The Pennsylvania State University

The Graduate School

College of Engineering

AN INVESTIGATION OF SUSTAINABILITY METRICS IN INDUSTRY TO AID PRODUCT DESIGN, PRODUCTION, AND DISTRIBUTION PROCESSES

A Thesis in

Industrial Engineering and Operations Research

by

Jordan D. Shelton

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

December 2010

The thesis of Jordan D. Shelton was reviewed and approved* by the following:

Gül E. Okudan Kremer
Associate Professor of Industrial Engineering
Thesis Advisor

Charles D. Ray
Associate Professor of Wood Operations Research

Paul Griffin
Professor of Industrial Engineering
Head of the Department of Industrial Engineering

*Signatures are on file in the Graduate School

ABSTRACT

In recent years, resource depletion and amplified social pressures have increased environmental awareness to the point where companies must consider production and supply decisions from both ecological and economic points of view. Finding a way to quantitatively measure the sustainability of various production and distribution alternatives would greatly benefit industry; however, to date, no single measure of sustainability has been universally accepted. Through an analysis of literature and current practices, this research aims to develop a refined sustainability index based on what have been deemed to be the most important and influential metrics available. The chosen collection of metrics was identified through research, at which point, the metrics discovered were streamlined and quantified for easy implementation in industry. A number of industry representatives, both domestically and abroad, were presented with the matrix of metrics and their subsequent descriptions, formulas, and complexity indices. Upon review, these representatives provided their feedback about the feasibility, cost, and benefits of implementing measurement and tracking systems within their corporations. Through statistical analysis of these responses, a comprehensive set of metrics is identified and recommended for industry use. The use of such a system of metrics allows companies measure their progress as they work towards implementing environmental improvement efforts.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to thank Dr. Gül Kremer for her patience and guidance during the development and the writing of this thesis. Without her drive, experience, and long term vantage point, I cannot imagine this research taking shape and becoming a successful effort. I would also like to acknowledge Dr. Charles Ray for evaluating the work. Additionally, as my advisors over the past four and a half years Dr. Paul Griffin and Dr. Richard Koubek have provided me with a great deal of guidance and helped shape my path and career as an industrial engineer.

For educating me regarding general research practices and procedures, I would like to thank the members of the ADAPS research team, including Ming-Chuan Chiu and Wu Hsun ‘Roger’ Chung. These individuals, as well as exchange student Caroline Segard, were extremely helpful in completing this endeavor – from assisting with my literature review, to gathering data from online survey sources. Along these lines, I would like to thank all of the industry representatives who took the time to complete the extensive survey that formed the basis for much of this research, as well as the individuals at Cannondale Bicycles, Inc. for their time, thoughts, and opinions.

Lastly, and most importantly, I would like to thank my parents for their love and support. Through grade school and college, their encouragement and belief in my abilities and determination – even when I haven’t believed in myself – has been unwavering. They have helped push me to reach my goals and be where I am today.

Chapter 1

Introduction

1.1 Background Information Concerning Sustainability

One of the cornerstones of industrial engineering is to eliminate waste. Eliminating waste makes the workplace safer, cleaner, and more efficient – all contributing to a company's bottom line. With increased emphasis in recent years on cost cutting and lean philosophies, one element which has traditionally been overlooked throughout industry is sustainability and environmental concerns. Many governing bodies such as the Environmental Protection Agency as well as state and local regulatory entities ensure that toxins and pollutants released from the manufacture and transport of goods are reduced to safe levels, but should corporations only live up to the requirements of the law or should they strive for higher levels of corporate and environmental responsibility? Having said this, it is extremely likely that companies have a great deal to gain from exploring the possibility of developing sustainable products, manufacturing processes, and supply chains.

Traditionally, manufacturing firms have used component costs, labor costs, and supply chain expenses as the three main decision making factors regarding product design and production. For those who have worked in industry, one of the most important lessons to be learned is that saving money and increasing profits is of the utmost importance. In today's corporate climate, safety, equality, diversity, and other similar initiatives are all critical; however, it is easy to understand that profits still drive the bottom line and are what keep companies in business.

Over time, a number of trends and fads have developed – some fading after a few years, others remaining in the forefront of the corporate conscious. In the past ten years, one of these trends is that of environmental responsibility and sustainability. Sustainability can take many definitions depending upon the situation and usage, however, a common definition is “the ability to meet the needs of the present without compromising the needs of future generations” (Rosbjerg et al., 1997, pg. 3). This concept includes management of natural resources, proper energy usage, and adequate disposal of waste. “Over the past decade public concern about sustainable development has profoundly transformed attitudes, and to a lesser extent, practices in manufacturing industries” (Gaughran et al., 2007, pg. 704). Many recent strategies for sustainability also focus on product design, life cycle analysis, remanufacturing, and recycling.

One reason that sustainability still is – and will continue to be – a growing and important trend in international industry, is that as citizens of this planet, we are beginning to come to the realization that our environmental impact today will have an irreversible effect on those coming after us. Recent trends such as diminishing natural resources and increased social pressures have amplified environmental awareness to the point where companies must now consider production decisions from an ecological as well as an economic point of view. These realizations call for “satisfying our needs by judiciously using renewable resources, recycling wastes and end-of life products for beneficial uses, and reversing environmental degradation in some areas and minimizing environmental impacts in others” (Sikdar, 2007, pg. 167). Significant differences currently exist between production expenses, component costs, and product design for sustainable versus non-sustainable products. Finding a way to objectively weight and compare these tradeoffs would benefit industry greatly. Furthermore, some industries are beginning to explore and implement stricter regulations with sustainability in mind. Factors such as these are making sustainability in manufacturing and supply chains a topic of growing concern amongst industry leaders.

This thesis will explore sustainability in detail and analyze quantitative forms of measuring sustainable progress in industry. A number of metrics will be identified for presentation to company representatives, both from the United States and abroad, for their input and thoughts. Using statistical theories and analysis based on these responses, a system of metrics will be proposed for corporate use. Though this result will not prove comprehensive for all industries and will likely need updating and revision over time, it will provide a basis from which to begin implementing sustainable measurement systems in industry and serve as a basis for future work. "It is clear that there is a long journey ahead to finally achieve or implement the ideal metrics from where we are" (Jin and High, 2004, pg. 294), but this is a process that must begin somewhere, step by step, company by company until environmental impacts begin trending downwards both domestically and internationally over time. "Sustainability is… not instantly achievable. We continually move in the direction of sustainability by making continual improvement in product and process design" (Sikdar, 2007, pg. 167).

1.2 Need for Increased Focus on Metric Analysis

"Applying metrics is a dominant practice of measuring sustainability in recent years" (Jin and High, 2004, pg. 291). Unfortunately, more often than not, the metrics presented to companies are immeasurable, difficult to calculate, too complex, or too difficult to monitor to be used successfully in industry. "It is difficult to tell which metric is actually better if assessors do not know how many options they could have or they barely understand the underlying difference between various alternatives" (Jin and High, 2004, pg. 295).

No single measure for sustainability has been universally accepted and little research has been done to analyze the effectiveness of various sustainability metrics. In order for true sustainable progress to occur in industry, a small set of understandable, measureable metrics must emerge for defining the environmental impact of business processes. Industry could benefit greatly through the development of a system of accurate sustainability metrics.

For the most part, all phases of manufacturing, logistical, and disposal of the products consumers use on a daily basis contribute to environmental degradation and decay. With this in mind, metrics generated and implemented must consider raw materials, suppliers, product design, manufacturing, packaging, distribution, recycling, and disposal at the end of a product's life cycle. Further complicating matters is the fact that traditional metrics and methods of measure have not differentiated between pollutants and the environmental impacts that they cause (Jin and High, 2004). Making this distinction, and developing metrics that account for both factors, is critical to successfully enhancing sustainability at a corporate level.

"A quantitative gauge is urgently needed" (Jin and High, 2004, pg. 291) and a best practice set of metrics would be a large step in the right direction. This would give companies the information required to make decisions regarding the implantation of sustainable practices throughout their design, manufacturing, and delivery methods.

1.3 Composition of this Study

Following a thorough literature review, the first step in completing this study is to gather as many current and proposed metrics for sustainability as possible. These metrics will be analyzed as to their usefulness, complexity, ease of measure, and relationship to specific manufacturing or distribution processes. This analysis will lead to the eventual creation of a matrix of metrics to be presented to corporate representatives. These representatives – from the United States, Canada, Jordan, Taiwan, Turkey, China, and France – will be asked a variety of questions about the possibility of implementing measurement systems to track the metrics in the matrix. Additionally, they will be asked which metrics they view as feasible or any that are currently in use. Through this data collection, a repository of information regarding the metrics of interest will be generated. Statistical analysis will be conducted with the collected data to determine which metrics would adequately account for as many aspects of sustainability as possible. The overarching goal of this research is to develop a refined sustainability index based on what are deemed to be the most applicable, beneficial, and useful metrics available.

After performing statistical analysis to determine the ideal set of metrics, this cost-effective, practical set of metrics through which companies can measure, manage and maintain their environmental sustainability will be determined. The findings of this research and analysis will be generalized so that they are not only relevant to a specific industry, but can be applied in a variety of different applications. These uses will be relevant for any company designing and manufacturing products in order to improve their supply chain and process integrity with regards to sustainability. The resulting information has and will continue to be made available to industry partners and interested parties with the hope that the resulting system of metrics gains a foothold, creating awareness and spurring action towards sustainable ideals.

A major topic for further exploration would be the effect of sustainability metrics and sustainable manufacturing on reverse logistics. With a greater demand for specialized and remanufactured products, reverse logistics will continue to become a topic of interest in sustainability circles as companies are forced to consider costs and processes associated with the reuse or remanufacture of defective, recycled, and returned products.

By getting the ball rolling towards these ideals, research and development is bound to bring more advanced metrics into play in the near future, creating a future opportunity for research to build upon the set of metrics and systems of measure presented here. In the past, “predefined goals [have been] compromised based on indicator availability” (Jin and High, 2004, pg. 298). It is our hope that this study will help move away from this trend, providing value to industry as well as all of the citizens of this planet – current and future.

Chapter 2

Literature Review

2.1 Sustainability Overview

This literature review will aim to identify exactly what sustainability is – from its various, wide-ranging definitions – and will also explore its importance and illustrate how it is a growing trend in industry today. Barriers to wide spread implementation of sustainable concepts in industry will also be discussed. A major focus will revolve around the importance of identifying metrics through which to quantify, measure, and analyze sustainable progress as well as selection criteria through which environmental improvements can be selected and implemented by corporations. Through an analysis of metrics – both indicators and indices – it will become clear that challenges arise when quantifying and categorizing environmental effects. The differing effects of varied production locations, the disconnect between pollutions emitted and environmental effects, the complexity associated with dealing with various elements of supply chains, and other factors make this topic a difficult one to truly grasp. One thing is known for sure, however, the topic of sustainability and sustainability metrics has wide ranging applications and numerous possible uses in the improvement of industry and the natural world around us.

2.1.1 Introduction to Sustainability

Corporate industries are always looking for a way to get ahead of the competition – including new features in their products, adopting new manufacturing processes to save money, and doing whatever they can to make and sell more for less. In the 1960's and 1970's quality was a focal point as manufacturers looked to produce durable products that would last and provide value to consumers. In the 1980's, speed of production was a key initiative companies used as they looked to produce as much as possible, as quickly and efficiently as possible to meet the demands of a growing population. In the 1990's, cost of production – be it in raw materials and production processes – was the name of the game. Over the last ten years, the newest initiative companies are using to gain market share and recognition over their competitors is to create sustainable products, services, and processes (Franchetti et al., 2009). This initiative stems from the commonly known fact that in recent years, we have discovered that Earth's oceans, atmosphere, and living species are more vulnerable than ever imagined. "The need for environmentally benign manufacturing technology and processes will be a prerequisite for manufacturing enterprises competing in most global markets" (Sarkis, 1995, pg. 79). In other words, it is becoming increasingly obvious that economic sustainability has significant environmental cost (Naidu et al., 2008).

The definition of sustainability and exactly what makes a sustainable product, however, is rather unclear. The World Commission on Environment and Development defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," while the US National Research Council defines sustainability as "the level of human consumption and activity… so that the systems that provide goods and services to humans persist indefinitely" (Rachuri et al., 2009, pg. 472). In their piece Creating Competitive Advantage Through Resource Productivity, Eco-Efficiency, and Sustainability in the Supply Chain, Mosovsky, Dickinson, and Morabito define sustainability as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with Earth's carrying capacity" (2000, pg. 233). Others argue that "qualitatively, the concept of sustainable development is simple enough; the natural resources of the Earth are limited… yet the rate of use of these resources is ever-increasing and must be reduced" (Sikdar, 2003, pg. 1928). Regardless of technicalities and language, all of these definitions have similarities and differences and it becomes apparent through simple study that sustainability is a worldwide and intergenerational phenomenon (Jin and High, 2004). Through these definitions, it is easy to see that sustainability is a grand concept. Based on the widespread nature of manufacturing and human process, these definitions – in essence – dictate that sustainability incorporates almost every aspect of the environment and human interaction therein (Jin and High, 2004).

The ideals of sustainability dictate that virgin resource, water, and energy usage as well as emissions should be targets for reduction (Hervani et al., 2005). As would be expected, the manufacturing sector is the greatest user of our natural resources and is a significant contributor to environmental damage in this country and abroad (Reich-Weiser and Dornfeld, 2009). Combustion alone is responsible for nearly two thirds of total transportation life cycle greenhouse gas emissions (Reich-Weiser and Dornfeld, 2009). "Even those products with consumable potential, such as packing materials, are often deliberately designed not to break down under natural conditions," and exist in such quantities that in China, Styrofoam is referred to in many regions as "white pollution" (McDonough and Braungart, 2002, pg. 140). Furthermore, obvious solutions to problems exist but are often not identified in a way conducive to making improvements. For example, air conditioning is one of the largest methods of power consumption and is most often used during the daytime – exactly when solutions such as solar electricity would be most effective (McDonough and Braungart, 2002).

Innovative solutions and recycling efforts are not unheard of. For example, Henry Ford had his Model A trucks shipped in crates that became the vehicle's floorboards when it reached its destination. In more recent times, Korean rice husks are currently used as a shipping material for stereo components sent to and are then used as a material for making bricks – eliminating the concept of waste (McDonough and Braungart, 2002). These solutions, however, are the exception, not the norm.

Initiatives such as green engineering were developed in the 1970's when companies realized their high levels of waste and consumption in manufacturing processes (Franchetti et al., 2009). This led to the creation of measures such as footprint analysis to identify the residual effects of the raw material and energy usage, as well as the byproducts from corporate industry. These metrics and measurements were also used to measure the cost of living as well as the energy cost of living for individuals in residential settings, but are primarily used today in industry (Hertwich and Peters, 2009).

Increased and faster demand for new, innovative products continues to push companies to design quicker and more efficient than ever before, but little improvement has been made in design processes (Cooper and Edgett, 2008). In the innovative book, Cradle to Cradle – Rethinking the Way We Make Things, McDonough and Braungart argue that human design processes were never effective and efficient since they did not account for natural considerations (2002). They argue that early design goals were limited to the practical, efficient, and linear without viewing any processes outside an economic vantage point. Products were made to meet regulations, market expectations, and perform well. Products and the processes used to make them were reliant on an endless supply of natural 'capital' and would be discarded at the end of their useful lives. Furthermore, products have traditionally been designed to be universally acceptable in order to facilitate the largest possible market. This ideal does not take into account considerations made for specific end users and local environments with regards to disposal and reuse. Companies must recognize the voice of their customers and take a more holistic approach to projects – relying on spiral rather than linear development – to account for entire product life cycles.

In their book Use Less Stuff: Environmentalism for Who We Really Are Rathje and Lilienfeld state that "consumers must take the lead in reducing negative environmental impact… not by recycling more, but by producing and disposing of less" (1998, pg. 50). By following this ideal, consumers can demand that corporations abandon old practices of building in obsolescence – or making products that last just long enough for consumer's likings. Furthermore, implementing efforts such as continuous improvement, scalable and adaptable processes, and removal of waste through lean processes must be incorporated in the idea-to-launch cycle of product design (Cooper and Edgett, 2008).

Gradually, new trends have emerged in industry such as the aforementioned lean movement. These trends can be viewed as complementary in their partnership of achieving business goals. The only difference between green and lean engineering, for example, is that green treats the environment as a constraint and lean treats it as a valuable resource (Franchetti et al., 2009). In this way, lean should be viewed as a supporter of the environment and as a bridge to the ultimate goal of complete sustainability (Franchetti et al., 2009). Additional efforts fall into the sustainable realm and relate to products, processes, and services from technological and cultural standpoints. Environmentally conscious manufacturing, design for disassembly, carbon footprint analysis, resource tolerance, remanufacturing, recycling, energy resource management, hazardous material tractability, and alternative processing technologies have all been developed in recent years and will be discussed in detail throughout this review.

What we traditionally consider to be recycling is actually down-cycling, as waste is still a byproduct of a majority of recycling processes (McDonough and Braungart, 2002). There are a variety of different levels to reuse, including repair, remanufacturing, and recycling. It is important to make the distinction between these classifications, with regards to the resulting product quality, work requirements, and warranty guidelines, as briefly shown in Figure 2-1.

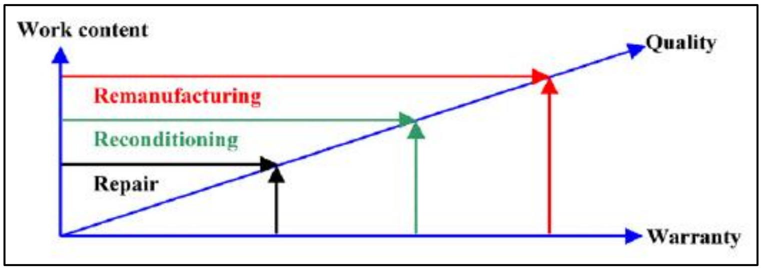

Figure 2-1: A hierarchy of secondary market production processes (Adopted from Ijomah et al., 2009).

Under optimal conditions, all products we produce and use on a daily basis would be 100% recyclable and that complete disassembly and reuse of a product's components at the end of its life cycle would be possible (Rachuri et al., 2009). In doing so, we could take what would generally be considered wastes and turn them into viable assets. While this might seem far-fetched today, we must be open to new ideas and methods of thinking in order to advance such a grand ideology. The answer to these problems does not lie in passing the buck by sending manufacturing overseas or forcing changes on suppliers or other partners. We must consider not just ourselves, but the entirety of the planet in this shrinking world that we live in. As put best by McDonough and Braungart, "in planetary terms, we're all downstream" (2002, pg. 127).

Many claim that sustainability will continue to be "fuzzy, elusive, contestable, and ideologically controversial" into the future; however, the lack of a universally accepted definition and systematically organized metrics are mostly to blame for this belief (Jin and High, 2004, pg. 292). Researchers agree that there is and cannot be a single metric that can measure and/or compare sustainability (Sekulic, 2008). Through analysis of and agreement upon a set of metrics to help define this abstract concept, companies and consumers should be able to benefit from increased awareness and scope in the years to come. "Insanity has been defined as doing the same thing over and over and expecting a different outcome. Negligence is described as doing the same thing over and over even though you know it is dangerous, stupid, or wrong"

(McDonough and Braungart, 2002, pg. 117). Through innovation and a greater understanding of sustainable concepts, neither insanity nor negligence should be excuses for corporations and consumers alike in the years to come. Companies must stop viewing economic growth as their end all, be all. The deficiency in systemizing and classifying existing metrics must be addressed (Jin and High, 2004). Metrics must be uncovered to allow sustainability to be used as a substitute for the age-old practice of finding a less-bad solution to our environmental negligence.

2.1.2 Importance of Sustainability

While sustainability might appear as a utopian idea, where human processes and practices coexist in harmony with environmental conservation and ideals, many argue that implementing sustainable concepts or guidelines would hinder our way of life. For example, processes emitting greenhouse gasses benefit humans and our way of life by allowing for easier, cheaper transport methods and through the provision of consumer goods and services. "We are accustomed to thinking of industry and the environment as being at odds with each other, because conventional methods of extraction, manufacture, and disposal are destructive to the natural world. Environmentalists often characterize business as a bad and industry itself as inevitably destructive. On the other hand, industrialists often view environmentalists as an obstacle to growth" (McDonough and Braungart, 2002, pg. 6). Regardless, in today's world "there is hardly any industry sector in which the management of environmental sustainability is not of significant relevance" (Gaughran et al., 2007, pg. 704).

Supporting the ideology that sustainable development hinders quality of living is the fact that developed and developing countries are larger contributors to greenhouse gas emissions and other pollutants – in fact, for every doubling of national consumption, a nation's carbon footprint increases by 57% (Hertwich and Peters, 2009). As Hertwich and Peters go on to discuss in their piece Carbon Footprint of Nations: A Global, Trade-Linked Analysis, the United States and Luxembourg, two of the countries in the world with the highest standards of living, exhibit emissions of 28 tons per person per year, whereas many African countries with substandard living conditions create less than 1 ton per person over the same period (2009). The greenhouse gas emissions of these countries can be compared further and broken down into categories to determine exactly what needs to be targeted for reduced consumption. According to Hertwich and Peters' study, consumption of household products accounts for approximately 72% of emissions – greatly exceeding the 18% for construction and 10% for governmental reasons. Of household consumption, 20% of emissions result from food products, 19% result from upkeep and control of residences, and 17% results from transportation (2009).

Through similar facts and assertions, it becomes obvious that "[i]ncreasing global population and consumption are causing declining natural and social systems" (Mosovsky et al., 2000, pg. 230). Ecosystems are in various stages of degradation – mainly due to current marketing practices pushing consumption and trashing of products (Fuller and Ottman, 2004). The purchase of luxury items as well as leisure activities contributes greatly to the skewed ratios of emissions towards higher grossing nations. The abundance of these items as well as the current manufacturing processes used to produce and transport them stands out as a target for improvement for companies looking to become more sustainable and environmentally responsible. The common belief and corporate creation of 'throwaway' products – one-time-use products as well as products with a designed limited life cycle – is degrading our ecosystems and filling our landfills (Fuller and Ottman, 2004). International trade and transport are also becoming more and more common and must be addressed with regards to carbon footprints and carbon leakage. In many countries, governments and regulatory agencies are not taking a stand to address these issues. Regulatory practices must develop beyond command and control efforts and industry governing bodies must work with governments to create cooperative and acceptable policies to work towards sustainability (Sarkis, 1999).

Various industries exhibit different levels of productivity with regards to the manufacture of products and services – from a very high productivity in consumer goods to very low in pharmaceuticals. This illustrates that some industries are either naturally environmentally conscious or have stepped up their efforts in this realm. For example, the energy industry benefits greatly from reducing waste and improving productivity since the energy expended directly affects their bottom line – the energy they can provide to their customers. Furthermore, within industries there are large gaps between proactive and reactive corporations, or those who are attempting to improve their own sustainable and environmental practices and those who are focusing their efforts on lower cost alternatives with regards to raw materials, labor, and regulatory compliance (Cooper and Edgett, 2008). In traditional trains of thought, science is often viewed as a tool for research without implementing methods of change; however, on the front of sustainability, industry must work hand in hand with researchers to put environmental knowledge to work with beautiful designs – especially in lagging or reactionary industries (McDonough and Braungart, 2002).

Traditionally, the driving force behind the private market sector is to achieve competitive financial returns while meeting consumer needs. Eco-attributes in products have not been shown to align with these goals (Fuller and Ottman, 2004). Corporations are well aware that as consumer desires and demands will gradually develop and change over time, their needs will not reduce and their consumption is unlikely to diminish. Since environmental problems occur because people want and need products and all of these products have some environmental impact, companies and/or industry groups and regulators must recognize their responsibilities in product design and distribution. All products are designed at some point by a variety of processes and means and all of these designs are manufactured – most commonly through mass production in modern society. Since all of these manufacturing processes – in addition to all of the products they produce – have environmental impacts, the companies undertaking these ventures are doubly responsible for environmental effects (Franchetti et al., 2009). Conventional design criteria – such as the Triple Bottom Line approach of cost, aesthetics, and performance – must be supplemented with environmental consciousness and responsibility to achieve these ends (McDonough and Braungart, 2002). This means addressing all facets of product manufacturing and distribution.

Over 70% of cost decisions regarding a new or altered product are made in the product development stage (Lin et al., 2009). Products must be designed right from the beginning and the environment must be considered throughout the entire design process (Franchetti et al., 2009). As the old saying goes, "an ounce of prevention is worth a pound of cure." With this in mind, companies must design products efficiently, effectively, and environmentally consciously and in doing so will likely see cost reductions as well (Franchetti et al., 2009).

Recent research has showed positive results – both relationally and through financial performance – for corporations who incorporate their green product development and practices into their marketing and advertising campaigns. This shows that as sustainability becomes more and more of a public topic, green consumerism is catching on and end users of products are looking for change in the marketplace. Corporations should look to build upon this fact and take the initiative to exceed consumer expectations rather than following lagging indicators such as financial performance and responses (Sarkis, 1999). As sustainability and eco-conscious concepts increase in their size and scope, performance reporting to stakeholders and regulators, policy and investment evaluation, technology assessment, risk management, employee training, and public relations will all have to be updated to follow suit. It is likely that these elements will all be improved through increased sustainable practices, but with all new developments, a learning curve will be in effect (Jin and High, 2004).

In their book Logistical Management: The Integrated Supply Chain Process, Bowersox and Closs define supply chain management as "those activities associated with the transformation and flow of goods and services, including their attendant information flows, from the sources of materials to end users. Management refers to integration of these activities, both internal and external to the firm" (1996, pg. 17). This definition includes elements related to suppliers, manufacturers, vendors and end users. Historical approaches for reducing costs in product manufacture, such as outsourcing and supply chain tradeoffs are not the solution. For decades, manufacturing locations have been updated and altered to save costs relating to labor and materials (Genaidy and Karwowski, 2008). The supply chains utilized by these nationwide and worldwide production networks, however, are greatly to blame for resulting contaminations and inefficiencies. This trend – as well as the uncertainty of product components and origins – is a troubling one discussed in Cradle to Cradle as follows: "High-tech products are usually composed of low-quality materials… globally sourced from the lowest-cost provider, which may be halfway around the world. This means that even substances banned for use in the United States and Europe can reach this country via products and parts made elsewhere. The problem intensifies when parts from numerous countries are assembled into one product, as is often the case with high-tech items such as electronic equipment and appliances. Manufactures do not necessarily keep track of – nor are they required to know – what exactly is in all of these parts" (McDonough and Braungart, 2002, pg. 39).

Supply chains have been shown to account for over a quarter of total product costs as well as over a quarter of emissions throughout a product's life cycle – including extraction, manufacturing, transportation, use, and end of life considerations. Greenhouse gas emissions and other pollutants have a global impact regardless of emission locations even though resource availability, labor, policy, regulation, and technology determine where emissions take place in a product's life cycle (Reich-Weiser and Dornfeld, 2009). Having said this, making pollution and emissions another country's problems is not a viable or ethical solution. As quoted from Cradle to Cradle in section 2.1.1, "In planetary terms, we're all downstream… It is not viable to poison local water and air with waste. It is equally unacceptable to send it downstream, or to ship it overseas to other, less regulated shores" (McDonough and Braungart, 2002, pg. 125-127). There are many ways that companies can alter their supply chains to improve efficiency. Avoiding vertical integration and using new technologies, local suppliers, and improved management practices can prove very successful and lower costs of supply chain related expenses (Mosovsky et al., 2000).

New design methodologies, such as green engineering, target the heart of negative current design practices. A product's design determines what that product is made of, how it functions, how long it lasts, how it will be packaged and distributed, how it will be used, how it will be disposed of, and all waste streams related to use and manufacture (Fuller and Ottman, 2004). We must keep the end goal in mind, knowing that "[u]ltimately, we want to be designing processes and products that not only return the biological and technical nutrients they use, but pay back with interest the energy they consume" (McDonough and Braungart, 2002, pg. 138). From the onset, green engineering aims to select low environmental impact materials and cleaner production processes. In this way, when a product is designed it is done so hand in hand with the process used to produce that product so as to minimize net environmental effects. Toxic and hazardous materials are avoided – both due to environmental concerns as well as the wellbeing and safety of the end user – and water and energy efficiency is maximized. This is done in order to limit environmental impacts and to produce as the lowest possible cost. In this way, energy and water usage are also targeted for recycling and conservation by purifying existing water supplies for reuse or grouping similar machines and processes in a plant to help save on heating and cooling costs. The well-known Hanover Principles argue that waste must be eliminated by design – not avoided, minimized, or reduced – but eliminated altogether (McDonough and

Braungart, 2002). All processes have side effects, but through careful design of both products and processes, companies can create those that are deliberate and sustaining rather than unintended and pernicious (McDonough and Braungart, 2002).

Green engineering also embraces waste minimization in design and reuse and recycling of components – thinking restoration over replacement (Fuller and Ottman, 2004). "Products can be composed either of materials that biodegrade or become food for biological cycles, or of technical materials that stay in closed-loop technical cycles, in which they continually circulate as valuable nutrients for industry" (McDonough and Braungart, 2002, pg. 104). This presents the challenge of collecting and disassembling older products, but in the long run will save money and improve environmental relations. It is also important to note that by designing products initially with these goals in mind, companies can save a great deal through practices such as design for disassembly. It is well known that recycling can result in great cost savings, but these savings can be even more recognized if plans are in place for the collection, disassembly, and future use of components (Franchetti et al., 2009). The overarching design of a typical reuse and recycle supply chain, or network, is shown below in Figure 2-2 and a more detailed diagram – including considerations for demand and customer interaction – is shown in Figure 2-3. Some components – specifically outdated electrical technologies or components – have no second life or reusability potential, essentially down-cycling; however, these elements are the exception and not the norm (Kaebernick et al., 2003).

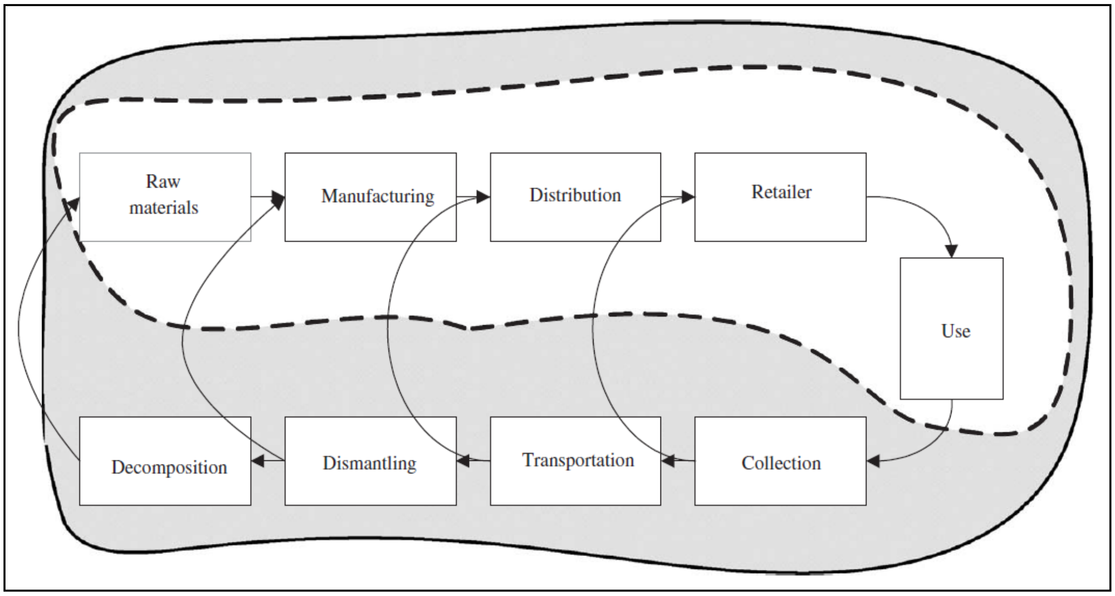

Figure 2-2: Typical network design for supply chains designed for reuse/recycling (Adopted from Kainuma and Tawara, 2005).

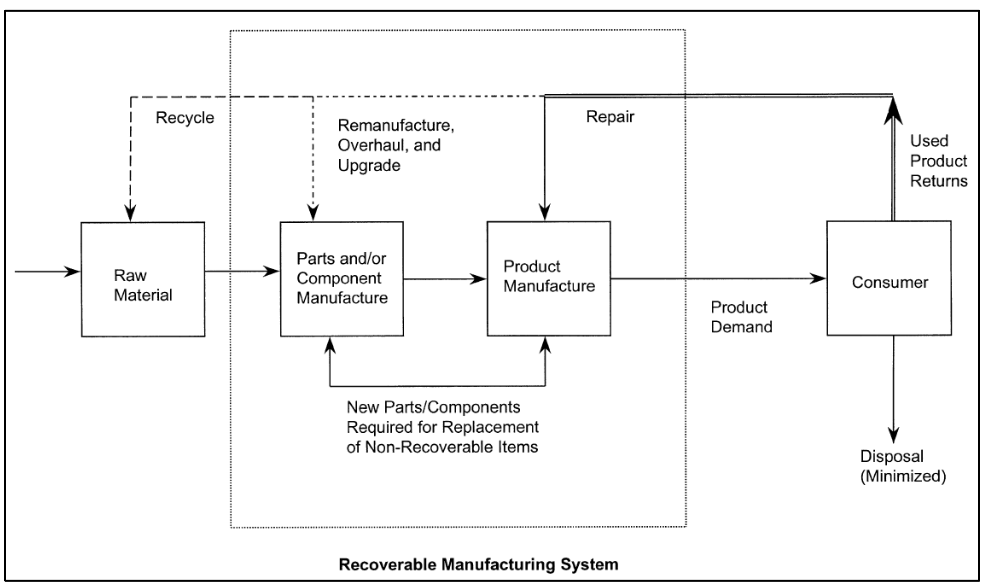

Figure 2-3: Typical recoverable product environment diagram (Adopted from Guide et al., 2000).

While taking care to reuse as much as possible, we must not blindly adopt superficial environmental approaches and assume that all recycling is positive. Rather, we must fully understand the effects and design processes and products to allow for useful and positive recycling efforts. “Just because a material is recycled does not make it ecologically benign, especially if it was not designed specifically for recycling” (McDonough and Braungart, 2002, pg. 59). Many of these improvements – specifically in the improved design of manufacturing processes – can be supported by lean methods and beliefs. Lean can be used to eliminate non-value-added activities and produce products more efficiently with lower costs – more so if applied during the product’s initial design stages than later in the product life cycle. In this way, lean should be viewed as a supporting resource to the ultimate goal of green engineering (Franchetti et al., 2009).

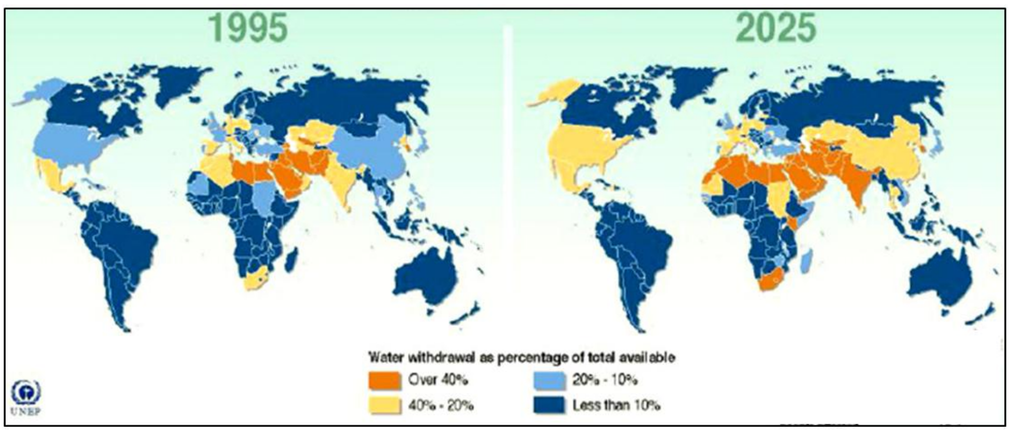

Figure 2-4: Freshwater stress developments between 1995 and 2025 (Adopted from Gaughran et al., 2007).

The increasing scarcity of resources and raw materials as well as increasing governmental and environmental regulations that are sure to emerge in the coming years will have drastic impacts on manufacturing and production (Rachuri et al., 2009). Companies would be well advised to be proactive in these sustainable ideals and set the tone for implementation and development. As stated in the work of Franchetti, Bedal, Ulloa, and Grondek, we must learn to "treat nature fairly or suffer the consequences" (2009, pg. 29) Without concerted efforts, it is likely that in the next few generations the Earth will reach its 'critical limit' or its carrying capacity of improved human life (Jin and High, 2004). Demands for energy, water, and resources will continue to increase with the Earth's growing population and steps need to be taken to curb consumption. Figure 2-4, for example, illustrates the projected increase in the scarcity of freshwater between the years 1995 and 2025. It is a given that human industry and consumption will not decrease, so it is important that products and processes are designed to "get bigger and better in a way that replenishes, restores, and nourishes the rest of the world" (McDonough and Braungart, 2002, pg. 78).

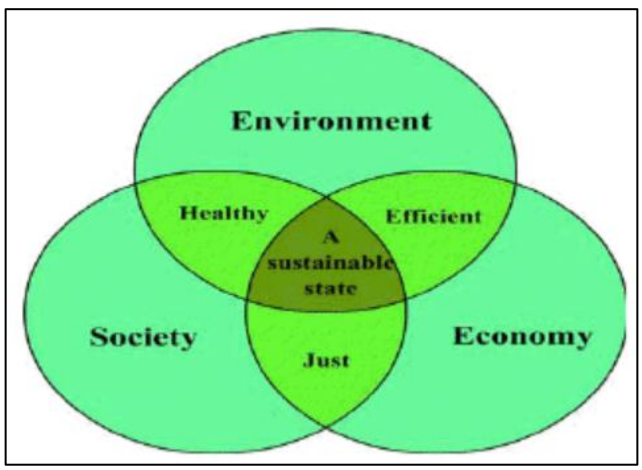

Figure 2-5: Relationship between environmental, societal, and economic factors in product design (Adopted from Azapagic and Perdan, 2000).

Sustainable development addresses economic success, environmental quality, and social equity to these ends (Mosovsky et al., 2000). While considering two of these three areas of focus results in product improvements, true production optimization come when design, functionality, affordability, safety, and life-cycle considerations are accounted for, as shown in Figure 2-5 (Sikdar, 2007). Identifying what constitutes sustainability through a system of metrics and methods as well as implementing resulting sustainable processes will likely go a long way towards improving environmental, social, and economic objectives. Metrics exist to describe a variety of factors, from socio-ecological, socio-economic, and eco-efficiency. Each of these areas fits into one of the life-cycle considerations of a product, but as shown in Figure 2-6, sustainability metrics exist when all factors overlap. This Venn diagram shows a slightly altered version of that in Figure 2-5, but works towards the same ends.

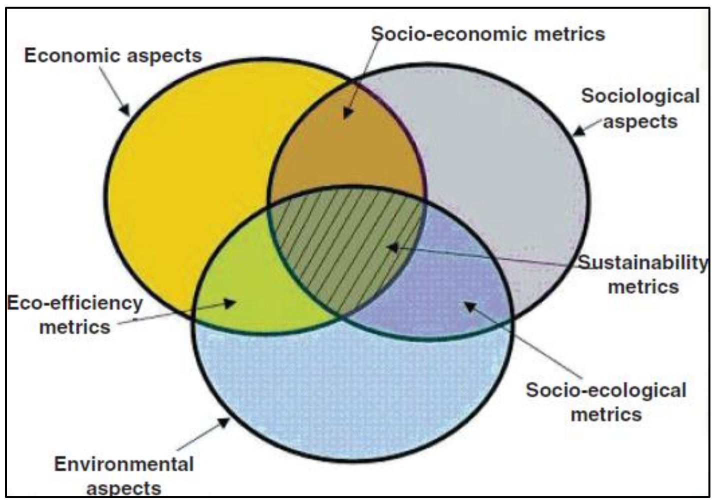

Figure 2-6: Venn diagram illustrating typical sustainable development relationships (Adopted from Sikdar, 2008).

Obviously sustainability is based on one's value orientation, knowledge horizon, and individual perspective and "the impact of a new sustainability context is… more consequential, far-reaching, holistic, obscure, and harder to observe", but taking steps in the right direction is a path that must be followed in order to achieve visible and measured results both today and into the future (Jin and High, 2004, pg. 294). In this way, sustainable initiatives and production processes can "provide the value demanded by society without causing significant negative environmental impacts while also providing competitive advantage to those companies who incorporate them" (Mosovsky et al., 2000, pg. 233). With all of this in mind, it is easy to see and understand the increased interest in the business potential of sustainable development as well as the importance of developing a "consensus, agreed upon context, or environmental metric on how to measure progress" and work towards these ends (Mosovsky et al., 2000, pg. 230). Product and process design is the primary solution to these issues, but distribution, marketing, promotion, and pricing are all important elements which must be analyzed in the future (Fuller and Ottman, 2004).

2.1.3 Sustainability as a Growing Trend in Industry

Once one conceptualizes what exactly is encompassed by the term sustainability and understands incorporating sustainable ideals is important, it is easy to see why sustainability is a growing trend in industry today. The goal of many corporations – stated or unstated – has always been to develop high-quality products with beneficial economic outcomes, but blending these elements with minimal ecological footprints is becoming an important aspect as well (Sekulic, 2008). The importance of improving our overall ecological footprint is shown in Figure 2-7. More and more, sustainability is gaining acceptance in practice as opposed to solely in principle (Kaebernick et al., 2003). The driving force behind the private market sector has always been to meet customer needs and achieve competitive financial returns; for a majority of companies it has and will continue to be unacceptable for eco-attributes to have negative tradeoffs with these goals. In other words, sustainable products must be able to compete in markets where the rule is the survival of the economic fittest (Fuller and Ottman, 2004). This belief is further emphasized of Stephan Schmidheiney of Earth Summit, who stated that "Within a decade it is going to be next to impossible for a business to be competitive without also being eco-efficient" (McDonough and Braungart, 2002, pg. 52). "A recent survey of 41 Fortune 200 non-service firms showed that environmental management is becoming central to corporate strategy and is being managed as an area of completion rather than as a compliance driving function" (Sarkis, 1995, pg. 95). Furthermore, a recent survey of CEOs found that 90% agreed that environmental challenges were sure to be one of the central issues of the next century (Sarkis, 1995).

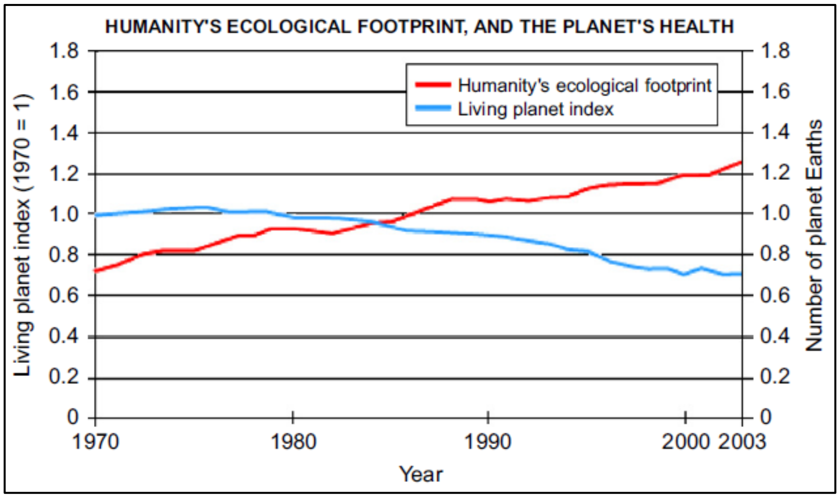

Figure 2-7: The impact of humans on natural resources and ecological footprint (Adopted from Gaughran et al., 2007).

Using recent and developing technologies, it can be seen that a world is possible where sustainable products can be produced, distributed, and used in a sustainable manner (Rachuri et al., 2009). Zero impact products, though currently in small scale production and distribution, have been used as feasible alternatives to throwaway products and represent current best-case scenarios with regards to sustainability. These products can be remanufactured again and again using only the materials and energies left behind after their original manufacture and use (Rachuri et al., 2009). Concepts such as this are great motivators to corporations looking into sustainable improvements because they "focus on what businesses had to gain from a new ecological awareness rather than on what the environment stood to lose if industry continued current patterns" highlighting the advantages to the company first and foremost (McDonough and Braungart, 2002, pg. 52). Obviously economic as well as environmental considerations are important when assessing possible improvements. Companies must determine how the money saved by installing clean technologies could be used to avoid pollution in other aspects of their production and distribution facilities, making the largest possible positive impact with available resources (Eriksson, 2004). In the future, making these changes could determine the life or death of corporations, and at the very least, will have a great effect on their market competitiveness (Sarkis, 1998).

It has been argued in the past that companies must realize the benefits of environmentally conscious practices for themselves and that regulations and efficiency requirements that force environmental improvements are not as efficient as if companies actively seek proactive solutions (Hervani et al., 2005). While it might be true that allowing companies to find the benefits for themselves is more valuable than forcing restrictions, industries and governments appear to be coming to the conclusion that products must be made for profit and environmental friendliness (Rachuri et al., 2009). An emphasis on environmental impacts of waste streams and production practices is creeping into mainstream society and consumers are becoming more environmentally conscious not just in their opinions, but more importantly, in their buying decisions (Franchetti et al., 2009). Consumers, the drivers of product consumption are putting their money where their mouths are. Luckily, to these ends, businesses are also realizing that profitability exists in environmentally conscious practices and that financial performance can be greatly influenced by environmental measures and practices (Sarkis, 1998). Global climate change concerns, for example, are leading many companies and organizations to estimate or measure, and then seek to reduce their carbon footprints (Matthews et al., 2008).

In the past, environmental conscious design has often been associated with increased constraints and costs (Kaebernick et al., 2003). While this might still hold true in theory today, environmental friendliness is more often being viewed as a competitive strategic perspective, as evidenced by the inclusion of environmental improvements and initiatives in shareholder reports of many major publicly held firms (Sarkis, 1999). In recent years, a good portion of Fortune 250 companies are even going public in their publishing of corporate reports on sustainability (Jin and High, 2004). Arm and Hammer Corporation as well as Bell Labs have estimated that their sales are 5 to 15 percent higher due to the company's eco-friendly image and branding (Fuller and Ottman, 2004). As quoted in Cradle to Cradle, "It is a commercial company's responsibility to provide shareholder value and increase wealth – but not at the expense of social structure and the natural world" (McDonough and Braungart, 2002, pg. 151). Companies are realizing that they can impress their customers – both end users and throughout the supply chain – by showing continuous improvement and long term sustainability goals of reducing risk and environmental penalties (Hervani et al., 2005). These improvements will require a change in mindset, from one where "cutting-edge environmental approaches are still based on the idea that human being are inevitably destructive towards nature," to one where designs must consider environmental aspects and conservation from the onset (McDonough and Braungart, 2002, pg. 155). These realizations, combined with increased pressure from consumers and regulators to be more environmentally friendly, are fueling increased research in the area of sustainability (Sarkis, 1998). Over the past two decades, the number of journal articles regarding sustainability in various fields has been steadily increasing, as shown in Figure 2-8.

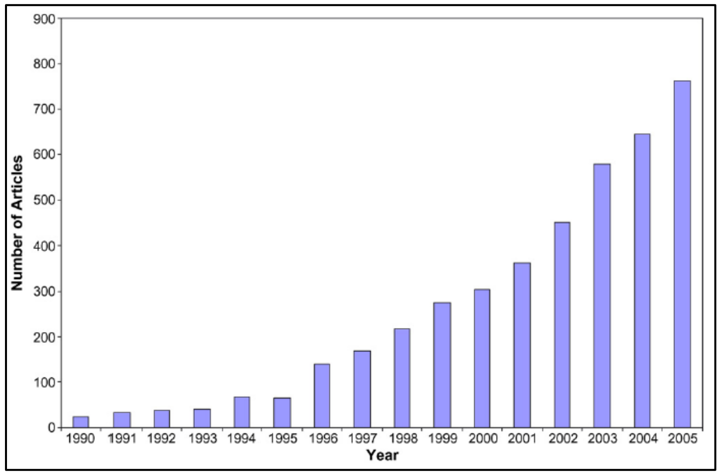

Figure 2-8: Increasing trend in number of articles from various fields dealing with environmental sustainability topics (Adopted from Linton et al., 2007).

Consumers have and will continue to act with some sense of idealism – consciously or unconsciously – purchasing products with positive environmental relations over otherwise identical, but less environmentally-friendly alternatives. Consumers perceive some additional utility when the good that they buy is clean. Even though each individual knows that the effects of their choices are negligible individually, they simply experience a “warm glow for doing their bit” (Eriksson, 2004, pg. 282). In 2009, 80% of consumers surveyed in Taiwan agreed with the statement that they “believed one can positively influence environmental quality by individual green behavior” (Tsay, 2009, pg. 2367). Furthermore, the same survey indicated that “61% of respondents would be willing to purchase green products, even when the green product costs more than a non-green alternative” (Tsay, 2009, pg. 2367). In the future, companies who are reacting to compliance rather than proactively seeking solutions for their products and processes must be targeted and educated about the financial and sustainable benefits of such practices (Hervani et al., 2005).

A great deal of research is being done to investigate managerial practices, business practices, and technology as they apply to environmentally conscious manufacturing (Sarkis, 1999). While many companies are resistant to change at first, a variety of success stories have sprung up around those willing to seriously analyze and consider changes. In one example in Cradle to Cradle, a small-scale textile manufacturer was approached about incorporating sustainable materials and processes into their factory, including the elimination of toxic dyes and materials. In reporting the results of their study and implementation, the authors state that "what might have seemed like an expensive and laborious research process turned out to solve multiple problems and to contribute to a higher-quality product that was ultimately more economical" thus illustrating the successes of such implementations (McDonough and Braungart, 2002, pg. 115). In this way, corporations are beginning to realize that a shift needs to occur from controlling our environmental impacts to preventing them altogether (Franchetti et al., 2009). It is a positive sign to see corporations taking such steps. In order to make the most effective, lasting impact however, sustainable initiatives must be undertaken collaboratively across industries in order to pool resources as well as the development of ideas.

One of the most recognizable companies to take a proactive stance on sustainable initiatives and supplier relations is Wal-Mart. With over 7,900 retail stores worldwide, Wal-Mart is an international company operating primarily in North and South America, as well as Asia. In October 2005, Wal-Mart set three core goals, "to be supplied 100 percent by renewable energy; to create zero waste; and to sell products that sustain our resource and the environment" (Wal-Mart Corporation, 2009, pg. 2). From upper management throughout all associates and employees – beginning with Chief Executive Officer Mike Duke – Wal-Mart is placing a company-wide emphasis on integrating sustainability in all aspects as well as the communities that the company touches around the world. The company has recognized that in addition to meeting its ethical responsibility, sustainable practices and conservation can go a long way towards improving the overall bottom line – key in the retail world. Duke has even reiterated that "sustainability is built into our business because it's so good for our business" (Wal-Mart Corporation, 2009, pg. 3).

In making such substantial strides, Wal-Mart has faced many of the challenges that come with sustainable improvement initiatives. For example, the company traditionally had not measured or tracked the amount of landfill waste produced. Beginning in 2005, this figure and others were collected for the first time and in 2009, 57% of Wal-Mart's generated waste worldwide was redirected from landfills. Furthermore, Wal-Mart is utilizing solar and wind energy throughout Canada, Mexico, and the United States and is incorporating energy-saving measures into stores, distribution centers, and their in-house trucking fleet. Examples of these measures include technology to utilize natural daylight in stores, dimming interior lighting on sunny days, as well as the use of generators to run truck cab utilities, eliminating the need to idle engines while waiting for pick-ups or deliveries. Wal-Mart is also attempting to focus on sustainable suppliers and packaging as well as generating environmental awareness in consumers. Consumers are becoming accustomed to reusable shopping bags in many Wal-Mart stores and displays showcasing organic foods and energy efficient appliances. Sustainable milestones for the company over the past 2 years also include the sale of solely concentrated liquid laundry detergent, installation of reduced flow toilets and sinks in all facilities, installation of light-emitting diodes (LEDs) in display case lighting, the improvement in fleet-wide fuel-mileage initiatives, and the creation of programs to help consumers recycle used electronics (Wal-Mart Corporation, 2009).

From the supplier and packaging perspective, Wal-Mart has set the goal to reduce packaging by 5% globally by 2013 and to be packaging-neutral globally by 2025. These goals require the reduction of greenhouse gas emissions during the manufacture of packaging as well as the reduction of other harmful chemicals and materials in all packaging (Wal-Mart Corporation, 2009). Wal-Mart has worked with many international suppliers towards these ends and "developed an online packaging scorecard to gather information on suppliers' product packaging in order to establish a baseline and help buyers make more informed purchasing decisions" (Wal-

Mart Corporation, 2009, pg. 48). In order to reach the goal of package neutrality, buyers at the company begin using these packaging scorecards in February 2008, showing a preference for more sustainable and environmentally friendly alternatives. In terms of composition, the "scorecard is a measurement tool that allows supplier to evaluate themselves relative to other suppliers, based on specific metrics" (Wal-Mart Corporation, 2006, pg. 1). Though slightly controversial due to a weighting system which places varied emphasis on a number of component metrics, the system is in use today to evaluate suppliers versus their peers based on "packaging innovations, environmental standards, energy-efficiencies, and use of materials" (Wal-Mart Corporation, 2006, pg. 1). The components in this scorecard are listed in Table 2-1. As part of the company's ongoing sustainable initiatives, plans are currently under development for the creation of a more comprehensive supplier scorecard to measure the overall sustainability of suppliers, with regards to packaging, production, and distribution. Such a drastic measure from an industry leader illustrates the increased leanings towards sustainable improvements in the global retail industry (Wal-Mart Corporation, 2009).

Table 2-1: Components in Wal-Mart's packaging scorecard

Weighting	Component
15%	GHG/CO2 Per Ton of Production
15%	Material Value
15%	Product/Package Ratio
15%	Cube Utilization
10%	Transpiration
10%	Recycled Content
10%	Recovery Value
5%	Renewable Energy
5%	Innovation

Many corporations and industries have begun to implement sustainable practices such as those described here in the hopes of recognizing changing, updated customer concerns and desires as well as to improve their bottom lines through improved efficiency and reduced waste (Sarkis, 1999). Reactive responses to environmental pressures and competition are being replaced by proactive, strategic, competitive responses (Sarkis, 1999). Groups such as the Global Reporting Initiative are also working as independent institutions to develop and disseminate globally applicable sustainability reporting guidelines, providing and invaluable resource for companies and industries alike (Hervani et al., 2005). Statistical analysis and quality control are being increasingly used to help improve processes and conservative measures (Franchetti et al., 2009). Furthermore, regulatory policies are shifting from command and control efforts to cooperative government and industry policies (Sarkis, 1999). "As new research and facts are made available… industries invested solely in the current system will be at a serious disadvantage" (McDonough and Braungart, 2002, pg. 32).

In order to accurately assess improvements and proposed changes, a trusted system of measures relating to energy consumption, hazardous materials usage, recycling, ultimate disposal, remanufacturing, reclamation, and carbon output must be developed, encompassing a product's entire life cycle (Rachuri et al., 2009). "Metric identification has received growing attention as more alternatives become available for quantifying the sustainability-oriented performance of a target human activity" (Jin and High, 2004, pg. 291). Metrics are required to develop standards used in models and business objectives (Rachuri et al., 2009). For example, the trading of carbon credits – a commonly discussed and proposed method of policing and enforcing environmental restrictions on corporations – requires quantization and measurement of carbon budgets at each stage of manufacturing over the life cycle of a product (Rachuri et al., 2009). Further complicating matters is the fact that these emerging environmental criteria for product design, production, and distribution must be aligned with and compared against more traditional requirements such as cost, function, and quality (Kaebernick et al., 2003).

Additional complications arise from the fact that companies must begin to look outside of their own walls to improve their eco-efficiencies, requiring measurement or verification of their suppliers' eco-relations. Limited vertical integration in today's economy has led to suppliers who provide a great deal of the raw materials – be it individual assemblies or subcomponents – that manufacturers use in their products (Mosovsky et al., 2000). To these ends, third party suppliers with common goals must be selected who will enforce environmental policies and stick to green practices. Metrics must be in place to measure and assess these suppliers in order to reduce high risk or incapable partners (Franchetti et al., 2009). This endeavor provides a challenge due to the fact that in supply chains with multiple vendors, manufacturers, distributors, and retailers regionally and globally dispersed, it is difficult to measure performance across various methods of measurements and attributes (Hervani et al., 2005). Regardless, these obstacles must be overcome and informational models must be developed to facilitate development of specifications of environmental performance measures so that we can quantifiably evaluate the impact of a product or manufacturing process on the environment (Rachuri et al., 2009).

Improvement in design processes and methodologies is also integral to environmental improvements. In the past, failures in information exchange and interfaces between design, engineering, and manufacturing groups, as well as the consideration of long term product use and the end of life options for products inhibited designs against environmental concerns. Product and sustainability information must be shared across business and engineering units in order to realize and publicize maximum value from minimal resources (Rachuri et al., 2009). Additionally, distribution, marketing, promotion, and pricing of products can all contribute to environmental consciousness (Fuller and Ottman, 2004). Material selection is paramount to sustainability in product design. Materials must enable functional manufacturing performance, energy efficiency, minimum discharge, low emissions, and low waste (Lin et al., 2009). In summary, raw material selection must focus on avoiding materials and wastes that cannot be readily absorbed by natural systems (Fuller and Ottman, 2004).

Additionally, small scale improvements such as so-called eco-redesigns require minimal product alterations while picking the low hanging fruit regarding environmental sustainability in products and manufacturing processes. Such improvements would address many easily-altered processes and systems in order to improve a corporation's environmental relations with limited expense (Fuller and Ottman, 2004). Such smaller practices pave the way for larger initiatives, dubbed eco-innovations. Eco-innovations are longer-term, highly-functional product changes that think outside the box and may alter existing product designs or structures to reap environmental benefits (Fuller and Ottman, 2004). Such improvements would further emphasize sustainability throughout corporations and place these changes at the forefront from an environmental and economically sustainable perspective. These changes and alterations must be implemented early in design processes, when cost savings can be recognized, as opposed to late in design processes where including environmental considerations as an afterthought boosts expenses (Kaebernick et al., 2003).

Consumers must also alter their actions in addition to their buying decisions with regards to sustainable ideals and initiatives. Preferences for product functionality must be supplemented with preferences for product life expectancies and recycling (Lin et al., 2009). As discussed in works such as Cradle to Cradle, the concept of a 'product of service' would greatly benefit consumers, the environment, and corporations alike (McDonough and Braungart, 2002). In this system, customers would purchase the service of a product, such as a car or home appliance for a defined period. At the conclusion of this period, the manufacturer would replace the product, taking the old model back and breaking it down to use its complex and reusable components for new products. Such a system represents a complete shift in the traditional purchase, use, throwaway, purchase a replacement lifecycle that most consumers follow; however it "would produce no useless and potentially dangerous waste; would save manufacturers billions of dollars in valuable materials over time; and, because nutrients for new products are constantly circulated, it would diminish the extraction of raw materials and the manufacture of potentially disruptive materials and eventually phase them out, resulting in more savings to the manufacturer and enormous benefit to the environment" (McDonough and Braungart, 2002, pg. 115). Xerox Corporation has moved to the forefront in this type of initiative with its recently unveiled programs to lease and buy back copier machines from customers to reuse components and remanufacture machines using older parts (Fuller and Ottman, 2004). This is one example of how a concept to change people's mindsets about environmental conservation could go a long way were it to be implemented.

Methods for how corporations and industries have, can, and will improve their environmental impacts are abundant – from raw materials usage and supplier selection, to manufacturing, to facility layout and supply chain decisions. For example, stricter inventory control is being pushed down from management of many corporations, leading to smaller facilities, fewer construction resources, and lower heating and cooling requirements – just to name a few benefits (Franchetti et al., 2009). As can be surmised, businesses are not only improving their environmental impacts through these changes that reduce their energy consumptions and footprints, but they are also saving a great deal of expense. Implementations such as improved facility layout have been shown to minimize heating and cooling while reducing unnecessary product flow. Such steps decrease forklift and employee movement as well as excessive handling, simply by grouping similar processes together where they can take advantage of grouped workstations and similar temperature requirements (Franchetti et al., 2009). Even chemical companies, traditionally viewed as an influential, but high pollution industry, have proved that considering sustainable ideas can improve their bottom lines and environmental friendliness (Jin and High, 2004).

Improved manufacturing processes are also making better use of raw materials, eliminating, recycling, or minimizing scrap, saving money and preserving raw goods (Franchetti et al., 2009). Additionally, lean, six sigma, and other statistical quality initiatives are helping to reduce rework as well as the number of defective products, fitting hand in hand with environmental conservation and waste reduction ideals (Franchetti et al., 2009). From a supply chain perspective, route optimization and fuel economy maximization helps to decrease emissions and wasted work and reusable/returnable packaging is becoming increasingly popular, saving time, money, and precious resources (Franchetti et al., 2009). Possible reuse and alternative stages for the end of product life-cycles are also important to analyze and have been shown to have great successes. From corporations teaching the importance of looking for alternative uses for products to innovative and creative end-users making glasses and cups out of old jars and containers, the possibilities are endless. Moving forward, consumers and companies alike must ask themselves not what has worked in the past, but what will and what should work in the future in the attempt to improve the sustainability of our everyday lives (McDonough and Braungart, 2002). Looking at ways that products can be used in conjunction with one another to save resources and increase performance also opens a variety of possibilities for improved environmental friendliness (Fuller and Ottman, 2004).

"With increased emphasis on the natural environment by organizational stakeholders, including governments, stockholders, customers, employees, and communities, the need for explicit consideration and incorporation of environmental strategy within corporate strategy has never been more critical to the organization" (Sarkis, 1998, pg. 159). A variety of options exist for companies looking to improve their sustainability through methodologies and measurement metrics as well as progress benchmarking. In the sections to follow, a variety of these methods will be discussed, ultimately leading to recommendations for the implementation of a comprehensive set of metrics to create a sustainability index.

2.2 Sustainability Ideologies

As would be expected with any emerging trends or practices in the economic realm, numerous individuals and groups in academia and industry alike have begun to develop ideologies to classify and categorize sustainable initiatives. Of these initiatives, Design for Environment, Life Cycle Analysis, Total Quality Environmental Management, Green Supply Chain Management, and ISO 14000 certification have emerged as leading models and tools and will be discussed in detail in sections 2.2.1 through 2.2.5. Additionally, design for disassembly and remanufacturing, as well as other models have gained ground and continue in their development towards the same basis sustainable ideals (Sarkis, 1999).

2.2.1 Design for Environment

At the center of the Design for Environment (DFE) concept is the idea that throughout every phase of product conceptualization and design, environmental considerations should take center stage. In this way, this ideology sits hand in hand with life cycle analysis, emphasizing how the design of a product will affect its manufacture, use, and disposal (Hervani et al., 2005).

Design for Environment considers the complete product life cycle at the design stage, including, but not limited to, the recyclability and reusability of individual components in the product as well as the long term environmental and human impacts of these components. The amount of treatment and resources needed in specialized processing facilities to obtain recyclability or reuse is also carefully considered, so as to limit burdens on the environment or raw goods in order to completely recycle the original product. Some materials, such as electronics components, have extremely intricate processes and many considerations that must be made when recycling or reusing components. An example of the recovery or recycling process for electronic components is shown in Figure 2-9.

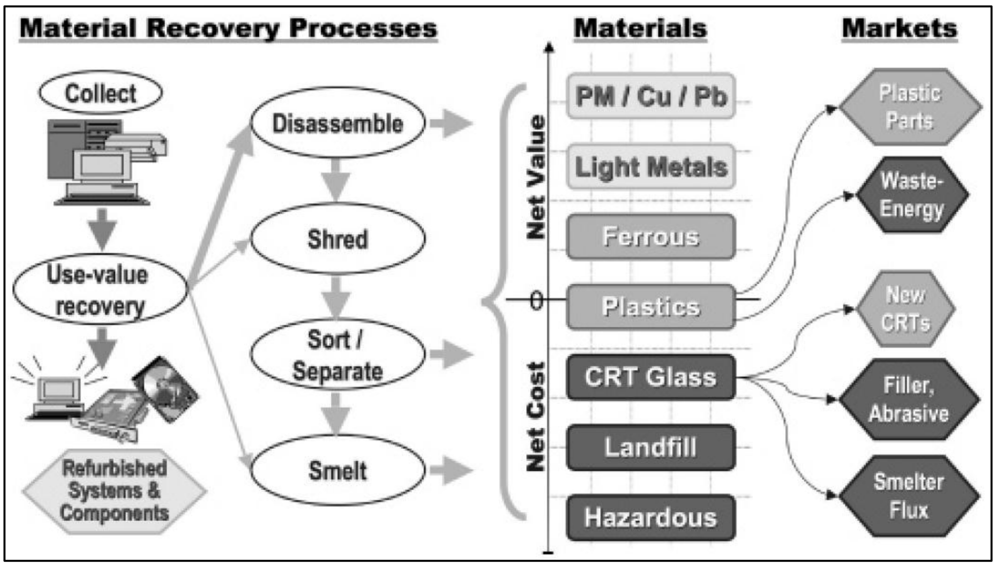

Figure 2-9: Schematic of electronic components' end of life material recovery process pathways (Adopted from Atlee and Kirchain, 2006).

In many cases, in order to increase reuse potential, components which are interchangeable between product lines or various goods are chosen to maximize potential outlets at the end of life. Along these lines, special adhesives are often used in products designed with the environment in mind. These adhesives and similar connecting devices allow for easy disassembly and help to limit damages associated with removing traditional components. Biodegradable and non-toxic materials are also used, especially in non-reusable components, in order to limit further environmental impact from disposal. In addition to design considerations with regards to the product itself, Design for Environment also considers the production processes used to manufacture or produce components. Processes are examined with regards to their efficiency, energy usage, water usage, and waste in order to eliminate excess material goods and energies (Sarkis, 1998). As illustrated in Figure 2-10, energy needs for industry and transportation make up a large percentage of total energy usage.

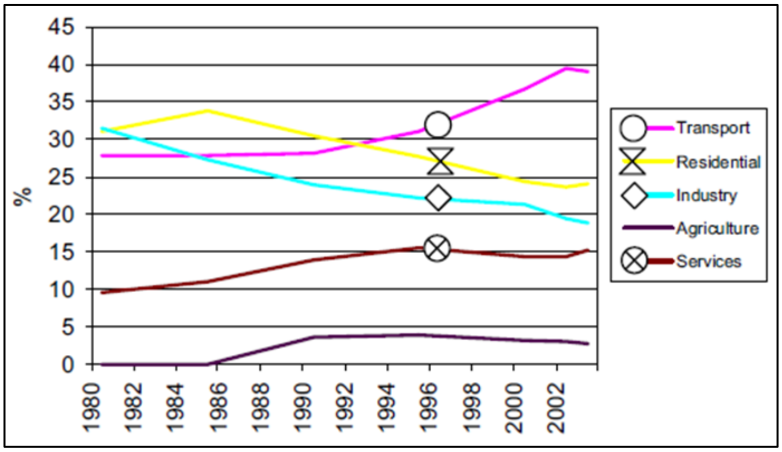

Figure 2-10: Percent energy usage by sector (Adopted from Gaughran et al., 2007).

2.2.2 Life Cycle Analysis

Hand in hand with Design for Environment is the concept of Life Cycle Analysis or Environmental Life Cycle Analysis (Hervani et al., 2005). Life Cycle Analysis is a process through which the environmental impact of a product, process, or service is assessed. Life Cycle Analysis systematically analyzes material flows through every state of a product's existence (Reich-Weiser and Dornfeld, 2009). In this way, a cradle to grave approach is undertaken from design through disposal for products studied through this analytic technique (Sarkis, 1998). The distinct phase classifications for Life Cycle Analysis are materials, manufacturing, usage, and disposal (Kaebernick et al., 2003). Figure 2-11 shows the accumulated life cycle costs associated with each of these phases, as they relate to both the user and society on the whole.

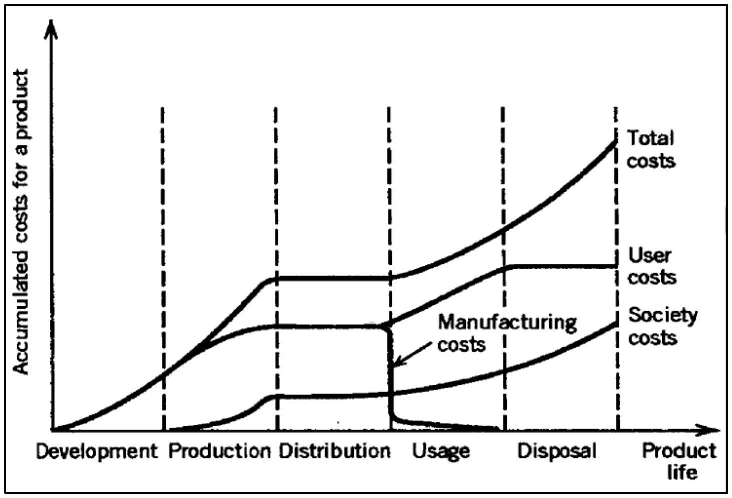

Figure 2-11: Accumulated life cycle costs associated with product design (Adopted from Akao, 1990).

Like Design for Environment, Life Cycle Analysis begins during a product's design stages, where that product's potential for reuse and recycling as well as the possible processes used to produce that product are analyzed (Kaebernick et al., 2003). Examples of inputs studied in Life Cycle Analysis are energy, raw materials, and water usage. Atmospheric emissions, solid and waterborne wastes, and the end product are all outputs considered (Sarkis, 1998). For ease of use, simple versions of Life Cycle Analysis have been created and implemented for companies to easily factor life cycle decisions into early product design without a great knowledge of concepts regarding sustainability (Kaebernick et al., 2003). Inventory Analysis, Impact Analysis, Life Cycle Costing, and Improvement Analysis are all tools that are used in conjunction with Life Cycle Analysis to further assist corporations with their decision making processes (Sarkis, 1998).

It is important to note that as with all of these sustainable ideologies, constant developments and improvements are commonplace. As Jin and High discuss in their piece A New Conceptual Hierarchy for Identifying Environmental Sustainability Metrics, "Over the past 20 to 30 years Life Cycle Analysis has been in a process of persistent development and standardization" (2004, pg. 297). This spans the early stages of environmental consideration in industry up through today. Further changes and refinements are forthcoming in the next few years. "Life Cycle Analysis is still at a fairly early stage in its development and will continue to evolve in response to research and application in the marketplace" (Jin and High, 2004, pg. 297). One area that has been targeted for improvement in Life Cycle Analysis and other evaluation techniques is a system of metrics. Since the majority of these concepts are ideological frameworks, default metrics are not provided in many cases, leading to slower implementation and lower levels of adoption by corporations in industry (Jin and High, 2004).

Further extensions of Life Cycle Analysis attempt to further quantify and classify life cycle assessments. One major example includes Economic Input-Output Life Cycle Analysis. Economic Input-Output Life Cycle Analysis utilizes economic input and output tables for environmental data and compares the findings with monetary figures. In this way, for given industries, the environmental impact can be determined or quantified with regards to dollars of production. A free online modeling tool for assessing Economic Input-Output Life Cycle Analysis is and has been available through Carnegie Mellon University since 1997. Over this time, the model has been used over one million times to assess and estimate life-cycle and supply chain environmental impacts. The combination of economic and environmental ideologies has led to tools such as this falling into the category of 'hybrid analysis' tools (Matthews et al., 2008). This type of tool helps management and designers assess how much of an impact individual products will have on the environment when compared with industry norms, existing products, and even competitors' products (Reich-Weiser and Dornfeld, 2009). Additionally, mathematical formulas and equations are often employed by companies to assist in their Life Cycle Analysis versus economic considerations. The product gain equation, stating that product gain equals the product value minus the product life cycle cost, illustrates the considerations that must be made in terms of what the product adds in terms of value to the user versus the cost to the environment due to the product's existence – be it through raw material value, wastes and byproducts of manufacturing, emissions and waste created during product usage, and considerations for disposal (Kaebernick et al., 2003).

One of the challenges of Life Cycle Analysis is that boundaries must be set or determined in order to establish responsibility for the different phases of a product's life cycle. Obviously environmental impacts occur at the raw materials, manufacturing, distribution, useful life, and end of life stages of a product's existence (Reich-Weiser and Dornfeld, 2009). Different classifications of products affect the environment in different ways and during different portions of their life cycles. For example, passive products such as household consumer goods, mainly affect the environment in the materials and manufacturing phases. Active products, however, such as cars and appliances, have a great environmental impact during the usage phase – in many cases far greater impacts than during the original manufacturing and assembly of the products (Kaebernick et al., 2003). Life Cycle Analysis attempts to distinguish boundaries to highlight where suppliers, manufacturers, distributors, and end-users can improve their interaction with products to improve environmental outcomes and lessen negative impacts (Reich-Weiser and Dornfeld, 2009). One tool that has been used to break a product's life cycle into stages to assist in this analysis is Product System Life Cycle (Fuller and Ottman, 2004). As one can imagine, however, few entities want to take responsibility for products once they have moved on in the supply chain, making collaboration between manufacturers, suppliers, and sub-suppliers a very elusive and foreign concept (Reich-Weiser and Dornfeld, 2009).

2.2.3 Total Quality Environmental Management

Another ideology to assist corporations in improving their environmental friendliness and sustainability is the concept of Total Quality Environmental Management. Like Life Cycle

Analysis and Design for Environment, Total Quality Environmental Management aims to decrease environmental impacts and waste streams through product design and consideration of a product's entire life cycle. Total Quality Environmental Management, however, takes a very high level approach and does not include the specific techniques and guidelines of the previously discussed methods.

The first key component of Total Quality Environmental Management is management support of environmental initiatives. Without leadership at manufacturing facilities and design centers buying in to changing environmental performance and impacts, it is very unlikely that positive progress will be made at any corporation. With this in mind, it is important to start from the top, for both monetary and procedural support, when implementing such initiatives. Such buy-in from key stakeholders is likely to have a trickledown effect on all employees, bringing up the second key component of Total Quality Environmental Management – human resources development of all employees with regards to environmental considerations. Hourly employees and engineers alike must know the benefits and savings – to themselves as well as the company – to make such initiatives successful. Teaching how environmental improvements could limit waste, save the company money, keep facilities in business, and even improve the world for future generations are key ways to put a positive spin on environmental awareness and changes.

The next key components of Total Quality Environmental Management relate to the inclusion of environmental concepts in all facets of company procedure and policy. Environmental considerations should be stated and included in strategic planning. Stating that a company is aiming to improve their environmental responsibilities and putting such a goal in critical documents and ideologies emphasizes the importance placed on the environment and will make reaching these goals more of an obtainable focus. Furthermore, company driven stakeholder analysis should include environmental considerations as they relate to environmental impacts on the company's community, government, customers, and suppliers. Performing such an analysis will identify the improvements these parties can expect to see from proposed environmental initiatives and what contributions will be needed from them in order to reach environmental goals. Such actions can improve relations of a facility with its neighboring towns and citizens and can also help to improve the sustainability of a corporation's entire supply chain, eliminating companies unwilling to improve their environmental policies and practices in favor of more forward-thinking, innovative alternatives.

Lastly, companies aiming to implement Total Quality Environmental Management must integrate environmental measurements and quality assurance into their tracking and data collection procedures and processes. Without accurate, complete data on environmental input and output factors, it is hard to assess the improvements of any initiatives of measures. With this in mind, environmental quality management systems need to be integrated and data needs to be analyzed and documented to these ends. In these ways, Total Quality Environmental Management serves as a solid, yet high level framework from which companies can improve their environmental relations through a top down approach from management through integrating these ideals in policies, including key stakeholders, and measuring and recording critical statistics and measures of environmental performance (Sarkis, 1999).

2.2.4 Green Supply Chain Management

Supply Chain Management involves sourcing raw materials and parts, manufacturing and assembly of products, order entry and tracking, distribution through various channels, and delivery to customers (Hervani et al., 2005). As previously discussed, one of the most daunting tasks in improving corporate environmental relations is not manufacturing alone, but the combination of manufacturing and distribution systems. Green Supply Chain Management aims to address this concern through improvement in buying, shipping, and disposal practices throughout entire supply chains (Sarkis, 1999). Throughout many supply chains, performance measurement with regards to environmental standards is virtually nonexistent (Hervani et al., 2005). Internal and external issues such as waste streams, disposal costs, overall waste and excess from a lack of recycling, and low employee interest threaten environmental improvements. Green Supply Chain Management aims to address these and other issues by employing external reporting practices, better collaborative management throughout the entire supply chain, and continuous improvement practices. The concept of Green Supply Chain Management is comprised of ideals such as green purchasing/procurement, materials management, green distribution, and reverse logistics (Hervani et al., 2005). These ideals can also be described as inbound logistics, materials management, outbound logistics, and packaging/reverse logistics (Sarkis, 1998).

Green purchasing/procurement, or inbound logistics, involves selecting external suppliers with highly regarded environmental records, policies, and practices to ensure that raw material flows align with environmental consciousness (Hertwich and Peters, 2009). In some cases, suppliers are even certified to assure that they are providers of environmentally sound products. This results in reduction in virgin resource usage, saving critical environmental resources, both renewable and nonrenewable (Hervani et al., 2005).

Materials management includes practices such as inventory reduction to save factory and warehouse space and reduce heating and cooling requirements, among other environmental and monetary savings (Sarkis, 1998). Additionally, managing materials includes limiting waste streams and reusing what might otherwise be classified as waste in order to maximize efficiency (Hervani et al., 2005).

The third key element of Green Supply Chain Management – green distribution, or outbound logistics – involves limiting transport of products and raw materials. Through transportation, warehouse, and distribution planning companies following these ideals can find reduction by optimizing space on trucks and other transport methods, resulting in lower fuel consumption and lower emission levels. Furthermore, loading time and handling are likely improvements in efficiency stemming from improved planning efforts, thus improving a company's bottom line and freeing up workers to complete other tasks or improve their handling capacities (Sarkis, 1998).

Finally, green packaging and reverse logistics are essential to determining the environmental friendliness of a product through its supply chain. Primary packaging consists of the packaging of an individual unit of product, as purchased by the end consumer. Secondary packaging consists of the packaging for a bundle of individual units, and shipment packaging consists of larger boxes or crates specifically designed for optimizing shipping efficiency. Reducing primary, secondary, and shipment packaging assists in outbound logistics by lessening the weight and size of products, allowing for greater optimization with regards to shipments (Sarkis, 1998). Additionally, less material is used in packaging due to these reductions, saving raw materials (Hervani et al., 2005). With regards to reverse logistics, packaging can also be designed to facilitate return of products for recycling or reuse, as specified in Design for Environment and Life Cycle Analysis ideologies. Packaging that allows for easy collection, separation, densification, transitional processing, delivery, and integration of complete products, subassemblies, or components for reuse improves customer satisfaction and ease of use, resulting in greater recyclability of everyday and specialized products alike (Sarkis, 1998). Through Green Supply Chain Management, the hope is that not only manufacturing, but also other elements of the product life cycle are improved, thus lessening the environmental impact of a product while also providing benefits to a company's profits and expenses.

2.2.5 ISO 14000 Standards

ISO 14000 Standards were created in 1996 and 1997 and serve as an environmental management family of standards aimed to develop "environmentally benign" corporations and processes (Sarkis, 1998, pg. 163). Companies aiming to meet ISO 14000 standards use this systematic approach to reduce their impact on the environment (Rachuri et al., 2009). These companies commit to compliance, pollution prevention, continual improvement, and documentation of their results and use human, physical, and financial resources to do so. In an ongoing six-step process, companies aim to set environmental policy, plan how goals can be obtained, carry out the plans, check on progress, act accordingly to fix issues as they arise, and continually improve environmental standards. In this way, a loop occurs much as in lean processes, through which standards are continually rising, setting the bar higher and higher to improve efficiency and environmental friendliness. One of the most important steps in this process is planning. This stage includes defining controllable environmental aspects, determining which of the environmental impacts of a company are significant and determining any legal dimensions or requirements. Based on the findings in these steps, objectives and targets are established to improve the targets of highest importance. Management systems are then established to remedy problems and reach targeted goals (Sarkis, 1998). Many of the sustainable ideologies discussed can be incorporated and used in company plans in order to reach the ISO 14000 Standards and goals set out by regulating groups and management (Hervani et al., 2005). Throughout the process, a variety of stakeholders, from governmental agencies to vendors and management are involved and constant communication and reporting is critical to achieving company environmental goals. If done properly, all of these stakeholders will likely benefit from improved environmental input and output from the companies under review (Sarkis, 1998).

2.3 Barriers to Industrial Adoption of Sustainable Thinking

While a good number of companies have begun to implement initiatives towards sustainability, those companies making widespread changes and vast quantifiable improvements still represent the minority within industry. With so many economic and environmental benefits from implementing sustainable practices and ideologies throughout manufacturing and supply chain operations, it is unanticipated that more companies have not followed this growing trend. Having said this, there must be some logical reason or barrier to entry that prohibits or deters management and decision makers within corporations from green-lighting sustainable initiatives and policy changes. Two of the most common inhibitors of sustainable implementation in the industrial sector are the complexity of metrics and concepts used to quantify sustainability as well as the expense and complexity of collecting data to measure sustainable progress. These two hurdles will be discussed in detail before analyzing how companies, as well as entire industries, should go about identifying and selecting beneficial metrics to meet their needs.

2.3.1 Complexity of Metrics and Concepts

"Although there is increasing interest in the business potential of sustainable development, there is no consensus, agreed upon context or 'environmental metric' on how to measure progress" (Mosovsky et al., 2000, pg. 230). To adequately understand the concept of metric identification and selection, one first needs to understand what metrics are and what roles they serve in the measure of environmental sustainability. "A metric is a devised means often obtained through reducing data complexity and integrating information that provides quantitative information regarding the variable of interest that cannot always be directly observed" (Jin and

High, 2004, pg. 291-292). Simply put, a metric is a combination of recorded data used to tell a story about some portion of a company's environmental input, output, or overall sustainability.

"Applying metrics [has become] a dominant practice of measuring sustainability in recent years" (Jin and High, 2004, pg. 291). With this in mind, "metric identification has received growing attention as more alternatives become available for quantifying the sustainability-oriented performance of a target human activity" (Jin and High, 2004, pg. 291). Environmental metrics alone are plentiful – in their piece A New Conceptual Hierarchy for Identifying Environmental Sustainability Metrics Jin and High state that they believe over 500 metrics to be in existence (2004). Great difficulty exists, however, in the determination of which to use when, how to compare similar metrics with one another, and how to measure them (Hervani et al., 2005). Great deficiencies exist in the systemization and classification of existing metrics. When companies cannot find a metric to fit their needs, they often develop their own, leading to too many competing metrics on hand to unify standards across industries or solve specific problems (Jin and High, 2004). Furthermore, many metrics do not reflect the difference between pollutants and their impact on the environment – the ultimate indicator of sustainable progress (Jin and High, 2004). These facts, as well as many other complexities discussed in this section as well as section 2.3.2, leads to slow adoption of environmental improvements and tracking systems. Further complications arise from discrepancies and disagreements with regards to the definition of sustainability, leading to a variety of metrics tailored to one adaptation or another (Jin and High, 2004). Knowing the desired end points and what falls underneath the sustainability umbrella will help to great lengths in metric selection (Jin and High, 2004).

Many metrics and indicators that could be used to represent elements of a given company's sustainability are extremely complicated and foreign to typical workers and –, in many cases – management as well (Sarkis, 1999). "It is difficult for decision makers to tell which metric is actually better if they themselves do not know how many options they could have or they barely understand the underlying difference between various alternatives" (Jin and High, 2004, pg. 295). Implementing new policies which require a set of metrics to be monitored requires a high level of understanding and adoption at all levels of the corporation – a difficult task for the application of even the most basic and universal concepts (Sarkis, 1999). In theory, it is easy to identify what a desired metric should look like, but in reality they are extremely hard to put into service (Jin and High, 2004). Many factors suggested for implementation and tracking are difficult to quantify, at times even requiring complex formulas or input from various levels of supply chains (Sarkis, 1999).

No one size fits all metric exists and metrics which stand alone are often misleading and may lack the technical depth needed to truly assess progress, inhibiting the ease of implementation and understanding (Jin and High, 2004). "To concentrate on any single criterion creates instability in the larger context and represents… an extreme position, disconnected from the overall structure" (McDonough and Braungart, 2002, pg. 147). Many companies still do not understand or comprehend the need for combined metrics to work in unison to measure sustainable progress with regards to environmental impacts (Sarkis, 1999). Some characteristics of the environment and human interaction with it can only be discovered when a wholeness, or complete picture view, is stressed (Jin and High, 2004). "Published works on metrics for sustainability show that either (i) the chosen metrics are not truly reflective of all three aspects of sustainability; (ii) they are too many and, consequently, are too difficult to apply; or (iii) both" (Martins et al., 2007, pg. 2962). These facts prohibit quick fixes in many cases regarding sustainable measurement and data collection, requiring companies to put much more time, effort, and capital into systems to track and measure multiple important metrics with regards to sustainability.

A variety of conceptual frameworks for metric classification have been devised over the years, from the pressure, state, response framework to a new ideology developed by Jin and High in their work on sustainability metrics (2004). In the pressure, state, response framework, environmental concerns related to industry and business are classified based on how the environment acts with relation to outside influences. Jin and High's work builds upon this framework, using five classifications: stressor, status, effect, integrality, and well-being (2004). The stressor metric classification describes a direct physical pressure that a given human activity has imposed on the environment; stressors typically involve simple indicators and measures. Status involves the degree to which the change in physical elements exists based on the stressor. Effect is the resulting impacts caused by the stressor and status change. Integrality is the potential influence on the entire ecosystem from a stressor. Well-being describes the extent to which certain damages are caused to human welfare by all prior factors. In this manner, this framework uses a hierarchy to classify the environmental impacts due to a variety of causes from industry and human activity. Metrics to accompany this work exist as they relate to sustainability, but are hard to define or measure at this point in time (Jin and High, 2004).

Another complexity is the fact that even though sustainable methodologies – such as those discussed previously – exist, very few come with sets of universally accepted metrics. As theoretical frameworks, these methodologies cannot account for differences in local, industry, capabilities of individual facilities, or industry and governmental regulations (Jin and High, 2004). Of those theoretical frameworks and industry standards which do include a set slate of sustainability metrics, they range in size from 10 metrics all the way up to 134 different metrics – many more than most companies would be willing to track or able to easily implement (Jin and High, 2004). Furthermore, sustainability metrics are often inconsistently defined and business specific, both hindrances to universal, general metric or index adoption (Rachuri et al., 2009). Metrics need to be diversified and partitioned based on usage and relevance in order to maximize their adoption and usefulness (Jin and High, 2004). Until this step is taken, there is and will not be a 'one stop shop' where companies can find set guidelines for exactly which factors and metrics they should be monitoring. For some industries, standards exist; however, without further regulation or collaboration between corporations, it is unlikely that stringent guidelines or suggestions will emerge in the near future (Jin and High, 2004). Furthermore, many regulations currently in existence are not adequately addressing long term sustainability and viable solutions. This is due to the fact that for regulators who are attempting to safeguard whole industries, the readiest solutions are often those that can be applied on a very large scale, or end-of-pipe solutions, in which regulations are applied to the waste and polluting streams of a process or system. The net result, in many cases, of such restrictions is dilution of emissions to a more acceptable level. Unfortunately, this 'solution' "…is an outdated and ineffective response that does not examine the design that caused the pollution in the first place" (McDonough and Braungart, 2002, pg. 60).

Further hindering the implementation and usefulness of metrics to measure sustainability and environmental performance is the poor data quality of many company's environmental measurements (Sarkis, 1999). Failures in information exchange between design, engineering, and manufacturing personnel and departments inhibit good product design and require rework when determining environmental impact upon product completion. Standards must be implemented between various departments, and if possible across multiple facilities and even industries (Rachuri et al., 2009). Such steps would require overcoming obstacles such as data irregularities or non-standard data across from facility to facility, as well as poor technical integration across various sites (Sarkis, 1999).

Resource availability, governmental regulations and policy, labor, and technology are often determining factors as to where products are produced, assembled, and transported. Subsequently, these factors often determine where emissions and pollution occur throughout a supply chain (Reich-Weiser and Dornfeld, 2009). With widespread globalization more the norm than the exception in today's manufacturing and distribution networks, other obstacles including geographical differences, varying standards of measure, and cultural differences also provide barriers to acceptance and implementation of sustainable ideals (Sarkis, 1999). Manufacturers cannot only consider the emissions and efficiency of their own operations, but must consider emissions across their entire supply chains (Matthews et al., 2008). When multiple vendors, manufacturers, distributors, and retailers are involved, regionally and globally dispersed, it is difficult to measure performance due to these varying methods of measure (Hervani et al., 2005). This global nature of business also creates problems because of the fact that different organizations are willing to take on differing levels of responsibility with regards to their emissions.

The concept of a carbon footprint is very vaguely defined. The term finds its roots in the term ‘ecological footprint,’ defined as “the land area needed to produce a given level of human consumption” (Matthews et al., 2008, pg. 5840). As one can imagine, however, industry often uses such a vague definition loosely and translates it to fit their needs and reporting structures. Businesses, like consumers, can influence their carbon footprints through their purchasing decisions, but can only affect the purchasing decisions so far up their supply chains. For any complicated product, anyone in the supply chain could be held accountable for emissions associated with the production, chemicals, and other low value added parts and pieces (Matthews et al., 2008). To what extent should a producer be held responsible for the components and subassemblies going into their products?

The global nature of industry today also results in discrepancies with regards to the relative comparison of input and output data that is successfully collected. Due to varying levels of development, resource usage, technology, and power generation techniques, emissions resulting from electricity used in operations differ greatly based on the international location of production. Electrical distribution and conversion efficiencies vary from region to region and must be taken into account. This phenomenon even uncovers obvious differences from production in various states around the United States (Reich-Weiser and Dornfeld, 2009). Such differences due to the international marketplace further complicate metric definition and make it difficult to accurately assess the efficiencies and relative effects of production from one locale to another (Reich-Weiser and Dornfeld, 2009). Further complicating matters is that once metrics are identified, scopes must be defined and means need to be implemented for collecting and quantifying data and information to assess progress towards sustainability goals.

As with most decisions in the business world, capital and finances also come into play with decisions regarding sustainability and metric selection. Limited financial resources must be used efficiently to appropriately quantify data required to identify problem areas and reach targets and goals regarding sustainability (Mosovsky et al., 2000). Improvements in the area of environmental impacts must be justifiable through traditional financial and nonfinancial performance measures to ensure rapid adoption and long term solutions will be pursued and implemented (Sarkis, 1999). Metrics have tradeoffs in their desirable functions, costs, and flexibilities and must be tailored to these ends for adoption by differing corporations (Jin and High, 2004). Comprehensive modeling systems must be developed to help companies consider the tradeoffs between changes in system complexity and theoretical reductions in environmental impact (Rachuri et al., 2009).

The development of such a metric is not an unexplored concept. Previous attempts have been made at creating metrics to quantify suppliers with regards to quality and timeliness, as well as other measurements of business and manufacturing acumen. One example of metric creation that came to light during this research was the development of a Lean Index for the wood products industry. Lean manufacturing is a systematic approach towards improving operational, manufacturing efficiency through the minimization of waste in processes. Towards these ends, components such as continuous improvement practices, defect and rework reductions, and enhanced inventory management and reduction are included in the lean ideology and methodology. In the creation of a Lean Index for the wood products industry, it was discovered that 81 possible metrics existed for determining a company's level of leanness in the industry. From these metrics, however, management did not have a clear way to effectively analyze or compare lean practices from one facility to the next or between competitors (Ray et al., 2006). Much like this work aims to create a metric for analyzing and ranking sustainable practices, the work done towards the Lean Index aimed to create a metric for analyzing and ranking Lean practices. Through model formulation, data collection, and standardization, "factor analysis was used to develop a quantitative definition and assessment of the concept of 'leanness' for any wood products company" (Ray et al., 2006, pg. 253). The parallels between the creation of the Lean Index and the motivations and goals towards creating a sustainability index are strong. The success of the Lean Index, as well as similar metric categorizations for other aspects of production and distribution processes illustrates the feasibility and realism of developing such a tool regarding sustainability.

2.3.2 Data Collection Expense, Scope, and Complexity

Even after metrics have been identified and tailored to conform to a company's operations and business needs, a great deal of work must still be done. Once indicators have been identified, the real problem with applying them results from the chaos in interpreting them and the decisions drawn from them (Jin and High, 2004). The inclusion of global players across multiple time zones, poor technological integration, cultural differences, and non-standard systems of measure further complicate the implementation of universally accepted measurement methods and standards (Hervani et al., 2005). Measurement and tracking must be done throughout the entire supply chain, not simply manufacturing processes. The fact that supply chains are influenced by a variety of factors, such as customer expectations, globalization, information technology, competition, and governmental regulations makes including and measuring environmental factors very difficult across all phases and elements of the chain (Hervani et al., 2005). Lack of uniform management and management practices, mistrust, lack of understanding, lack of control, differing goals, disjoint informational systems, a lack of standardized performance measures, and even deciding where to begin implementation can all provide large hurdles to successful environmental metric integration and acceptance (Hervani et al., 2005).

Past efforts such as voluntary data collection, reporting, and submission leaves measurement and tracking up to individual companies and production units. As the employees of these individual facilities are likely not familiar with measurement and reporting procedures, the accuracy of statistics obtained through these means is questionable, at best. Current practices for reporting carbon footprints, for example, request voluntary data submission which likely is far from painting a complete picture (Hertwich and Peters, 2009). Typically, carbon footprint data submitted by companies considers only direct emissions as well as emissions from purchased energy resources. This practice neglects consideration of the carbon footprint from a product's distribution and supply chain – where a great deal of pollution generally occurs. This leads to large underestimations in reported figures regarding the total carbon footprint impact of products (Matthews et al., 2008). It has been found that emissions within a supply chain are, on average, three times greater than direct industry emissions from the production of a product in the manufacturing stage (Reich-Weiser and Dornfeld, 2009). Of all pollution, direct or tier 1 emissions, only account for 14% of a supply chain's total carbon emissions. Direct emissions plus industry energy usage, or tier 2 emissions, account for only 26% of total emissions (Matthews et al., 2008).

In one stunning industry example of this phenomenon, Dell Computers claimed carbon neutrality, a laudable environmental feat for such a large scale manufacturing and assembly process. Unfortunately, Dell failed to realize or recognize that their suppliers and consumers combined to create ten times the emissions Dell had defined as the carbon footprint of their products (Reich-Weiser and Dornfeld, 2009). This example illustrates the importance at recognizing and identifying tier 3 emissions, or all other indirect activities which create emissions and greenhouse gasses through a product's life cycle (Matthews et al., 2008). When unclear lines are drawn with regards to carbon footprint boundaries, like other metric complexities, data can provide very skewed and misleading results.

Since carbon emissions basically have the same effect, regardless of where they occur, it is theoretically possible to trade them throughout the supply chain. This has led to speculation and debate regarding emissions trading systems for global carbon emissions, a policy which is likely imminent (Matthews et al., 2008). In this manner, it is reasonable to slightly increase emissions in one area, such as transportation, if they can be drastically reduced elsewhere, such as manufacturing processes. This represents another consideration that companies must take into account when determining global suppliers, facility locations, and energy usage (Reich-Weiser and Dornfeld, 2009).

In order to facilitate more accurate tracking and measurement of sustainable progress in all phases of a product's life cycle, tools and devices must be devised, purchased, constructed, and implemented to quantifiably measure selected metrics. Furthermore, the scope and boundaries for data collection must be identified. Where one company's responsibilities end and another's begin throughout the supply chain is often a puzzling concept when the intent is to analyze the environmental impact of an individual product. In the past, environmental observation frameworks have included data from a variety of indicators, basically for value tracking and recording, and no general aggregate index was created from the resulting data. One step which would help with data collection and reporting would be the development of more affordable, accurate, and comprehensive sensors to monitor environmental impacts easily – even for employees unfamiliar with low level environmental topics. This data could then, in turn, be used to compose an overarching environmental tracking system at a high level, taking into account multiple sensors and indicators in an expansive, complete framework (Rachuri et al., 2009). As more progress is made and more process inefficiencies are identified, gains will become more difficult to achieve – following with the concept of addressing low hanging fruit. As this phenomenon occurs, it may become necessary for governmental regulators to impose limitations regarding greenhouse gas emissions, energy use, water use and discharge, and hazardous waste in order to spur compliance by lagging corporations as well as to keep challenging and improving the environmental standards of industry leaders (Mosovsky et al., 2000).

2.4 Decision Methods for Industry Selection of Sustainable Concepts

With the growing number of ideologies and methods for environmental sustainability available to corporations, methods of analyzing and classifying the best solutions for each unique product, facility, or environment must be determined. Traditionally, Return on Asset is used as a decision making tool in industry, but with environmental concerns, it has been discovered that customer satisfaction, life cycle considerations, and other factors must also be considered (Kainuma and Tawara, 2006). Characteristics of comprehensive or useful solutions to environmental concerns as well as many multi-attribute utility theories will be briefly discussed in this section. “In sustainability analysis of multidimensional states of a system, it is required to establish the relative superiority of states… Sometimes, unequal weighting factors are ascribed to metrics to show the relative importance of the metrics, further complicating comparison” (Sikdar, 2009, pg. 157). These topics will assist companies aiming to understand the possible means for determining which sustainability metrics and concepts fit their needs.

2.4.1 Characteristics of Comprehensive Solutions

Based on the discussion here, it quickly becomes obvious that a "perfect" sustainable solution does not presently exist. With this in mind, comprehensive and adequate solutions must be implemented and continually improved upon in the pursuit of complete sustainability. The implications of environmental interactions and sustainable initiatives alike are far reaching, overstepping functional and organizational boundaries (Sarkis, 1999). The governments, populations, wildlife, and landscapes of communities are likely to be affected on a daily basis – knowingly or unknowingly – by the environmental decisions made by nearby manufacturing and distribution facilities. With this in mind, corporations must consider far beyond standard financial criteria measures when evaluating possible solutions and implementing new environmental standards.

Environmental programs must be aligned with organizational strategies to achieve these ends (Sarkis, 1999). This requires consideration not only of manufacturing processes, but also distribution, transportation choices, and supplier selection. Companies must also assess the flexibility of the environmental programs they will be implementing as well as the reliability of the data they will be collecting. Furthermore, as environmental concerns and initiatives are often drawn out processes, the timeliness of implementation must be considered by companies wishing to have faster or more immediate environmental changes (Reich-Weiser and Dornfeld, 2009). A balance must also exist between proactive and reactive factors to account for preventing environmental impacts before they occur and reacting to unforeseen circumstances and addressing them with as little impact as possible (Sarkis, 1999). Until regulatory requirements exist across entire industries, companies will have to consider issues such as these and weigh the risks and rewards of various environmental improvements and initiatives of their efforts to become more sustainable (Reich-Weiser and Dornfeld, 2009).

2.4.2 Decision Methodologies

Once a company aims to implement environmental changes, the number of metrics and variety of improvement techniques may be daunting. A variety of decision making techniques is often used in order to come to a strong conclusion about the best practices and measures to implement. Analysis techniques should be inclusive as possible while still allowing for management interaction and input for decision making (Sarkis, 1999).

A variety of methods have been used in the past for ranking alternatives. As shown in the example in Figure 2-12, relationships exist between elements of product design and functionality that must be considered when determining the best product from a group of alternatives. Decision theory, dynamic programming, game theory, linear or goal programming, multi-attribute utility theory, outranking approaches, and risk situation analysis are a few of these methods (Ravindran, 2006; Ravindran, 2008). Of these methodologies, some represent top down comparison techniques that analyze the company's goals before looking for solutions. Others work from the bottom up, analyzing individual alternatives first and foremost, before relating them back to high level goals (Jin and High, 2004). Recently the Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), and Data Envelopment Analysis (DEA) have been added to the list of alternative selection methods at management's disposal (Sarkis, 1999). Data Envelopment Analysis, the Analytical Hierarchy Process, and the Analytical Network Process have been applied in a number of fields and applications since their inception. Fields include automotive manufacturing, consumer goods and general manufacturing for applications such as process selection, investment decision making, production planning, and product design criteria analysis (Ravindran, 2009). These methodologies will be briefly introduced here.

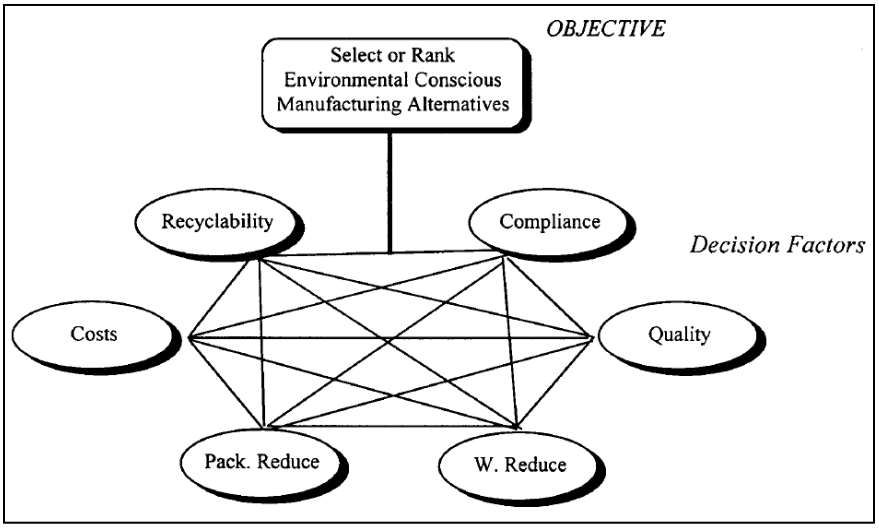

Figure 2-12: Network hierarchy and relationships between product qualities for selecting alternatives (Adopted from Sarkis, 1999).

2.4.2a Analytical Hierarchy Process (AHP)

"Perhaps the most creative task in making a decision is to choose the factors that are important for that decision" (Saaty, 1990, pg. 9). To address this critical juncture of the decision making process, the Analytical Hierarchy Process was developed as a multicriteria decision making approach, employing a unidirectional hierarchical relationship among decision levels (Saaty, 1990). To these ends, the Analytical Hierarchy Process works from the top down by identifying the overall goal for a decision model and decomposing this goal into sub-levels and more specific attributes where management and other decision makers can easily identify their preference (Sarkis, 1998). Breaking down high level decisions into smaller choices aids in the decision making process and allows management to more easily come to optimal solutions given their criteria at hand. Pairwise comparisons are often used for assessment and analysis and generate relative importance levels for alternate solutions (Sarkis, 1998). As with a many newer decision making methodologies, the Analytical Hierarchy Process uses the relative importance and strength of impacts and inputs to generate a ratio scale used to compare alternative solutions (Sarkis, 1999).

2.4.2b Analytical Network Process (ANP)

The Analytical Network Process is very similar to the Analytical Hierarchy Process in that it narrows down alternative solutions through comparison and ranking. Unlike, the Analytical Hierarchy Process; however, the Analytical Network Process allows for more complex interrelationships between decision levels and components or alternatives (Saaty and Vargas, 2006). This is due to the fact that the Analytical Network Process is more general than the Analytical Hierarchy Process, relying less on a unidirectional hierarchical relationships and structure and more on composite weights between elements (Sarkis, 1999). Such a system results in more and better used feedback from managers and decision makers. Such techniques are commonly used in the selection of environmental initiatives as well as other business decisions such as capital investments and risk analysis (Sarkis, 1998).

2.4.2c Data Envelopment Analysis (DEA)

Data Envelopment Analysis is a decision making methodology which takes into consideration multiple input parameters, multiple output production correspondences, and the evaluation of the production efficiency of multiple production, or decision making units (Lin et al., 2009). Based on inputs and outputs, a linear programming formulation is created to measure the relative productivity and efficiency of production or decision making units, with reference to a set of additional production units. Through this manner, a base facility or production process can be compared to a variety of alternatives and assessed with regards to improved statistics regarding multiple inputs and outputs simultaneously (Sarkis, 1999). A strong benefit of Data Envelopment Analysis is the resulting ratios and numerical feedback scores which can be provided to management in order to assist in the decision making process (Lin et al., 2009). In terms of environmental considerations, Data Envelopment Analysis could be used to compare the current conditions of a production and distribution facility to a variety of alternatives, each alternative employing differing environmental and sustainable improvement. A ratio of scores would result from the analysis, allowing for improved ease in decision making. Data Envelopment for past environmental considerations has been made with regards to the assembly, functionality, cost, compatibility, and sustainability indexes of given alternatives (Lin et al., 2009). The relative merits and strengths of each alternative can be analyzed further in order to aid management in selecting the best economically and environmentally feasible solution for implementation.

2.5 Steps for Metrics Implementation

2.5.1 Suggested Metrics

"As new scientific and technological innovations are exploited… tools and methods are needed to ascertain the direction of sustainable progress" (Sikdar, 2007, pg. 167). As referenced earlier, in their piece, A New Conceptual Hierarchy for Identifying Environmental Sustainability Metrics, Jin and High state that "A metric is a devised means often obtained through reducing data complexity and integrating information that provides quantitative information regarding the variable of interest that cannot always be directly observed" (2004, pg. 291-292). With this definition in mind, it can be argued that there is no single metric that can measure and/or compare sustainability. Rather, a combination of metrics must be implemented uniquely for every company, conforming to their business needs and available resources (Sekulic, 2008). A universally agreed upon system of sustainability metrics from which companies could choose to meet these needs would represent a huge step towards implementing wide ranging standards for the measurement of sustainability in corporate manufacturing and distribution networks. Such a step would allow for the development of models and setting of business objectives to help companies achieve their sustainable goals, goals both economically and environmentally motivated (Rachuri et al., 2009). Though the relationship between environmental and economic benefit of proposed changes is not linear, as shown in Figure 2-13, the merits of such sustainable improvements are very real.

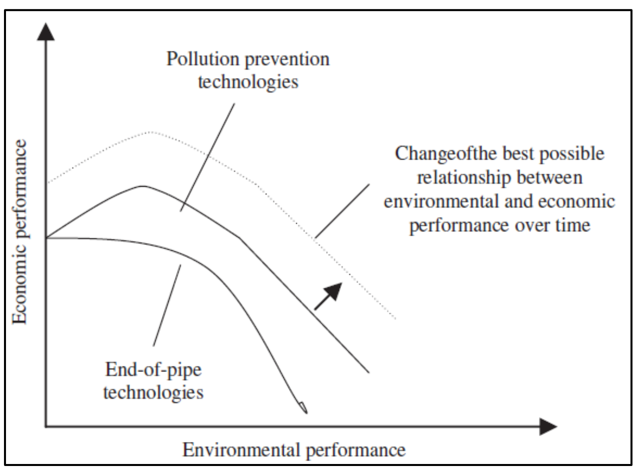

Figure 2-13: Nonlinear relationship between environmental and economic performance (Adopted from Claver et al., 2007).

The corporate world already identifies metrics for marketing and economic decisions. Return on investment/capital costs, operating costs, market share, profitability, revenue growth, customer service, and other figures all exist and are familiar to anyone in business or management. Incorporating environmental measurements and tracking follows as a logical step towards improving sustainability and environmental relations (Hervani et al., 2005). Numerous factors for quantifying and addressing a variety of environmental concerns must be implemented. Concerns to be considered include the following: recyclability, waste and packaging reduction, regulatory compliance, resource depletion, greenhouse effects, acidification and oxidation potential, mass of air and soil pollutants, mass of water contaminants, human health and safety risk, and ecological risk (Lin et al., 2009). Identifying metrics to assess 'impact drivers,' or those byproducts of products and processes having the greatest environmental impacts, serves as the first step towards improvement in this area (Kaebernick et al., 2003). Following such a step, metrics to identify and measure lesser known or recognized environmental impacts could be implemented in continuous improvement efforts.

It is not expected that any single metric will be comprehensive, although "it has been deemed desirable to consolidate all the usable metrics into one aggregate system of metrics" (Sikdar, 2009, pg. 157). Since no one size fits all metric exists, metrics come in a variety of forms and formats (Jin and High, 2004). Differences in metric types often result from how data is collected to determine or compute the value of the metric. The simplest metrics, called indicators, are read directly from a gauge or monitor and represent measurements of a single parameter of a system. These metrics stand alone to demonstrate the status of one aspect of the environmental performance of a system or process. CO_2 emissions readings are one example of such a metric (Rachuri et al., 2009). Companies that choose to focus on indicators must recognize that multiple indicators will be needed to paint a full picture of their environmental impacts and relations. Failing to do so by focusing on a single criterion will result in a limited view of the company's sustainability (McDonough and Braungart, 2002).

More complicated metrics, called indices, may require more complicated computations or formulas, combining a variety of values read from monitoring systems. Indices often combine a variety of indicators into a single score which serves as a metric to express a broader view of a system's sustainability (Rachuri et al., 2009). In this way, indices explore and assess the interaction between various effects on an ecosystem as opposed to isolated elements (Jin and High, 2004). The Environmental Vulnerability Index, composed of indicators to monitor hazard levels, resistance to change, and damage to the environment resulting from a manufacturing process is an example of an index metric. Ecological Footprint is another example of an index metric, comprised of the ratio of the land and water required to sustain a population to the available land and water available to that population. Indices can often be more useful than indicators because they provide a wider, broader range of information and data about a process or system; however, they are more costly and difficult to monitor and track due to their multiple input requirements and formulations (Rachuri et al., 2009).

Metrics differ in cost, ease of measurement, flexibility, and implementation (Jin and High, 2004). To realize the maximum value from resources dedicated towards measuring environmental sustainability and making improvements in environmental impact levels, companies must share product and sustainability information across business and engineering groups. In some cases this may mean simply sharing information on how product design could impact manufacturing and distribution processes with regards to waste, required packaging, and the like (Rachuri et al., 2009). Different corporate environments stimulate varying levels and types of sustainable improvements, so it is essential to train employees with regards to sustainable concepts to help facilitate conversation and improvements at all levels within the company (Sarkis, 1998).

Using cross functional project teams to gather viewpoints on sustainable design from a wide range of disciplines would go a long way towards improving overall recyclability, reducing waste, and improving processes. Using a good portfolio management system and stage-gate processes to select, rank, and prioritize projects so only the best overall concepts are selected for production and distribution would also help to eliminate waste (Cooper and Edgett, 2008). Additionally, integrating standards and metrics between various domains and across industries would likely improve overall sustainability through collaboration (Rachuri et al., 2009). Providing further benefits, some metrics may be aligned with monetary savings due to environmental impacts, fines, regulations, or the expense of dealing with waste and byproducts. By tracking progress of such environmental metrics, companies will be able to financially measure environmental progress as it impacts management level business objectives (Sekulic, 2008).

Traditional environmental factors and statistics in business include the cost of waste and emissions processing, recyclability, process waste reduction, packaging waste reduction, regulatory compliance, community support, and quality issues such as the percentage of products remanufactured. Some of these factors might raise questions, but deeper thought reveals that tracked statistics such as regulatory compliance and community support illustrate more than one would imagine with regards to environmental impacts while costing very little to track. Regulatory compliance, for example, is tracked and often monitored by governmental agencies, incorporating set environmental codes and guidelines. Keeping track of such information represents little to no cost to the corporation while providing a rough benchmark on environmental performance. The major downside to tracking environmental performance through such means is that agencies and regulators are often overworked and have limited opportunities to track all corporations in their jurisdictions through all possible tests and means. This results in inadequate data that might illustrate blatant environmental issues, but does not paint anywhere near a complete picture of a company’s environmental impact. In much the same way, community support will likely be low if severe or obvious environmental infringements are being made by a company or industry. However, simply because there are no complaints from surrounding businesses and citizens by no means indicates that a company has a clean environmental record and is doing all that they can to improve their global sustainability (Hertwich and Peters, 2009).

Some localities and states have enacted stricter rules and regulations regarding sustainability. The California Climate Action Registry, for example, requires reporting of all direct facility and vehicle emissions, as well as all electricity, steam, heating, and cooling purchases by businesses. This registry also recommends that all greenhouse gases, as identified by the Kyoto Protocol, are reported. These gases include Carbon Dioxide, Nitrous Oxide, Methane, Hydro Fluorocarbons, Perfluorcarbons, and Sulfur Hexafluoride, among others (Matthews et al., 2008). Additionally, groups and independent organizations such as the Global Reporting Initiative are working to develop and disseminate globally acceptable sustainability reporting guidelines to these ends (Hervani et al., 2005). Groups such as this will assist in the creation and monitoring of metrics and environmental standards without divulging sensitive business information (Mosovsky et al., 2000), providing solutions incorporating all aspects of production and distribution rather than narrow-minded, reactionary following of regulations (Jin and High, 2005). Following these early steps, a trusted system of measures must be developed to support the monitoring and tracking of energy consumption, hazardous materials usage, recycling, ultimate end of life disposal, remanufacturing, reclamation, and carbon output for all products (Rachuri et al., 2009).

In order to prove effective and drive environmental improvements, systems and sets of sustainability metrics must be comprised of meaningful indicators and indices, representing holistic fields. As stated earlier, no one size fits all solution exists, so indices and indicators must be used collaboratively. Clear boundaries and scope for what metrics should account for are also critical in obtaining accurate, useful information (Rachuri et al., 2009). Indicators and indices should also be focused on measuring input and output with regards to processes, facilitating improvements to specific systems – both manufacturing and distribution – in the future. Furthermore, data must also be reliably collected, normalized, and weighted over long time horizons (Rachuri et al., 2009). Standardization of metric data based upon the weight or volume of cargo shipments helps to account for differences and normalizes data from varying suppliers and distribution networks (Reich-Weiser and Dornfeld, 2009). Such requirements will ensure that data proves useful to allow for adequate comparison when generating trends and patterns (Rachuri et al., 2009).

One system of metrics suggested by Mosovsky, Dickinson, and Morabito in their piece Creating Competitive Advantage Through Resource Productivity, Eco-Efficiency, and Sustainability in the Supply Chain is the EcoPro system (2000). The EcoPro system is a universal environmental metric framework based on eco-efficiency and resource productivity guidelines. EcoPro focuses on value creation, aspect levels, and environmental impacts for targeted firms and provides a clear indication of progress towards sustainability through full product life cycles, additively along supply chains. Based on factors such as ratios between cost, environmental impact, and revenue as well as existing standards such as ISO 14000 principles and factory emissions standards, EcoPro determines if the environmental impact of given products are significant or if those products are sustainable. One key metric of note is the so-called, resource productivity indicator, dividing production rate by environmental impact, allowing for a direct comparison of the environmental impact of different products. Additional benefits of this system include its focus on targeting where improvements will have the greatest effects on environmental impact reduction and through EcoPro's systematic approach – an approach which can be compared over time through different industries and firms under observation (Mosovsky et al., 2000). Metrics which incorporate and analyze the true effects and environmental impacts of a system over time even uncover dependencies and issues not visible from simply obtaining snapshot data at one moment in time (Jin and High, 2004). Users and the creators of EcoPro have also found that energy requirements tend to dominate product lines that are assembly and test intensive, while waste appears to dominate product lines that are assembly and process intensive – identifying areas for improvement based on industry (Mosovsky et al., 2000).

The identification of further indicators, indices, and systems of metrics along these lines would help companies make smarter decisions with more impact on the environment and bottom lines. As discussed, an emerging focus in sustainable ideology emphasizes improvements throughout the supply chain. Many regulatory values collected relate to supply chains, such as the Toxins Release Inventory measured by the Environmental Protection Agency (Hervani et al., 2005). Traditional supply chains have been rated according to lead times, customer satisfaction, and inventory levels (Kainuma and Tawara, 2006). Building upon these standard metrics and focusing on more environmental concepts would be a beneficial step. Since companies can incorporate changes at the supply chain or direct manufacturing levels they must recognize where implementations to reduce emissions and carbon footprints are the most feasible and cost effective (Matthews et al., 2008). To these ends, it is also important to note that in many cases, larger corporations can improve their own sustainability and overall worldwide environmental impacts simply by outsourcing to or selecting suppliers with better eco-efficiency ratings than themselves (Mosovsky et al., 2000). In such a system, all suppliers would be measured and rated based on traditional metrics such as timeliness, quality, reliability of shipments and products as well as new environmental considerations. Systems such as ECOSCAN assess supply chains and other emissions stressors for various steps throughout supply chains to these ends (Hervani et al., 2005).

"You cannot manage what you do not measure" (Cooper and Edgett, 2008, pg. 54). Without metrics, managers will have insurmountable odds against them in their attempts to improve environmental relations in today's manufacturing and distribution systems. Metrics allow for a determination of not only where to focus resources and energy for improvement, but also provide a basis to determine the success versus failure of improvements (Cooper and Edgett, 2008). The identification of operational efficiencies through leading, predictive metrics and indicators would represent a large step in the right direction towards environmental improvement over current reactionary, evaluative, and lagging measures; or worse yet, over nothing at all (Mosovsky et al., 2000). Incorporating metrics and implementing concepts such as the Triple Bottom Line approach, measuring the economic success of products as well measuring objectives related to products' environmental and social welfare aspects would go a long way towards these ends (Rachuri et al., 2009). Further complicating matters is the fact that environmental metrics are plentiful, but there is difficulty in determining which to use when and how to measure them. Addressing this pressing need will help engrain sustainable concepts into the public and economic systems pervasive in society (Hervani et al., 2005).

2.5.2 Overcoming Barriers and Implementation

Based on the merits and multitude of possible benefits associated with sustainable initiatives and improvements, it would logically follow that companies would be aggressively pursuing and implementing policies to these ends. As discussed, however, while it is easy to envision how a desired metric should look and function, it is much harder to implement one – not to mention the multiple metrics required for true improvements (Jin and High, 2004). Typically, corporations are over reliant on financial and performance factors that are tied into long run strategic goals and performance measures. To address these issues, the benefits of implementing environmentally sound practices – with regards to economics, customer satisfaction, and corporate environmental responsibility – must be stressed and tied into long term goals and plans.

The intangible benefits of improving environmental relations must be stressed to management. Without input and buy in from upper echelon decision makers, the trickle-down effect to facilitate change and improvements throughout the company is unlikely to occur. To help avoid unnecessary tracking and measurements, the metrics devised and developed must be limited in number and tailored to company needs. Such precautions will help sustainable ideas gain acceptance by reducing non-value added steps which might otherwise evoke negative responses from employees and management alike (Sarkis, 1999).

Different corporate environments affect which sustainability practices and implementations will work the best (Sarkis, 1998). In some corporations, the environment and culture might be such that it is reasonable to set outrageous environmental goals and use them as a springboard for new ideas. However, this concept will not work in the majority of companies (Fuller and Ottman, 2004). On the whole, sharing and presenting ideas to improve sustainability should be done much in the same manner as presenting any other business improvement or capital expense (Sarkis, 1998). With this in mind, it is important to clearly lay out the costs and timeline for proposed improvements as well as the reasoning and benefits of each (Jin and High, 2004). Additionally, providing management with alternative solutions or gathering their input and feedback through ranking systems will help evoke buy-in and result in greater levels of support. For this purpose, metrics should be diversified and partitioned according to usage and relevance. “It is difficult to tell which metric is actually better if assessors do not know how many options they could have or if they barely understand the difference between alternatives” (Jin and High, 2004, pg. 295).

Once approved, it is essential that metrics are clearly defined and quantified so that the analysis of preset goals can be made to see if and when they are fulfilled. If met at an allowable cost and schedule, such steps will likely spur additional, future improvements and approvals (Mosovsky et al., 2000). Environmental improvements require knowledge about products, processes, material characteristics, and technological improvements (Hervani et al., 2005). With this in mind, it is essential that complete buy in and informational sharing occurs within the company, eliminating informational silos and disconnects (Rachuri et al., 1999). The actual benefits and tracking systems should be highlighted to show management the enhancements – with regards to both the environment and the bottom line – that resulted from changes (Jin and High, 2004).

Stressing the side effects or indirect consequences of implementing sustainable ideologies is also important to gaining acceptance and implementation. Highlighting improvements in waste reduction, efficiency of processes, and supplier quality can make sustainable initiatives something more than an environmental movement. "What might seem like an expensive and laborious research process [to improve sustainability] will likely solve multiple problems and to contribute to a higher-quality product that was ultimately more economical" (McDonough and Braungart, 2002, pg. 108). In this way, highlighting the improvements in productivity for existing systems as a result of sustainable, eco-friendly initiatives is helpful to creating buy in (Mosovsky et al., 2000).

Proactive steps to anticipate regulatory requirements and legislation through forward thinking with regards to sustainability are also key steps for those looking to implement sustainability ideologies in their companies. It is argued that regulations and environmental efficiency requirements forced upon companies do not facilitate creativity and problem solving, but rather, they result in compliance and workarounds. Companies working proactively in the greenness of their products should be identified and lauded (Hervani et al., 2005). Apart from the economic and consumer benefits that come with being an industry leader on environmental issues, such steps would limit or "[eliminate] the need for regulation, something that any businessperson will appreciate as extremely valuable" (McDonough and Braungart, 2002, pg. 109).

When devising and implementing a framework for sustainability and environmental improvement a systems approach should be used, taking into account processes and practices from raw material selection and procurement up through the end of a product's life cycle. Such an approach captures and formalizes descriptions of processes and interactions (Rachuri et al., 2009). "Sustainability calls for the integrated assessment of all the variables and processes that are involved" (Jin and High, 2004, pg. 298). Interactions at various levels between suppliers, manufacturers, distributors, and customers must be considered with regards to economic, ecological, and society issues and concerns. One of these areas cannot be examined completely independently because of interactions between them (Rachuri et al., 1999).

On the whole, implementing sustainable concepts requires all aspects of production and distribution. Improving manufacturing processes to limit scrap and waste, selecting reusable packaging to improve logistics, and controlling product flow to eliminate excessive handling all improve process efficiency while working towards sustainable goals (Franchetti et al., 2009). Unfortunately, when dealing with supply chains, the involvement of global players spanning multiple time zones as well as complications such as varying systems of measure and vaguely defined boundaries of responsibility cause problems (Hervani et al., 2005). Businesses can affect their environmental impacts by altering their supply chains and purchasing decisions, but companies cannot be held responsible for distant suppliers (Matthews et al., 2008).

Within the supply chain, selecting third-party suppliers sharing common environmental goals and optimizing route selection for decreased emissions and fuel economy maximization can have great effects. As discussed in section 2.1.2, the supply chain can account for a quarter of total manufacturing costs and upwards of 75% of emissions (Reich-Weiser and Dornfeld, 2009). Identifying where greenhouse gas emissions occur throughout supply chains can also allow for insights and management to reduce risk and environmental vulnerabilities. Taking steps such as limiting transport distance between suppliers and manufacturing facilities or constructing manufacturing facilities near distribution centers and customer bases can drastically reduce greenhouse gas emissions – at all tiers throughout a corporation and its supply network (Reich-Weiser and Dornfeld, 2009). Small improvements add up significantly with percentages such as those. Since carbon emissions have the same planetary effect no matter where they occur, they can be traded across the supply chain, slightly increasing emissions in one area in exchange for drastic decreases elsewhere. It must be noted, however, that a tradeoff in emissions should not be made without consideration to other aspects of environmental and economic effects of such an action. For example, electricity requirements, security risks, reliability, technology, and flexibility must be made with regards to manufacturing and distribution changes (Reich-Weiser and Dornfeld, 2009). Additional techniques, such as implementing operations research and quality engineering practices to reduce rework and defective product levels can also save money and improve efficiency and sustainability (Franchetti et al., 2009).

With regards to selection of individual indicators and indices, companies must identify their needs and goals in order to properly select and implement accurate measurement systems. Metrics are proper as long as they meet users' specific requirements, align with regulatory policy (if applicable), and are derived on a scientifically valid basis (Jin and High, 2004). "Sometimes predefined goals have to be compromised based on [metric] availability," but for the most part, metrics can be identified and implemented to meet basic needs (Jin and High, 2004, pg. 299). In the past, metrics have evolved in response to end-of pipe and regulatory requirements. In the future, companies should set environmental goals – which will likely be compliant with all previous requirements – that will be used to identify metrics of interest. This includes identifying the differences between pollutants and their environmental impacts as well as capture and trending data over a long period of time to assess causes and effects of environmental damages as well as the effectiveness of environmental improvements (Jin and High, 2004). "The task of scientific and technological professionals is to provide as much information as possible on which ultimate decision can be made that satisfy societal and economic interests of corporations and even of society at large" (Sikdar, 2007, pg. 173).

Simple solutions exist to begin implementing sustainable practices through the assignment of metrics and indicators, identifying areas for improvement. As early as the year 2000, the Environmental Protection Agency published a guide titled The Lean and Green Supply Chain to demonstrate opportunities for improving both financial and environmental performance (Kainuma and Tawara, 2006). Similarly, companies are encouraged to implement extensive vendor selection and performance evaluation processes and suppliers are asked to go beyond environmental compliance requirements from their customers in the attempt to proactively improve their sustainability (Kainuma and Tawara, 2006). In this way, suppliers must be classified and evaluated not only with regards to traditional factors such as timeliness and reliability, but also environmental characteristics (Hervani et al., 2005).

As previously discussed, a new or existing product's design or redesign phase is an extremely important period for implementing sustainable concepts and ideas. Environmental considerations are mainly viewed as requirements which generate additional design constraints and costs for products. This belief is further exasperated by the fact that environmental considerations are often implemented late in the design process when they are likely to increase development costs (Kaebernick et al., 2003). As upwards of 70% of product and production costs are accounted for or determined in the design phase, it is extremely important to consider factors such as natural resources, material selection, energy efficiency, and options for modular assembly (Lin et al., 2009). Knowing this, information about the environmental impact and costs of a product must be available at early design stages – from the availability of raw materials from sustainable suppliers, to the possibility for recycling or reuse of components (Rachuri et al., 1999). Appropriate organizational structures must be in place to enact environmental innovation, resulting in the production of less waste, the consumption of fewer resources, and the creation of less environmental harm (Hervani et al., 2005). Based on the ideas and concepts implemented in design and production, steps must then be taken to assure that customers or end users are aware of how to properly dispose of or reclaim a product at the end of its life cycle (Rachuri et al., 1999). Simply identifying ways in which products can be used together or for multiple purposes can also help reduce waste and improve sustainability (Fuller and Ottman, 2004).

Through collaboration as well as industry coalitions and environmental groups, it can be assured that sets of metrics, indicators, and indices can be developed to benefit entire industries and corporations without divulging sensitive business information (Mosovsky et al., 2000). Faults identified in older frameworks include elements of data collection without aggregated or interpreted results created from data (Rachuri et al., 1999). Collaboration and research can help ensure that limited resources for environmental improvement are used to their fullest extents and increase competition and progress (Mosovsky et al., 2000). The integration of standards between various domains and across industries as well as the development of informational models for quantitatively using data to evaluate the environmental impact of products and processes would go a long way towards these ends (Rachuri et al., 2009).

2.6 Summary and Research Goals

Throughout this chapter as well as the introduction, the basic concept and ideals associated with environmental sustainability have been introduced and examined in detail. As discussed, the term sustainability has a number of meanings and can be applied in different industries in a variety of forms. This research aims to investigate sustainability at a high level, from a perspective inclusive of product design, raw materials procurement, manufacturing processes, distribution and supply chain networks, and product usage considerations. Without analyzing a product's entire life cycle, it is impossible to develop a comprehensive picture of that product's true environmental impact. With all of these ideals in mind, the goal of this research, moving forward, is to uncover a number of pre-existing sustainability metrics, spanning all elements of a product's life cycle. These metrics will be included in a matrix which will be categorized and analyzed with regards to the usefulness, feasibility, and value of all included metrics. Through communications with corporate representatives, the metrics presented will be evaluated, leading to an overarching set of sustainability metrics to be recommended to industry.

Chapter 3

Methodology

3.1 Overview of Metric Matrix Creation

With the growing importance of sustainable ideologies comes a growing importance of metrics through which to measure the input and output of manufacturing and distribution processes. As discussed throughout the introduction and literature review above, without a compact set of metrics that are relatively easy for those in industry to understand and implement, it is unlikely that goals regarding sustainable progress will be met in the near future. The structure of this research aims to pool existing metrics and ideologies so that they may be narrowed down to develop a comprehensive set of metrics. This comprehensive metrics set can then be suggested or recommended to corporations for implementation in concept selection as well as the design, manufacturing, distribution, usage, and disposal stages that comprise a product's life cycle. This section of the methodology will discuss the proposed and actual steps for creating a matrix of sustainability metrics. Steps to be discussed include collecting and researching various metrics as well of the process for narrowing down the findings to a discrete, but comprehensive list. Furthermore, the process of supplementing written and qualitative descriptions of metrics with quantifiable formulas or definitions will be included. This section is meant to provide a high level overview of the details provided in section 4.1 below. To aide in understanding the methodology used in this work, Figure 3-1 includes a detailed flow diagram to provide a step-by-step look at the major elements of this research. This diagram begins with the research's origins and literature review and concludes with the final recommendation of sustainability metrics for use in industry.

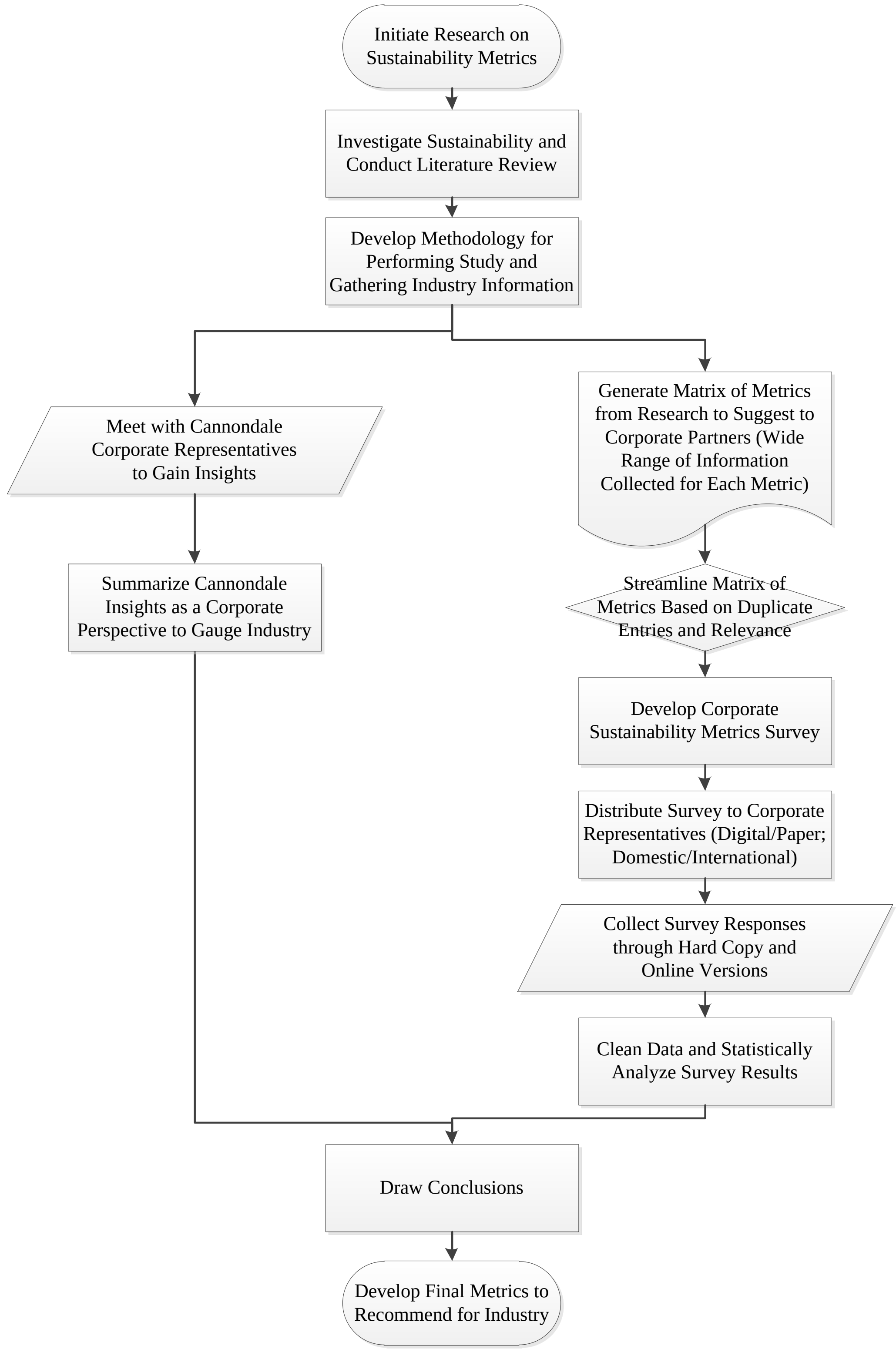

Figure 3-1: Detailed flow diagram showing the step-by-step approach used in this research to generate a comprehensive set of metrics for industry usage.

In order to facilitate the development of the desired, comprehensive set of metrics, a variety of resources will be dissected – from journal papers to books and other published works – to gather a set of indices and indicators to analyze. As these papers and other works are read, all measured input and output metrics with regards to production and distribution processes will be recorded. In this manner, a comprehensive list of various techniques for recording dimensional data regarding environmental impact measurements, production specifications, raw material usage, and energy efficiency will be gathered. For each of these metrics, a variety of fields will be populated in a matrix of sustainability metrics. These fields, as shown in Table 3-1, include a name describing the metric, specification of whether the metric is an indicator or an index, and a brief explanation of the metric's purpose. Other forms of classification, such as if the metric refers to input or output of a manufacturing or distribution process as well as the life cycle category most closely associated with that metric are included. Additionally, if the metric is derived from a computational formula, the formula is included with a brief description of any included terms or values. Basic identification information such as the source in which the reference was found, an identification number for the specific reference, and the name of the researcher reviewing the source where the metric was discovered are also included for each metric. Furthermore, it is noted if one metric was discovered in multiple sources. The advantages and disadvantages of each metric are included for future evaluation and a level of complexity is assigned to each metric.

Table 3-1: Components included in matrix of metrics

Column	Component
A	Metric Identification Number
B	Reviewer Identification
C	Indicator or Index Declaration
D	Metric Name
E	Brief Explanation
F	Data Gathering Technique
G	Product Life Cycle Category
H	Production Input/Output
I	Formula
J	Formula Terms
K	Indicators Included (Index)
L	Complexity
M	Advantages/Disadvantages
N	Publication Reference Source
O	Additional Publication References

The level of complexity is an important element of the metric matrix. Ranging from one to seven, the complexity level categorizes the ease of implementing and understanding the given metric. A complexity of one relates to an indicator with a value which can be read directly off of a gauge, from production, distribution, etc. Complexity levels two through four represent indicators composed of formulas with varying numbers of terms. Finally, the most complex metrics, ranging from five to seven complexity levels, encompass indices composed of varying numbers of indicators. As discussed in section 2.5.1 above, indices are measures composed of a number of indicators, making them much more complex to gather information for and work with.

One obstacle that is anticipated in this step of the data collection process is the fact that many published works simply reference the summary statistics regarding environmental, process, and production data. In other words, it is expected that many journals and books will not provide complete information regarding the formula, measurement technique, or collection methods used to measure and quantify all metrics of interest. With this in mind, researchers will use context clues and their knowledge of environmental sustainability, gained through prior research, to infer a quantitative, formulated value for each metric. Complexity and other information, such as life cycle period and advantages/disadvantages will be determined based on the context in which they are found as well as analysis and inference. In order to further validate the metrics collected and to ensure the reliability of subjective categorization, a number of researchers will be reviewing all pieces of interest and verifying the findings of one another's work. This will help guarantee that assumptions and inferences are accurate and that all possible metrics are uncovered. As stated in Jin and High's work, over 700 metrics are in existence today, so this analysis to uncover as many as possible from a selected set of text represents a comprehensive task (2004).

In the next step of this research process, the metric matrix will be vetted and a consistent set of variables and formulas will be applied. For each indicator or index listed, a unique formula had been created or recorded from the original source in which it was found. For ease of understanding, these formulas will all be analyzed. Common terms will be assigned universal variables to be used throughout the metric matrix. This step will help to reduce or eliminate confusion associated with variables. Without this step of uniformity, variables appearing in formulas may be assigned different meanings throughout the entire matrix if left in their original states. Furthermore, through the refinement of formulas and the definition of a universal set of variables, metrics with similar meanings or purposes can be combined or eliminated as duplicates. With a variety of reviewers collecting data for this research process, chances are that duplicate entries will appear throughout the matrix of metrics. With this in mind, the next step to be taken is to eliminate similar entries so that the matrix is as concise as possible, while keeping the integrity and wide range of data. Logically, it would follow that a comparison of formulas for similarities would serve as a good step for vetting the matrix of duplicate entries. It is also important to note that many formulas for indicators are likely to be subcomponents of larger formulas used for indices, assuming that the indicators are included in the index in question.

Following the work done with the formulas for each metric, the next step in the process of creating a comprehensive matrix of metrics is to organize the matrix into a logical order. This entails grouping the identified metrics into classifications of some sort. For this research, metrics were grouped based on their interaction with the environment. For example, metrics were grouped into categories such as energy-related metrics, water-related metrics, resource-related metrics, pollution/emission-related metrics, and so forth. The categories used are shown in Table 3-2.

Table 3-2: Categories for classifying metrics

Classification	Description
Energy	Includes metrics to measure input energy for processes of manufacturing and distributing products; also includes ratios of renewable and recyclable energy used
Water	Includes metrics to measure the amount of water used, recycled, and wasted in production as well as water quality measures
Resources	A broad category including measures of land, facility, and raw material usage; also factors such as transport distance for raw materials, efficient use of materials, and recycled material used
Pollution	Measures of the amount of solid, airborne, and chemical wastes generated as a byproduct of manufacturing and transportation
Environment	Factors to measure environmental byproducts of industrial activities, including smog, greenhouse gases, carbon intensity, ozone depletion, and pollution plume dispersion
Technique/Process	Implementation of practices and policies that limit environmental damage, including regulatory compliance, lean standards, and product life cycle assessment capabilities

Identifying these categories helped to refine the scope of the study and allowed further vetting of similar or duplicate metrics from the matrix. After this final vetting, the metrics within each category formed comprehensive, cohesive sets of indicators and indices. These sets helped provide a basic structure that corporate personnel could easily sort through to find metrics suiting their needs in specific functional roles. These sets of metrics were presented to company representatives, as discussed in section 3.2 below, in order to determine the feasibility of implementation and the usefulness to business and environmental objectives of each metric. In this way, the best metrics for corporations to use in measuring and analyzing their environmental impacts and overall sustainability can be identified.

3.2 Overview of Corporate Survey on Sustainability Metrics

After conducting the necessary background research regarding sustainability and the development of a standard system of metrics, input from industry will be required in order to develop a strong understanding as to prevailing trends and beliefs in industry. As the end goal of this research is the adoption and implementation of an overarching sustainability index within industry, including the viewpoints and perceptions of individuals with backgrounds and experiences in manufacturing and distribution is essential for success. A variety of proposed methods for gaining these insights will be investigated, from site visits and discussions with corporate representatives to widely distributed surveys. On the surface, there appears to be benefits and drawbacks of using both methods. For example, a survey would allow for easy distribution and collection of data from a wide variety of individuals and companies, possibly domestically and abroad. Site visits and personal discussions, however, would allow for more in depth feedback and understanding of the needs and concerns of corporations as they relate to sustainability measurement and metrics. With these factors in mind, both approaches will be taken to varying extents in order to collect necessary and adequate feedback and responses. The online survey will be the primary method for data collection, but some feedback will be gathered through a limited number of site visits to Cannondale Bicycles, Inc. – mainly performed in the spring of 2010.

In order to develop a strong working knowledge and understanding of the concerns and environmental awareness of a strong corporation, a relationship with representatives from the Cannondale Bicycles, Inc. production facility in Bedford, PA will be cultivated. Located approximately one hour from the Pennsylvania State University, Cannondale operates as an industry leader in the design and production of high quality road, full-suspension off-road, and specialty bicycles. Focusing on performance, innovation, and superior products, this company will likely be able to provide a great deal of in depth information with regards to their knowledge of sustainable ideologies as well as their thoughts on current practice and future implementation. A preliminary visit was made on November 5, 2009 where members of the research team were able to meet with company representatives, share ideas regarding sustainability and our research, and tour the factory facilities. Following this introduction, additional site visits as well as teleconferences and other correspondences will be made with corporate representatives to discuss the topics of interest. The findings of this research and analysis will be generalized so that they are not only relevant to a specific industry, but can be applied in a variety of different applications for any company designing and manufacturing products in order to improve supply chain operations and process integrity with regards to sustainability.

In addition to partnering with Cannondale to develop a strong interpersonal relationship through which information and opinions can be obtained, it has been decided that an extensive, detailed survey will be created and distributed in order to gather data and input from a wider range of industries, individuals, and geographic locations. Both the paper and digital copies of the survey will be identical, containing basic information about the completing parties, such as their positions within their companies and years of experience. Additionally, to form a basis for their responses, their pre-existing knowledge of sustainable concepts will be recorded with regards to a variety of current sustainable ideologies and regulatory factors. This survey will be distributed through a variety of channels, including corporations holding pre-existing partnerships with members of the research team and the Pennsylvania State University. One large pool of possible participants will be the companies participating in The College of Engineering's Spring 2010 Capstone Design program. These companies have all illustrated a vested interest in Penn State engineering students and their representatives will likely be willing to complete a survey to discuss their personal experiences and beliefs regarding sustainability and its effects on manufacturing and supply chain processes. Additionally, other universities internationally that have formed partnerships with the Pennsylvania State University in the past will be contacted and asked to distribute the survey to a number of their corporate contacts. This set of universities includes institutions throughout the United States as well as in Canada, France, Turkey, China, Taiwan, and Jordan and will thus be able to gather a wide range of internationally relevant data.

In addition to basic data regarding their companies, participants will be asked to gauge the current use, feasibility, value, and future implementation of all of the sustainability metrics identified and included in the matrix of metrics generated as described in section 3.1. Through these current use questions, responses will help to identify which metrics are currently used in industry around the world in various geographies. Looking towards the development of a sustainability index, the feasibility, or ease of implementation, for including the suggested metrics will also be gathered. This is important because it is unlikely that the results of this research will be adopted if metrics are suggested which do not allow for easy implementation in industry – be it due to the expense of measurement equipment, the lack of technology to truly determine the value of a given metric, or similar complications. Additionally, knowing the perceived value from a corporate perspective of being able to measure and analyze the results of the suggested metrics will be determined. This will help to identify those relevant metrics that could significantly improve the environmental performance of industry on the whole. When combined with the feasibility of implementing these high value metrics, a great understanding of those metrics which should be recommended for implementation can be identified. Lastly, participants will be asked about the likelihood of future implementation for the metrics suggested from the matrix in this research. Asking this question will help bridge the gap between earlier responses through a comparison of metrics that were identified as feasible and value-adding against those which are likely to be implemented. Understanding the likelihood of future implementation also illustrates the beliefs of the participating corporate representatives with regards to their companies' willingness to enact environmentally sound practices and measurement techniques in the near future.

In addition to these pre-set questions, participants will also be asked for their input regarding additional metrics that should be considered. This will help gauge the level of accuracy in data collection and generation of the original matrix of metrics. Obviously, if a large number of unanalyzed metrics are suggested for inclusion, the matrix of metrics will need to be reexamined and possibly altered or updated accordingly.

For identification purposes and to understand the applicability of the results of this survey, the individual completing the survey will also have the option to include information about their company, including the company name, its main industry of focus, its geographic location, its major market regions, and its size – with regards to both the number of employees and total revenue, in U.S. dollars.

After all survey results are collected, both from hard copies as well as digital sources, a variety of methods will be used to statistically analyze the information received. Focusing on those metrics identified as having high values and feasibility levels, a comprehensive analysis will be conducted to generate a set of suggested metrics. Care will be taken to assure that the final set of metrics includes elements relating to the raw material selection, manufacturing, supply chain, and end-of-life aspects of a product's development and life cycle. Additionally, metrics will be selected from all six categories in the matrix of metrics: energy, water, resources, pollution, environment, and technology/process. This will ensure that the metrics selected provide, as close as possible, a complete picture of environmental sustainability in all aspects of production and distribution. The resulting set of sustainability metrics will then be shared with the corporate partners who indicated their interest through their survey responses, as well as Cannondale Bicycles, Inc.

3.3 Overview of Statistical Procedures Used to Analyze Survey Results

This research will analyze the survey responses through a variety of statistical methods. This section explains these statistical methods as well as the data manipulation required to implement these techniques. The first step will be to export all data from the online survey in order to vet and sort the raw information in Microsoft Excel. Data will then be manipulated using the software program R in order to create a structure that is easily read and used by Minitab. Using Minitab, box plots will be created to gain a better understanding of the data and to observe apparent differences in responses. After these initial observations, two types of analysis of variance (ANOVA) tests will be performed in order to determine which metrics are considered to be statistically significant and by survey respondents. The first, more robust ANOVA test uses Tukey simultaneous comparison tests to account for the difference between the six pre-determined metric groups as well as the difference between metrics within each of these groups. The second ANOVA test also uses a Tukey test, but only compares the differences between metrics in the same group. This type of test does not account for the possibility that metrics were incorrectly assigned when developing the six original, baseline metric groups. Furthermore, both ANOVA tests will be performed using each of the four individual response categories per metric – current usage level, value added, feasibility, and likelihood for future implementation – as well as using the overall average from these four response categories. Each step throughout the process of the statistical analysis will be discussed in detail below.

3.3.1 Initial Data Manipulation and Vetting

Based upon closing the survey collection process online, all survey results will be exported to Microsoft Excel. Using this program's basic data manipulation functions, the resulting data set will be vetted in order to eliminate incomplete or extraneous data sets. Due to the length of the survey, many respondents will likely begin the survey without completing it, resulting in partial data sets that are of little use for data analysis. Missing information concerning the respondent's background experiences or company will not affect the outcome of the survey analysis and will not result in deletion. Incomplete data with regards to the respondent's viewpoints on the current usage level, value added, feasibility or practicality, and likelihood for future implementation of any of the 55 metrics under consideration would have serious implications in the statistical analysis to be performed. With this in mind, vetting will begin with the elimination of all responses which are incomplete in these critical areas.

$$X = \frac{X_{Current\ Use} + X_{Value\ Added} + X_{Practicality} + X_{Suggested\ for\ Future}}{4} \qquad \text{Equation 3-1}$$

After all initial deletions, the results will then be broken down into various worksheets to group those responses related to each of the six metric categories: energy, water, resources, pollution, environment, and techniques/processes. The same sorting and manipulation will be performed on each subset of the data. This manipulation includes determining the average response level, on a scale of one to five, for each respondent, for each metric using Equation 3-1. This average will represent a given respondent's overall evaluation of the feasibility, value added, likelihood for future implementation, and current usage level for the metric in question. Statistical tests will be conducted to generate comparisons among all metrics and recommend which metrics to incorporate into a sustainability index using both the overall average of all four response topics, as well as each of the four response topics individually. With this in mind, all of the response values for each metric will be saved in separate worksheets for each of the four response categories as well as a fifth worksheet for the overall average from all response categories for each respondent, for each metric. This will result in five worksheets, each composed of the 55 metrics and the average responses across all four response categories for each respondent.

3.3.2 Data Adjustment with R for Use in Minitab

The next step towards statistically analyzing the data includes using the statistical software program R to transform the data from Microsoft Excel in an appropriate way for further analysis. In order to obtain a data set which is both easy to read and manipulate, R is employed due to hindrances in Microsoft Excel and Minitab. The code included in Figure 3-2 is used to take the manipulated response values from previous steps out of Microsoft Excel and transform them into a usable comma separated values format in a Minitab friendly structure. The resulting output file includes four columns for the following: (1) respondent number (company or individual), (2) response value, (3) metric of interest, and (4) metric category as shown in Figure 3-3. One such file will be generated for each of the four response categories, as well as the overall average of all response categories for each respondent. After these steps, data will be in a format that can be copied and pasted into Minitab for analysis.

```
data.metrics = read.table("metrics_data.csv", sep=',', header = F)
metrics = as.matrix(data.metrics)
metdat = metrics[-1,-1]
metric.name = metrics[,-1][1,]
n = dim(metdat)[1]-1; m = dim(metdat)[2]

metric.new = matrix(1,nrow=n*m,ncol=4)
for (i in 1:n)
{
	l = 1+(i-1)*m
	r = i*m
	metric.new[l:r,1] = i
	metric.new[l:r,2] = metdat[i,]
	metric.new[l:r,3] = metric.name
	metric.new[l:r,4] = metdat[n+1,]
}

write.table(metric.new, file="metrics.csv", sep = ",", row.names = F, col.names = F)
```

Figure 3-2: R code to transform data for ANOVA testing in Minitab (Adopted from Zhong and Zhang, 2010)

	A	B	C	D	E
1	1	2.75	Eint	Energy	
2	1	3	EU	Energy	
3	1	3	EEI	Energy	
4	1	3	LCEInt	Energy	
5	1	3	EUNR	Energy	
6	1	2.5	TEInt	Energy	
7	1	1.75	CWI	Water	
8	1	1.75	EUT	Water	
9	1	1.75	WDI	Water	
10	1	1.75	WP	Water	
11	1	1.75	WQ	Water	
12	1	1.75	WU	Water	
13	1	1.75	Wint	Water	
14	1	2.25	Futil	Resources	
15	1	3.75	IP	Resources	
16	1	2.75	LU	Resources	

Figure 3-3: Screenshot of sample transformed data for use in Minitab

3.3.3 Initial Data Analysis and Exploration in Minitab

In order to evaluate the data initially, before any ANOVA tests are conducted, box plots will be generated using Minitab. Through observing the range, mean, and any outliers for each metric and lining up all box plots side by side, initial conclusions can be drawn regarding the comparison of all metrics with one another. A sample of such box plots is included in Figure 3-4. This can give an early indication about which metrics will be the highest rated, both within and between the six pre-specified metric groups.

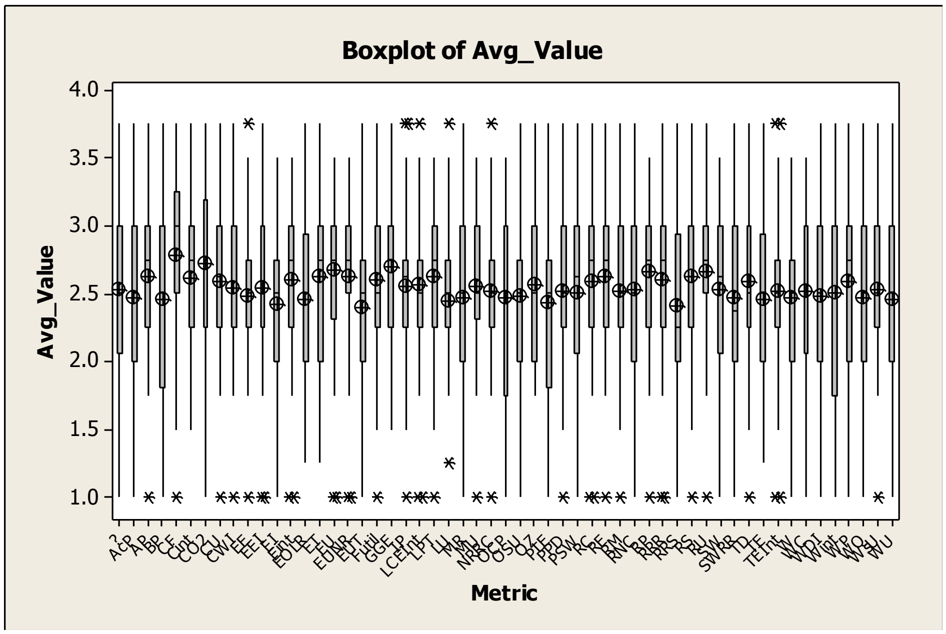

Figure 3-4: Screenshot of sample box plots for the average value across all four response categories for metrics of interest

3.3.4 Repeated Measures Analysis of Variance (ANOVA)

Analysis of variance testing is a statistical test to determine whether or not the mean of several groups are all equal. In this way, analysis of variance testing generalizes t-testing to more than two groups, but in a manner such to limit the chance of performing a type I error – where the null hypothesis is rejected when it is actually true (Zhong and Zhang, 2010). Repeated measures analysis of variance testing, as proposed for this research, uses the Tukey simultaneous comparison test. This test takes into account both the difference between metrics in each of the six pre-specified groups as well as the difference between each of these metric groups. In order to perform this test, Minitab is used to set response and explanatory variables. The response variable is the value of the response category of interest, be it the average of all responses for a given metric and observation, or a single response for a metric and observation. The explanatory variables, attempting to predict the value of the response variable, are the metric of interest as well as the group to which it is classified. Through the step-by-step procedures laid out in Minitab, a comparison can then be made for each metric to all other metrics both within and between groups. The setup in Minitab for this procedure is shown in Figure 3-5. Additionally, a four in one residual plot is generated – such as the one shown in Figure 3-6 – to verify that the data analyzed is normal and independently distributed, validating the assumptions for analysis of variance testing (Zhong and Zhang, 2010).

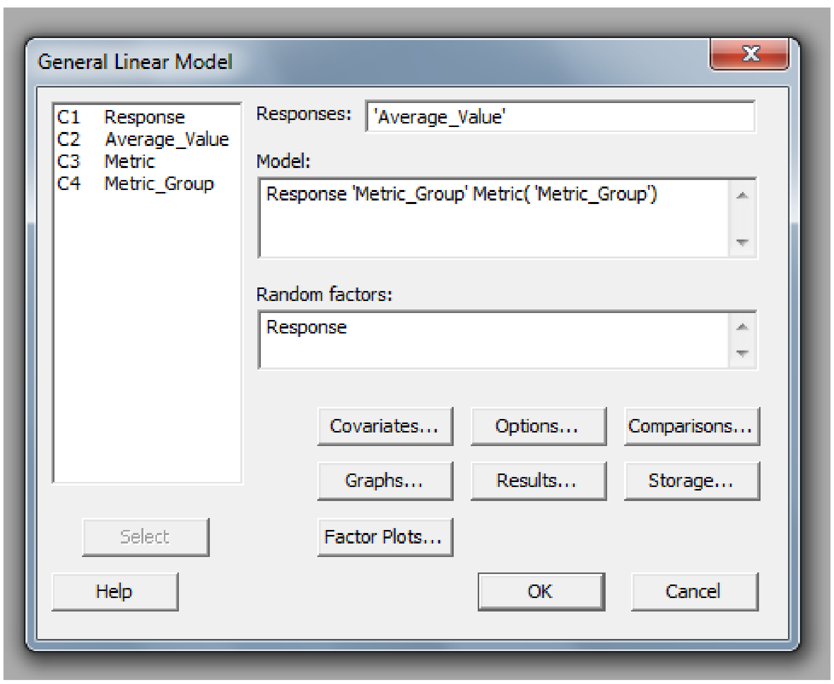

Figure 3-5: Screenshot for repeated measures ANOVA testing input in Minitab

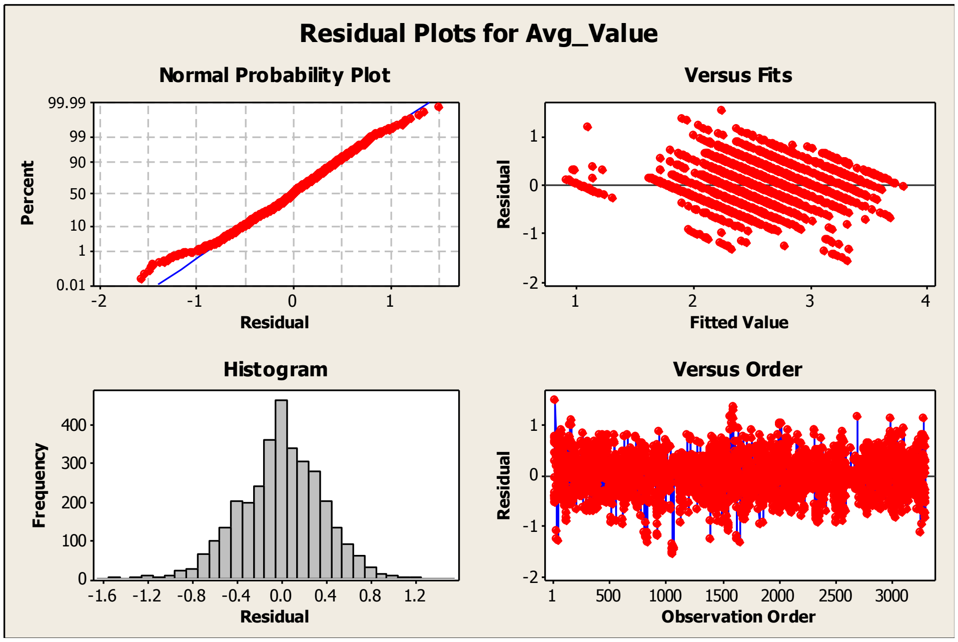

Figure 3-6: Screenshot of a sample four in one residual plot for ANOVA testing, illustrating normality and independence as required

3.3.5 One Way Analysis of Variance (ANOVA)

In addition to repeated measures analysis of variance testing, one way analysis of variance testing will also be performed. The procedure for conducting such a test is similar in nature to the repeated measures analysis of variance, except that instead of taking into account the difference between metrics within and between each of the six pre-specified metric groups, one way analysis of variance only takes into account the difference within each pre-specified metric group. For this reason, this testing procedure is somewhat dependent on the accurate classification of the metrics into groups during the earlier parts of this research. The output from this analysis of variance test will be similar to that from the previous test, except that it will be limited to comparing within groups. As explained in section 3.3.4 for the repeated measures analysis of variance test, the procedures in Minitab for this procedure are easy to implement. The required commands are included in Figure 3-7. Additionally, the four in one residual plots to test for independence and normality will also be produced as shown in Figure 3-6 (Zhong and Zhang, 2010).

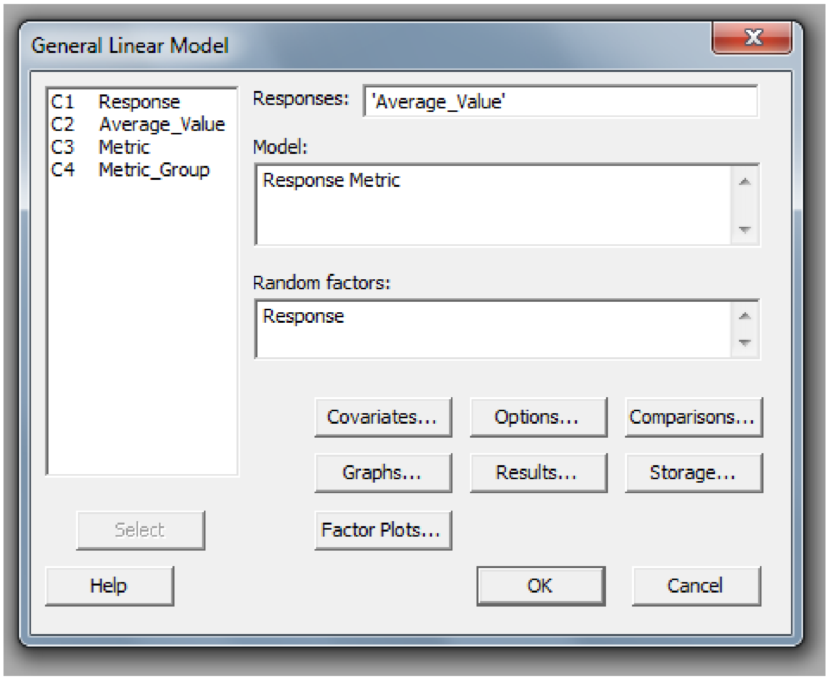

Figure 3-7: Screenshot for one way ANOVA testing input in Minitab

3.3.6 Summary of Statistical Procedures

Upon completion of both analysis of variance tests, the resulting p-values will be compared to specified alpha values in order to narrow down the original 55 metrics to smaller suggested sets for implementation. Based on initial and test observations, the repeated measures analysis of variance will likely not eliminate a great deal of metrics due to minor differences between the response values for metrics when compared to overall averages, across all pre-specified metric groups. This likely occurrence will lead to a suggested set of metrics which is similar in size to the original set of 55 metrics. The one way analysis of variance test, however, is likely to result in a more diverse set of p-values and thus the rejection of a greater number of metrics. By only comparing metrics within the six pre-specified sets, differences are likely to be more apparent, resulting in the recommendation of fewer metrics, likely within the suggested range of 30-40.

Through these methods, two suggested sets of metrics – one limited set and one more extensive set – will be identified based on each of the four response categories, practicality, current usage, suggested for future use, and value-added. Subsequently, two overall suggested sets of metrics will also be developed based on the average values from each respondent across all four response categories. These sets will be analyzed further in the results and conclusions sections.

Chapter 4

Results and Discussion

4.1 Creation of a Metric Matrix

Since the end goal of this work is to develop a set of suggested metrics for use in industry, the review and compilation of existing metrics represents a vital step in the research process. With this in mind, a great deal of work went into the generation of a matrix of metrics, as described in the methodology above. Throughout the process of studying existing works and developing a literature review, some specific journal articles, books, and other pieces were identified as useful sources for obtaining the basis for metrics to be included. Approximately 40 sources were read and analyzed for possible metrics. Of these sources, the majority were published since the year 2005, while a select few earlier works came from the 1990s. By focusing primarily on recent work, it could be ensured that this research touches current topics and eliminates metrics which have been supplemented with newer measurements or practices in academia and industry.

While reading each source, attention was given specifically to quantified or descriptive metrics. For example, while reading the piece “Framework for Sustainability Metrics” by Martins et al., energy consumption and energy intensity were discussed as quantifiable ways with which companies in chemical industries can assess their process improvements and environmental sustainability. Energy intensity was defined as “the amount of energy used in making a mass unit of a product” and energy consumption was defined as “the total energy consumed in the production of a product” (Martins et al., 2007, pg. 2963). Throughout the review process for the resources studied, similar terms and definitions were found in works by

Rachuri et al. (2009), Gaughran et al. (2007), Naidu et al. (2008), and Wilson et al. (2007). Through all of the information gathered from these sources regarding these two terms, a row was generated for each term in the raw matrix of metrics. All of the original sources were identified for each term and key information was populated in the matrix. This information included the definitions of the individual terms, formulas and equations associated with the terms, and the benefits and drawbacks of each specific metric. For the energy intensity metric, for example, it was recorded that it was mainly focused in manufacturing applications and could be calculated as total energy usage divided by the quantity of units produced. It was also noted that the information required for this metric was easy to calculate and that one drawback of deploying this metrics in a large company would be difficult because of complications in quantifying which energy use was associated with the production of various product offerings.

Once all of the sources examined were studied and information was recorded in the raw matrix of metrics, each metric was analyzed. This analysis mainly focused on streamlining the data included for each metric to a manageable amount by consolidating information gathered from all of the sources in which a given metric was mentioned. Through this consolidation, the key points and components of each metric were highlighted and a quantitative formula and variables were established to mathematically describe the metric's measurement in an industrial setting. Referencing the example of energy intensity, the formula generated was EInt = EU / Q, including the variables EInt for energy intensity, EU for energy usage, and Q for the quantity of units produced. For simplicity, each variable was defined to have the same meaning throughout all formulas in the matrix. This avoided duplicate variables throughout the work and helped ensure a seamless understanding from metric to metric for anyone looking to analyze or apply the metrics and formulas. Whenever possible, metrics and accompanying information, formulas, and descriptions were mined from the resources studied. In some cases, this entailed recording formulas, while in others it meant that formula had to be written based upon a qualitative description of a metric. In all cases where formulas were nonexistent or slightly differed for the same metric from source to source, accommodations were made so that the most appropriate quantification method was included in the matrix.

Table 4-1: Critical sources for metric identification, quantification, description, and formulation

Source Title	Authors	Year
Input-Output Models for the Analysis of a Local/Global Supply Chain	Albino et al.	2002
A Multiple Attribute Utility Theory Approach to Lean and Green Supply Chain Management	Kainuma and Tawara	2006
Sustainable Project Life Cycle Management: The Need to Integrate Life Cycles in the Manufacturing Sector	Labuschagne and Brent	2005
Sustainable Supply Chains: An Introduction	Linton et al.	2007
Framework for Sustainability Metrics	Martins et al.	2007
Creating Competitive Advantage Through Resource Productivity, Eco-Efficiency, and Sustainability in the Supply Chain	Mosovsky et al.	2000
Eco-Efficiency Indicators: Measuring Environmental Implications of Economic Performance	Nam	2008
Eco-Efficiency Indicators Workbook	National Round Table on the Environment and Economy	2007
Decision Support Frameworks and Metrics for Sustainable Development of Minerals and Metals	Petrie et al.	2007
Sustainable and Recycle-Reuse in Process Systems	Sikdar	2007
A Methodology to Incorporate Life Cycle Analysis and the Triple Bottom Line Mechanism for Sustainable Management of Industrial Enterprises	Wang and Lin	2004
Supply Chain Optimization of Continuous Process Industries with Sustainability Considerations	Zhou et al.	2000

While over 40 sources were analyzed and read to extract metrics of interest for this research, a number of these sources were not entirely useful. Some sources failed to include any formulas or metrics for measuring sustainable progress, focusing on the topic of sustainability from a wider, broader perspective. Other sources included metrics which were too specific and focused on one industry, one company, or even one production facility. After a thorough analysis of all of the sources, approximately 12 proved to be the critical set from which a majority of the information regarding the derived metrics was pulled. These critical sources are listed in Table 4-1. This is not to say that the other 28+ sources were unused. Many of the metrics pulled from the 12 critical sources were repeated in the other references, further emphasizing their importance for inclusion in the matrix. Additionally, it is important to note that no entirely new metrics were generated from this research. Rather, this study aimed to gather, quantify, and analyze a large portion of the vast set of existing metrics for possible inclusion in the suggested set of metrics.

Once all information was entered into the raw matrix, work began to streamline the resulting entries into a more selective and limited set. The first major step in completing this work was to consolidate similar metrics. For example, those metrics pertaining to the amount of recycled materials used in production processes and the amount of reused materials in production processes were combined into one metric – Recycle/Reuse Rate (RRR). This single metric combined what had previously been multiple metrics, while keeping the integrity of what each unique metric aimed to measure and quantify. Additionally, a handful of metrics were dismissed due to a lack of information or definition. While a good deal of information was available in the sources for the majority of the metrics discovered, some such as noise pollution and smog formation were listed as possible metrics, but were vaguely defined with regards to formulas, descriptions, or measures that could be implemented. These metrics were tabled both to slim the data set and to allow for a more comprehensive understanding all included metrics.

After these two steps, the matrix still included over 70 entries – far too many to suggest for implementation in industry and also an excessive number to present to corporate representatives for analysis and feedback. With this in mind, the list of metrics was pared further based on applicability and relevance to this research and sustainability. A number of the metrics uncovered and included in the raw matrix dealt with the evaluation of manufacturing processes and supply chains from an economic and operational standpoint. While these metrics would be very useful in creating a big picture view of a company's production and distribution processes on the whole, they do not directly contribute to measuring sustainable or environmental progress. As discussed in sections 2.1.2 and 2.5.2, a majority of companies focus a great deal of their decision making on economic and monetary information; however, these factors do not apply directly to this research. Through this step, metrics such as supply chain return on assets and out of stock ratio were eliminated. Finally, once the matrix had been trimmed down to a manageable size, the final suggested metrics were grouped into classification areas to allow for easier reference and evaluation. This allows assessors to focus on one type of metric at a time – those dealing with energy, pollution, etc. – when considering the metrics presented.

The resulting matrix of metrics includes 55 distinct metrics, classified in 6 areas as shown in Table 4-2. Please note that the majority of examples in this section revolved around the energy usage, energy intensity, and recycle/reuse rate metrics; however, the same basic processes and procedures were taken when analyzing and streamlining all other metrics included in the matrix. Classifications were generated based on distinctions provided in literature as well as a systematic sorting method utilized when determining the best logical and representative groups for associating similar metrics. Table 3-2 above describes brief descriptions of the 6 classifications used for grouping the selected metrics. Each classification includes between 6 and 16 metrics, sorted solely on the descriptive and formulated clues and suggestions in the pieces studied and analyzed for this work. Apart from some metrics which fell into gray areas, the majority of the classifications have firm boundaries. In other words, the energy classification deals purely with energy related metrics such as energy intensity, energy use, excess energy intensity, etc. The complete matrix of metrics is included in Appendix A, for reference.

Table 4-2: Metrics, by classification, included in matrix of metrics

Classification	Number	Metric	Abbreviation
Energy	6	Energy Intensity Energy Use Excess Energy Intensity Life Cycle Energy Intensity Non-Renewable Energy Use Transportation Energy Intensity	EInt EU EEI LCEInt EUNR TEInt
Water	7	Core Water Intensity Eutrophication Water Discharge Intensity Water Pollution Water Quality Water Usage Waste Water Intensity	CWI EUT WDI WP WQ WU WInt
Resources	16	Facility Utilization Import Percentage Land Use Material Use Mineral Reserves Used Non-Renewable Resource Consumption Rate Number of Chemicals Used Organic Solvent Usage Rate of Resource Savings Resource Consumption Resource Efficiency Environmental Impact Resource Productivity Resource Sustainability Resource Use Travel Distance	FUtil IP LU MU MR NRRC CU OSU RS RC RE EI RP RS RU TD
Pollution	12	Air Pollution Byproducts Produced Carbon Dioxide Emissions Chemicals in Waste Percent of Solid Waste Recycling/Reuse Rate Recyclability Rate for Metals Solid Waste Solid Waste Reuse Rate Transportation Emissions Per Unit Waste Generation Waste Utilization	AP BP CO2 WC PSW RRR RM SW SWRR TE W WsU
Environment	8	Acidification Potential Carbon Footprint Carbon Intensity Ecological Toxicity Greenhouse Gas Emission Ozone Depletion Photochemical Ozone Creation Potential Pollution Plume Dispersion	AcP CF CInt ET GGE OZ OCP PPD

Classification	Number	Metric	Abbreviation
Technique/Process	6	Value Ratio for a Firm Eco-efficiency End of Life Recovery Process Lean Production Techniques Product Life Extension Regulatory Non-Compliance	B EE EOLR LPT PLE RNC

Following the creation of the matrix of metrics, corporate representatives were interviewed regarding their knowledge of sustainability as well as their company's commitment towards improving environmental interactions. Furthermore, the completed matrix was presented to corporate representatives for analysis and evaluation. This allowed for further vetting and improvements in the metrics to be suggested to industry, as discussed below.

4.2 Analysis of Corporate Feedback

This research was well received, both by Cannondale Bicycles, Inc. as well as the corporate and university partners asked to participate in the survey on sustainability. Discussions with Cannondale representatives, as well as the survey responses provided a great deal of background and insight regarding sustainable practices in industry as well as the suggested metrics from this research. This section will discuss the findings from the collaboration with Cannondale Bicycles, Inc. and will review, in detail, the survey results collected from industry representatives between May and November 2010. In all, over 200 survey responses were collected.

As discussed in the methodology of section 3.2, multiple site visits were made to Cannondale Bicycles, Inc., a high-end manufacturer of bicycles. While this partnership provided limited data from a single corporation having a limited employment, revenue, and manufacturing base, a variety of insights were gained at a personal level. A full transcript of one interactive survey with two Cannondale representatives is included in Appendix B. One interesting finding was that when asked which metrics were most important to their business, both representatives responded that cost and quality were paramount, followed by delivery time. Sustainability and environmental consciousness were not mentioned and it was even noted that suppliers are rarely, if ever, evaluated with regards to their environmental impacts of transporting and manufacturing raw materials. When asked about the key metrics used to evaluate their supply chain, respondents mentioned accuracy of forecasts and lead times as well as cost. It was also discovered that much of the lack of analysis was due to the fact that a majority of the company's suppliers are overseas in Taiwan and Inland China. These suppliers provide low cost products though lead times and transportation distances are large. It was noted that local suppliers are mainly used for repair and maintenance purposes only.

Apart from their supply chain, however, it was discovered that Cannondale excelled in their efforts to reduce emissions and wastes in their own manufacturing and assembly processes. Whereas a score of 1 was assigned to green purchasing initiatives, Cannondale placed a 4 out of 5 rating on their green manufacturing, materials management, and reverse logistics efforts. These targets were achieved by using recycled products, providing annual reports for corporate recycling and waste emissions, and driving cost savings through these initiatives. Additionally, fluids are consistently filtered for reuse and all scrap metal is meticulously recycled.

One large challenge that was identified as an area of improvement in the bicycle industry, specifically, was the fact that Carbon Fiber bicycle frames – some of the latest lightweight technology for high-performance bicyclists – are not recyclable or re-moldable like traditional aluminum framed bicycles. Additionally, a challenge for Cannondale in their environmental improvement efforts is that the distributors of their products place a very low importance on environmental concerns, focusing solely on cost and quality. While many of those who ride and purchase bicycles are environmentally conscious, until the middlemen recognize and accept that they can keep consistent profits while improving environmental standards, nothing will change. These two areas, the lack of environmental interest by distributors as well as the lack of reuse potential in Carbon Fiber products, represent areas for improvement in the bicycle industry. Furthermore, it can be stated that these two concerns likely represent two common hindrances to environmental sustainability in all industries – lack of willingness to sacrifice profit for improved environmental qualities and the issues in recycling and reusing specialized, highly technical products. These in depth discussions were very informative in collecting the responses of individuals in industry as well as their general opinions and feelings regarding sustainable improvements and environmental concerns. The lessened regard for the effects of the supply chain on the environment, when compared to manufacturing, illustrates the findings discussed in chapter 2 that companies must expand their realm of responsibly in order to accurately account for their full environmental impacts.

Similar findings resulted from the sustainability survey. This survey, included in Appendix C, uncovered a great deal of information from industry representatives regarding their companies' perceptions about sustainability as well as current and future practices for measurement of sustainable progress. As mentioned above, over 200 responses were collected for the survey on sustainability, with 68 of these responses consisting of complete data sets. One reason for the low rate of complete responses is the length of the survey. With over 200 questions, it is likely that many respondents completed as many questions as their time and/or knowledge of sustainability allowed. The results of the completed surveys are included in Appendix D, for reference.

One of the most successful elements of the survey on sustainability was both the depth and breadth of companies who responded. Due to the international nature of survey distribution, originating from universities in the United States, Canada, France, Turkey, China, Taiwan, and Jordan, corporate responses were truly of a global nature. Many companies represented operate manufacturing and distribution centers situated across the globe, catering to international markets. The preliminary survey information showed that 71.5% of the companies responding sold to North American markets, while 45%, 41%, 24%, 19.5%, and 14.5% sold to the European, Asian, South American, African, and Australian/Oceanic regions, respectively. These companies ranged in size from those employing a few individuals with revenues under $100,000 per year to industry giants employing over 300,000 people with annual revenues over $50 billion dollars. Companies such as IBM, Harris Corporation, Microline Surgical, Ford Motor Company, Heinz Foods, Xerox, Armstrong World Industries, Grainger, Dresser Rand, Johnson Supply, Ingersoll Rand, LG Electronics, Coastal Chemical Co., Brenntag Canada, CertainTeed, 3M, Baker Hughes, Trane, CSAV Mexico, Hewlett-Packard, and Eaton, as well as many others completed the survey. These companies specialize in everything from automotive manufacturing to tire production, metal fabrication, helicopter services, electric power, turbo-compressors, packaging materials, detergent, cosmetics, roofing, siding, chemicals, telecommunications, and numerous other products and services. This wide range of specialties helps to validate the results of this survey and ensure that the findings are applicable to an expansive set of corporations and industries.

Furthermore, the respondents to the survey were a diverse group geographically as well as from the perspective of their positions and lengths of employment with their respective companies. The individuals responding hailed from all regions of the United States – from California to Texas, Pennsylvania, and Florida – as well as international locations throughout North America, Europe, and Asia, including Canada, Mexico, Korea, China, Thailand, Indonesia, India, Bulgaria, Taiwan, Finland, Turkey, and Jordan. On average, respondents had 10.93 years of employment with their current companies, but ranged from a few months to 51 years of experience overall. The job titles held by these individuals included Chairman, Director of Research, Director of Maintenance, Owner, Quality Engineer, Production/Manufacturing Manager, Production Engineer, Environmental Engineer, Consultant, Account Manager, Purchasing Engineer, Laboratory Chief, Supply Chain Engineer, Project Manager, Compliance Coordinator, and Salesman, among others. Additionally, large percentages of those surveyed indicated that they had prior experience in manufacturing, logistics, product design, and quality.

In order to determine the level of knowledge and familiarity with a variety of concepts for sustainability, one of the first sets of questions in the survey asked for respondents' level of understanding of a variety of sustainable ideologies and regulatory practices. As would be expected, respondents indicated that they had a high level of knowledge in areas such as "activities towards improving sustainable practices in their companies" and "their knowledge of sustainability." These responses were promising because they showed that employees were in touch with the steps their employers were taking – or were not taking – to implement sustainable improvements. Additionally, responses indicated that those participating in the survey were fairly familiar with ISO 19001 and ISO 14000 standards for audit procedures and policies, as well as Energy Star and LEED standards. Some specialized standards, such as ASPI in Europe, NRE in France, ELV for automobiles and vehicles, and NSF-140 for the carpet industry, were mostly unknown. Based on these findings, it became obvious that though some knowledge of sustainability exists, a greater level of training and information needs to be available in the corporate world if improvements in sustainability are to occur. Following this set of questions, respondents were introduced to the key component of this research – the metrics identified and included in the matrix of metrics. For each of these 55 metrics, they were asked to indicate the current usage level, value added, feasibility or practicality, and likelihood for future implementation.

A scale from 1 to 5 was employed in the survey to gauge the value and practicality of the metrics under consideration. On this scale, a value of 1 indicated no value or practicality, a value of 3 indicated neutral value or practicality, and a value of 5 indicated strong value and practicality. The responses collected indicated that the majority of proposed metrics added significant value, with an average rating of 3.329 out of 5 with a relatively low standard deviation of 0.305. These statistics illustrate an above-average acceptance of the metrics as well as a rather uniform importance in weighting, as no metric scored above 4.217 or below 2.833 on average. Furthermore, the practicality of the metrics examined also scored above neutral on the 1 to 5 scale, with an average rating of 3.105 with a small standard deviation of 0.277. These results show that on the whole, industry professionals from a variety of sectors, companies of various sizes, and differing geographical locations do, in fact, see the importance and value of sustainability metrics. Unfortunately, responses also indicated the lack of current implementation as well as the difficulties in future implementation of sustainable metrics, as discussed in section 2.3.

While responses indicated that many metrics were identified as having high values and practicalities, responses indicated that corporate representatives witnessed very low current usage of these metrics. On average, of the 55 metrics analyzed, a score of 2.338 out of 5 resulted from the question regarding how often, on average, these metrics were used in current practice. This lack of usage shows the need for increased measurement of sustainability factors as well as the need for consistency between corporations. Furthermore, a more worrisome response, given the need for sustainable improvements in international manufacturing and distribution, was the fact that the overall score for the metrics in terms of suggested future use was only 1.435 out of 5. More alarming is that the metric with the highest rate of suggestion, Photochemical Ozone Creation Potential – measuring regional air quality as a result of industrial development – was only given an overall suggestion rating of 1.6 out of 5. Combined, these facts illustrate that this diverse mix of corporate representatives do not foresee significant increases in the use of these sustainability metrics in the near future.

A reassuring result of the survey was the fact that the majority of respondents indicated that those metrics included were enough or more than enough to adequately assess overall environmental sustainability. This conclusion was made based on the low number of responses to the open ended question asking for suggestions of additional metrics to include. Responses included comments such as "the listed indicators are enough" and "this list is sufficient." Of those suggestions made, a number referred to specific products or industries such as medical/radiological waste generated. A number of others focused on metrics which did not directly relate to sustainability, such as occupational safety (incidents/near-miss incidents), and cash flow considerations. Of those useful suggestions, the most relevant were raw material to final product ratio, process waste reduction ratios, and electricity reduction ratios. As indicated by the titles of these metrics, a number of them relate to improvements over existing levels of waste and material usage – items that may or may not be currently measured by companies who may be using the suggested set of sustainability metrics.

4.3 Analysis of Survey Results

Upon the closure of the corporate sustainability survey on November 6, 2010, the 223 responses collected were analyzed using a variety of statistical tests in order to determine the optimal suggested sustainability metrics. Following the methodology outlined in Section 3.3, the raw data was cleaned to eliminate incomplete entries, narrowing the final data set to only the 68 completed responses. Using these responses, the data was formatted using Microsoft Excel and the software program R to cordon the data into five sets. Four of these five sets corresponded to the questions asked regarding each metric: whether it was currently in use, what its perceived corporate value was, what its perceived corporate practicality of measure was, and whether it would be suggested for future use. The fifth set was comprised of the weighted average of these four responses, calculated using Equation 3-1, for each individual metric.

After generating and formatting all five data sets, Minitab was utilized in order to develop box plots to perform a quick, visual inspection of the data. This quick, visual inspection could identify metrics which generated uniform responses through the survey versus those having a wide range of response values. Furthermore, these plots could be used to illustrate general normality in the data sets. After this analysis, the main statistical analysis was performed for each of the five data sets – analysis of variance (ANOVA) testing. For each of the five data sets, two types of ANOVA testing were performed; a repeated measures ANOVA test and a one way ANOVA test. As discussed in Section 3.3, the repeated measures ANOVA tests assessed the relationship between each metric and all other metrics, both those within and outside of its categorical group. The one way ANOVA tests only assessed the relationship between each metric and other metrics within its categorical group.

Upon the completion of these tests, the results for each of the five data sets were compared and analyzed. It is important to note that an alpha value of 0.30 was used for all statistical tests. For Tukey simultaneous comparison tests, a large p-value, greater than a chosen alpha, leads to the conclusion that the corresponding metric is not significantly difference from the metric to which it is being compared. From a review of the p-values for all tests, included in Appendix E, one can see that most of the p-values in this research were large, greater than 0.30. With this in mind, 0.30 was selected as the reference alpha value. It is common to use an alpha value of 0.05 or 0.10 for statistical testing; however, in cases where the majority of p-values are large, using an alpha of 0.25 or 0.30 is typical practice (Zhong and Zhang, 2010).

4.3.1 Analysis of Metrics – Metrics Currently Used in Practice

The first data for each of the 55 metrics to be analyzed through ANOVA testing and box plots was the data regarding whether the metric was currently used in practice. This question aimed to identify those metrics which are currently employed by industry in order to gauge or measure sustainability. As shown in Figure 4-1, the box plot for the responses regarding current use of metrics in industry, all metrics score between a 1 and 3 on a scale of 5 with regards to current use. This illustrates that very few companies are currently using these metrics in industry. Furthermore, from the ANOVA tests performed, it was determined that 15 of the 55 metrics stood out from the others in terms of current use.

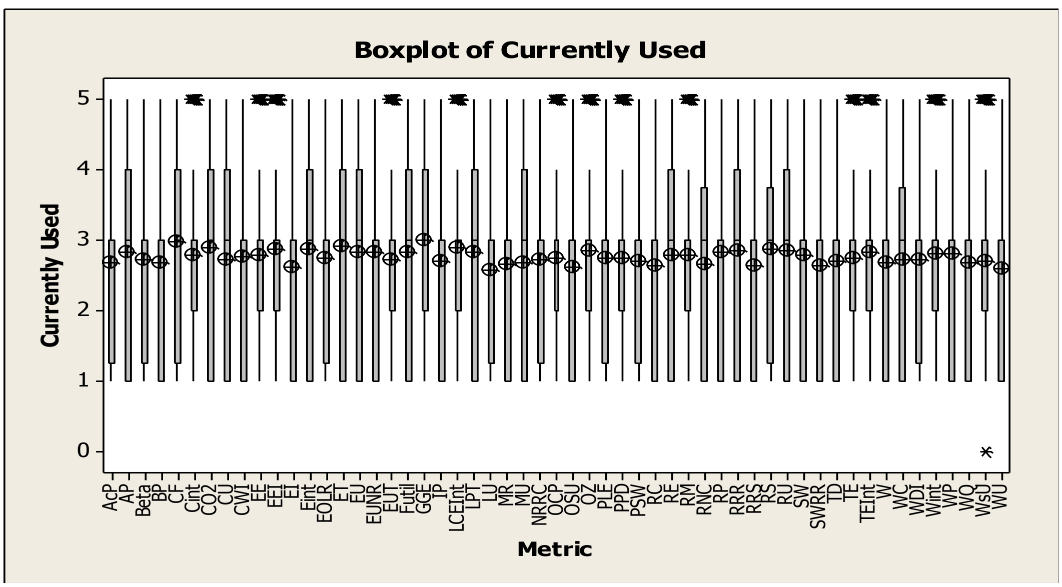

Figure 4-1: Used in Practice – Box plot results of all metrics

Approximately half of the metrics classified in the energy, pollution, and technique/process categories distinguished themselves, as shown in Table 4-3. This shows that current industry practices focus on these areas for measurement and regulation more so than those metrics that this study classified into the water, environment, and resources categories. Non-renewable energy use, carbon footprint, ozone depletion, carbon dioxide emissions, solid waste considerations, waste utilization, the number of chemicals used in processes, recycle/reuse rates, lean production techniques, regulatory compliance, and product life cycle considerations received significantly higher current usage figures than the other metrics studied. This result identifies which metrics are currently considered by larger and innovative corporations and illustrates that respondents had a familiarity with these measures more than the others proposed. In future work, this set of metrics could be used as a basis from which to work moving forward to implement new metrics. It is important to note that between the repeated measures and one way ANOVA tests, there were no differences in results for this question. After assessing this baseline for current use, the same box plot illustration and ANOVA tests were performed with regards to the other questions for each metric on the survey.

Table 4-3: Used in Practice - statistically significant and non-significant metrics identified as through ANOVA testing

Group	Non-Statistically Significant Metrics	Metrics currently used in industry, according to survey repondents, based on ANOVA Statistical Signifciance (Both Tests)
Energy	Energy Intensity Energy Use Life Cycle Energy Intensity	Excess Energy Intensity Non-Renewable Energy Use Transportation Energy Intensity
Environment	Acidification Potential Carbon Intensity Ecological Toxicity Greenhouse Gas Emission Photochemical Ozone Creation Potential Pollution Plume Dispersion	Carbon Footprint Ozone Depletion
Pollution	Air Pollution Byproducts Produced Chemicals in Waste Recyclability Rate for Metals Transportation Emissions Per Unit Waste Generation	Carbon Dioxide Emissions Percent of Solid Waste Recycling/Reuse Rate Solid Waste Solid Waste Reuse Rate Waste Utilization
Resources	Facility Utilization Import Percentage Land Use Material Use Mineral Reserves Used Non-Renewable Resource Consumption Rate Organic Solvent Usage Rate of Resource Savings Resource Consumption Resource Efficiency Environmental Impact Resource Productivity Resource Sustainability Resource Use Travel Distance	Number of Chemicals Used
Technique/Process	Value Ratio for a Firm Eco-efficiency End of Life Recovery Process	Lean Production Techniques Product Life Extension Regulatory Non-Compliance
Water	Core Water Intensity Eutrophication Water Discharge Intensity Water Pollution Water Quality Water Usage Waste Water Intensity	

4.3.2 Analysis of Metrics – Perceived Level of Metric Value

The next data analyzed from the survey results was the data regarding the perceived value of each of the 55 metrics presented to respondents. For the purposes of this research, value and feasibility were deemed necessary qualities of metrics to be suggested for industry use. A metric must have an inherent value in order for implementation to be profitable for a corporation. With this in mind, survey respondents were asked to rate the value of each metric on a scale of 1 to 5. As shown in the box plots of Figure 4-2, the average value associated with each proposed metric typically hovered around 3 on the 1-5 scale. When analyzed using both versions of the ANOVA tests, 27 of the 55 metrics were identified as having statistically significant responses with regards to their inherent values to corporations. In this manner, the survey respondents identified those 27 environmental sustainability metrics which they believe contribute the most to bottom line values for industry. It is important to note that the suggested metrics through this category, for the most part, span all six proposed metric groups, focusing heavily on the environment, pollution, and resources areas. This shows that corporations feel that these three areas of interest weigh heavily in assessing the sustainability of their procurement, distribution, and manufacturing processes. Once again, it is important to note that there were no discrepancies regarding metric value between the two ANOVA tests conducted.

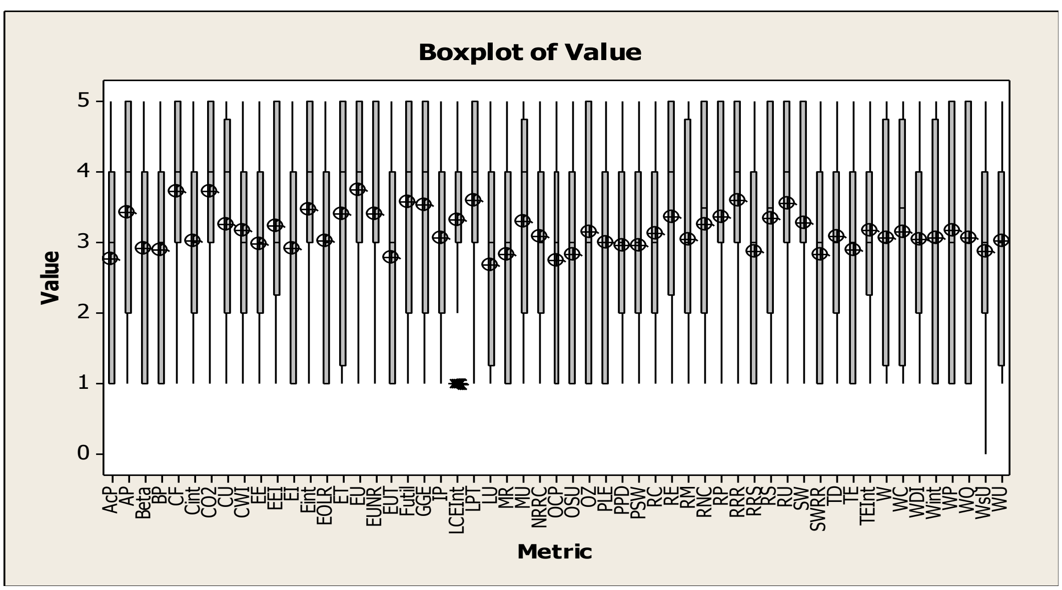

Figure 4-2: Level of Value – Box plot results of all metrics

Table 4-4: Level of Value - statistically significant and non-significant metrics identified as through ANOVA testing

Group	Non-Statistically Significant Metrics	Metrics valued by survey repondents, based on ANOVA Statistical Signifciance (Both Tests)
Energy	Energy Intensity Energy Use Excess Energy Intensity Life Cycle Energy Intensity Non-Renewable Energy Use	Transportation Energy Intensity
Environment	Acidification Potential Photochemical Ozone Creation Potential	Carbon Footprint Carbon Intensity Ecological Toxicity Greenhouse Gas Emission Ozone Depletion Pollution Plume Dispersion
Pollution	Air Pollution Byproducts Produced Recyclability Rate for Metals Waste Generation	Carbon Dioxide Emissions Chemicals in Waste Percent of Solid Waste Recycling/Reuse Rate Solid Waste Solid Waste Reuse Rate Transportation Emissions Per Unit Waste Utilization
Resources	Facility Utilization Import Percentage Material Use Organic Solvent Usage Resource Consumption Travel Distance	Land Use Mineral Reserves Used Non-Renewable Resource Consumption Rate Number of Chemicals Used Rate of Resource Savings Resource Efficiency Environmental Impact Resource Productivity Resource Sustainability Resource Use
Technique/Process	Value Ratio for a Firm Eco-efficiency End of Life Recovery Process Regulatory Non-Compliance	Lean Production Techniques Product Life Extension
Water	Core Water Intensity Eutrophication Water Discharge Intensity Water Pollution Water Quality Water Usage Waste Water Intensity	

4.3.3 Analysis of Metrics – Perceived Level of Metric Practicality/Feasibility

Going hand in hand with the consideration of the value required for implementing a given sustainability metric is the feasibility or practicality of implementing that metric. Using current practices and technology, there is only so many ways to quantify, collect, and record data with regards to environmental impacts and sustainability. With this in mind, it is not practical or feasible to suggest the implementation of a metric that cannot be easily measured, be this through existing methods or easily installed or applied methods. Following the question regarding the perceived value from each metric, survey respondents were asked to rate the practicality or feasibility of each metric on the same 1 to 5 scale. As shown in the box plots of Figure 4-3, the level of practicality or feasibility associated with the metrics presented in the survey averaged slightly below 3, just under the mean for the value of the proposed metrics in Figure 4-2 above.

As expected, the value of implementing metrics exceeded the feasibility of implementation for almost all proposed metrics. This led to higher average response values as well as a lesser number of statistically significant recommended metrics with regards to feasibility. Whereas 27 metrics were statistically significant to be recommended for implementation based on the value they were expected to deliver, only 17 metrics – shown in Table 4-5 – were identified as feasible or practical for implementation by respondents. Some metrics, such as solid waste and total resource use are easier to quantify and measure. Based on survey results, however, resource sustainability, waste utilization, transportation emissions per unit, and recycle/reuse rate –among others – would be key metrics to implement if they were easier to track and monitor. Over the coming years, it will be important to identify technological advances in measurement and recording techniques so that all metrics identified as valuable to measuring sustainability can be more easily implemented.

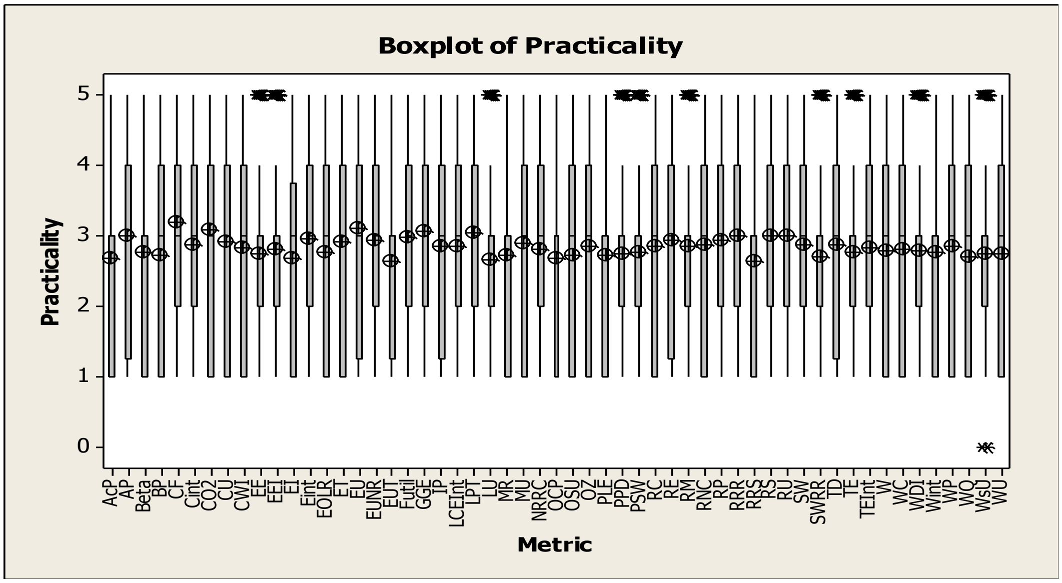

Figure 4-3: Level of Practicality/Feasibility – Box plot results of all metrics

Table 4-5: Level of Practicality/Feasibility - statistically significant and non-significant metrics identified as through ANOVA testing

Group	Non-Statistically Significant Metrics	Metrics indicated as feasible/practical by survey repondents, based on ANOVA Statistical Signifciance (Both Tests)
Energy	Energy Intensity Energy Use Life Cycle Energy Intensity	Excess Energy Intensity Non-Renewable Energy Use Transportation Energy Intensity
Environment	Acidification Potential Carbon Intensity Greenhouse Gas Emission	Carbon Footprint Ecological Toxicity Ozone Depletion Photochemical Ozone Creation Potential Pollution Plume Dispersion
Pollution	Air Pollution Byproducts Produced Percent of Solid Waste Recycling/Reuse Rate Recyclability Rate for Metals Transportation Emissions Per Unit Waste Generation Waste Utilization	Carbon Dioxide Emissions Chemicals in Waste Solid Waste Solid Waste Reuse Rate
Resources	Facility Utilization Import Percentage Land Use Material Use Mineral Reserves Used Non-Renewable Resource Consumption Rate Number of Chemicals Used Organic Solvent Usage Rate of Resource Savings Resource Consumption Resource Efficiency Environmental Impact Resource Sustainability Travel Distance	Resource Productivity Resource Use
Technique/Process	Value Ratio for a Firm Eco-efficiency End of Life Recovery Process	Lean Production Techniques Product Life Extension Regulatory Non-Compliance
Water	Core Water Intensity Eutrophication Water Discharge Intensity Water Pollution Water Quality Water Usage Waste Water Intensity	

4.3.4 Analysis of Metrics – Suggested Metrics for Future Use

As the final question presented to those completing the corporate sustainability survey through this research, participants were asked to rate the level for suggested implementation for each metric proposed. As would be expected, the response for this question generated rather low results. Likely because of respondents' low levels of familiarity with many of the proposed metrics, as well as concerns over quantifying, implementing, and measuring these metrics, the average level of suggestion was approximately 1.5 on a 1 to 5 scale, as shown in Figure 4-4 below. Having said this, it is important to consider respondents' unfamiliarity with these concepts and accept that growing trends in the field of environmental sustainability will gradually improve overall confidence and belief in implementing such systems in the future. Because of the tightly grouped responses for this question, very few metrics were singled out as statistically significant with regards to this question. Only 7 of 55 metrics – excess energy intensity, life cycle energy intensity, non-renewable energy use, ozone depletion, solid waste, lean production techniques, and product life extension – distinguished themselves statistically with regards to suggested implementation. As discussed, however, this is not to say that more were not to be suggested, but rather, that none of the others statistically stood out from the remaining 48 metrics, as shown in Table 4-6.

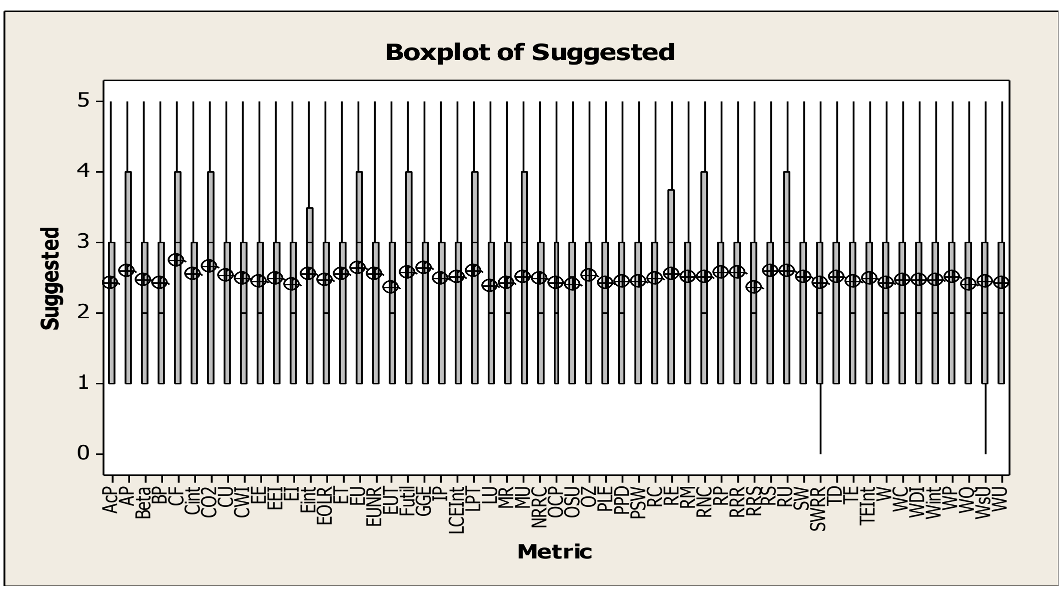

Figure 4-4: Suggested for Future Use – Box plot results of all metrics

Table 4-6: Suggested for Future Use - statistically significant and non-significant metrics identified as through ANOVA testing

Group	Non-Statistically Significant Metrics	Metrics suggested for future use by survey repondents, based on ANOVA Statistical Signifciance (Both Tests)	Metrics suggested for future use by survey repondents, based on ANOVA Statistical Signifciance (One Test)
Energy	Energy Intensity Energy Use Transportation Energy Intensity	Excess Energy Intensity Life Cycle Energy Intensity Non-Renewable Energy Use	
Environment	Acidification Potential Carbon Footprint Carbon Intensity Ecological Toxicity Greenhouse Gas Emission Photochemical Ozone Creation Potential Pollution Plume Dispersion	Ozone Depletion	
Pollution	Air Pollution Byproducts Produced Carbon Dioxide Emissions Chemicals in Waste Percent of Solid Waste Recycling/Reuse Rate Recyclability Rate for Metals Solid Waste Reuse Rate Transportation Emissions Per Unit Waste Generation	Solid Waste	Waste Utilization
Resources	Facility Utilization Import Percentage Land Use Material Use Mineral Reserves Used Non-Renewable Resource Consumption Rate Number of Chemicals Used Organic Solvent Usage Rate of Resource Savings Resource Consumption Resource Efficiency Environmental Impact Resource Productivity Resource Sustainability Resource Use Travel Distance		
Technique/Process	Value Ratio for a Firm Eco-efficiency End of Life Recovery Process Regulatory Non-Compliance	Lean Production Techniques Product Life Extension	
Water	Core Water Intensity Eutrophication Water Discharge Intensity Water Pollution Water Quality Water Usage Waste Water Intensity		

4.3.5 Analysis of Metrics – Average Response Values for Metrics

In order to develop a stronger sense of the overall responses for each proposed metric, the values from the 1 to 5 scale for each of the 4 questions presented and discussed above were averaged for each metric. An average value for considering the overall contribution and recommendation for each metric was thus developed. As shown in the box plot of Figure 4-5, the means of these average values were rather consistent for all 55 metrics – approximately 2.5. Similarly, very few metrics stood out as statistically significant. Only 8 of the 55 metrics proposed – carbon footprint, ozone depletion, pollution plume dispersion, carbon dioxide emissions, solid waste, transportation emission intensity, resource sustainability, and resource use – were statistically significant from the overall ANOVA averages for the group. Greenhouse gas emissions was determined to be a statistically significant metric through one way ANOVA testing, but not through repeated measures ANOVA testing. With all this in mind, it is hard to develop a true recommended set from these overall average values as so few metrics were categorized as statistically significantly better or worse than other proposed metrics.

In the final conclusion and analysis of these results and this research study on the whole, recommendations will be made for determining metrics to suggest moving forward as well as how this work can be used moving forward to develop stronger sets of suggested metrics in the future.

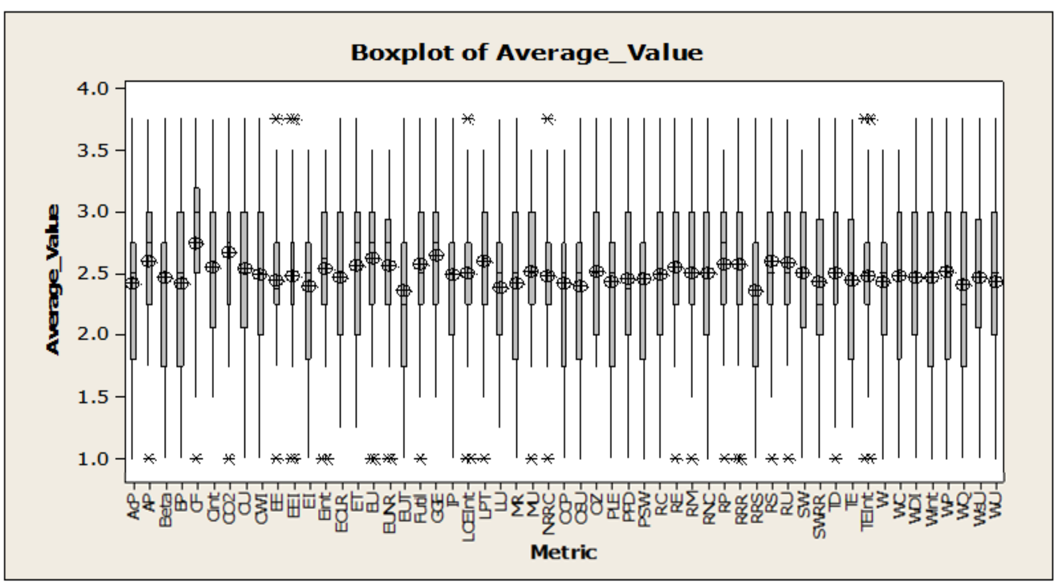

Figure 4-5: Average across all 4 survey questions – Box plot results of all metrics

Table 4-7: Average across all 4 survey questions - statistically significant and non-significant metrics identified as through ANOVA testing

Group	Non-Statistically Significant Metrics	Metrics recommended, on average, by survey repondents, based on ANOVA Statistical Signifciance (Both Tests)	Metrics recommended, on average, by survey repondents, based on ANOVA Statistical Signifciance (One Test)
Energy	Energy Intensity Energy Use Excess Energy Intensity Life Cycle Energy Intensity Non-Renewable Energy Use Transportation Energy Intensity		
Environment	Acidification Potential Carbon Intensity Ecological Toxicity Photochemical Ozone Creation Potential	Carbon Footprint Ozone Depletion Pollution Plume Dispersion	Greenhouse Gas Emission
Pollution	Air Pollution Byproducts Produced Chemicals in Waste Percent of Solid Waste Recycling/Reuse Rate Recyclability Rate for Metals Solid Waste Reuse Rate Waste Generation Waste Utilization	Carbon Dioxide Emissions Solid Waste Transportation Emissions Per Unit	
Resources	Facility Utilization Import Percentage Land Use Material Use Mineral Reserves Used Non-Renewable Resource Consumption Rate Number of Chemicals Used Organic Solvent Usage Rate of Resource Savings Resource Consumption Resource Efficiency Environmental Impact Resource Productivity Travel Distance	Resource Sustainability Resource Use	
Technique/Process	Value Ratio for a Firm Eco-efficiency End of Life Recovery Process Lean Production Techniques Product Life Extension Regulatory Non-Compliance		
Water	Core Water Intensity Eutrophication Water Discharge Intensity Water Pollution Water Quality Water Usage Waste Water Intensity		

Chapter 5

Summary, Conclusion, and Future Research

5.1 Summary and Conclusions

With growing concerns about the environmental impacts of everyday activities, sustainable initiatives and movements for change are beginning to permeate our everyday lives. Renewable energy sources such as solar and wind power are beginning to dot the landscape, recycling programs are gaining traction worldwide, and electric and hybrid vehicles are becoming commonplace in mass markets. As would be expected, this trend has not been lost on industry. Over the years to come, manufacturing, procurement, and distribution networks will be challenged to improve their environmental relations by reducing waste and pollution, reusing and recycling products, and designing products that are more environmentally friendly throughout their life cycles.

While many of these changes can be made through the improvement of practices and systems, possibly through process improvement strategies including lean or six sigma, a method for accurately assessing these improvements and monitoring the overall environmental sustainability of a firm, facility, or industry must be developed. Such a method would provide a tool to allow companies to assess their progress towards environmental improvements as well as objectively weigh themselves versus competition or past products. Creating such a tool, however, is much more difficult than it would appear on the surface. This difficulty is primarily due to two factors: (1) the excessive set of metrics and measurement tools that are currently in existence, as well as (2) the reluctance of companies to consider wholesale changes or adoptions of new methods for measurement and assessment. There are currently hundreds of means through which corporations gauge their environmental relations. The majority of these measures are company or facility specific, and thus it proves difficult or impossible to compare various facilities, let along companies. By conveying the importance of pooling resources and developing a wide-ranging, overarching sustainability index, this work aims to bridge the gap and eventually achieve this desired outcome.

This work consisted of an in depth analysis into the basics of the movement towards improved environmental sustainability for industry on the whole. Through an extremely detailed review of literature and background information, a great deal was covered with regards to the definition and classification of sustainable improvements and initiatives. While many steps have been taken to investigate sustainability in manufacturing, little work has been done to explore the interaction between sustainable manufacturing, distribution, procurement, and design planning in industry. Furthermore, as discussed above, very little work has been done investigating methods of measuring and analyze sustainability across industries and even larger, multi-facility companies. Monitoring and assessing sustainability at multiple levels within a corporate structure entails solving and answering a number of difficult questions. The first and foremost of these questions is the identification of key metrics to measure.

This research aimed to identify a method with which to analyze metrics from an academic and corporate perspective in order to determine which metrics are critical to successfully measuring environmental sustainability. Using this method, an attempt was made to develop a finite, suggested set of metrics for recommendation to corporate partners. Through this process, it was discovered that achieving these ends presented a difficult and challenging task. Through the 55 initially proposed metrics, a smaller set was suggested for implementation, but a great deal of work remains in order to develop a plan for implementing, monitoring, and measuring these metrics in an industry setting.

From the survey conducted as part of this research, a number of key ideas and findings were reinforced and/or developed. Primarily, it was discovered that many of the companies surveyed had limited knowledge of sustainable concepts and ideologies and were thus more averse to change than expected. Of the 55 metrics suggested, it was determined that very few were currently used in practice within industry. Of those metrics which were identified as being in use, many such as Solid Waste and Number of Chemicals Used represented figures which are relatively easy to quantify and track, a fact which likely led to their implementation and adoption. Other metrics which were identified as current measures employed by industry included Carbon Footprint, Carbon Dioxide Emissions, and Ozone Depletion. While efforts may be underway to lessen the environmental impacts related to these metrics, it was unclear from the survey results and structure how exactly these metrics are being applied. These three metrics in particular represent vague, often misinterpreted measures. Moving forward, it is highly recommended that metrics be applied with clearly defined formulas and data collection practices, as outlined in this research through the matrix of metrics. Doing so will enable companies to clearly assess their own impacts and to actively compare their input and output with competitors or between facilities.

While the survey responses regarding currently used metrics tended to indicate a leaning towards easily recognizable terms or concepts, much more diversity in responses resulted when the topic of metric value was presented. While only 15 metrics were indicated as those currently in use, 27 metrics were found to be statistically significant in their identification as metrics that would add value if implemented. These metrics included a number of categories, focused primarily in the realms of environment, resources, and pollution. These results show that corporations and individuals in positions of leadership understand the value that is associated with measuring and implementing environmental improvement processes and metrics, but currently do not know how or do not have the resources required to enact these systems. This concept was reinforced by the next set of survey questions, asking which metrics participants thought were feasible or practical for implementation. Whereas 27 metrics were identified as having high value, only 17 metrics were identified as feasible or practical for implementation. Through further research and development of clearly defined metrics, a greater number of metrics will be easy for those in business and manufacturing to understand, implement, track, and asses in everyday operations. Such practices would lead to process improvements aimed to enhance these metrics, resulting in more positive environmental interactions, lower wastes, and higher reuse and recyclability.

The three focuses of the survey discussed here – current use, value, and practicality/feasibility – all lead to the final question presented to survey participants. This question asked which metrics should be suggested for future use and implementation. While answers to this question were undoubtedly based on previous responses, it was interesting to see that far fewer of the metrics were statistically significantly different from one another. With this in mind, as well as the average response for each metric across all four questions, the suggested set of metrics shown in Table 5-1 was developed to identify those metrics recommended for further emphasis.

Table 5-1: Recommended metrics classifications based on the corporate sustainability survey, ANOVA testing, and consideration of respondent opinions

Category	Not Recommended	Possible Recommendations	Highly Recommended
Energy	*Excess Energy Intensity	*Energy Intensity *Life Cycle Energy Intensity	*Transportation Energy Intensity *Energy Use *Non-Renewable Energy Use
Environment	*Acidification Potential *Pollution Plume Dispersion *Photochemical Ozone Creation Potential	*Carbon Intensity *Ecological Toxicity *Greenhouse Gas Emissions	*Carbon Footprint *Ozone Depletion
Pollution	*Air Pollution *Byproducts Produced	*Transportation Emissions Per Unit *Chemicals in Waste *Percent of Solid Waste *Recyclability Rate for Metals *Waste Generation	*Carbon Dioxide Emissions *Recycling/Reuse Rate *Solid Waste *Solid Waste Reuse Rate *Waste Utilization
Resources	*Facility Utilization *Import Percentage *Organic Solvent Usage *Resource Consumption *Travel Distance	*Material Use *Rate of Resource Savings	*Land Use *Mineral Reserves Used *Resource Use *Number of Chemicals Used *Resource Efficiency *Environmental Impact *Resource Productivity *Resource Sustainability *Non-Renewable Resource Consumption Rate
Technique/Process	*Eco-efficiency	*Regulatory Non-Compliance *Value Ratio for a Firm	*End of Life Recovery Process *Lean Production Techniques *Product Life Extension
Water	*Core Water Intensity *Eutrophication *Water Discharge Intensity *Water Quality		*Water Pollution *Water Usage *Waste Water Intensity

It is important to note that the results from all ANOVA tests were considered when developing this table, as well as feedback from industry partners and the free response portions of the survey. When recommending the suggested set of 27 metrics, creating a diverse perspective of sustainability was considered as well as the ease of implementation and measurement techniques for suggested metrics. With this in mind, metrics from all six categories – energy, environment, pollution, resources, technique/process, and water – were included. This posed a challenge, particularly with regards to the water group, since no metrics stood out through statistical significance in the survey results. It is also important to note that some metrics, such as

Pollution Plume Dispersion and Eco-Efficiency were not recommended because of respondents' confusion in clearly defining and categorizing these metrics. While this set does not represent a firm, unalterable solution, it provides a basis from which future research can begin when assessing suggested sustainability metrics. It is also important to highlight that many of the metrics included in this suggested list would require enhanced definition and tracking practices in order to implement monitoring in an industrial setting.

In closing, following the procedure presented in this research can provide a starting point from which work can be completed to assess future sustainability metrics and initiatives. As we learn more about the environment and the interactions between nature and industrial systems, new discoveries are bound to occur which emphasize alternate existing metrics or bring to light new targets for sustainable measurements or improvements. Coupling these ideas with new measurement technologies or practices will further enhance environmental sustainability efforts and work towards the creation of a true, international, cross-industry set of sustainability metrics.

5.2 Areas for Future Research

On the whole, corporate feedback illustrated a strong sense of skepticism in the ability to implement and use sustainability metrics. Representatives from Cannondale Bicycles, Inc. as well as survey respondents showed low levels of familiarity with many sustainable ideologies and proposed metrics. On the other hand, those questioned in the survey seemed to perceive and acknowledge the value of this research as well as possible future implementation of sustainability metrics and tracking programs. With these things in mind, it is important to focus on the positive aspects and outcomes of this research and study. The literature review and background analysis in this study provides a great reference for those interested in learning about sustainability, methods for measuring sustainable improvement, and analyzing various metrics. Furthermore, through the selection criteria and methodology presented here, further metrics can be analyzed in the future as more technology improvements are made to measure and monitor sustainable factors.

This study provides a great starting point for any individual or corporation looking to learn about sustainability and implement a system of metrics to assess the level of sustainability of a corporation. Through discussion with a number of corporations – specifically Cannondale Bicycles, Inc. – as well as the 68 completed survey responses, a great deal of information was gathered about current perspectives and beliefs regarding sustainability. Through statistical analysis, a preferred set of metrics was identified for corporate use and should be developed further as new technology and methods for quantifying and measuring sustainable factors are developed. All of these results and developments illustrate encouraging signs with regards to the adoption and implementation of sustainable mindsets in industry and are likely to spur a great deal of corporate interest and thought in this topic moving forward. While much has been accomplished, a great deal remains to be done towards improving industry's relationship with this planet and our analysis and measurement of these interactions.

Moving forward, using the methods discussed and presented in this research, it is recommended that the existing metric set is further analyzed and also supplemented with additional metrics for analysis. For each of these metrics, it is of great importance to develop stronger quantification techniques and methods for assessing the present state of a facility or company and developing an easily followed procedure for measuring and assessing future improvements. Corporate skepticism with regards to this research reached a pinnacle due to doubts surrounding the methods for implementing and measuring the metrics presented as many did not have clear collection devices, monitors, or variables. With this in mind, the explicit quantification of and analysis of implementation techniques is essential to further adoption and implementation in industry. Additionally, gathering additional feedback from corporations to provide a larger, stronger data pool will help distinguish responses and create more of a significant sampling. With additional data, analysis could also be performed to compare responses from various industries and geographical regions. Such analysis could help draw conclusions concerning the leaders in sustainable initiatives and identify best practices and innovative, progressive companies. Unfortunately, due to the limited number of responses and the scattered data – no country had more than 20 completed responses and no industry had more than 15 – such a breakdown was not possible in this study. It is the hopes of the research team that the work can be used as a stepping stone to create further awareness of sustainable ideologies and hasten the adoption of metric creation and monitoring practices in worldwide industry in the years to come.

Appendix A

Generated Matrix of Metrics

This appendix houses the matrix of metrics identified during the literature review and metric identification stages of research. This matrix was trimmed down to 55 metrics for use in the corporate sustainability survey. Those metrics shaded in gray were not used in the corporate sustainability survey for a variety of reasons, including duplicate/similar entries and a lack of relevance to sustainable considerations.

ID Number	Reviewer	Metric or Indicator	Metric/Indicator Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Disadvantages	Publication Source ID(s)
1	*	Indicator	Energy Use **EU**	Sum of all energy used during manufacturing process	Direct measurement	Manufacturing	Input	**Σ EU**	**EU** energy use (Watts)	N/A	1 - Indicator Read Directly from Gauge (No Formula)		(Rachuri et al., 2009); (Gaughran et al., 2007); (Naidu et al., 2008); (Martins et al., 2007); (Wilson et al., 2007)
2	#, *	Indicator	Energy Intensity **EInt**	Describes the energy input required for each unit produced	Direct Measurement	Manufacturing	Input	**Σ (EU) / Q**	**EU** energy use (Watts), **Q** units produced	N/A	2 - Indicator Requiring Formula (< 5 Terms)	Easy to gather information; average over all products produced	(Martins et al., 2007); (Sikdar et al., 2007); (Mosovsky et al., 2000); (Sikdar, 2003); (NRTEE, 2007)
3	*	Indicator	Life Cycle Energy Intensity **LCEInt**	Sum of all energy consumed during all the phase of the product's life-cycle	Product life cycle	All Phases	Output	**Σ EC**	**EC** energy consumed throughout life cycle (Watts)	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(NRTEE, 2007)
4	*	Indicator	Excess Energy Intensity **EEI**	Total excess energy generated during manufacturing processes	Direct measurement	Manufacturing	Output	**Σ EEG**	**EEG** excess energy generated (Watts)	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(NRTEE, 2007)
5	#	Indicator	Non-Renewable Energy Use **EUNR**	Energy consumed which is supplied by gas, petroleum, electricity, coal or other non-renewable sources	Direct Measurement	Manufacturing	Input	**Σ EUNR**	**EUNR** non-renewable energy use (Watts)		1 - Indicator Read Directly from Gauge (No Formula)	Can be read from one location, but may be related to multiple products/services	(Labuschagne and Brent, 2005); (Zhou et al., 2000); (Albino et al., 2002); (Wang and Lin, 2004); (Petrie et al., 2007)
6	*	Indicator	Energy Intensity of GPD **EIntGDP**		Governmental database	Manufacturing	Output			N/A		Vague/Unclear	(Nam, 2008)
7	*	Indicator	Transportation Energy Intensity **TEInt**	Describes the energy input required for the transportation of each unit	Direct measurement	Transportation	Output	**Σ (EUT) / Q**	**EUT** transportation energy use (Watts), **Q** units produced	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(NRTEE, 2007)

ID Number	Reviewer	Metric or Indicator	Metric/Indicator or Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Disadvantages	Publication Source ID(s)
8	#	Indicator	Water Usage **WU**	Measurement of the water used or affected for withdrawal, consumptive, and non-withdrawal; both surface and no surface	Direct Measurement	Manufacturing	Input	**Σ WU**	**WU** water used (volume)		1 - Indicator Read Directly from Gauge (No Formula)	Does not account for recycled water; some processes water intensive	(Sikdar et al., 2007); (Labuschagne and Brent, 2005); (Wang and Lin, 2004); (Petrie et al., 2007)
9	*	Indicator	Water Pollution **WP**	Ratio of polluted water divided by total water emitted	Direct measurement	Manufacturing	Output	**Σ (PW/WE) x 100**	**PW** polluted water (volume), **WE** total water emission (volume)	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Nam, 2008)
10	*	Indicator	Water Quality **WQ**	Physical, chemical and biological characteristics of water	Direct measurement	Manufacturing	Output	**Σ WQ**	**WQ** water quality	N/A	1 - Indicator Read Directly from Gauge (No Formula)	Very vague and broad, could be measured countless ways	(Nam, 2008)
11	#	Indicator	Eutrophication **EUT**	Determines effect on water	Direct Measurement	Manufacturing	Input	**Σ EUT**	**EUT** PO4 equivalents released (kg)		1 - Indicator Read Directly from Gauge (No Formula)	Hard to understand	(Sikdar et al., 2007); (Labuschagne and Brent, 2005)
12	*	Indicator	Water Waste Intensity **WInt**	Quantity of emission of polluted water divided by units produced	Direct measurement	Manufacturing	Output	**Σ PW / Q**	**PW** polluted water (volume), **Q** units produced	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(NRTEE, 2007)
13	*	Indicator	Core Water Intensity **CWI**	Water used divided by units produced	Direct measurement	Manufacturing	Output	**Σ WI / Q**	**WI** water used (volume), **Q** units produced	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(NRTEE, 2007)
14	*	Indicator	Water Discharge Intensity **WDI**	Water discharged divided by units production	Firm database	Manufacturing	Output	**Σ WD / Q**	**WD** water discharged (volume), **Q** units produced	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(NRTEE, 2007)
15	#	-	Waterborne Wastes **WW**	Vague description/Not Described		-	-				-		(Albino et al., 2002); (Wang and Lin, 2004)
16	*	Indicator	Wasted Material Resources **WR**	Total material (direct + indirect) entering the product/manufacturing process less material that ends up in the product divided by the units of production	Direct measurement	Manufacturing	Output	**Σ (IM - OM) / Q**	**IM** input material, **OM** output material, **Q** units produced	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Fuller and Ottman, 2004); (NRTEE, 2007)
17	*	Indicator	Resource Efficiency **RE**	Ratio of useful material output divided by material input	Firm database	Manufacturing	Input	**Σ (UMO / MI) x 100**	**UMO** useful material output (units, volume, or weight), **MI** material input (units, volume, or weight)	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Nam, 2008)
18	#	Indicator	Resource Consumption **RC**	Materials used to make products and packaging (minerals and metals, primary and recycled sources)	Direct Measurement	Manufacturing	Input	**Σ RC**	**RC** resources consumed (units, volume, or weight)		1 - Indicator Read Directly from Gauge (No Formula)	Is a simple number, but requires gathering a lot of information	(Zhou et al., 2000); (Albino et al., 2002); (Wang and Lin, 2004); (Petrie et al., 2007)

ID Number	Reviewer	Metric or Indicator	Metric/Indicator Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Disadvantages	Publication Source ID(s)
19	*	Indicator	Resource Intensity **RInt**	Sum of all the resources used per unit of Gross Domestic Product	Firm database	Manufacturing	Input	**Σ RC / GDP**	**RC** resources consumed (units, volume, or weight), **GDP** Gross Domestic Product	N/A	1 - Indicator Read Directly from Gauge (No Formula)	Based on country or company	(Mosovsky et al., 2000); (Nam, 2008)
20	*	Indicator	Stock Turns **ST**	Measure of how frequently the stock, raw material, work-in-progress and finished goods are turned over in relation to the sales revenue of a product	Direct measurement	Manufacturing	-	**Σ Turn Time / Q**	**Turn Time** turnover time for all stock, raw material, work-in-progress, and finished goods; **Q** units produced	N/A		Seemingly not directly environmental	(Atlee and Kirchain, 2006)
21	*	Indicator	Reorder Point **Ki**	Minimum level of Inventory at which a new order must be placed	Firm database	Raw material	-	**S x L + J (S x R x L)**	**S** usage in units, **L** lead time in days, **R** average number of units per order, **J** stock out acceptance factor	N/A	2 - Indicator Requiring Formula (< 5 Terms)	Seemingly not directly environmental	(Kainuma and Tawara, 2006)
22	*	Indicator	Material Use **MU**	The number of different types of raw materials used	Direct measurement	Manufacturing	-	**Σ MU**	**MU** materials used (count, volume)	N/A			(Martins et al., 2007); (Ijomah et al., 2007)
23	*	Indicator	Solid Waste **SW**	Amount of solid waste created	Direct measurement	Manufacturing	Output	**Σ SW**	**SW** total units/volume of solid waste	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Martins et al., 2007); (Kainuma and Tawara, 2006); (Atlee and Kirchain, 2006); (Albino et al., 2002); (Wang and Lin, 2004)
24	*, #	Indicator	Percent of Solid Waste **PSW**	Quantity of solid in waste divided by quantity of solid use	Direct measurement	Manufacturing	Output	**Σ (SiW / SU) x 100**	**SW** total units/volume of solid waste, **SU** total units/volume of solid used	N/A	2 - Indicator Requiring Formula (< 5 Terms)	Waste can originate as non-solids	(Martins et al., 2007); (Kainuma and Tawara, 2006); (Atlee and Kirchain, 2006); (Albino et al., 2002); (Wang and Lin, 2004); (Nam, 2008)
25	#	Indicator	Solid Waste Reuse Rate **SWRR**	The rate of using a product or component of solid waste in its original form more than once	Direct Measurement	Manufacturing	Input	**Σ (SWR / SW) x 100**	**RSW** units/volume of reused solid waste, **SW** total units of solid/volume waste		2 - Indicator Requiring Formula (< 5 Terms)		(Wang and Lin, 2004)
26	*	Indicator	Eco-efficiency **EE**	Quantifies environmental impact, resource productivity, and eco-efficiency in a firm	Firm database	Manufacturing	Input	**β / EI (= 1 / EI*)**	**EE** eco-efficiency, **β** value ratio for a firm, **EI** environmental Impact, **EI*** adjusted environmental impact	N/A	2 - Indicator Requiring Formula (< 5 Terms)	Difficult to figure out how many times something is used, factors into recyclability	(Mosovsky et al., 2000)

ID Number	Reviewer	Metric or Indicator	Metric/Indicator Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Disadvantages	Publication Source ID(s)
27	*	Indicator	Environmental Impact **EI**	The EI quantitatively as a single dimensionless number	Firm database	Manufacturing	Output	**Σ EI Supply + EI Output**	**EI Supply** environmental impact of raw/supplied materials; **EI Output** environmental impact of produced materials and waste	N/A	2 - Indicator Requiring Formula (< 5 Terms)	Very vague and high level	(Mosovsky et al., 2000)
28	*	Indicator	Value ratio for a firm **β**	Value ratio	Aspect reference level for a firm	Manufacturing	Input	**V / VC**	**Vr** reference firm value, **VC** value creation by firm	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Mosovsky et al., 2000)
29	*	Indicator	Adjusted environmental impact **EI***	If EI* >1 the environmental impact exceed	Firm database	Manufacturing	Output	**EI / β**	**EI** environmental impact, **β** value ratio for a firm	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Mosovsky et al., 2000)
30	#	Indicator	Acidification Potential **AP**	Measures regional air quality through kg of SO2 equivalents	Direct Measurement	Manufacturing	Input	**Σ SO2**	**SO2** SO2 equivalents released (kg)		1 - Indicator Read Directly from Gauge (No Formula)	Hard to measure	(Sikdar et al., 2007); (Labuschagne and Brent, 2005)
31	#	Indicator	Acid Rain **AR**	Vague description/Not Described	Weather Databases	Manufacturing	Output	**Σ AR**	**AR** instances of acid rain that could be attributed to facility (precautionary)		1 - Indicator Read Directly from Gauge (No Formula)	Hard to determine direct causes of acid rain	(Sikdar et al., 2007)
32	#	Indicator	Photochemical ozone creation potential **OCP**	Measures regional air quality through kg O3 equivalents	Direct Measurement	Manufacturing	Input	**Σ O3**	**O3** O3 possibly created kg		2 - Indicator Requiring Formula (< 5 Terms)	How does one determine the potential ozone created?	(Labuschagne and Brent, 2005)
33	#	Indicator	Ozone Depletion **OZ**	Amount of chemicals used with ozone depleting potential or more specifically, kg of CFC-11 equivalents released	Count or Direct Measurement	Manufacturing	Input	**Σ Ochem or Σ CFC**	**Ochem** number of ozone depleting chemicals used; **CFC** CFC-11 equivalents released (kg)		1 - Indicator Read Directly from Gauge (No Formula)	Hard to quantify, may use small quantities of many	(Sikdar et al., 2007); (Labuschagne and Brent, 2005); (Linton et al., 2007)
34	#	Indicator	Global Warming **GW**	Measures global warming potential through kg of CO2 equivalents released	Direct Measurement	Manufacturing	Input	**Σ CO2**	**CO2** carbon dioxide equivalents released (kg)		1 - Indicator Read Directly from Gauge (No Formula)	What is a CO2 equivalent?	(Sikdar et al., 2007); (Labuschagne and Brent, 2005); (Linton et al., 2007); (Nagurney et al., 2007)
35	*	Indicator	Carbon Intensity **CInt**	Amount of carbon by weight emitted per unit of energy consumed	Governmental database	Manufacturing	Output	**Σ CE / EU**	**CE** quantity of carbon emitted, **EU** energy use (Watts)	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Sarkis, 1999); (Nam, 2008)
36	*	Indicator	Carbon Footprint **CF**	Total amount of CO2 and other greenhouse gases, emitted over the full life cycle of a process	Direct measurement	Manufacturing	Output	**Σ CO2**	**CO2** carbon dioxide equivalents released (kg)	N/A	4 - Indicator Requiring Formula (> 10 Terms)	Measured many different ways; include manufacturing and transport and transport/manufacturing of raw goods	(Matthews et al., 2008); (Hertwich and Peters, 2009)

ID Number	Reviewer	Metric or Indicator	Metric/Indicator or Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Disadvantages	Publication Source ID(s)
37	#	Indicator	Carbon Dioxide Emissions **CO2**	A measure of the Carbon Dioxide released by a process	Direct Measurement	Manufacturing	Output	**Σ CO2**	**CO2** carbon dioxide equivalents released (kg)		1 - Indicator Read Directly from Gauge (No Formula)	Should be as easy as reading gauge since regulated	(Linton et al., 2007); (Nagurney et al., 2007); (Wang and Lin, 2004); (Petrie et al., 2007)
38	#	Indicator	Smog Formation **SF**	Vague description/Not Described		-	-				-	How can this be measured or identified?	(Sikdar et al., 2007)
39	*	Indicator	Climate Change **CC**		Governmental database	-	-			N/A			(Rachuri et al., 2009); (Reich-Weiser and Dornfeld, 2009); (Hertwich and Peters, 2009)
40	*	Indicator	Ecological Footprint of GDP **EF**	analysis of natural resources and human demand that is used to measure or estimate the consumption of natural resources for an entire economy	governmental database	Manufacturing	Output			N/A			(Gaughran et al., 2007); (Nam, 2008)
41	*	Indicator	Supply Chain Return on Asset **ROA**	Net income divided by total assets	Firm database	Manufacturing	Input	**NI / TA**	**NI** net income, **A** total assets	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Investopedia, 2010)
42	*, #	Indicator	Life Cycle Assessment **LCA**	Used to determine the environmental impact associated to a process, a product or service; Is a product life cycle assessment conducted during product design?	Yes/No	Manufacturing	Output			N/A	1 - Indicator Read Directly from Gauge (No Formula)	Could help companies implement more environmentally friendly designs	(Naidu et al., 2008); (Linton et al., 2007); (Kainuma and Tawara, 2006)
43	*	Indicator	Out of Stock Ratio **OSR**	Evaluate favor and customer service	Firm database	Retail	Output	**OS / D**	**OS** days out of stock, **D** total days	N/A	1 - Indicator Read Directly from Gauge (No Formula)	Not directly related to environment	(Kainuma and Tawara, 2006)
44	*	Indicator	Resource Use Intensity **RUInt**	Unit of resource use divided by unit of value creation per unit of GDP	Firm database	Manufacturing	Input	**RU / VC**	**VC** value creation by a firm, **RU** resource use	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Nam, 2008)
45	#	Metric	Resource Use **RU**	Total resources used	Computation	Manufacturing	Input	**Σ EU + WU + MU**	**EU** energy use (Watts), **WU** water used (volume), **MU** materials used (count/volume)	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Labuschagne and Brent, 2005); (Nam, 2008); (Ichimura, 2009); (Tallis, 1997)
46	*	Indicator	Resource Productivity **RP**	Value rating of suppliers	Supply and output data	Manufacturing	Input	**P / EI**	**P** production rate, **EI** environmental Impact	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Mosovsky et al., 2000); (Fuller and Ottman, 2004)
47	*	Indicator	Rate of Resource Saving **RS**	Unit of environmental benefit divided by unit of value creation	Firm database	Manufacturing	Output	**EB / VC**	**EB** environmental benefit, **VC** value creation by a firm	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Ichimura, 2009)

ID Number	Reviewer	Metric or Indicator	Metric/Indicat or Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Di sadvantages	Publication Source ID(s)
48	#	Indicator	Recycling/Reuse Rate **RRR**	Rate of resource recovery involving collection and treatment of a waste product for use as a raw material	Direct Measurement	Manufacturing	Input	**Σ (RR / RU) x 100**	**RR** reused/recycled resources, **RU** resource use		2 - Indicator Requiring Formula (< 5 Terms)	Must identify what is recycled or reused versus what is virgin	(Linton et al., 2007); (Wang and Lin, 2004); (Zhou et al., 2000); (Ijomah et al., 2007)
49	*	Indicator	Waste Utilization **WU**	Ratio of Waste utilized divided by total waste output	Direct measurement	Manufacturing	Output	**Σ (RW / WW + WR) x 100**	**RW** reused waste, **WR** wasted material resources, **WW** waterborne waste	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(NRTEE, 2007)
50	*	Indicator	Air pollution (SO2, NO2) **AP**	Ratio of pollutant gas emission divided by total of gas emissions	Direct measurement	Manufacturing	Output	**Σ (PE / GE) x 100**	**PE** pollutant gas emission (kg), **GE** total gas emission (kg)	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Jin and High, 2004); (Kainuma and Tawara, 2006); (Nam, 2008)
51	#	Indicator	Import Percentage **IP**	Determines the amount of raw materials imported from outside a geographic region	Count	Raw Materials	Input	**(Σ (IR) / NR) x 100**	**IR** count of imported resources, **NR** number of resources used on product		1 - Indicator Read Directly from Gauge (No Formula)	What constitutes a local region is vaguely defined	(Albino et al., 2002)
52	#	Indicator	Resource Sustainability **RS**	Determines how sustainable the resources used on a product are; how long is the resource expected to be available for use on Earth before depletion	Calculation	Manufacturing	Input	**Σ (IRS) / NR**	**IRS** resource availability of individual product, **NR** number of resources used on product		2 - Indicator Requiring Formula (< 5 Terms)	Very vague as resource sustainability are up to interpretation; benefits manufacturers who are using renewable energy and not fossil fuels	(Ghomshei and Villecco, 2009)
53	#	Indicator	Pollution Plume Dispersion **PPD**	Determines how many people are exposed to an emission	Count	Manufacturing	Input	**Σ ExpInd**	**ExpInd** count of the number of individuals exposed to a plume of pollution on a daily basis		1 - Indicator Read Directly from Gauge (No Formula)	Very vague, doesn't specify if plume is toxic; how do you determine who is exposed? Distance?	(Petrie et al., 2007)
54	#	Indicator	Soil Pollution **SP**	Measures soil contamination		Manufacturing	Input				-	Very hard to define and determine; if soil was affected, it should be violation	(Petrie et al., 2007)
55	#	Indicator	Mineral Reserves Used **MR**	Measures the amount of minerals used	Direct Measurement	Raw Materials	Input	**MR**	**MR** coal equivalents used (kg)		2 - Indicator Requiring Formula (< 5 Terms)	What good is coal equivalents?	(Labuschagne and Brent, 2005)
56	#	Indicator	Byproducts Produced **BP**	Count of the number of byproducts produced	Count	Manufacturing	Input	**Σ BP**	**BP** number of byproducts produced		1 - Indicator Read Directly from Gauge (No Formula)	Difficult to determine based solely on count, what about recycled byproducts?	(Linton et al., 2007)
57	#	Indicator	End of Life Recovery Process **EOLR**	Is a clear end of life recovery process in place and defined?	Yes/No	End of Life Disposal	Output	Yes/No			1 - Indicator Read Directly from Gauge (No Formula)	Makes company consider this	(Linton et al., 2007)
58	#	Indicator	Product Life Extension **PLE**	Is there a way to extend the life of the product once its initial life is over?	Yes/No	End of Life Disposal	Output	Yes/No			1 - Indicator Read Directly from Gauge (No Formula)	Makes company consider this	(Linton et al., 2007)

ID Number	Reviewer	Metric or Indicator	Metric/Indicator or Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Disadvantages	Publication Source ID(s)
59	#	Indicator	Lean Production Techniques **LPT**	Are lean and quality control techniques used to minimize waste?	Yes/No	Manufacturing	Input	Yes/No			1 - Indicator Read Directly from Gauge (No Formula)	Could be done improperly	(Linton et al., 2007)
60	#	Indicator	Noise Pollution **NP**	Vague description/Not Described		-	-				-		(Linton et al., 2007)
61	#	Indicator	Transportation Emissions per Unit **TE**	Emissions into the atmosphere associated with transportation per unit product produced	Direct Measurement	Transportation	Input	**Σ (TE) / Q**	**TE** emissions from transport of products (volume/kg), **Q** units produced		2 - Indicator Requiring Formula (< 5 Terms)	Could be defined a lot of ways, not clear what is counted	(Nagurney et al., 2007)
62	#	Indicator	Travel Distance **TD**	Distance traveled between factory and end consumer sales point	Direct Measurement	Transportation	Input	**Σ TD**	**TD** total distance traveled by product to end consumer		1 - Indicator Read Directly from Gauge (No Formula)	Does not account for supplier/raw material transport or quantity of goods shipped at once	(Albino et al., 2002)
63	#	Indicator	Human Toxicity **HT**	The degree to which substances used are harmful to humans or animals	Derived effect	Manufacturing	Input	**Σ Pb**	**Pb** Pb equivalents released (kg)		1 - Indicator Read Directly from Gauge (No Formula)	Very hard to quantify; just lead accounted for in formula	(Sikdar et al., 2007); (Labuschagne and Brent, 2005); (Wang and Lin, 2004); (Petrie et al., 2007)
64	#	Indicator	Ecological Toxicity **ET**	The degree to which substances used are harmful to the environment	Derived effect	Manufacturing	Input	**Σ Pb**	**Pb** Pb equivalents released (kg)		1 - Indicator Read Directly from Gauge (No Formula)	Very hard to quantify; just lead accounted for in formula	(Sikdar et al., 2007); (Labuschagne and Brent, 2005); (Wang and Lin, 2004)
65	#	-	Carcinogenic and Noncarcinogenic Releases	Vague description/Not Described		-	-				-		(Sikdar et al., 2007)
66	#	Indicator	Land Use **LU**	Describes the land used by a particular firm in the production of product	Direct Measurement	Manufacturing	Input	**Σ L**	**L** land used/occupied/transformed by corporation (m^2 or km^2)		1 - Indicator Read Directly from Gauge (No Formula)	Hard to distinguish what land use is due to which production	(Labuschagne and Brent, 2005); (Wang and Lin, 2004)
67	#	Indicator	Greenhouse Gas Emission **GGE**	Anthropogenic emissions of CO2, CH4, N2O, HFCs, PFCs, SF6, CFCs, HCFCs, NO, CO, and NMVOCs	Direct Measurement	Manufacturing	Input	**Σ All Gases Released**	Combine all emissions from these gases		4 - Indicator Requiring Formula (> 10 Terms)	Very hard to collect and summarize data for so many chemicals and gases being released	(Wang and Lin, 2004)
68	#	Indicator	Regulatory Non-Compliance **RNC**	Determines how many citations or non-compliance incidents have occurred at a given facility	Governmental Database	Manufacturing	Input	**NCI**	**NCI** noncompliance incidents		1 - Indicator Read Directly from Gauge (No Formula)	Might be hard to compile in one location; based on regulations in place/locality	(Wang and Lin, 2004)
69	#	Indicator	Non-Renewable Resource Consumption Rate **NRRC**	Determines the total amount of non-renewable resources used	Direct Measurement	Manufacturing	Input	**Σ (NRR / RU) x 100**	**NRR** nonrenewable resource consumption, **RU** resource usage		2 - Indicator Requiring Formula (< 5 Terms)	Not all resources are created equal	(Zhou et al., 2000)
70	#	Indicator	Facility Utilization **FUtil**	Determines how effectively a company uses their resources/facilities	Direct Measurement	Manufacturing	Input	**Σ (UF / F) x 100**	**F** total facilities space available, **UF** facilities space used towards production		2 - Indicator Requiring Formula (< 5 Terms)	What space is deemed utilized versus non-utilized	(Zhou et al., 2000)

ID Number	Reviewer	Metric or Indicator	Metric/Indicator Name	Brief Explanation	Data Source	Life Cycle Category	Production Input/Output	Formula (Metrics)	Formula Terms	Included Indicators (Metric)	Complexity	Advantages/Disadvantages	Publication Source ID(s)
71	*	Indicator	Pressure on Environmental Absorptive Capacity **PEAC**	Unit of EI divided by unit of environmental resource absorbing EI	Governmental database	Manufacturing	Output	**EI / ERA**	**ERA** environmental resource absorbing, **EI** environmental impact	N/A	2 - Indicator Requiring Formula (< 5 Terms)		(Ichimura, 2009)
72	#	Metric	Toxin Release Inventory **TRI**	Describes the emissions, discharges, and transfers of chemicals from facilities	Direct Measurement or Gauge	Manufacturing	Input				7 - Metric Comprised of More than 10 Indicators	Many distinct terms go into TRI and aren't all connected	(Sikdar et al., 2007)
73	#	Indicator	Recyclability Rate for Metals **RM**	The amount of metal used in a product that is purely recycled	Product Life Cycle	End of Life Disposal	Output	**Σ (MR / M) x 100**	**M** metals used in production (volume/weight), **MR** metals recycled (volume/weight)		2 - Indicator Requiring Formula (< 5 Terms)	Very hard to collect at end of product life cycle; does not count waste	(Sikdar et al., 2007)
74	#	Indicator	Chemicals in Waste **WC**	The percentage of chemicals used that ends up in production wastes	Direct Measurement or Gauge	Manufacturing	Input	**ChemW/Chem**	**ChemW** number of chemicals in waste (count), **Chem** number of chemicals used (count)		2 - Indicator Requiring Formula (< 5 Terms)	Must measure and calculate at end of process	(Sikdar et al., 2007)
75	#	Indicator	Organic Solvent Usage **OSU**	The percentage of organic solvents used in processes	Direct Measurement or Gauge	Manufacturing	Input	**OrgC/Chem**	**OrgC** number of organic solvents or chemical used (count), **Chem** number of chemicals used (count)		2 - Indicator Requiring Formula (< 5 Terms)	Must measure and calculate at end of process; incurs excess cost	(Sikdar et al., 2007)
76	#	Indicator	Number of Chemicals Used **CU**	A count of the number of chemicals used in a manufacturing process	Direct Measurement	Manufacturing	Input	**Σ Chem**	**Chem** chemicals used (count)		1 - Indicator Read Directly from Gauge (No Formula)	Not always indicative of sustainability	(Sikdar et al., 2007)
77	#	Indicator	Waste Generation **W**	Describes the waste generated by production/transportation process	Direct Measurement	Manufacturing	Input	**Σ W**	**W** weight or volume of waste entering the waste stream		1 - Indicator Read Directly from Gauge (No Formula)	Hard to classify waste versus recycling; difficult to measure	(Zhou et al., 2000); (Wang and Lin, 2004); (Ijomah et al., 2007)

Reviewer Key: # - Jordan, * - Caroline

Appendix B

Cannondale Data

What metrics would you consider the most important to your business? (cost, delivery time, quality, etc.)
Employee 1: Cost (1), Quality (2), Delivery Time (3)
Employee 2: Quality, then Cost

How are suppliers evaluated with regards to their environmental impacts? (transportation, location, quality, previous experience, certifications, awards, accidents)
Employee 1: Not really; many components are imported from off shore locations.
Employee 2: No

On a scale of 1-5, with 5 being the strongest response, what emphasis does Cannondale place on the following elements of Green Supply Chain Management? (Briefly explain each answer)
<u>Green Purchasing</u>
Employee 1: 1
Employee 2: 1 (No consideration of purchasing based on Green products)
<u>Green Manufacturing/Materials Management</u>
Employee 1: 4 (Byproducts are recycled)
Employee 2: 2 (Only consideration is driven by cost avoidance/savings or regulation by government)
<u>Green Distribution/Marketing</u>
Employee 1: 4 (Must provide annual report to corporate for recycle and waste emission)
Employee 2: 2 (Green is marketed by product – bicycles)
<u>Reverse Logistics</u>
Employee 1: 3 (We use recycled products as they are available or practical in our manufacturing process)
Employee 2: 2

Please list the inputs required for production (materials, energy), where they originate, and costs. What inputs originate from the furthest location? What about the closest?
Employee 1: Asian suppliers – Taiwan and Inland China (Lead time = 120 days)
Employee 2: Farthest suppliers are in Asia – produce frames and components. Lead times are approximately 90-120 days. They are selected due to lower costs. Close suppliers are local and provide supplies for repair and maintenance and also office suppliers. They are selected on the basis of cost and availability. Lead times can vary from 1-2 days up to 30 days.

Please list the final outputs/byproducts from production, indicating which outputs are regulated/measured and how the measurement is done (product, waste, emissions, pollution – air, water, noise, heat)
Employee 1: Annually issue reports on hazardous, non-hazardous, and residual waste to state of Pennsylvania. We also report VOC and HAP emissions to the state of Pennsylvania annually.
Employee 2: Air – HAP's/VOC's – measurement based on paint usage. Hazardous waste, Non-hazardous waste, residual waste – Measured in pounds or tons.

What type of data is available about emissions, waste, and recycling at your production facility? Ask for these; but also indicate that as part of your work, you might help them to estimate the ones they are not currently measuring.
Employee 1: Via spreadsheets/computer programs we track and maintain environmental data.
Employee 2: Forms and reports for government are available.

Have you ever heard of the Triple Bottom Line (TBL) approach to product design? If so, how is it employed at Cannondale; Economic (profit), Environmental (planet), Social Welfare (people)
Employee 1: No
Employee 2: No

Have you measured the carbon footprint associated with producing one bicycle? (includes supply chain, production, distribution, etc.)
Employee 1: Not to my knowledge
Employee 2: No

What metrics/factors do you consider the most important when evaluating the effectiveness of your supply chain? (transportation time, stock-out risk, probability distribution of demand, etc.)
Employee 1: Accuracy of forecasts and transportation time
Employee 2: Stock out risk and re-stock time

Which of these metrics/factors account for the environmental impact of the supply chain? (fuels used, method of transportation, transportation distance, etc.)
Employee 1: Method of transportation
Employee 2: Method of transportation and distance

How willing are your customers to pay for improved environmental sustainability in the design and manufacture of the products you sell?
Employee 1: Dealers (Middlemen) – 1; end consumer - 4
Employee 2: 3

Explain how Cannondale eliminates waste (energy, emissions, chemical/hazardous, solid wastes) through reuse, remanufacturing, recycling.
Employee 1: Where practical we recycle
Employee 2: Filtering of fluids for reuse; recycling of scrap materials

How is the environmental impact of your products assessed with regards to the end of the product's life cycle? What cares are taken to reuse or recycle as much of the bike as possible?
Employee 1: Aluminum bike for the most part is recyclable. Carbon fiber is not.
Employee 2: Nothing is stated to the consumer regarding re-use or recycling of products at the end of the life cycle.

How do bicycle owners know how to properly dispose of or recycle bicycles?
Employee 1: Common knowledge
Employee 2: There is nothing I am aware of that would make them aware of properly disposing of bicycles

Use the following table to explain your knowledge of the following sustainability indices and standards. Please indicate which of these are currently enforced or referenced by Cannondale.

Indices	
Ecological Footprint	*Employee 1: No* *Employee 2: Impact of manufacturing process on environment*
Environmental Vulnerability Index	*Employee 1: No* *Employee 2: None*
Standards	
RoHS (Registration of Hazardous Substances)	*Employee 1: Not applicable* *Employee 2: Reviewed and reported by OSHA compliance personnel*
REACH (Registration, Evaluation, Authorization of Chemicals)	*Employee 1: Not applicable* *Employee 2: Reviewed by OHSA/safety personnel*
Energy Star	*Employee 1: Not applicable* *Employee 2: Efficiency rating for appliances/equipment*
JIG-101 (Material Declaration)	*Employee 1: Not applicable* *Employee 2: None*
ISO 14000 (Processes)	*Employee 1: No* *Employee 2: None*
IPC 1752 (Material Declaration)	*Employee 1: No* *Employee 2: None*

Appendix C

Sustainability Survey

Sustainability Performance Management: An Investigation on Potential Metrics

Dear Participant,

As the industry enacts stricter environmental policies to meet the demands of consumers and governmental officials, sustainability in manufacturing and supply chains is becoming a topic of growing concern. Griffith University defines sustainability as "the environmental actions or impacts of what we do. In moving towards sustainability, we are attempting to reduce our ecological footprint and tread more lightly on the Earth. This equates to reducing the amount of resources we use (and buy), the waste we produce, and the emissions we produce." According to the Brundtland Commission, sustainability is "the ability to meet the needs of the present without compromising the needs of future generations." This entails management of natural resources, proper energy usage, and adequate disposal of waste. Many recent strategies for sustainability also focus on product design, life cycle analysis, remanufacturing, and recycling.

With the growing importance of sustainability in today's corporate environment, the ADAPS Group at Penn State is attempting to generate a cost-effective, practical set of metrics through which companies can measure, manage and maintain their environmental sustainability. To this end, we would appreciate your input. In return, we will be happy to share the results of the survey along with the definition and designation of all the metrics studied as per their relevance to product life cycle.

Thank you for your participation.

If you prefer to complete this survey and return it by mail, please address it to:
Dr. Gül Kremer
213Hammond Building
University Park, PA 16802

Jordan Shelton
PSU Graduate Student
jshelton@psu.edu

Ming-Chuan Chiu
PSU Doctoral Candidate
mzc148@psu.edu

Caroline Segard
PSU Visiting Scholar
c.segard46@gmail.com

Section I. Company Profile

a. Please indicate the name of the company you work for (optional)

____

b. Main industry sector (circle all that apply)
   a. Basic Materials
   b. Conglomerates
   c. Consumer Goods
   d. Financial
   e. Healthcare
   f. Industrial Goods
   g. Services
   h. Technology
   i. Utilities

c. Please list the main product lines of your company

____

d. Company size (number of workers).

____

e. Company size (in terms of revenue).

____

f. Location(s) of manufacturing facilities.

____

g. Location of major markets (circle all that apply)
   a. Africa
   b. Asia
   c. Australia/Oceania
   d. Europe
   e. North America
   f. South America

Section II. Respondent Profile

a. How long have you been working for the company?

____

b. What is your current title?

____

c. In what positions have you worked in the past (including other companies)? Circle all that apply
   a. Design
   b. Manufacturing
   c. Logistics
   d. Quality Control
   e. Other (please list) __________________________

d. On a scale of 1-5, how would you rate your knowledge of sustainability?
   (1 – No knowledge, 3 – Average knowledge, 5 – Very knowledgeable)

   1 2 3 4 5

e. On a scale of 1-5, how would you rate your knowledge about the level of activities towards improving sustainability practices in your company?
   (1 – No knowledge, 3 – Average knowledge, 5 – Very knowledgeable)

   1 2 3 4 5

Section III. Energy-Related Metrics

For the following metrics, please complete the table by doing the following:

- Rate the value of each metric in terms of usefulness (1-5, with 5 being more valuable)
- Rate the practicality (cost and time commitment) of implementing/measuring each metric (1-5, with 5 being more practical)
- Indicate the metrics your company is monitoring at this time (1-5, with 5 being highly utilized)
- Would each metric benefit your company if implemented in the future? (1-5, with 5 being more recommended)

Metric (Energy)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Energy Intensity **EInt**	Describes the energy input required for each unit produced	**Σ (EU) / Q**	**EU** energy use (Watts), **Q** units produced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Energy Use **EU**	Sum of all energy used during manufacturing process	**Σ EU**	**EU** energy use (Watts)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Excess Energy Intensity **EEI**	Total excess energy generated during manufacturing processes	**Σ EEG**	**EEG** excess energy generated (Watts)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Life Cycle Energy Intensity **LCEInt**	Sum of all energy consumed during all the phase of the product's life-cycle	**Σ EC**	**EC** energy consumed throughout life cycle (Watts)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Non-Renewable Energy Use **EUNR**	Energy consumed which is supplied by gas, petroleum, electricity, coal or other non-renewable sources	**Σ EUNR**	**EUNR** non-renewable energy use (Watts)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Transportation Energy Intensity **TEInt**	Describes the energy input required for the transportation of each unit	**Σ (EUT) / Q**	**EUT** transportation energy use (Watts), **Q** units produced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Section IV. Water-Related Metrics

For the following metrics, please complete the table following the same guidelines as previous sections.

Metric (Water)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Core Water Intensity **CWI**	Water used divided by units produced	**Σ WI / Q**	**WI** water used (volume), **Q** units produced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Eutrophication **EUT**	Determines manufacturing process's effect on water	**Σ EUT**	**EUT** PO4 equivalents released (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Water Discharge Intensity **WDI**	Water discharged divided by units production	**Σ WD / Q**	**WD** water discharged (volume), **Q** units produced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Water Pollution **WP**	Ratio of polluted water divided by total water emitted	**Σ (PW/WE) x 100**	**PW** polluted water (volume), **WE** total water emission (volume)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Water Quality **WQ**	Physical, chemical and biological characteristics of water	**Σ WQ**	**WQ** water quality	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Water Usage **WU**	Measurement of the water used or affected for withdrawal, consumptive, and non-withdrawal; both surface and non-surface	**Σ WU**	**WU** water used (volume)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Water Waste Intensity **WInt**	Quantity of emission of polluted water divided by units produced	**Σ PW / Q**	**PW** polluted water (volume), **Q** units produced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Section V. Resource-Related Metrics

For the following metrics, please complete the table following the same guidelines as previous sections.

Metric (Resource)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Facility Utilization **FUtil**	Determines how effectively a company uses their resources/facilities	**Σ (UF / F) x 100**	**F** total facilities space available, **UF** facilities space used towards production	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Import Percentage **IP**	Determines the amount of raw materials imported from outside a geographic region	**(Σ (IR) / NR) x 100**	**IR** count of imported resources, **NR** number of resources used on product	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Land Use **LU**	Describes the land used by a particular firm in the production of product	**Σ L**	**L** land used/occupied/transformed by corporation (m^2 or km^2)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Material Use **MU**	The number of different types of raw materials used	**Σ MU**	**MU** materials used (count, volume)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Mineral Reserves Used **MR**	Measures the amount of minerals used	**MR**	**MR** coal equivalents used (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Non-Renewable Resource Consumption Rate **NRRC**	Determines the total amount of non-renewable resources used	**Σ (NRR / RU) x 100**	**NRR** nonrenewable resource consumption, **RU** resource usage	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Number of Chemicals Used **CU**	A count of the number of chemicals used in a manufacturing process	**Σ Chem**	**Chem** chemicals used (count)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Metric (Resource Ctd)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Organic Solvent Usage **OSU**	The percentage of organic solvents used in processes	**OrgC/Chem**	**OrgC** number of organic solvents or chemical used (count), **Chem** number of chemicals used (count)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Rate of Resource Saving **RS**	Unit of environmental benefit divided by unit of value creation	**EB / VC**	**EB** environmental benefit, **VC** value creation by a firm	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Resource Consumption **RC**	Materials used to make products and packaging (minerals and metals, primary and recycled sources)	**Σ RC**	**RC** resources consumed (units, volume, or weight)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Resource Efficiency **RE**	Ratio of useful material output divided by material input	**Σ (UMO / MI) x 100**	**UMO** useful material output (units, volume, or weight), **MI** material input (units, volume, or weight)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Resource Productivity **RP**	Value rating of suppliers	**P / EI**	**P** production rate, **El** environmental Impact	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Resource Sustainability **RS**	Determines sustainability of resources used on a product are; how long is the resource expected to be available on Earth before depletion	**Σ (IRS) / NR**	**IRS** resource availability of individual product, **NR** num. of resources used on product	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Resource Use **RU**	Total resources used	**Σ EU + WU + MU**	**EU** energy use (Watts), **WU** water used (volume), **MU** materials used (count/volume)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Travel Distance **TD**	Distance traveled between factory and end consumer	**Σ TD**	**TD** total distance traveled by product	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Section VI. Pollution/Emission-Related Metrics

For the following metrics, please complete the table following the same guidelines as previous sections.

Metric (Pollution)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Air pollution (SO2, NO2) **AP**	Ratio of pollutant gas emission divided by total of gas emissions	**Σ (PE / GE) x 100**	**PE** pollutant gas emission (kg), **GE** total gas emission (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Byproducts Produced **BP**	Count of the number of byproducts produced	**Σ BP**	**BP** number of byproducts produced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Carbon Dioxide Emissions **CO2**	A measure of the Carbon Dioxide released by a process	**Σ CO2**	**CO2** carbon dioxide equivalents released (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Chemicals in Waste **WC**	The percentage of chemicals used that ends up in production wastes	**ChemW/Chem**	**ChemW** number of chemicals in waste (count), **Chem** number of chemicals used (count)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Percent of Solid Waste **PSW**	Quantity of solid in waste divided by quantity of solid use	**Σ (SiW / SU) x 100**	**SW** total units/volume of solid waste, **SU** total units/volume of solid used	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Recycling/Reuse Rate **RRR**	Rate of resource recovery involving collection and treatment of a waste product for use as a raw material	**Σ (RR / RU) x 100**	**RR** reused/recycled resources, **RU** resource use	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Recyclability Rate for Metals **RM**	The amount of metal used in a product that is purely recycled	**Σ (MR / M) x 100**	**M** metals used in production (volume/weight), **MR** metals recycled (volume/weight)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Metric (Pollution Ctd)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Solid Waste Reuse Rate **SWRR**	The rate of using a product or component of solid waste in its original form more than once	**Σ (SWR / SW) x 100**	**RSW** units/volume of reused solid waste, **SW** total units of solid/volume waste	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Solid Waste **SW**	Amount of solid waste created	**Σ SW**	**SW** total units/volume of solid waste	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Transportation Emissions per Unit **TE**	Emissions into the atmosphere associated with transportation per unit product produced	**Σ (TE) / Q**	**TE** emissions from transport of products (volume/kg), **Q** units produced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Waste Generation **W**	Describes the waste generated by production/transportation process	**Σ W**	**W** weight or volume of waste entering the waste stream	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Waste Utilization **WU**	Ratio of Waste utilized divided by total waste output	**Σ (RW / WW + WR) x 100**	**RW** reused waste, **WR** wasted material resources, **WW** waterborne waste	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Section IV. Environmental-Related Metrics

For the following metrics, please complete the table following the same guidelines as previous sections.

Metric (Environ.)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Acidification Potential **AP**	Measures regional air quality through kg of SO_2 equivalents	**Σ SO_2**	**SO_2** SO_2 equivalents released (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Carbon Footprint **CF**	Total amount of CO_2 and other greenhouse gases, emitted over the full life cycle of a process	**Σ CO_2**	**CO_2** carbon dioxide equivalents released (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Carbon Intensity **CInt**	Amount of carbon by weight emitted per unit of energy consumed	**Σ CE / EU**	**CE** quantity of carbon emitted, **EU** energy use (Watts)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Ecological Toxicity **ET**	The degree to which substances used are harmful to the environment	**Σ Pb**	**Pb** Pb equivalents released (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Greenhouse Gas Emission **GGE**	Anthropogenic emissions of CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, CFCs, HCFCs, NO, CO, and NMVOCs	**Σ All Gases Released**	Combine all emissions from these gases	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Ozone Depletion **OZ**	Amount of chemicals used with ozone depleting potential or more specifically, kg of CFC-11 equivalents released	**Σ Ochem or Σ CFC**	**Ochem** number of ozone depleting chemicals used; **CFC** CFC-11 equivalents released (kg)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Photochemical ozone creation potential **OCP**	Measures regional air quality through kg O_3 equivalents	**Σ O_3**	**O_3** O_3 possibly created kg	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Metric (Environ. Ctd)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Pollution Plume Dispersion **PPD**	Determines how many people are exposed to an emission	**Σ ExpInd**	**ExpInd** count of the number of individuals exposed to a plume of pollution on a daily basis	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Section VII. Technique/Practice-Related Metrics

For the following metrics, please complete the table following the same guidelines as previous sections.

Metric (Practice)	Brief Description	Formula	Relevant Terms	Metric Value	Metric Practicality	Used in Practice	Suggested for Future
Eco-efficiency **EE**	Quantifies environmental impact, resource productivity, and eco-efficiency in a firm	**β / EI (= 1 / EI*)**	**EE** eco-efficiency, **β** value ratio for a firm, **EI** environmental Impact, **EI*** adjusted environmental impact	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
End of Life Recovery Process **EOLR**	Is a clear end of life recovery process in place and defined?	Yes/No		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Environmental Impact **EI**	The EI quantitatively as a single dimensionless number	**Σ EI Supply + EI Output**	**EI Supply** environmental impact of raw/supplied materials; **EI Output** environmental impact of produced materials and waste	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lean Production Techniques **LPT**	Are lean and quality control techniques used to minimize waste?	Yes/No		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Product Life Extension **PLE**	Is there a way to extend the life of the product once its initial life is over?	Yes/No		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Regulatory Non-Compliance **RNC**	Determines how many citations or non-compliance incidents have occurred at a given facility	**NCI**	**NCI** noncompliance incidents	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Metric (Practice Ctd)	**Brief Description**	**Formula**	**Relevant Terms**	**Metric Value**	**Metric Practicality**	**Used in Practice**	**Suggested for Future**
Value ratio for a firm **β**	Value ratio	**V / VC**	**Vr** reference firm value, **VC** value creation by firm	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Section VIII. Additional Metrics

Please list and/or describe any additional metrics your company is currently monitoring or any practices that are being taken to improve sustainability

Section IX. Request for Results

Thank you again for your participation and time. ***Please contact our research team if you would like more information or if you have additional qualified personnel who would like to participate in this study.***

Would you like to receive the compiled list of metrics resulting from this survey and research? This information will not be associated with your unique survey results for the purpose of confidentiality.

________ Yes ________ No

Name/Address/E-Mail (If yes only)

____

____

____

____

Appendix D

Sustainability Survey Results

The following data sets represent the averages for each metric, for each of the 5 questions posed to respondents in the sustainability survey. Only summary data has been presented to protect the privacy of respondents.

Used in Practice		
OCP	Environment	2.750
EUT	Water	2.647
AcP	Environment	2.618
EE	Technique/Process	2.603
TE	Pollution	2.588
Wint	Water	2.559
Cint	Environment	2.559
OZ	Environment	2.559
RM	Pollution	2.529
WsU	Pollution	2.529
PPD	Environment	2.529
TEInt	Energy	2.515
Beta	Technique/Process	2.515
EEI	Energy	2.500
PLE	Technique/Process	2.500
MR	Resources	2.485
LCEInt	Energy	2.471
BP	Pollution	2.471
SWRR	Pollution	2.471
GGE	Environment	2.471
EOLR	Technique/Process	2.471
PSW	Pollution	2.456
WP	Water	2.441
LU	Resources	2.441
ET	Environment	2.426
WDI	Water	2.412
RS	Resources	2.412
OSU	Resources	2.397
RRS	Resources	2.397
CWI	Water	2.353
NRRC	Resources	2.353
WQ	Water	2.324
IP	Resources	2.324
EI	Resources	2.324
RP	Resources	2.324
W	Pollution	2.324
TD	Resources	2.309
WC	Pollution	2.309
SW	Pollution	2.294
Eint	Energy	2.250
EUNR	Energy	2.250
CF	Environment	2.250
RE	Resources	2.235
AP	Pollution	2.221
WU	Water	2.176
CU	Resources	2.162
RU	Resources	2.162
RC	Resources	2.132
RRR	Pollution	2.118
Futil	Resources	2.088
RNC	Technique/Process	2.074
MU	Resources	2.059
CO2	Pollution	2.059
LPT	Technique/Process	2.059
EU	Energy	1.912

Value		
EU	Energy	3.750
CO2	Pollution	3.721
CF	Environment	3.721
RRR	Pollution	3.603
LPT	Technique/Process	3.603
Futil	Resources	3.574
RU	Resources	3.544
GGE	Environment	3.529
Eint	Energy	3.471
AP	Pollution	3.426
EUNR	Energy	3.397
ET	Environment	3.397
RE	Resources	3.353
RP	Resources	3.353
RS	Resources	3.338
LCEInt	Energy	3.324
MU	Resources	3.294
SW	Pollution	3.279
CU	Resources	3.265
RNC	Technique/Process	3.250
EEI	Energy	3.235
CWI	Water	3.176
WP	Water	3.176
TEInt	Energy	3.162
WC	Pollution	3.147
OZ	Environment	3.147
RC	Resources	3.132
NRRC	Resources	3.088
TD	Resources	3.088
IP	Resources	3.074
WQ	Water	3.059
Wint	Water	3.059
W	Pollution	3.059
WDI	Water	3.044
RM	Pollution	3.044
WU	Water	3.029
Cint	Environment	3.029
EOLR	Technique/Process	3.015
PLE	Technique/Process	3.000
EE	Technique/Process	2.971
PSW	Pollution	2.956
PPD	Environment	2.956
EI	Resources	2.912
Beta	Technique/Process	2.912
BP	Pollution	2.897
TE	Pollution	2.897
RRS	Resources	2.882
WsU	Pollution	2.882
MR	Resources	2.824
OSU	Resources	2.824
SWRR	Pollution	2.824
EUT	Water	2.779
AcP	Environment	2.765
OCP	Environment	2.735
LU	Resources	2.691

Practicality/Feasibility		
EU	Energy	3.632
CF	Environment	3.588
CO2	Pollution	3.500
LPT	Technique/Process	3.485
MU	Resources	3.338
AP	Pollution	3.338
CU	Resources	3.294
RC	Resources	3.294
Futil	Resources	3.279
RU	Resources	3.279
RNC	Technique/Process	3.279
RRR	Pollution	3.250
RE	Resources	3.235
RS	Resources	3.221
TD	Resources	3.191
GGE	Environment	3.162
RP	Resources	3.147
Eint	Energy	3.132
EUNR	Energy	3.132
IP	Resources	3.132
WU	Water	3.044
SW	Pollution	3.044
Cint	Environment	3.044
NRRC	Resources	3.015
W	Pollution	2.985
CWI	Water	2.971
WC	Pollution	2.971
RM	Pollution	2.956
ET	Environment	2.941
OSU	Resources	2.926
WDI	Water	2.912
WP	Water	2.912
PSW	Pollution	2.897
LU	Resources	2.868
Beta	Technique/Process	2.868
OZ	Environment	2.853
TEInt	Energy	2.838
MR	Resources	2.838
EI	Resources	2.824
SWRR	Pollution	2.824
WsU	Pollution	2.824
EOLR	Technique/Process	2.824
BP	Pollution	2.809
TE	Pollution	2.809
LCEInt	Energy	2.735
WQ	Water	2.721
PPD	Environment	2.721
EEI	Energy	2.706
AcP	Environment	2.676
PLE	Technique/Process	2.676
Wint	Water	2.662
RRS	Resources	2.662
EE	Technique/Process	2.647
OCP	Environment	2.559
EUT	Water	2.471

Suggested for Future Use		
OCP	Environment	1.647
PPD	Environment	1.618
AcP	Environment	1.603
Wint	Water	1.588
Cint	Environment	1.574
WsU	Pollution	1.559
Beta	Technique/Process	1.559
PLE	Technique/Process	1.559
EUT	Water	1.544
WQ	Water	1.544
LU	Resources	1.544
MR	Resources	1.544
SWRR	Pollution	1.544
EE	Technique/Process	1.544
EOLR	Technique/Process	1.544
WP	Water	1.529
EI	Resources	1.529
OZ	Environment	1.529
BP	Pollution	1.515
PSW	Pollution	1.515
EEI	Energy	1.500
LCEInt	Energy	1.500
WDI	Water	1.500
RRS	Resources	1.500
RP	Resources	1.500
TE	Pollution	1.500
NRRC	Resources	1.485
WC	Pollution	1.485
RM	Pollution	1.485
ET	Environment	1.485
EUNR	Energy	1.471
WU	Water	1.471
CWI	Water	1.456
IP	Resources	1.456
OSU	Resources	1.456
CU	Resources	1.426
RC	Resources	1.426
TD	Resources	1.426
GGE	Environment	1.426
RNC	Technique/Process	1.426
TEInt	Energy	1.412
RE	Resources	1.412
RS	Resources	1.412
AP	Pollution	1.412
SW	Pollution	1.412
CF	Environment	1.412
CO2	Pollution	1.397
MU	Resources	1.368
RU	Resources	1.368
W	Pollution	1.368
Futil	Resources	1.353
RRR	Pollution	1.324
Eint	Energy	1.309
LPT	Technique/Process	1.265
EU	Energy	1.221

Average Across All Categories		
CF	Environment	2.743
CO2	Pollution	2.669
GGE	Environment	2.647
EU	Energy	2.629
LPT	Technique/Process	2.603
AP	Pollution	2.599
RS	Resources	2.596
RU	Resources	2.588
RP	Resources	2.581
Futil	Resources	2.574
RRR	Pollution	2.574
EUNR	Energy	2.563
ET	Environment	2.563
RE	Resources	2.559
Cint	Environment	2.551
Eint	Energy	2.540
CU	Resources	2.537
OZ	Environment	2.522
WP	Water	2.515
MU	Resources	2.515
LCEInt	Energy	2.507
SW	Pollution	2.507
RNC	Technique/Process	2.507
TD	Resources	2.504
RM	Pollution	2.504
IP	Resources	2.496
RC	Resources	2.496
CWI	Water	2.489
EEI	Energy	2.485
NRRC	Resources	2.485
TEInt	Energy	2.482
WC	Pollution	2.478
WDI	Water	2.467
Wint	Water	2.467
WsU	Pollution	2.467
Beta	Technique/Process	2.463
EOLR	Technique/Process	2.463
PSW	Pollution	2.456
PPD	Environment	2.456
TE	Pollution	2.449
EE	Technique/Process	2.441
W	Pollution	2.434
PLE	Technique/Process	2.434
WU	Water	2.430
SWRR	Pollution	2.429
MR	Resources	2.423
BP	Pollution	2.423
OCP	Environment	2.423
AcP	Environment	2.415
WQ	Water	2.412
OSU	Resources	2.401
EI	Resources	2.397
LU	Resources	2.386
EUT	Water	2.360
RRS	Resources	2.360

Appendix E

ANOVA Results

General Linear Model: Use Value versus Response, Metric Group, Metric (ANOVA 1)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric Group	fixed	6	Energy, Environment, Pollution, Resources, Technique/Process, Water
Metric(Metric Group)	fixed	55	EEI, Eint, EU, EUNR, LCEInt, TEInt, AcP, CF, Cint, ET, GGE, OCP, OZ, PPD, AP, BP, CO2, PSW, RM, RRR, SW, SWRR, TE, W, WC, WsU, CU, EI, Futil, IP, LU, MR, MU, NRRC, OSU, RC, RE, RP, RRS, RS, RU, TD, Beta, EE, EOLR, LPT, PLE, RNC, CWI, EUT, WDI, Wint, WP, WQ, WU

Analysis of Variance for Use Value, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	1310.022	1310.022	19.553	41.19	0.000
Metric Group	5	21.822	21.822	4.364	9.20	0.000
Metric(Metric Group)	49	97.350	97.350	1.987	4.19	0.000
Error	3618	1717.228	1717.228	0.475		
Total	3739	3146.422				

S = 0.688937   R-Sq = 45.42%   R-Sq(adj) = 43.60%

Tukey Simultaneous Tests
Response Variable Use Value
All Pairwise Comparisons among Levels of Metric(Metric Group)
Metric Group = Energy
Metric = EEI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	Eint	-0.2500	0.1182	-2.116	0.9985
Energy	EU	-0.5882	0.1182	-4.979	0.0010
Energy	EUNR	-0.2500	0.1182	-2.116	0.9985
Energy	LCEInt	-0.0294	0.1182	-0.249	1.0000
Energy	TEInt	0.0147	0.1182	0.124	1.0000

Metric Group = Energy
Metric = Eint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EU	-0.3382	0.1182	-2.863	0.7873
Energy	EUNR	-0.0000	0.1182	-0.000	1.0000
Energy	LCEInt	0.2206	0.1182	1.867	0.9999
Energy	TEInt	0.2647	0.1182	2.240	0.9947

Metric Group = Energy
Metric = EU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EUNR	0.3382	0.1182	2.863	0.7873
Energy	LCEInt	0.5588	0.1182	4.730	0.0030
Energy	TEInt	0.6029	0.1182	5.103	0.0006

Metric Group = Energy
Metric = EUNR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	LCEInt	0.2206	0.1182	1.867	0.9999
Energy	TEInt	0.2647	0.1182	2.240	0.9947

Metric Group = Energy
Metric = LCEInt subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	TEInt	0.0441	0.1182	0.373	1.0000

Metric Group = Environment
Metric = AcP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	CF	-0.3676	0.1182	-3.112	0.5788
Environment	Cint	-0.0588	0.1182	-0.498	1.0000
Environment	ET	-0.1912	0.1182	-1.618	1.0000
Environment	GGE	-0.1471	0.1182	-1.245	1.0000
Environment	OCP	0.1324	0.1182	1.120	1.0000
Environment	OZ	-0.0588	0.1182	-0.498	1.0000
Environment	PPD	-0.0882	0.1182	-0.747	1.0000

Metric Group = Environment
Metric = CF subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	Cint	0.3088	0.1182	2.614	0.9268
Environment	ET	0.1765	0.1182	1.494	1.0000
Environment	GGE	0.2206	0.1182	1.867	0.9999
Environment	OCP	0.5000	0.1182	4.232	0.0242
Environment	OZ	0.3088	0.1182	2.614	0.9268
Environment	PPD	0.2794	0.1182	2.365	0.9848

Metric Group = Environment
Metric = Cint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	ET	-0.1324	0.1182	-1.120	1.0000
Environment	GGE	-0.0882	0.1182	-0.747	1.0000
Environment	OCP	0.1912	0.1182	1.618	1.0000
Environment	OZ	0.0000	0.1182	0.000	1.0000
Environment	PPD	-0.0294	0.1182	-0.249	1.0000

Metric Group = Environment
Metric = ET subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	GGE	0.0441	0.1182	0.373	1.0000
Environment	OCP	0.3235	0.1182	2.738	0.8681
Environment	OZ	0.1324	0.1182	1.120	1.0000
Environment	PPD	0.1029	0.1182	0.871	1.0000

Metric Group = Environment
Metric = GGE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OCP	0.2794	0.1182	2.365	0.9848
Environment	OZ	0.0882	0.1182	0.747	1.0000
Environment	PPD	0.0588	0.1182	0.498	1.0000

Metric Group = Environment
Metric = OCP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OZ	-0.1912	0.1182	-1.618	1.0000
Environment	PPD	-0.2206	0.1182	-1.867	0.9999

Metric Group = Environment
Metric = OZ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	PPD	-0.0294	0.1182	-0.249	1.0000

Metric Group = Pollution
Metric = AP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	BP	0.2500	0.1182	2.116	0.9985
Pollution	CO2	-0.1618	0.1182	-1.369	1.0000
Pollution	PSW	0.2353	0.1182	1.991	0.9997
Pollution	RM	0.3088	0.1182	2.614	0.9268
Pollution	RRR	-0.1029	0.1182	-0.871	1.0000
Pollution	SW	0.0735	0.1182	0.622	1.0000
Pollution	SWRR	0.2500	0.1182	2.116	0.9985
Pollution	TE	0.3676	0.1182	3.112	0.5788
Pollution	W	0.1029	0.1182	0.871	1.0000
Pollution	WC	0.0882	0.1182	0.747	1.0000
Pollution	WsU	0.3088	0.1182	2.614	0.9268

Metric Group = Pollution
Metric = BP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	CO2	-0.4118	0.1182	-3.485	0.2717
Pollution	PSW	-0.0147	0.1182	-0.124	1.0000
Pollution	RM	0.0588	0.1182	0.498	1.0000
Pollution	RRR	-0.3529	0.1182	-2.987	0.6884
Pollution	SW	-0.1765	0.1182	-1.494	1.0000
Pollution	SWRR	0.0000	0.1182	0.000	1.0000
Pollution	TE	0.1176	0.1182	0.996	1.0000
Pollution	W	-0.1471	0.1182	-1.245	1.0000
Pollution	WC	-0.1618	0.1182	-1.369	1.0000
Pollution	WsU	0.0588	0.1182	0.498	1.0000

Metric Group = Pollution
Metric = CO2 subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	PSW	0.397059	0.1182	3.36058	0.3633
Pollution	RM	0.470588	0.1182	3.98291	0.0607
Pollution	RRR	0.058824	0.1182	0.49786	1.0000
Pollution	SW	0.235294	0.1182	1.99146	0.9997
Pollution	SWRR	0.411765	0.1182	3.48505	0.2717
Pollution	TE	0.529412	0.1182	4.48078	0.0088
Pollution	W	0.264706	0.1182	2.24039	0.9947
Pollution	WC	0.250000	0.1182	2.11592	0.9985
Pollution	WsU	0.470588	0.1182	3.98291	0.0607

Metric Group = Pollution
Metric = PSW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RM	0.0735	0.1182	0.622	1.0000
Pollution	RRR	-0.3382	0.1182	-2.863	0.7873
Pollution	SW	-0.1618	0.1182	-1.369	1.0000
Pollution	SWRR	0.0147	0.1182	0.124	1.0000
Pollution	TE	0.1324	0.1182	1.120	1.0000
Pollution	W	-0.1324	0.1182	-1.120	1.0000
Pollution	WC	-0.1471	0.1182	-1.245	1.0000
Pollution	WsU	0.0735	0.1182	0.622	1.0000

Metric Group = Pollution
Metric = RM subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RRR	-0.4118	0.1182	-3.485	0.2717
Pollution	SW	-0.2353	0.1182	-1.991	0.9997
Pollution	SWRR	-0.0588	0.1182	-0.498	1.0000

Pollution	TE	0.0588	0.1182	0.498	1.0000
Pollution	W	-0.2059	0.1182	-1.743	1.0000
Pollution	WC	-0.2206	0.1182	-1.867	0.9999
Pollution	WsU	-0.0000	0.1182	-0.000	1.0000

Metric Group = Pollution
Metric = RRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SW	0.17647	0.1182	1.4936	1.0000
Pollution	SWRR	0.35294	0.1182	2.9872	0.6884
Pollution	TE	0.47059	0.1182	3.9829	0.0607
Pollution	W	0.20588	0.1182	1.7425	1.0000
Pollution	WC	0.19118	0.1182	1.6181	1.0000
Pollution	WsU	0.41176	0.1182	3.4850	0.2717

Metric Group = Pollution
Metric = SW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SWRR	0.1765	0.1182	1.494	1.0000
Pollution	TE	0.2941	0.1182	2.489	0.9641
Pollution	W	0.0294	0.1182	0.249	1.0000
Pollution	WC	0.0147	0.1182	0.124	1.0000
Pollution	WsU	0.2353	0.1182	1.991	0.9997

Metric Group = Pollution
Metric = SWRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	TE	0.1176	0.1182	0.996	1.0000
Pollution	W	-0.1471	0.1182	-1.245	1.0000
Pollution	WC	-0.1618	0.1182	-1.369	1.0000
Pollution	WsU	0.0588	0.1182	0.498	1.0000

Metric Group = Pollution
Metric = TE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	W	-0.2647	0.1182	-2.240	0.9947
Pollution	WC	-0.2794	0.1182	-2.365	0.9848
Pollution	WsU	-0.0588	0.1182	-0.498	1.0000

Metric Group = Pollution
Metric = W subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WC	-0.0147	0.1182	-0.124	1.0000
Pollution	WsU	0.2059	0.1182	1.743	1.0000

Metric Group = Pollution
Metric = WC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WsU	0.2206	0.1182	1.867	0.9999

Metric Group = Resources
Metric = CU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	EI	0.1618	0.1182	1.3691	1.0000
Resources	Futil	-0.0735	0.1182	-0.6223	1.0000
Resources	IP	0.1618	0.1182	1.3691	1.0000
Resources	LU	0.2794	0.1182	2.3649	0.9848
Resources	MR	0.3235	0.1182	2.7383	0.8681
Resources	MU	-0.1029	0.1182	-0.8713	1.0000
Resources	NRRC	0.1912	0.1182	1.6181	1.0000
Resources	OSU	0.2353	0.1182	1.9915	0.9997
Resources	RC	-0.0294	0.1182	-0.2489	1.0000
Resources	RE	0.0735	0.1182	0.6223	1.0000
Resources	RP	0.1618	0.1182	1.3691	1.0000
Resources	RRS	0.2353	0.1182	1.9915	0.9997
Resources	RS	0.2500	0.1182	2.1159	0.9985
Resources	RU	-0.0000	0.1182	-0.0000	1.0000
Resources	TD	0.1471	0.1182	1.2447	1.0000

Metric Group = Resources
Metric = EI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	Futil	-0.2353	0.1182	-1.991	0.9997
Resources	IP	-0.0000	0.1182	-0.000	1.0000
Resources	LU	0.1176	0.1182	0.996	1.0000
Resources	MR	0.1618	0.1182	1.369	1.0000
Resources	MU	-0.2647	0.1182	-2.240	0.9947
Resources	NRRC	0.0294	0.1182	0.249	1.0000
Resources	OSU	0.0735	0.1182	0.622	1.0000
Resources	RC	-0.1912	0.1182	-1.618	1.0000
Resources	RE	-0.0882	0.1182	-0.747	1.0000
Resources	RP	-0.0000	0.1182	-0.000	1.0000
Resources	RRS	0.0735	0.1182	0.622	1.0000
Resources	RS	0.0882	0.1182	0.747	1.0000
Resources	RU	-0.1618	0.1182	-1.369	1.0000
Resources	TD	-0.0147	0.1182	-0.124	1.0000

Metric Group = Resources
Metric = Futil subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	IP	0.23529	0.1182	1.9915	0.9997
Resources	LU	0.35294	0.1182	2.9872	0.6884
Resources	MR	0.39706	0.1182	3.3606	0.3633
Resources	MU	-0.02941	0.1182	-0.2489	1.0000
Resources	NRRC	0.26471	0.1182	2.2404	0.9947
Resources	OSU	0.30882	0.1182	2.6138	0.9268
Resources	RC	0.04412	0.1182	0.3734	1.0000
Resources	RE	0.14706	0.1182	1.2447	1.0000
Resources	RP	0.23529	0.1182	1.9915	0.9997
Resources	RRS	0.30882	0.1182	2.6138	0.9268
Resources	RS	0.32353	0.1182	2.7383	0.8681
Resources	RU	0.07353	0.1182	0.6223	1.0000
Resources	TD	0.22059	0.1182	1.8670	0.9999

Metric Group = Resources
Metric = IP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	LU	0.1176	0.1182	0.996	1.0000
Resources	MR	0.1618	0.1182	1.369	1.0000
Resources	MU	-0.2647	0.1182	-2.240	0.9947
Resources	NRRC	0.0294	0.1182	0.249	1.0000
Resources	OSU	0.0735	0.1182	0.622	1.0000
Resources	RC	-0.1912	0.1182	-1.618	1.0000
Resources	RE	-0.0882	0.1182	-0.747	1.0000
Resources	RP	0.0000	0.1182	0.000	1.0000
Resources	RRS	0.0735	0.1182	0.622	1.0000
Resources	RS	0.0882	0.1182	0.747	1.0000
Resources	RU	-0.1618	0.1182	-1.369	1.0000
Resources	TD	-0.0147	0.1182	-0.124	1.0000

Metric Group = Resources
Metric = LU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MR	0.0441	0.1182	0.373	1.0000
Resources	MU	-0.3824	0.1182	-3.236	0.4677
Resources	NRRC	-0.0882	0.1182	-0.747	1.0000
Resources	OSU	-0.0441	0.1182	-0.373	1.0000
Resources	RC	-0.3088	0.1182	-2.614	0.9268
Resources	RE	-0.2059	0.1182	-1.743	1.0000
Resources	RP	-0.1176	0.1182	-0.996	1.0000
Resources	RRS	-0.0441	0.1182	-0.373	1.0000
Resources	RS	-0.0294	0.1182	-0.249	1.0000
Resources	RU	-0.2794	0.1182	-2.365	0.9848
Resources	TD	-0.1324	0.1182	-1.120	1.0000

Metric Group = Resources
Metric = MR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MU	-0.4265	0.1182	-3.610	0.1961
Resources	NRRC	-0.1324	0.1182	-1.120	1.0000
Resources	OSU	-0.0882	0.1182	-0.747	1.0000
Resources	RC	-0.3529	0.1182	-2.987	0.6884
Resources	RE	-0.2500	0.1182	-2.116	0.9985
Resources	RP	-0.1618	0.1182	-1.369	1.0000
Resources	RRS	-0.0882	0.1182	-0.747	1.0000
Resources	RS	-0.0735	0.1182	-0.622	1.0000
Resources	RU	-0.3235	0.1182	-2.738	0.8681
Resources	TD	-0.1765	0.1182	-1.494	1.0000

Metric Group = Resources
Metric = MU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	NRRC	0.294118	0.1182	2.48932	0.9641
Resources	OSU	0.338235	0.1182	2.86272	0.7873
Resources	RC	0.073529	0.1182	0.62233	1.0000
Resources	RE	0.176471	0.1182	1.49359	1.0000
Resources	RP	0.264706	0.1182	2.24039	0.9947
Resources	RRS	0.338235	0.1182	2.86272	0.7873
Resources	RS	0.352941	0.1182	2.98718	0.6884
Resources	RU	0.102941	0.1182	0.87126	1.0000
Resources	TD	0.250000	0.1182	2.11592	0.9985

Metric Group = Resources
Metric = NRRC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	OSU	0.0441	0.1182	0.373	1.0000
Resources	RC	-0.2206	0.1182	-1.867	0.9999
Resources	RE	-0.1176	0.1182	-0.996	1.0000
Resources	RP	-0.0294	0.1182	-0.249	1.0000
Resources	RRS	0.0441	0.1182	0.373	1.0000
Resources	RS	0.0588	0.1182	0.498	1.0000
Resources	RU	-0.1912	0.1182	-1.618	1.0000
Resources	TD	-0.0441	0.1182	-0.373	1.0000

Metric Group = Resources
Metric = OSU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RC	-0.2647	0.1182	-2.240	0.9947
Resources	RE	-0.1618	0.1182	-1.369	1.0000
Resources	RP	-0.0735	0.1182	-0.622	1.0000
Resources	RRS	0.0000	0.1182	0.000	1.0000
Resources	RS	0.0147	0.1182	0.124	1.0000
Resources	RU	-0.2353	0.1182	-1.991	0.9997
Resources	TD	-0.0882	0.1182	-0.747	1.0000

Metric Group = Resources
Metric = RC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RE	0.10294	0.1182	0.8713	1.0000
Resources	RP	0.19118	0.1182	1.6181	1.0000
Resources	RRS	0.26471	0.1182	2.2404	0.9947
Resources	RS	0.27941	0.1182	2.3649	0.9848
Resources	RU	0.02941	0.1182	0.2489	1.0000
Resources	TD	0.17647	0.1182	1.4936	1.0000

Metric Group = Resources
Metric = RE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RP	0.0882	0.1182	0.747	1.0000
Resources	RRS	0.1618	0.1182	1.369	1.0000
Resources	RS	0.1765	0.1182	1.494	1.0000
Resources	RU	-0.0735	0.1182	-0.622	1.0000
Resources	TD	0.0735	0.1182	0.622	1.0000

Metric Group = Resources
Metric = RP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RRS	0.0735	0.1182	0.622	1.0000
Resources	RS	0.0882	0.1182	0.747	1.0000
Resources	RU	-0.1618	0.1182	-1.369	1.0000
Resources	TD	-0.0147	0.1182	-0.124	1.0000

Metric Group = Resources
Metric = RRS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RS	0.0147	0.1182	0.124	1.0000
Resources	RU	-0.2353	0.1182	-1.991	0.9997
Resources	TD	-0.0882	0.1182	-0.747	1.0000

Metric Group = Resources
Metric = RS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RU	-0.2500	0.1182	-2.116	0.9985
Resources	TD	-0.1029	0.1182	-0.871	1.0000

Metric Group = Resources
Metric = RU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	TD	0.1471	0.1182	1.2447	1.0000

Metric Group = Technique/Process
Metric = Beta subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EE	0.0882	0.1182	0.747	1.0000
Technique/Process	EOLR	-0.0441	0.1182	-0.373	1.0000
Technique/Process	LPT	-0.4559	0.1182	-3.858	0.0925
Technique/Process	PLE	-0.0147	0.1182	-0.124	1.0000
Technique/Process	RNC	-0.4412	0.1182	-3.734	0.1368

Metric Group = Technique/Process
Metric = EE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EOLR	-0.1324	0.1182	-1.120	1.0000
Technique/Process	LPT	-0.5441	0.1182	-4.605	0.0052
Technique/Process	PLE	-0.1029	0.1182	-0.871	1.0000
Technique/Process	RNC	-0.5294	0.1182	-4.481	0.0088

Metric Group = Technique/Process
Metric = EOLR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	LPT	-0.4118	0.1182	-3.485	0.2717
Technique/Process	PLE	0.0294	0.1182	0.249	1.0000
Technique/Process	RNC	-0.3971	0.1182	-3.361	0.3633

Metric Group = Technique/Process
Metric = LPT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	PLE	0.44118	0.1182	3.7340	0.1368
Technique/Process	RNC	0.01471	0.1182	0.1245	1.0000

Metric Group = Technique/Process
Metric = PLE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	RNC	-0.4265	0.1182	-3.610	0.1961

Metric Group = Water
Metric = CWI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	EUT	0.2941	0.1182	2.489	0.9641
Water	WDI	0.0588	0.1182	0.498	1.0000
Water	Wint	0.2059	0.1182	1.743	1.0000
Water	WP	0.0882	0.1182	0.747	1.0000
Water	WQ	-0.0294	0.1182	-0.249	1.0000
Water	WU	-0.1765	0.1182	-1.494	1.0000

Metric Group = Water
Metric = EUT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WDI	-0.2353	0.1182	-1.991	0.9997
Water	Wint	-0.0882	0.1182	-0.747	1.0000
Water	WP	-0.2059	0.1182	-1.743	1.0000
Water	WQ	-0.3235	0.1182	-2.738	0.8681
Water	WU	-0.4706	0.1182	-3.983	0.0607

Metric Group = Water
Metric = WDI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	Wint	0.1471	0.1182	1.245	1.0000
Water	WP	0.0294	0.1182	0.249	1.0000
Water	WQ	-0.0882	0.1182	-0.747	1.0000
Water	WU	-0.2353	0.1182	-1.991	0.9997

Metric Group = Water
Metric = Wint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WP	-0.1176	0.1182	-0.996	1.0000
Water	WQ	-0.2353	0.1182	-1.991	0.9997
Water	WU	-0.3824	0.1182	-3.236	0.4677

Metric Group = Water
Metric = WP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WQ	-0.1176	0.1182	-0.996	1.0000
Water	WU	-0.2647	0.1182	-2.240	0.9947

Metric Group = Water
Metric = WQ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WU	-0.1471	0.1182	-1.245	1.000

General Linear Model: Use Value versus Response, Metric (ANOVA 2)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric	fixed	55	AcP, AP, Beta, BP, CF, Cint, CO2, CU, CWI, EE, EEI, EI, Eint, EOLR, ET, EU, EUNR, EUT, Futil, GGE, IP, LCEInt, LPT, LU, MR, MU, NRRC, OCP, OSU, OZ, PLE, PPD, PSW, RC, RE, RM, RNC, RP, RRR, RRS, RS, RU, SW, SWRR, TD, TE, TEInt, W, WC, WDI, Wint, WP, WQ, WsU, WU

Analysis of Variance for Use Value, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	1310.022	1310.022	19.553	41.19	0.000
Metric	54	119.172	119.172	2.207	4.65	0.000
Error	3618	1717.228	1717.228	0.475		
Total	3739	3146.422				

S = 0.688937   R-Sq = 45.42%   R-Sq(adj) = 43.60%

Tukey Simultaneous Tests
Response Variable Use Value
All Pairwise Comparisons among Levels of Metric
Metric = AcP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CF	-0.3676	0.1182	-3.112	0.5788
Cint	-0.0588	0.1182	-0.498	1.0000
ET	-0.1912	0.1182	-1.618	1.0000
GGE	-0.1471	0.1182	-1.245	1.0000
OCP	0.1324	0.1182	1.120	1.0000
OZ	-0.0588	0.1182	-0.498	1.0000
PPD	-0.0882	0.1182	-0.747	1.0000

Metric = AP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BP	0.2500	0.1182	2.116	0.9985
CO2	-0.1618	0.1182	-1.369	1.0000
PSW	0.2353	0.1182	1.991	0.9997
RM	0.3088	0.1182	2.614	0.9268
RRR	-0.1029	0.1182	-0.871	1.0000
SW	0.0735	0.1182	0.622	1.0000
SWRR	0.2500	0.1182	2.116	0.9985
TE	0.3676	0.1182	3.112	0.5788
W	0.1029	0.1182	0.871	1.0000
WC	0.0882	0.1182	0.747	1.0000
WsU	0.3088	0.1182	2.614	0.9268

Metric = Beta subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EE	0.0882	0.1182	0.747	1.0000
EOLR	-0.0441	0.1182	-0.373	1.0000
LPT	-0.4559	0.1182	-3.858	0.0925
PLE	-0.0147	0.1182	-0.124	1.0000
RNC	-0.4412	0.1182	-3.734	0.1368

Metric = BP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CO2	-0.4118	0.1182	-3.485	0.2717
PSW	-0.0147	0.1182	-0.124	1.0000
RM	0.0588	0.1182	0.498	1.0000
RRR	-0.3529	0.1182	-2.987	0.6884
SW	-0.1765	0.1182	-1.494	1.0000
SWRR	-0.0000	0.1182	-0.000	1.0000
TE	0.1176	0.1182	0.996	1.0000
W	-0.1471	0.1182	-1.245	1.0000
WC	-0.1618	0.1182	-1.369	1.0000
WsU	0.0588	0.1182	0.498	1.0000

Metric = CF subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Cint	0.3088	0.1182	2.614	0.9268
ET	0.1765	0.1182	1.494	1.0000
GGE	0.2206	0.1182	1.867	0.9999
OCP	0.5000	0.1182	4.232	0.0242
OZ	0.3088	0.1182	2.614	0.9268
PPD	0.2794	0.1182	2.365	0.9848

Metric = Cint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
ET	-0.1324	0.1182	-1.120	1.0000
GGE	-0.0882	0.1182	-0.747	1.0000
OCP	0.1912	0.1182	1.618	1.0000
OZ	-0.0000	0.1182	-0.000	1.0000
PPD	-0.0294	0.1182	-0.249	1.0000

Metric = CO2 subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PSW	0.3971	0.1182	3.361	0.3633
RM	0.4706	0.1182	3.983	0.0607
RRR	0.0588	0.1182	0.498	1.0000
SW	0.2353	0.1182	1.991	0.9997
SWRR	0.4118	0.1182	3.485	0.2717
TE	0.5294	0.1182	4.481	0.0088
W	0.2647	0.1182	2.240	0.9947
WC	0.2500	0.1182	2.116	0.9985
WsU	0.4706	0.1182	3.983	0.0607

Metric = CU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EI	0.1618	0.1182	1.369	1.0000

Futil	-0.0735	0.1182	-0.622	1.0000
IP	0.1618	0.1182	1.369	1.0000
LU	0.2794	0.1182	2.365	0.9848
MR	0.3235	0.1182	2.738	0.8681
MU	-0.1029	0.1182	-0.871	1.0000
NRRC	0.1912	0.1182	1.618	1.0000
OSU	0.2353	0.1182	1.991	0.9997
RC	-0.0294	0.1182	-0.249	1.0000
RE	0.0735	0.1182	0.622	1.0000
RP	0.1618	0.1182	1.369	1.0000
RRS	0.2353	0.1182	1.991	0.9997
RS	0.2500	0.1182	2.116	0.9985
RU	0.0000	0.1182	0.000	1.0000
TD	0.1471	0.1182	1.245	1.0000

Metric = CWI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUT	0.2941	0.1182	2.489	0.9641
WDI	0.0588	0.1182	0.498	1.0000
Wint	0.2059	0.1182	1.743	1.0000
WP	0.0882	0.1182	0.747	1.0000
WQ	-0.0294	0.1182	-0.249	1.0000
WU	-0.1765	0.1182	-1.494	1.0000

Metric = EE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EOLR	-0.1324	0.1182	-1.120	1.0000
LPT	-0.5441	0.1182	-4.605	0.0052
PLE	-0.1029	0.1182	-0.871	1.0000
RNC	-0.5294	0.1182	-4.481	0.0088

Metric = EEI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Eint	-0.2500	0.1182	-2.116	0.9985
EU	-0.5882	0.1182	-4.979	0.0010
EUNR	-0.2500	0.1182	-2.116	0.9985
LCEInt	-0.0294	0.1182	-0.249	1.0000
TEInt	0.0147	0.1182	0.124	1.0000

Metric = EI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Futil	-0.2353	0.1182	-1.991	0.9997
IP	-0.0000	0.1182	-0.000	1.0000
LU	0.1176	0.1182	0.996	1.0000
MR	0.1618	0.1182	1.369	1.0000
MU	-0.2647	0.1182	-2.240	0.9947
NRRC	0.0294	0.1182	0.249	1.0000
OSU	0.0735	0.1182	0.622	1.0000
RC	-0.1912	0.1182	-1.618	1.0000
RE	-0.0882	0.1182	-0.747	1.0000
RP	-0.0000	0.1182	-0.000	1.0000
RRS	0.0735	0.1182	0.622	1.0000
RS	0.0882	0.1182	0.747	1.0000
RU	-0.1618	0.1182	-1.369	1.0000

TD	-0.0147	0.1182	-0.124	1.0000

Metric = Eint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EU	-0.3382	0.1182	-2.863	0.7873
EUNR	0.0000	0.1182	0.000	1.0000
LCEInt	0.2206	0.1182	1.867	0.9999
TEInt	0.2647	0.1182	2.240	0.9947

Metric = EOLR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LPT	-0.4118	0.1182	-3.485	0.2717
PLE	0.0294	0.1182	0.249	1.0000
RNC	-0.3971	0.1182	-3.361	0.3633

Metric = ET subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
GGE	0.0441	0.1182	0.373	1.0000
OCP	0.3235	0.1182	2.738	0.8681
OZ	0.1324	0.1182	1.120	1.0000
PPD	0.1029	0.1182	0.871	1.0000

Metric = EU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUNR	0.3382	0.1182	2.863	0.7873
LCEInt	0.5588	0.1182	4.730	0.0030
TEInt	0.6029	0.1182	5.103	0.0006

Metric = EUNR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LCEInt	0.2206	0.1182	1.867	0.9999
TEInt	0.2647	0.1182	2.240	0.9947

Metric = EUT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WDI	-0.2353	0.1182	-1.991	0.9997
Wint	-0.0882	0.1182	-0.747	1.0000
WP	-0.2059	0.1182	-1.743	1.0000
WQ	-0.3235	0.1182	-2.738	0.8681
WU	-0.4706	0.1182	-3.983	0.0607

Metric = Futil subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
IP	0.23529	0.1182	1.9915	0.9997
LU	0.35294	0.1182	2.9872	0.6884
MR	0.39706	0.1182	3.3606	0.3633
MU	-0.02941	0.1182	-0.2489	1.0000
NRRC	0.26471	0.1182	2.2404	0.9947
OSU	0.30882	0.1182	2.6138	0.9268

RC	0.04412	0.1182	0.3734	1.0000
RE	0.14706	0.1182	1.2447	1.0000
RP	0.23529	0.1182	1.9915	0.9997
RRS	0.30882	0.1182	2.6138	0.9268
RS	0.32353	0.1182	2.7383	0.8681
RU	0.07353	0.1182	0.6223	1.0000
TD	0.22059	0.1182	1.8670	0.9999

Metric = GGE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OCP	0.2794	0.1182	2.365	0.9848
OZ	0.0882	0.1182	0.747	1.0000
PPD	0.0588	0.1182	0.498	1.0000

Metric = IP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LU	0.1176	0.1182	0.996	1.0000
MR	0.1618	0.1182	1.369	1.0000
MU	-0.2647	0.1182	-2.240	0.9947
NRRC	0.0294	0.1182	0.249	1.0000
OSU	0.0735	0.1182	0.622	1.0000
RC	-0.1912	0.1182	-1.618	1.0000
RE	-0.0882	0.1182	-0.747	1.0000
RP	0.0000	0.1182	0.000	1.0000
RRS	0.0735	0.1182	0.622	1.0000
RS	0.0882	0.1182	0.747	1.0000
RU	-0.1618	0.1182	-1.369	1.0000
TD	-0.0147	0.1182	-0.124	1.0000

Metric = LCEInt subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TEInt	0.0441	0.1182	0.373	1.0000

Metric = LPT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PLE	0.441176	0.1182	3.73398	0.1368
RNC	0.014706	0.1182	0.12447	1.0000

Metric = LU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MR	0.0441	0.1182	0.373	1.0000
MU	-0.3824	0.1182	-3.236	0.4677
NRRC	-0.0882	0.1182	-0.747	1.0000
OSU	-0.0441	0.1182	-0.373	1.0000
RC	-0.3088	0.1182	-2.614	0.9268
RE	-0.2059	0.1182	-1.743	1.0000
RP	-0.1176	0.1182	-0.996	1.0000
RRS	-0.0441	0.1182	-0.373	1.0000
RS	-0.0294	0.1182	-0.249	1.0000
RU	-0.2794	0.1182	-2.365	0.9848
TD	-0.1324	0.1182	-1.120	1.0000

Metric = MR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MU	-0.4265	0.1182	-3.610	0.1961
NRRC	-0.1324	0.1182	-1.120	1.0000
OSU	-0.0882	0.1182	-0.747	1.0000
RC	-0.3529	0.1182	-2.987	0.6884
RE	-0.2500	0.1182	-2.116	0.9985
RP	-0.1618	0.1182	-1.369	1.0000
RRS	-0.0882	0.1182	-0.747	1.0000
RS	-0.0735	0.1182	-0.622	1.0000
RU	-0.3235	0.1182	-2.738	0.8681
TD	-0.1765	0.1182	-1.494	1.0000

Metric = MU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
NRRC	0.29412	0.1182	2.4893	0.9641
OSU	0.33824	0.1182	2.8627	0.7873
RC	0.07353	0.1182	0.6223	1.0000
RE	0.17647	0.1182	1.4936	1.0000
RP	0.26471	0.1182	2.2404	0.9947
RRS	0.33824	0.1182	2.8627	0.7873
RS	0.35294	0.1182	2.9872	0.6884
RU	0.10294	0.1182	0.8713	1.0000
TD	0.25000	0.1182	2.1159	0.9985

Metric = NRRC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OSU	0.0441	0.1182	0.373	1.0000
RC	-0.2206	0.1182	-1.867	0.9999
RE	-0.1176	0.1182	-0.996	1.0000
RP	-0.0294	0.1182	-0.249	1.0000
RRS	0.0441	0.1182	0.373	1.0000
RS	0.0588	0.1182	0.498	1.0000
RU	-0.1912	0.1182	-1.618	1.0000
TD	-0.0441	0.1182	-0.373	1.0000

Metric = OCP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OZ	-0.1912	0.1182	-1.618	1.0000
PPD	-0.2206	0.1182	-1.867	0.9999

Metric = OSU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RC	-0.2647	0.1182	-2.240	0.9947
RE	-0.1618	0.1182	-1.369	1.0000
RP	-0.0735	0.1182	-0.622	1.0000
RRS	-0.0000	0.1182	-0.000	1.0000
RS	0.0147	0.1182	0.124	1.0000
RU	-0.2353	0.1182	-1.991	0.9997
TD	-0.0882	0.1182	-0.747	1.0000

Metric = OZ subtracted from:

	Difference	SE of		Adjusted

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PPD	-0.0294	0.1182	-0.249	1.0000

Metric = PLE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RNC	-0.4265	0.1182	-3.610	0.1961

Metric = PSW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RM	0.0735	0.1182	0.622	1.0000
RRR	-0.3382	0.1182	-2.863	0.7873
SW	-0.1618	0.1182	-1.369	1.0000
SWRR	0.0147	0.1182	0.124	1.0000
TE	0.1324	0.1182	1.120	1.0000
W	-0.1324	0.1182	-1.120	1.0000
WC	-0.1471	0.1182	-1.245	1.0000
WsU	0.0735	0.1182	0.622	1.0000

Metric = RC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RE	0.10294	0.1182	0.8713	1.0000
RP	0.19118	0.1182	1.6181	1.0000
RRS	0.26471	0.1182	2.2404	0.9947
RS	0.27941	0.1182	2.3649	0.9848
RU	0.02941	0.1182	0.2489	1.0000
TD	0.17647	0.1182	1.4936	1.0000

Metric = RE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RP	0.0882	0.1182	0.747	1.0000
RRS	0.1618	0.1182	1.369	1.0000
RS	0.1765	0.1182	1.494	1.0000
RU	-0.0735	0.1182	-0.622	1.0000
TD	0.0735	0.1182	0.622	1.0000

Metric = RM subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRR	-0.4118	0.1182	-3.485	0.2717
SW	-0.2353	0.1182	-1.991	0.9997
SWRR	-0.0588	0.1182	-0.498	1.0000
TE	0.0588	0.1182	0.498	1.0000
W	-0.2059	0.1182	-1.743	1.0000
WC	-0.2206	0.1182	-1.867	0.9999
WsU	0.0000	0.1182	0.000	1.0000

Metric = RP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRS	0.0735	0.1182	0.622	1.0000
RS	0.0882	0.1182	0.747	1.0000
RU	-0.1618	0.1182	-1.369	1.0000
TD	-0.0147	0.1182	-0.124	1.0000

Metric = RRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SW	0.17647	0.1182	1.4936	1.0000
SWRR	0.35294	0.1182	2.9872	0.6884
TE	0.47059	0.1182	3.9829	0.0607
W	0.20588	0.1182	1.7425	1.0000
WC	0.19118	0.1182	1.6181	1.0000
WsU	0.41176	0.1182	3.4850	0.2717

Metric = RRS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RS	0.0147	0.1182	0.124	1.0000
RU	-0.2353	0.1182	-1.991	0.9997
TD	-0.0882	0.1182	-0.747	1.0000

Metric = RS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RU	-0.2500	0.1182	-2.116	0.9985
TD	-0.1029	0.1182	-0.871	1.0000

Metric = RU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TD	0.14706	0.1182	1.2447	1.0000

Metric = SW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SWRR	0.1765	0.1182	1.4936	1.0000
TE	0.2941	0.1182	2.4893	0.9641
W	0.0294	0.1182	0.2489	1.0000
WC	0.0147	0.1182	0.1245	1.0000
WsU	0.2353	0.1182	1.9915	0.9997

Metric = SWRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TE	0.1176	0.1182	0.996	1.0000
W	-0.1471	0.1182	-1.245	1.0000
WC	-0.1618	0.1182	-1.369	1.0000
WsU	0.0588	0.1182	0.498	1.0000

Metric = TE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
W	-0.2647	0.1182	-2.240	0.9947
WC	-0.2794	0.1182	-2.365	0.9848
WsU	-0.0588	0.1182	-0.498	1.0000

Metric = W subtracted from:

Difference SE of Adjusted

Metric	of Means	Difference	T-Value	P-Value
WC	-0.0147	0.1182	-0.124	1.0000
WsU	0.2059	0.1182	1.743	1.0000

Metric = WC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WsU	0.2206	0.1182	1.867	0.9999

Metric = WDI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Wint	0.1471	0.1182	1.245	1.0000
WP	0.0294	0.1182	0.249	1.0000
WQ	-0.0882	0.1182	-0.747	1.0000
WU	-0.2353	0.1182	-1.991	0.9997

Metric = Wint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WP	-0.1176	0.1182	-0.996	1.0000
WQ	-0.2353	0.1182	-1.991	0.9997
WU	-0.3824	0.1182	-3.236	0.4677

Metric = WP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WQ	-0.1176	0.1182	-0.996	1.0000
WU	-0.2647	0.1182	-2.240	0.9947

Metric = WQ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WU	-0.1471	0.1182	-1.245	1.000

General Linear Model: Practicality versus Response, Metric Group, Metric (ANOVA 1)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric Group	fixed	6	Energy, Environment, Pollution, Resources, Technique/Process, Water
Metric(Metric Group)	fixed	55	EEI, Eint, EU, EUNR, LCEInt, TEInt, AcP, CF, Cint, ET, GGE, OCP, OZ, PPD, AP, BP, CO2, PSW, RM, RRR, SW, SWRR, TE, W, WC, WsU, CU, EI, Futil, IP, LU, MR, MU, NRRC, OSU, RC, RE, RP, RRS, RS, RU, TD, Beta, EE, EOLR, LPT, PLE, RNC, CWI, EUT, WDI, Wint, WP, WQ, WU

Analysis of Variance for Practicality, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	3481.741	3481.741	51.966	51.61	0.000
Metric Group	5	29.681	29.681	5.936	5.90	0.000
Metric(Metric Group)	49	233.668	233.668	4.769	4.74	0.000
Error	3618	3642.906	3642.906	1.007		
Total	3739	7387.996				

S = 1.00344   R-Sq = 50.69%   R-Sq(adj) = 49.04%

Tukey Simultaneous Tests
Response Variable Practicality
All Pairwise Comparisons among Levels of Metric(Metric Group)
Metric Group = Energy
Metric = EEI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	Eint	0.4265	0.1721	2.478	0.9665
Energy	EU	0.9265	0.1721	5.384	0.0003
Energy	EUNR	0.4265	0.1721	2.478	0.9665
Energy	LCEInt	0.0294	0.1721	0.171	1.0000
Energy	TEInt	0.1324	0.1721	0.769	1.0000

Metric Group = Energy
Metric = Eint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EU	0.5000	0.1721	2.905	0.7550
Energy	EUNR	0.0000	0.1721	0.000	1.0000
Energy	LCEInt	-0.3971	0.1721	-2.307	0.9904
Energy	TEInt	-0.2941	0.1721	-1.709	1.0000

Metric Group = Energy
Metric = EU subtracted from:

Difference	SE of	Adjusted

Metric Group	Metric	of Means	Difference	T-Value	P-Value
Energy	EUNR	-0.500	0.1721	-2.905	0.7550
Energy	LCEInt	-0.897	0.1721	-5.213	0.0005
Energy	TEInt	-0.794	0.1721	-4.615	0.0050

Metric Group = Energy
Metric = EUNR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	LCEInt	-0.3971	0.1721	-2.307	0.9904
Energy	TEInt	-0.2941	0.1721	-1.709	1.0000

Metric Group = Energy
Metric = LCEInt subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	TEInt	0.1029	0.1721	0.598	1.0000

Metric Group = Environment
Metric = AcP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	CF	0.9118	0.1721	5.298	0.0004
Environment	Cint	0.3676	0.1721	2.136	0.9981
Environment	ET	0.2647	0.1721	1.538	1.0000
Environment	GGE	0.4853	0.1721	2.820	0.8173
Environment	OCP	-0.1176	0.1721	-0.684	1.0000
Environment	OZ	0.1765	0.1721	1.025	1.0000
Environment	PPD	0.0441	0.1721	0.256	1.0000

Metric Group = Environment
Metric = CF subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	Cint	-0.544	0.1721	-3.162	0.5336
Environment	ET	-0.647	0.1721	-3.760	0.1264
Environment	GGE	-0.426	0.1721	-2.478	0.9665
Environment	OCP	-1.029	0.1721	-5.982	0.0002
Environment	OZ	-0.735	0.1721	-4.273	0.0206
Environment	PPD	-0.868	0.1721	-5.042	0.0008

Metric Group = Environment
Metric = Cint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	ET	-0.1029	0.1721	-0.598	1.0000
Environment	GGE	0.1176	0.1721	0.684	1.0000
Environment	OCP	-0.4853	0.1721	-2.820	0.8173
Environment	OZ	-0.1912	0.1721	-1.111	1.0000
Environment	PPD	-0.3235	0.1721	-1.880	0.9999

Metric Group = Environment
Metric = ET subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	GGE	0.2206	0.1721	1.282	1.0000
Environment	OCP	-0.3824	0.1721	-2.222	0.9955
Environment	OZ	-0.0882	0.1721	-0.513	1.0000
Environment	PPD	-0.2206	0.1721	-1.282	1.0000

Metric Group = Environment
Metric = GGE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OCP	-0.6029	0.1721	-3.504	0.2594
Environment	OZ	-0.3088	0.1721	-1.795	1.0000
Environment	PPD	-0.4412	0.1721	-2.564	0.9442

Metric Group = Environment
Metric = OCP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OZ	0.29412	0.1721	1.7091	1.0000
Environment	PPD	0.16176	0.1721	0.9400	1.0000

Metric Group = Environment
Metric = OZ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	PPD	-0.1324	0.1721	-0.769	1.0000

Metric Group = Pollution
Metric = AP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	BP	-0.5294	0.1721	-3.076	0.6104
Pollution	CO2	0.1618	0.1721	0.940	1.0000
Pollution	PSW	-0.4412	0.1721	-2.564	0.9442
Pollution	RM	-0.3824	0.1721	-2.222	0.9955
Pollution	RRR	-0.0882	0.1721	-0.513	1.0000
Pollution	SW	-0.2941	0.1721	-1.709	1.0000
Pollution	SWRR	-0.5147	0.1721	-2.991	0.6852
Pollution	TE	-0.5294	0.1721	-3.076	0.6104
Pollution	W	-0.3529	0.1721	-2.051	0.9993
Pollution	WC	-0.3676	0.1721	-2.136	0.9981
Pollution	WsU	-0.5147	0.1721	-2.991	0.6852

Metric Group = Pollution
Metric = BP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	CO2	0.6912	0.1721	4.016	0.0540
Pollution	PSW	0.0882	0.1721	0.513	1.0000
Pollution	RM	0.1471	0.1721	0.855	1.0000
Pollution	RRR	0.4412	0.1721	2.564	0.9442
Pollution	SW	0.2353	0.1721	1.367	1.0000
Pollution	SWRR	0.0147	0.1721	0.085	1.0000
Pollution	TE	-0.0000	0.1721	-0.000	1.0000
Pollution	W	0.1765	0.1721	1.025	1.0000
Pollution	WC	0.1618	0.1721	0.940	1.0000
Pollution	WsU	0.0147	0.1721	0.085	1.0000

Metric Group = Pollution
Metric = CO2 subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	PSW	-0.603	0.1721	-3.504	0.2594
Pollution	RM	-0.544	0.1721	-3.162	0.5336
Pollution	RRR	-0.250	0.1721	-1.453	1.0000
Pollution	SW	-0.456	0.1721	-2.649	0.9125
Pollution	SWRR	-0.676	0.1721	-3.931	0.0726
Pollution	TE	-0.691	0.1721	-4.016	0.0540
Pollution	W	-0.515	0.1721	-2.991	0.6852
Pollution	WC	-0.529	0.1721	-3.076	0.6104
Pollution	WsU	-0.676	0.1721	-3.931	0.0726

Metric Group = Pollution
Metric = PSW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RM	0.0588	0.1721	0.342	1.0000
Pollution	RRR	0.3529	0.1721	2.051	0.9993
Pollution	SW	0.1471	0.1721	0.855	1.0000
Pollution	SWRR	-0.0735	0.1721	-0.427	1.0000
Pollution	TE	-0.0882	0.1721	-0.513	1.0000
Pollution	W	0.0882	0.1721	0.513	1.0000
Pollution	WC	0.0735	0.1721	0.427	1.0000
Pollution	WsU	-0.0735	0.1721	-0.427	1.0000

Metric Group = Pollution
Metric = RM subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RRR	0.2941	0.1721	1.709	1.0000
Pollution	SW	0.0882	0.1721	0.513	1.0000
Pollution	SWRR	-0.1324	0.1721	-0.769	1.0000
Pollution	TE	-0.1471	0.1721	-0.855	1.0000
Pollution	W	0.0294	0.1721	0.171	1.0000
Pollution	WC	0.0147	0.1721	0.085	1.0000
Pollution	WsU	-0.1324	0.1721	-0.769	1.0000

Metric Group = Pollution
Metric = RRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SW	-0.2059	0.1721	-1.196	1.0000
Pollution	SWRR	-0.4265	0.1721	-2.478	0.9665
Pollution	TE	-0.4412	0.1721	-2.564	0.9442
Pollution	W	-0.2647	0.1721	-1.538	1.0000
Pollution	WC	-0.2794	0.1721	-1.624	1.0000
Pollution	WsU	-0.4265	0.1721	-2.478	0.9665

Metric Group = Pollution
Metric = SW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SWRR	-0.2206	0.1721	-1.282	1.0000
Pollution	TE	-0.2353	0.1721	-1.367	1.0000
Pollution	W	-0.0588	0.1721	-0.342	1.0000
Pollution	WC	-0.0735	0.1721	-0.427	1.0000
Pollution	WsU	-0.2206	0.1721	-1.282	1.0000

Metric Group = Pollution
Metric = SWRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	TE	-0.0147	0.1721	-0.085	1.0000
Pollution	W	0.1618	0.1721	0.940	1.0000
Pollution	WC	0.1471	0.1721	0.855	1.0000
Pollution	WsU	0.0000	0.1721	0.000	1.0000

Metric Group = Pollution
Metric = TE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	W	0.1765	0.1721	1.025	1.0000
Pollution	WC	0.1618	0.1721	0.940	1.0000
Pollution	WsU	0.0147	0.1721	0.085	1.0000

Metric Group = Pollution
Metric = W subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WC	-0.0147	0.1721	-0.085	1.0000
Pollution	WsU	-0.1618	0.1721	-0.940	1.0000

Metric Group = Pollution
Metric = WC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WsU	-0.1471	0.1721	-0.855	1.0000

Metric Group = Resources
Metric = CU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	EI	-0.4706	0.1721	-2.735	0.8702
Resources	Futil	-0.0147	0.1721	-0.085	1.0000
Resources	IP	-0.1618	0.1721	-0.940	1.0000
Resources	LU	-0.4265	0.1721	-2.478	0.9665
Resources	MR	-0.4559	0.1721	-2.649	0.9125
Resources	MU	0.0441	0.1721	0.256	1.0000
Resources	NRRC	-0.2794	0.1721	-1.624	1.0000
Resources	OSU	-0.3676	0.1721	-2.136	0.9981
Resources	RC	-0.0000	0.1721	-0.000	1.0000
Resources	RE	-0.0588	0.1721	-0.342	1.0000
Resources	RP	-0.1471	0.1721	-0.855	1.0000
Resources	RRS	-0.6324	0.1721	-3.675	0.1630
Resources	RS	-0.0735	0.1721	-0.427	1.0000
Resources	RU	-0.0147	0.1721	-0.085	1.0000
Resources	TD	-0.1029	0.1721	-0.598	1.0000

Metric Group = Resources
Metric = EI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	Futil	0.4559	0.1721	2.649	0.9125
Resources	IP	0.3088	0.1721	1.795	1.0000
Resources	LU	0.0441	0.1721	0.256	1.0000

Resources	MR	0.0147	0.1721	0.085	1.0000
Resources	MU	0.5147	0.1721	2.991	0.6852
Resources	NRRC	0.1912	0.1721	1.111	1.0000
Resources	OSU	0.1029	0.1721	0.598	1.0000
Resources	RC	0.4706	0.1721	2.735	0.8702
Resources	RE	0.4118	0.1721	2.393	0.9813
Resources	RP	0.3235	0.1721	1.880	0.9999
Resources	RRS	-0.1618	0.1721	-0.940	1.0000
Resources	RS	0.3971	0.1721	2.307	0.9904
Resources	RU	0.4559	0.1721	2.649	0.9125
Resources	TD	0.3676	0.1721	2.136	0.9981

Metric Group = Resources
Metric = Futil subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	IP	-0.1471	0.1721	-0.855	1.0000
Resources	LU	-0.4118	0.1721	-2.393	0.9813
Resources	MR	-0.4412	0.1721	-2.564	0.9442
Resources	MU	0.0588	0.1721	0.342	1.0000
Resources	NRRC	-0.2647	0.1721	-1.538	1.0000
Resources	OSU	-0.3529	0.1721	-2.051	0.9993
Resources	RC	0.0147	0.1721	0.085	1.0000
Resources	RE	-0.0441	0.1721	-0.256	1.0000
Resources	RP	-0.1324	0.1721	-0.769	1.0000
Resources	RRS	-0.6176	0.1721	-3.589	0.2074
Resources	RS	-0.0588	0.1721	-0.342	1.0000
Resources	RU	-0.0000	0.1721	-0.000	1.0000
Resources	TD	-0.0882	0.1721	-0.513	1.0000

Metric Group = Resources
Metric = IP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	LU	-0.2647	0.1721	-1.538	1.0000
Resources	MR	-0.2941	0.1721	-1.709	1.0000
Resources	MU	0.2059	0.1721	1.196	1.0000
Resources	NRRC	-0.1176	0.1721	-0.684	1.0000
Resources	OSU	-0.2059	0.1721	-1.196	1.0000
Resources	RC	0.1618	0.1721	0.940	1.0000
Resources	RE	0.1029	0.1721	0.598	1.0000
Resources	RP	0.0147	0.1721	0.085	1.0000
Resources	RRS	-0.4706	0.1721	-2.735	0.8702
Resources	RS	0.0882	0.1721	0.513	1.0000
Resources	RU	0.1471	0.1721	0.855	1.0000
Resources	TD	0.0588	0.1721	0.342	1.0000

Metric Group = Resources
Metric = LU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MR	-0.0294	0.1721	-0.171	1.0000
Resources	MU	0.4706	0.1721	2.735	0.8702
Resources	NRRC	0.1471	0.1721	0.855	1.0000
Resources	OSU	0.0588	0.1721	0.342	1.0000
Resources	RC	0.4265	0.1721	2.478	0.9665
Resources	RE	0.3676	0.1721	2.136	0.9981
Resources	RP	0.2794	0.1721	1.624	1.0000
Resources	RRS	-0.2059	0.1721	-1.196	1.0000
Resources	RS	0.3529	0.1721	2.051	0.9993
Resources	RU	0.4118	0.1721	2.393	0.9813
Resources	TD	0.3235	0.1721	1.880	0.9999

Metric Group = Resources
Metric = MR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MU	0.5000	0.1721	2.905	0.7550
Resources	NRRC	0.1765	0.1721	1.025	1.0000
Resources	OSU	0.0882	0.1721	0.513	1.0000
Resources	RC	0.4559	0.1721	2.649	0.9125
Resources	RE	0.3971	0.1721	2.307	0.9904
Resources	RP	0.3088	0.1721	1.795	1.0000
Resources	RRS	-0.1765	0.1721	-1.025	1.0000
Resources	RS	0.3824	0.1721	2.222	0.9955
Resources	RU	0.4412	0.1721	2.564	0.9442
Resources	TD	0.3529	0.1721	2.051	0.9993

Metric Group = Resources
Metric = MU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	NRRC	-0.3235	0.1721	-1.880	0.9999
Resources	OSU	-0.4118	0.1721	-2.393	0.9813
Resources	RC	-0.0441	0.1721	-0.256	1.0000
Resources	RE	-0.1029	0.1721	-0.598	1.0000
Resources	RP	-0.1912	0.1721	-1.111	1.0000
Resources	RRS	-0.6765	0.1721	-3.931	0.0726
Resources	RS	-0.1176	0.1721	-0.684	1.0000
Resources	RU	-0.0588	0.1721	-0.342	1.0000
Resources	TD	-0.1471	0.1721	-0.855	1.0000

Metric Group = Resources
Metric = NRRC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	OSU	-0.0882	0.1721	-0.513	1.0000
Resources	RC	0.2794	0.1721	1.624	1.0000
Resources	RE	0.2206	0.1721	1.282	1.0000
Resources	RP	0.1324	0.1721	0.769	1.0000
Resources	RRS	-0.3529	0.1721	-2.051	0.9993
Resources	RS	0.2059	0.1721	1.196	1.0000
Resources	RU	0.2647	0.1721	1.538	1.0000
Resources	TD	0.1765	0.1721	1.025	1.0000

Metric Group = Resources
Metric = OSU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RC	0.3676	0.1721	2.136	0.9981
Resources	RE	0.3088	0.1721	1.795	1.0000
Resources	RP	0.2206	0.1721	1.282	1.0000
Resources	RRS	-0.2647	0.1721	-1.538	1.0000
Resources	RS	0.2941	0.1721	1.709	1.0000
Resources	RU	0.3529	0.1721	2.051	0.9993
Resources	TD	0.2647	0.1721	1.538	1.0000

Metric Group = Resources
Metric = RC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RE	-0.0588	0.1721	-0.342	1.0000
Resources	RP	-0.1471	0.1721	-0.855	1.0000
Resources	RRS	-0.6324	0.1721	-3.675	0.1630
Resources	RS	-0.0735	0.1721	-0.427	1.0000
Resources	RU	-0.0147	0.1721	-0.085	1.0000
Resources	TD	-0.1029	0.1721	-0.598	1.0000

Metric Group = Resources
Metric = RE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RP	-0.0882	0.1721	-0.513	1.0000
Resources	RRS	-0.5735	0.1721	-3.333	0.3857
Resources	RS	-0.0147	0.1721	-0.085	1.0000
Resources	RU	0.0441	0.1721	0.256	1.0000
Resources	TD	-0.0441	0.1721	-0.256	1.0000

Metric Group = Resources
Metric = RP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RRS	-0.4853	0.1721	-2.820	0.8173
Resources	RS	0.0735	0.1721	0.427	1.0000
Resources	RU	0.1324	0.1721	0.769	1.0000
Resources	TD	0.0441	0.1721	0.256	1.0000

Metric Group = Resources
Metric = RRS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RS	0.5588	0.1721	3.247	0.4578
Resources	RU	0.6176	0.1721	3.589	0.2074
Resources	TD	0.5294	0.1721	3.076	0.6104

Metric Group = Resources
Metric = RS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RU	0.0588	0.1721	0.342	1.0000
Resources	TD	-0.0294	0.1721	-0.171	1.0000

Metric Group = Resources
Metric = RU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	TD	-0.0882	0.1721	-0.513	1.0000

Metric Group = Technique/Process
Metric = Beta subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EE	-0.2206	0.1721	-1.282	1.0000
Technique/Process	EOLR	-0.0441	0.1721	-0.256	1.0000
Technique/Process	LPT	0.6176	0.1721	3.589	0.2074
Technique/Process	PLE	-0.1912	0.1721	-1.111	1.0000
Technique/Process	RNC	0.4118	0.1721	2.393	0.9813

Metric Group = Technique/Process
Metric = EE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EOLR	0.1765	0.1721	1.025	1.0000
Technique/Process	LPT	0.8382	0.1721	4.871	0.0016
Technique/Process	PLE	0.0294	0.1721	0.171	1.0000
Technique/Process	RNC	0.6324	0.1721	3.675	0.1630

Metric Group = Technique/Process
Metric = EOLR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	LPT	0.6618	0.1721	3.846	0.0964
Technique/Process	PLE	-0.1471	0.1721	-0.855	1.0000
Technique/Process	RNC	0.4559	0.1721	2.649	0.9125

Metric Group = Technique/Process
Metric = LPT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	PLE	-0.809	0.1721	-4.700	0.0034
Technique/Process	RNC	-0.206	0.1721	-1.196	1.0000

Metric Group = Technique/Process
Metric = PLE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	RNC	0.6029	0.1721	3.504	0.2594

Metric Group = Water
Metric = CWI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	EUT	-0.5000	0.1721	-2.905	0.7550
Water	WDI	-0.0588	0.1721	-0.342	1.0000
Water	Wint	-0.3088	0.1721	-1.795	1.0000
Water	WP	-0.0588	0.1721	-0.342	1.0000
Water	WQ	-0.2500	0.1721	-1.453	1.0000
Water	WU	0.0735	0.1721	0.427	1.0000

Metric Group = Water
Metric = EUT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WDI	0.4412	0.1721	2.564	0.9442
Water	Wint	0.1912	0.1721	1.111	1.0000
Water	WP	0.4412	0.1721	2.564	0.9442
Water	WQ	0.2500	0.1721	1.453	1.0000
Water	WU	0.5735	0.1721	3.333	0.3857

Metric Group = Water

Metric = WDI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	Wint	-0.2500	0.1721	-1.453	1.000
Water	WP	-0.0000	0.1721	-0.000	1.000
Water	WQ	-0.1912	0.1721	-1.111	1.000
Water	WU	0.1324	0.1721	0.769	1.000

Metric Group = Water
Metric = Wint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WP	0.25000	0.1721	1.4527	1.0000
Water	WQ	0.05882	0.1721	0.3418	1.0000
Water	WU	0.38235	0.1721	2.2218	0.9955

Metric Group = Water
Metric = WP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WQ	-0.1912	0.1721	-1.111	1.000
Water	WU	0.1324	0.1721	0.769	1.000

Metric Group = Water
Metric = WQ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WU	0.3235	0.1721	1.880	0.9999

General Linear Model: Practicality versus Response, Metric (ANOVA 2)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric	fixed	55	AcP, AP, Beta, BP, CF, Cint, CO2, CU, CWI, EE, EEI, EI, Eint, EOLR, ET, EU, EUNR, EUT, Futil, GGE, IP, LCEInt, LPT, LU, MR, MU, NRRC, OCP, OSU, OZ, PLE, PPD, PSW, RC, RE, RM, RNC, RP, RRR, RRS, RS, RU, SW, SWRR, TD, TE, TEInt, W, WC, WDI, Wint, WP, WQ, WsU, WU

Analysis of Variance for Practicality, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	3481.741	3481.741	51.966	51.61	0.000
Metric	54	263.349	263.349	4.877	4.84	0.000
Error	3618	3642.906	3642.906	1.007		
Total	3739	7387.996				

S = 1.00344 R-Sq = 50.69% R-Sq(adj) = 49.04%

Tukey Simultaneous Tests
Response Variable Practicality
All Pairwise Comparisons among Levels of Metric
Metric = AcP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CF	0.9118	0.1721	5.298	0.0004
Cint	0.3676	0.1721	2.136	0.9981
ET	0.2647	0.1721	1.538	1.0000
GGE	0.4853	0.1721	2.820	0.8173
OCP	-0.1176	0.1721	-0.684	1.0000
OZ	0.1765	0.1721	1.025	1.0000
PPD	0.0441	0.1721	0.256	1.0000

Metric = AP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BP	-0.5294	0.1721	-3.076	0.6104
CO2	0.1618	0.1721	0.940	1.0000
PSW	-0.4412	0.1721	-2.564	0.9442
RM	-0.3824	0.1721	-2.222	0.9955
RRR	-0.0882	0.1721	-0.513	1.0000
SW	-0.2941	0.1721	-1.709	1.0000
SWRR	-0.5147	0.1721	-2.991	0.6852
TE	-0.5294	0.1721	-3.076	0.6104
W	-0.3529	0.1721	-2.051	0.9993
WC	-0.3676	0.1721	-2.136	0.9981
WsU	-0.5147	0.1721	-2.991	0.6852

Metric = Beta subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EE	-0.2206	0.1721	-1.282	1.0000
EOLR	-0.0441	0.1721	-0.256	1.0000
LPT	0.6176	0.1721	3.589	0.2074
PLE	-0.1912	0.1721	-1.111	1.0000
RNC	0.4118	0.1721	2.393	0.9813

Metric = BP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CO2	0.6912	0.1721	4.016	0.0540
PSW	0.0882	0.1721	0.513	1.0000
RM	0.1471	0.1721	0.855	1.0000
RRR	0.4412	0.1721	2.564	0.9442
SW	0.2353	0.1721	1.367	1.0000
SWRR	0.0147	0.1721	0.085	1.0000
TE	0.0000	0.1721	0.000	1.0000
W	0.1765	0.1721	1.025	1.0000
WC	0.1618	0.1721	0.940	1.0000
WsU	0.0147	0.1721	0.085	1.0000

Metric = CF subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Cint	-0.544	0.1721	-3.162	0.5336
ET	-0.647	0.1721	-3.760	0.1264
GGE	-0.426	0.1721	-2.478	0.9665
OCP	-1.029	0.1721	-5.982	0.0002
OZ	-0.735	0.1721	-4.273	0.0206
PPD	-0.868	0.1721	-5.042	0.0008

Metric = Cint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
ET	-0.1029	0.1721	-0.598	1.0000
GGE	0.1176	0.1721	0.684	1.0000
OCP	-0.4853	0.1721	-2.820	0.8173
OZ	-0.1912	0.1721	-1.111	1.0000
PPD	-0.3235	0.1721	-1.880	0.9999

Metric = CO2 subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PSW	-0.603	0.1721	-3.504	0.2594
RM	-0.544	0.1721	-3.162	0.5336
RRR	-0.250	0.1721	-1.453	1.0000
SW	-0.456	0.1721	-2.649	0.9125
SWRR	-0.676	0.1721	-3.931	0.0726
TE	-0.691	0.1721	-4.016	0.0540
W	-0.515	0.1721	-2.991	0.6852
WC	-0.529	0.1721	-3.076	0.6104
WsU	-0.676	0.1721	-3.931	0.0726

Metric = CU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EI	-0.4706	0.1721	-2.735	0.8702
Futil	-0.0147	0.1721	-0.085	1.0000
IP	-0.1618	0.1721	-0.940	1.0000
LU	-0.4265	0.1721	-2.478	0.9665
MR	-0.4559	0.1721	-2.649	0.9125
MU	0.0441	0.1721	0.256	1.0000
NRRC	-0.2794	0.1721	-1.624	1.0000
OSU	-0.3676	0.1721	-2.136	0.9981
RC	0.0000	0.1721	0.000	1.0000
RE	-0.0588	0.1721	-0.342	1.0000
RP	-0.1471	0.1721	-0.855	1.0000
RRS	-0.6324	0.1721	-3.675	0.1630
RS	-0.0735	0.1721	-0.427	1.0000
RU	-0.0147	0.1721	-0.085	1.0000
TD	-0.1029	0.1721	-0.598	1.0000

Metric = CWI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUT	-0.5000	0.1721	-2.905	0.7550
WDI	-0.0588	0.1721	-0.342	1.0000
Wint	-0.3088	0.1721	-1.795	1.0000
WP	-0.0588	0.1721	-0.342	1.0000
WQ	-0.2500	0.1721	-1.453	1.0000
WU	0.0735	0.1721	0.427	1.0000

Metric = EE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EOLR	0.1765	0.1721	1.025	1.0000
LPT	0.8382	0.1721	4.871	0.0016
PLE	0.0294	0.1721	0.171	1.0000
RNC	0.6324	0.1721	3.675	0.1630

Metric = EEI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Eint	0.4265	0.1721	2.478	0.9665
EU	0.9265	0.1721	5.384	0.0003
EUNR	0.4265	0.1721	2.478	0.9665
LCEInt	0.0294	0.1721	0.171	1.0000
TEInt	0.1324	0.1721	0.769	1.0000

Metric = EI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Futil	0.4559	0.1721	2.649	0.9125
IP	0.3088	0.1721	1.795	1.0000
LU	0.0441	0.1721	0.256	1.0000
MR	0.0147	0.1721	0.085	1.0000
MU	0.5147	0.1721	2.991	0.6852
NRRC	0.1912	0.1721	1.111	1.0000
OSU	0.1029	0.1721	0.598	1.0000
RC	0.4706	0.1721	2.735	0.8702
RE	0.4118	0.1721	2.393	0.9813
RP	0.3235	0.1721	1.880	0.9999
RRS	-0.1618	0.1721	-0.940	1.0000
RS	0.3971	0.1721	2.307	0.9904
RU	0.4559	0.1721	2.649	0.9125

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TD	0.3676	0.1721	2.136	0.9981

Metric = Eint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EU	0.5000	0.1721	2.905	0.7550
EUNR	-0.0000	0.1721	-0.000	1.0000
LCEInt	-0.3971	0.1721	-2.307	0.9904
TEInt	-0.2941	0.1721	-1.709	1.0000

Metric = EOLR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LPT	0.6618	0.1721	3.846	0.0964
PLE	-0.1471	0.1721	-0.855	1.0000
RNC	0.4559	0.1721	2.649	0.9125

Metric = ET subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
GGE	0.2206	0.1721	1.282	1.0000
OCP	-0.3824	0.1721	-2.222	0.9955
OZ	-0.0882	0.1721	-0.513	1.0000
PPD	-0.2206	0.1721	-1.282	1.0000

Metric = EU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUNR	-0.500	0.1721	-2.905	0.7550
LCEInt	-0.897	0.1721	-5.213	0.0005
TEInt	-0.794	0.1721	-4.615	0.0050

Metric = EUNR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LCEInt	-0.3971	0.1721	-2.307	0.9904
TEInt	-0.2941	0.1721	-1.709	1.0000

Metric = EUT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WDI	0.44118	0.1721	2.5637	0.9442
Wint	0.19118	0.1721	1.1109	1.0000
WP	0.44118	0.1721	2.5637	0.9442
WQ	0.25000	0.1721	1.4527	1.0000
WU	0.57353	0.1721	3.3328	0.3857

Metric = Futil subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
IP	-0.1471	0.1721	-0.855	1.0000
LU	-0.4118	0.1721	-2.393	0.9813
MR	-0.4412	0.1721	-2.564	0.9442
MU	0.0588	0.1721	0.342	1.0000
NRRC	-0.2647	0.1721	-1.538	1.0000
OSU	-0.3529	0.1721	-2.051	0.9993
RC	0.0147	0.1721	0.085	1.0000
RE	-0.0441	0.1721	-0.256	1.0000
RP	-0.1324	0.1721	-0.769	1.0000
RRS	-0.6176	0.1721	-3.589	0.2074
RS	-0.0588	0.1721	-0.342	1.0000
RU	0.0000	0.1721	0.000	1.0000
TD	-0.0882	0.1721	-0.513	1.0000

Metric = GGE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OCP	-0.6029	0.1721	-3.504	0.2594
OZ	-0.3088	0.1721	-1.795	1.0000
PPD	-0.4412	0.1721	-2.564	0.9442

Metric = IP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LU	-0.2647	0.1721	-1.538	1.0000
MR	-0.2941	0.1721	-1.709	1.0000
MU	0.2059	0.1721	1.196	1.0000
NRRC	-0.1176	0.1721	-0.684	1.0000
OSU	-0.2059	0.1721	-1.196	1.0000
RC	0.1618	0.1721	0.940	1.0000
RE	0.1029	0.1721	0.598	1.0000
RP	0.0147	0.1721	0.085	1.0000
RRS	-0.4706	0.1721	-2.735	0.8702
RS	0.0882	0.1721	0.513	1.0000
RU	0.1471	0.1721	0.855	1.0000
TD	0.0588	0.1721	0.342	1.0000

Metric = LCEInt subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TEInt	0.1029	0.1721	0.598	1.0000

Metric = LPT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PLE	-0.8088	0.1721	-4.700	0.0034
RNC	-0.2059	0.1721	-1.196	1.0000

Metric = LU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MR	-0.0294	0.1721	-0.171	1.0000
MU	0.4706	0.1721	2.735	0.8702
NRRC	0.1471	0.1721	0.855	1.0000
OSU	0.0588	0.1721	0.342	1.0000
RC	0.4265	0.1721	2.478	0.9665
RE	0.3676	0.1721	2.136	0.9981
RP	0.2794	0.1721	1.624	1.0000
RRS	-0.2059	0.1721	-1.196	1.0000
RS	0.3529	0.1721	2.051	0.9993
RU	0.4118	0.1721	2.393	0.9813
TD	0.3235	0.1721	1.880	0.9999

Metric = MR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MU	0.5000	0.1721	2.905	0.7550
NRRC	0.1765	0.1721	1.025	1.0000
OSU	0.0882	0.1721	0.513	1.0000
RC	0.4559	0.1721	2.649	0.9125
RE	0.3971	0.1721	2.307	0.9904
RP	0.3088	0.1721	1.795	1.0000
RRS	-0.1765	0.1721	-1.025	1.0000
RS	0.3824	0.1721	2.222	0.9955
RU	0.4412	0.1721	2.564	0.9442
TD	0.3529	0.1721	2.051	0.9993

Metric = MU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
NRRC	-0.3235	0.1721	-1.880	0.9999
OSU	-0.4118	0.1721	-2.393	0.9813
RC	-0.0441	0.1721	-0.256	1.0000
RE	-0.1029	0.1721	-0.598	1.0000
RP	-0.1912	0.1721	-1.111	1.0000
RRS	-0.6765	0.1721	-3.931	0.0726
RS	-0.1176	0.1721	-0.684	1.0000
RU	-0.0588	0.1721	-0.342	1.0000
TD	-0.1471	0.1721	-0.855	1.0000

Metric = NRRC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OSU	-0.0882	0.1721	-0.513	1.0000
RC	0.2794	0.1721	1.624	1.0000
RE	0.2206	0.1721	1.282	1.0000
RP	0.1324	0.1721	0.769	1.0000
RRS	-0.3529	0.1721	-2.051	0.9993
RS	0.2059	0.1721	1.196	1.0000
RU	0.2647	0.1721	1.538	1.0000
TD	0.1765	0.1721	1.025	1.0000

Metric = OCP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OZ	0.2941	0.1721	1.7091	1.0000
PPD	0.1618	0.1721	0.9400	1.0000

Metric = OSU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RC	0.3676	0.1721	2.136	0.9981
RE	0.3088	0.1721	1.795	1.0000
RP	0.2206	0.1721	1.282	1.0000
RRS	-0.2647	0.1721	-1.538	1.0000
RS	0.2941	0.1721	1.709	1.0000
RU	0.3529	0.1721	2.051	0.9993
TD	0.2647	0.1721	1.538	1.0000

Metric = OZ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PPD	-0.1324	0.1721	-0.769	1.0000

Metric = PLE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RNC	0.60294	0.1721	3.50368	0.2594

Metric = PSW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RM	0.0588	0.1721	0.342	1.0000
RRR	0.3529	0.1721	2.051	0.9993
SW	0.1471	0.1721	0.855	1.0000
SWRR	-0.0735	0.1721	-0.427	1.0000
TE	-0.0882	0.1721	-0.513	1.0000
W	0.0882	0.1721	0.513	1.0000
WC	0.0735	0.1721	0.427	1.0000
WsU	-0.0735	0.1721	-0.427	1.0000

Metric = RC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RE	-0.0588	0.1721	-0.342	1.0000
RP	-0.1471	0.1721	-0.855	1.0000
RRS	-0.6324	0.1721	-3.675	0.1630
RS	-0.0735	0.1721	-0.427	1.0000
RU	-0.0147	0.1721	-0.085	1.0000
TD	-0.1029	0.1721	-0.598	1.0000

Metric = RE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RP	-0.0882	0.1721	-0.513	1.0000
RRS	-0.5735	0.1721	-3.333	0.3857
RS	-0.0147	0.1721	-0.085	1.0000
RU	0.0441	0.1721	0.256	1.0000
TD	-0.0441	0.1721	-0.256	1.0000

Metric = RM subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRR	0.2941	0.1721	1.709	1.0000
SW	0.0882	0.1721	0.513	1.0000
SWRR	-0.1324	0.1721	-0.769	1.0000
TE	-0.1471	0.1721	-0.855	1.0000
W	0.0294	0.1721	0.171	1.0000
WC	0.0147	0.1721	0.085	1.0000
WsU	-0.1324	0.1721	-0.769	1.0000

Metric = RP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRS	-0.4853	0.1721	-2.820	0.8173
RS	0.0735	0.1721	0.427	1.0000
RU	0.1324	0.1721	0.769	1.0000

TD	0.0441	0.1721	0.256	1.0000

Metric = RRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SW	-0.2059	0.1721	-1.196	1.0000
SWRR	-0.4265	0.1721	-2.478	0.9665
TE	-0.4412	0.1721	-2.564	0.9442
W	-0.2647	0.1721	-1.538	1.0000
WC	-0.2794	0.1721	-1.624	1.0000
WsU	-0.4265	0.1721	-2.478	0.9665

Metric = RRS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RS	0.558824	0.1721	3.24732	0.4578
RU	0.617647	0.1721	3.58914	0.2074
TD	0.529412	0.1721	3.07640	0.6104

Metric = RS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RU	0.0588	0.1721	0.342	1.0000
TD	-0.0294	0.1721	-0.171	1.0000

Metric = RU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TD	-0.0882	0.1721	-0.513	1.0000

Metric = SW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SWRR	-0.2206	0.1721	-1.282	1.0000
TE	-0.2353	0.1721	-1.367	1.0000
W	-0.0588	0.1721	-0.342	1.0000
WC	-0.0735	0.1721	-0.427	1.0000
WsU	-0.2206	0.1721	-1.282	1.0000

Metric = SWRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TE	-0.0147	0.1721	-0.0855	1.0000
W	0.1618	0.1721	0.9400	1.0000
WC	0.1471	0.1721	0.8546	1.0000
WsU	0.0000	0.1721	0.0000	1.0000

Metric = TE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
W	0.1765	0.1721	1.0255	1.000
WC	0.1618	0.1721	0.9400	1.000
WsU	0.0147	0.1721	0.0855	1.000

Metric = W subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WC	-0.0147	0.1721	-0.085	1.0000
WsU	-0.1618	0.1721	-0.940	1.0000

Metric = WC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WsU	-0.1471	0.1721	-0.855	1.000

Metric = WDI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Wint	-0.2500	0.1721	-1.453	1.000
WP	-0.0000	0.1721	-0.000	1.000
WQ	-0.1912	0.1721	-1.111	1.000
WU	0.1324	0.1721	0.769	1.000

Metric = Wint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WP	0.25000	0.1721	1.4527	1.0000
WQ	0.05882	0.1721	0.3418	1.0000
WU	0.38235	0.1721	2.2218	0.9955

Metric = WP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WQ	-0.1912	0.1721	-1.111	1.000
WU	0.1324	0.1721	0.769	1.000

Metric = WQ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WU	0.3235	0.1721	1.8800	0.9999

General Linear Model: Value versus Response, Metric Group, Metric (ANOVA 1)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric Group	fixed	6	Energy, Environment, Pollution, Resources, Technique/Process, Water
Metric(Metric Group)	fixed	55	EEI, Eint, EU, EUNR, LCEInt, TEInt, AcP, CF, Cint, ET, GGE, OCP, OZ, PPD, AP, BP, CO2, PSW, RM, RRR, SW, SWRR, TE, W, WC, WsU, CU, EI, Futil, IP, LU, MR, MU, NRRC, OSU, RC, RE, RP, RRS, RS, RU, TD, Beta, EE, EOLR, LPT, PLE, RNC, CWI, EUT, WDI, Wint, WP, WQ, WU

Analysis of Variance for Value, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	4279.659	4279.659	63.876	64.68	0.000
Metric Group	5	28.808	28.808	5.762	5.83	0.000
Metric(Metric Group)	49	245.035	245.035	5.001	5.06	0.000
Error	3618	3572.739	3572.739	0.987		
Total	3739	8126.240				

S = 0.993725   R-Sq = 56.03%   R-Sq(adj) = 54.56%

Tukey Simultaneous Tests
Response Variable Value
All Pairwise Comparisons among Levels of Metric(Metric Group)
Metric Group = Energy
Metric = EEI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	Eint	0.2353	0.1704	1.381	1.0000
Energy	EU	0.5147	0.1704	3.020	0.6600
Energy	EUNR	0.1618	0.1704	0.949	1.0000
Energy	LCEInt	0.0882	0.1704	0.518	1.0000
Energy	TEInt	-0.0735	0.1704	-0.431	1.0000

Metric Group = Energy
Metric = Eint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EU	0.2794	0.1704	1.640	1.0000
Energy	EUNR	-0.0735	0.1704	-0.431	1.0000
Energy	LCEInt	-0.1471	0.1704	-0.863	1.0000
Energy	TEInt	-0.3088	0.1704	-1.812	1.0000

Metric Group = Energy
Metric = EU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EUNR	-0.353	0.1704	-2.071	0.9991
Energy	LCEInt	-0.426	0.1704	-2.502	0.9611
Energy	TEInt	-0.588	0.1704	-3.452	0.2948

Metric Group = Energy
Metric = EUNR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	LCEInt	-0.0735	0.1704	-0.431	1.0000
Energy	TEInt	-0.2353	0.1704	-1.381	1.0000

Metric Group = Energy
Metric = LCEInt subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	TEInt	-0.1618	0.1704	-0.949	1.0000

Metric Group = Environment
Metric = AcP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	CF	0.95588	0.1704	5.6089	0.0002
Environment	Cint	0.26471	0.1704	1.5532	1.0000
Environment	ET	0.63235	0.1704	3.7105	0.1467
Environment	GGE	0.76471	0.1704	4.4871	0.0086
Environment	OCP	-0.02941	0.1704	-0.1726	1.0000
Environment	OZ	0.38235	0.1704	2.2436	0.9945
Environment	PPD	0.19118	0.1704	1.1218	1.0000

Metric Group = Environment
Metric = CF subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	Cint	-0.691	0.1704	-4.056	0.0469
Environment	ET	-0.324	0.1704	-1.898	0.9999
Environment	GGE	-0.191	0.1704	-1.122	1.0000
Environment	OCP	-0.985	0.1704	-5.781	0.0002
Environment	OZ	-0.574	0.1704	-3.365	0.3596
Environment	PPD	-0.765	0.1704	-4.487	0.0086

Metric Group = Environment
Metric = Cint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	ET	0.3676	0.1704	2.157	0.9977
Environment	GGE	0.5000	0.1704	2.934	0.7326
Environment	OCP	-0.2941	0.1704	-1.726	1.0000
Environment	OZ	0.1176	0.1704	0.690	1.0000
Environment	PPD	-0.0735	0.1704	-0.431	1.0000

Metric Group = Environment
Metric = ET subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	GGE	0.1324	0.1704	0.777	1.0000
Environment	**OCP**	**-0.6618**	**0.1704**	**-3.883**	**0.0852**

Environment	OZ	-0.2500	0.1704	-1.467	1.0000
Environment	PPD	-0.4412	0.1704	-2.589	0.9359

Metric Group = Environment
Metric = GGE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OCP	-0.7941	0.1704	-4.660	0.0040
Environment	OZ	-0.3824	0.1704	-2.244	0.9945
Environment	PPD	-0.5735	0.1704	-3.365	0.3596

Metric Group = Environment
Metric = OCP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OZ	0.41176	0.1704	2.4161	0.9779
Environment	PPD	0.22059	0.1704	1.2944	1.0000

Metric Group = Environment
Metric = OZ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	PPD	-0.1912	0.1704	-1.122	1.0000

Metric Group = Pollution
Metric = AP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	BP	-0.5294	0.1704	-3.106	0.5835
Pollution	CO2	0.2941	0.1704	1.726	1.0000
Pollution	PSW	-0.4706	0.1704	-2.761	0.8547
Pollution	RM	-0.3824	0.1704	-2.244	0.9945
Pollution	RRR	0.1765	0.1704	1.035	1.0000
Pollution	SW	-0.1471	0.1704	-0.863	1.0000
Pollution	SWRR	-0.6029	0.1704	-3.538	0.2376
Pollution	TE	-0.5294	0.1704	-3.106	0.5835
Pollution	W	-0.3676	0.1704	-2.157	0.9977
Pollution	WC	-0.2794	0.1704	-1.640	1.0000
Pollution	WsU	-0.5441	0.1704	-3.193	0.5060

Metric Group = Pollution
Metric = BP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	CO2	0.8235	0.1704	4.832	0.0019
Pollution	PSW	0.0588	0.1704	0.345	1.0000
Pollution	RM	0.1471	0.1704	0.863	1.0000
Pollution	RRR	0.7059	0.1704	4.142	0.0341
Pollution	SW	0.3824	0.1704	2.244	0.9945
Pollution	SWRR	-0.0735	0.1704	-0.431	1.0000
Pollution	TE	-0.0000	0.1704	-0.000	1.0000
Pollution	W	0.1618	0.1704	0.949	1.0000
Pollution	WC	0.2500	0.1704	1.467	1.0000
Pollution	WsU	-0.0147	0.1704	-0.086	1.0000

Metric Group = Pollution
Metric = CO2 subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	PSW	-0.765	0.1704	-4.487	0.0086
Pollution	RM	-0.676	0.1704	-3.969	0.0636
Pollution	RRR	-0.118	0.1704	-0.690	1.0000
Pollution	SW	-0.441	0.1704	-2.589	0.9359
Pollution	SWRR	-0.897	0.1704	-5.264	0.0004
Pollution	TE	-0.824	0.1704	-4.832	0.0019
Pollution	W	-0.662	0.1704	-3.883	0.0852
Pollution	WC	-0.574	0.1704	-3.365	0.3596
Pollution	WsU	-0.838	0.1704	-4.919	0.0013

Metric Group = Pollution
Metric = PSW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RM	0.0882	0.1704	0.518	1.0000
Pollution	RRR	0.6471	0.1704	3.797	0.1127
Pollution	SW	0.3235	0.1704	1.898	0.9999
Pollution	SWRR	-0.1324	0.1704	-0.777	1.0000
Pollution	TE	-0.0588	0.1704	-0.345	1.0000
Pollution	W	0.1029	0.1704	0.604	1.0000
Pollution	WC	0.1912	0.1704	1.122	1.0000
Pollution	WsU	-0.0735	0.1704	-0.431	1.0000

Metric Group = Pollution
Metric = RM subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RRR	0.5588	0.1704	3.279	0.4304
Pollution	SW	0.2353	0.1704	1.381	1.0000
Pollution	SWRR	-0.2206	0.1704	-1.294	1.0000
Pollution	TE	-0.1471	0.1704	-0.863	1.0000
Pollution	W	0.0147	0.1704	0.086	1.0000
Pollution	WC	0.1029	0.1704	0.604	1.0000
Pollution	WsU	-0.1618	0.1704	-0.949	1.0000

Metric Group = Pollution
Metric = RRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SW	-0.3235	0.1704	-1.898	0.9999
Pollution	SWRR	-0.7794	0.1704	-4.573	0.0059
Pollution	TE	-0.7059	0.1704	-4.142	0.0341
Pollution	W	-0.5441	0.1704	-3.193	0.5060
Pollution	WC	-0.4559	0.1704	-2.675	0.9008
Pollution	WsU	-0.7206	0.1704	-4.228	0.0245

Metric Group = Pollution
Metric = SW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SWRR	-0.4559	0.1704	-2.675	0.9008
Pollution	TE	-0.3824	0.1704	-2.244	0.9945
Pollution	W	-0.2206	0.1704	-1.294	1.0000
Pollution	WC	-0.1324	0.1704	-0.777	1.0000
Pollution	WsU	-0.3971	0.1704	-2.330	0.9884

Metric Group = Pollution
Metric = SWRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	TE	0.0735	0.1704	0.4315	1.0000
Pollution	W	0.2353	0.1704	1.3807	1.0000
Pollution	WC	0.3235	0.1704	1.8984	0.9999
Pollution	WsU	0.0588	0.1704	0.3452	1.0000

Metric Group = Pollution
Metric = TE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	W	0.1618	0.1704	0.949	1.0000
Pollution	WC	0.2500	0.1704	1.467	1.0000
Pollution	WsU	-0.0147	0.1704	-0.086	1.0000

Metric Group = Pollution
Metric = W subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WC	0.0882	0.1704	0.518	1.0000
Pollution	WsU	-0.1765	0.1704	-1.035	1.0000

Metric Group = Pollution
Metric = WC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WsU	-0.2647	0.1704	-1.553	1.0000

Metric Group = Resources
Metric = CU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	EI	-0.3529	0.1704	-2.071	0.9991
Resources	Futil	0.3088	0.1704	1.812	1.0000
Resources	IP	-0.1912	0.1704	-1.122	1.0000
Resources	LU	-0.5735	0.1704	-3.365	0.3596
Resources	MR	-0.4412	0.1704	-2.589	0.9359
Resources	MU	0.0294	0.1704	0.173	1.0000
Resources	NRRC	-0.1765	0.1704	-1.035	1.0000
Resources	OSU	-0.4412	0.1704	-2.589	0.9359
Resources	RC	-0.1324	0.1704	-0.777	1.0000
Resources	RE	0.0882	0.1704	0.518	1.0000
Resources	RP	0.0882	0.1704	0.518	1.0000
Resources	RRS	-0.3824	0.1704	-2.244	0.9945
Resources	RS	0.0735	0.1704	0.431	1.0000
Resources	RU	0.2794	0.1704	1.640	1.0000
Resources	TD	-0.1765	0.1704	-1.035	1.0000

Metric Group = Resources
Metric = EI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	Futil	0.6618	0.1704	3.883	0.0852
Resources	IP	0.1618	0.1704	0.949	1.0000
Resources	LU	-0.2206	0.1704	-1.294	1.0000
Resources	MR	-0.0882	0.1704	-0.518	1.0000
Resources	MU	0.3824	0.1704	2.244	0.9945
Resources	NRRC	0.1765	0.1704	1.035	1.0000
Resources	OSU	-0.0882	0.1704	-0.518	1.0000
Resources	RC	0.2206	0.1704	1.294	1.0000
Resources	RE	0.4412	0.1704	2.589	0.9359
Resources	RP	0.4412	0.1704	2.589	0.9359
Resources	RRS	-0.0294	0.1704	-0.173	1.0000
Resources	RS	0.4265	0.1704	2.502	0.9611
Resources	RU	0.6324	0.1704	3.711	0.1467
Resources	TD	0.1765	0.1704	1.035	1.0000

Metric Group = Resources
Metric = Futil subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	IP	-0.5000	0.1704	-2.934	0.7326
Resources	LU	-0.8824	0.1704	-5.177	0.0005
Resources	MR	-0.7500	0.1704	-4.401	0.0123
Resources	MU	-0.2794	0.1704	-1.640	1.0000
Resources	NRRC	-0.4853	0.1704	-2.848	0.7982
Resources	OSU	-0.7500	0.1704	-4.401	0.0123
Resources	RC	-0.4412	0.1704	-2.589	0.9359
Resources	RE	-0.2206	0.1704	-1.294	1.0000
Resources	RP	-0.2206	0.1704	-1.294	1.0000
Resources	RRS	-0.6912	0.1704	-4.056	0.0469
Resources	RS	-0.2353	0.1704	-1.381	1.0000
Resources	RU	-0.0294	0.1704	-0.173	1.0000
Resources	TD	-0.4853	0.1704	-2.848	0.7982

Metric Group = Resources
Metric = IP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	LU	-0.3824	0.1704	-2.244	0.9945
Resources	MR	-0.2500	0.1704	-1.467	1.0000
Resources	MU	0.2206	0.1704	1.294	1.0000
Resources	NRRC	0.0147	0.1704	0.086	1.0000
Resources	OSU	-0.2500	0.1704	-1.467	1.0000
Resources	RC	0.0588	0.1704	0.345	1.0000
Resources	RE	0.2794	0.1704	1.640	1.0000
Resources	RP	0.2794	0.1704	1.640	1.0000
Resources	RRS	-0.1912	0.1704	-1.122	1.0000
Resources	RS	0.2647	0.1704	1.553	1.0000
Resources	RU	0.4706	0.1704	2.761	0.8547
Resources	TD	0.0147	0.1704	0.086	1.0000

Metric Group = Resources
Metric = LU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MR	0.13235	0.1704	0.7766	1.0000
Resources	MU	0.60294	0.1704	3.5379	0.2376
Resources	NRRC	0.39706	0.1704	2.3299	0.9884
Resources	OSU	0.13235	0.1704	0.7766	1.0000
Resources	RC	0.44118	0.1704	2.5887	0.9359
Resources	RE	0.66176	0.1704	3.8831	0.0852
Resources	RP	0.66176	0.1704	3.8831	0.0852
Resources	RRS	0.19118	0.1704	1.1218	1.0000
Resources	RS	0.64706	0.1704	3.7968	0.1127

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RU	0.85294	0.1704	5.0049	0.0009
Resources	TD	0.39706	0.1704	2.3299	0.9884

Metric Group = Resources
Metric = MR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MU	0.47059	0.1704	2.7613	0.8547
Resources	NRRC	0.26471	0.1704	1.5532	1.0000
Resources	OSU	0.00000	0.1704	0.0000	1.0000
Resources	RC	0.30882	0.1704	1.8121	1.0000
Resources	RE	0.52941	0.1704	3.1065	0.5835
Resources	RP	0.52941	0.1704	3.1065	0.5835
Resources	RRS	0.05882	0.1704	0.3452	1.0000
Resources	RS	0.51471	0.1704	3.0202	0.6600
Resources	RU	0.72059	0.1704	4.2282	0.0245
Resources	TD	0.26471	0.1704	1.5532	1.0000

Metric Group = Resources
Metric = MU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	NRRC	-0.2059	0.1704	-1.208	1.0000
Resources	OSU	-0.4706	0.1704	-2.761	0.8547
Resources	RC	-0.1618	0.1704	-0.949	1.0000
Resources	RE	0.0588	0.1704	0.345	1.0000
Resources	RP	0.0588	0.1704	0.345	1.0000
Resources	RRS	-0.4118	0.1704	-2.416	0.9779
Resources	RS	0.0441	0.1704	0.259	1.0000
Resources	RU	0.2500	0.1704	1.467	1.0000
Resources	TD	-0.2059	0.1704	-1.208	1.0000

Metric Group = Resources
Metric = NRRC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	OSU	-0.2647	0.1704	-1.553	1.0000
Resources	RC	0.0441	0.1704	0.259	1.0000
Resources	RE	0.2647	0.1704	1.553	1.0000
Resources	RP	0.2647	0.1704	1.553	1.0000
Resources	RRS	-0.2059	0.1704	-1.208	1.0000
Resources	RS	0.2500	0.1704	1.467	1.0000
Resources	RU	0.4559	0.1704	2.675	0.9008
Resources	TD	-0.0000	0.1704	-0.000	1.0000

Metric Group = Resources
Metric = OSU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RC	0.30882	0.1704	1.8121	1.0000
Resources	RE	0.52941	0.1704	3.1065	0.5835
Resources	RP	0.52941	0.1704	3.1065	0.5835
Resources	RRS	0.05882	0.1704	0.3452	1.0000
Resources	RS	0.51471	0.1704	3.0202	0.6600
Resources	RU	0.72059	0.1704	4.2282	0.0245
Resources	TD	0.26471	0.1704	1.5532	1.0000

Metric Group = Resources
Metric = RC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RE	0.2206	0.1704	1.294	1.0000
Resources	RP	0.2206	0.1704	1.294	1.0000
Resources	RRS	-0.2500	0.1704	-1.467	1.0000
Resources	RS	0.2059	0.1704	1.208	1.0000
Resources	RU	0.4118	0.1704	2.416	0.9779
Resources	TD	-0.0441	0.1704	-0.259	1.0000

Metric Group = Resources
Metric = RE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RP	-0.0000	0.1704	-0.000	1.0000
Resources	RRS	-0.4706	0.1704	-2.761	0.8547
Resources	RS	-0.0147	0.1704	-0.086	1.0000
Resources	RU	0.1912	0.1704	1.122	1.0000
Resources	TD	-0.2647	0.1704	-1.553	1.0000

Metric Group = Resources
Metric = RP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RRS	-0.4706	0.1704	-2.761	0.8547
Resources	RS	-0.0147	0.1704	-0.086	1.0000
Resources	RU	0.1912	0.1704	1.122	1.0000
Resources	TD	-0.2647	0.1704	-1.553	1.0000

Metric Group = Resources
Metric = RRS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RS	0.4559	0.1704	2.6750	0.9008
Resources	RU	0.6618	0.1704	3.8831	0.0852
Resources	TD	0.2059	0.1704	1.2081	1.0000

Metric Group = Resources
Metric = RS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RU	0.2059	0.1704	1.208	1.0000
Resources	TD	-0.2500	0.1704	-1.467	1.0000

Metric Group = Resources
Metric = RU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	TD	-0.4559	0.1704	-2.675	0.9008

Metric Group = Technique/Process
Metric = Beta subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EE	0.0588	0.1704	0.3452	1.0000
Technique/Process	EOLR	0.1029	0.1704	0.6040	1.0000
Technique/Process	LPT	0.6912	0.1704	4.0557	0.0469

Metric Group = Resources

Technique/Process	PLE	0.0882	0.1704	0.5177	1.0000
Technique/Process	RNC	0.3382	0.1704	1.9847	0.9997

Metric Group = Technique/Process
Metric = EE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EOLR	0.0441	0.1704	0.259	1.0000
Technique/Process	LPT	0.6324	0.1704	3.711	0.1467
Technique/Process	PLE	0.0294	0.1704	0.173	1.0000
Technique/Process	RNC	0.2794	0.1704	1.640	1.0000

Metric Group = Technique/Process
Metric = EOLR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	LPT	0.5882	0.1704	3.452	0.2948
Technique/Process	PLE	-0.0147	0.1704	-0.086	1.0000
Technique/Process	RNC	0.2353	0.1704	1.381	1.0000

Metric Group = Technique/Process
Metric = LPT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	PLE	-0.6029	0.1704	-3.538	0.2376
Technique/Process	RNC	-0.3529	0.1704	-2.071	0.9991

Metric Group = Technique/Process
Metric = PLE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	RNC	0.2500	0.1704	1.467	1.000

Metric Group = Water
Metric = CWI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	EUT	-0.3971	0.1704	-2.330	0.9884
Water	WDI	-0.1324	0.1704	-0.777	1.0000
Water	Wint	-0.1176	0.1704	-0.690	1.0000
Water	WP	-0.0000	0.1704	-0.000	1.0000
Water	WQ	-0.1176	0.1704	-0.690	1.0000
Water	WU	-0.1471	0.1704	-0.863	1.0000

Metric Group = Water
Metric = EUT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WDI	0.2647	0.1704	1.553	1.0000
Water	Wint	0.2794	0.1704	1.640	1.0000
Water	WP	0.3971	0.1704	2.330	0.9884
Water	WQ	0.2794	0.1704	1.640	1.0000
Water	WU	0.2500	0.1704	1.467	1.0000

Metric Group = Water
Metric = WDI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	Wint	0.01471	0.1704	0.08629	1.000
Water	WP	0.13235	0.1704	0.77662	1.000
Water	WQ	0.01471	0.1704	0.08629	1.000
Water	WU	-0.01471	0.1704	-0.08629	1.000

Metric Group = Water
Metric = Wint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WP	0.11765	0.1704	0.6903	1.000
Water	WQ	-0.00000	0.1704	-0.0000	1.000
Water	WU	-0.02941	0.1704	-0.1726	1.000

Metric Group = Water
Metric = WP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WQ	-0.1176	0.1704	-0.6903	1.000
Water	WU	-0.1471	0.1704	-0.8629	1.000

Metric Group = Water
Metric = WQ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WU	-0.02941	0.1704	-0.1726	1.000

General Linear Model: Value versus Response, Metric (ANOVA 2)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric	fixed	55	AcP, AP, Beta, BP, CF, Cint, CO2, CU, CWI, EE, EEI, EI, Eint, EOLR, ET, EU, EUNR, EUT, Futil, GGE, IP, LCEInt, LPT, LU, MR, MU, NRRC, OCP, OSU, OZ, PLE, PPD, PSW, RC, RE, RM, RNC, RP, RRR, RRS, RS, RU, SW, SWRR, TD, TE, TEInt, W, WC, WDI, Wint, WP, WQ, WsU, WU

Analysis of Variance for Value, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	4279.659	4279.659	63.876	64.68	0.000
Metric	54	273.843	273.843	5.071	5.14	0.000
Error	3618	3572.739	3572.739	0.987		
Total	3739	8126.240				

S = 0.993725   R-Sq = 56.03%   R-Sq(adj) = 54.56%

Tukey Simultaneous Tests
Response Variable Value
All Pairwise Comparisons among Levels of Metric
Metric = AcP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CF	0.95588	0.1704	5.6089	0.0002
Cint	0.26471	0.1704	1.5532	1.0000
ET	0.63235	0.1704	3.7105	0.1467
GGE	0.76471	0.1704	4.4871	0.0086
OCP	-0.02941	0.1704	-0.1726	1.0000
OZ	0.38235	0.1704	2.2436	0.9945
PPD	0.19118	0.1704	1.1218	1.0000

Metric = AP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BP	-0.5294	0.1704	-3.106	0.5835
CO2	0.2941	0.1704	1.726	1.0000
PSW	-0.4706	0.1704	-2.761	0.8547
RM	-0.3824	0.1704	-2.244	0.9945
RRR	0.1765	0.1704	1.035	1.0000
SW	-0.1471	0.1704	-0.863	1.0000
SWRR	-0.6029	0.1704	-3.538	0.2376
TE	-0.5294	0.1704	-3.106	0.5835
W	-0.3676	0.1704	-2.157	0.9977
WC	-0.2794	0.1704	-1.640	1.0000
WsU	-0.5441	0.1704	-3.193	0.5060

Metric = Beta subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EE	0.0588	0.1704	0.345	1.0000
EOLR	0.1029	0.1704	0.604	1.0000
LPT	0.6912	0.1704	4.056	0.0469
PLE	0.0882	0.1704	0.518	1.0000
RNC	0.3382	0.1704	1.985	0.9997

Metric = BP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CO2	0.8235	0.1704	4.832	0.0019
PSW	0.0588	0.1704	0.345	1.0000
RM	0.1471	0.1704	0.863	1.0000
RRR	0.7059	0.1704	4.142	0.0341
SW	0.3824	0.1704	2.244	0.9945
SWRR	-0.0735	0.1704	-0.431	1.0000
TE	0.0000	0.1704	0.000	1.0000
W	0.1618	0.1704	0.949	1.0000
WC	0.2500	0.1704	1.467	1.0000
WsU	-0.0147	0.1704	-0.086	1.0000

Metric = CF subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Cint	-0.691	0.1704	-4.056	0.0469
ET	-0.324	0.1704	-1.898	0.9999
GGE	-0.191	0.1704	-1.122	1.0000
OCP	-0.985	0.1704	-5.781	0.0002
OZ	-0.574	0.1704	-3.365	0.3596
PPD	-0.765	0.1704	-4.487	0.0086

Metric = Cint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
ET	0.3676	0.1704	2.157	0.9977
GGE	0.5000	0.1704	2.934	0.7326
OCP	-0.2941	0.1704	-1.726	1.0000
OZ	0.1176	0.1704	0.690	1.0000
PPD	-0.0735	0.1704	-0.431	1.0000

Metric = CO2 subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PSW	-0.765	0.1704	-4.487	0.0086
RM	-0.676	0.1704	-3.969	0.0636
RRR	-0.118	0.1704	-0.690	1.0000
SW	-0.441	0.1704	-2.589	0.9359
SWRR	-0.897	0.1704	-5.264	0.0004
TE	-0.824	0.1704	-4.832	0.0019
W	-0.662	0.1704	-3.883	0.0852
WC	-0.574	0.1704	-3.365	0.3596
WsU	-0.838	0.1704	-4.919	0.0013

Metric = CU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EI	-0.3529	0.1704	-2.071	0.9991

Futil	0.3088	0.1704	1.812	1.0000
IP	-0.1912	0.1704	-1.122	1.0000
LU	-0.5735	0.1704	-3.365	0.3596
MR	-0.4412	0.1704	-2.589	0.9359
MU	0.0294	0.1704	0.173	1.0000
NRRC	-0.1765	0.1704	-1.035	1.0000
OSU	-0.4412	0.1704	-2.589	0.9359
RC	-0.1324	0.1704	-0.777	1.0000
RE	0.0882	0.1704	0.518	1.0000
RP	0.0882	0.1704	0.518	1.0000
RRS	-0.3824	0.1704	-2.244	0.9945
RS	0.0735	0.1704	0.431	1.0000
RU	0.2794	0.1704	1.640	1.0000
TD	-0.1765	0.1704	-1.035	1.0000

Metric = CWI subtracted from:

	Difference	SE of		Adjusted
EUT	-0.3971	0.1704	-2.330	0.9884
WDI	-0.1324	0.1704	-0.777	1.0000
Wint	-0.1176	0.1704	-0.690	1.0000
WP	-0.0000	0.1704	-0.000	1.0000
WQ	-0.1176	0.1704	-0.690	1.0000
WU	-0.1471	0.1704	-0.863	1.0000

Metric = EE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EOLR	0.0441	0.1704	0.259	1.0000
LPT	0.6324	0.1704	3.711	0.1467
PLE	0.0294	0.1704	0.173	1.0000
RNC	0.2794	0.1704	1.640	1.0000

Metric = EEI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Eint	0.2353	0.1704	1.381	1.0000
EU	0.5147	0.1704	3.020	0.6600
EUNR	0.1618	0.1704	0.949	1.0000
LCEInt	0.0882	0.1704	0.518	1.0000
TEInt	-0.0735	0.1704	-0.431	1.0000

Metric = EI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Futil	0.6618	0.1704	3.883	0.0852
IP	0.1618	0.1704	0.949	1.0000
LU	-0.2206	0.1704	-1.294	1.0000
MR	-0.0882	0.1704	-0.518	1.0000
MU	0.3824	0.1704	2.244	0.9945
NRRC	0.1765	0.1704	1.035	1.0000
OSU	-0.0882	0.1704	-0.518	1.0000
RC	0.2206	0.1704	1.294	1.0000
RE	0.4412	0.1704	2.589	0.9359
RP	0.4412	0.1704	2.589	0.9359
RRS	-0.0294	0.1704	-0.173	1.0000
RS	0.4265	0.1704	2.502	0.9611
RU	0.6324	0.1704	3.711	0.1467
TD	0.1765	0.1704	1.035	1.0000

Metric = Eint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EU	0.2794	0.1704	1.640	1.0000
EUNR	-0.0735	0.1704	-0.431	1.0000
LCEInt	-0.1471	0.1704	-0.863	1.0000
TEInt	-0.3088	0.1704	-1.812	1.0000

Metric = EOLR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LPT	0.5882	0.1704	3.452	0.2948
PLE	-0.0147	0.1704	-0.086	1.0000
RNC	0.2353	0.1704	1.381	1.0000

Metric = ET subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
GGE	0.1324	0.1704	0.777	1.0000
OCP	-0.6618	0.1704	-3.883	0.0852
OZ	-0.2500	0.1704	-1.467	1.0000
PPD	-0.4412	0.1704	-2.589	0.9359

Metric = EU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUNR	-0.353	0.1704	-2.071	0.9991
LCEInt	-0.426	0.1704	-2.502	0.9611
TEInt	-0.588	0.1704	-3.452	0.2948

Metric = EUNR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LCEInt	-0.0735	0.1704	-0.431	1.0000
TEInt	-0.2353	0.1704	-1.381	1.0000

Metric = EUT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WDI	0.26471	0.1704	1.5532	1.0000
Wint	0.27941	0.1704	1.6395	1.0000
WP	0.39706	0.1704	2.3299	0.9884
WQ	0.27941	0.1704	1.6395	1.0000
WU	0.25000	0.1704	1.4669	1.0000

Metric = Futil subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
IP	-0.5000	0.1704	-2.934	0.7326
LU	-0.8824	0.1704	-5.177	0.0005
MR	-0.7500	0.1704	-4.401	0.0123
MU	-0.2794	0.1704	-1.640	1.0000
NRRC	-0.4853	0.1704	-2.848	0.7982
OSU	-0.7500	0.1704	-4.401	0.0123
RC	-0.4412	0.1704	-2.589	0.9359

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RE	-0.2206	0.1704	-1.294	1.0000
RP	-0.2206	0.1704	-1.294	1.0000
RRS	-0.6912	0.1704	-4.056	0.0469
RS	-0.2353	0.1704	-1.381	1.0000
RU	-0.0294	0.1704	-0.173	1.0000
TD	-0.4853	0.1704	-2.848	0.7982

Metric = GGE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OCP	-0.7941	0.1704	-4.660	0.0040
OZ	-0.3824	0.1704	-2.244	0.9945
PPD	-0.5735	0.1704	-3.365	0.3596

Metric = IP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LU	-0.3824	0.1704	-2.244	0.9945
MR	-0.2500	0.1704	-1.467	1.0000
MU	0.2206	0.1704	1.294	1.0000
NRRC	0.0147	0.1704	0.086	1.0000
OSU	-0.2500	0.1704	-1.467	1.0000
RC	0.0588	0.1704	0.345	1.0000
RE	0.2794	0.1704	1.640	1.0000
RP	0.2794	0.1704	1.640	1.0000
RRS	-0.1912	0.1704	-1.122	1.0000
RS	0.2647	0.1704	1.553	1.0000
RU	0.4706	0.1704	2.761	0.8547
TD	0.0147	0.1704	0.086	1.0000

Metric = LCEInt subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TEInt	-0.1618	0.1704	-0.949	1.0000

Metric = LPT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PLE	-0.6029	0.1704	-3.538	0.2376
RNC	-0.3529	0.1704	-2.071	0.9991

Metric = LU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MR	0.13235	0.1704	0.7766	1.0000
MU	0.60294	0.1704	3.5379	0.2376
NRRC	0.39706	0.1704	2.3299	0.9884
OSU	0.13235	0.1704	0.7766	1.0000
RC	0.44118	0.1704	2.5887	0.9359
RE	0.66176	0.1704	3.8831	0.0852
RP	0.66176	0.1704	3.8831	0.0852
RRS	0.19118	0.1704	1.1218	1.0000
RS	0.64706	0.1704	3.7968	0.1127
RU	0.85294	0.1704	5.0049	0.0009
TD	0.39706	0.1704	2.3299	0.9884

Metric = MR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MU	0.47059	0.1704	2.7613	0.8547
NRRC	0.26471	0.1704	1.5532	1.0000
OSU	0.00000	0.1704	0.0000	1.0000
RC	0.30882	0.1704	1.8121	1.0000
RE	0.52941	0.1704	3.1065	0.5835
RP	0.52941	0.1704	3.1065	0.5835
RRS	0.05882	0.1704	0.3452	1.0000
RS	0.51471	0.1704	3.0202	0.6600
RU	0.72059	0.1704	4.2282	0.0245
TD	0.26471	0.1704	1.5532	1.0000

Metric = MU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
NRRC	-0.2059	0.1704	-1.208	1.0000
OSU	-0.4706	0.1704	-2.761	0.8547
RC	-0.1618	0.1704	-0.949	1.0000
RE	0.0588	0.1704	0.345	1.0000
RP	0.0588	0.1704	0.345	1.0000
RRS	-0.4118	0.1704	-2.416	0.9779
RS	0.0441	0.1704	0.259	1.0000
RU	0.2500	0.1704	1.467	1.0000
TD	-0.2059	0.1704	-1.208	1.0000

Metric = NRRC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OSU	-0.2647	0.1704	-1.553	1.0000
RC	0.0441	0.1704	0.259	1.0000
RE	0.2647	0.1704	1.553	1.0000
RP	0.2647	0.1704	1.553	1.0000
RRS	-0.2059	0.1704	-1.208	1.0000
RS	0.2500	0.1704	1.467	1.0000
RU	0.4559	0.1704	2.675	0.9008
TD	0.0000	0.1704	0.000	1.0000

Metric = OCP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OZ	0.41176	0.1704	2.4161	0.9779
PPD	0.22059	0.1704	1.2944	1.0000

Metric = OSU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RC	0.308824	0.1704	1.81211	1.0000
RE	0.529412	0.1704	3.10647	0.5835
RP	0.529412	0.1704	3.10647	0.5835
RRS	0.058824	0.1704	0.34516	1.0000
RS	0.514706	0.1704	3.02018	0.6600
RU	0.720588	0.1704	4.22825	0.0245
TD	0.264706	0.1704	1.55323	1.0000

Metric = OZ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value

PPD	-0.1912	0.1704	-1.122	1.0000

Metric = PLE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RNC	0.2500	0.1704	1.467	1.0000

Metric = PSW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RM	0.0882	0.1704	0.5177	1.0000
RRR	0.6471	0.1704	3.7968	0.1127
SW	0.3235	0.1704	1.8984	0.9999
SWRR	-0.1324	0.1704	-0.7766	1.0000
TE	-0.0588	0.1704	-0.3452	1.0000
W	0.1029	0.1704	0.6040	1.0000
WC	0.1912	0.1704	1.1218	1.0000
WsU	-0.0735	0.1704	-0.4315	1.0000

Metric = RC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RE	0.2206	0.1704	1.294	1.0000
RP	0.2206	0.1704	1.294	1.0000
RRS	-0.2500	0.1704	-1.467	1.0000
RS	0.2059	0.1704	1.208	1.0000
RU	0.4118	0.1704	2.416	0.9779
TD	-0.0441	0.1704	-0.259	1.0000

Metric = RE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RP	-0.0000	0.1704	-0.000	1.0000
RRS	-0.4706	0.1704	-2.761	0.8547
RS	-0.0147	0.1704	-0.086	1.0000
RU	0.1912	0.1704	1.122	1.0000
TD	-0.2647	0.1704	-1.553	1.0000

Metric = RM subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRR	0.5588	0.1704	3.279	0.4304
SW	0.2353	0.1704	1.381	1.0000
SWRR	-0.2206	0.1704	-1.294	1.0000
TE	-0.1471	0.1704	-0.863	1.0000
W	0.0147	0.1704	0.086	1.0000
WC	0.1029	0.1704	0.604	1.0000
WsU	-0.1618	0.1704	-0.949	1.0000

Metric = RP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRS	-0.4706	0.1704	-2.761	0.8547
RS	-0.0147	0.1704	-0.086	1.0000
RU	0.1912	0.1704	1.122	1.0000
TD	-0.2647	0.1704	-1.553	1.0000

Metric = RRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SW	-0.3235	0.1704	-1.898	0.9999
SWRR	-0.7794	0.1704	-4.573	0.0059
TE	-0.7059	0.1704	-4.142	0.0341
W	-0.5441	0.1704	-3.193	0.5060
WC	-0.4559	0.1704	-2.675	0.9008
WsU	-0.7206	0.1704	-4.228	0.0245

Metric = RRS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RS	0.45588	0.1704	2.6750	0.9008
RU	0.66176	0.1704	3.8831	0.0852
TD	0.20588	0.1704	1.2081	1.0000

Metric = RS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RU	0.2059	0.1704	1.208	1.0000
TD	-0.2500	0.1704	-1.467	1.0000

Metric = RU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TD	-0.4559	0.1704	-2.675	0.9008

Metric = SW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SWRR	-0.4559	0.1704	-2.675	0.9008
TE	-0.3824	0.1704	-2.244	0.9945
W	-0.2206	0.1704	-1.294	1.0000
WC	-0.1324	0.1704	-0.777	1.0000
WsU	-0.3971	0.1704	-2.330	0.9884

Metric = SWRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TE	0.07353	0.1704	0.4315	1.0000
W	0.23529	0.1704	1.3807	1.0000
WC	0.32353	0.1704	1.8984	0.9999
WsU	0.05882	0.1704	0.3452	1.0000

Metric = TE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
W	0.16176	0.1704	0.94920	1.000
WC	0.25000	0.1704	1.46694	1.000
WsU	-0.01471	0.1704	-0.08629	1.000

Metric = W subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WC	0.0882	0.1704	0.518	1.000
WsU	-0.1765	0.1704	-1.035	1.000

Metric = WC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WsU	-0.2647	0.1704	-1.553	1.000

Metric = WDI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Wint	0.0147	0.1704	0.0863	1.000
WP	0.1324	0.1704	0.7766	1.000
WQ	0.0147	0.1704	0.0863	1.000
WU	-0.0147	0.1704	-0.0863	1.000

Metric = Wint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WP	0.1176	0.1704	0.690	1.000
WQ	-0.0000	0.1704	-0.000	1.000
WU	-0.0294	0.1704	-0.173	1.000

Metric = WP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WQ	-0.1176	0.1704	-0.690	1.000
WU	-0.1471	0.1704	-0.863	1.000

Metric = WQ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WU	-0.0294	0.1704	-0.173	1.000

General Linear Model: Suggested versus Response, Metric Group, Metric (ANOVA 1)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric Group	fixed	6	Energy, Environment, Pollution, Resources, Technique/Process, Water
Metric(Metric Group)	fixed	55	EEI, Eint, EU, EUNR, LCEInt, TEInt, AcP, CF, Cint, ET, GGE, OCP, OZ, PPD, AP, BP, CO2, PSW, RM, RRR, SW, SWRR, TE, W, WC, WsU, CU, EI, Futil, IP, LU, MR, MU, NRRC, OSU, RC, RE, RP, RRS, RS, RU, TD, Beta, EE, EOLR, LPT, PLE, RNC, CWI, EUT, WDI, Wint, WP, WQ, WU

Analysis of Variance for Suggested, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	435.0340	435.0340	6.4930	49.87	0.000
Metric Group	5	6.0140	6.0140	1.2028	9.24	0.000
Metric(Metric Group)	49	21.9352	21.9352	0.4477	3.44	0.000
Error	3618	471.0690	471.0690	0.1302		
Total	3739	934.0521				

S = 0.360834   R-Sq = 49.57%   R-Sq(adj) = 47.88%

Tukey Simultaneous Tests
Response Variable Suggested
All Pairwise Comparisons among Levels of Metric(Metric Group)
Metric Group = Energy
Metric = EEI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	Eint	-0.1912	0.06188	-3.089	0.5988
Energy	EU	-0.2794	0.06188	-4.515	0.0076
Energy	EUNR	-0.0294	0.06188	-0.475	1.0000
Energy	LCEInt	0.0000	0.06188	0.000	1.0000
Energy	TEInt	-0.0882	0.06188	-1.426	1.0000

Metric Group = Energy
Metric = Eint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EU	-0.08824	0.06188	-1.426	1.0000
Energy	EUNR	0.16176	0.06188	2.614	0.9267
Energy	LCEInt	0.19118	0.06188	3.089	0.5988
Energy	TEInt	0.10294	0.06188	1.663	1.0000

Metric Group = Energy
Metric = EU subtracted from:

		Difference	SE of		Adjusted

Metric Group	Metric	of Means	Difference	T-Value	P-Value
Energy	EUNR	0.25000	0.06188	4.0399	0.0496
Energy	LCEInt	0.27941	0.06188	4.5152	0.0076
Energy	TEInt	0.19118	0.06188	3.0893	0.5988

Metric Group = Energy
Metric = EUNR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	LCEInt	0.0294	0.06188	0.475	1.0000
Energy	TEInt	-0.0588	0.06188	-0.951	1.0000

Metric Group = Energy
Metric = LCEInt subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	TEInt	-0.0882	0.06188	-1.426	1.0000

Metric Group = Environment
Metric = AcP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	CF	-0.1912	0.06188	-3.089	0.5988
Environment	Cint	-0.0294	0.06188	-0.475	1.0000
Environment	ET	-0.1176	0.06188	-1.901	0.9999
Environment	GGE	-0.1765	0.06188	-2.852	0.7952
Environment	OCP	0.0441	0.06188	0.713	1.0000
Environment	OZ	-0.0735	0.06188	-1.188	1.0000
Environment	PPD	0.0147	0.06188	0.238	1.0000

Metric Group = Environment
Metric = CF subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	Cint	0.1618	0.06188	2.614	0.9267
Environment	ET	0.0735	0.06188	1.188	1.0000
Environment	GGE	0.0147	0.06188	0.238	1.0000
Environment	OCP	0.2353	0.06188	3.802	0.1107
Environment	OZ	0.1176	0.06188	1.901	0.9999
Environment	PPD	0.2059	0.06188	3.327	0.3905

Metric Group = Environment
Metric = Cint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	ET	-0.0882	0.06188	-1.426	1.0000
Environment	GGE	-0.1471	0.06188	-2.376	0.9834
Environment	OCP	0.0735	0.06188	1.188	1.0000
Environment	OZ	-0.0441	0.06188	-0.713	1.0000
Environment	PPD	0.0441	0.06188	0.713	1.0000

Metric Group = Environment
Metric = ET subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	GGE	-0.0588	0.06188	-0.951	1.0000
Environment	OCP	0.1618	0.06188	2.614	0.9267
Environment	OZ	0.0441	0.06188	0.713	1.0000
Environment	PPD	0.1324	0.06188	2.139	0.9981

Metric Group = Environment
Metric = GGE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OCP	0.2206	0.06188	3.565	0.2214
Environment	OZ	0.1029	0.06188	1.663	1.0000
Environment	PPD	0.1912	0.06188	3.089	0.5988

Metric Group = Environment
Metric = OCP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OZ	-0.1176	0.06188	-1.901	0.9999
Environment	PPD	-0.0294	0.06188	-0.475	1.0000

Metric Group = Environment
Metric = OZ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	PPD	0.0882	0.06188	1.426	1.0000

Metric Group = Pollution
Metric = AP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	BP	0.1029	0.06188	1.663	1.0000
Pollution	CO2	-0.0147	0.06188	-0.238	1.0000
Pollution	PSW	0.1029	0.06188	1.663	1.0000
Pollution	RM	0.0735	0.06188	1.188	1.0000
Pollution	RRR	-0.0882	0.06188	-1.426	1.0000
Pollution	SW	-0.0000	0.06188	-0.000	1.0000
Pollution	SWRR	0.1324	0.06188	2.139	0.9981
Pollution	TE	0.0882	0.06188	1.426	1.0000
Pollution	W	-0.0441	0.06188	-0.713	1.0000
Pollution	WC	0.0735	0.06188	1.188	1.0000
Pollution	WsU	0.1471	0.06188	2.376	0.9834

Metric Group = Pollution
Metric = BP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	CO2	-0.1176	0.06188	-1.901	0.9999
Pollution	PSW	0.0000	0.06188	0.000	1.0000
Pollution	RM	-0.0294	0.06188	-0.475	1.0000
Pollution	RRR	-0.1912	0.06188	-3.089	0.5988
Pollution	SW	-0.1029	0.06188	-1.663	1.0000
Pollution	SWRR	0.0294	0.06188	0.475	1.0000
Pollution	TE	-0.0147	0.06188	-0.238	1.0000
Pollution	W	-0.1471	0.06188	-2.376	0.9834
Pollution	WC	-0.0294	0.06188	-0.475	1.0000
Pollution	WsU	0.0441	0.06188	0.713	1.0000

Metric Group = Pollution
Metric = CO2 subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	PSW	0.1176	0.06188	1.901	0.9999
Pollution	RM	0.0882	0.06188	1.426	1.0000
Pollution	RRR	-0.0735	0.06188	-1.188	1.0000
Pollution	SW	0.0147	0.06188	0.238	1.0000
Pollution	SWRR	0.1471	0.06188	2.376	0.9834
Pollution	TE	0.1029	0.06188	1.663	1.0000
Pollution	W	-0.0294	0.06188	-0.475	1.0000
Pollution	WC	0.0882	0.06188	1.426	1.0000
Pollution	WsU	0.1618	0.06188	2.614	0.9267

Metric Group = Pollution
Metric = PSW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RM	-0.0294	0.06188	-0.475	1.0000
Pollution	RRR	-0.1912	0.06188	-3.089	0.5988
Pollution	SW	-0.1029	0.06188	-1.663	1.0000
Pollution	SWRR	0.0294	0.06188	0.475	1.0000
Pollution	TE	-0.0147	0.06188	-0.238	1.0000
Pollution	W	-0.1471	0.06188	-2.376	0.9834
Pollution	WC	-0.0294	0.06188	-0.475	1.0000
Pollution	WsU	0.0441	0.06188	0.713	1.0000

Metric Group = Pollution
Metric = RM subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RRR	-0.1618	0.06188	-2.614	0.9267
Pollution	SW	-0.0735	0.06188	-1.188	1.0000
Pollution	SWRR	0.0588	0.06188	0.951	1.0000
Pollution	TE	0.0147	0.06188	0.238	1.0000
Pollution	W	-0.1176	0.06188	-1.901	0.9999
Pollution	WC	0.0000	0.06188	0.000	1.0000
Pollution	WsU	0.0735	0.06188	1.188	1.0000

Metric Group = Pollution
Metric = RRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SW	0.08824	0.06188	1.4258	1.0000
Pollution	SWRR	0.22059	0.06188	3.5646	0.2214
Pollution	TE	0.17647	0.06188	2.8517	0.7952
Pollution	W	0.04412	0.06188	0.7129	1.0000
Pollution	WC	0.16176	0.06188	2.6141	0.9267
Pollution	WsU	0.23529	0.06188	3.8023	0.1107

Metric Group = Pollution
Metric = SW subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SWRR	0.1324	0.06188	2.139	0.9981
Pollution	TE	0.0882	0.06188	1.426	1.0000
Pollution	W	-0.0441	0.06188	-0.713	1.0000
Pollution	WC	0.0735	0.06188	1.188	1.0000
Pollution	WsU	0.1471	0.06188	2.376	0.9834

Metric Group = Pollution
Metric = SWRR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	TE	-0.0441	0.06188	-0.713	1.0000
Pollution	W	-0.1765	0.06188	-2.852	0.7952
Pollution	WC	-0.0588	0.06188	-0.951	1.0000
Pollution	WsU	0.0147	0.06188	0.238	1.0000

Metric Group = Pollution
Metric = TE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	W	-0.1324	0.06188	-2.139	0.9981
Pollution	WC	-0.0147	0.06188	-0.238	1.0000
Pollution	WsU	0.0588	0.06188	0.951	1.0000

Metric Group = Pollution
Metric = W subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WC	0.1176	0.06188	1.901	0.9999
Pollution	WsU	0.1912	0.06188	3.089	0.5988

Metric Group = Pollution
Metric = WC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WsU	0.0735	0.06188	1.188	1.0000

Metric Group = Resources
Metric = CU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	EI	0.1029	0.06188	1.663	1.0000
Resources	Futil	-0.0735	0.06188	-1.188	1.0000
Resources	IP	0.0294	0.06188	0.475	1.0000
Resources	LU	0.1176	0.06188	1.901	0.9999
Resources	MR	0.1176	0.06188	1.901	0.9999
Resources	MU	-0.0588	0.06188	-0.951	1.0000
Resources	NRRC	0.0588	0.06188	0.951	1.0000
Resources	OSU	0.0294	0.06188	0.475	1.0000
Resources	RC	0.0000	0.06188	0.000	1.0000
Resources	RE	-0.0147	0.06188	-0.238	1.0000
Resources	RP	0.0735	0.06188	1.188	1.0000
Resources	RRS	0.0735	0.06188	1.188	1.0000
Resources	RS	-0.0147	0.06188	-0.238	1.0000
Resources	RU	-0.0588	0.06188	-0.951	1.0000
Resources	TD	0.0000	0.06188	0.000	1.0000

Metric Group = Resources
Metric = EI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	Futil	-0.1765	0.06188	-2.852	0.7952
Resources	IP	-0.0735	0.06188	-1.188	1.0000
Resources	LU	0.0147	0.06188	0.238	1.0000
Resources	MR	0.0147	0.06188	0.238	1.0000

Resources	MU	-0.1618	0.06188	-2.614	0.9267
Resources	NRRC	-0.0441	0.06188	-0.713	1.0000
Resources	OSU	-0.0735	0.06188	-1.188	1.0000
Resources	RC	-0.1029	0.06188	-1.663	1.0000
Resources	RE	-0.1176	0.06188	-1.901	0.9999
Resources	RP	-0.0294	0.06188	-0.475	1.0000
Resources	RRS	-0.0294	0.06188	-0.475	1.0000
Resources	RS	-0.1176	0.06188	-1.901	0.9999
Resources	RU	-0.1618	0.06188	-2.614	0.9267
Resources	TD	-0.1029	0.06188	-1.663	1.0000

Metric Group = Resources
Metric = Futil subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	IP	0.10294	0.06188	1.663	1.0000
Resources	LU	0.19118	0.06188	3.089	0.5988
Resources	MR	0.19118	0.06188	3.089	0.5988
Resources	MU	0.01471	0.06188	0.238	1.0000
Resources	NRRC	0.13235	0.06188	2.139	0.9981
Resources	OSU	0.10294	0.06188	1.663	1.0000
Resources	RC	0.07353	0.06188	1.188	1.0000
Resources	RE	0.05882	0.06188	0.951	1.0000
Resources	RP	0.14706	0.06188	2.376	0.9834
Resources	RRS	0.14706	0.06188	2.376	0.9834
Resources	RS	0.05882	0.06188	0.951	1.0000
Resources	RU	0.01471	0.06188	0.238	1.0000
Resources	TD	0.07353	0.06188	1.188	1.0000

Metric Group = Resources
Metric = IP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	LU	0.0882	0.06188	1.426	1.0000
Resources	MR	0.0882	0.06188	1.426	1.0000
Resources	MU	-0.0882	0.06188	-1.426	1.0000
Resources	NRRC	0.0294	0.06188	0.475	1.0000
Resources	OSU	-0.0000	0.06188	-0.000	1.0000
Resources	RC	-0.0294	0.06188	-0.475	1.0000
Resources	RE	-0.0441	0.06188	-0.713	1.0000
Resources	RP	0.0441	0.06188	0.713	1.0000
Resources	RRS	0.0441	0.06188	0.713	1.0000
Resources	RS	-0.0441	0.06188	-0.713	1.0000
Resources	RU	-0.0882	0.06188	-1.426	1.0000
Resources	TD	-0.0294	0.06188	-0.475	1.0000

Metric Group = Resources
Metric = LU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MR	0.0000	0.06188	0.000	1.0000
Resources	MU	-0.1765	0.06188	-2.852	0.7952
Resources	NRRC	-0.0588	0.06188	-0.951	1.0000
Resources	OSU	-0.0882	0.06188	-1.426	1.0000
Resources	RC	-0.1176	0.06188	-1.901	0.9999
Resources	RE	-0.1324	0.06188	-2.139	0.9981
Resources	RP	-0.0441	0.06188	-0.713	1.0000
Resources	RRS	-0.0441	0.06188	-0.713	1.0000
Resources	RS	-0.1324	0.06188	-2.139	0.9981
Resources	RU	-0.1765	0.06188	-2.852	0.7952
Resources	TD	-0.1176	0.06188	-1.901	0.9999

Metric Group = Resources
Metric = MR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MU	-0.1765	0.06188	-2.852	0.7952
Resources	NRRC	-0.0588	0.06188	-0.951	1.0000
Resources	OSU	-0.0882	0.06188	-1.426	1.0000
Resources	RC	-0.1176	0.06188	-1.901	0.9999
Resources	RE	-0.1324	0.06188	-2.139	0.9981
Resources	RP	-0.0441	0.06188	-0.713	1.0000
Resources	RRS	-0.0441	0.06188	-0.713	1.0000
Resources	RS	-0.1324	0.06188	-2.139	0.9981
Resources	RU	-0.1765	0.06188	-2.852	0.7952
Resources	TD	-0.1176	0.06188	-1.901	0.9999

Metric Group = Resources
Metric = MU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	NRRC	0.1176	0.06188	1.901	0.9999
Resources	OSU	0.0882	0.06188	1.426	1.0000
Resources	RC	0.0588	0.06188	0.951	1.0000
Resources	RE	0.0441	0.06188	0.713	1.0000
Resources	RP	0.1324	0.06188	2.139	0.9981
Resources	RRS	0.1324	0.06188	2.139	0.9981
Resources	RS	0.0441	0.06188	0.713	1.0000
Resources	RU	-0.0000	0.06188	-0.000	1.0000
Resources	TD	0.0588	0.06188	0.951	1.0000

Metric Group = Resources
Metric = NRRC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	OSU	-0.0294	0.06188	-0.475	1.0000
Resources	RC	-0.0588	0.06188	-0.951	1.0000
Resources	RE	-0.0735	0.06188	-1.188	1.0000
Resources	RP	0.0147	0.06188	0.238	1.0000
Resources	RRS	0.0147	0.06188	0.238	1.0000
Resources	RS	-0.0735	0.06188	-1.188	1.0000
Resources	RU	-0.1176	0.06188	-1.901	0.9999
Resources	TD	-0.0588	0.06188	-0.951	1.0000

Metric Group = Resources
Metric = OSU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RC	-0.0294	0.06188	-0.475	1.0000
Resources	RE	-0.0441	0.06188	-0.713	1.0000
Resources	RP	0.0441	0.06188	0.713	1.0000
Resources	RRS	0.0441	0.06188	0.713	1.0000
Resources	RS	-0.0441	0.06188	-0.713	1.0000
Resources	RU	-0.0882	0.06188	-1.426	1.0000
Resources	TD	-0.0294	0.06188	-0.475	1.0000

Metric Group = Resources

Metric = RC subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RE	-0.0147	0.06188	-0.238	1.0000
Resources	RP	0.0735	0.06188	1.188	1.0000
Resources	RRS	0.0735	0.06188	1.188	1.0000
Resources	RS	-0.0147	0.06188	-0.238	1.0000
Resources	RU	-0.0588	0.06188	-0.951	1.0000
Resources	TD	0.0000	0.06188	0.000	1.0000

Metric Group = Resources
Metric = RE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RP	0.0882	0.06188	1.426	1.0000
Resources	RRS	0.0882	0.06188	1.426	1.0000
Resources	RS	0.0000	0.06188	0.000	1.0000
Resources	RU	-0.0441	0.06188	-0.713	1.0000
Resources	TD	0.0147	0.06188	0.238	1.0000

Metric Group = Resources
Metric = RP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RRS	0.0000	0.06188	0.000	1.0000
Resources	RS	-0.0882	0.06188	-1.426	1.0000
Resources	RU	-0.1324	0.06188	-2.139	0.9981
Resources	TD	-0.0735	0.06188	-1.188	1.0000

Metric Group = Resources
Metric = RRS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RS	-0.0882	0.06188	-1.426	1.0000
Resources	RU	-0.1324	0.06188	-2.139	0.9981
Resources	TD	-0.0735	0.06188	-1.188	1.0000

Metric Group = Resources
Metric = RS subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RU	-0.0441	0.06188	-0.713	1.0000
Resources	TD	0.0147	0.06188	0.238	1.0000

Metric Group = Resources
Metric = RU subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	TD	0.0588	0.06188	0.951	1.0000

Metric Group = Technique/Process
Metric = Beta subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EE	-0.0147	0.06188	-0.238	1.0000
Technique/Process	EOLR	-0.0147	0.06188	-0.238	1.0000
Technique/Process	LPT	-0.2941	0.06188	-4.753	0.0027
Technique/Process	PLE	0.0000	0.06188	0.000	1.0000
Technique/Process	RNC	-0.1324	0.06188	-2.139	0.9981

Metric Group = Technique/Process
Metric = EE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EOLR	-0.0000	0.06188	-0.000	1.0000
Technique/Process	LPT	-0.2794	0.06188	-4.515	0.0076
Technique/Process	PLE	0.0147	0.06188	0.238	1.0000
Technique/Process	RNC	-0.1176	0.06188	-1.901	0.9999

Metric Group = Technique/Process
Metric = EOLR subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	LPT	-0.2794	0.06188	-4.515	0.0076
Technique/Process	PLE	0.0147	0.06188	0.238	1.0000
Technique/Process	RNC	-0.1176	0.06188	-1.901	0.9999

Metric Group = Technique/Process
Metric = LPT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	PLE	0.2941	0.06188	4.753	0.0027
Technique/Process	RNC	0.1618	0.06188	2.614	0.9267

Metric Group = Technique/Process
Metric = PLE subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	RNC	-0.1324	0.06188	-2.139	0.9981

Metric Group = Water
Metric = CWI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	EUT	0.08824	0.06188	1.4258	1.0000
Water	WDI	0.04412	0.06188	0.7129	1.0000
Water	Wint	0.13235	0.06188	2.1388	0.9981
Water	WP	0.07353	0.06188	1.1882	1.0000
Water	WQ	0.08824	0.06188	1.4258	1.0000
Water	WU	0.01471	0.06188	0.2376	1.0000

Metric Group = Water
Metric = EUT subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WDI	-0.04412	0.06188	-0.713	1.000
Water	Wint	0.04412	0.06188	0.713	1.000
Water	WP	-0.01471	0.06188	-0.238	1.000
Water	WQ	0.00000	0.06188	0.000	1.000
Water	WU	-0.07353	0.06188	-1.188	1.000

Metric Group = Water
Metric = WDI subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	Wint	0.08824	0.06188	1.4258	1.000
Water	WP	0.02941	0.06188	0.4753	1.000
Water	WQ	0.04412	0.06188	0.7129	1.000
Water	WU	-0.02941	0.06188	-0.4753	1.000

Metric Group = Water
Metric = Wint subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WP	-0.0588	0.06188	-0.951	1.0000
Water	WQ	-0.0441	0.06188	-0.713	1.0000
Water	WU	-0.1176	0.06188	-1.901	0.9999

Metric Group = Water
Metric = WP subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WQ	0.01471	0.06188	0.2376	1.000
Water	WU	-0.05882	0.06188	-0.9506	1.000

Metric Group = Water
Metric = WQ subtracted from:

Metric Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WU	-0.07353	0.06188	-1.188	1.000

General Linear Model: Suggested versus Response, Metric

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric	fixed	55	AcP, AP, Beta, BP, CF, Cint, CO2, CU, CWI, EE, EEI, EI, Eint, EOLR, ET, EU, EUNR, EUT, Futil, GGE, IP, LCEInt, LPT, LU, MR, MU, NRRC, OCP, OSU, OZ, PLE, PPD, PSW, RC, RE, RM, RNC, RP, RRR, RRS, RS, RU, SW, SWRR, TD, TE, TEInt, W, WC, WDI, Wint, WP, WQ, WsU, WU

Analysis of Variance for Suggested, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	435.0340	435.0340	6.4930	49.87	0.000
Metric	54	27.9492	27.9492	0.5176	3.98	0.000
Error	3618	471.0690	471.0690	0.1302		
Total	3739	934.0521				

S = 0.360834   R-Sq = 49.57%   R-Sq(adj) = 47.88%

Tukey Simultaneous Tests
Response Variable Suggested
All Pairwise Comparisons among Levels of Metric
Metric = AcP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CF	-0.1912	0.06188	-3.089	0.5988
Cint	-0.0294	0.06188	-0.475	1.0000
ET	-0.1176	0.06188	-1.901	0.9999
GGE	-0.1765	0.06188	-2.852	0.7952
OCP	0.0441	0.06188	0.713	1.0000
OZ	-0.0735	0.06188	-1.188	1.0000
PPD	0.0147	0.06188	0.238	1.0000

Metric = AP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BP	0.1029	0.06188	1.663	1.0000
CO2	-0.0147	0.06188	-0.238	1.0000
PSW	0.1029	0.06188	1.663	1.0000
RM	0.0735	0.06188	1.188	1.0000
RRR	-0.0882	0.06188	-1.426	1.0000
SW	0.0000	0.06188	0.000	1.0000
SWRR	0.1324	0.06188	2.139	0.9981
TE	0.0882	0.06188	1.426	1.0000
W	-0.0441	0.06188	-0.713	1.0000
WC	0.0735	0.06188	1.188	1.0000
WsU	0.1471	0.06188	2.376	0.9834

Metric = Beta subtracted from:

Difference	SE of	Adjusted

Metric	of Means	Difference	T-Value	P-Value
EE	-0.0147	0.06188	-0.238	1.0000
EOLR	-0.0147	0.06188	-0.238	1.0000
LPT	-0.2941	0.06188	-4.753	0.0027
PLE	-0.0000	0.06188	-0.000	1.0000
RNC	-0.1324	0.06188	-2.139	0.9981

Metric = BP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CO2	-0.1176	0.06188	-1.901	0.9999
PSW	-0.0000	0.06188	-0.000	1.0000
RM	-0.0294	0.06188	-0.475	1.0000
RRR	-0.1912	0.06188	-3.089	0.5988
SW	-0.1029	0.06188	-1.663	1.0000
SWRR	0.0294	0.06188	0.475	1.0000
TE	-0.0147	0.06188	-0.238	1.0000
W	-0.1471	0.06188	-2.376	0.9834
WC	-0.0294	0.06188	-0.475	1.0000
WsU	0.0441	0.06188	0.713	1.0000

Metric = CF subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Cint	0.1618	0.06188	2.614	0.9267
ET	0.0735	0.06188	1.188	1.0000
GGE	0.0147	0.06188	0.238	1.0000
OCP	0.2353	0.06188	3.802	0.1107
OZ	0.1176	0.06188	1.901	0.9999
PPD	0.2059	0.06188	3.327	0.3905

Metric = Cint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
ET	-0.0882	0.06188	-1.426	1.0000
GGE	-0.1471	0.06188	-2.376	0.9834
OCP	0.0735	0.06188	1.188	1.0000
OZ	-0.0441	0.06188	-0.713	1.0000
PPD	0.0441	0.06188	0.713	1.0000

Metric = CO2 subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PSW	0.1176	0.06188	1.901	0.9999
RM	0.0882	0.06188	1.426	1.0000
RRR	-0.0735	0.06188	-1.188	1.0000
SW	0.0147	0.06188	0.238	1.0000
SWRR	0.1471	0.06188	2.376	0.9834
TE	0.1029	0.06188	1.663	1.0000
W	-0.0294	0.06188	-0.475	1.0000
WC	0.0882	0.06188	1.426	1.0000
WsU	0.1618	0.06188	2.614	0.9267

Metric = CU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EI	0.1029	0.06188	1.663	1.0000
Futil	-0.0735	0.06188	-1.188	1.0000
IP	0.0294	0.06188	0.475	1.0000
LU	0.1176	0.06188	1.901	0.9999
MR	0.1176	0.06188	1.901	0.9999
MU	-0.0588	0.06188	-0.951	1.0000
NRRC	0.0588	0.06188	0.951	1.0000
OSU	0.0294	0.06188	0.475	1.0000
RC	-0.0000	0.06188	-0.000	1.0000
RE	-0.0147	0.06188	-0.238	1.0000
RP	0.0735	0.06188	1.188	1.0000
RRS	0.0735	0.06188	1.188	1.0000
RS	-0.0147	0.06188	-0.238	1.0000
RU	-0.0588	0.06188	-0.951	1.0000
TD	-0.0000	0.06188	-0.000	1.0000

Metric = CWI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUT	0.0882	0.06188	1.426	1.0000
WDI	0.0441	0.06188	0.713	1.0000
Wint	0.1324	0.06188	2.139	0.9981
WP	0.0735	0.06188	1.188	1.0000
WQ	0.0882	0.06188	1.426	1.0000
WU	0.0147	0.06188	0.238	1.0000

Metric = EE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EOLR	0.0000	0.06188	0.000	1.0000
LPT	-0.2794	0.06188	-4.515	0.0076
PLE	0.0147	0.06188	0.238	1.0000
RNC	-0.1176	0.06188	-1.901	0.9999

Metric = EEI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Eint	-0.1912	0.06188	-3.089	0.5988
EU	-0.2794	0.06188	-4.515	0.0076
EUNR	-0.0294	0.06188	-0.475	1.0000
LCEInt	-0.0000	0.06188	-0.000	1.0000
TEInt	-0.0882	0.06188	-1.426	1.0000

Metric = EI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Futil	-0.1765	0.06188	-2.852	0.7952
IP	-0.0735	0.06188	-1.188	1.0000
LU	0.0147	0.06188	0.238	1.0000
MR	0.0147	0.06188	0.238	1.0000
MU	-0.1618	0.06188	-2.614	0.9267
NRRC	-0.0441	0.06188	-0.713	1.0000
OSU	-0.0735	0.06188	-1.188	1.0000
RC	-0.1029	0.06188	-1.663	1.0000
RE	-0.1176	0.06188	-1.901	0.9999
RP	-0.0294	0.06188	-0.475	1.0000
RRS	-0.0294	0.06188	-0.475	1.0000
RS	-0.1176	0.06188	-1.901	0.9999
RU	-0.1618	0.06188	-2.614	0.9267
TD	-0.1029	0.06188	-1.663	1.0000

Metric = Eint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EU	-0.08824	0.06188	-1.426	1.0000
EUNR	0.16176	0.06188	2.614	0.9267
LCEInt	0.19118	0.06188	3.089	0.5988
TEInt	0.10294	0.06188	1.663	1.0000

Metric = EOLR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LPT	-0.2794	0.06188	-4.515	0.0076
PLE	0.0147	0.06188	0.238	1.0000
RNC	-0.1176	0.06188	-1.901	0.9999

Metric = ET subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
GGE	-0.0588	0.06188	-0.951	1.0000
OCP	0.1618	0.06188	2.614	0.9267
OZ	0.0441	0.06188	0.713	1.0000
PPD	0.1324	0.06188	2.139	0.9981

Metric = EU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUNR	0.25000	0.06188	4.0399	0.0496
LCEInt	0.27941	0.06188	4.5152	0.0076
TEInt	0.19118	0.06188	3.0893	0.5988

Metric = EUNR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LCEInt	0.0294	0.06188	0.475	1.0000
TEInt	-0.0588	0.06188	-0.951	1.0000

Metric = EUT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WDI	-0.0441	0.06188	-0.713	1.0000
Wint	0.0441	0.06188	0.713	1.0000
WP	-0.0147	0.06188	-0.238	1.0000
WQ	0.0000	0.06188	0.000	1.0000
WU	-0.0735	0.06188	-1.188	1.0000

Metric = Futil subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
IP	0.10294	0.06188	1.663	1.0000
LU	0.19118	0.06188	3.089	0.5988
MR	0.19118	0.06188	3.089	0.5988
MU	0.01471	0.06188	0.238	1.0000
NRRC	0.13235	0.06188	2.139	0.9981
OSU	0.10294	0.06188	1.663	1.0000
RC	0.07353	0.06188	1.188	1.0000
RE	0.05882	0.06188	0.951	1.0000
RP	0.14706	0.06188	2.376	0.9834
RRS	0.14706	0.06188	2.376	0.9834
RS	0.05882	0.06188	0.951	1.0000
RU	0.01471	0.06188	0.238	1.0000
TD	0.07353	0.06188	1.188	1.0000

Metric = GGE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OCP	0.2206	0.06188	3.565	0.2214
OZ	0.1029	0.06188	1.663	1.0000
PPD	0.1912	0.06188	3.089	0.5988

Metric = IP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LU	0.0882	0.06188	1.426	1.0000
MR	0.0882	0.06188	1.426	1.0000
MU	-0.0882	0.06188	-1.426	1.0000
NRRC	0.0294	0.06188	0.475	1.0000
OSU	-0.0000	0.06188	-0.000	1.0000
RC	-0.0294	0.06188	-0.475	1.0000
RE	-0.0441	0.06188	-0.713	1.0000
RP	0.0441	0.06188	0.713	1.0000
RRS	0.0441	0.06188	0.713	1.0000
RS	-0.0441	0.06188	-0.713	1.0000
RU	-0.0882	0.06188	-1.426	1.0000
TD	-0.0294	0.06188	-0.475	1.0000

Metric = LCEInt subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TEInt	-0.0882	0.06188	-1.426	1.0000

Metric = LPT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PLE	0.29412	0.06188	4.7528	0.0027
RNC	0.16176	0.06188	2.6141	0.9267

Metric = LU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MR	-0.0000	0.06188	-0.000	1.0000
MU	-0.1765	0.06188	-2.852	0.7952
NRRC	-0.0588	0.06188	-0.951	1.0000
OSU	-0.0882	0.06188	-1.426	1.0000
RC	-0.1176	0.06188	-1.901	0.9999
RE	-0.1324	0.06188	-2.139	0.9981
RP	-0.0441	0.06188	-0.713	1.0000
RRS	-0.0441	0.06188	-0.713	1.0000
RS	-0.1324	0.06188	-2.139	0.9981
RU	-0.1765	0.06188	-2.852	0.7952
TD	-0.1176	0.06188	-1.901	0.9999

Metric = MR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MU	-0.1765	0.06188	-2.852	0.7952
NRRC	-0.0588	0.06188	-0.951	1.0000
OSU	-0.0882	0.06188	-1.426	1.0000
RC	-0.1176	0.06188	-1.901	0.9999
RE	-0.1324	0.06188	-2.139	0.9981
RP	-0.0441	0.06188	-0.713	1.0000
RRS	-0.0441	0.06188	-0.713	1.0000
RS	-0.1324	0.06188	-2.139	0.9981
RU	-0.1765	0.06188	-2.852	0.7952
TD	-0.1176	0.06188	-1.901	0.9999

Metric = MU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
NRRC	0.11765	0.06188	1.9011	0.9999
OSU	0.08824	0.06188	1.4258	1.0000
RC	0.05882	0.06188	0.9506	1.0000
RE	0.04412	0.06188	0.7129	1.0000
RP	0.13235	0.06188	2.1388	0.9981
RRS	0.13235	0.06188	2.1388	0.9981
RS	0.04412	0.06188	0.7129	1.0000
RU	-0.00000	0.06188	-0.0000	1.0000
TD	0.05882	0.06188	0.9506	1.0000

Metric = NRRC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OSU	-0.0294	0.06188	-0.475	1.0000
RC	-0.0588	0.06188	-0.951	1.0000
RE	-0.0735	0.06188	-1.188	1.0000
RP	0.0147	0.06188	0.238	1.0000
RRS	0.0147	0.06188	0.238	1.0000
RS	-0.0735	0.06188	-1.188	1.0000
RU	-0.1176	0.06188	-1.901	0.9999
TD	-0.0588	0.06188	-0.951	1.0000

Metric = OCP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OZ	-0.1176	0.06188	-1.901	0.9999
PPD	-0.0294	0.06188	-0.475	1.0000

Metric = OSU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RC	-0.0294	0.06188	-0.475	1.0000
RE	-0.0441	0.06188	-0.713	1.0000
RP	0.0441	0.06188	0.713	1.0000
RRS	0.0441	0.06188	0.713	1.0000
RS	-0.0441	0.06188	-0.713	1.0000
RU	-0.0882	0.06188	-1.426	1.0000
TD	-0.0294	0.06188	-0.475	1.0000

Metric = OZ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PPD	0.0882	0.06188	1.426	1.0000

Metric = PLE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RNC	-0.1324	0.06188	-2.139	0.9981

Metric = PSW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RM	-0.0294	0.06188	-0.475	1.0000
RRR	-0.1912	0.06188	-3.089	0.5988
SW	-0.1029	0.06188	-1.663	1.0000
SWRR	0.0294	0.06188	0.475	1.0000
TE	-0.0147	0.06188	-0.238	1.0000
W	-0.1471	0.06188	-2.376	0.9834
WC	-0.0294	0.06188	-0.475	1.0000
WsU	0.0441	0.06188	0.713	1.0000

Metric = RC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RE	-0.0147	0.06188	-0.238	1.0000
RP	0.0735	0.06188	1.188	1.0000
RRS	0.0735	0.06188	1.188	1.0000
RS	-0.0147	0.06188	-0.238	1.0000
RU	-0.0588	0.06188	-0.951	1.0000
TD	-0.0000	0.06188	-0.000	1.0000

Metric = RE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RP	0.08824	0.06188	1.426	1.0000
RRS	0.08824	0.06188	1.426	1.0000
RS	0.00000	0.06188	0.000	1.0000
RU	-0.04412	0.06188	-0.713	1.0000
TD	0.01471	0.06188	0.238	1.0000

Metric = RM subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRR	-0.1618	0.06188	-2.614	0.9267
SW	-0.0735	0.06188	-1.188	1.0000
SWRR	0.0588	0.06188	0.951	1.0000
TE	0.0147	0.06188	0.238	1.0000
W	-0.1176	0.06188	-1.901	0.9999
WC	0.0000	0.06188	0.000	1.0000
WsU	0.0735	0.06188	1.188	1.0000

Metric = RP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRS	-0.0000	0.06188	-0.000	1.0000
RS	-0.0882	0.06188	-1.426	1.0000
RU	-0.1324	0.06188	-2.139	0.9981
TD	-0.0735	0.06188	-1.188	1.0000

Metric = RRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SW	0.08824	0.06188	1.4258	1.0000
SWRR	0.22059	0.06188	3.5646	0.2214
TE	0.17647	0.06188	2.8517	0.7952
W	0.04412	0.06188	0.7129	1.0000
WC	0.16176	0.06188	2.6141	0.9267
WsU	0.23529	0.06188	3.8023	0.1107

Metric = RRS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RS	-0.0882	0.06188	-1.426	1.0000
RU	-0.1324	0.06188	-2.139	0.9981
TD	-0.0735	0.06188	-1.188	1.0000

Metric = RS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RU	-0.04412	0.06188	-0.7129	1.0000
TD	0.01471	0.06188	0.2376	1.0000

Metric = RU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TD	0.058824	0.06188	0.95057	1.0000

Metric = SW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SWRR	0.13235	0.06188	2.1388	0.9981
TE	0.08824	0.06188	1.4258	1.0000
W	-0.04412	0.06188	-0.7129	1.0000
WC	0.07353	0.06188	1.1882	1.0000
WsU	0.14706	0.06188	2.3764	0.9834

Metric = SWRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TE	-0.0441	0.06188	-0.713	1.0000
W	-0.1765	0.06188	-2.852	0.7952
WC	-0.0588	0.06188	-0.951	1.0000
WsU	0.0147	0.06188	0.238	1.0000

Metric = TE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
W	-0.1324	0.06188	-2.139	0.9981
WC	-0.0147	0.06188	-0.238	1.0000
WsU	0.0588	0.06188	0.951	1.0000

Metric = W subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WC	0.1176	0.06188	1.901	0.9999
WsU	0.1912	0.06188	3.089	0.5988

Metric = WC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WsU	0.07353	0.06188	1.1882	1.000

Metric = WDI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Wint	0.08824	0.06188	1.4258	1.000
WP	0.02941	0.06188	0.4753	1.000
WQ	0.04412	0.06188	0.7129	1.000
WU	-0.02941	0.06188	-0.4753	1.000

Metric = Wint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WP	-0.0588	0.06188	-0.951	1.0000
WQ	-0.0441	0.06188	-0.713	1.0000
WU	-0.1176	0.06188	-1.901	0.9999

Metric = WP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WQ	0.01471	0.06188	0.2376	1.000
WU	-0.05882	0.06188	-0.9506	1.000

Metric = WQ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WU	-0.07353	0.06188	-1.188	1.000

General Linear Model: Average_Value versus Response, Metric_Group, Metric

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric_Group	fixed	6	Energy, Environment, Pollution, Resources, Technique/Process, Water
Metric(Metric_Group)	fixed	55	EEI, Eint, EU, EUNR, LCEInt, TEInt, AcP, CF, Cint, ET, GGE, OCP, OZ, PPD, AP, BP, CO2, PSW, RM, RRR, SW, SWRR, TE, W, WC, WsU, CU, EI, Futil, IP, LU, MR, MU, NRRC, OSU, RC, RE, RP, RRS, RS, RU, TD, Beta, EE, EOLR, LPT, PLE, RNC, CWI, EUT, WDI, Wint, WP, WQ, WU

Analysis of Variance for Average_Value, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	687.9915	687.9915	10.2685	68.93	0.000
Metric_Group	5	2.7434	2.7434	0.5487	3.68	0.003
Metric(Metric_Group)	49	20.3603	20.3603	0.4155	2.79	0.000
Error	3618	538.9516	538.9516	0.1490		
Total	3739	1250.0468				

S = 0.385958   R-Sq = 56.89%   R-Sq(adj) = 55.44%

Tukey Simultaneous Tests
Response Variable Average_Value
All Pairwise Comparisons among Levels of Metric(Metric_Group)
Metric_Group = Energy
Metric = EEI subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	Eint	0.0551	0.06619	0.833	1.0000
Energy	EU	0.1434	0.06619	2.166	0.9974
Energy	EUNR	0.0772	0.06619	1.166	1.0000
Energy	LCEInt	0.0221	0.06619	0.333	1.0000
Energy	TEInt	-0.0037	0.06619	-0.056	1.0000

Metric_Group = Energy
Metric = Eint subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EU	0.0882	0.06619	1.333	1.0000
Energy	EUNR	0.0221	0.06619	0.333	1.0000
Energy	LCEInt	-0.0331	0.06619	-0.500	1.0000
Energy	TEInt	-0.0588	0.06619	-0.889	1.0000

Metric_Group = Energy
Metric = EU subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	EUNR	-0.0662	0.06619	-1.000	1.0000
Energy	LCEInt	-0.1213	0.06619	-1.833	1.0000
Energy	TEInt	-0.1471	0.06619	-2.222	0.9955

Metric_Group = Energy
Metric = EUNR subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	LCEInt	-0.0551	0.06619	-0.833	1.0000
Energy	TEInt	-0.0809	0.06619	-1.222	1.0000

Metric_Group = Energy
Metric = LCEInt subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Energy	TEInt	-0.0257	0.06619	-0.389	1.0000

Metric_Group = Energy
Metric_Group = Environment
Metric = AcP subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	CF	0.32721	0.06619	4.9433	0.0012
Environment	Cint	0.13603	0.06619	2.0551	0.9993
Environment	ET	0.14706	0.06619	2.2217	0.9955
Environment	GGE	0.23162	0.06619	3.4992	0.2623
Environment	OCP	0.00735	0.06619	0.1111	1.0000
Environment	OZ	0.10662	0.06619	1.6107	1.0000
Environment	PPD	0.04044	0.06619	0.6110	1.0000

Metric_Group = Environment
Metric = CF subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	Cint	-0.1912	0.06619	-2.888	0.7682
Environment	ET	-0.1801	0.06619	-2.722	0.8773
Environment	GGE	-0.0956	0.06619	-1.444	1.0000
Environment	OCP	-0.3199	0.06619	-4.832	0.0019
Environment	OZ	-0.2206	0.06619	-3.333	0.3859
Environment	PPD	-0.2868	0.06619	-4.332	0.0162

Metric_Group = Environment
Metric = Cint subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	ET	0.0110	0.06619	0.167	1.0000
Environment	GGE	0.0956	0.06619	1.444	1.0000
Environment	OCP	-0.1287	0.06619	-1.944	0.9998
Environment	OZ	-0.0294	0.06619	-0.444	1.0000
Environment	PPD	-0.0956	0.06619	-1.444	1.0000

Metric_Group = Environment
Metric = ET subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value

Environment	GGE	0.0846	0.06619	1.277	1.0000
Environment	OCP	-0.1397	0.06619	-2.111	0.9986
Environment	OZ	-0.0404	0.06619	-0.611	1.0000
Environment	PPD	-0.1066	0.06619	-1.611	1.0000

Metric_Group = Environment
Metric = GGE subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OCP	-0.2243	0.06619	-3.388	0.3417
Environment	OZ	-0.1250	0.06619	-1.888	0.9999
Environment	PPD	-0.1912	0.06619	-2.888	0.7682

Metric_Group = Environment
Metric = OCP subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	OZ	0.09926	0.06619	1.4997	1.0000
Environment	PPD	0.03309	0.06619	0.4999	1.0000

Metric_Group = Environment
Metric = OZ subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Environment	PPD	-0.0662	0.06619	-1.000	1.0000

Metric_Group = Pollution
Metric = AP subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	BP	-0.1765	0.06619	-2.666	0.9049
Pollution	CO2	0.0699	0.06619	1.055	1.0000
Pollution	PSW	-0.1434	0.06619	-2.166	0.9974
Pollution	RM	-0.0956	0.06619	-1.444	1.0000
Pollution	RRR	-0.0257	0.06619	-0.389	1.0000
Pollution	SW	-0.0919	0.06619	-1.389	1.0000
Pollution	SWRR	-0.1703	0.06619	-2.573	0.9411
Pollution	TE	-0.1507	0.06619	-2.277	0.9925
Pollution	W	-0.1654	0.06619	-2.499	0.9618
Pollution	WC	-0.1213	0.06619	-1.833	1.0000
Pollution	WsU	-0.1324	0.06619	-2.000	0.9996

Metric_Group = Pollution
Metric = BP subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	CO2	0.24632	0.06619	3.7214	0.1421
Pollution	PSW	0.03309	0.06619	0.4999	1.0000
Pollution	RM	0.08088	0.06619	1.2219	1.0000
Pollution	RRR	0.15074	0.06619	2.2773	0.9925
Pollution	SW	0.08456	0.06619	1.2775	1.0000
Pollution	SWRR	0.00613	0.06619	0.0926	1.0000
Pollution	TE	0.02574	0.06619	0.3888	1.0000
Pollution	W	0.01103	0.06619	0.1666	1.0000
Pollution	WC	0.05515	0.06619	0.8331	1.0000
Pollution	WsU	0.04412	0.06619	0.6665	1.0000

Metric_Group = Pollution
Metric = CO2 subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	PSW	-0.2132	0.06619	-3.221	0.4806
Pollution	RM	-0.1654	0.06619	-2.499	0.9618
Pollution	RRR	-0.0956	0.06619	-1.444	1.0000
Pollution	SW	-0.1618	0.06619	-2.444	0.9733
Pollution	SWRR	-0.2402	0.06619	-3.629	0.1858
Pollution	TE	-0.2206	0.06619	-3.333	0.3859
Pollution	W	-0.2353	0.06619	-3.555	0.2274
Pollution	WC	-0.1912	0.06619	-2.888	0.7682
Pollution	WsU	-0.2022	0.06619	-3.055	0.6295

Metric_Group = Pollution
Metric = PSW subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RM	0.04779	0.06619	0.722	1.0000
Pollution	RRR	0.11765	0.06619	1.777	1.0000
Pollution	SW	0.05147	0.06619	0.778	1.0000
Pollution	SWRR	-0.02696	0.06619	-0.407	1.0000
Pollution	TE	-0.00735	0.06619	-0.111	1.0000
Pollution	W	-0.02206	0.06619	-0.333	1.0000
Pollution	WC	0.02206	0.06619	0.333	1.0000
Pollution	WsU	0.01103	0.06619	0.167	1.0000

Metric_Group = Pollution
Metric = RM subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	RRR	0.0699	0.06619	1.055	1.0000
Pollution	SW	0.0037	0.06619	0.056	1.0000
Pollution	SWRR	-0.0748	0.06619	-1.129	1.0000
Pollution	TE	-0.0551	0.06619	-0.833	1.0000
Pollution	W	-0.0699	0.06619	-1.055	1.0000
Pollution	WC	-0.0257	0.06619	-0.389	1.0000
Pollution	WsU	-0.0368	0.06619	-0.555	1.0000

Metric_Group = Pollution
Metric = RRR subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SW	-0.0662	0.06619	-1.000	1.0000
Pollution	SWRR	-0.1446	0.06619	-2.185	0.9969
Pollution	TE	-0.1250	0.06619	-1.888	0.9999
Pollution	W	-0.1397	0.06619	-2.111	0.9986
Pollution	WC	-0.0956	0.06619	-1.444	1.0000
Pollution	WsU	-0.1066	0.06619	-1.611	1.0000

Metric_Group = Pollution
Metric = SW subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	SWRR	-0.0784	0.06619	-1.185	1.0000
Pollution	TE	-0.0588	0.06619	-0.889	1.0000
Pollution	W	-0.0735	0.06619	-1.111	1.0000
Pollution	WC	-0.0294	0.06619	-0.444	1.0000
Pollution	WsU	-0.0404	0.06619	-0.611	1.0000

Metric_Group = Pollution
Metric = SWRR subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	TE	0.01961	0.06619	0.296	1.0000
Pollution	W	0.00490	0.06619	0.074	1.0000
Pollution	WC	0.04902	0.06619	0.741	1.0000
Pollution	WsU	0.03799	0.06619	0.574	1.0000

Metric_Group = Pollution
Metric = TE subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	W	-0.01471	0.06619	-0.222	1.0000
Pollution	WC	0.02941	0.06619	0.444	1.0000
Pollution	WsU	0.01838	0.06619	0.278	1.0000

Metric_Group = Pollution
Metric = W subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WC	0.04412	0.06619	0.667	1.0000
Pollution	WsU	0.03309	0.06619	0.500	1.0000

Metric_Group = Pollution
Metric = WC subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Pollution	WsU	-0.0110	0.06619	-0.167	1.0000

Metric_Group = Resources
Metric = CU subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	EI	-0.1397	0.06619	-2.111	0.9986
Resources	Futil	0.0368	0.06619	0.555	1.0000
Resources	IP	-0.0404	0.06619	-0.611	1.0000
Resources	LU	-0.1507	0.06619	-2.277	0.9925
Resources	MR	-0.1140	0.06619	-1.722	1.0000
Resources	MU	-0.0221	0.06619	-0.333	1.0000
Resources	NRRC	-0.0515	0.06619	-0.778	1.0000
Resources	OSU	-0.1360	0.06619	-2.055	0.9993
Resources	RC	-0.0404	0.06619	-0.611	1.0000
Resources	RE	0.0221	0.06619	0.333	1.0000
Resources	RP	0.0441	0.06619	0.667	1.0000
Resources	RRS	-0.1765	0.06619	-2.666	0.9049
Resources	RS	0.0588	0.06619	0.889	1.0000
Resources	RU	0.0515	0.06619	0.778	1.0000
Resources	TD	-0.0331	0.06619	-0.500	1.0000

Metric_Group = Resources
Metric = EI subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	Futil	0.17647	0.06619	2.6661	0.9049
Resources	IP	0.09926	0.06619	1.4997	1.0000
Resources	LU	-0.01103	0.06619	-0.1666	1.0000
Resources	MR	0.02574	0.06619	0.3888	1.0000
Resources	MU	0.11765	0.06619	1.7774	1.0000
Resources	NRRC	0.08824	0.06619	1.3330	1.0000
Resources	OSU	0.00368	0.06619	0.0555	1.0000
Resources	RC	0.09926	0.06619	1.4997	1.0000
Resources	RE	0.16176	0.06619	2.4439	0.9733
Resources	RP	0.18382	0.06619	2.7772	0.8451
Resources	RRS	-0.03676	0.06619	-0.5554	1.0000
Resources	RS	0.19853	0.06619	2.9993	0.6780
Resources	RU	0.19118	0.06619	2.8882	0.7682
Resources	TD	0.10662	0.06619	1.6107	1.0000

Metric_Group = Resources
Metric = Futil subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	IP	-0.0772	0.06619	-1.166	1.0000
Resources	LU	-0.1875	0.06619	-2.833	0.8086
Resources	MR	-0.1507	0.06619	-2.277	0.9925
Resources	MU	-0.0588	0.06619	-0.889	1.0000
Resources	NRRC	-0.0882	0.06619	-1.333	1.0000
Resources	OSU	-0.1728	0.06619	-2.611	0.9281
Resources	RC	-0.0772	0.06619	-1.166	1.0000
Resources	RE	-0.0147	0.06619	-0.222	1.0000
Resources	RP	0.0074	0.06619	0.111	1.0000
Resources	RRS	-0.2132	0.06619	-3.221	0.4806
Resources	RS	0.0221	0.06619	0.333	1.0000
Resources	RU	0.0147	0.06619	0.222	1.0000
Resources	TD	-0.0699	0.06619	-1.055	1.0000

Metric_Group = Resources
Metric = IP subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	LU	-0.1103	0.06619	-1.666	1.0000
Resources	MR	-0.0735	0.06619	-1.111	1.0000
Resources	MU	0.0184	0.06619	0.278	1.0000
Resources	NRRC	-0.0110	0.06619	-0.167	1.0000
Resources	OSU	-0.0956	0.06619	-1.444	1.0000
Resources	RC	0.0000	0.06619	0.000	1.0000
Resources	RE	0.0625	0.06619	0.944	1.0000
Resources	RP	0.0846	0.06619	1.277	1.0000
Resources	RRS	-0.1360	0.06619	-2.055	0.9993
Resources	RS	0.0993	0.06619	1.500	1.0000
Resources	RU	0.0919	0.06619	1.389	1.0000
Resources	TD	0.0074	0.06619	0.111	1.0000

Metric_Group = Resources
Metric = LU subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MR	0.03676	0.06619	0.5554	1.0000
Resources	MU	0.12868	0.06619	1.9440	0.9998
Resources	NRRC	0.09926	0.06619	1.4997	1.0000
Resources	OSU	0.01471	0.06619	0.2222	1.0000
Resources	RC	0.11029	0.06619	1.6663	1.0000
Resources	RE	0.17279	0.06619	2.6105	0.9281
Resources	RP	0.19485	0.06619	2.9438	0.7245
Resources	RRS	-0.02574	0.06619	-0.3888	1.0000

Resources	RS	0.20956	0.06619	3.1660	0.5300
Resources	RU	0.20221	0.06619	3.0549	0.6295
Resources	TD	0.11765	0.06619	1.7774	1.0000

Metric_Group = Resources
Metric = MR subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	MU	0.09191	0.06619	1.3886	1.0000
Resources	NRRC	0.06250	0.06619	0.9442	1.0000
Resources	OSU	-0.02206	0.06619	-0.3333	1.0000
Resources	RC	0.07353	0.06619	1.1109	1.0000
Resources	RE	0.13603	0.06619	2.0551	0.9993
Resources	RP	0.15809	0.06619	2.3884	0.9819
Resources	RRS	-0.06250	0.06619	-0.9442	1.0000
Resources	RS	0.17279	0.06619	2.6105	0.9281
Resources	RU	0.16544	0.06619	2.4994	0.9618
Resources	TD	0.08088	0.06619	1.2219	1.0000

Metric_Group = Resources
Metric = MU subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	NRRC	-0.0294	0.06619	-0.444	1.0000
Resources	OSU	-0.1140	0.06619	-1.722	1.0000
Resources	RC	-0.0184	0.06619	-0.278	1.0000
Resources	RE	0.0441	0.06619	0.667	1.0000
Resources	RP	0.0662	0.06619	1.000	1.0000
Resources	RRS	-0.1544	0.06619	-2.333	0.9881
Resources	RS	0.0809	0.06619	1.222	1.0000
Resources	RU	0.0735	0.06619	1.111	1.0000
Resources	TD	-0.0110	0.06619	-0.167	1.0000

Metric_Group = Resources
Metric = NRRC subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	OSU	-0.0846	0.06619	-1.277	1.0000
Resources	RC	0.0110	0.06619	0.167	1.0000
Resources	RE	0.0735	0.06619	1.111	1.0000
Resources	RP	0.0956	0.06619	1.444	1.0000
Resources	RRS	-0.1250	0.06619	-1.888	0.9999
Resources	RS	0.1103	0.06619	1.666	1.0000
Resources	RU	0.1029	0.06619	1.555	1.0000
Resources	TD	0.0184	0.06619	0.278	1.0000

Metric_Group = Resources
Metric = OSU subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RC	0.09559	0.06619	1.4441	1.0000
Resources	RE	0.15809	0.06619	2.3884	0.9819
Resources	RP	0.18015	0.06619	2.7216	0.8773
Resources	RRS	-0.04044	0.06619	-0.6110	1.0000
Resources	RS	0.19485	0.06619	2.9438	0.7245
Resources	RU	0.18750	0.06619	2.8327	0.8086
Resources	TD	0.10294	0.06619	1.5552	1.0000

Metric_Group = Resources
Metric = RC subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RE	0.0625	0.06619	0.944	1.0000
Resources	RP	0.0846	0.06619	1.277	1.0000
Resources	RRS	-0.1360	0.06619	-2.055	0.9993
Resources	RS	0.0993	0.06619	1.500	1.0000
Resources	RU	0.0919	0.06619	1.389	1.0000
Resources	TD	0.0074	0.06619	0.111	1.0000

Metric_Group = Resources
Metric = RE subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RP	0.0221	0.06619	0.333	1.0000
Resources	RRS	-0.1985	0.06619	-2.999	0.6780
Resources	RS	0.0368	0.06619	0.555	1.0000
Resources	RU	0.0294	0.06619	0.444	1.0000
Resources	TD	-0.0551	0.06619	-0.833	1.0000

Metric_Group = Resources
Metric = RP subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RRS	-0.2206	0.06619	-3.333	0.3859
Resources	RS	0.0147	0.06619	0.222	1.0000
Resources	RU	0.0074	0.06619	0.111	1.0000
Resources	TD	-0.0772	0.06619	-1.166	1.0000

Metric_Group = Resources
Metric = RRS subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RS	0.235294	0.06619	3.55476	0.2274
Resources	RU	0.227941	0.06619	3.44367	0.3005
Resources	TD	0.143382	0.06619	2.16618	0.9974

Metric_Group = Resources
Metric = RS subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	RU	-0.0074	0.06619	-0.111	1.0000
Resources	TD	-0.0919	0.06619	-1.389	1.0000

Metric_Group = Resources
Metric = RU subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Resources	TD	-0.0846	0.06619	-1.277	1.0000

Metric_Group = Technique/Process
Metric = Beta subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EE	-0.0221	0.06619	-0.333	1.0000

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EOLR	-0.0000	0.06619	-0.000	1.0000
Technique/Process	LPT	0.1397	0.06619	2.111	0.9986
Technique/Process	PLE	-0.0294	0.06619	-0.444	1.0000
Technique/Process	RNC	0.0441	0.06619	0.667	1.0000

Metric_Group = Technique/Process
Metric = EE subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	EOLR	0.02206	0.06619	0.333	1.0000
Technique/Process	LPT	0.16176	0.06619	2.444	0.9733
Technique/Process	PLE	-0.00735	0.06619	-0.111	1.0000
Technique/Process	RNC	0.06618	0.06619	1.000	1.0000

Metric_Group = Technique/Process
Metric = EOLR subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	LPT	0.1397	0.06619	2.111	0.9986
Technique/Process	PLE	-0.0294	0.06619	-0.444	1.0000
Technique/Process	RNC	0.0441	0.06619	0.667	1.0000

Metric_Group = Technique/Process
Metric = LPT subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	PLE	-0.1691	0.06619	-2.555	0.9469
Technique/Process	RNC	-0.0956	0.06619	-1.444	1.0000

Metric_Group = Technique/Process
Metric = PLE subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Technique/Process	RNC	0.07353	0.06619	1.111	1.000

Metric_Group = Water
Metric = CWI subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	EUT	-0.1287	0.06619	-1.944	0.9998
Water	WDI	-0.0221	0.06619	-0.333	1.0000
Water	Wint	-0.0221	0.06619	-0.333	1.0000
Water	WP	0.0257	0.06619	0.389	1.0000
Water	WQ	-0.0772	0.06619	-1.166	1.0000
Water	WU	-0.0588	0.06619	-0.889	1.0000

Metric_Group = Water
Metric = EUT subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WDI	0.10662	0.06619	1.6107	1.0000
Water	Wint	0.10662	0.06619	1.6107	1.0000
Water	WP	0.15441	0.06619	2.3328	0.9881
Water	WQ	0.05147	0.06619	0.7776	1.0000
Water	WU	0.06985	0.06619	1.0553	1.0000

Metric_Group = Water
Metric = WDI subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	Wint	0.00000	0.06619	0.0000	1.000
Water	WP	0.04779	0.06619	0.7221	1.000
Water	WQ	-0.05515	0.06619	-0.8331	1.000
Water	WU	-0.03676	0.06619	-0.5554	1.000

Metric_Group = Water
Metric = Wint subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WP	0.04779	0.06619	0.7221	1.000
Water	WQ	-0.05515	0.06619	-0.8331	1.000
Water	WU	-0.03676	0.06619	-0.5554	1.000

Metric_Group = Water
Metric = WP subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WQ	-0.1029	0.06619	-1.555	1.000
Water	WU	-0.0846	0.06619	-1.277	1.000

Metric_Group = Water
Metric = WQ subtracted from:

Metric_Group	Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Water	WU	0.01838	0.06619	0.2777	1.000

General Linear Model: Average_Value versus Response, Metric (ANOVA 2)

Factor	Type	Levels	Values
Response	random	68	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Metric	fixed	55	AcP, AP, Beta, BP, CF, Cint, CO2, CU, CWI, EE, EEI, EI, Eint, EOLR, ET, EU, EUNR, EUT, Futil, GGE, IP, LCEInt, LPT, LU, MR, MU, NRRC, OCP, OSU, OZ, PLE, PPD, PSW, RC, RE, RM, RNC, RP, RRR, RRS, RS, RU, SW, SWRR, TD, TE, TEInt, W, WC, WDI, Wint, WP, WQ, WsU, WU

Analysis of Variance for Average_Value, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Response	67	687.9915	687.9915	10.2685	68.93	0.000
Metric	54	23.1037	23.1037	0.4278	2.87	0.000
Error	3618	538.9516	538.9516	0.1490		
Total	3739	1250.0468				

S = 0.385958   R-Sq = 56.89%   R-Sq(adj) = 55.44%

Tukey Simultaneous Tests
Response Variable Average_Value
All Pairwise Comparisons among Levels of Metric
Metric = AcP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CF	0.32721	0.06619	4.9433	0.0012
Cint	0.13603	0.06619	2.0551	0.9993
ET	0.14706	0.06619	2.2217	0.9955
GGE	0.23162	0.06619	3.4992	0.2623
OCP	0.00735	0.06619	0.1111	1.0000
OZ	0.10662	0.06619	1.6107	1.0000
PPD	0.04044	0.06619	0.6110	1.0000

Metric = AP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BP	-0.1765	0.06619	-2.666	0.9049
CO2	0.0699	0.06619	1.055	1.0000
PSW	-0.1434	0.06619	-2.166	0.9974
RM	-0.0956	0.06619	-1.444	1.0000
RRR	-0.0257	0.06619	-0.389	1.0000
SW	-0.0919	0.06619	-1.389	1.0000
SWRR	-0.1703	0.06619	-2.573	0.9411
TE	-0.1507	0.06619	-2.277	0.9925
W	-0.1654	0.06619	-2.499	0.9618
WC	-0.1213	0.06619	-1.833	1.0000
WsU	-0.1324	0.06619	-2.000	0.9996

Metric = Beta subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EE	-0.0221	0.06619	-0.333	1.0000
EOLR	-0.0000	0.06619	-0.000	1.0000
LPT	0.1397	0.06619	2.111	0.9986
PLE	-0.0294	0.06619	-0.444	1.0000
RNC	0.0441	0.06619	0.667	1.0000

Metric = BP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
CO2	0.24632	0.06619	3.7214	0.1421
PSW	0.03309	0.06619	0.4999	1.0000
RM	0.08088	0.06619	1.2219	1.0000
RRR	0.15074	0.06619	2.2773	0.9925
SW	0.08456	0.06619	1.2775	1.0000
SWRR	0.00613	0.06619	0.0926	1.0000
TE	0.02574	0.06619	0.3888	1.0000
W	0.01103	0.06619	0.1666	1.0000
WC	0.05515	0.06619	0.8331	1.0000
WsU	0.04412	0.06619	0.6665	1.0000

Metric = CF subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Cint	-0.1912	0.06619	-2.888	0.7682
ET	-0.1801	0.06619	-2.722	0.8773
GGE	-0.0956	0.06619	-1.444	1.0000
OCP	-0.3199	0.06619	-4.832	0.0019
OZ	-0.2206	0.06619	-3.333	0.3859
PPD	-0.2868	0.06619	-4.332	0.0162

Metric = Cint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
ET	0.0110	0.06619	0.167	1.0000
GGE	0.0956	0.06619	1.444	1.0000
OCP	-0.1287	0.06619	-1.944	0.9998
OZ	-0.0294	0.06619	-0.444	1.0000
PPD	-0.0956	0.06619	-1.444	1.0000

Metric = CO2 subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PSW	-0.2132	0.06619	-3.221	0.4806
RM	-0.1654	0.06619	-2.499	0.9618
RRR	-0.0956	0.06619	-1.444	1.0000
SW	-0.1618	0.06619	-2.444	0.9733
SWRR	-0.2402	0.06619	-3.629	0.1858
TE	-0.2206	0.06619	-3.333	0.3859
W	-0.2353	0.06619	-3.555	0.2274
WC	-0.1912	0.06619	-2.888	0.7682
WsU	-0.2022	0.06619	-3.055	0.6295

Metric = CU subtracted from:

	Difference	SE of		Adjusted

Metric	of Means	Difference	T-Value	P-Value
EI	-0.1397	0.06619	-2.111	0.9986
Futil	0.0368	0.06619	0.555	1.0000
IP	-0.0404	0.06619	-0.611	1.0000
LU	-0.1507	0.06619	-2.277	0.9925
MR	-0.1140	0.06619	-1.722	1.0000
MU	-0.0221	0.06619	-0.333	1.0000
NRRC	-0.0515	0.06619	-0.778	1.0000
OSU	-0.1360	0.06619	-2.055	0.9993
RC	-0.0404	0.06619	-0.611	1.0000
RE	0.0221	0.06619	0.333	1.0000
RP	0.0441	0.06619	0.667	1.0000
RRS	-0.1765	0.06619	-2.666	0.9049
RS	0.0588	0.06619	0.889	1.0000
RU	0.0515	0.06619	0.778	1.0000
TD	-0.0331	0.06619	-0.500	1.0000

Metric = CWI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUT	-0.1287	0.06619	-1.944	0.9998
WDI	-0.0221	0.06619	-0.333	1.0000
Wint	-0.0221	0.06619	-0.333	1.0000
WP	0.0257	0.06619	0.389	1.0000
WQ	-0.0772	0.06619	-1.166	1.0000
WU	-0.0588	0.06619	-0.889	1.0000

Metric = EE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EOLR	0.02206	0.06619	0.333	1.0000
LPT	0.16176	0.06619	2.444	0.9733
PLE	-0.00735	0.06619	-0.111	1.0000
RNC	0.06618	0.06619	1.000	1.0000

Metric = EEI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Eint	0.0551	0.06619	0.833	1.0000
EU	0.1434	0.06619	2.166	0.9974
EUNR	0.0772	0.06619	1.166	1.0000
LCEInt	0.0221	0.06619	0.333	1.0000
TEInt	-0.0037	0.06619	-0.056	1.0000

Metric = EI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Futil	0.17647	0.06619	2.6661	0.9049
IP	0.09926	0.06619	1.4997	1.0000
LU	-0.01103	0.06619	-0.1666	1.0000
MR	0.02574	0.06619	0.3888	1.0000
MU	0.11765	0.06619	1.7774	1.0000
NRRC	0.08824	0.06619	1.3330	1.0000
OSU	0.00368	0.06619	0.0555	1.0000
RC	0.09926	0.06619	1.4997	1.0000
RE	0.16176	0.06619	2.4439	0.9733
RP	0.18382	0.06619	2.7772	0.8451
RRS	-0.03676	0.06619	-0.5554	1.0000
RS	0.19853	0.06619	2.9993	0.6780
RU	0.19118	0.06619	2.8882	0.7682
TD	0.10662	0.06619	1.6107	1.0000

Metric = Eint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EU	0.0882	0.06619	1.333	1.0000
EUNR	0.0221	0.06619	0.333	1.0000
LCEInt	-0.0331	0.06619	-0.500	1.0000
TEInt	-0.0588	0.06619	-0.889	1.0000

Metric = EOLR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LPT	0.1397	0.06619	2.111	0.9986
PLE	-0.0294	0.06619	-0.444	1.0000
RNC	0.0441	0.06619	0.667	1.0000

Metric = ET subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
GGE	0.0846	0.06619	1.277	1.0000
OCP	-0.1397	0.06619	-2.111	0.9986
OZ	-0.0404	0.06619	-0.611	1.0000
PPD	-0.1066	0.06619	-1.611	1.0000

Metric = EU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
EUNR	-0.0662	0.06619	-1.000	1.0000
LCEInt	-0.1213	0.06619	-1.833	1.0000
TEInt	-0.1471	0.06619	-2.222	0.9955

Metric = EUNR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LCEInt	-0.0551	0.06619	-0.833	1.0000
TEInt	-0.0809	0.06619	-1.222	1.0000

Metric = EUT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WDI	0.106618	0.06619	1.61075	1.0000
Wint	0.106618	0.06619	1.61075	1.0000
WP	0.154412	0.06619	2.33281	0.9881
WQ	0.051471	0.06619	0.77760	1.0000
WU	0.069853	0.06619	1.05532	1.0000

Metric = Futil subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
IP	-0.0772	0.06619	-1.166	1.0000
LU	-0.1875	0.06619	-2.833	0.8086
MR	-0.1507	0.06619	-2.277	0.9925
MU	-0.0588	0.06619	-0.889	1.0000
NRRC	-0.0882	0.06619	-1.333	1.0000

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OSU	-0.1728	0.06619	-2.611	0.9281
RC	-0.0772	0.06619	-1.166	1.0000
RE	-0.0147	0.06619	-0.222	1.0000
RP	0.0074	0.06619	0.111	1.0000
RRS	-0.2132	0.06619	-3.221	0.4806
RS	0.0221	0.06619	0.333	1.0000
RU	0.0147	0.06619	0.222	1.0000
TD	-0.0699	0.06619	-1.055	1.0000

Metric = GGE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OCP	-0.2243	0.06619	-3.388	0.3417
OZ	-0.1250	0.06619	-1.888	0.9999
PPD	-0.1912	0.06619	-2.888	0.7682

Metric = IP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
LU	-0.1103	0.06619	-1.666	1.0000
MR	-0.0735	0.06619	-1.111	1.0000
MU	0.0184	0.06619	0.278	1.0000
NRRC	-0.0110	0.06619	-0.167	1.0000
OSU	-0.0956	0.06619	-1.444	1.0000
RC	0.0000	0.06619	0.000	1.0000
RE	0.0625	0.06619	0.944	1.0000
RP	0.0846	0.06619	1.277	1.0000
RRS	-0.1360	0.06619	-2.055	0.9993
RS	0.0993	0.06619	1.500	1.0000
RU	0.0919	0.06619	1.389	1.0000
TD	0.0074	0.06619	0.111	1.0000

Metric = LCEInt subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TEInt	-0.0257	0.06619	-0.389	1.0000

Metric = LPT subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PLE	-0.1691	0.06619	-2.555	0.9469
RNC	-0.0956	0.06619	-1.444	1.0000

Metric = LU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MR	0.03676	0.06619	0.5554	1.0000
MU	0.12868	0.06619	1.9440	0.9998
NRRC	0.09926	0.06619	1.4997	1.0000
OSU	0.01471	0.06619	0.2222	1.0000
RC	0.11029	0.06619	1.6663	1.0000
RE	0.17279	0.06619	2.6105	0.9281
RP	0.19485	0.06619	2.9438	0.7245
RRS	-0.02574	0.06619	-0.3888	1.0000
RS	0.20956	0.06619	3.1660	0.5300
RU	0.20221	0.06619	3.0549	0.6295
TD	0.11765	0.06619	1.7774	1.0000

Metric = MR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
MU	0.09191	0.06619	1.3886	1.0000
NRRC	0.06250	0.06619	0.9442	1.0000
OSU	-0.02206	0.06619	-0.3333	1.0000
RC	0.07353	0.06619	1.1109	1.0000
RE	0.13603	0.06619	2.0551	0.9993
RP	0.15809	0.06619	2.3884	0.9819
RRS	-0.06250	0.06619	-0.9442	1.0000
RS	0.17279	0.06619	2.6105	0.9281
RU	0.16544	0.06619	2.4994	0.9618
TD	0.08088	0.06619	1.2219	1.0000

Metric = MU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
NRRC	-0.0294	0.06619	-0.444	1.0000
OSU	-0.1140	0.06619	-1.722	1.0000
RC	-0.0184	0.06619	-0.278	1.0000
RE	0.0441	0.06619	0.667	1.0000
RP	0.0662	0.06619	1.000	1.0000
RRS	-0.1544	0.06619	-2.333	0.9881
RS	0.0809	0.06619	1.222	1.0000
RU	0.0735	0.06619	1.111	1.0000
TD	-0.0110	0.06619	-0.167	1.0000

Metric = NRRC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OSU	-0.0846	0.06619	-1.277	1.0000
RC	0.0110	0.06619	0.167	1.0000
RE	0.0735	0.06619	1.111	1.0000
RP	0.0956	0.06619	1.444	1.0000
RRS	-0.1250	0.06619	-1.888	0.9999
RS	0.1103	0.06619	1.666	1.0000
RU	0.1029	0.06619	1.555	1.0000
TD	0.0184	0.06619	0.278	1.0000

Metric = OCP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
OZ	0.09926	0.06619	1.4997	1.0000
PPD	0.03309	0.06619	0.4999	1.0000

Metric = OSU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RC	0.09559	0.06619	1.4441	1.0000
RE	0.15809	0.06619	2.3884	0.9819
RP	0.18015	0.06619	2.7216	0.8773
RRS	-0.04044	0.06619	-0.6110	1.0000
RS	0.19485	0.06619	2.9438	0.7245
RU	0.18750	0.06619	2.8327	0.8086
TD	0.10294	0.06619	1.5552	1.0000

Metric = OZ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PPD	-0.0662	0.06619	-1.000	1.0000

Metric = PLE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RNC	0.07353	0.06619	1.111	1.0000

Metric = PSW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RM	0.04779	0.06619	0.722	1.0000
RRR	0.11765	0.06619	1.777	1.0000
SW	0.05147	0.06619	0.778	1.0000
SWRR	-0.02696	0.06619	-0.407	1.0000
TE	-0.00735	0.06619	-0.111	1.0000
W	-0.02206	0.06619	-0.333	1.0000
WC	0.02206	0.06619	0.333	1.0000
WsU	0.01103	0.06619	0.167	1.0000

Metric = RC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RE	0.0625	0.06619	0.944	1.0000
RP	0.0846	0.06619	1.277	1.0000
RRS	-0.1360	0.06619	-2.055	0.9993
RS	0.0993	0.06619	1.500	1.0000
RU	0.0919	0.06619	1.389	1.0000
TD	0.0074	0.06619	0.111	1.0000

Metric = RE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RP	0.0221	0.06619	0.333	1.0000
RRS	-0.1985	0.06619	-2.999	0.6780
RS	0.0368	0.06619	0.555	1.0000
RU	0.0294	0.06619	0.444	1.0000
TD	-0.0551	0.06619	-0.833	1.0000

Metric = RM subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRR	0.0699	0.06619	1.055	1.0000
SW	0.0037	0.06619	0.056	1.0000
SWRR	-0.0748	0.06619	-1.129	1.0000
TE	-0.0551	0.06619	-0.833	1.0000
W	-0.0699	0.06619	-1.055	1.0000
WC	-0.0257	0.06619	-0.389	1.0000
WsU	-0.0368	0.06619	-0.555	1.0000

Metric = RP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RRS	-0.2206	0.06619	-3.333	0.3859
RS	0.0147	0.06619	0.222	1.0000
RU	0.0074	0.06619	0.111	1.0000
TD	-0.0772	0.06619	-1.166	1.0000

Metric = RRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SW	-0.0662	0.06619	-1.000	1.0000
SWRR	-0.1446	0.06619	-2.185	0.9969
TE	-0.1250	0.06619	-1.888	0.9999
W	-0.1397	0.06619	-2.111	0.9986
WC	-0.0956	0.06619	-1.444	1.0000
WsU	-0.1066	0.06619	-1.611	1.0000

Metric = RRS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RS	0.23529	0.06619	3.5548	0.2274
RU	0.22794	0.06619	3.4437	0.3005
TD	0.14338	0.06619	2.1662	0.9974

Metric = RS subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
RU	-0.0074	0.06619	-0.111	1.0000
TD	-0.0919	0.06619	-1.389	1.0000

Metric = RU subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TD	-0.0846	0.06619	-1.277	1.0000

Metric = SW subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
SWRR	-0.07843	0.06619	-1.185	1.000
TE	-0.05882	0.06619	-0.889	1.000
W	-0.07353	0.06619	-1.111	1.000

Metric = SWRR subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
TE	0.01961	0.06619	0.2962	1.000
W	0.00490	0.06619	0.0741	1.000
WC	0.04902	0.06619	0.7406	1.000
WsU	0.03799	0.06619	0.5739	1.000

Metric = TE subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
W	-0.01471	0.06619	-0.2222	1.000
WC	0.02941	0.06619	0.4443	1.000
WsU	0.01838	0.06619	0.2777	1.000

Metric = W subtracted from:

	Difference	SE of		Adjusted

Metric	of Means	Difference	T-Value	P-Value
WC	0.04412	0.06619	0.6665	1.000
WsU	0.03309	0.06619	0.4999	1.000

Metric = WC subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WsU	-0.01103	0.06619	-0.1666	1.000

Metric = WDI subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Wint	0.00000	0.06619	0.0000	1.000
WP	0.04779	0.06619	0.7221	1.000
WQ	-0.05515	0.06619	-0.8331	1.000
WU	-0.03676	0.06619	-0.5554	1.000

Metric = Wint subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WP	0.04779	0.06619	0.7221	1.000
WQ	-0.05515	0.06619	-0.8331	1.000
WU	-0.03676	0.06619	-0.5554	1.000

Metric = WP subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WQ	-0.1029	0.06619	-1.555	1.000
WU	-0.0846	0.06619	-1.277	1.000

Metric = WQ subtracted from:

Metric	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
WU	0.01838	0.06619	0.2777	1.000

References

Akao, Yoji. Quality Function Deployment: Integrating Customer Requirements Into Product Design. Trans. Glen H. Mazur. Cambridge, MA: Productivity P, 1990.

Albino, Vito, Carmen Izzo, and Silvana Kuhtz. "Input-Output Models for the Analysis of a Local/Global Supply Chain." International Journal of Production Economics 78 (2002): 119-31.

Atlee, Jennifer, and Randolph Kirchain. "Operational Sustainability Metrics Assessing Metric Effectiveness in the Context of Electronics-Recycling Systems." Environmental Science & Technology 40.14 (2006): 4506-513

Azapagic, A., and S. Perdan. "Indicators of Sustainable Development for Industry: A General Framework." Process Safety and Environmental Protection 78.4 (2000): 243-61.

Bowersox, Donald J., and David J. Closs. Logistical Management: The Integrated Supply Chain Process. New York: McGraw-Hill Companies, 1996.

Cannondale. Cannondale Philosophy. Retrieved October 29, 2009, from Cannondale Bicycle Corp.: http://www3.cannondale.com/company/philosophy.html.

Claver, Enrique, Maria D. Lopez, Jose F. Molina, and Juan J. Tari. "Environmental Management and Firm Performance: A Case Study." Journal of Environmental Management 84.4 (2007): 606-19.

Cooper, Robert G., and Scott J. Edgett. "Maximizing Productivity in Product Innovation." Industrial Research Institute, Inc. (2008): 47-58.

Eriksson, Clas. "Can Green Consumerism Replace Environmental Regulation? A Differentiated-Products Example." Resource and Energy Economics 26 (2004): 281-93.

Fan, Chengcheng, John D. Carrell, and Hong-Chao Zhang. "An Investigation of Indicators for Measuring Sustainable Manufacturing." IEEE (2008): 1-5.

Franchetti, Matthew, Kyle Bedal, Jenny Ulloa, and Selena Grodek. "Lean to Green." Industrial Engineer Sept. 2009: 25-29.

Fuller, D., and Jacquelyn A. Ottman. "Moderating Unintended Pollution: The Role of Sustainable Product Design." Journal of Business Research 57 (2004): 1231-238.

Genaidy, Ash, and Waldemar Karwowski. "A Roadmap for Methodology to Assess, Improve, and Sustain Intra- and Inter-Enterprise System Performance with Respect to Technology-Product Life Cycle in Small and Medium Manufacturers." Human Factors and Ergonomics in Manufacturing 18.1 (2008): 70-84.

Ghomshei, Mory, and Francesco Villecco. "Energy Metrics and Sustainability." Proc. of International Conference on Complex Systems and Applications 2009, Le Havre, Normandy, France. 693-98.

Gaughran, William F., Stephen Burke, and Patrick Phelan. "Intelligent Manufacturing and Environmental Sustainability." Robotics and Computer-Integrated Manufacturing 23.6 (2007): 704-11.

Guide, V. Daniel R., Vaidyanathan Jayaraman, Rajesh Srivastava, and W. C. Benton. "Supply-Chain Management for Recoverable Manufacturing Systems." Interfaces 30.3 (2000): 125-42.

Herron, C., and P. Braiden. "A Methodology for Developing Sustainable Quantifiable Productivity Improvement and Manufacturing Companies." International Journal of Production Economics 104.1 (2006): 143-53.

Hertwich, Edgar G., and Glen P. Peters. "Carbon Footprint of Nations: A Global, Trade-Linked Analysis." Environmental Science & Technology 43 (2009): 6414-420.

Hervani, Aref A., Marilyn M. Helms, and Joseph Sarkis. "Performance Measurement for Green Supply Chain Management." Benchmarking: An International Journal 12 (2005): 330-53.

Ichimura, Masakazu. Eco-efficiency Indicators: Measuring Resource Use Efficiency and the Impact of Economic Activities on the Environment. Rep. United Nations Economic and Social Commission for Asia and the Pacific, 2009.

Ijomah, Winifred L., Christopher A. McMahon, Geoffrey P. Hammond, and Stephen T. Newman. "Development of Design for Remanufacturing Guidelines to Support Sustainable Manufacturing. "Robotics and Computer-Integrated Manufacturing 23.6 (2007): 712-19.

Jin, Xun, and Karen A. High. "A New Conceptual Hierarchy for Identifying Environmental Sustainability Metrics." Environmental Progress 23 (2004): 291-301.

Kaebernick, H., S. Kara, and M. Sun. "Sustainable Product Development and Manufacturing by Considering Environmental Requirements." Robotics and Computer-Integrated Manufacturing 19 (2003): 461-68.

Kainuma, Yasutaka, and Nobuhiko Tawara. "A Multiple Attribute Utility Theory Approach to Lean and Green Supply Chain Management." International Journal of Production Economics 101 (2006): 99-108.

Labuschagne, Carin, and Alan C. Brent. "Sustainable Project Life Cycle Management: The Need to Integrate Life Cycles in the Manufacturing Sector." International Journal of Project Management 23.2 (2005): 159-68.

Lin, Chun-Yu, Ming-Chuan Chiu, and Gül Okudan. "Design for Sustainability During Conceptual Design Stage." IIE Annual Conference and Expo. Proc. of IERC 2009, Miami, FL.

Linton, J., R. Klassen, and V. Jayaraman. "Sustainable Supply Chains: An Introduction." Journal of Operations Management 25.6 (2007): 1075-082.

Martins, António A., Teresa M. Mata, Carlos A. V. Costa, and Subhas K. Sikdar. "Framework for Sustainability Metrics." Industrial & Engineering Chemistry Research 46.10 (2007): 2962-973.

McDonough, William, and Michael Braungart. Cradle to Cradle: Rethinking the Way We Make Things. New York: North Point, 2002.

Matthews, H. Scott, Chris T. Hendrickson, and Christopher L. Weber. "The Importance of Carbon Footprint Estimation Boundaries." Environmental Science & Technology 42 (2008): 5839-842.

Mosovsky, John, David Dickinson, and Joe Morabito. "Creating Competitive Advantage Through Resource Productivity, Eco-Efficiency, and Sustainability in the Supply Chain." ISEE. Proc. of IEEE International Symposium on Electronics and the Environment, San Francisco, CA. 2000. 230-37.

Nagurney, Anna, Zugang Liu, and Trisha Woolley. "Sustainable Supply Chain and Transportation Networks." International Journal of Sustainable Transportation 1.1 (2007): 29-51.

Naidu, Sasikumar, Rapinder Sawhney, and Xueping Li. "A Methodology for Evaluation and Selection of Nanoparticle Manufacturing Processes Based on Sustainability Metrics." Environmental Science & Technology 42.17 (2008): 6697-702.

Nam, Sangmin. "Eco-Efficiency Indicators: Measuring Environmental Implications of Economic Performance." 2008. Lecture.

National Round Table on the Environment and the Economy (NRTEE). Eco-Efficiency Indicators Workbook. Rep. Ottawa, ON: Renouf, 2007.

Petrie, J., B. Cohen, and M. Stewart. "Decision Support Frameworks and Metrics for Sustainable Development of Minerals and Metals." *Clean* Technologies and Environmental Policy 9.2 (2007): 133-45.

Rachuri, Sudarsan, Ram D. Sriram, and Prabir Sarkar. "Metrics, Standards and Industry Best Practices for Sustainable Manufacturing Systems." IEEE Conference on Automation Sciences and Engineering 5 (2009): 472-77.

Rathje, William L., and Robert M. Lilienfeld. Use Less Stuff: Environmentalism for Who We Really Are. New York: Ballantine Pub. Group, 1998.

Ravindran, A. Ravi, G. V. Reklaitis, and K. M. Ragsdell. Engineering Optimization: Methods and Applications. Hoboken, NJ: John Wiley & Sons, 2006.

Ravindran, A. Ravi. Operations Research and Management Science Handbook. Boca Raton, Florida: CRC, 2008.

Ravindran, A. Ravi. Operations Research Applications. Boca Raton, Florida: CRC, 2009.

Ray, Charles D., Xiaoqiu Zuo, Judd H. Michael, and Janice K. Wiedenbeck. "The Lean Index: Operational "Lean" Metrics for the Wood Products Industry." Wood and Fiber Science 38.2 (2006): 238-55.

Reich-Weiser, C., and D.A. Dornfeld. "A Discussion of Greenhouse Gas Emission Tradeoffs and Water Scarcity Within the Supply Chain." Journal of Manufacturing Systems 28 (2009): 23-27.

"Return On Assets (ROA) Definition." Investopedia.com. Web. 23 Mar. 2010. <http://www.investopedia.com/>.

Rosbjerg, D., N. E. Boutayeb, A. Gustard, Z. W. Kundzewicz, and P. F. Rasmussen. Sustainability of Water Resources Under Increasing Uncertainty. Wallingford, Oxfordshire, UK: IAHS, 1997.

Saaty, Thomas L., and Luis G. Vargas. Decision Making with the Analytic Network Process. New York: Springer Science Business Media, LLC, 2006.

Saaty, Thomas L. "How to Make a Decision: The Analytic Hierarchy Process." European Journal of Operational Research 48.1 (1990): 9-26.

Sarkis, Joseph. "A Methodological Framework for Evaluating Environmentally Conscious Manufacturing Programs." Computers & Industrial Engineering 36 (1999): 793-810.

Sarkis, Joseph. "Evaluating Environmentally Conscious Business Practices." European Journal of Operational Research 107 (1998): 159-74.

Sarkis, Joseph. "Manufacturing Strategy and Environmental Consciousness." Technovation 15.2 (1995): 79-97.

Sekulic, Dusan P. "An Entropy Generation Metric for Non-Energy Systems Assessments." Energy 34 (2009): 587-92.

Sikdar, Subhas K. "On Aggregating Multiple Indicators Into a Single Metric for Sustainability." Clean Technologies and Environmental Policy 11.2 (2009): 157-61.

Sikdar, Subhas K. "Sustainability and Recycle–Reuse in Process Systems." Clean Technologies and Environmental Policy 9.3 (2007): 167-74.

Sikdar, Subhas K. "Sustainable Development and Sustainability Metrics." AIChE Journal 49.8 (2003): 1928-932.

Tallis, Bill. The Sustainability Metrics: Sustainable Development Progress Metrics. Rep. Institution of Chemical Engineers, 1997.

Tsay, Yau-Yuh. "The Impacts of Economic Crisis on Green Consumption in Taiwan." Proc. of PICMET, Portland, Oregon. 2009. 2367-374.

Wal-Mart Corporation. 2009 Global Corporate Sustainability Report. Rep. Bentonville, AR.

Wal-Mart Corporation. "Wal-Mart Unveils "Packaging Scorecard" to Suppliers." PACK Expo 2006. Chicago, IL. Address.

Wang, Jinfu, and Daohong Zhang. "Study on the Sustainability Mechanism of Self-Organized Supply Chain." IEEE (2007): 1-4.

Wang, Ling, and Li Lin. "A Methodology to Incorporate Life Cycle Analysis and the Triple Bottom Line Mechanism for Sustainable Management of Industrial Enterprises." Proc. of Environmentally Conscious Manufacturing III. 2004. 201-09.

Wilson, Jeffrey, Peter Tyedmers, and Ronald Pelot. "Contrasting and Comparing Sustainable Development Indicator Metrics." Ecological Indicators 7.2 (2007): 299-314.

Zhong, Wei, and Ying Zhang. Consulting Report for Sustainability Metrics Research. Rep. State College, PA: Pennsylvania State University Department of Statistics: Statistical Consulting Center, 2010. Print.

Zhou, Zhangyu, Siwei Cheng, and Ben Hua. "Supply Chain Optimization of Continuous Process Industries with Sustainability Considerations." Computers & Chemical Engineering 24.2-7 (2000): 1151-158.