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MANUFACTURING: UNDERSTANDING LEAN AND GREEN

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Abstract

The efficiency of manufacturing practices has been continuously improving over the past century. Just-in-time allowed for reductions in inventory which reduced overall costs to companies. Lean initiatives were put in place in the 1990's in order to reduce overall waste from the manufacturing processes. Although waste reduction has environmental benefits, manufacturers do not always attempt to pursue sustainability and the triple bottom line, but rather the bottom line. Lean initiatives can be altered to create sustainability which would reduce wastes and improve the triple bottom line. Along with the addition of sustainable practices to lean, there are multiple tools that companies can implement which will have positive sustainable benefits: sustainable product design, reverse logistics, energy management, and life-cycle costing. A review of cross-industry best practices and sustainability successes will be presented.

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Chapter 1

Introduction

The manufacturing industry has long been established in the United States. During the 19th century industrial revolution, the United States boosted its economy, shifting to a modern industrial state. Companies moved away from handmade production and witnessed an overall cost reduction enhancing their bottom line.

1.1 Initial Background

The identification and removal of waste were recognized in practices during the era of Henry Ford in the early 1900's. From then until now, companies have placed a stronger emphasis on waste management to further reduce costs. Through lean practices, established in the 1990's, companies identified wastes in the following eight categories:

- *Overproduction* – Recognized as excess production of customer requirements, overproduction is often considered one of the worst wastes as it multiplies the effects of subsequent wastes.
- *Inventory* – Unused and unsold parts and products, either pre or post-production, tie up capital, become obsolete and clog valuable shelf space.
- *Defects* – Often due to human or equipment error, deficiencies cause a product to be scrapped or reworked, demanding excess time and capital from the manufacturer.

- *Waiting* – Stations within a production line depend on the speed and reliability of the upstream and downstream processes. Bottlenecks are potentially people, equipment or materials and increase production time and costs.
- *Transportation* – The unnecessary movement of products or information can cause loss of product or rework.
- *Motion* – The unneeded movement of people around work stations wastes time and effort.
- *Over Processing* – Seen when nonessential steps are taken throughout the production process. These steps may cause wasted time due to communication errors, poor process design or quality that is above the customer's standards.
- *Unidentified Employee Creativity* – Untapped employee creativity causes companies to lose skills and ideas that could improve processes. Employees with ample involvement during manufacturing processes may recognize practices to reduce the other seven wastes.

Consumers and governments recognized issues such as excess volatile organic compounds, solid wastes and a depletion of natural resources during the early 2000's. Both parties are pressuring companies to preserve the environment and place emphasis on people by implementing sustainability into corporate strategies.

1.2 Problem Statement

A strong consumer and governmental emphasis on sustainable practices is forcing manufacturers to become socially responsible. Although many companies already eliminate waste through lean manufacturing, greater focus on the ecosystem creates internal and external

sustainability. Addressing sustainability within a facility gives a company the potential to further reduce their footprint. This thesis provides insight into the best practices and industry standards surrounding sustainability. Ideas from multiple industries will be brought together to assess what standards may be adopted across industries. Issues with sustainable practices will also be acknowledged.

Chapter 2

Background

It is difficult to identify the beginning of the sustainability movement. However, there has been vast research and attention given to the subject. With rising energy, raw material and waste processing costs, people are becoming environmentally conscious, pressuring companies to do the same. Coincidentally, companies are recognizing the financial benefits associated with sustainable strategies, and are thus responding to social pressures.

2.1 Sustainability Defined

The World Commission on Environment and Development was launched by the United Nations to globally push the three pillars of sustainable development: economic growth, social equality, and environmental protection. In 1987 sustainable development was defined as, "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (World). Though this is an important concept into sustainble practices, companies who take sustainability further have noticed greater success.

From a business and manufacturing standpoint, companies must focus on more than just the bottom line. Those who embrace a triple bottom line strategy of profit, people, and planet, incorporate the two major goals of sustainability. Preserving the planet's limited resource supply and environment is largely a part of sustainable practice. In addition, conservation of a company's people, both internal and external, should be coupled with their environmental sustainability goals.

2.2 The Case for Sustainable Manufacturing

Sustainability has been regularly pursued in the 21st century due to increased global awareness. The issue of global warming emerged more consistently in the 1980's and stemmed a debate over its severity. To investigate this matter, the United Nations started the Intergovernmental Panel on Climate Change in 1989. The Global Climate Coalition and the Competitive Enterprise Institute were formed by companies in order to debate and determine the causes for climate change (Phillips et al. viii). They agreed that climate change may be occurring, but disagreed on its origins.

The Global Climate Coalition was disbanded during the 2000's and many companies began to incorporate sustainability into their corporate strategies. DuPont, Nike and Timberland have had corporate policies of sustainability at the heart of their supply chain for years. In 2009, MIT conducted a survey with over 1,500 corporate executives. Listed by order of importance, are the responses from the companies to the question, "What are the greatest benefits to your organization in addressing sustainability issues?" (Hopkins et al. 23):

1) Improved company or brand image
2) Cost savings
3) Competitive advantage
4) Employee satisfaction, morale or retention
5) Product, service or market innovation
6) Business model or process innovation
7) New sources of revenue or cash flow
8) Effective risk management
9) Enhanced stakeholder relations

Corporate image ranked higher than cost savings by roughly two and a half times. This shows the importance of a company's image to a consumer when purchasing products. When pursuing sustainability, the best strategy is to focus on the triple bottom line by incorporating people and planet. By doing this, companies have attained the nine above benefits.

2.2.1 People

Companies that have aimed to please their stakeholders rather than strictly their shareholders are more likely to see greater success. Consumers are more susceptive to products produced by companies who care about their local communities (Hudson et al. 3). Empowered employees are less likely to leave a company causing decreased costs in recruitment. Subsequently, satisfying those inside and out of the company leads to a higher profitability for the shareholders.

Timberland Co., a publically traded footwear and clothing company, initiated an overall corporate policy of sustainability long before it was considered the "norm." This allows Timberland's employees to receive 40 hours of paid volunteer work each year along with participation in a daylong "Serv-a-palooza" which is conducted in multiple countries with thousands of volunteers (Reingold 82). Their values are embedded through all levels of the company.

Timberland's strong support of sustainable lifestyles can be seen through their mission statement: "Our mission is to equip people to make a difference in their world. We do this by creating outstanding products and by trying to make a difference in the communities where we live and work" ("The Timberland Story"). In 2007, CEO Jeffrey Swartz shared his belief on Timberland and their policy stating, "No one believes in this more than we do, and that is our

competitive advantage" (Reingold 82). When asked to create uniforms for fast food giant McDonald's, he did not bring samples of clothing. Rather, he brought ideas to incorporate their policies into McDonalds to create a bond between the two companies.

The strong emphasis placed on corporate values struck a chord with their stakeholders. Over a five year period, Timberland witnessed a 9.7% annual sales growth, 20% earnings per share and a 64% stock price increase. They were also able create an atmosphere which kept employees satisfied. They used the sustainable service programs to help team building within the company. In an internal company survey, 75% of employees stated that if they again found themselves looking for work they would choose Timberland. Also, 79% said that their decision to work for the company correlates with the company's reputation (Reingold 84). Through focus on stakeholders, Timberland exhibits an overall success with its positive reputation.

2.2.2 Planet

The U.S. is transforming from a take-make-waste manufacturing process to one which eliminates waste and endorses recycling practices. Companies cannot consume resources with the mentality that they are infinite. Sustainability fosters the preservation of Earth's finite resource supply. The need to reduce our reliance on fossil fuels, reduce our carbon footprint and preserve our world is leading to the implementation of sustainable practices.

There are multiple renewable energy sources that are natural to Earth such as solar, wind and water. The amount of crude oil within the Earth's reserves is continually decreasing. Many oil fields are past their peak of production. According to the United Nations, it is expected that the world's natural resource consumption will triple by the year 2050 to over 140 billion tons each year (Lubin). On top of this, in the 1970-1990 period natural gas was used heavily for

power generation (Wilson 82). Though we are not immediately running out of fossil fuels, people and companies must recognize the need to switch from crude oil and natural gas to renewable sources.

Along with the depletion of Earth's resources companies must pay attention to production byproducts. It is known that global warming exists, but uncertainty surrounds the question of speed and severity. PriceWaterhouseCoopers, a consulting firm, conducted a study in the United Kingdom to determine consumers' feelings towards sustainability. When referring to manufacturing, they found that 62% of consumers believed that the reduction of packaging is the most important step a consumer goods company can take (Hudson et al. 7). This may be due to the fact that packaging is the most outward facing part of a product to a consumer.

Sustainable production measures need to be taken to keep companies in the positive light. Reducing waste and pollution outputs gives companies a competitive advantage. It is evident that sustainability is changing the way consumers purchase goods.

2.3 From JIT to Lean

Lean manufacturing focuses on efficiencies within the production environment. It requires a significant shift in the manufacturing thought process and the willingness to rework accepted and understood practices. Lean has been proven to reduce operational costs as well as production wastes. Although sustainability is not always a goal for lean practices, companies often create marketing strategies from their recognized strategies.

With the implementation of just-in-time (JIT) early in the 1980's, companies began streamlining production practices. The original concept was to reduce inventory within facilities. Just-in-time stressed the arrival of products only as they were needed for production. This could

have been as frequent as shipments every two hours. By reducing inventories and receiving more shipments, companies were unknowingly implementing sustainable practices.

Soon after companies began to react to JIT and the surrounding changes, lean manufacturing emerged. According to the EPA, lean is a process aimed "to reduce production resource requirements and costs, to increase customer responsiveness, and to improve product quality" (Ross 1). The term "Lean Production" came from the 1990 book entitled *The Machine that Changed the World*, when speaking of Toyota's ahead-of-its-time production system (Womack et al.).

The concept of waste elimination originated before Toyota had implemented JIT. Henry Ford, in his book *My Life and Work,* spoke of the wastes on farmland in the early 1900's:

> A farmer doing his chores will walk up and down a rickety ladder a dozen times. He will carry water for years instead of putting in a few lengths of pipe. His whole idea, when there is extra work to do, is to hire extra men. He thinks of putting money into improvements as an expense... It is waste motion – waste effort – that makes farm prices high and profits low. (Ford and Crowther 15)

Ford, though his overall thinking was not to reduce waste, was at the forefront of recognizing that waste was lost profits. Prior to this, he argued that a farmer only makes good use of 5% of the energy expended throughout the day.

Lean's thinking challenges a company's manufacturing process. Often, there is a "batch and queue" thought where processes are laid out to be produced in high volume and then moved to the next location. Lean has changed this thought processes to a "one-piece flow" focusing on

a pull production method. It requires the changing of processes already embedded into a facility's culture and involves all company employees.

Lean fosters a culture with continuous improvement central to the production process. Waste is constantly a target for elimination. Continuous improvement requires employee involvement to help identify problems, from the lowest to highest levels. A metrics-driven focus on operations is utilized to optimize performances. This will, however, sometimes come with a higher supply chain investment.

After implementing these changes, companies are able to recognize the following (Ross 8):

- Reduced inventory levels
- Decreased material usage
- Optimized equipment
- Reduced need for factory facilities
- Increased production velocity
- Enhanced production flexibility
- Reduced complexity

Chapter 3

Transforming Lean

Lean is an initiative taken to reduce a company's waste and non-value added components. Originally, lean did not have sustainability as a goal. Companies take the principles they learn with lean and transform them to produce sustainability. By doing this they are able to use lean to help identify and measure environmental wastes.

3.1 Lean Initiatives

Over the years, companies used many methods to implement lean strategies. Multiple strategies correlate and can overlap with other initiatives. Programs are typically started in single departments or plants. Success is then documented and the programs spread. The following is the list of typical types of lean practices that are often implemented (Ross 10):

1) Kaizen Rapid Improvement Process
2) 5S
3) Total Productive Maintenance (TPM)
4) Cellular Manufacturing
5) Just-in-time / Kanban
6) Six Sigma
7) Pre-Production Planning (3P)
8) Lean Enterprise Supplier Network

3.1.1 Kaizen Rapid Improvement Process

Kaizen, a Japanese word for "rapid improvement," implements a strategy where small, continuous changes are implemented and sustained for long term results. Employees from all levels and facets of a business meet and work together to identify process improvements. Value stream mapping, a common practice used, involves mapping a process from start to end while noting all inputs and outputs. Mapping quickly identifies opportunities for waste elimination within a process. Once a kaizen initiative is completed, it is revisited to maintain its quality and identify new areas of improvement. Kaizen can also be used to implement other lean strategies.

3.1.2 5S

5S, also a Japanese methodology, instills lean goals through maintenance of current processes. The five pillars of 5S are: Sorting (Seiri), Stabilizing (Seiton), Shining (Seiso), Standardizing (Seiketsu), and Sustaining (Shitsuke). 5S typically does not rework the entirety of processes within a plant; however, it reorganizes and creates the most efficient flows of people and equipment. Facilities are able to organize and develop productivity on the floor when following these pillars. 5S sets the foundation for multiple other lean methods.

3.1.3 Total Productive Maintenance (TPM)

TPM is used to engage and familiarize all members of facilities with the maintenance of machinery. Traditionally, maintenance personnel are the ones who oversee the effectiveness and maintenance of facility machines. Autonomous maintenance informs employees to upkeep the machines with which they work. This method focuses on preventative maintenance, corrective

maintenance and breakdown maintenance. With successful implementation, waste is reduced by eliminating breakdowns thus removing adjustment losses, rework and defects.

3.1.4 Cellular Manufacturing

Within this method of lean manufacturing, the machinery in the production facility is arranged to be product-aligned allowing for easy flow from one station to the next. There should be little delay between each of the stations during production. Often, major changes in the production floor layout are required. Successes with this layout move the processes from batch-and-queue to a high velocity and highly flexible production system. By allowing quick changeovers, cellular manufacturing allows for increased response to changes in customer demand. This reduces excess inventory, shortens cycle times and changeover rates and allows for a pull type of production.

3.1.5 Just-in-time / Kanban

Just-in-time is a system that works closely with the cellular manufacturing models. It is based on receiving inventory that will be going into products only before they are needed. With the elimination of inventory, the production process is smoothed causing processes to flow more freely between stations. Often once a physical inventory cue is struck, suppliers will be notified to send product. This type of system reduces waste through unwanted inventory and work-in-progress components.

3.1.6 Six Sigma

Developed in the 1990's by Motorola, Six Sigma's determines and reduces the level of variability, or how often defects will occur within a process or product. When achieving Six Sigma, it is estimated that of every one million processes there are only 3.4 defects, representing low variability within the production. Six Sigma heavily revolves around statistical process controls and metrics to analyze and reduce process variance. The diagnostics used within this process often will help identify the root cause for problems leading to the higher variances.

3.1.7 Pre-Production Planning (3P)

Rather than focusing solely on efficiencies, 3P eliminates waste through product and process design. Customer requirements are built into a rethought design. These designs optimize current production setups, materials and resources. The new products are often easy to manufacture, low in complexity and have simplistic maintenance.

3.1.8 Lean Enterprise Supplier Network

This method includes the incorporation and cooperation of the entire supplier network. It consists of utilizing and leveraging all suppliers to implement lean strategies within a production process. Results show shared cost reductions, higher quality and overall lower waste. This collaboration and shared knowledge can lead to tailored product design. The larger number of key players in a supply network that are leaned allows for greater leaning across the entire supply chain.

3.2 Adding Sustainability to Lean

It is noticeable that lean initiatives are effective in reducing waste and creating sustainability within a company. Typically, environmental performances are rarely a key aspect of lean. Emphasis placed on these performances would further reduce costs and environmental footprints.

Often, the assumption by companies is that the implementation of an environmental strategy is long term with high investment. This is true in some cases, however not all sustainable ideas implemented within facilities are high investment (See chapter 3.3 Baxter International Case Study). Facilities have the ability to see improvements in as little as 6-to-12 months (Langenwalter 5). When regarding environmental waste, reduced energy consumption always has a visible impact on a company's bottom line.

There are ways for a facility to reduce their environmental footprint while also concentrating on their current lean initiatives. When regarding 3P, during the design of a product, raw materials that have negative impacts on the environment or that are finite should be avoided. Even if this requires the use of higher quality materials, these products potentially will have a longer product life and require less rework.

When working with 5S, companies are also beginning to add a sixth 'S' (safety) in order to create greater sustainability within the company. The creation of a safer work environment for employees can cause higher employee morale. This further supports lean but also fosters greater employee engagement. 6S can cause innovation within a company and is often one of the first lean initiatives implemented.

During the implementation of a JIT system, companies have the ability to implement reusable containers for shipments. These containers can reduce packaging waste and can be used

to signify when a new shipment is needed. These containers were implemented by General Motors at their Tennessee automotive plant. They receive 95% of their parts using reusable containers which reduce the costs, space and energy invested in waste management (United, "General Motors Corporation").

The incorporation of an Environmental, Health and Safety Officer (EHSO) will provide sustainable ideas. These employees are likely to realize a cost-effective way to implement sustainability within current lean practices. They are trained in understanding how to create a worker-friendly, safe workplace and find environmental benefits. They have the ability to look at the "big picture," identifying components in a process that may be considered environmental risks. They then identify ways to remove these risks while also providing cost savings. The greater stress facilities place on sustainable and environmental practices, the higher potential there is for creating savings.

3.3 Baxter International Case Study

In the early 2000's, Baxter International, a manufacturer of medical products, expressed concern that the environmental footprint of their products was growing. To initiate sustainability, Baxter began using lean manufacturing practices. As they saw their environmental footprint drop due to these lean practices, their environmental engineers wanted to place more emphasis on environmental metrics. By doing so, they created an "environmental leg" of the traditional lean process. Due to their implementations, the company was able to double its size since 1996 while maintaining the same waste output.

The Corporate Vice President of Manufacturing placed pressure on facilities to minimize the amount of water waste. One of Baxter's largest plants was selected for a study and requested

to use value stream mapping on their utilities. Though the facility had its own water wells, there were large amounts of energy tied in with water usage. The employees began to map the processes and wastes. Originally conducted at high levels, each process was eventually broken down into different metrics such as water consumption and cycle-times. The team also compared expected outcomes to actual outcomes on the service floor. One of the most important decisions was determining which metrics to use to help identify water consumption issues.

Upon completion, the team had come up with a plan that provided substantial savings. It was estimated that 170,000 gallons of water was saved per day and a cost savings of $17,000 was recognized in as little as three months. This was all done with minimal capital investment (United, “Baxter Healthcare Corporation”).

Chapter 4

Tools for Sustainable Manufacturing

Companies have the ability to embark on quests for sustainability through multiple channels. Product design, reverse supply chains, energy management and life-cycle assessments all provide sustainable practices.

4.1 Product Design

The initial design stage offers the ability to build a product with low environmental impact through its life-cycle. The thought process of cradle-to-grave designing has been around for over a century. Henry Ford kept design for manufacturing in the company's thought process allowing for cost reductions by eliminating waste. In his autobiography he notes, "As we cut out useless parts and simplify necessary ones we also cut down the cost of making. This is simple logic, but oddly enough the ordinary process starts with a cheapening of the manufacturing instead of with a simplifying of the article" (Ford and Crowther 15). Henry Ford noticed that by making simplistic products he was able to go lean and reduce wastes that were identified by his company. Typically, though, this would not be followed and companies would pursue cheap manufacturing. Design for manufacturing has expanded into design for environment (DfE) which is being implemented into companies with environmental concern at the top of their list of core responsibilities.

4.1.1 DfE Explained

Design for environment is a strategy utilized in companies as well as an EPA sponsored program. The program was created in 1992 and works to prevent pollution and the risks of pollution to both the environment and its inhabitants. The three main goals of the EPA's program are:

- Recognize safer consumer and industrial and institutional products. DfE allows products that have been determined to be effective and safer for human health and the environment to carry its label. Before you buy, look for the DfE label on household cleaners and other products.
- Define Best Practices in areas ranging from auto refinishing to nail salon safety.
- Identify safer chemicals, including life cycle considerations, through Alternatives Assessment. (United, "Design for the Environment")

Compliance by companies earns the right to place the DfE logo on their products. This shows consumers that the company is environmentally conscious and has had the chemicals within the products reviewed by the EPA's team of scientists to determine they are safe for the environment.

The EPA's program is not a legal requirement, rather an incentive. However, many companies have built sustainability into products due to global requirements. For example, the European Union has much stricter manufacturing regulations than the United States. Companies selling skin care products in Europe provide research that shows they are not hazardous prior to being placed on shelves. Due to international regulations such as this, companies must put extra effort into changing the chemicals used in their products and prove their products are deemed

safe for human usage. Companies such as Revlon ensure that their products meet European standards and have the ability to sell their products globally. Proctor and Gamble only produces products that meet standards in their target markets (Langenwalter 7).

In regards to sustainability, placing a focus on safety and environment of product design allows companies to gain recognition. Revlon provides a perfect example of how companies should monitor the chemicals that are being placed in their products. Whether the EPA or international regulations disallow chemical use, companies should recognize the benefits of producing environmentally safe products.

4.1.2 DuPont Case Study

In 1989 Ed Woolard, CEO of Dupont, coined the term "Corporate Environmentalism" which was used to show DuPont's long standing sustainability efforts. The company annually sets environmental goals. In 1993, DuPont worked to create a Safety, Health, and Environmental Health Commitment which had two main goals: Zero injuries, illnesses, incidents, waste and emissions; and employees would be held accountable to reach this commitment. They continuously created new goals and in 2000 they set forth to reduce air toxins by 90% (Rittenhouse 28).

Following these commitments, DuPont began to maintain closer relations with their customers. They worked closely with their customers in the carpeting industry that purchased nylon fibers. DuPont estimated that roughly two million pounds of carpet was thrown away each year and were questioning how to make the industry more sustainable. Their business strategy was to manufacture and sell white nylon strands to carpet manufactures. They realized that the

companies were dying them using tremendous amounts of water and requiring the water treatment facilities to take on the burden of re-purifying the water.

It was recognized that manufacturing pre-dyed fibers could reduce waste costs and environmental footprints. Since doing so, DuPont became the largest producer of pre-dyed fibers. This process requires close work with customers and cooperation between the entire supply chain. DuPont consistently needs to manage targets and demands so they are able to manufacture the fibers. In addition, they have opened a recycling facility in Tennessee where they reuse the nylon within old carpets in a separate polymers business.

By working closely with their suppliers DuPont created a lean enterprise supplier network, reducing wastes and creating sustainability. The environmental benefits they received are passed on to their customers who no longer have the burden of dying the fibers. This reduced costs and the stress that water treatment facilities experience (Rittenhouse 27).

4.1.3 Dell Case Study

When manufacturing computers, Dell has implemented DfE throughout their supply chain to help evaluate environmental footprints. They consider the environmental footprint of their products through all stages of the lifecycle. When coming up with product design, it is important to stay away from hazardous materials that create subsequent disposal problems. Their DfE program minimizes consequences on the environment.

Along with maintaining environmentally sustainable components, Dell places emphasis on the power consumption of the parts they are using within their computers. They have recently partnered with ENERGY STAR, a branch of the EPA, to help reduce the power usage of their

products. They have implemented Dell Energy Smart technologies that claim to have caused them to, “lead the industry in energy efficiency” (Dell).

Along with having a sustainable physical product design, Dell also maintains sustainable sourcing to their manufacturing facilities. Instead of using pallets to receive their products, they switched to slipsheets, or thin, reusable pallet-sized sheets typically made of plastic. This change has reduced the wood usage for the company by over 10,000 tons in just one year (Kulwiec 51).

With the successes Dell has from the implemented product design and sourcing strategies, they have become recognized as a socially responsible corporation. They have also achieved ISO 14001, the international standard for environmental management systems.

4.2 Reverse Supply Chain

Most supply chains are based off the SCOR model which is supported by the Supply-Chain Council and accepted as an industry standard. The original SCOR model consists of plan, source, make and deliver. Companies have added a fifth pillar to the SCOR model: return. The return segment covers the flow of products from the end consumer back through the supply chain incorporating parts such as logistics, remanufacturing and recycling.

4.2.1 Reverse Supply Chain Defined

A reverse supply chain includes the flow of products from downstream in the supply chain back to the suppliers. This can include both unsold products and products at the end of their life-cycle. Incorporated are all aspects of a product including its materials and the packaging. This is pushing supply chains away from the take-make-waste mentality that once was filling landfills with barely used products.

Reverse supply chain processes include remanufacturing, recycling, reuse as well as material substitution. This provides companies with a way to reincorporate products into production and eliminate potential landfill waste. However, in order to ensure success, all levels of a supply chain must be closely working together. Reverse supply chains heavily revolve around life-cycle assessment.

4.2.2 Government Regulations

Aside from consumer activism and noticeable profits from implementing reverse supply chain programs, governmental regulations are playing a role as well. Though the United States does not have as strong recycling laws as other countries, many states have individual laws concerning the matter. In California, Maryland, and Maine there are current laws that regulate the recycling of computers. Companies, like Dell, must follow these laws and many are following international standards and are beginning to gain ISO certifications.

Internationally, companies are forced to implement reverse supply chain strategies. In the Netherlands, companies are responsible for the collection and recycling of washers, refrigerators, televisions, consumer electronics and freezers. Japanese companies wishing to sell to governmental entities are required to manufacture with certain amounts of recycled material in their products. Finally, the European Union has a directive set on the collection and recovery on wastes from electrical and electronic equipment (Kulwiec 44).

4.2.3 Methods Used

There are four main methods that can be used in a company's reverse supply chain. These are listed as follows:

- *Direct reuse*: Certain cases allow for a direct reuse of a product. This may come after minimal reconstruction or cleaning, however the product does not need to be drastically changed.
- *Repair*: When a product only has minimal repairs needed this is the method of choice. It involves finding and fixing the product's issues and returning it to the customer. If a consumer does not require a specific serial number to be returned to them, then a duplicate of the product may be shipped. Their product will be fixed and shipped to the next customer requiring repairs on the same product.
- *Remanufacture:* Remanufacturing a product comes only when certain components within the product are high value and can be salvaged. This is common in the automotive, computer, and aerospace industries. The product is completely disassembled and all components are examined and either replaced or repaired.
- *Recycle:* When some of the parts from a component may be reused while the rest of the product is considered scrap this is the method of choice. These parts are typically then sent to be used within remanufactured or new items.

4.2.4 Recycling Success – Coors Brewing Company

In 1959, Coors Brewing Company revolutionized the process industry and recycling. During this year, the aluminum can was introduced and was quickly followed by a recycling program. The company implemented "Cash for Cans" which offered one cent to consumers for

every can that they returned (MillerCoors). Time Magazine reported that by the mid-1960's Coors was seeing an 85% return rate ("Setting An Example").

When recycling their newly found aluminum cans they were able to notice the energy and natural resources that were being saved. The recycling of aluminum saves 95% of the energy needed to produce new raw materials for production. Currently, Coors has roughly 40% of their aluminum cans made from recycled product (Kulwiec 47).

Coors did not stop with solely recycling aluminum either. CEO Bill Coors was famously quoted as saying, "Waste is a resource out of place" (MillerCoors). Since then they have been recycling both glass and packaging materials. Coors purchases over 75,000 tons of used glass each year making bottles with roughly 30% recycled material. Packaging has also been targeted to reduce the weight and improve recyclability. This has allowed for Coors to reduce the amount of corrugated by roughly 8 million pounds annually (Kulwiec 47).

Coors has stayed true to their strategies by having all employees receive training within the areas of recyclability and environmental sustainability at their facilities. This has led the company to winning numerous awards and achievements. Coors prides themselves in not only being successful on a financial level but also on their success with corporate citizenship. It is from their long standing recycling program that they have captured the hearts of many consumers.

4.3 Energy Management

Though energy management is a concept that seems relatively simplistic to understand and implement, many companies do not follow through. Energy conservation comes in all sorts of forms such as turning off machines, computers and lights in facilities. This also includes the

thought of upgrading components in facilities with energy usage in mind. These improvements will bring long term financial benefits for a company as well as provide a greater environmental awareness and competitiveness.

3M has taken energy conservation seriously at their plants realizing that this is a continuous improvement exercise that can be given to their employees. Their energy program manager, Steve Schultz, stated: "We look at energy use as an important part of overall operating costs and effectiveness," (Tokin 61) showing that it takes precedent in their company as they maintain operating costs.

In one of their Wisconsin plants, they improved lighting efficiency by working with the EPA's ENERGY STAR Program. They were able to estimate savings of $69,325 annually (Tokin 62). Also, they began implementing a policy to turn off computers and printers at night to further cut energy consumption. By replacing two underutilized pieces of equipment with components of higher efficiency they were able to use the other equipment pieces elsewhere.

Stressing energy usage in their plants, 3M was able to annually save tens of thousands of dollars. On top of cost reductions, they were able to identify more sustainable practices allowing them to increase efficiencies. By having their employees work closely together, 3M was able to successfully implement these strategies.

4.4 Life-Cycle Assessment

Life-Cycle Assessment (LCA) follows a process where a company identifies the impact on the environment from a product through its entire life. Typically, LCA is a full assessment of a product's environmental impact, given all inputs and outputs from its initial inception through its end use and disposal on the consumer level, cradle-to-grave. When recycling, either partial or

full, is incorporated into a product's end-of-life this type of LCA is known as cradle-to-cradle. During these assessments, the products are reviewed from every angle and questions are raised. Companies must think: Who is the supplier of raw materials? How are these raw materials transported? What is done during manufacturing? How will consumers receive the items? Once its life is complete, what will become of the product?

The entire LCA process is extensive and costly, however it often has payouts from cost and environmental impact standpoints. A full assessment will include quantitative and descriptive analyses of energy and material use, outputs and potentially resource depletion. The mapping out of a supply chain's processes often will coincide with LCA and be used to identify inputs and outputs. When looking to conduct a less comprehensive LCA, companies have the ability to conduct one of the following:

- *Cradle-to-gate* – Analyzing the upstream functions from a point in the supply chain
- *Gate-to-gate* – The analysis between two points in a supply chain
- *Gate-to-grave* – Analyzing downstream from a certain point to the end of the supply chain

In 2004, a life-cycle assessment was conducted with jeans sold through both the UK and France. The study included the entire process used to manufacture jeans from the growth of cotton and manufacturing of fibers through the end-life of the product. It was noted that only 2% of total energy consumed was from commercial transportation while 6% represented the actual manufacturing of the jeans. The researchers found that 75% of the energy in the supply chain was used on the consumer's end during the washing of the jeans (Browne et al. 766).

Proctor and Gamble conducted a LCA in both cradle-to-grave and cradle-to-gate forms for detergents during the 1990's. During the cradle-to-gate process they followed the product

from their suppliers, transportation, manufacturing, and then to packaging. To complete the cradle-to-grave process they added consumer use and then final disposal. They reviewed three detergents from Proctor and Gamble: a standard powder detergent, compact detergent and a super compact detergent. During their assessment, between 1988 and 1998, they were able to make several reductions to their products which produced visible environmental benefits.

When reviewing the entire LCA, it was evident that 80% of energy consumption was linked to the end consumer heating the water to use the washing machine. In both the Netherlands and Sweden, they witnessed a respective 30% and 20% reduction from the 1988 traditional detergent to the super compact detergent in 1998 (Proctor 4). These results came from a lower average washing temperature and less detergent used which inadvertently corresponded with lower environmental emissions.

Due to the improvements they saw, Proctor and Gamble began to incorporate environmentalism into their detergents and making assessments based on the environment. By noticing they have the ability to change the chemistry of the product to reduce ozone depletion, toxicity, and greenhouse gasses they successfully demonstrated the use of the LCA.

Chapter 5

Conclusion

The shift in corporate strategy from the bottom line to the triple bottom line is the challenge many companies face with sustainability. Though the focus on people and planet seems relatively simplistic, companies must follow through with goals by funding sustainable strategies. A goal of zero landfill waste is trivial until followed through. Lean practices advocate sustainability through waste reduction and the establishment of altered corporate strategic thought processes. These changes in thinking, from factory workers to corporate managers, are also essential in sustainability.

A guide to sustainable implementation does not exist. Companies must tailor their own sustainable strategy after questioning:

- *What type of product is manufactured?* – Product type may hinder sustainable strategies or present new ones. Automotive, consumer packaged goods, and medical manufacturers, for instance, shape sustainable strategies with the same end-goal differently.
- *What is the nature of the manufacturing process?* – The fundamental qualities of a manufacturing process allow for different opportunities in sustainable operations. The arrangement of machinery and employees will determine a sustainable approach.
- *What is the scope of the sustainability program?* – It is important for companies to start with small ideas. The implementation of large sustainable strategies, such as zero waste creation, need to be initiated by smaller goals.
- *What is the size of the footprint?* – The size and type of footprint is regarded differently during the planning process. Whether companies are trying to eliminate landfill waste,

reduce volatile organic compounds or go organic, they must recognize what is to be eliminated.

- *What metrics will be measured?* – Key metrics to be measured are necessary as they help improve processes and report successes. When tracking metrics, it is important to keep the overall number small and track only what is necessary.
- *What level of supply chain integration has been achieved?* – Though many questions deal with the scope of a manufacturing process or product, integration is just as important. Supply chains that are strictly horizontal have greater difficulty implementing strategies than those that are vertically integrated. Further, companies that do not empower their employees may find difficulty with switching employee thinking towards sustainability.

Upon answering these questions, companies can create sustainability through the previously mentioned strategies. Depending on their decisions, they may alter product design, initiate a reverse supply chain, conduct life cycle assessments or begin energy management.

Lean transformation greatly resembles the SCOR model. Plan, source, make and deliver, the original four pillars of SCOR, were altered when return was added through reverse supply chain practices. Return was added as a fifth pillar of SCOR as well as an overarching theme within each pillar. This principle can be applied to lean, by creating an overarching theme of sustainability in lean practices.

No longer is sustainability reserved for "tree huggers." Green strategies have become world renowned bringing positive marketing, cost savings and waste reduction. The triple bottom line offers a crossroad for society and companies. With focus on people and planet, companies create a positive reputation and brand loyalty in a market increasingly focused on social and environmental responsibility. Doing good is visibly good for business.

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Education:

Smeal College of Business at The Pennsylvania State University
Bachelor of Science in Supply Chain and Information Systems
Minor in Information Systems Management
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Work Experience:

Unilever Trumbull, CT
International Customer Service Analyst Co-op
January 2011 – June 2011

- Led multiple teams through continuous-improvement exercises for import/export processes
  - Reduced lead time for export process by 2 – 4 days
  - Facilitated implementation of new order entry process for Canadian location
- Built customer database to house all information on international customers
- Managed 20 customer accounts with $8.5 million worth of sales
- Scheduled over 110 free goods orders for international shipment
- Provided customs clearance documentation for over 550 loads destined to Canada

Temple University Hospital Philadelphia, PA
Supply Chain Management Intern
June 2010 – August 2010

- Implemented inventory management system, Pyxis, in operating rooms
- Coordinated with suppliers to accurately maintain the inventory database
- Managed inventory master data catalog records
- Reconciled physical inventory and database accounting errors

Awards/Honors:

1st Place at APICS Mid-Atlantic District Student Case Competition
Smeal Representative at General Motors Supply Chain Case Competition
Beta Gamma Sigma Honor Society
National Society of Collegiate Scholars
Dean's List – All Semesters

Leadership:

The Pennsylvania State University University Park, PA
Management Information Systems Teaching Intern
February 2010 – December 2010

- Developed and assigned a podcasting project for class of 150 students
- Taught information sessions on web-portfolio development to assist students with their final project
- Communicated with students through online office hours and email

Information, Sciences and Technology Teaching Intern
February 2010 – May 2010

- Created security awareness assignment to be used as an introduction to information security
- Required roughly 90 hours to create seven documents for the assignment which totaled 40 pages

Director of Smeal Relations
Management Information Systems Association
August 2011 – May 2012

- Enhanced student involvement through recruitment and networking events
- Organized corporate information sessions with alumni to promote the major

President
Paintball Club
August 2010 – May 2012

- Established contact with companies and successfully obtained new sponsorships
- Drafted club constitution defining leadership roles and gained permission to practice on-campus
- Danced during 2012 IFC / Panhellenic Dance Marathon