PROPOSED ALTERNATIVE OUTLET TO LANDFILL FOR ONE WASTE STREAM AT A MANUFACTURING FACILITY

BY

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ABSTRACT

Kraft Foods Group, Inc., a North American food manufacturer, sought to divert the waste at its Wausau, WI facility from landfill to an alternative “green” disposal outlet. To achieve this goal, a two-stage process was executed. The first stage was a waste characterization study to identify the percent by weight composition of the waste. Waste was collected over two separate 24-hour periods, each period representing a sample. The two samples were sorted into categories and the mass of each category was measured. The percent by weight of each component for each sample was calculated. The largest component of the waste was the pouches at an average of 27.27%, followed by ingredient bags at 17.80%, and rigid feta containers at 11.91%. When all feta components were looked at in summation, they became the second largest percentage at 24.69%. The second stage focused on finding an alternative outlet for the polypropylene feta containers. Pouches were the largest percent of the waste, but these contained a more complex material structure that would likely prove problematic in energy recovery systems. The feta containers were the second largest component, were made of plastic, and could not be recycled due to food residue; therefore, they were the component of priority. After researching energy recovery processes including anaerobic digestion, pyrolysis, gasification, and refuse derived fuel, a form of refuse derived fuel proved to be the leading energy recovery option because numerous commercial operations exist in Wisconsin. Greenwood Energy produced fuel pellets from paper and plastic waste. These pellets were currently co-combusted with coal. A cost-benefit analysis assessed the economic viability of diverting Wausau’s feta-container waste from the landfill to Greenwood Energy. Although the cost to send waste to Greenwood Energy would be increased compared to landfill because of new labor and practices associated with bailing the feta containers, the recommendation stood. The incremental cost had the potential to be negligible if Kraft could increase its sales of feta through marketing its sustainability. Research indicated that consumers would be willing to pay more for consumer goods from companies practicing social responsibility.

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CHAPTER 1: INTRODUCTION

Sustainability has become an integral part of building corporate strategies regarding energy use, supply chain, and waste management. Considering sustainability is advantageous for corporations by addressing the concerns of a growing number of consumers, benefiting economically, and managing risk. The United Nations (UN) definition of sustainability, "to meet the present needs without compromising the ability of future generations to meet their own needs," has been a foundation upon which to build corporate strategy (Choi & Ng, 2011). A corporate look at sustainability takes a multi-dimensional approach, also referred to as the triple bottom line (TBL), encompassing economic, environmental, and social domains (Choi & Ng, 2011). Dr. Timothy F. Slaper, Director of Economic Analysis at Indiana University Kelley School of Business's Indiana Business Research Center, wrote in 2011, "The TBL and its core value of sustainability have become compelling in the business world due to accumulating anecdotal evidence of greater long-term profitability. For example, reducing waste from packaging can also reduce costs. Among the firms that have been exemplars of these approaches are General Electric, Unilever, Proctor and Gamble, 3M and Cascade Engineering." Dr. Slaper attributed these well-known companies taking on sustainability to anecdotal beneficial evidence. However, empirical evidence exists to support the benefits in developing sustainability strategies. Choi & Ng (2011) studied the effects of economic and environmental sustainability on consumer evaluation of the company and purchase intent by surveying 219 diverse consumers. The survey asked consumers to provide opinions on companies depending on whether or not they used recycled materials, polluted, conserved water and energy, employed people in the community, and used community-supplied renewable energy. Results showed, "sustainability information has a significantly positive impact on the evaluation of the company and purchase intent" (Choi & Ng, 2011). Furthermore, "poor sustainability orientations and policies damage the evaluation of the company, which reveals the importance of sustainability information in consumer responses" (Choi & Ng, 2011). Similar results were found in Trudel & Cotte's (2009) experiment regarding ethical companies. Consumers demonstrated willingness to pay more for fair-trade coffee, up to 15% more, and organic cotton t-shirts, from 2% - 6% more. Consumers also punished unethical companies by spending less on their goods. Consumer research regarding sustainability provided support for companies who chose to look at the triple bottom line and incorporate sustainable practices into their organization.

Kraft Foods Group, Inc., a consumer packaged goods company with $18 billion in annual sales and headquartered in Northfield, IL, developed sustainability strategies and implemented sustainable practices at its manufacturing facilities. In business since 1903, Kraft manufactures products such as natural cheese, dry packaged dinners, ready-to-eat desserts, and beverages. With 98% of North American households having a Kraft product in their kitchens, Kraft products are a mainstay in American life. Through energy efficiency, renewable energy generation, diversion of waste from landfill and alternative sourcing of resources, Kraft has taken great strides in reducing its carbon footprint and strain on resources. For example, the Lehigh Valley, PA facility achieved zero-waste to landfill and generates some energy from wind power; the Lowville and Campbell, NY and Beaver Dam, WI plants use their waste streams to produce biogas via anaerobic digestion, an environmentally-friendly innovation that powers portions of their cities; and Springfield, MO uses underground caves as refrigerated storage to save on cost and energy.

Through the University of Illinois at Urbana-Champaign's Natural Resources and Environmental Science (NRES) graduate program, I completed an internship at Kraft Foods Group, Inc. Using scientific literature, data collection and knowledge from the Masters' program, I submitted a proposal to the Safety, Security and Environmental Manager at Kraft's Wausau, WI manufacturing plant strategizing how to divert waste from the landfill. This proposal aimed to move Kraft towards increased sustainability by transitioning waste to an energy recovery outlet. This internship was supervised by Scott Clark, Associate Director of Business Development in the Beverages Business Unit at Kraft. His role as liaison between Research and Development (R&D) and plant operations ensured he had working knowledge of Kraft's operational processes. This internship began in July 2013 and finished in August 2014, during which 240 hours of work was completed.

Initially, two plants were identified as candidates for a waste diversion strategy, Champaign, IL and Wausau, WI, for their proximity to the internship office in Glenview, IL. After touring both facilities and interviewing their Safety, Security and Environmental Managers (interview questions can be found in Appendix A), who had responsibilities for coordinating and driving projects that reduce waste and water usage, managing the recycling center, and ensuring compliance with air and water permits, Wausau was chosen as the focus plant. Champaign possessed the largest recycling center at Kraft and it evolved over 22 years of operation. Champaign diverted [REDACTED] percent of its waste from the landfill. Wausau, on the other hand, diverted [REDACTED] percent of its waste from the landfill.

[SENTENCE REDACTED]Unlike Champaign, Wausau did not send any materials to waste-to-energy. While Wausau made extraordinary efforts towards waste reduction, it could benefit from a waste characterization study and analysis of alternative outlets to increase its landfill diversion rate closer to that of Champaign.

The product of this internship was a proposal to Kraft for increased sustainability at the Wausau manufacturing facility, which produced majority cheese-based products. The proposal suggested an alternative disposal site to the landfill, the rationale and requirements for achieving diversion, identification of obstacles and a cost-benefit analysis. The four main objectives of this internship to deliver a waste diversion proposal included:

- Collect data and evaluate current waste stream characteristics (composition and quantity of solid waste materials generated at the Kraft manufacturing plant) and assess current methods of disposal.
- Compare alternative collection and disposal strategies described in relevant scientific literature. Identify processes at other Kraft manufacturing plants and prioritize waste management options for Wausau plant.
- Identify the obstacles to establishing a long-term, targeted approach to improving Kraft's "green" solid waste disposal initiatives and developing compliance with these suggested initiatives.
- Develop a proposal to present to Kraft management suggesting the best management strategies as determined from this study. Proposal should include goals, phases/steps, timelines, and cost-benefit analysis.

CHAPTER 2: WASTE CHARACTERIZATON STUDY: METHOD/RESULTS

2.1: Basis for pursuing a waste characterization study

The initial step in building the waste diversion strategy entailed reviewing primary literature to provide background for the development of the waste characterization strategy relevant to zero waste, landfill diversion, and minimizing food waste/industrial waste. In addition, I conducted interviews and visited with relevant industry experts, the Illinois Sustainable Technology Center (ISTC), and Waste Management (WM) to gain knowledge about landfill diversion techniques. The visit to the Illinois Sustainable Technology Center at University of Illinois – Urbana-Champaign (UIUC) was particularly fruitful in that it introduced the idea of a waste audit. ISTC employees executed a waste audit at its facility to meet three goals:

1. Identify trends in waste composition
2. Establish baseline volumes for future comparison
3. Reveal any red flags (i.e. all aluminum cans were thought to be recycled, yet they make up 5% of the waste stream)

They developed a sampling plan instructing when and where to collect, the sample size, and sampling frequency using hauling cards (which contain mass of waste sent to landfill) and the American Society for Testing and Materials (ASTM) standard 5231-92 as a guide (http://www.astm.org/). ASTM 5231-92 was the standard method for "Determination of the Composition of Unprocessed Municipal Solid Waste." The samples were sorted into 13 predetermined categories of waste types. Based on the results, the ISTC was able to implement straightforward actions to increase its recycling percentage. The center initiated behavior change by using prompts to show people where to recycle and implementing a partnership with teracycle through Kimberly Clark professionals to recycle lab gloves. Shantanu Pai, Waste Research Specialist of the ISTC, developed ISTC's waste audit; therefore, Pai served as a valuable reference contact for the Wausau waste characterization study. He assisted in designing the study and connecting Kraft with Marathon County Solid Waste. Once familiar with the idea of a waste characterization study, a review of waste management literature supported the idea that this should be the logical first step in developing a strategy for Wausau. Researchers Chang & Davila (2008) used the same rationale for executing a waste characterization study, "Decision makers…are considering management alternatives for the final waste disposal, which requires an understanding of the make-up of the MSW stream. … Waste characteristics can help capture much-needed trends in treatment and disposal based on material and energy recovery potentials." They also consulted the ASTM 5231-92 protocols for determining solid waste composition. Additionally, a presentation on the UIUC Sustainability website given by Michael Brown of the Ecology Action Center (2013), affirmed waste characterization studies with his recommended outline to achieve zero waste, which began with, the "need to understand your waste (identify it, what is it and where it comes from, understand the local requirements, apply waste hierarchy, plan to collect waste accordingly)." Information about the waste composition provided a foundation upon which to start making changes or to steer research for alternative disposal outlets. This method was pursued to help with the Wausau strategy.

Before conducting a waste characterization study, Damgaard & Barlaz (2014) of North Carolina State University recommend collecting pre-data. In their lecture, they described the need for pre-data collection, which included amount of waste generated, what were the waste generators, patterns to generation (i.e. heavier loads at certain points of the year), and current collection. This pre-data shaped the study, answering questions such as, should any streams be omitted from the analysis, and how, when and where to sample. Damgaard & Barlaz also highlighted the challenges in spatial variation, temporal variation, and uncertain variation (i.e. potential for an atypical day) when aiming to collect a representative sample. Forouhar & Hristovski (2012) conducted a study in Afghanistan, describing pre-data collection to understand a number of factors that affect the solid waste stream in Kabul before a proper methodology could be created: (1) demographics; (2) potential large scale solid waste generators; (3) solid waste collection routes; and (4) status of the solid waste collection fleet. Developing nations' waste often consisted of over 80% organic matter, which was compostable, whereas Wausau's waste was largely inorganic waste. While these studies were less relevant in suggesting outlets for inorganic waste, they were helpful in structuring a study.

Understanding the value in pre-data collection to structure a study, I gathered information about Wausau waste management. Wausau's Safety, Security and Environment Manager, Karen Camden, provided waste disposal records detailing the amount of waste sent to landfill each month in 2013 and associated cost. Camden had observed that no spikes in waste generation exist at particular times of the year or days of the week. I also toured the plant to become familiar with the various generation sites. Waste was generated on four floors over three shifts. After this information was collected, a waste characterization study was designed specific to Wausau and executed to deliver on the following objectives:

1. Determine the percent composition of the waste, which can then be used to prioritize which waste component should be the focus in researching a landfill-alternative outlet
2. Potentially reveal any waste transferred to landfill that was thought to be transferred to a materials recovery facility

2.2: Method

The ASTM 5231-92 recommended examining ¼ of a vehicle load of waste sent to landfill and selecting a time period covering at least one week (http://www.astm.org/). At Wausau, one vehicle load consisted of one week's worth of waste. Ideally, ¼ of a vehicle load hauled from Wausau to the landfill would have been sorted to meet the recommendation of the standard method. However, the ASTM called for sorting unprocessed waste and Kraft did not have the required resources to send a vehicle load of uncompacted waste to the landfill for sorting. Therefore, other sampling techniques needed to be identified that would accommodate uncompacted waste. Sorting smaller samples on-site immediately following collection from the plant floor and then disposing of it in the compactor would have been the second best option in terms of ease of logistics, increased sample size, and allowing for segregation of the samples by plant floor for data analysis; however, Kraft quality and safety constraints prevented pursuing that methodology. Finally, consensus was reached to place characterization study samples in a separate waste box and transfer them to Marathon County Solid Waste for sorting.

I developed a sampling methodology that aimed to achieve an unbiased collection of Wausau waste. Camden observed consistent waste generation throughout the week, meaning no particular day produced more than other days. The largest volume products in the plant, the feta cheese, parmesan cheese, and cheese powder ran consistently each week. To create a feasible scale for collecting, transporting and sorting as uncompacted waste, one shift was equated to one vehicle load. This allowed for the same framework as the ASTM recommended only at a smaller scale. The hauling invoices were used to calculate the average kg/shift. Based on prior year 2013, the average mass sent to landfill was [REDACTED] kg/month. Calculations using a five-day production week (20 days/month) and three-shift day determined the waste to collect per shift to be [REDACTED] kg. The mass equaling ¼ of total generated per shift was intended to serve as one sample. Because each production floor produced different products, to obtain a comprehensive sampling of Wausau waste, each sample mass was divided evenly over the four floors. The goal was to collect a total waste mass of [REDACTED] kg. To account for temporal variation the waste was collected over two 24-hour periods and all three shifts per 24-hour period. This resulted in an *n* of six. A sample size of six allowed for a systematic approach to sampling that represented temporal variation while maintaining a manageable mass in sorting. Table 1 shows the intended sample collection. The samples were measured and recorded on each floor from which they were collected, transported via cart out of the plant, and placed in the waste box corresponding to the appropriate 24-hour period.

Table 1. Sample collection [TABLE REDACTED]

		First 24 Hour Period					
Sample		Floor 1	Floor 2	Floor 3	Floor 4	Total	
1	Shift 1						kg
2	Shift 2						Kg
3	Shift 3						kg
		Second 24 Hour Period					
Sample		Floor 1	Floor 2	Floor 3	Floor 4	Total	
4	Shift 1						kg
5	Shift 2						Kg
6	Shift 3						kg

After the first day of collection, it became evident that sample collection would need to deviate from the proposed protocol for three reasons: varying generation rates on the separate floors, tediousness and potential for inaccuracy in segregating the samples by shift and floor, and the volume of the waste exceeding the available space within the waste box. During an initial tour of the plant, it was observed that the plant floors generated waste at different rates; however, the generation rate was unknown. During the time of collection, Floor 3 and Floor 4 did not generate enough mass to meet the [REDACTED] collection target. Initially samples were going to be segregated by placing a label on each bag indicating the 24-hour period, shift and floor from which it was collected. However, this proved to be impractical as not all waste was bagged and some of the waste fell from its bags once in the waste box. Also, the volume of the waste collected was always an unknown; however, based on best estimates from experienced Waste Management employees, two eight-yard boxes were anticipated to fully contain the targeted [REDACTED] kg per box. The waste boxes were essentially at capacity with [REDACTED] respectively for the first and second 24-hour periods. All of these factors steered sample analysis to an *n* of 2 as opposed to the original n of 6. Sample one was the first 24-hour period and sample two was the second 24-hour period. Figures 1 and 2 display the actual mass collected.

Figure 1. Samples collected during the first 24 hour period at Wausau [FIGURE REDACTED]

Figure 2. Samples collected during the second 24 hour period at Wausau [FIGURE REDACTED]

Post collection, Waste Management delivered the two boxes to Marathon County Solid Waste, where a building remote from truck traffic and the daily work of the Solid Waste Company was made available as working space. Each box was sorted separately. All the contents of the box were emptied into the workspace. The waste was sorted into like categories and retained in plastic bags. A table onto which contents were emptied allowed for a more ergonomic sorting experience. The plastic bags were placed into a bin and measured with a scale capable of reading up to 136 kg +/- 0.23kg.
The waste was sorted into the following categories:

- Multi-material pouches (whether or not they contained cheese powder)
- Raw material, multi-material ingredient bags
- Plastic bags
- Rigid feta containers (PP)
- Rigid feta lids (PP)
- Soft feta containers (PVC)
- Soft feta lids (PVC)
- Food Powder
- Smocks
- Nitrile gloves
- Stickers
- Tape
- Office paper
- Paper towels
- Cardboard
- Caps with foil liners
- Miscellaneous

The miscellaneous pile consisted of items that were sparse, small in volume even though they were numerous (i.e. earplugs and small pieces of wood) or present singly (i.e. a pair of shoes). The mass of each category of waste for each day was recorded.

2.3: Results

The mass summed after sorting was [REDACTED] kg and [REDACTED] kg for the first and second 24-hour period respectively. The largest component of the waste was the pouches at an average of 27.27%, followed by ingredient bags at 17.80%, and rigid feta containers at 11.91%. When all feta components were looked at in summation, they became the second largest percentage at 24.69%. Together, pouches, feta containers and ingredient bags accounted for 69.7% of the waste collected. The standard deviation was highest for the pouches, the rigid feta containers were second, and then the plastic bags [REDACTED]. Table 2 contains the mass measured for each category, the average of the two 24-hour periods, the percent composition of the waste for each category, and the standard deviation. Figure 3 is a graphical representation of the average mass for each component. Figure 4 compares the percent mass of each day. The four largest streams vary more widely between the two 24-hour periods than the smaller streams. Plastic bags and rigid feta containers more than double for one 24-period compared to the other.

Table 2. Mass of each category for each day, average and standard deviation [TABLE REDACTED]

Component	Mass (kg) Day 1	% of Total Day 1	Mass (kg) Day 2	% of Total Day 2	Mass Avg (kg)	Standard Deviation (kg)	% Avg	Standard Deviation (%)
Pouches		33.37%		21.18%			27.27%	0.06
Ingredient bags		16.22%		19.37%			17.80%	0.02
Plastic bags		9.77%		4.09%			6.93%	0.03
Rigid feta containers		6.96%		16.85%			11.91%	0.05
Food powder		5.93%		9.51%			7.72%	0.02
Soft feta containers		5.41%		4.57%			4.99%	0.00
Rigid feta lids		4.16%		4.69%			4.43%	0.00
Soft feta lids		3.85%		2.89%			3.37%	0.00
Paper towels		3.74%		3.97%			3.86%	0.00
Misc.		2.29%		4.57%			3.43%	0.01
Tape		1.87%		2.53%			2.20%	0.00
Smocks		1.77%		1.81%			1.79%	0.00
Cardboard		1.66%		1.08%			1.37%	0.00
Nitrile Gloves		1.35%		0.72%			1.04%	0.00
Stickers		0.83%		1.08%			0.96%	0.00
Office paper		0.42%		0.60%			0.51%	0.00
Caps with foil liners		0.42%		0.48%			0.45%	0.00
Total		**100.00%**		**100.00%**			**100.00%**	**N/A**
Total Feta		20.37%		29.00%			24.69%	0.04

Figure 3. Average mass of two 24 hour waste collection periods [TABLE REDACTED]

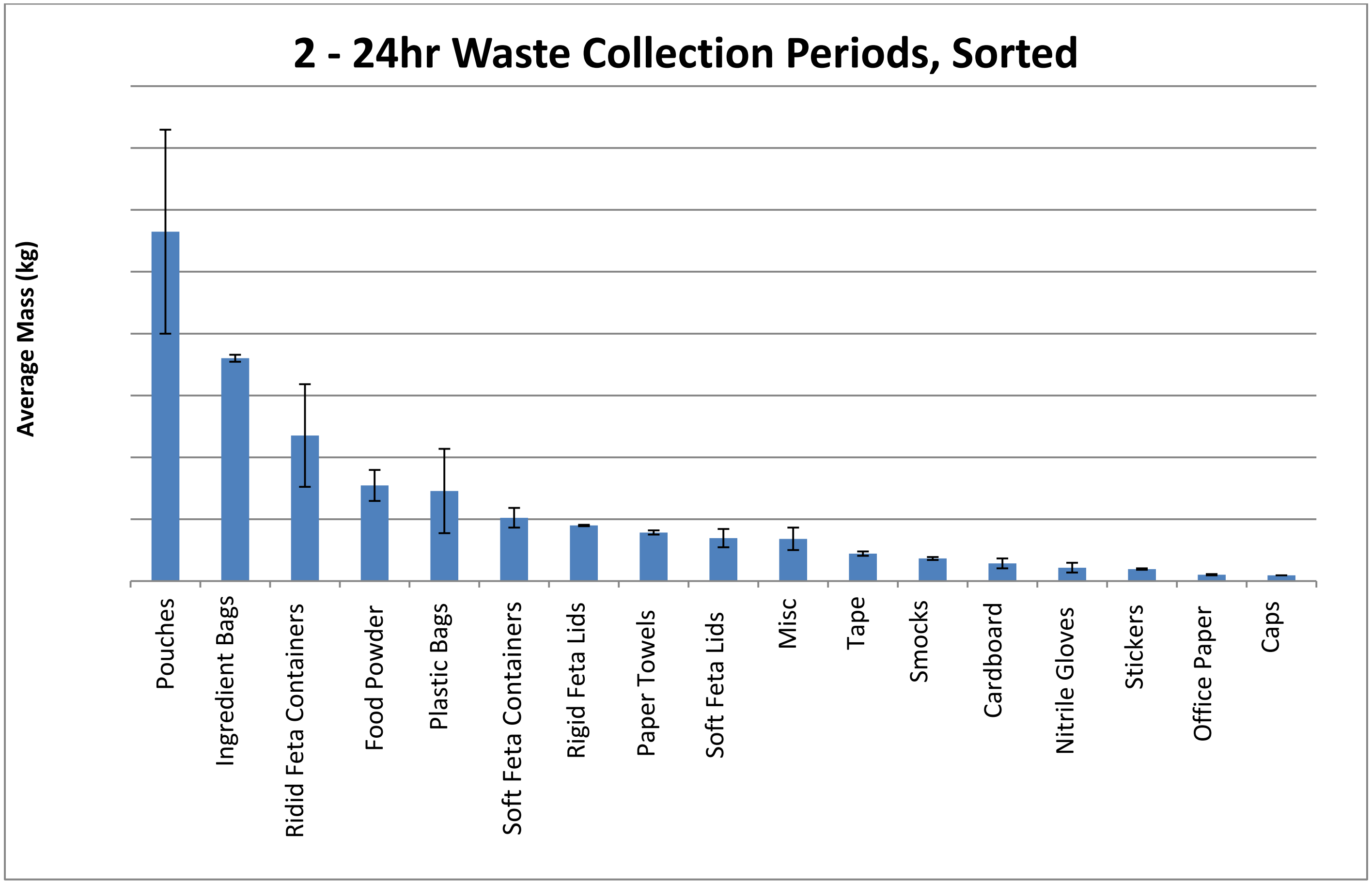
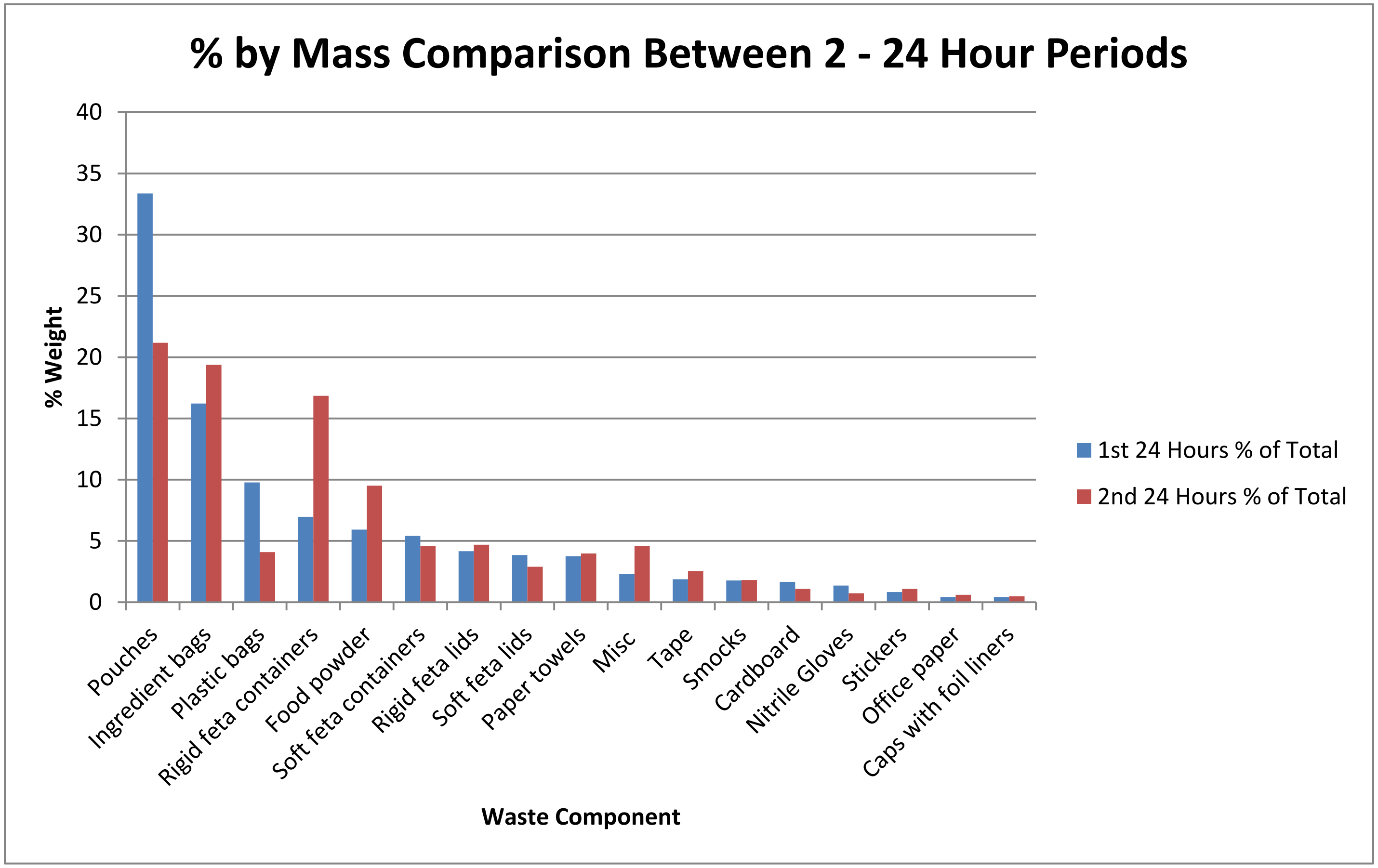


Figure 4. Percent mass comparison between the two 24-hour periods



Confidence Interval

x +/- t[s/sqrt(n)]

n = number of samples

*t** = student *t* statistic corresponding to the desired level of confidence

s = estimated standard deviation

x = estimated mean

Table 3. Determining the confidence interval

	n	t 90%	t 95%	s	sqrt(n)	mean	low 90%	high 90%	low 95%	high 95%
Pouches	2	6.314	12.706	6.09	1.4142	27.27	0.08014	54.4598	-27.4455	81.9855
Ingredient Bags	2	6.314	12.706	1.58	1.4142	17.8	10.7458	24.8541	3.6044	31.9955
Total Feta Containers	2	6.314	12.706	4.31	1.4142	24.69	5.4472	43.9327	-14.0331	63.4131

Table 4. Confidence interval of the three highest percentage components at 90% confidence level.

	low 90%	high 90%	low 95%	high 95%
Pouches	0.08014	54.4598	-27.4455	81.9855
Ingredient Bags	10.7458	24.8541	3.6044	31.9955
Total Feta Containers	5.4472	43.9327	-14.0331	63.4131

CHAPTER 3: DISCUSSION

Although the confidence intervals were wide, indicating the estimates had low precision, the sample size (n =2) was sufficient to meet study objectives. The confidence intervals could have been tightened had more 24-hour periods been sampled. As evident in the confidence interval equation, a larger n would result in a smaller fraction. Also, according to the ASTM Table 4, t becomes smaller as n increases, leading to a smaller fraction result. Because the objective of this study was to get a preliminary understanding of Wausau's waste to determine focus, particularly by understanding the largest percent by weight components, these results with a wide confidence interval and large standard deviation aided in prioritizing the component on which to focus. The results were aligned with the reality that high volumes of pouching cheese powder and packaging feta occurred daily at the plant and were expected to make up a large portion of the waste stream. Logistically, accomplishing the objective of the study required generosity on the part of the Wausau plant, Waste Management, and Marathon County Solid Waste, who all donated their time and materials, such as waste collection boxes, a scale, sorting table, and sorting site. To carry out a second study would likely require compensation and would definitely require more time.

When totaling up the recorded mass from sorting, both days had lower weights than what was collected at the plant. The first 24-hour period [REDACTED] kg were collected, but only [REDACTED] kg were measured during sorting. The second 24-hour period [REDACTED]kg were collected and [REDACTED] kg were accounted for during sorting. This difference may be attributed to lost material during transfer to the box or during the sorting process. For example, the pouches and ingredient bags contained food powder, some of which was contained at the bottom of the waste box and swept up from the floor post sorting (this was discarded and not measured because it contained other debris from the floor). Some food powder was collected from the plastic bags and measured; this food powder was of substantial weight at [REDACTED] kg and [REDACTED] kg for period one and period two respectively, taking up 6% to 9.5% of the composition but only filling the bottom of a plastic bag. Thus, some of the unaccounted-for mass was attributed to the dense food powder. Also observed was residual moisture at the bottom of the waste boxes (from the plastic brine bags); this water loss accounted for some of the lower mass.

The pouches, made from a paper-poly-foil material, were filled with various food powders, i.e. cheese powder, parmesan cheese, herbs, or garlic powder. Not all of the pouches were filled; some of the waste was simply the film. The food powder was not sorted from the pouching film because this type of separation process was not something the plant had the capability to accomplish before disposing. An outlet for this waste stream would need a diversion strategy that would either not require the film to be separated from the food or need to entail some type of separation mechanism as part of the outlet process. The spike in data representing pouches during period one and the large standard deviation resulted from collecting [REDACTED] kg more from Floor 2 during period one than period two. Over third shift during period one, Floor 2 was the only floor producing waste at that time; therefore, this was the only mass collected during that shift. The feta line on Floor 1, which generated a large volume of feta containers, shut down at midnight for sanitation each night and resumed production at 6am on first shift. The lack of generation on third shift led to no collection from third shift during the second 24-hour period. The ingredient bags comprised the second largest percent by mass of waste. These were a mixed material as well: a paper exterior with a plastic lining that came into direct contact with the ingredient. These bags still contained residue after emptied of their contents during production. As of August 1, 2014, Wausau transferred its recycling contract from Sonoco to Waste Management, who accepted the ingredient bags for recycling. Therefore, this stream did not need to be considered when determining on which waste stream to focus.

The feta containers and lids were separated into four categories based on their material and color. They were sorted in anticipation of a diversion option being available for one type of plastic and not another. When combined, these four categories of feta comprised an average of [REDACTED] kg or 24.69% of the composition (ranking it the second largest stream). The rigid containers and lids were made of polypropylene (PP), the containers were clear and the lids were green. The soft containers were a more complex structure, a semi-rigid forming film that was majority polyvinylchloride (PVC). The containers were clear and the lids were green. According to the feta packaging developer, the PVC containers will be transitioned to polyethylene terephthalate (PET). The feta containers, which contained feta residue, were prioritized as the focal waste stream for the following reasons: they comprised 24.69% of the waste stream, making them the second largest component; the feta residue rendered them non-recyclable; and emerging technologies in plastic conversion increased the likelihood an alternative outlet could be found.

Were a Wausau waste characterization study to be completed again with the same objectives, more accuracy could probably be achieved if a vehicle load could be sent to the landfill without being compacted. This would be representative of a week's worth of production as opposed to two days. While attempting to be strategic in collecting samples for the study, it still resulted in random sampling.

CHAPTER 4: EVALUATION OF ENERGY RECOVERY PROCESSES

The first objective of this internship was met through the waste characterization study. The study results directed the focus for the remaining internship objectives and are outlined in the following chapters. According to a widely-circulated waste management hierarchy (Figure 5, retrieved from the Environmental Protection Agency's (EPA) website), the most preferred option for managing waste was to reduce and reuse. If those strategies could not be applied, recycling/composting followed by energy recovery were the preferred options.

Figure 5. Non-Hazardous Waste Management Hierarchy

http://www.epa.gov/solidwaste/nonhaz/municipal/hierarchy.htm

The waste stream of diversion focus, PP and PVC containers with feta residue, falls into the energy recovery portion of the waste hierarchy because food residue and material type prevent recycling. Researching energy recovery possibilities for Wausau's plastic was the emphasis of this research and the author found practical examples of recovery technologies. For example, Waste Management was working in these two areas:

1. Convert plastics to crude bio-oil through pyrolysis
2. Use non-recyclable material to create SpecFuel (a pellet fuel used as a coal-substitute)

According to information sheets (Appendix D) shared by WM, "the technology at the WM Plastics Recovery plant is known as 'anaerobic thermal reclamation,' which uses an oxygen-free chamber and heat to process the plastics. Contaminants such as dirt, fiber and food are not problematic, so there's no need to clean the plastics before processing. The plastics travel by truck to the WM Plastics Recovery facility, where technicians can turn plastic into crude oil in less than five hours. The final step is loading the oil into tanker trucks and hauling it to refineries". SpecFUEL was another option WM presented, where post-consumer waste is transformed into a high-BTU pellet to be burned in place of coal, petroleum coke or biomass. Because WM refuse conversion did not require cleaning of food from plastic before processing, these technologies seemed worthy of further research for Wausau's waste streams.

Scientific review of pyrolysis and gasification did support the technical feasibility and industrial value of the processes' products; however, the lack of commercial availability near the Wausau facility and the need for increased efficiency through preprocessing the waste led the author to focus on refuse-derived fuel pellets. Sarc & Lorber (2013) gave a broad definition of refuse-derived fuel (RDF), "a nearly unlimited broad range of solid, liquid and gaseous waste materials from household, commerce, forestry, agriculture and industry, which have a certain calorific value, may be applied as 'waste fuel' or RDF in Waste to Energy (WtE) or co-incineration plants after having undergone different levels of prior processing." Chunguang et al. (2013) made a case for RDF explaining that pelletization reduced transportation costs and allowed for more stability in the physical and chemical characteristics of the pellets, such as heating value, uniform particle size, and density. This stability allowed for a variety of wastes to be used in the same gasifier.

Both processing and type of feedstock played a role in determining RDF quality. Sarc & Lorber (2013) generalized the process in RDF plants, explaining, "a modern and advanced mechanical sorting plant (MSP) for RDF consists of at least two or even three shredding steps, at least two magnetic separation steps (rejection of Fe-metals), at least one eddy-current separator (rejecting of NON-Fe-metals, mostly only for fine fraction) and, depending on customer requirements, at least two sieving." When creating RDF, suppliers should consider the following characteristics in their specification (Sarc and Lorber, 2013):

- well defined calorific value
- low chlorine content
- quality controlled composition (few impurities)
- defined grain size
- defined bulk density
- availability of sufficient quantities with required specifications

Myrin et al. focused on the feedstock when comparing the ash content and formation of dioxins in three fuels: RDF without food waste, RDF with food waste and recovered wood. The RDF sample with food waste was higher in ash and significantly higher in chlorine than the other two fuels, reducing its quality as a combustion fuel. The production of ash added cost associated with hazardous waste removal and the presence of chlorine resulted in the formation of dioxins, which were an environmental concern. This study pointed to the benefit in separating food from other waste sent to energy recovery in order to create drier and lower-chlorine-content fuel. The feta containers in Wausau's waste stream were coated with residue of the highly-salted cheese, potentially creating a disadvantage to pursuing RDF. However, the level of residue that would be considered contamination of the pellet was unknown. Also, the level of allowable food residue could vary by consuming plant. Therefore, RDF was still pursued as the energy recovery option, knowing this issue would have to be addressed when more information became available from the specific plant absorbing Wausau's waste.

The RDF approach was most accessible with the pelletization of plastics for fuel occurring in at least four plants near Wausau: Greenwood Energy in Green Bay, WI, Xcel Energy in LaCrosse, WI, Pellet America in Appleton, WI and Great River Energy in Elk River, MN. Based on the research pyrolysis and gasification ran more efficiently when a uniform feedstock was consumed; therefore, by incorporating Wausau's waste into a uniform fuel pellet, it has the potential to be more readily taken up by gasification or pyrolysis processes when these become more commercially available.

CHAPTER 5: PROPOSED OUTLET FOR MANUFACTURING WASTE

5.1 Pursuing Greenwood Energy

After deciding to pursue WtE, the author received from Waste Management the names of companies nearby Wausau transforming waste into fuel pellets. Greenwood Energy in Green Bay, WI was one of those companies, and it focused on three business areas: manufacturing a cleaner, cost-effective and renewable solid fuel that can directly replace coal, investing in alternative energy technologies and developing clean energy assets. Greenwood used "non-recyclable manufacturing waste – all destined for local landfills – to create sustainable fuel pellets that handle and burn with the performance qualities of coal but significantly lower emissions." (http://www.gwenergy.com/) In meeting with Greenwood Energy General Manager Ted Hansen, an important distinction was made between its pellets and RDF from municipal solid waste (MSW). RDF includes post-consumer waste, and burning post-consumer waste must follow incineration regulations, which have strict air emission controls on the boiler. Greenwood avoided post-consumer waste because a fuel that mimicked traditional fossil fuel without increasing emissions could be considered a non-waste fuel or non-hazardous secondary materials (NHSM), as recognized by the EPA. NHSM could be sold as a direct coal substitute and resulted in a 90% reduction in NO_X and mercury compared to coal. Depending on the type of coal, Greenwood would or would not be a reduction in chlorine. To maintain Greenwood's classification as non-waste fuel, it produced pellets that were 60% paper and 40% plastic. PVC was avoided by Greenwood because it maintained its chlorine to less than 15ppm in its pellets and PVC was around 300,000 – 500,000 ppm chlorine. Also, chlorine produced HCl, resulting in a corrosive environment in the boiler. Hansen's comment about HCl production was supported through Aznar et al. (2006), "The main disadvantages of study of plastic pyrolysis and gasification is that it is necessary to control chloride content in feedstock and the risk of bad fluidisation because of particle agglomeration." In addition, Kaminsky et al. (2004) state "Pyrolysis proceeds smoothly for polyolefins, polystyrene, acrylonitrile-butadiene, rubber, styrene terpolymers (ABS), polyesters, and mixtures thereof. Problems occur with PVC, polyamides and polycarbonate owing to the formation of toxic compounds or through agglomeration of the fluidised bed." Hansen pointed to HCl formation when Greenwood trialed pizza packaging film in its process. Occasionally some plastic arrived with pizza sauce on the film, when tested for chlorine the results were high from the salt in the pizza sauce. This was pertinent information because Wausau's feta containers often carried residue of the highly-salted cheese. Hansen recommended a lab in Superior, WI where Wausau could send a sample for chlorine testing. Greenwood was also willing to conduct a trial on Wausau plastic for free. Wausau would send a test sample of 20 pounds. To learn more about Greenwood Energy's operation, the author toured the plant's pellet production process on July 27, 2014. The plant already received PP material from other suppliers and the process possessed the capability to handle the feta containers. The open-space warehouse receiving site would allow for the unloading of bailed plastic. The size of the feta containers would not be an issue as they are small enough to fit into the initial shredding process that reduces the size of the feedstock. The moisture of the feta containers would need to be analyzed because the pellets are tested to ensure the average 3% moisture target is achieved. Reviewing the process with Hansen resulted in a promising preliminary assessment on the feasibility of processing feta containers into pellets.

5.2 Cost/Benefit Analysis

To understand from an economic perspective the costs and benefits to Kraft Foods Group, Inc. in sending feta containers to Greenwood Energy as opposed to the landfill, I conducted a cost/ benefit analysis. To complete this analysis, calculations were carried out using 2013 Wausau waste management data for the annual mass of waste and average tonnes per vehicle load.

First, the costs were identified and estimated; they included preprocessing of the plastic feta containers for transport (equipment and labor), storage of the plastic before sending to Greenwood, the tipping fee, and transportation. To achieve an economic advantage in transporting to Greenwood, the feta containers should be preprocessed through bailing to obtain a more dense shipment. Bailing would allow a 16.15 meter trailer to haul 10.9 tonnes, double the average compacted tonnage currently hauled to the landfill in one truckload. The cost of renting a bailer was entered into the cost-benefit analysis, but it is of note that if Kraft were to buy a bailer at $14,000 (price quoted by WM), it would pay for itself after three years and eleven months at the $300 rental fee. However, finding an available investment source for this capital could be problematic. Labor took into account plant employees' training time, operating the bailer, and separating/preparing the plastic for pick up at [LABOR COST REDACTED] per hour. Cost associated with remotely storing bailed plastic on pallets was taken into consideration knowing that one pallet can hold approximately 909 kg and it would cost $15 per pallet to transfer. Hauling and tipping at Greenwood would actually be a cost savings compared to sending waste to the landfill; however, the increased cost stems from the introduction of preprocessing. The total cost associated with shipping plastic feta containers to Greenwood was estimated to be [REDACTED] per year.

Second, the financial benefits were evaluated. Because Kraft is charged by WM a hauling fee per truck and a tipping fee per ton, Kraft would reduce disposal cost by sending fewer trucks for waste removal and less mass to the landfill. This amount totaled [REDACTED], which is not enough to offset increased cost from preprocessing. Kraft could possibly offset the higher cost through increased sales by marketing this landfill diversion practice. As mentioned in the introduction, Choi & Ng (2011) as well as Trudel & Cotte (2009) found consumers were willing to pay more for goods produced under corporate social responsibility. Bhaduri et al. (2011) researched the question "Do Transparent Business Practices Pay?" and found that being transparent did increase consumer purchase intent by 15% - 20% on apparel, but the competitive advantage Kraft would gain on its feta cheese business by marketing feta as "produced on a line with zero waste to landfill" (or some such wording) cannot be determined with certainty. Kraft would need to conduct a consumer test to validate consumers' willingness to increase spending (and how much more) on sustainably-manufactured feta cheese. However, at present, assumptions can be made in knowing that the aforementioned studies saw increased consumer spend ranging from 2% - 20% [REDACTED]. For the cost-benefit analysis in Table 5, a 1% increase in annual sales was used. Table 6 is a sensitivity analysis around increased sales from sustainability marketing, incremental sales ranging from 0% to 10%, and how this would affect the net benefits. The costs incurred from the new disposal practices could be offset with just a 0.13% increase in sales through marketing. With a 1% sales increase, the net benefit of this project would be [REDACTED]. Table 5 sums up the cost benefit analysis and more detailed information on cost-benefit calculations can be found in Appendix C.

Table 5. Annualized Cost-Benefit to Kraft Foods Group, Inc. Analyzing Transfer of Feta Container Waste to Greenwood Energy vs. Landfill [TABLE REDACTED]

Costs	$$	
Hauling Waste to Greenwood		
Tipping Fee		
Renting a bailer		
Wausau labor for bailing, assuming 10 hrs./week		
Separate collection for PP vs PVC feta containers (labor)		
Separate storage location for bailed plastic		
Training (10 hrs.)		
TOTAL		
Benefits		$$
Fewer trucks hauled to the landfill		
Less weight hauled to landfill		
Consumers willing to pay more for sustainability		
TOTAL		
NET BENEFIT		

Table 6. Sensitivity Analysis Around Increased Sales with Sustainability Marketing [TABLE REDACTED]

% Increase in Sales	Dollar Value of Increased Sales (USD)	Benefit Total (USD)	Net Benefit Total (USD)
0	0	0	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

5.3 Obstacles to Implementation

Of Wausau's two types of feta containers, only PP could be considered for Greenwood energy. The chlorine concentration in PVC is too high. To allow for the introduction of all feta containers to Greenwood, the PVC material must shift to PP or PET. As noted in Chapter 4, the chlorine content of the PP feta containers is not known and was not within the scope of this internship. However, the concentration would need to be determined before Greenwood could run a pilot sample of Wausau's waste. Too high of a concentration could lead to the formation of hazardous materials and out of spec pellets for Greenwood.

Without an increase in sales via marketing sustainability, the cost-benefit analysis would indicate this project is not economically viable. Convincing Kraft there is a subset of consumers motivated to consider sustainability when purchasing products may require a proposal in itself. Kraft's Philadelphia cream cheese labels its product as "Made with Renewable Energy", speaking with its marketing team could provide insight into any increase in sales from this messaging. Another obstacle in this vein would be finding on-point, compelling marketing to communicate feta cheese was made on a production line that generated zero waste. Consumers need to be educated on sustainability initiatives in order to influence corporate decisions through their purchase power.

CHAPTER 6: CONCLUSION

Sustainability has become a consideration for corporations and their customers in this time of increased awareness about anthropogenic change to the environment. To potentially reduce environmental impacts at Kraft Foods Group, Inc., this internship resulted in a proposal for the Wausau, WI plant to divert waste from the landfill by sending plastic feta containers to Greenwood Energy for pellet fuel production. A characterization of [REDACTED] kg of Wausau's waste collected over a 48-hour period led to the focused prioritization in diverting feta cheese containers made of PP. Feta containers comprised the second largest percent by weight of Wausau waste. While the transition to Greenwood Energy requires an upfront investment of a bailer, this bailer would be offset within approximately 4 years and could potentially provide unexplored benefit to the plant. Also, a 0.13% increase in sales would offset the purchase of and labor associated with a bailer. Using Wausau's plastic waste as a fuel has potentially fewer negative effects on the environment by keeping plastic out of the landfill, gaining energy recovery from the plastic, and burning less fossil fuel; however, environmental benefit would need to be confirmed. Rigamonti et al. (2012) completed a life cycle analysis of three different waste-burning scenarios in Italy and their results supported the benefits of co-combustions of fuel pellets with coal. Scenario one was the production of RDF and its co-combustion in a coal-fired power plant, scenario two was combustion of residual waste without any pretreatment in a moving-grate mass burn WtE plant, scenario three was RDF combustion in a dedicated WtE plant equipped with a fluidized bed combustor. They found that of these particular scenarios in their specific processes, co-combustion of RDF performed better on the impact categories evaluated (Global warming potential (GWP) as defined by the Intergovernmental Panel on Climate Change, human toxicity potential, acidification potential, and photochemical ozone creation potential).

In diverting waste to Greenwood Energy, Kraft waste would be converted to pellet form, a form more readily taken up by gasification and pyrolysis when those processes become commercially available. Also, Greenwood seeks to be a closed-loop process, purposing the vision to one day help Kraft install a gasifier at Wausau in which it could generate on-site energy which could be fueled, in part by its own waste processed by Greenwood. A Kraft-Greenwood partnership has the potential to help Kraft achieve increased sustainability.

CHAPTER 7: INTERNSHIP EVALUATION

Through structuring and executing a waste characterization study, I was able to gain experience in developing a research protocol that provides analyzed data to inform the development of management strategies. Developing a sampling procedure required an assessment of statistical sampling methods, and executing the procedure required adaptability and problem solving to achieve unbiased, usable data. The goal of the waste characterization study is to have a deeper understanding of the starting landscape and use this information to guide the project towards a more successful result. I still could have achieved progress in diverting waste at Wausau without conducting a waste characterization study, but the impact may not have been as strong. This study pointed me in the direction of a waste component that exists at a higher level than most other components, allowing for a larger diversion rate. I aim to apply this learning to future projects, asking myself if I understand the landscape of the project enough to make the highest positive impact when working towards my goals, and if not, identifying what information I need to gather in order to increase my understanding. While the waste characterization study was time well-spent and the results informed next steps, an execution that results in higher precision would be recommended for a repeat study. The sampling protocol had to be adjusted mid-execution due to inadequate observation time before the study (referring to the varying generation rates on the individual floors) and limitations of the waste collection containers. Had more time and money been available, sorting an uncompacted vehicle load containing a week's worth of waste would have led to more samples and would represent each floor more thoroughly. It would also be worthwhile to investigate whether compacted waste could be sorted, reducing the cost of a study in not having to transport a vehicle of uncompacted waste. I do feel an adequate sampling was acquired within the limitations of this study; however, based on this experience, I feel an execution that would allow for more samples would help to strengthen the precision.

Food residue on the containers prevented recycling and drove the need to find an alternative outlet; therefore, it was certainly a consideration when finding an outlet for this project. However, I initially, and falsely, assumed that when burning waste, food residue would not be an obstacle. The presence of chlorine in a waste-to-energy feedstock leads to the production of dioxins and HCl. These hazardous products become problematic by either creating a corrosive environment in the boiler or creating noncompliance with air permits. The salt content of food thus creates a potential obstacle, depending on the amount of residue and concentration of chlorine, when attempting to create pellets out of plastic with food residue.

In addition to monitoring emissions from food residue, other environmental impacts resulting from burning plastic should be considered. Although the waste management hierarchy depicts energy recovery over landfill as a preferable option, a life cycle assessment (LCA) comparing the new diversion practice to Greenwood with the current practice of landfilling the feta containers should be performed to validate environmental benefits are achieved. A LCA of these processes would, "evaluate environmental burdens associated with… [the] process…by identifying energy and materials used and emissions released to the environment" (Cherubini, 2009). The LCA system boundaries for Kraft's current practice would begin where feta containers are collected in waste bins at the production line and finish with their deposition in the landfill. The system boundaries of the Greenwood practice would begin at the same stage as the landfill process and end with pellet consumption in a coal-fired power plant. Information regarding the input and outputs of mass and energy flows would need to be inventoried, such as amount of material resources used and their energy value, the electricity used and generated, how the electricity is generated, and liquid, solid, and gaseous emissions generated. Because Greenwood's fuel pellets displace coal, the inputs and outputs related to burning coal would also need to be assessed and added to the waste disposal analysis for Greenwood. Some of the information required in this assessment is proprietary to Greenwood, such as the energy required to make the pellets. To conduct a LCA, an agreement with Greenwood would be necessary to acquire a freer flow of information. Other pieces of information are available, such as the carbon dioxide emissions from transportation, the amount of energy in BTU's Kraft would be sending to Greenwood annually in the form of PP, and how much coal this would displace on a BTU equivalent.

Cherubini and his colleagues focused their LCA on four scenarios: landfill without biogas utilization, landfill with biogas combusted for electricity generation, sorting waste to pull feedstocks for RDF and anaerobic digestion, and direct incineration of waste. Evaluation of environmental disturbance from materials and energy flows for all four scenarios led to the conclusion that landfill systems were the "worst management options and that significant environmental savings are achieved from undertaking energy recycling" (Cherubini, 2009). This study points to landfilling as the worst option; however, a review of LCAs comparing various types of RDF combustion to landfilling reveal that more research is needed and making a generalization about plastic waste management may lead to inaccuracies. Lazarevic et al. questioned “the legitimacy of applying the waste hierarchy to the plastic waste stream” (2010) and conducted a review of plastic waste management LCAs over a 15-year period to identify a consensus on this practice. The end-of-life technologies included in the review were mechanical recycling, feedstock recycling (i.e. pyrolysis, gasification), incineration (MSW, solid recovered fuel (SRF) in a cement kiln), and landfill. For the purposes of this internship, it would have been helpful for Lazarevic et al. to have made a direct comparison between SRF in a cement kiln to landfill, which is closest to the Kraft scenario. Worth noting, however, is their comparison of feedstock recycling to incineration, where they found “for GWP, the preference is determined by the incineration technology and fuel source of the substituted energy” (2010). Additionally, in their comparison of MSW incineration to landfill, “the majority of landfill scenarios were associated with a lower GWP than MSW incineration scenarios…. The two scenarios where MSW incineration was favoured…were due to high efficiency and high electricity-to-heat ratio where electricity replaces fossil fuels for direct heating” (Lazarevic, 2010). Overall, “landfill was the least preferred treatment option for all impact categories except for GWP, highlighting the importance to consider other environmental impacts other than GWP” (Lazarevic 2010). Because many environmental factors are assessed in LCAs, such as GWP, acidification potential, and energy use, a company should identify which factors need to be reduced in order to consider a practice sustainable. Lazarevic’s final conclusion, “due to the uncertainty surrounding some of the critical assumptions in LCAs of plastic waste management, a case by case assessment would be required to demonstrate in which situations the waste hierarchy is applicable,” (2010) emphasizes the need for a specific LCA of Kraft’s scenario to draw a conclusion regarding environmental impact. I also recommend looking into the other pelletization plants in Wisconsin, particularly if Greenwood cannot accept the plastic because of chlorine concentration, to see if the environmental impact is more favorable.

This internship research suggests the best approach is to look at the larger picture. While diverting waste from the landfill component by component may be the short term goal and reduces environmental impact, Kraft should strongly consider the potential for a higher beneficial future state through a comprehensive, long-term strategy that couples waste reduction and energy. Four fuel pellet-producing sites exist close to Wausau; gasification and pyrolysis plants are commercial or close to commercialization in the United States, and Kraft have set precedence in turning waste streams to energy at a number of its plants. What is evident to me from this research is that Kraft should be looking at a holistic approach to dealing with these issues; how can it use plant waste to meet its own energy needs? As recommended by this study, an immediate solution to reducing Wausau's waste to landfill provides an opportunity for the plant to also generate energy, provided the obstacles mentioned above can be overcome. However, this research also provides insight into the potential for even greater sustainability. Imagine a continuum of energy production strategies with the combustion of fossil fuels at one end and renewable, zero –carbon-emission energy at the other. As Kraft couples waste reduction and energy needs/efficiencies, its aim should be move across the continuum towards renewable, zero-carbon-emissions energy. In the short-term, that seems likely to involve advancing its waste-to-energy from pellets for combustion to pellets for gasification. In the long-term Kraft may benefit from having a gasifier on-site in Wausau that uses Wausau's waste as a feedstock and supplies the plant with energy.

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APPENDIX A

Questions asked of both Champaign and Wausau in determining for which plant to pursue a landfill diversion strategy.

1. How often are landfill pickups? Amounts?
2. How often are recycling, composting, etc. pickups? Amounts?
3. Any other waste streams besides:
    a. Fiber drums used for garlic, onion, and cucumber juices
    b. Lunchroom and office waste (plates, wrappers, paper towels, etc.)
    c. Raw material bags/jugs with liquid/powder residue
    d. General raw/pack/wip materials out of code
    e. Totes of material that don't come down to the recycle center properly separated
    f. Certain product wrappers
    g. Wooden pallet pieces
    h. Easy Mac cups with the labels on
4. Any electronic waste?
5. How is the waste water treated?
6. Cost associated with waste removal
7. What is the biggest problem with waste streams? What is your largest/most expensive waste stream?
8. What are the biggest complications encountered in handling the waste

APPENDIX B

Photographs from waste sorting study.

Figure 6. Kraft plant entrance, Wausau, WI

Figure 7. Waste collection box with collected samples

Figure 8. Sorting site, Marathon Co. Landfill, Ringle, WI

Figure 9. Scale with maximum measurement of 136 kg +/- 0.23 kg

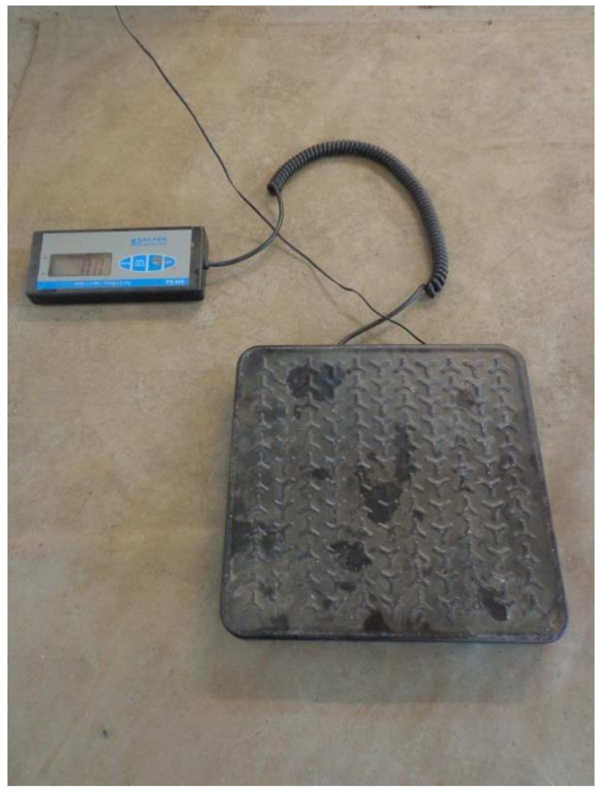

Figure 10. Indoor sorting location at the landfill

Figure 11. Post-sorted waste, bagged and ready for measuring

Figure 12. Ingredient bags

Figure 13. Example of items in miscellaneous waste category

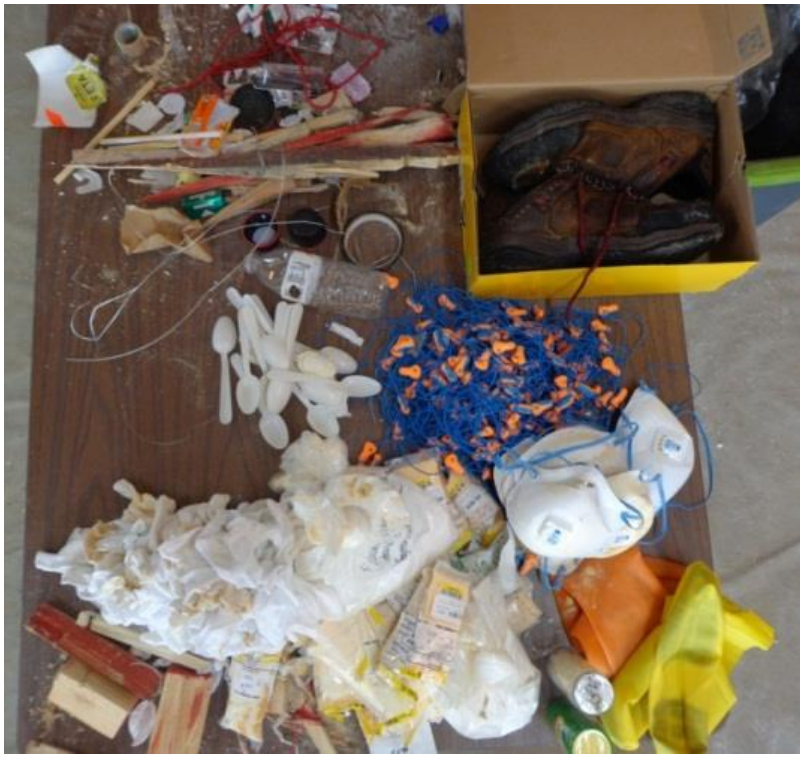

Figure 14. Feta containers from left to right: PP container, PP lid, PVC container, PVC lid

APPENDIX C [REDACTED]

Cost/Benefit Analysis Calculations

ASSUMPTIONS IN COST/BENEFIT ANALYSIS

Wausau average 5.591 tonnes/truck to landfill

Wausau average 12.272 tonnes/truck to Greenwood

Based on 2013 annual Wausau waste weight of [REDACTED] tonnes

Based on Marketing Feta as Zero-Waste to Landfill Production

Of note, a bailer could be purchased for $14,000 and would pay for itself in [REDACTED]

WASTE MANAGEMENT INFORMATION

	Waste to Landfill	Waste to Greenwood
Hauling Fee	$135/truck (what is this size normally for truck?)	$250/53' Trailer
Tipping Fee	$35/ton	$25/ton
Bailer Rental	N/A	$250/mo

WAUSAU INFORMATION

2013 waste pounds was [REDACTED]

16.33% of waste was rigid feta containers & lids

Wausau average 6.15 tons/truck

Minimum of 3 ton or charge extra.

New rate effective August 1st on compactor - $135 from $149.17

Waste Management Charge $35/ton, originally $41.16/ton

$80/month in state taxes

Pounds of rigid feta plastic annually [REDACTED]

Average pounds on a truck 12391

Number of trucks annually with feta waste [REDACTED]

$MM in annual sales for 6oz feta (PP containers) [REDACTED]

Wausau labor for bailing (training?) **$[REDACTED] / hour and approximately 10 hours to train, (that would be 5 hours for trainer and 5 hours for trainees.)**

Separate collection for PET vs PVC feta containers (labor?) **Same as above**

Separate storage location for bailed plastic **This will run about $15 / per pallet, 40 pallets for a truck load. We would have to ship to an outside storage, would not be able to store on site.**

Training? **– Same as above**

Number of pallets/year, assuming 2,000lbs/pallet [REDACTED]

APPENDIX D

Promotional Material from Waste Management Regarding Their Energy Recovery Technologies

SUSTAINABLE ENERGY

Which solid fuel is sustainable and cleaner-burning than coal? Waste Management SpecFUEL.™

As you look to reduce both your environmental impact and overall costs, there's an innovative solution for you to consider. One that is made from a sustainable source that burns cleaner than coal. This clean fuel is Waste Management SpecFUEL.

For your solid fuel requirements, Waste Management SpecFUEL is a low-emission energy source that is an alternative to coal, petroleum coke and biomass. So what is it? This product is made from high-energy materials that are mechanically extracted from post-consumer and post-industrial waste sources, then converted into a high-BTU, clean-burning, marketable fuel product. And, depending on your operation, it can also be a part of a closed-loop system that lets you use your facility's own waste as fuel.

Waste Management SpecFUEL offers you:

- A sustainable energy replacement for coal or other traditional solid fuels to produce steam, electricity or heat in kilns
- A marketable energy product designed to meet strict end-user requirements for solid fuel
- An energy source that can be economically co-fired with conventional solid fuels and biomass
- A dependable high-BTU energy product that burns cleaner than solid fossil fuels
- A product that is easy to handle and ready to use in existing end-user facilities

WASTE MANAGEMENT

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TECHNICAL SPECIFICATIONS

HEAT VALUE (BTU#)	
SpecFUEL	7,500-11,000
U.S. Coal	11,000-14,500
MOISTURE WEIGHT %	
SpecFUEL	4-6
U.S. Coal	2-20
ASH CONTENT WEIGHT %	
SpecFUEL	2-15
U.S. Coal	3-16
SULFUR WEIGHT %	
SpecFUEL	0.02-0.20
U.S. Coal	0.5-4.7
HALOGEN WEIGHT %	
SpecFUEL	0.03-0.5
U.S. Coal	0.01-0.9

What is Waste Management SpecFUEL™ and how is it created?

This product is produced under strict, engineered controls. The demonstrated process is designed and engineered to create value by mechanically extracting beneficial materials in the form of recyclables, organics and non-recyclable commodities contained within municipal solid waste. The non-recyclable commodities captured in the mechanical extraction stage are then categorically separated and proportionately recombined to produce a predictable and uniform BTU, low-moisture, clean-burning, solid fuel.

SpecFUEL is formulated to meet end-user strict solid fuel specifications.

In addition to the many environmental and economic benefits, the SpecFUEL process provides the means to divert as much as 80% of the materials of value it extracts from local landfills.

Compared to refuse-delivered fuel (RDF), process-engineered fuel is a highly refined and marketable low-moisture product with predictable and uniform heat content. Our process converts post-consumer and post-industrial materials into a value-added fuel product that is easy to handle, economically transportable by truck, rail or barge, and ready to use in end-user energy facilities.

Who should use this product?

Waste Management SpecFUEL is ideal for any industrial user of coal or other conventional solid fuels to produce energy or steam. This includes:

- Cement, chemical, pulp and paper, textiles, pharmaceutical and metal manufacturing
- Industrial users that currently rely on coal
- Manufacturers that use kiln-based plants

WASTE MANAGEMENT

Let's talk about how Waste Management can help your operation.

Contact Rich Toberman today at 281 543 8100 or rtoberma@wm.com

THINK GREEN.®

October 2011

For hard-to-recycle plastics, a green and revolutionary solution.

Innovation for our sustainable future, from Waste Management.

It seems like something out of a science-fiction novel: Powering cars and industrial processes with old plastic bags, computer cases and broken plastic toys – while reducing landfill waste at the same time.

The beauty is, it's not science fiction – it's a real-world solution. Waste Management is now turning hard-to-recycle plastics into crude oil at its new plant in Portland, Oregon.

It is also part of Waste Management's transformation from a waste collection and disposal company to one that sees waste as a resource.

New life for plastics that used to go to landfills.

Many plastics today are difficult to recycle because they're made of mixed materials or they are dirty from use in manufacturing settings. Difficult but not impossible for a company committed to extracting value from what used to go to waste.

At Waste Management's new Plastics Recovery facility, low-value, hard-to-recycle plastics are being utilized to generate crude oil for use in practical applications, including low-carbon transportation fuels, inks and printing supplies, and even new plastics.

The process is currently designed for plastics recovered from commercial and manufacturing settings. This includes film plastics used to wrap shipping pallets, tarps used to cover farm crops, pots used at plant nurseries, and dirty containers used at industrial sites. These plastics have been have been going to landfills for decades because a solution hasn't been available or affordable - until now.

WASTE MANAGEMENT

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GREEN TECHNOLOGIES

Extracting value from hard-to-recycle plastics.

The technology at the WM Plastics Recovery plant is known as "anaerobic thermal reclamation," which uses an oxygen-free chamber and heat to process the plastics. It essentially gasifies the plastics, purifies the gaseous compounds and condenses the volatile material into crude oil.

The process begins when plastics arrive at the Waste Management's Gold LEED-certified facility in Hillsboro, Oregon, where employees process plastics into small pieces. Contaminants such as dirt, fiber and food are not problematic, so there's no need to clean the plastics before processing.

Then the plastics travel by truck to the WM Plastics Recovery facility, where technicians can turn plastic pieces into crude oil in less than five hours. The final step is loading the oil into tanker trucks and hauling it to refineries in the area.

The current plant is designed to process 40 tons of plastics per day, producing 1.5 million gallons of crude oil per year.

"Waste Management understands that green jobs and green technologies are important to our customers. This solution reflects our long-standing commitment to doing good things with waste and helping businesses and communities across the Pacific Northwest achieve their world-class sustainability goals."

Jason Rose,
Area Vice President
Waste Management - Pacific Northwest Area

New Technology. New Questions.

Q: Does this mean I can throw plastic bags and old toys into my curbside recycling cart?

A: Not yet. This technology isn't intended to change how we recycle at the curb; that process is already quite efficient, thanks to advances in local recycling infrastructure. This new technology is designed for low-value, difficult-to-recycle plastics recovered from businesses and industrial operations.

Q: But I have plastics that are not acceptable in my curbside cart. Is there a place I can drop off them off for use at the Waste Management plant?

A: In the years ahead, yes. For the latest information about this technology, go to http://wmnorthwest.com/otherservices/plasticsrecovery.html.

Q: What about REDUCE, REUSE and RECYCLE? Will this encourage the use of more plastics?

A: REDUCE, REUSE and RECYCLE is still the best approach. Now we are adding RECOVER as new technologies prove viable to extract value from materials that used to go to waste.

Q: Doesn't this process compete with recycling?

A: No, it complements recycling. The WM Plastics Recovery plant is designed to process commercial and industrial plastics that cannot be efficiently or economically recycled through existing community recycling programs.

Q: How much plastic does it take to make a gallon of oil?

A: On average, it takes nine pounds of plastic to produce one gallon of crude oil.

LEARN MORE

http://wmnorthwest.com/otherservices/plasticsrecovery.html

GOOD FOR THE PLANET.

GOOD FOR THE ECONOMY.

45 new green-tech, family-wage jobs

Clean technology with a net reduction in carbon footprint emissions compared to traditional oil extraction

Less waste for landfills

Another world-class sustainability success for the Pacific Northwest

WASTE MANAGEMENT

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