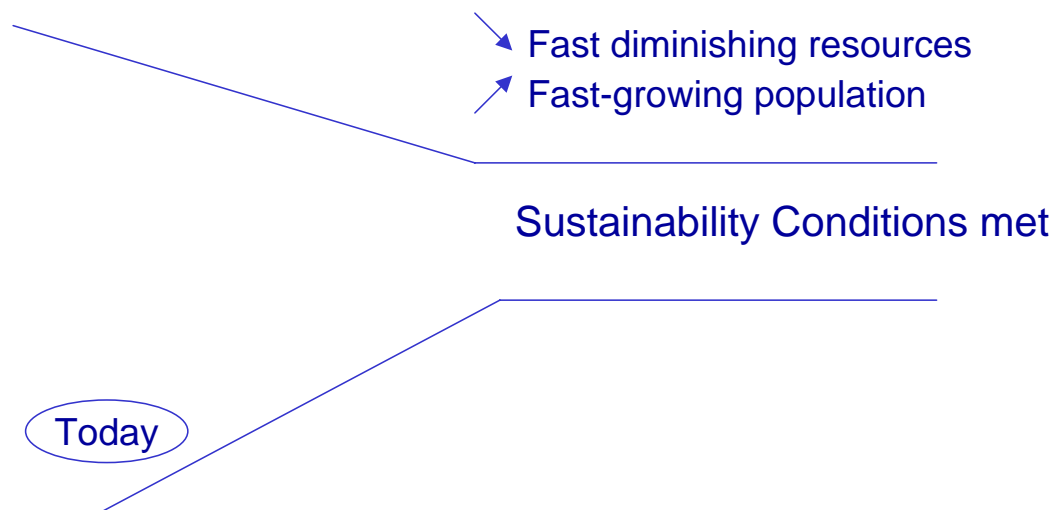
system differs from an environmental management system in its consideration of social impacts (e.g., employees, community) in addition to environmental and financial impacts. Most simply, The Natural Step consists of four system conditions derived from laws of thermodynamics and mass conservation. These system conditions are as follows (Reichert 1998):

1. Concentrations of substances extracted from the Earth's crust must not systematically increase in nature: Does an action reduce the use of finite fossil fuel and mineral resources or molecules?
2. Substances produced by society must not systematically increase in nature: Does an action reduce the use of long-lived synthetic products or materials?
3. The physical basis for the productivity and diversity of nature must not be systematically reduced: Does an activity preserve or increase natural diversity and the capacity of ecocycles?
4. Energy and other resources must not be used unjustly or inefficiently: Does an activity reduce the consumption of energy and other natural resources?

According to The Natural Step, problems with environmental waste will not cease until all four conditions are achieved. It advocates that political and economic issues need to be re-prioritized such that society can reduce, and eventually remove, its heavy dependence on natural resources. Serving as an example of reprioritization, the four system conditions of The Natural Step should be used to formulate a strategic step-by-step plan for success. If this is not achieved, organizations will find they will receive a negative return on investment because finding resources will become increasingly expensive as they become rarer.

According to Robert, "Non-sustainable development could be visualized as entering deeper and deeper into a funnel, in which the space becomes narrower and narrower [Fig. 2]. To the individual, company, municipality, or country wanting to make skillful investments, the crucial thing must be to direct its investments toward the opening of the funnel rather than into the wall. In reality, this means that

the smart investor makes himself less and less economically dependent on continued violation of the system conditions” (Reichert 1998, 21).



**Figure 2.** The Natural Step sustainability funnel. To prevent themselves from running into the wall of the funnel, corporations must incorporate system conditions into their operations which will reduce their dependence on resources and move them toward the open space (adapted from Fig. 1 in Leadbitter 2002, 2207).

The strategic principle used in The Natural Step (TNS) is backcasting, or looking at the current situation from a future perspective. The first step in backcasting is envisioning the desired future situation that is in line with the four system conditions. Next, organizations must assess their current situation from the perspective of their future situation. Using the results of the assessment, organizations can determine what actions they must take and investments they must make in order to arrive at the desired future state. To ensure that operations stay within the constraints of The Natural Step, every new strategy for pursuing the future state must be assessed against the four system conditions (Ciegis and Grunda 2006).

Unlike ISO14001 or EMAS, there are no documentation requirements. Organizations that choose to implement The Natural Step are accountable only to themselves. The Natural Step Network

(www.thenaturalstep.org), a non-profit organization with offices in 11 countries, will provide assistance to organizations that choose to implement The Natural Step management system; however, it does not have any enforcement responsibilities. Thus, the effectiveness of The Natural Step is significantly dependent on the extent to which an organization chooses to adhere to the system conditions. Table 1 below provides a comparison of the characteristics of the three EMSs.

## **OBJECTIVES**

The objectives of this master's project were:

- to build a decision analysis tool to assist corporations in choosing among three or more environmental and/or sustainable management systems;
- to demonstrate the functionality of the tool by applying it to the choice among three EMSs by four companies, two chemical manufacturers and two general manufacturing facilities; and,
- to evaluate the effectiveness of such a tool and refine the tool based on testing with one corporation that has either implemented a system or is considering implementation.

## **METHODS**

I undertook this project using the following research methods:

### **Multicriteria Decision Analysis**

One way managers can sort out the conflicting objectives and varying attributes present in environmental management systems is through the use of a multicriteria decision analysis approach. Robert Clemen discusses when decision analysis can be useful: "...the problems utilities face are particularly appropriate for treatment with decision analysis techniques; they involve long time frames

**Table 1.** A summary of the differences among ISO14001, EMAS and The Natural Step.

	<b>ISO 1400</b>	<b>EMAS</b>	<b>The Natural Step</b>
<b><i>Foundational structure</i></b>	An underlying commitment to continuous improvement with requirements for setting of objectives and targets and implementation of an audit program to measure progress towards objectives and targets <sup>1</sup>	Four-step process including environmental impact assessment, EMS implementation, internal audits and external certification audits <sup>2</sup>	Four System Conditions 1. Concentrations of substances extracted from the Earth's crust must not systematically increase in nature 2. Substances produced by society must not systematically increase in nature 3. The physical basis for the productivity and diversity of nature must not be systematically reduced 4. Energy and other resources must not be used unjustly or inefficiently <sup>3</sup>
<b><i>3<sup>rd</sup> party certification required</i></b>	Optional <sup>1</sup>	YES <sup>4</sup>	NO <sup>3</sup>
<b><i>Specific environmental performance requirements</i></b>	NO: only a commitment to continuous improvement <sup>1</sup>	YES: specific environmental performance indicators must be met to maintain certification <sup>4</sup>	NO: only a commitment to the system conditions <sup>3</sup>
<b><i>Date program started</i></b>	1996 <sup>5</sup>	1995 <sup>4</sup>	1989 <sup>3</sup>
<b><i>Number of facilities with implementation</i></b>	>50,000 <sup>5</sup>	>4100 <sup>4</sup>	>1000 <sup>6</sup>
<b><i>Stated benefits</i></b>	<ul style="list-style-type: none"> <li>• Improve environmental performance</li> <li>• Increase competitive advantage</li> <li>• Ensure compliance</li> <li>• Provide employee assurance<sup>7</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Reduced costs</li> <li>• Risk minimization</li> <li>• Competitive advantage</li> <li>• Increased employee involvement<sup>2,4</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Reduced material usage</li> <li>• Good environmental stewardship</li> <li>• Reduction of waste material</li> <li>• Outreach to the community<sup>6</sup></li> </ul>

<sup>1</sup> Martin 1998

<sup>2</sup> Bracke et al. 2008

<sup>3</sup> Reichert 1998

<sup>4</sup> European Commission on Environment 2008

<sup>5</sup> International Organization for Standardization 2008

<sup>6</sup> The Natural Step 2009

<sup>7</sup> Gonzalez-Benito 2005

and hence a high degree of uncertainty. In addition, multiple objectives must be considered when a decision affects many different stakeholder groups” (Clemen and Reilly 2001, 8). These are exactly the same difficulties that environmental managers must address with respect to environmental management system decisions. Thus, multicriteria decision analysis provides a practical approach for environmental managers to differentiate among the multitude of environmental management systems available to them. The utility of decision analysis lies in the framework it provides for incorporating different criteria with differing priorities on a common, comparable scale.

According to Robert Clemen, “Decision analysis provides both an overall paradigm and a set of tools with which a decision maker can construct and analyze a model of a decision situation” (Clemen and Reilly 2001, xxi). For complex problems, decision analysis breaks down a complex decision problem into smaller, manageable parts, such that they can be analyzed piece by piece. These parts may include possible courses of action, potential outcomes and the likelihood of the various outcomes (Clemen and Reilly 2001, 2).

Multicriteria decision analysis effectively and efficiently addresses tradeoffs among multiple, conflicting objectives. The method achieves this by requiring scoring of each decision alternative on how well it meets each objective or subobjective. These scores are then weighted based on how important an objective or subobjective is to the decision maker. Thus, the choice reflects the decision maker’s preferences. The alternative with the highest final score can be considered to meet the objectives and subobjectives of the decision maker best (Clemen and Reilly 2001, 2-3).

In his article, Renato Orsato (Orsato 2006, 140) discussed the accountability managers must accept for their decisions. While decision analysis is in itself a quantitative method, its purpose is not just to yield a single numerical answer. The value of decision analysis for decision makers, and specifically managers, is to be “an information source, providing insight about the situation, uncertainty, objectives and trade-offs, and possibly yielding a recommended course of action” (Clemen and Reilly 2001, 4). Thus, decision analysis provides a tool that managers can use to be not only accountable but also transparent in their decision making.

## **Research Design**

The design of this project was to compare three environmental management systems: ISO14001, Eco-Management and Audit Scheme and The Natural Step. ISO14001 was an easy choice for this project because it is the most widely implemented environmental management system. Additionally, it is an international standard, and thus has been widely adopted across the world. The Eco-Management and Audit Scheme was of interest because it contrasts with ISO14001, both in implementation breadth (confined to Europe) and its very stringent compliance requirements. I selected the Natural Step (TNS) as the third system in the project because TNS focuses on the softer, human component of an organization's operations, in addition to the environmental component. Comparing this type of softer system against more regimented systems such as ISO and EMAS was intriguing. An additional benefit of all three of these systems was that none of them were sector-specific. They can all be applied to and adopted by many types and sizes of organizations.

To narrow the scope of my research, I chose to focus on two types of companies: chemical and general manufacturing. I selected these companies because I had relationships with environmental employees in both types of these organizations, and because they are two of the more common industrial sectors, so their responses would resonate with a large proportion of the corporate and industrial population.

To determine a set of attributes for comparing EMSs, and then to assess each of the systems on these attributes, I consulted with several EMS "experts." They were people who have significant experience with environmental management systems and are either currently working with or have worked with environmental management systems in the past. Most of these people were consultants or academics with whom I had professional relationships prior to this project. I also solicited feedback from an EMS specialist at a state regulatory agency.

To characterize the preferences and priorities among attributes for representative corporations, I solicited preference feedback from a number of corporate environmental managers from a spectrum of business sectors, from the financial industry to the chemicals industry and

including the food industry. These respondents were selected based on professional relationships from my work as a consultant. Additionally, several respondents were selected from my relationships with environmental professionals in the Air and Waste Management Association.

Finally, to evaluate the effectiveness and “user friendliness” of my decision tool, I solicited feedback from the environmental manager of a small chemicals company that does not currently have an EMS in place but is considering implementation of a formal system. This environmental manager is someone with whom I have worked professionally. He inspired me to make this tool because he is someone who wants to do the right thing and be proactive, but he does not always have the financial and human resources to do it the “fancy” way.

### **Surveys and Interviews**

I used both surveys and interviews to solicit feedback and personal preferences on the attributes, measurement scales and final decision analysis tool from my research subjects. Table 2 summarizes the research instruments which were used for each group of research subjects. The content of each of the surveys/interviews is summarized below.

The purpose of the surveys and interviews with the corporate environmental representatives was to:

- assess the organization’s priorities with respect to the implementation of their environmental management systems;
- understand how the management system decision was made at their organizations and what the driving factors were in those decisions; and,
- solicit respondents assessments of each of the decision criteria based on how important it was to them and their organizations (assessment of weights).

**Table 2.** Research instruments used for groups of research subjects.

<b>Research group</b>	<b>Participants</b>	<b>Research instrument</b>	<b>Feedback solicited</b>
Corporate respondents	Environmental managers	Surveys, interviews	Personal preference for attributes
Experts (Group 1)	Academics and consultants	Interviews	Appropriateness of proposed attributes, measurement scales
Experts (Group 2)	Industry managers, consultants, regulatory agency	Surveys	Assessment of each EMS with provided attributes and measurement scales
Corporate environmental managers	two chemical, two manufacturing	Survey, interviews	Personal preference for attributes, levels of measurement scales
Reviewer	Environmental manager at chemical company	Interview	Personal preference for attributes, levels of measurement scales; comments regarding the interview process and the tool itself

The purpose of the interviews with environmental management system experts (Group 1) was to determine the most appropriate attributes and associated measurement scales to be used for this decision process. In the interview, I provided the respondents with copies of the proposed objectives hierarchy, attributes and measurement scales. I requested the following feedback with closed-ended questions:

- agreement/disagreement regarding primary objectives and definition of attributes for an EMS; and,
- opinions regarding the measurement scales defined for each attribute.

The purpose of the surveys with environmental management system experts (Group 2) was to determine how well each of the selected environmental management systems performed based on the

decision criteria provided. The survey requested the following information from respondents using closed-ended questions:

- scores for each assigned attribute for each system;
- comments regarding the definitions of attributes for an EMS; and,
- comments regarding clarity of the measurement scales defined for each attribute.

In some instances, I conducted interviews in place of surveys. I asked the subjects' opinions regarding the primary objectives and attributes of environmental management systems. Interviewees were also asked for opinions regarding the clarity of the measurement scales defined for scoring each attribute and also how they rated each attribute using the defined measurement scales.

Interviews were also conducted to follow up with survey subjects on their responses. Topics for discussion included clarification of survey responses and inquiries regarding the quality of the survey itself.

The purpose of the interviews and surveys with the environmental managers from the four selected companies was to determine their personal preferences with respect to each level on the measurement scales (utilities) and with respect to each attribute relative to the others (weights). The objective of the surveys was to:

- solicit respondents' assessments of each of the decision criteria listed based on how important it was to them and their organizations (assessment of weights); and
- solicit respondents' assessments of their relative preference for each value on the measurement scale relative to the others (utilities).

The purpose of the interview with the reviewer was to evaluate the "rough draft" of the decision tool. I selected this reviewer because he was available, comfortable with the method and familiar with the concept of environmental management systems. The interview consisted of a full run of decision analysis

methods. These included questions to understand the reviewer's preference for each level on a measurement scale relative to the other levels, and also the respondent's priorities for each of the attributes relative to each other (attribute weights). The interview occurred in two sittings due to the concentrated quantitative nature of the questions. The second meeting was used to fill in gaps from the initial interview, to clarify some lingering questions and to ask general questions about the nature of the tool itself.

### **Sensitivity Analysis**

A sensitivity analysis was conducted using Logical Decisions (LDW) (Logical Decisions 2009) software on the collected decision data to determine how sensitive the decision results were to variation in the weights of all attributes used as inputs to the decision model.

Due to the use of human subjects, I filed an application for exemption from full review with the Institutional Review Board regarding use of human subjects in this research. For this project, human subjects were used for both surveys and interviews. Most of these subjects were recruited through the researcher's personal and professional networks. The surveys and the email letters used to recruit survey respondents can be found in Appendix A.

## **APPLICATION OF METHODS**

To develop this decision analysis tool for environmental management systems, I applied multiattribute utility theory, a method of multicriteria decision analysis. As described briefly in the section above, multiattribute utility theory (MAUT) uses a combination of objectives, performance scores, utilities and weights to determine the most useful alternative for the decision maker. The required steps for decision analysis are described below as applied to this research project.

### **Determination of Decision Objective**

To initiate the MAUT process, I first defined the overall decision objective and selected the most likely alternatives for the decision. For this project, the decision objective was to select the environmental/sustainability management system that is the best fit for an organization/decision maker.

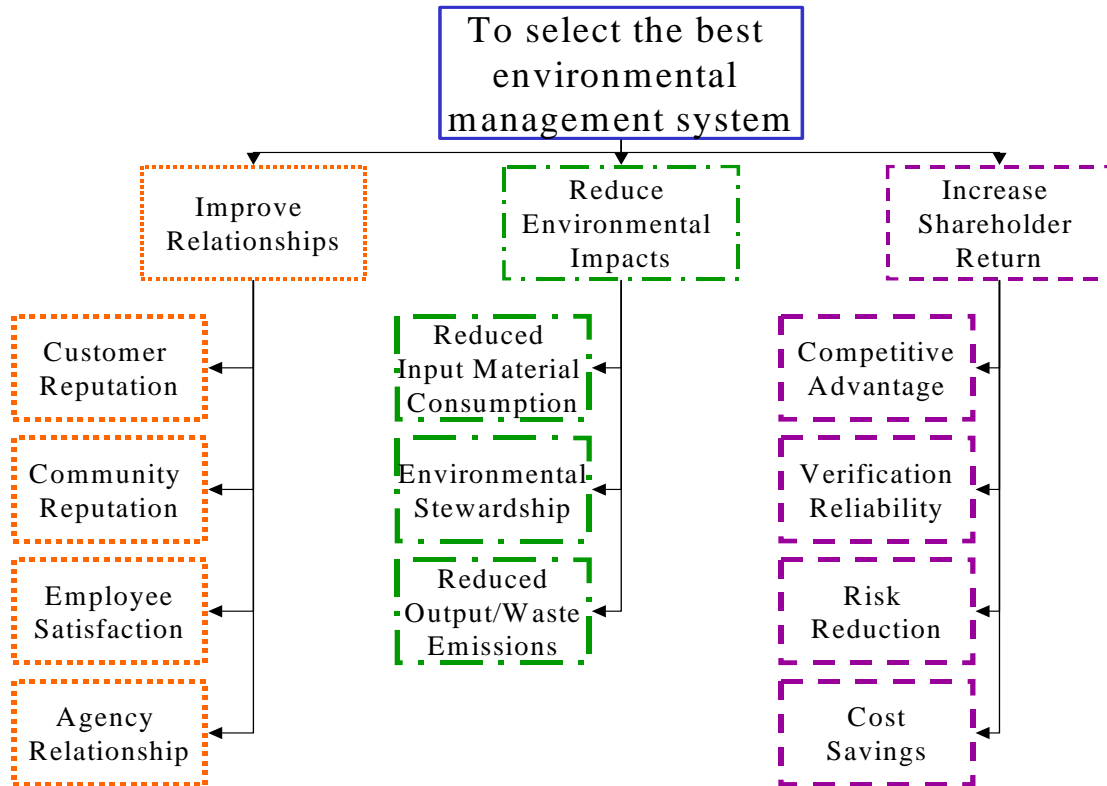
### **Determination of Subobjectives and Attributes**

Once an objective has been determined, MAUT mandates that the objective be broken into subobjectives, and the subobjectives into attributes, or criteria, that can be measured to determine the progress toward that subobjective. For this project, I first conducted a general review of the management systems that I used to generate an initial objectives hierarchy with attribute measurement scales. The objectives hierarchy is the pictorial breakdown of the primary and subgoals of a decision. The subgoals are further broken down into attributes, which are characteristics of the subgoals that can be assigned a rating (quantitative or qualitative) using a defined measurement scale. The ratings provide a means for comparison among various decision alternatives. The process of rating is often referred to as scoring.

By conducting a literature review, and using previous knowledge, I divided the objective into three subobjectives: stakeholder priorities, reduced environmental impact and improved stakeholder relationships. By researching the structure and formulation of each system, using feedback from some initial interviews with environmental management system professionals and drawing on my professional experience with management systems, I assembled an initial list of 25 criteria for assessing the differences among the three systems.

To verify that these criteria were both meaningful and appropriate, I interviewed two people with extensive management systems experience who work in the environmental field. The feedback indicated that the allocation of attributes into the social, environmental and business categories were fairly accurate. The most useful feedback was that out of the initial list of approximately 25 criteria, many of them would not vary enough in performance to differentiate the three systems in the eyes of

stakeholders. By working closely with an EMS expert in academia, I was able to trim the list of 25 criteria to a more reasonably sized list of 11 criteria. The trimming process entailed grouping the attributes into categories that were similar, and then eliminating those which could be considered redundant and/or correlated. Compiling all of this feedback yielded the objectives hierarchy displayed in Figure 3.



**Figure 3.** Environmental management system decision objective hierarchy.

The next step in the MAUT process is the definition of measurement scales. For each attribute, the measurement scales must be both transparent and operational, meaning they must be very clear about what is being measured in order to evaluate how well the goals are being achieved. The measurement scales must be defined clearly enough that anyone who observed the situation could unambiguously and correctly make an assessment using the provided scale.

The attribute scales which I determined through surveys and interviews are displayed in Tables 3,4 and 5 for maximizing shareholder return attributes, reducing environmental footprint attributes and improving stakeholder relationships attributes, respectively. I originally crafted measurement scales for each attribute based on initial management system research and professional knowledge of environmental management systems. I was able to finalize the scales using feedback from interviews with an environmental management systems expert and an environmental management systems practitioner. The feedback consisted mostly of adjustments to the numerical scales to be more realistic. For example, in the initial measurement scales, the levels for assessing competitive advantage were 0-5%, 5-10%, 10-15%, 15-20% and >20% additional business from new customers. This was an unrealistic proposition, because it would be extremely difficult for a business to recognize 0-5% additional business as the result of management system implementation. The statistics would get lost in the noise of highs and lows of an organization's business. Based on that feedback, I adjusted the scale to make it more realistic by widening the measurement levels. The interviewees also provided recommendations for proxy scales for several of the attributes. Proxy scales are strongly correlated with the attribute, but easier and more convenient to measure than the attribute itself. For example, one of the attributes I considered important in assessing these systems with respect to their effect on stakeholder relationships was the relationship of the facility/organization with the community. Trying to create a qualitative scale for this attribute that would be transparent to any intelligent person was challenging, if not impossible. One of the interviewees suggested that I instead assess the number of complaints received by the organization as a proxy for the status of the relationship between the organization and the community.

### **Scoring of Attributes**

After defining the measurement scales, the decision analyst must score the alternatives. In this step, each of the alternatives needs to be scored based on how well that alternative performs with respect to each attribute. To accurately assess how well each of the systems performs, I assembled a

**Table 3.** Attribute measurement scales for attributes related to increasing shareholder return.

<b>Attribute</b>	<b>Description</b>	<b>Measurement Levels</b>
Competitive Advantage	% additional business from new customers resulting from implementation of the EMS in the first five years	<i>0-10%</i>
		<i>10-20%</i>
		<i>20-30%</i>
		<i>30-40%</i>
		<i>&gt;40%</i>
Risk Reduction	% financial risk reduction due to EMS implementation	<i>None</i>
		<i>0-5%</i>
		<i>5-10%</i>
		<i>10-15%</i>
		<i>&gt;15%</i>
Cost Savings	% operational cost savings observed in first five years following implementation	<i>0-10%</i>
		<i>10-25%</i>
		<i>25-50%</i>
		<i>&gt;50%</i>
Verification Reliability	How verifiable is this system?	<i>Weak:</i> No verification mechanism is specified; there is no guarantee that system is implemented appropriately or that objectives and targets are being met
		<i>Effective:</i> A verification mechanism is specified; requires only internal verification
		<i>Very Effective:</i> A verification mechanism is specified in great detail; requires external verification

survey in which I asked management system experts (Experts Group 2) to evaluate each system using provided measurement scales. The survey included one column for each EMS and a list of the attributes and measurement scales. Experts were tasked with determining the appropriate level of performance of each system for each attribute. Expert participants were also asked to provide any questions or comments they had regarding the attributes or the measurement scales. This survey is displayed as Appendix B. I distributed fifteen surveys and received three responses. An EMS practitioner in the commercial chemical industry assessed only one system (ISO14001), an EMS consultant assessed two systems (ISO14001, EMAS) and an EMS expert at the Wisconsin Department of Natural

**Table 4.** Attribute measurement scales for attributes related to reducing environmental impact.

<b>Attribute</b>	<b>Description</b>	<b>Measurement Levels</b>
Reduced Consumption	How will this system contribute to reduction of total input material consumption?	<p><i>No Change</i></p> <p><i>Little (0-25%)</i></p> <p><i>Intermediate (25-50%)</i></p> <p><i>Significant (&gt;50%)</i></p>
Reduced Emissions	How will the system contribute to total reduced emissions/waste?	<p><i>No Change</i></p> <p><i>Little (0-25%)</i></p> <p><i>Intermediate (25-50%)</i></p> <p><i>Significant (&gt;50%)</i></p>
Environmental Stewardship	Does the system provide a framework for responding to new environmental management challenges?	<p><i>No:</i> Not at all</p> <p><i>Somewhat:</i> The system guidelines do not directly address environmental stewardship</p> <p><i>Moderate:</i> The system guidelines address environmental stewardship; however, no formal guidance is provided.</p> <p><i>Significant:</i> This is addressed directly in the system guidelines with specific guidance; the system is structured around predicting and preparing for future challenges</p>

Resources assessed all three systems. The performance scores for each system (Tables 6-8) were implemented in the decision tool as a reference score for future users. Among the three data sets, there were several slight discrepancies in assigned ratings. For any rating in which there was a discrepancy between reviewers, the highest assigned rating was used. The highest rating was used throughout because it reflects the maximum potential benefit of the implemented management system. I believe that a decision maker will want to understand the maximum potential benefit of performance with respect to a specific attribute, rather than an average, or conservative estimate.

All three systems scored the same for two of the attributes: employee satisfaction and customer relationships (Tables 6-8). Since there is no variation in the performance of these two attributes, they do not help differentiate among the three EMSs. However, since several of the other

**Table 5.** Attribute measurement scales for attributes related to improving stakeholder relationships.

<b>Attribute</b>	<b>Description</b>	<b>Measurement Levels</b>
Agency Relationship	How will this system affect the organization's relationship with regulatory agencies?	<p><i>None:</i> Agency relationship will remain unchanged</p> <p><i>Some:</i> The number of notices of violation will decrease by 0-20% in first five years</p> <p><i>Significant:</i> The number of notices of violation will decrease by greater than 20% in the first five years</p>
Employee Satisfaction	Will implementation of this system contribute to employee morale and satisfaction within the first five years?	<p><i>No:</i> There will be no observable change in morale/turnover rate</p> <p><i>Possible:</i> There is a potential for employee morale to improve and turnover will improve by up to 5%.</p> <p><i>Definite:</i> There will be an observable difference in morale and turnover will improve by greater than 5%</p>
Community Reputation	To what extent will implementation of this system improve the reputation of the organization in the community?	<p><i>None:</i> There will be no change in the number of complaints about operations</p> <p><i>Slight:</i> Number of complaints will decrease by 0-25%</p> <p><i>Moderate:</i> Number of complaints will decrease 25-50%</p> <p><i>Significant:</i> Number of complaints will decrease by more than 50%</p>
Customer Reputation	How much additional business will the organization receive from existing customers as a result of system implementation?	<p>&lt;5</p> <p>5-20%</p> <p>20-50%</p> <p>&gt;50%</p>

steps in the process, including personal preference surveys, were already complete before the systems were fully assessed, I retained them for consistency.

### **Utility Determination**

Once all of the alternatives were scored for each attribute, I determined how much the decision maker preferred one level of performance on an attribute to a higher or lower level. For this project, each point on each measurement scale for each attribute must be assessed.

**Table 6.** Performance ratings for ISO14001, EMAS and The Natural Step from three experts in consulting, industry and regulatory compliance for maximizing shareholder return. Boldface type denotes performance ratings which were used in the decision analysis.

<b>Attribute</b>	<b>Expert</b>	<b>ISO 14001</b>	<b>EMAS</b>	<b>The Natural Step</b>
<b>Cost savings</b>	Consulting	0-10%	0-10%	Not Assessed
	Industry	0-10%	Not Assessed	Not Assessed
	Compliance	<b>&gt;50%</b>	<b>25-50%</b>	<b>&gt;50%</b>
<b>Competitive advantage</b>	Consulting	<b>10-20%</b>	<b>0-10%</b>	Not Assessed
	Industry	0-10%	Not Assessed	Not Assessed
	Compliance	10-20%	0-10%	<b>0-10%</b>
<b>Verification reliability</b>	Consulting	<b>Effective</b>	<b>Very Effective</b>	Not Assessed
	Industry	Effective	Not Assessed	Not Assessed
	Compliance	Effective	Effective	<b>Weak</b>
<b>Risk reduction</b>	Consulting	<b>0-5%</b>	<b>5-10%</b>	Not Assessed
	Industry	None	Not Assessed	Not Assessed
	Compliance	0-5%	None	<b>None</b>

To elicit an accurate understanding of utility, I assembled a survey (Appendix C) in which I asked four environmental managers (two each from chemical industry and general manufacturing) to rate each measurement point relative to the others. In the survey, I asked respondents to rate each measurement point for each criterion from 1-100 based on their relative preference for that measurement point. Once all points values were assigned, the utilities were determined using the ratio method (Clemen and Reilly 2001, 612).

**Table 7.** Performance ratings for ISO14001, EMAS and The Natural Step from three experts in consulting, industry and regulatory compliance for reducing environmental impact. Boldface type denotes performance ratings used in the decision analysis.

<b>Attribute</b>	<b>Expert</b>	<b>ISO14001</b>	<b>EMAS</b>	<b>The Natural Step</b>
<b>Reduced outputs</b>	Consulting	<b>25-50%</b>	<b>&gt;50%</b>	Not Assessed
	Industry	25-50%	Not Assessed	Not Assessed
	Compliance	25-50%	25-50%	<b>25-50%</b>
<b>Reduced inputs</b>	Consulting	<b>25-50%</b>	<b>25-50%</b>	Not Assessed
	Industry	25-50%	Not Assessed	Not Assessed
	Compliance	0-25%	0-25%	<b>0-25%</b>
<b>Environmental stewardship</b>	Consulting	<b>Somewhat</b>	<b>Somewhat</b>	Not Assessed
	Industry	Somewhat	Not Assessed	Not Assessed
	Compliance	Somewhat	Somewhat	<b>Moderate</b>

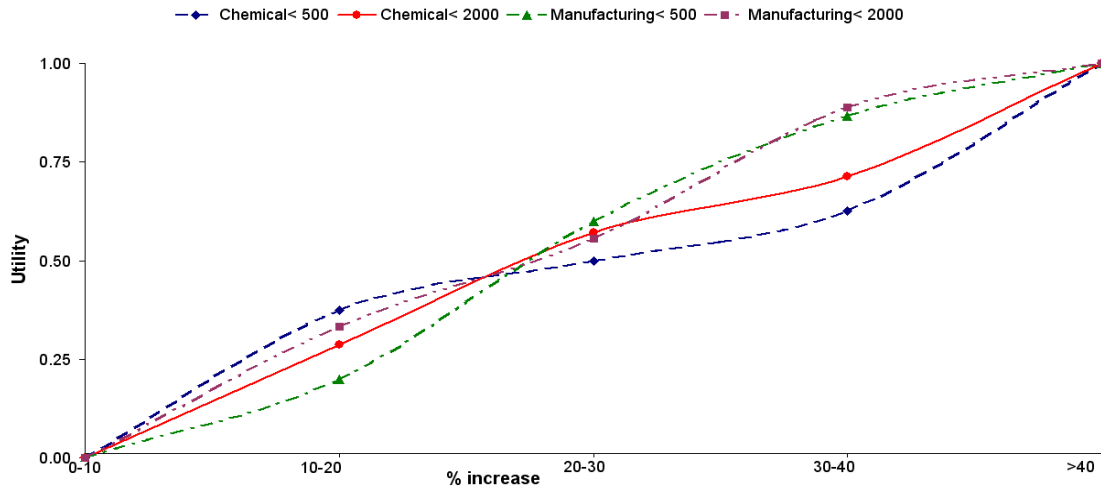
I received responses from four environmental managers, two from chemical manufacturing facilities, and two from general manufacturing facilities. The chemical facilities differed in size, with one having less than 500 people and one having up to 2,000 people. The manufacturing facilities also differed in size, with one having less than 500 people and one having a little over 2,000 people. Once all feedback was received, the utilities were input into the decision tool both as a reference for the decision maker and to demonstrate the tool's functionality. The corresponding utility functions for each of the four decisionmakers are displayed in Figures 4 through 14.

In general, the two chemical facilities had more similarities in preferences with respect to the environmental attributes than for those for either stakeholder relationships or shareholder return. They

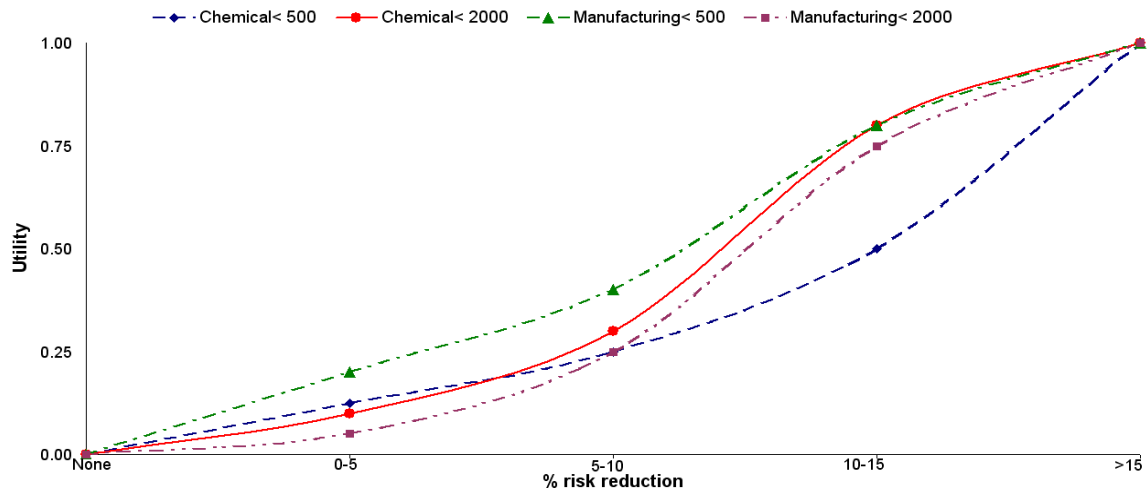
**Table 8.** Performance ratings for ISO14001, EMAS and The Natural Step from three experts in consulting, industry and regulatory compliance for improving stakeholder relationships. Boldface type denotes performance assessments used in the decision analysis.

Attribute	Expert	ISO14001	EMAS	The Natural Step
<b>Agency relationship</b>	Consulting	<b>Slight Improvement</b>	<b>Slight Improvement</b>	Not Assessed
	Industry	Slight Improvement	Not Assessed	Not Assessed
	Compliance	None	None	<b>None</b>
<b>Customer reputation</b>	Consulting	<5%	<5%	Not Assessed
	Industry	<5%	Not Assessed	Not Assessed
	Compliance	<5%	<5%	<b>&lt;5%</b>
<b>Community reputation</b>	Consulting	0-25% less complaints	<b>0-25% less complaints</b>	Not Assessed
	Industry	<b>25-50% less complaints</b>	Not Assessed	Not Assessed
	Compliance	0-25% less complaints	None	<b>0-25% less complaints</b>
<b>Employee satisfaction</b>	Consulting	<5% <b>turnover improvement</b>	<5% <b>turnover improvement</b>	Not Assessed
	Industry	<5% turnover improvement	Not Assessed	Not Assessed
	Compliance	<5% turnover improvement	<5% turnover improvement	<b>&lt;5% turnover improvement</b>

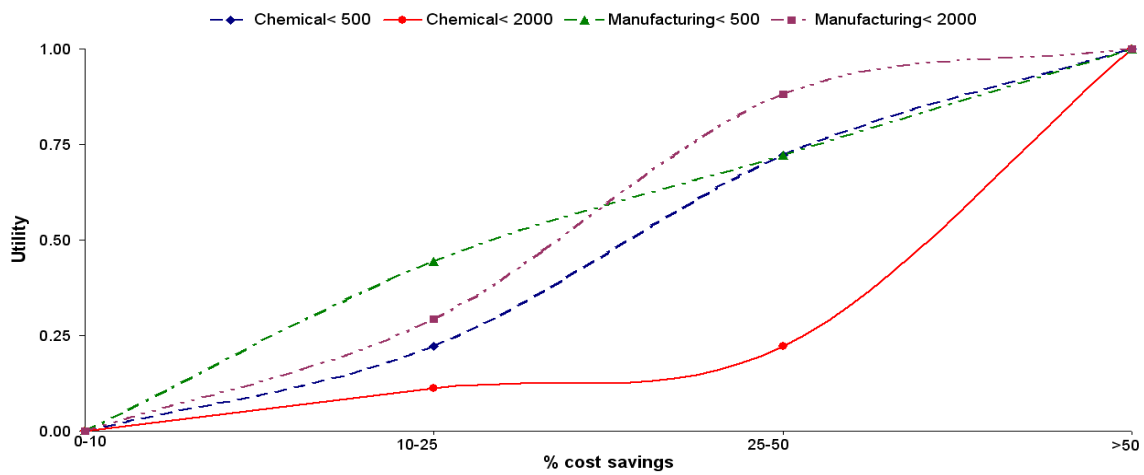
had the greatest number of differences in their preferences with respect to stakeholder relationship attributes. The two manufacturing facilities showed very similar preferences with respect to the attributes for both the environmental and the stakeholder relationships. This seems logical since these facilities are



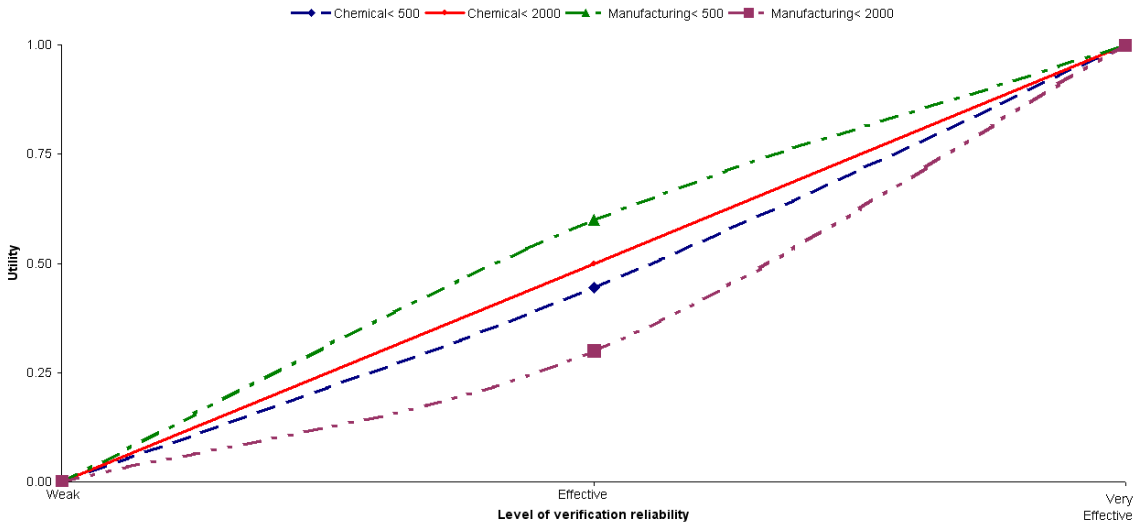
**Figure 4.** Utilities for competitive advantage from each of the four respondents.



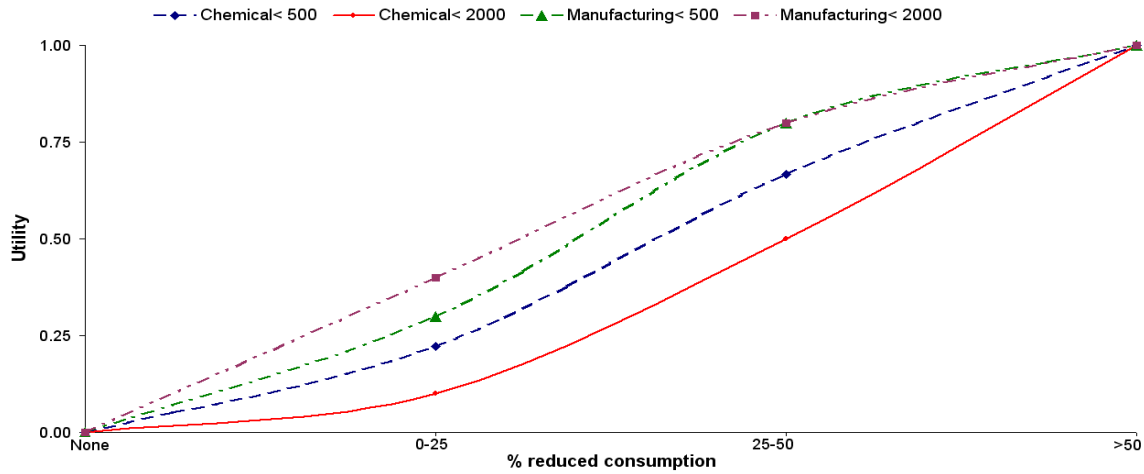
**Figure 5.** Utilities for risk reduction from each of the four respondents.



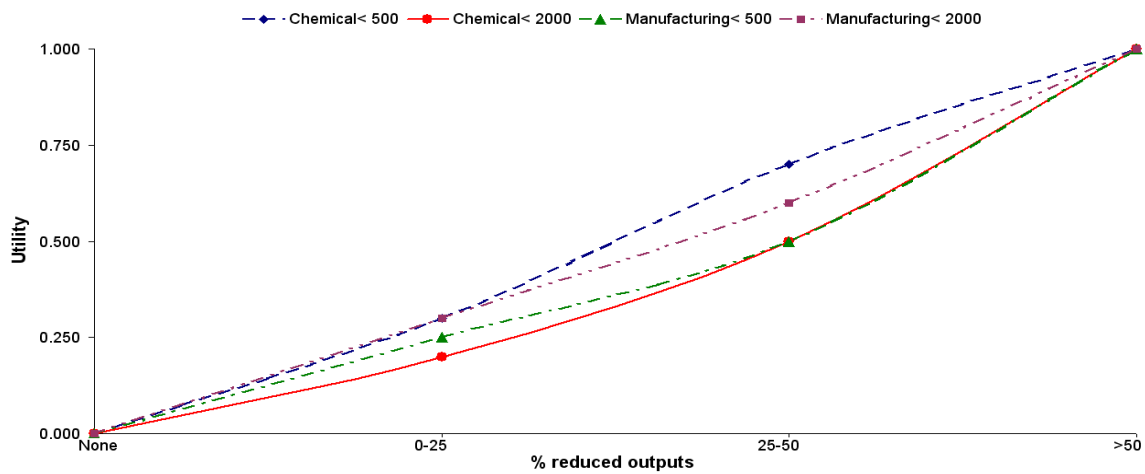
**Figure 6.** Utilities for cost savings from each of the four respondents.



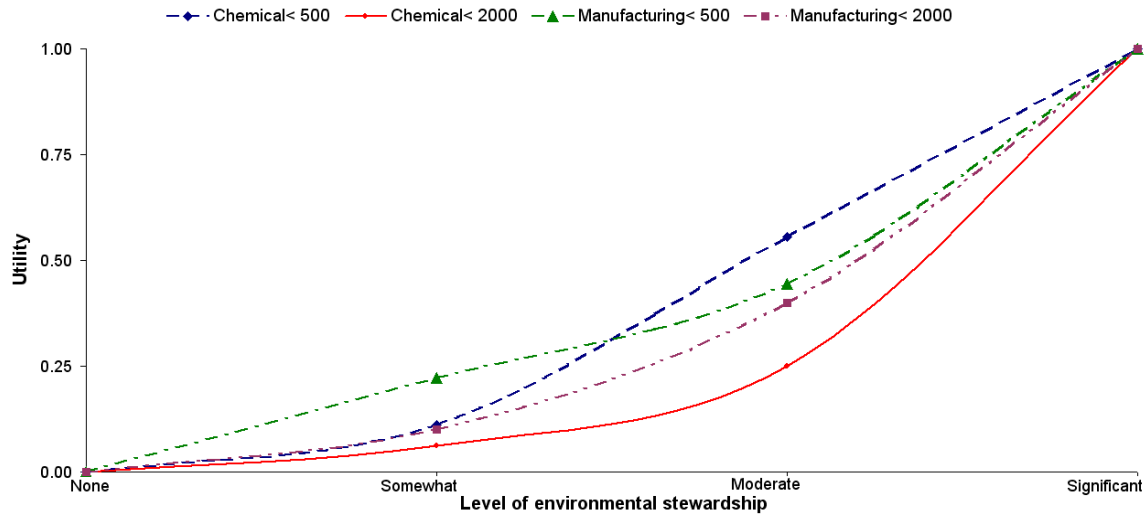
**Figure 7.** Utilities for verification reliability from each of the four respondents.



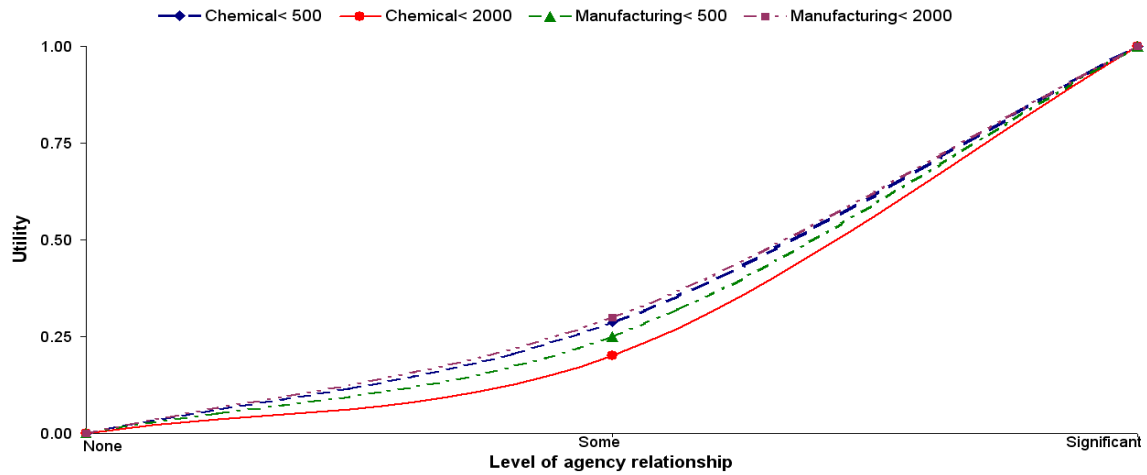
**Figure 8.** Utilities for reduced consumption from each of the four respondents.



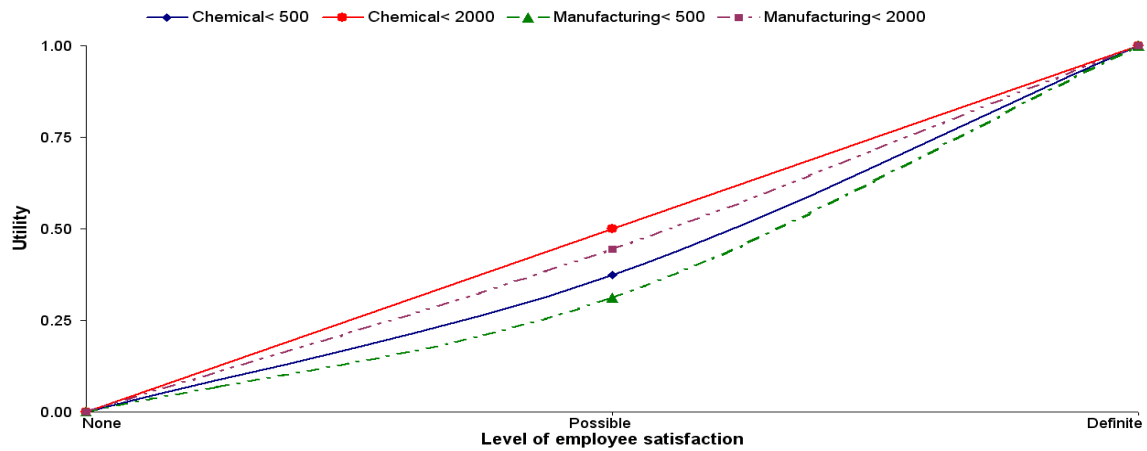
**Figure 9.** Utilities for reduced emissions from each of the four respondents.



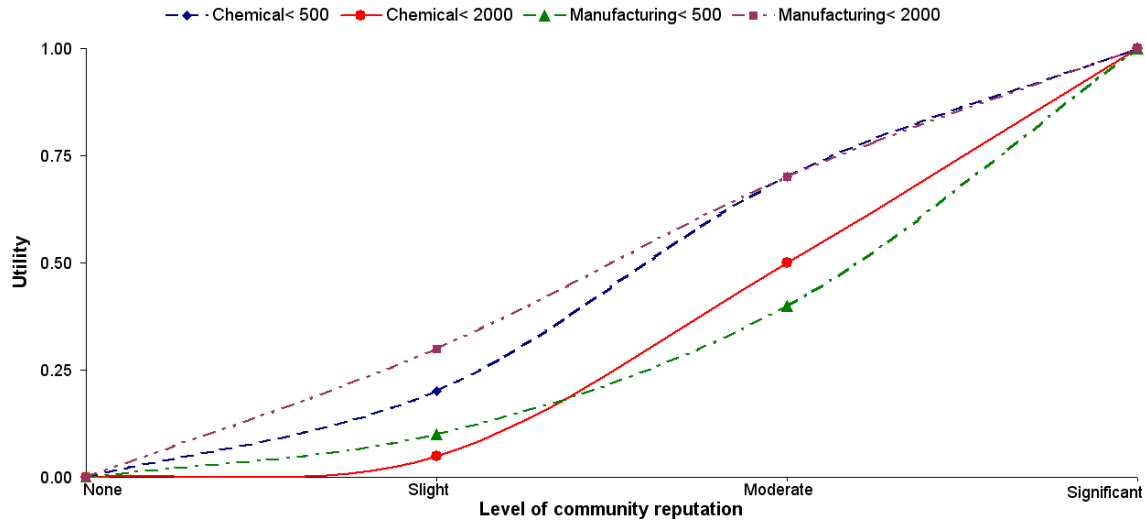
**Figure 10.** Utilities for environmental stewardship from each of the four respondents.



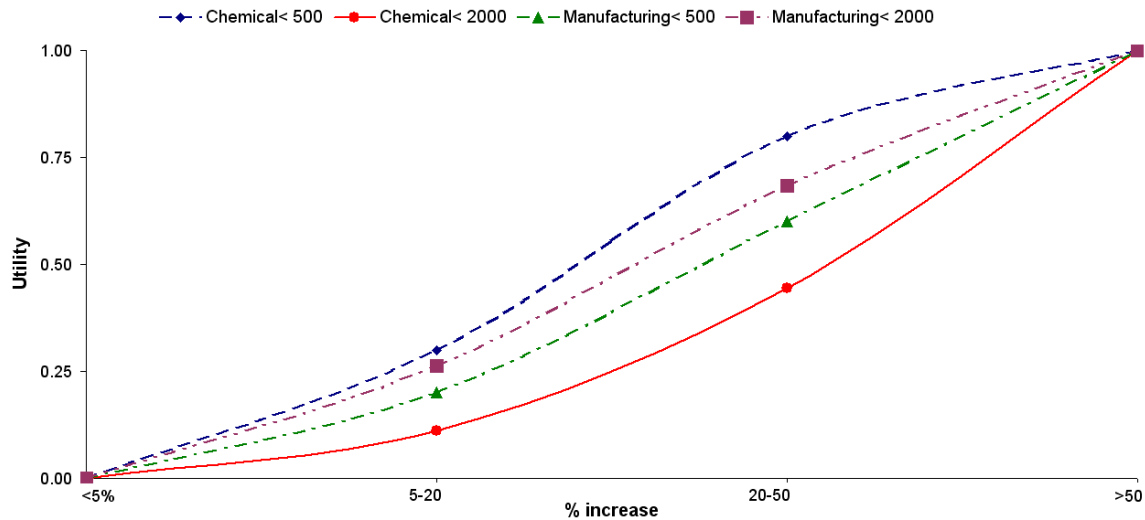
**Figure 11.** Utilities for agency relationship from each of the four respondents.



**Figure 12.** Utilities for employee satisfaction from each of the four respondents.



**Figure 13.** Utilities for community reputation from each of the four respondents.



**Figure 14.** Utilities for customer reputation from each of the four respondents.

of the same type. However, these similarities were not seen between the two chemical facilities, so it is possible that the similarities observed between the preferences of the decisionmakers at the manufacturing facilities were only a coincidence. If we look at the facilities of comparable size, we see that the two larger facilities had the greatest number of similarities in preferences with respect to those attributes which improved shareholder return and with respect to most of those attributes which measured stakeholder relationships. The two smaller facilities also demonstrated similar preferences

with respect to attributes which improved shareholder return and improved stakeholder relationships. Overall, more similarities were found between the facilities of equivalent size than between those in a similar industrial sector.

### **Determination of Weights**

After determining the relative levels of preference for each measurement level, I determined the relative importance of each attribute (weights). To determine an accurate assessment of weights, I assembled a survey in which I asked respondents to rate each attribute on a scale from 1-100 based on how important it is to the respondent and their organization as they consider environmental management systems (Appendix D). There were two groups of respondents for this survey. The first group was the four environmental managers from the chemical and manufacturing facilities. Approximately 45 other surveys were distributed to environmental managers working in a variety of sectors in the corporate world with some familiarity with management systems. Twelve surveys were returned yielding a response rate of 27%. I asked respondents to assign a weight of 0-100 both at the primary objective level, and then separately at the level of the 11 attributes. To calculate the weights from both sets of responses, I summed the total scores for all attributes. I then divided each individual score by the total, effectively normalizing them such that the sum of all the weights was one.

To ensure that the priorities of each respondent were properly aligned and that the respondent was consistent in his/her responses, I compared the weight assigned to each primary objective to the total weights of the attributes directly related to that primary objective. For example, I added up the weights for competitive advantage, risk reduction, cost savings and verification reliability and compared the total to the weight allocated to the maximizing shareholder return sub-objective. This comparison was conducted for all of the survey results received as an initial quality check of the consistency of the weights assigned. I followed up with three environmental manager respondents who had a discrepancy of greater than 5% between the subobjective weights and total of the

associated attribute weights. The responses from the chemical and manufacturing facilities' representatives were not consistent. The smaller chemical facility was the only respondent whose attribute weights reflected the weights given to the primary objectives. I followed up with the other three respondents to inquire about their inconsistent preferences. The two larger facilities indicated that they felt the weights allocated to the attributes were correct, so they reassigned weights to the primary objectives to consistently reflect the weights assigned to the attributes. The smaller manufacturing facility chose to reassign weights to some of the attributes to better align them with the weights assigned to the primary objectives.

With respect to the four representatives from the chemical and manufacturing facilities, the elicited weights differed among respondents (Table 9). However, I observed several similarities as well. In general, those attributes associated with improving shareholder value were weighted more heavily. Also, generally speaking, among the environmental attributes, these facilities valued environmental stewardship more than being able to decrease emissions or decrease the amount of material consumed. Additionally, verification reliability appears to be very important across all four facilities. It is also interesting to note that the two smaller facilities viewed competitive advantage as the most important attribute, but one of the larger facilities saw it as least important.

The survey responses of attribute weights from the variety of environmental managers across many industries also varied significantly as expected (Table 10). I averaged the weights by industry, for purposes of the tool. Consistent with the weights assigned by the four facility managers (Table 9), both the verification reliability and environmental stewardship attributes were weighted most heavily. These results contrast with those of Table 9 in that only one of the industries appears to strongly value cost savings and competitive advantage. These results seem to indicate that companies adopting EMSs are not as much motivated by financial indicators as they are by the reliability of the verification mechanism and the ability of the system to prepare them for future environmental challenges.

**Table 9.** Normalized weighting of attributes determined through surveys from two manufacturing industry environmental managers and two chemical industry managers.. Italicized numbers in parentheses are totals of associated attribute weights.

<b>Attribute</b>	<b>Small Chemical Facility</b>	<b>Large Chemical Facility</b>	<b>Small Manufacturing Facility</b>	<b>Large Manufacturing Facility</b>
<b><i>BUSINESS NEEDS</i></b>	0.63 ( <i>0.51</i> )	0.30 ( <i>0.31</i> )	0.33 ( <i>0.37</i> )	0.38 ( <i>0.30</i> )
<i>Competitive advantage</i>	0.15	0.010	0.13	0.10
<i>Cost savings</i>	0.11	0.077	0.067	0.067
<i>Reduced liability</i>	0.081	0.11	0.067	0.010
<i>Verification reliability</i>	0.16	0.12	0.093	0.13
<b><i>ENVIRONMENTAL IMPACT</i></b>	0.31 ( <i>0.15</i> )	0.36 ( <i>0.31</i> )	0.33 ( <i>0.34</i> )	0.38 ( <i>0.27</i> )
<i>Environmental stewardship</i>	0.11	0.11	0.12	0.10
<i>Reduced emissions</i>	0.016	0.10	0.11	0.067
<i>Reduce input material consumption</i>	0.016	0.10	0.11	0.10
<b><i>SOCIAL IMPACT</i></b>	0.063 ( <i>0.34</i> )	0.34 ( <i>0.38</i> )	0.33 ( <i>0.30</i> )	0.25 ( <i>0.43</i> )
<i>Improved agency relationship</i>	0.010	0.095	0.11	0.12
<i>Employee satisfaction</i>	0.081	0.095	0.013	0.10
<i>Customer reputation</i>	0.13	0.077	0.093	0.10
<i>Community reputation</i>	0.13	0.11	0.093	0.10

**Table 10.** Weight assigned to three objectives and 11 attribute measures by environmental managers from five industry sectors. Italicized numbers in parentheses represent the total of associated attribute weights.

<i>Corporate Sector/Attribute</i>	<i>Electronics Mfg and Service (n=2)</i>	<i>Financial (n=2)</i>	<i>Chemical (n=2)</i>	<i>Food (n=1)</i>	<i>Consulting (n=5)</i>
<b><i>BUSINESS NEEDS</i></b>	0.38 (0.37)	0.098 (0.24)	0.30 (0.29)	0.64 (0.51)	0.42 (0.46)
<i>Competitive advantage</i>	0.061	0.034	0.00	0.15	0.069
<i>Cost savings</i>	0.00	0.081	0.078	0.12	0.13
<i>Reduced liability</i>	0.18	0.00	0.11	0.082	0.14
<i>Verification reliability</i>	0.12	0.12	0.120	0.16	0.13
<b><i>ENVIRONMENTAL IMPACT</i></b>	0.38 (0.37)	0.46 (0.34)	0.36 (0.31)	0.31 (0.15)	0.23 (0.17)
<i>Environmental stewardship</i>	0.24	0.13	0.11	0.12	0.13
<i>Reduced emissions</i>	0.061	0.11	0.10	0.016	0.042
<i>Reduce input material consumption</i>	0.061	0.11	0.10	0.016	0.00
<b><i>SOCIAL IMPACT</i></b>	0.25 (0.27)	0.44 (0.42)	0.34 (0.38)	0.063 (0.34)	0.35 (0.37)
<i>Improved agency relationship</i>	0.061	0.10	0.096	0.000	0.11
<i>Employee satisfaction</i>	0.024	0.11	0.096	0.082	0.11
<i>Customer reputation</i>	0.12	0.081	0.078	0.13	0.083
<i>Community reputation</i>	0.061	0.13	0.11	0.13	0.069

### **Calculation of Overall Utility**

Using the performance scores, utilities and weights I solicited, I calculated overall utility of a given alternative as follows:

$$U_a = W_1 * u_{a1} + W_2 * u_{a2} + W_3 * u_{a3} + \dots + W_{11} * u_{a11}$$

where  $U_a$  is equal to the total utility of an alternative  $a$ ,  $W_x$  is the weight on attribute  $x$  and  $u_{ax}$  is the utility of the performance level of attribute  $x$  for alternative  $a$ .

I calculated the overall utility for each of the three EMSs, based on the preferences of the representatives of each of the two chemical facilities and each of the two general manufacturing facilities (Table 11). Based on these final utilities, EMAS was found to be the “best fit” system for three out of four of the facilities. ISO14001 was found to be the “best fit” system for the chemical facility with less than 500 employees. However, many of the final values for EMAS were quite close to those for ISO14001, indicating that small differences in utility or weight could have changed the results. I explored this possibility using sensitivity analysis.

**Table 11.** Overall utility of the three EMSs based on expert ratings of performance (Tables 6 through 8) and preferences of four industry representatives (Fig. 4-14 and Table 9).

<i>Respondent</i>	<i>ISO14001</i>	<i>EMAS</i>	<i>The Natural Step</i>
Small Chemical	0.41*	0.36	0.25
Large Chemical	0.38	0.40*	0.22
Small Manufacturing	0.40	0.43*	0.22
Large Manufacturing	0.40	0.45*	0.25

\* Most preferred alternative for each respondent

### Sensitivity Analysis

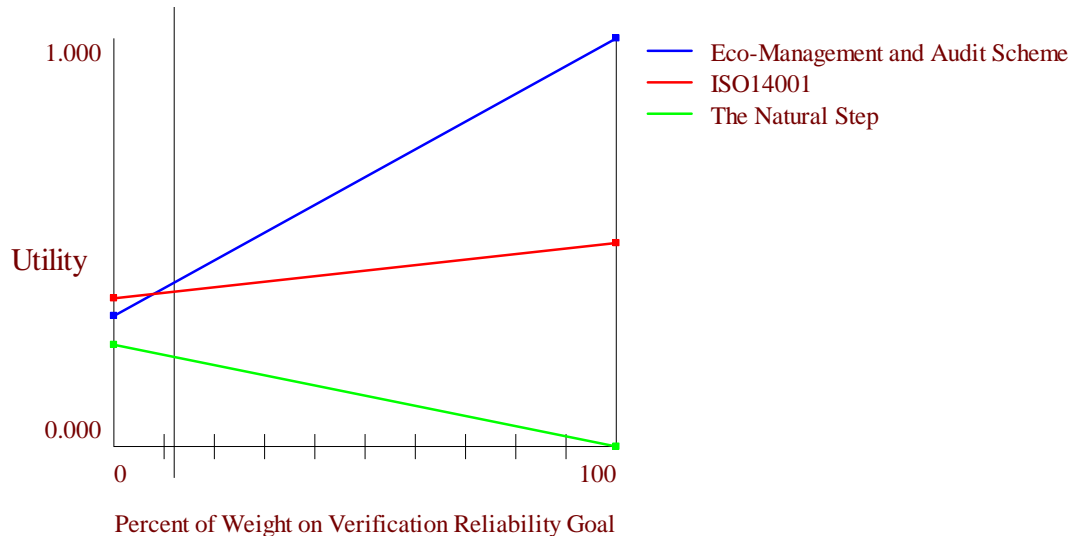
Sensitivity analysis involves adjusting the weights, utilities or performance ratings of various attributes to determine how much they must change for a different alternative to become preferred.

Sensitivity analysis can be conducted using a spreadsheet program such as Excel or specialized software programs such as Logical Decisions (Logical Decisions 2009). For this project, I used Logical Decisions (Logical Decisions 2009) to conduct sensitivity analysis on the preferences of each of the four environmental managers at the chemical and manufacturing facilities and on the weights allotted to each attribute by each of the four managers. I also built an Excel model to conduct sensitivity analysis on the performance assessments.

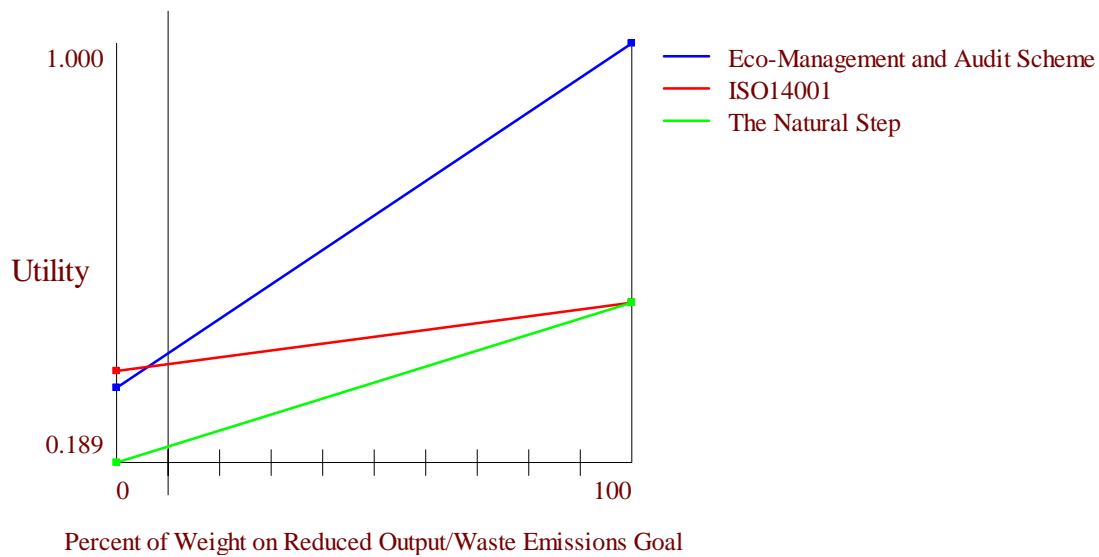
### **Sensitivity to Changes in Attribute Weights**

For this sensitivity analysis discussion, I originally intended to analyze only those attributes where a 10% increase or decrease in weight resulted in a different EMS being preferred. However, I found that there were several attributes, specifically cost savings and environmental stewardship, where there was significant variability in final utilities with a weight increase of greater than 10% that warranted inclusion in this discussion.

Overall utilities of the three EMSs were sensitive to changes in the weight on verification reliability for all four decisionmakers' preferences (e.g., Fig. 15). For example, the weight allocated to this attribute by the large chemical facility decisionmaker was about 12%, resulting in EMAS as the preferred alternative. However, when this weight decreased by approximately three percent, ISO14001 became the preferred alternative. EMAS became significantly more preferred as more weight was applied to verification reliability because EMAS received a higher performance score for verification reliability than either ISO14001 or The Natural Step. Also, note that no matter what weight was applied to verification reliability, The Natural Step never became the preferred alternative. The results of sensitivity analysis for change in weights on reduced outputs and emissions for the preferences of three of the four facility decisionmakers were very similar to those for verification reliability (e.g., Fig. 16). For the preference set of the large manufacturing facility decisionmaker, EMAS was the preferred alternative no matter what weight was applied to reduced outputs and emissions.



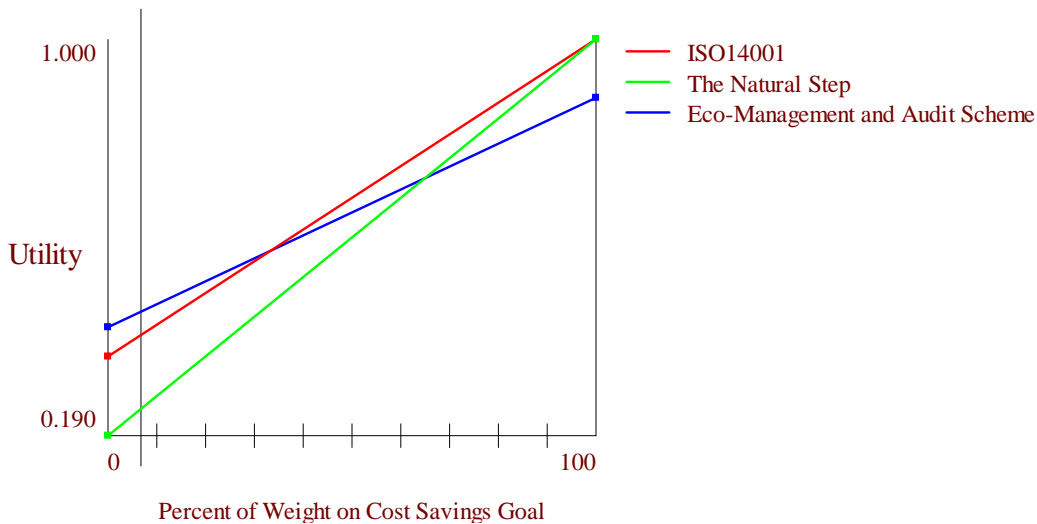
**Figure 15.** Sensitivity of overall utility to changes in the weight on verification reliability for the preferences of the large chemical facility.



**Figure 16.** Sensitivity of overall utility to changes in the weight on reduced outputs for the preferences of the large chemical facility.

The overall utilities for the three EMSs also showed significant sensitivity to changes in the weight on cost savings for three of the four facility decisionmakers. The preferred alternative for the preference set of the small chemical facility decisionmaker was consistently ISO14001, for all weights applied to the cost savings attribute. The overall utilities of the large chemical facility and

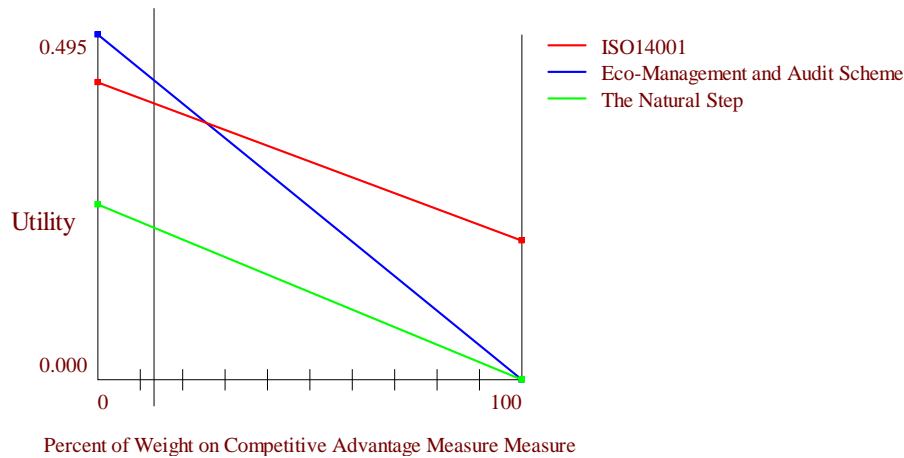
small manufacturing facility were highly sensitive to small changes in the weight applied to cost savings (<10%), where the large manufacturing facility required a larger weight change (>30%) to cause a change in the preferred alternative (Fig. 17). For the large manufacturing facility, the weight initially allocated to cost savings was about 8%, which resulted in EMAS as the preferred alternative. However, as more weight was applied to cost savings, ISO14001 became the preferred alternative at approximately 40% weight, and The Natural Step became more preferred than EMAS at approximately 70% weight. This was likely due to the better performance rating received by both The Natural Step and ISO14001 for cost savings compared to EMAS. Note that this is one of the few sensitivity analyses where The Natural Step was not completely dominated. Although the preferred alternative for the large manufacturing facility does not change within the 10% weight change limits originally set on the cost savings attribute, I included it in this discussion because all four decisionmakers ranked cost savings as one of the top five attributes of importance in their weight allocations.



**Figure 17** Sensitivity of overall utility to changes in the weight on cost savings for the preferences of the large manufacturing facility.

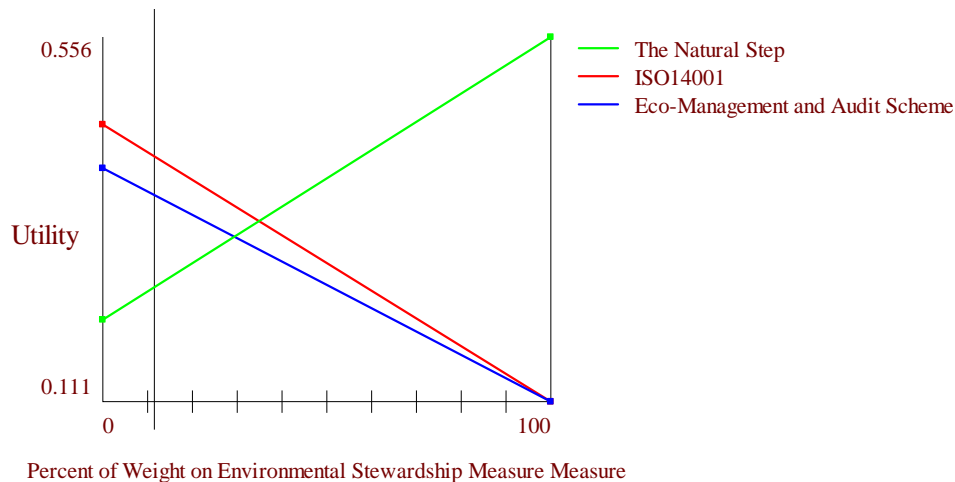
The overall utilities for the three EMSs also showed significant sensitivity to small changes in

the weight applied to competitive advantage for all four facilities (Fig. 18). For example, for the small manufacturing facility, at the 12% weight allocated by this decisionmaker, the preferred alternative was EMAS. However, as slightly more weight was applied, the preferred alternative became ISO14001 at approximately 20% weight. ISO14001 became significantly more preferred as more weight was applied to competitive advantage likely due to the higher performance rating received by ISO14001 on this attribute compared to EMAS and The Natural Step. Also note that no matter what weight was applied to competitive advantage, The Natural Step never became the preferred alternative.



**Figure 18.** Sensitivity of overall utility to changes in the weight on competitive advantage for the preferences of the small manufacturing facility.

The overall utilities for the three EMSs also showed sensitivity to larger changes in the weight applied to environmental stewardship for all four facilities (Fig. 19). For example, for the small chemical facility, the preferred alternative changed from ISO14001 to The Natural Step with an approximate 20% increase in weight on environmental stewardship. The Natural Step became the most preferred alternative at approximately 30% weight, due to the strong performance score received by The Natural Step on this attribute. A 20% weight increase is quite significant and highly



**Figure 19.** Sensitivity of overall utility to changes in the weight on environmental stewardship for the preferences of the small chemical facility.

unlikely; for The Natural Step to become preferred, this was needed to make up for the lower performance scores received by The Natural Step on so many other attributes. Also interesting to note, no matter what weight was applied to this attribute, EMAS never became the preferred alternative. The results were similar for the other three facilities, however the weight increase needed to create a change in the preferred alternative was even greater than that for the small chemical facility (~ 40%). While these analyses for environmental stewardship were also outside the bounds of the 10% weight change limits I initially set, this analyses was important to include because it was the only attribute on which The Natural Step received a higher performance score than both ISO14001 and EMAS.

### Performance Assessments

In addition to analyzing sensitivity of overall utilities of the EMSs to changes in weights , I also evaluated the sensitivity of the results to the performance scores given to each attribute for each system. Specifically, I assessed the sensitivity of overall utility to changes in performance ratings for attributes where there was disagreement among the experts. As shown in Tables 6 through 8, these attributes include: cost savings, competitive advantage, risk reduction, reduced inputs, reduced outputs, agency relationship and community relationship. I wanted to see if using the lower scores

from Tables 6 through 8 instead of higher ones when there was a disagreement would change the final results. I assessed the sensitivity to performance ratings by changing the performance scores for one attribute at a time from the highest to the lowest performance rating given by the experts, and finally, by changing all of them from their highest to their lowest values together (Table 12). For the most part, changing any one of the attribute performance ratings did not affect the final outcome. This indicated that the decision to use the higher performance rating provided by the experts when there was a discrepancy between two experts was acceptable. The most interesting result from this evaluation was that when all of the attributes for each alternative were assessed at the lowest rating received from an expert, for the preferences of all four environmental managers the preferred alternative was The Natural Step. In reviewing the scores received by The Natural Step as listed in Tables 6 through 8, the performance rating with the greatest impact was that assigned to cost savings. The lone evaluator for The Natural Step indicated that greater than 50% savings can be achieved with implementation of The Natural Step. This contrasted to the low scores (0-10%) received by ISO14001 and EMAS. Although EMAS and ISO14001 received higher performance ratings on other attributes than The Natural Step, the difference was not significant enough to overcome The Natural Step's cost savings advantage. Given that The Natural Step performed so much more poorly on most attributes than either ISO14001 and EMAS, and given the wide implementation of ISO14001 and EMAS, these results indicated that the use of higher performance ratings provided a more plausible assessment of the tradeoffs among the systems and that the assessment of greater than 50% cost savings for The Natural Step may have been overly optimistic. This also served as a reminder that these performance ratings would be more accurate if elicited from more experts. Thus, this assessment was only as good as the judgment of the experts who provided information.

### **Final Interview with Decision System Reviewer**

Once sufficient data were collected to determine expert values for performance scores, utilities and weights, I conducted an interview with a corporate environmental professional who is

**Table 12.** Sensitivity of overall utilities of EMSs to changes in performance ratings (i.e., using the lower scores assigned by the experts, where high and low scores are those denoted in Tables 6-8) for the preferences of environmental managers from four types of facilities. Boldface font indicates the most preferred alternative for each scenario. Large boldface font indicates the preferred alternative is different than the base case.

Performance Ratings	Alternative	Overall Utility of EMSs			
		Small Manufacturing	Large Manufacturing	Small Chemical	Large Chemical
All high (base case)	ISO14001	0.398	0.396	<b>0.411</b>	0.379
	EMAS	<b>0.429</b>	<b>0.445</b>	0.364	<b>0.402</b>
	TNS	0.218	0.245	0.251	0.220
Cost savings lowest, all others highest	ISO14001	0.33	0.328	<b>0.296</b>	0.301
	EMAS	<b>0.38</b>	<b>0.385</b>	0.281	<b>0.385</b>
	TNS	0.218	0.245	0.251	0.220
Competitive advantage lowest, all others highest	ISO14001	0.371	0.362	<b>0.355</b>	0.379
	EMAS	<b>0.429</b>	<b>0.445</b>	0.273	<b>0.402</b>
	TNS	0.218	0.245	0.251	0.220
Risk reduction lowest, all others highest	ISO14001	0.384	0.396	<b>0.4</b>	<b>0.379</b>
	EMAS	<b>0.402</b>	<b>0.445</b>	0.343	0.342
	TNS	0.218	0.245	0.251	0.220
Reduced outputs lowest, all others highest	ISO14001	<b>0.398</b>	0.396	<b>0.411</b>	0.368
	EMAS	0.375	<b>0.418</b>	0.359	<b>0.37</b>
	TNS	0.218	0.245	0.251	0.220
Reduced inputs lowest, all others highest	ISO14001	0.344	0.355	<b>0.404</b>	<b>0.379</b>
	EMAS	<b>0.375</b>	<b>0.405</b>	0.357	0.351
	TNS	0.218	0.245	0.251	0.220
Agency relationship lowest, all others highest	ISO14001	0.371	0.359	<b>0.411</b>	0.338
	EMAS	<b>0.402</b>	<b>0.409</b>	0.364	<b>0.361</b>
	TNS	0.218	0.245	0.251	0.220
Community relationship lowest, all others highest	ISO14001	0.37	0.365	<b>0.345</b>	0.36
	EMAS	<b>0.42</b>	<b>0.435</b>	0.338	<b>0.383</b>
	TNS	0.218	0.245	0.251	0.220
All lowest	ISO14001	0.18	0.187	0.157	0.181
	EMAS	0.17	0.177	0.131	0.176
	TNS	<b>0.218</b>	<b>0.245</b>	<b>0.251</b>	<b>0.220</b>

considering implementation of an environmental management system. The selection of this person was purposeful; he was the person I had in mind when I started this project. This professional works

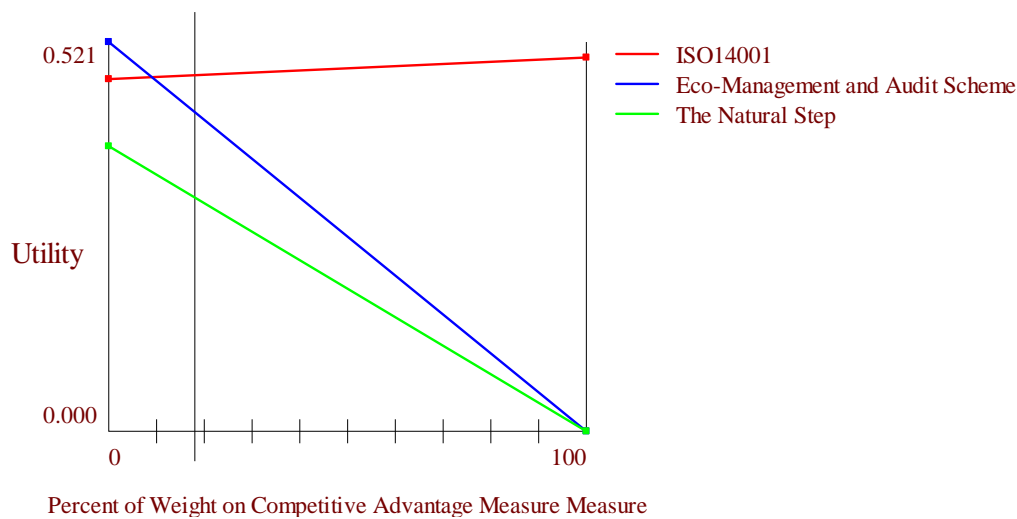
for a small chemical company (less than 500 employees) and has the title of facilities and operations manager. Since he is not an owner of the company, he requested anonymity both for him and his company. In my work with him professionally, I realized that he is someone who wants to do the right thing and wants to be proactive and compliant, but he does not have the human or financial resources to dedicate to research systems, make a custom EMS system or pay consultants a large sum of money to do this for him.

The purpose of the interview was to test the usefulness of the decision tool. First, I introduced the objectives hierarchy, and then each of the alternatives. Then, I explained the elicitation process. I elicited utilities using the certainty equivalent method (Clemen and Reilly 2001, 538) and I elicited weights using swing weighting (Clemen and Reilly 2001). I checked the weights for the 11 attributes to ensure that they were consistent with those allocated to the three primary objectives: maximizing shareholder return, reducing environmental impacts and improving stakeholder relationships. The stakeholder relationship subobjective had a discrepancy, so we repeated the allocation to make the attribute weights more consistent with the weight on stakeholder relationships. Following the interview, I used the elicited utilities and weights to determine the most preferred alternative for the decision maker. The most preferred alternative was ISO14001 with a final utility of 0.48, followed by EMAS with a final utility of 0.43 and then The Natural Step with a final utility of 0.31. This was a logical result for several reasons. First, ISO14001 has a good verification mechanism, it will help with environmental stewardship and it will help reduce financial risk, all factors which are important to the decision maker. Additionally, a third party audit is not required, which would be an additional expense for a small company with limited resources. Because it is managed and enforced by the European Union, EMAS is confined to the European continent. Since the decision maker works for an American company, certification under EMAS would be logistically impossible.

Similar to the results for the chemical and manufacturing facilities, I evaluated the sensitivity of the reviewer's results to determine which weights most significantly impacted the final outcome.

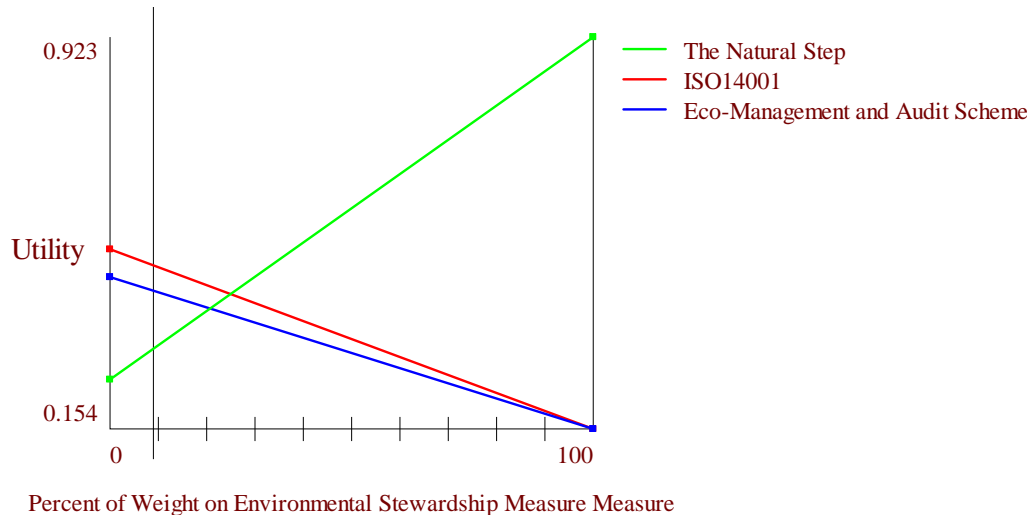
For the system reviewer, the weights with the most influence on the preferred alternative were competitive advantage, environmental stewardship and reduced outputs (Figs. 20 through 22).

For the initial weight allocated to competitive advantage by the decision system reviewer (~17%), the most preferred alternative was ISO14001 (Fig. 20). However, if this decisionmaker had allocated about ten percent less weight to this attribute, the preferred alternative would have become EMAS. ISO14001 became the preferred alternative at approximately 12% weight, likely due to the higher performance score it received for competitive advantage compared to EMAS and The Natural Step. This was also evident from how much more significantly ISO14001 became preferred as more weight was applied to competitive advantage. Also, note that The Natural Step never became preferred, no matter how much weight was applied to competitive advantage.



**Figure 20.** Sensitivity of overall utility to changes in the weight on competitive advantage for the preferences of the decision system reviewer.

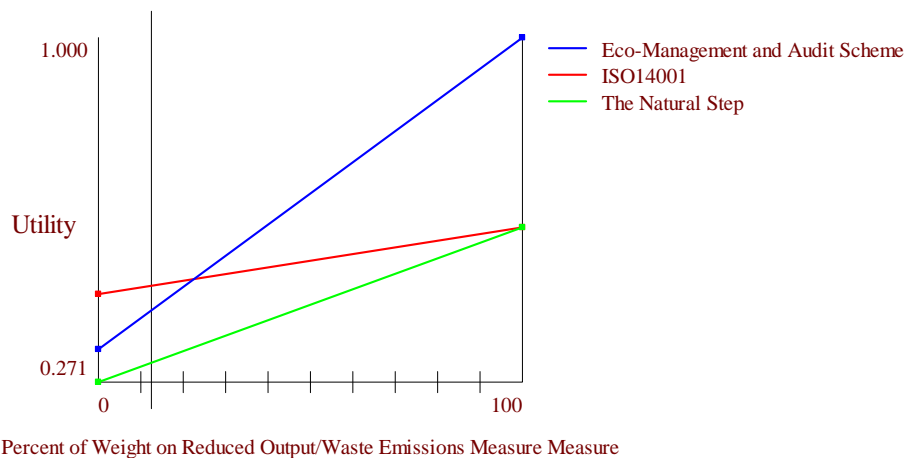
For the initial weight allocated to environmental stewardship by the decision system reviewer (~9%), the most preferred alternative was ISO14001 (Fig. 21). When the weight applied was increased to approximately 25%, The Natural Step became the most preferred alternative. This was logical since The Natural Step received a much higher performance rating on this attribute



**Figure 21.** Sensitivity of overall utility to changes in the weight on environmental stewardship for the preferences of the decision system reviewer.

than the other two systems did. No matter how much weight was applied to this attribute, EMAS never became preferred.

For the weight initially allocated to reduced outputs by the decision system reviewer (~12%), ISO14001 was the preferred alternative (Fig. 22). However, if the weight on reduced outputs was increased to about 18%, the preferred alternative became EMAS. This was likely due to the better performance rating on this attribute for EMAS compared to the other two systems. Also note that no matter how much weight was applied to this attribute, The Natural Step never became preferred.



**Figure 22.** Sensitivity of overall utility to changes in the weight on reduced outputs for the preferences of the decision system reviewer.

I also evaluated the sensitivity of the overall utilities of the three EMSs for my system reviewer to changes in performance ratings given by experts in Tables 6 through 8. I changed each attribute rating to its lowest level from Tables 6 through 8 one by one and also changed all 11 to their lowest levels together (Table 13). These results indicated that the decision to use the higher performance rating was acceptable because the rankings of EMSs are mostly the same. However, similar to the four facility cases (Table 12), when all the low ratings were used, The Natural Step was the most preferred alternative. As discussed previously, this indicated that the higher ratings provided a more plausible assessment of tradeoffs and that the performance rating of more than 50% for The Natural Step cost savings may be overly optimistic.

## **DISCUSSION**

By constructing this tool, I have learned a significant amount about the motivations of different types of companies implementing EMSs, the realities of implementation and the limitations of one-size-fits-all systems. In general, the attributes which were most important to companies were competitive advantage, verification reliability and environmental stewardship. Competitive advantage was especially important to smaller companies. This seemed logical because smaller companies have to work harder for customers, since many times they are limited in resources in comparison to larger corporations. The consistently high weight allocated to verification reliability indicated that when companies implement a system, they want confirmation that they have done it properly. This also seemed logical because a company would not want to spend much time and effort implementing a system without knowing whether it is operating correctly and/or efficiently. Environmental stewardship also was consistently allocated significant weight. This indicated that companies want a tool to help them prepare for the future with respect to environmental issues.

ISO14001 is the most implemented environmental management system in the world (Gavronski et al. 2008). One might infer from this statistic that ISO14001 is the best environmental

**Table 13.** Sensitivity of overall utilities of EMSs to changes in performance ratings (i.e., using the lower scores assigned by the experts, where high and low scores are those denoted in Tables 6-8) for the preferences of the decision system reviewer. Boldface font indicates the most preferred alternative for each scenario. Large boldface font indicates the preferred alternative is different than the base case.

Performance ratings of attributes	Alternative	Overall utility for EMS
All high (base case)	ISO14001	<b>0.477</b>
	EMAS	0.426
	TNS	0.313
Cost savings low, all others high	ISO14001	<b>0.404</b>
	EMAS	0.397
	TNS	0.313
Competitive advantage low, all others high	ISO14001	0.386
	EMAS	<b>0.426</b>
	TNS	0.313
Risk reduction low, all others high	ISO14001	<b>0.473</b>
	EMAS	0.385
	TNS	0.313
Reduced outputs low, all others high	ISO14001	<b>0.477</b>
	EMAS	0.376
	TNS	0.313
Reduced inputs low, all others high	ISO14001	<b>0.439</b>
	EMAS	0.388
	TNS	0.313
Agency relationship low, all others high	ISO14001	<b>0.453</b>
	EMAS	0.402
	TNS	0.313
Community relationship low, all others high	ISO14001	<b>0.461</b>
	EMAS	0.403
	TNS	0.313
All low	ISO14001	0.231
	EMAS	0.207
	TNS	<b>0.313</b>

management system for any and every type of organization. The results of this study question the accuracy of this premise. For three out of four organizations with environmental management systems already in place, the most preferred alternative was the Eco-Management and Audit Scheme. Because the Eco-Management and Audit Scheme is more stringent than ISO14001 with respect to verification practices and environmental performance requirements, these results indicated that companies may be looking for more structure and verification than ISO14001 has to offer. However, the name recognition associated with ISO14001, in addition to reported lower implementation costs and level of effort, are likely enough to sway companies toward that system. This would be especially true for smaller companies that do not have as many human or physical resources to spend on stringent verification processes and implementation efforts. This was further verified by the finding that ISO14001 is the preferred alternative for the smaller chemical company respondent and for the final tool reviewer, also from a small company.

Generally, EMAS and ISO14001 were very close in their overall performance scores, with each system having certain strengths. ISO14001 was favored by small companies who prioritize competitive advantage and cost savings. The larger companies tended to favor a system like EMAS, which has a stringent validation process and significant environmental performance requirements. The Natural Step was dominated on almost all attributes by the other two EMSs. The Natural Step would be a preferred alternative only for a company who prioritizes environmental stewardship above all else, a company not as concerned about validation or immediate cost savings or competitive advantage. Surprisingly, there were very few trends in preferences observed between companies in similar industrial sectors. The preferences of the two manufacturing companies were similar, but those of the two chemical companies were not.

I found that many companies are actually employing more than one of these management systems at a time. In my literature reviews, and in responses to several of my surveys, I saw examples of companies that used ISO14001 to help them meet their EMAS certification requirements. Other companies used ISO14001 to help them follow the four principles of The Natural Step. In fact, when I

contacted someone from The Natural Step (Jennifer Reid, Program Officer, The Natural Step Canada, March 1, 2010), she indicated that The Natural Step organization actually recommends that people have another system in place in tandem with The Natural Step. The representative stated that The Natural Step is meant to be more of a crown that sits on top of a structured environmental management system. She implied that The Natural Step was more of an add-on than a system in itself. For this project, The Natural Step was treated independently, perhaps explaining the low performance rating it received for so many of the attributes. However, I suspect that the scores would be quite different for the combination of two or more systems. For another study, it might be interesting to see how much more “useful” a set of systems would be to a decision maker instead of only one.

One expert said that he reviewed the survey, but did not feel it was realistic. The expert indicated that, in his experience, the decision about management systems usually came down to politics, control issues and corporate culture. He provided no other feedback. Because this comment significantly questioned the premise of the project, I took it very seriously. I discussed this with three professionals who work with environmental management systems on a regular basis. They confirmed that the project indeed was significant and that there was no reason to question its premise.

Although the scope of this tool was appropriate for this master’s project, it was quite limited in the grand scheme of things. At the beginning of the project, I struggled significantly in trying to assemble a reliable objectives hierarchy and reasonable number of associated attributes. This prolonged process likely would have been expedited had I conducted some preliminary interviews with industry representatives before assembling the oversized hierarchy and attribute list that I did initially. I solicited feedback from only two types of companies and from only two facilities of each type. I only interviewed one person to assess the usefulness of the tool. More interviews likely would have provided more well-rounded, valuable feedback. Also, due to time and resource constraints, the utility and weight elicitation from the chemical and manufacturing facilities were completed mostly by survey, whereas face to face interviews would likely have produced more accurate and thoughtful results. Finding experts knowledgeable enough about management systems to assess each of them on

the criteria I developed was challenging. The assessments are only as good as the judgments of the people who made the assessments. A larger number of experts would likely have resulted in more reliable performance ratings. Most potential experts were familiar with one or perhaps two of the systems, so the performance scores could potentially be biased because they were not scored relative to the others.

## **CONCLUSIONS AND RECOMMENDATIONS**

The results of this project demonstrated that the Eco-Management and Audit Scheme was the most preferred alternative for three out of four test cases. ISO14001 was the preferred alternative for one small chemical facility test case and one small chemical facility user.

The most important attributes contributing to the overall merit of EMSs were verification reliability and environmental stewardship. Companies want to ensure that the system they implement is verifiable and that it will provide them with a process and a strategy for addressing new environmental challenges. Some similarities were also seen in the decisionmakers' assessments of the importance of cost savings, competitive advantage and risk reduction for companies of similar size. The smaller companies in particular were concerned with competitive advantage.

On the whole, the Eco-Management and Audit Scheme scored the best of the three EMSs on the majority of the attributes. ISO14001 scored higher than EMAS only on cost savings, competitive advantage and community reputation. The Natural Step scored higher than EMAS only on cost savings and environmental stewardship. Although EMAS scored well, it was not perfect for all company objectives.

Through the course of this project, it became apparent that most people, when they discuss environmental management systems, have their own ideas about what they think the management system should accomplish at their organizations. These preferences will determine how the management system is implemented, and also how results are assessed. If cost savings are important, organizations will look at financial impacts. If environmental footprint is important, they will

consider production and emissions. For the most part, the tool I created captured these different preferences and provided one way to assess the tradeoffs among them.

Companies who do not know much about environmental management systems can use my tool as a guide to narrow the scope of the many EMS options which are available. The tool also serves as a good guide to sorting out what is really important to a company as they consider the usefulness of an environmental management system. My hope is that these companies will expand the tool for their own uses, populating the performance rating table with information about the systems which are of interest to the decisionmakers in their organizations and adding organization-specific preferences which may not be already included.

When companies use this tool and make decisions regarding environmental management systems, I encourage them to consider a combination of EMSs rather than a single system such as ISO14001. By implementing a combination of systems, such as ISO14001 and EMAS or ISO14001 and The Natural Step, companies can maximize the effectiveness of their efforts, meet more of their goals, and make greater headway toward the triple bottom line of increased shareholder return, reduced environmental impact and improved stakeholder relationships.

## **ACKNOWLEDGMENTS**

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## **APPENDICES**

## **Appendix A: Recruitment Letter for Project Participants**

### **RESEARCH INSTRUMENTS**

Recruitment will consist primarily of an initial email solicitation, and then either a phone call or another email follow-up after the subject has expressed interest in participating.

*Initial Email:*

Dear \_\_\_\_\_:

As you may know, in addition to my job at Environmental Resources Management, I am currently in my second year of a two-year graduate program through Duke University's Nicholas School of the Environment. My final master's project is the construction of a decision analysis tool to evaluate tradeoffs in environmental management systems. The three systems I am evaluating in this project are ISO14001, The Natural Step and the Eco-Management and Audit System (EMAS)

[For corporate representatives, this paragraph applies]: I am interested in better understanding what criteria are important to you and your organization as you consider implementing or when you implemented your environmental management system. What about the system makes it a good fit for your organization? What criteria did you consider significant? Insignificant? What was your organizations drivers in implementation?

[For consultants and experts in EMS]: Based on an understanding of each of these systems and a literature review, I have assembled a list of criteria which could be considered significant for one or more of these systems. To create an effective tool, I need an understanding of how well each of the systems scores for each of these criteria. Given your experience in this field, I am hoping that you will provide a realistic assessment of each of these systems using the given criteria and measurement scales. I am also interested in understanding how well I've captured relevant criteria and if the proposed measurement scales are appropriate for the given criteria.

Information gathered in this survey will be useful in building a realistic decision tool that corporations can use to evaluate the tradeoffs between these three systems. It will also be flexible enough to add or subtract one system or another for further comparison. If you or other colleagues would be interested in contributing to the project, please respond to this e-mail so I can provide more details. Then, if you decide to participate, I will administer a survey electronically or by telephone, whichever is most convenient for you and your colleagues.

Thank you for your time and please let me know if you have any questions. I look forward to hearing from you.

Sincerely,

Mary Pat Bomher  
DEL-MEM 08  
Nicholas School of the Environment

## Appendix B: Performance Assessment Survey

### Environmental Management System Assessment

INSTRUCTIONS: Below, you will find a table with a list of criteria for evaluating the differences between ISO 14001, Eco-Management and Audit System (EMAS) and The Natural Step. For each criteria, a scale has been proposed with between two and five assessment levels.

Based on your experience and expertise, please assign a rating to each of the three systems for each criteria using one of the points from the measurement scale provided. Please note any comments or questions you have regarding the criteria or measurement scales in the comments column.

Additional information on each system can be found at the following urls:

The Natural Step: <http://www.thenaturalstep.org/en/canada/>

ISO14001: [www.praxiom.com/iso-14001-2004.htm](http://www.praxiom.com/iso-14001-2004.htm)

EMAS: [http://ec.europa.eu/environment/emas/index\\_en.htm](http://ec.europa.eu/environment/emas/index_en.htm)

<b>Primary Objective: To select the "best" environmental management system</b>						
Criteria	Units	Measurement Points	ISO14001	EMAS	The Natural Step	Comments
<b>Sub-Objective: Increasing Shareholder Return</b>						
<b>Competitive Advantage:</b> What percent of additional business from <b>new</b> customers will be observed within the first five years of EMS implementation?	% Additional Profit	0-10%				
		10-20%				
		20-30%				
		30-40%				
		>40%				
<b>Cost Savings:</b> What percent of cost savings will be observed as a result of this EMS implementation within the first five years of implementation?	% cost savings	0-10%				
		10-25%				
		25-50%				
		>50%				

Criteria	Units	Measurement Points	ISO14001	EMAS	The Natural Step	Comments
<b>Risk Reduction:</b> What % financial risk reduction from production will be observed due to EMS implementation?	% risk reduction	<i>None</i>				
		<i>0-5%</i>				
		<i>5-10%</i>				
		<i>10-15%</i>				
		<i>&gt;15%</i>				
<b>Verification Liability:</b> How verifiable will the stakeholders of the organization view the system?		<i>Weak</i> : The verification mechanism is ineffective; both objectives and targets and continuous improvement are destined to fail				
		<i>Effective</i> : The verification mechanism will contribute to continual improvement but not all objectives and targets				
		<i>Very Effective</i> : The verification mechanism will result in continuous improvement and all objectives and targets being met.				
<b>Sub-objective: Reduce Environmental Impacts</b>						
<b>Reduced Input Material Consumption:</b> How will implementation of this system contribution to reducing input material consumption within the first five years?	% reduction	<i>No Change</i>				
		<i>Little</i> (0-25% reduction)				
		<i>Intermediate</i> (25-50% reduction)				
		<i>Significant</i> (>50% reduction)				

Criteria	Units	Measurement Points	ISO14001	EMAS	The Natural Step	Comments
<b>Reduced Emissions:</b> How will system implementation contribute to the reduction of emissions and/or waste within the first five years?	% reduction	<i>No Change</i>				
		<i>Little</i> (0-25% reduction)				
		<i>Intermediate</i> (25-50% reduction)				
		<i>Significant</i> (>50% reduction)				
<b>Environmental Stewardship:</b> Does this system provide a structure for responding to new environmental management challenges?		<i>No: Not at all</i>				
		<i>Somewhat:</i> System indirectly addresses the issue but provides no specific guidance on how to enact				
		<i>Moderate:</i> The system provides very general guidelines for change management but no direct detail.				
		<i>Significant :</i> This is a primary characteristic of the system; it is structured around predicting and preparing for future challenges.				
<b>Sub-objective: Improving Stakeholder Relationships</b>						

Criteria	Units	Measurement Points	ISO14001	EMAS	The Natural Step	Comments
<b>Agency Relationship:</b> How will implementation of this system affect the organization's relationship with regulatory agencies within the first five years?	% reduction in NOV's and inspections	<p><i>None</i> : Agency relationship will remain unchanged.</p> <p><i>Some</i> : The number of NOV's and inspections will decrease by up to 20% in the first five years.</p> <p><i>Significant</i> : The number of NOV's and inspections will decrease by greater than 20% in the first five years.</p>				
<b>Employee Satisfaction:</b> Will implementation of this system contribute to employee morale and satisfaction within the first five years?	Employee Turnover	<p><i>No</i> : There will be no observable change in employee morale and turnover rate.</p> <p><i>Possible</i> : Employee morale may improve and the employee turnover rate will improve by up to 5%.</p> <p><i>Certain</i> : There will be an observable difference in employee morale and the employee turnover rate will improve by greater than 5%</p>				
<b>Community Reputation:</b> To what extent will implementation of this system improve the reputation of the organization with the local community within the first five years?	% complaint reduction	<p><i>None</i> : There will be no change in the number of complaints about operations.</p> <p><i>Slight</i> : The number of complaints will decrease by 0-25%</p> <p><i>Moderate</i>: The number of complaints will decrease by 25-50%</p> <p><i>Significant</i>: The number of complaints will decrease by greater than 50%</p>				

Criteria	Units	Measurement Points	ISO14001	EMAS	The Natural Step	Comments
<b>Customer Reputation:</b> How much additional business will the organization receive from existing customers within the first five years as a result of system implementation?	% additional profit	<5%				
		5-20%				
		20-50%				
		>50%				

Do you give approval for the use of your name and company's name in the final, published version of this project?

YES  NO

## Environmental Management System Assessment Survey- Part II

INSTRUCTIONS: Below, you will find a table with a list of criteria for evaluating the tradeoffs between ISO 14001, Eco-Management and Audit System (EMAS) and The Natural Step. For each criterion, a scale has been proposed with 1-5 measurement points.

1. For each measurement point, please assign a points value between 0-100 based on the importance of that level of performance to you relative to the others. For example, to evaluate toppings for an ice cream dish, I might assign 25 points for chocolate sauce, 35 points for chocolate sauce with sprinkles but 90 points for chocolate sauce, sprinkles and whip cream because whip cream means that much more in my relative preference. For responses requesting numerical values, scores will be assigned using proportional scoring based on worst and best possible outcomes for that criteria. If you feel that any of the measurement scales or criteria are inappropriate or unclear, please note in the comment box. Also, please make suggestions for any other criteria you would consider important in evaluating tradeoffs between these systems.

Additional information on each system can be found at the following urls:

The Natural Step: <http://www.thenaturalstep.org/en/canada/>

ISO14001: [www.praxiom.com/iso-14001-2004.htm](http://www.praxiom.com/iso-14001-2004.htm)

EMAS: [http://ec.europa.eu/environment/emas/index\\_en.htm](http://ec.europa.eu/environment/emas/index_en.htm)

Attribute	Description	Measurement Levels	Score
<b>INCREASING SHAREHOLDER VALUE</b>			
Competitive Advantage	% additional business from new customers resulting from implementation of the EMS in the first five years	<i>0-10%</i>	
		<i>10-20%</i>	
		<i>20-30%</i>	
		<i>30-40%</i>	
		<i>&gt;40%</i>	
Risk Reduction	% financial risk reduction from production observed due to EMS implementation	<i>None</i>	
		<i>0-5%</i>	
		<i>5-10%</i>	
		<i>10-15%</i>	
		<i>&gt;15%</i>	
		<i>0-10%</i>	
		<i>10-25%</i>	

Cost Savings	% operational cost savings observed in first five years following implementation	25-50%	
		>50%	
Verification Reliability	How verifiable is this system?	<b>Weak</b> : No verification mechanism is specified; there is no guarantee that system is implemented appropriately or that objectives and targets are being met	
		<b>Effective</b> : A verification mechanism is specified; requires only internal verification	
		<b>Very Effective</b> : A verification mechanism is specified in great detail; requires external verification	
<b>REDUCING ENVIRONMENTAL IMPACT</b>			
Reduced Consumption	How will this system contribute to reduction of input material consumption?	<b>No Change</b>	
		<b>Little (0-25%)</b>	
		<b>Intermediate (25-50%)</b>	
		<b>Significant (&gt;50%)</b>	

Reduced Emissions	How will the system contributed to reduced emissions/waste?	<i>No Change</i>	
		<i>Little (0-25%)</i>	
		<i>Intermediate (25-50%)</i>	
		<i>Significant (&gt;50%)</i>	

Environmental Stewardship	Does the system provide a framework for responding to new environmental management challenges?	<i>No</i> : Not at all	
		<i>Somewhat</i> : The system guidelines do not directly address environmental stewardship	
		<i>Moderate</i> : The system guidelines address environmental stewardship, however, no formal guidance is provided.	
		<i>Significant</i> : This is addressed directly in the system guidelines with specific guidance; is the system is structured around predicting and preparing for future challenges	
<b>IMPROVING STAKEHOLDER RELATIONSHIPS</b>			
Agency Relationship	How will this system affect the organization's relationship with regulatory agencies?	<i>None</i> : Agency relationship will remain unchanged	
		<i>Some</i> : The number of notices of violation will decrease by 0-20% in first five years	
		<i>Significant</i> : The number of notices of violation will decrease by greater than 20% in the first five years	
Employee Satisfaction	Will implementation of this system contribute to employee morale and satisfaction within the first five years?	<i>No</i> : There will be no observable change in morale/turnover rate	
		<i>Possible</i> : Employee morale may improve and turnover may improve by up to 5%	
		<i>Definite</i> : There will be an observable difference in morale and turnover will improve by greater than 5%	

Community Reputation	To what extent will implementation of this system improve the reputation of the organization in the community?	<i>None:</i> There will be no change in the number of complaints about operations	
		<i>Slight:</i> Number of complaints will decrease by 0-25%	
		<i>Moderate:</i> Number of complaints will decrease 25-50%	
		<i>Significant:</i> Number of complaints will decrease by more than 50%	
Customer Reputation	How much additional business will the organization receive from existing customers as a result of system implementation?	<5	
		5-20%	
		20-50%	
		>50%	

## Environmental Management System Criteria Survey

Name: \_\_\_\_\_ Company: \_\_\_\_\_  
 Best Way to Contact: \_\_\_\_\_

### Section 1

**Instructions:** As you consider characteristics of environmental management systems in general, please first rate each of the criteria below from 1 to 3, with 1 being most important and three being least important. Then, rate each on a scale of 1-100 with 1 being least important and 100 being most important. The values do NOT have to add up to 100. Please complete this section before moving on to the next.

	(1-100)	(1-3)
Business Needs		
Environmental Impact		
Social Impact		

### Section 2

**Instructions:** As you consider characteristics of environmental management systems, please first rank each of the criteria below on a scale of 1-11, with one being highest and 11 being lowest. Then, rate each of the criteria from 0-100 with 0 being least important and 100 being most important. Please note that you do not need to provide a rating using the units listed. The units are listed only to provide you with more information regarding how the criteria will be assessed. You should only rate the criteria with respect to how important it is for you and your company as you consider the use/implementation of environmental management systems. I would also appreciate any feedback on the given criteria and proposed measurement scales. Additionally, if you have recommendations for additional criteria or different measurement scales, please make note of these.

<b>Business Needs</b>		
<i>Criteria</i>	<i>Rating (1-11)</i>	<i>Rating(0-100)</i>
<b>Competitive Advantage</b>		
<b>Verification Reliability</b>		
<b>Environmental Stewardship</b>		
<b>Reduced Emissions</b>		
<b>Reduced Material Inputs</b>		
<b>Improved Agency Relationship</b>		
<b>Employee Satisfaction</b>		
<b>Customer Reputation</b>		
<b>Community Reputation</b>		

Additional Comments: \_\_\_\_\_  
 \_\_\_\_\_

Do you give approval for the use of your name and company's name in the final, published version of this project?  
 \_\_\_\_\_ YES \_\_\_\_\_ NO