ALCOA Sustainability Project

Penn State Creamery Aluminum Bottles

December 5, 2013

Client: ALCOA

EDSGN 100.012 Team 3

Project Website:

http://sedtapp.psu.edu/design/design_projects/edsgn100/fa13/

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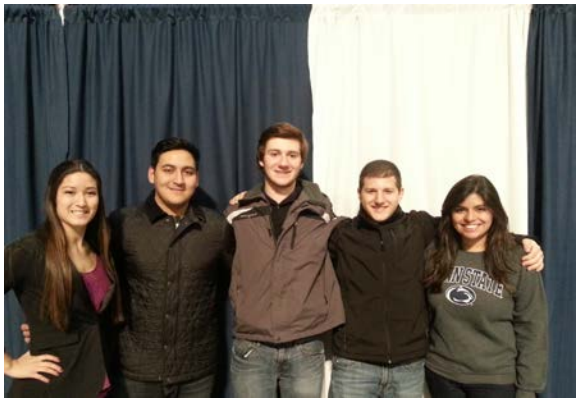

Summary

The Penn State Creamery produces and sells different beverages across campus to students, faculty, and visitors. Unfortunately, the containers are made out of HDPE plastic which is recyclable yet not the most sustainable material. Thus, with the support from ALCOA, the goal is to redesign the Creamery beverage containers using aluminum and integrate their recycling into the Mobius program without compromising the quality of the beverage. The team's solution will consist of a durable, sleek aluminum container that holds 500 ml and saves significant amounts of energy.

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Introduction

In the search for opportunities across campus where aluminum could be introduced to promote sustainability, three options were considered: aluminum tiles, food containers, and beverage containers. First of all, the group considered replacing Armstrong ceiling tiles in buildings around campus as they deteriorate constantly, get watermarked easily and are not reusable. For a second concept the group recognized that the various food containers used daily in the dining commons are not only made of Styrofoam, a material that is not easily recycled, but are also not frequently recycled. In the same way it was noticed that the plastic bottles used by the Penn State creamery are not the most energy efficient way to provide beverages. These observations helped to form the problem statement that centered on the fact that students across campus consume various beverages daily, yet the plastic bottles with code 1 recycling could be replaced with aluminum to benefit from its very efficient and sustainable recycling process. As a group, sustainability was defined as the maximum use of renewable resources so the world can meet the present needs without compromising the needs of future generations. Thus, sustainability includes recycling and reducing waste.

Ultimately, all three concepts addressed ALCOA's need for a product that would increase sustainability on campus. Nonetheless, through the design process that involved creating a selection matrix and carrying out surveys to key stakeholders, the group resolved to focus on redesigning creamery plastic bottles and integrating the recycling of aluminum bottles into Penn State's Mobius program.

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Concept Development

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Team 3 used six design criteria to determine which two concepts to pursue out of the initial three: aluminum containers replacing styrofoam to-go containers in the dining commons, aluminum containers replacing plastic Berkey Creamery beverage bottles, aluminum ceiling tiles replacing foam tiles in classroom buildings. As shown in Table 1 the first and most important criterion with a weight of 35%, was to maximize energy saved. The criterion with the next greatest importance was ease of implementation with a 30% weight. The next few criteria with weights of 10% were low cost, amount of impact, and functionality. The last criterion with the lowest weight of 5% was durability. After conducting the design selection matrix process, it was determined that the best concepts to continue with were aluminum food containers in the dining commons and aluminum beverage containers in the Creamery as they ranked highest in the selection matrix.

Table 1. Selection Matrix

Selection Criteria	**Weight**	**Food Containers**		**Beverage Containers**		**Aluminum Tiles**	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Maximize Energy Saved	35%	4	1.4	5	1.75	2	0.7
Low Cost	10%	3	0.3	3	0.3	2	0.2
Ease of implementation	30%	3	0.9	4	1.2	1	0.3
Scale (Convenience)	10%	5	0.5	4	1.6	3	0.3
Durability	5%	3	1.5	2	1	5	2.5
Functionality	10%	4	0.4	4	0.4	3	0.3
	Total	5		6.25		4.3	
	Rank	2		1		3	
	Continue	Yes		Yes		No	

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After the group narrowed down to two concepts, a survey was used to determine the final concept to pursue. A single survey that addressed both the food container and beverage container concepts was given to about 100 subjects using both in person interviews and the new media to

reach different groups of people across campus (see Appendix 1 for raw data). The results showed similar responses for both female and male students. Both groups of students tend to consume the same variety of beverages and recycle most of the time. Ultimately, team 3 decided to continue with the concept of aluminum Creamery beverage containers, in order to reach a larger consumer base and make a larger impact. This was due to the fact that 22% of people reported that they never get 'to-go' from the commons and 24% reported that they get 'to-go' slightly often, together this makes up almost 50% of our results (see Figure 1). On the other hand, in the results for the Creamery beverage containers only 15% of people reported that they never buy creamery beverages. In other words, the other 85% have purchased one or more drinks from the creamery in the past two weeks (see Figure 2).

Survey Results

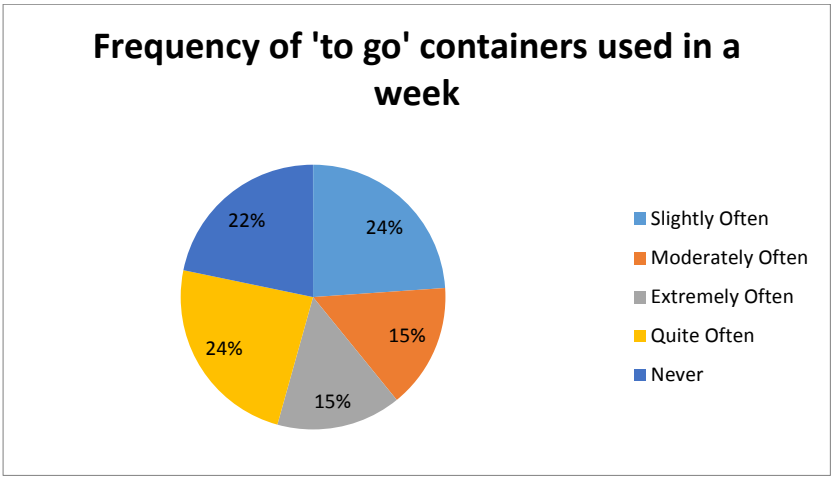

Figure 1. Frequency of Styrofoam containers used in a week

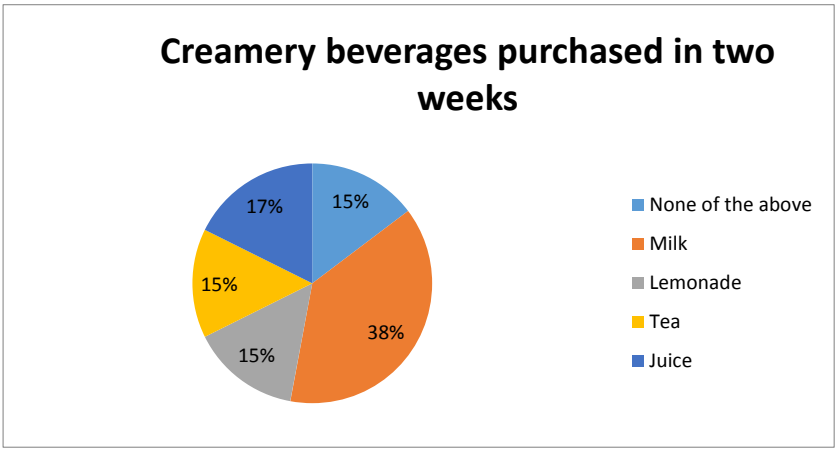

Figure 2. Creamery Beverages purchased in two weeks

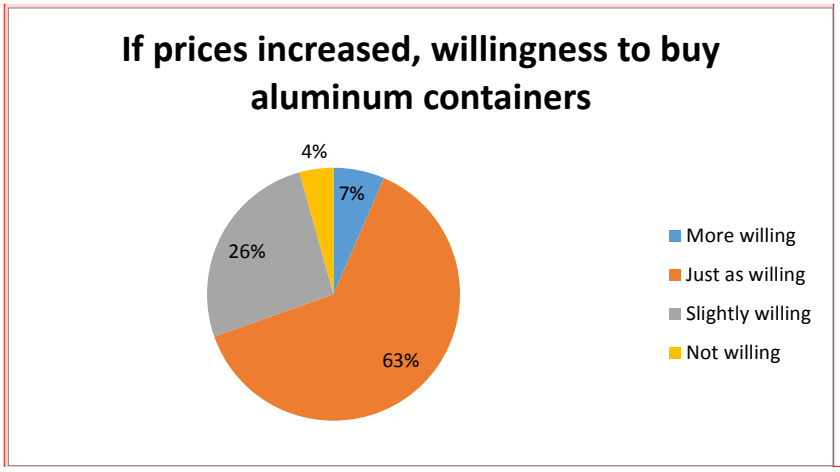

Figure 3. Response to a raise in price

Comment [K1]: Excellent work on the surveys - - - well done!!

The survey results along with the results from the selection matrix led to the decision of creating an original design of an aluminum bottle that could replace the current plastic one used on campus. The integration of the design on campus would affect different stakeholders including management and workers of the Berkey Creamery. Other key stakeholders would be consumers who include students, faculty, staff and visitors who would be impacted by a different package and a slight increase in price for beverages. In addition, the last key stakeholder of the

implementation of aluminum beverage containers for the Creamery is the Recycling and Waste management of Penn State via MOBIUS. There is already a large amount plastic and aluminum being recycled daily, but if the Creamery bottles were replaced with aluminum, there would be a significant increase in the amount of aluminum being recycled than plastic, and hopefully a larger incentive for students to recycle. Additionally, in the future new methods to promote aluminum recycling could be introduced. For instance, a card-swipe system could be placed around campus where a small sum of money would be reimbursed into student's Lion Cash for each bottle recycled. In a similar manner, students could bring in an empty aluminum bottle to the Creamery and receive a small discount on their next purchase. Funds for recycling incentive programs like these could be obtained from different recycling agencies that pay every pound of metal being sold to them.

Detailed Concept Development

When thinking of aluminum beverage containers, the first thing that came to the group's attention was an aluminum can design. After some thought, it was decided that the container should be able to reseal after opening like the current bottles. This would be beneficial to students that carry drinks in backpacks, purses, pockets, etc. It was also determined through research that aluminum is a better insulator than plastic, and therefore would be a better material for the beverage containers to keep the cooler longer, also benefiting consumers. The next idea came upon was a traditional glass bottle shape, but using aluminum rather than glass or plastic. It was then decided that the group wanted to create an original design for the bottle.

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Using solid works the group created a model for the bottle that the group designed as shown in Figure 4. The group decided to go for a classic, simple design that would be easy to manufacture and recognize. In order to show the bottle clearly the label was not placed but it will remain the same as the one currently in use.

Figure 4. Model for designed Aluminum Bottle

Another significant change in the design will also be the volume of the liquid; the measurements for the bottle are shown in Figure 5 where all dimensions are in inches. The new design will hold 500 ml, which is an increase of 27 ml that will allow the consumers to benefit from more product.

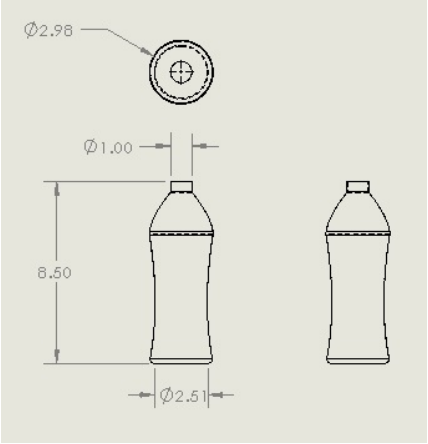

Figure 5. Drawing of Bottle with dimensions in inches

Furthermore, in redesigning the bottles it is crucial to account for the costs profits that will determine if the concept is profitable. First of all, the initial costs involve the fixed factors of production such as labor, machinery, and land. Assuming that we already have a factory, the initial cost of the new manufacturing machine would be $75,000. This machine would yield 500,000 aluminum bottles. Meanwhile, the NRE (Non-recurring engineering) based on two engineers each working two months for $5,000 a month, and one supervisor working one fourth of the time for two months for $8,000 a month, would result in a total of $43,200 (overhead included). Thus this first cost would sum up to $118, 200.

In terms of energy, 0.8KWh is used to produce one aluminum bottle. If not recycled, the effect would be equal to 3.13 KWh. Hence, the energy to produce one bottle would be 2.33KWh. The average cost of electricity in the US is $0.12 per KWh, so the total cost to produce one bottle would be $0.28. As for aluminum cost it would be $0.02 per bottle. However, because not all bottles are 100% recycled, virgin aluminum must be added making the total material cost $0.08 per bottle. As a result, the total cost per bottle is $0.36.

Then, if we produce 500,000 bottles, the production cost would be $180,000. The annual labor cost for one worker with a presumed wage of $40,000 a year would run the manufacturing process leading to an annual cost of $220,000. The calculations that sum these costs are seen in table 2 where it also shows that to achieve a 35.2% profit each bottles needs to be sold at a price of $0.63 a unit. Further calculations are seen in Appendix II.

Table 2. Summary of Costs

Discount rate	0.75%	Current U.S. discount rate (2013)
First Cost	$118,200	$75,000 capital for machine life of 250,000 units and NRE cost of $43,500
Annual Cost	$220,000	Fuel & Electricity to produce one bottle is $.28, material per bottle is $.08 and labor is $40k/year
Number of units sold annually	500,000	Output per machine
Cost per Unit	$0.63	Results in 35.2% profit

Conclusion

In this project team 3 designed a new sleek aluminum bottle that could be integrated into the Penn State Mobius program with the goal of increasing the sustainability of the campus. The design has many positive features that allow it to be a great insulator, easy to carry, save a significant amount of energy and provide a 100% recyclable bottle for Creamery beverages. The team is optimistic with the design as it was clear from the survey results that one of the key stake holders, the consumers, are eager to contribute and promote recycling across campus. It is true that costs are a setback but the design could be more feasible in the future with the implementation of a new recycling program that introduced a money incentive in recycling. Overall, the team learned more about the stages of the design process and the hard work that is required when designing a new product that will affect various stakeholders whom should always be accounted for. Ultimately team 3 hopes that in the future this design solution will be implemented along with other projects that will continue to promote the sustainability across campus.

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Appendix I

Team 3 Survey Results

Collected between Nov 17, 2013 – Nov 26, 2013 (A total of 93 respondents completed the survey)

Are you male or female?	Are you currently enrolled as a student?s	In the past two weeks, which of the following creamery beverages have you purchased? (please select all that apply.)	If the prices of beverages increased by 5% for the purpose of recycling, how willing would you be to buy the product	How likely would you be to use aluminum food and beverage containers?	How often do you recycle?	How often do you get 'to go' food from the dining commons?
Female	Yes, full time as an undergraduate student	None of the above	Just as willing	Moderately likely	About half of the time	Slightly often (one to two times a week)
Male	Yes, full time as an undergraduate student	None of the above	Just as willing	Moderately likely	Most of the time	Never
Female	Yes, full time as an undergraduate student	Milk	Just as willing	Moderately likely	About half of the time	Moderately often (three times a week)
Male	Yes, full time as an undergraduate student	None of the above	Slightly willing	Moderately likely	Always	Slightly often (one to two times a week)
Female	Yes, full time as an undergraduate student	None of the above	Slightly willing	Slightly likely	Once in a while	Quite often (five times a week)
Male	Yes, full time as an undergraduate student	Milk	More willing	Not at all likely	Always	Never
Female	Yes, full time as an undergraduate student	Lemonade	Just as willing	Slightly likely	Most of the time	Quite often (five times a week)
Male	Yes, full time as an undergraduate student	Milk	Just as willing	Very likely	Always	Quite often (five times a week)
Female	Yes, full time as an undergraduate student	Tea	Just as willing	Very likely	About half of the time	Quite often (five times a week)
Male	Yes, full time	Milk	Just as	Not at all	About half of	Extremely

	as an undergraduate student		willing	likely	the time	often (Everyday)
Female	Yes, full time as an undergraduate student	Milk, Lemonade, Tea	Just as willing	Moderately likely	Most of the time	Slightly often (one to two times a week)
Male	No, I am not currently enrolled as a student	None of the above	More willing	Not at all likely	Never	Extremely often (Everyday)
Male	Yes, full time as an undergraduate student	Juice, Lemonade, Tea	Just as willing	Slightly likely	About half of the time	Quite often (five times a week)
Male	Yes, full time as an undergraduate student	Milk, Juice	Just as willing	Very likely	Most of the time	Slightly often (one to two times a week)
Male	Yes, full time as an undergraduate student	None of the above	Slightly willing	Not at all likely	Most of the time	Slightly often (one to two times a week)
Male	Yes, full time as an undergraduate student	Tea	Just as willing	Moderately likely	Always	Never
Male	Yes, full time as an undergraduate student	Milk	Slightly willing	Moderately likely	Most of the time	Moderately often (three times a week)
Female	Yes, full time as an undergraduate student	Milk, Tea	Slightly willing	Not at all likely	Once in a while	Moderately often (three times a week)
Male	Yes, full time as an undergraduate student	Lemonade	Just as willing	Very likely	Most of the time	Slightly often (one to two times a week)
Male	Yes, full time as an undergraduate student	Juice	Slightly willing	Not at all likely	Most of the time	Slightly often (one to two times a week)
Male	Yes, full time as an undergraduate student	Milk	Just as willing	Moderately likely	Most of the time	Never
Male	Yes, full time as an undergraduate student	Juice	Just as willing	Moderately likely	Once in a while	Slightly often (one to two times a week)
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Male	Yes, full time as an undergraduate student	Juice	Just as willing	Slightly likely	most of the time	moderately often (three times a week)
Male	Yes, full time as an undergraduate student	milk, tea	Just as willing	very likely	About half of the time	moderately often (three times a week)
Male	Yes, full time as an undergraduate student	milk	Just as willing	moderately likely	once in a while	Extremely often (Everyday)
Male	Yes, full time as an undergraduate student	milk, tea	Just as willing	very likely	most of the time	Quite often (five times a week)
Male	Yes, full time as an undergraduate student	milk, lemonade	not willing	very likely	about half of the time	never
Male	Yes, full time as an undergraduate student	milk	just as willing	very likely	once in a while	Slightly often (one to two times a week)
Male	Yes, full time as an undergraduate student	milk, juice, tea	slightly willing	moderately likely	Always	quite often (five times a week)
Male	Yes, full time as an undergraduate student	milk, juice	just as willing	very likely	most of the time	Extremely often (Everyday)
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Female	Yes, full time as an undergraduate	none of the above	just as willing	moderately likely	always	quite often (five times a week)

	student					
Female	Yes, full time as an undergraduate student	milk	just as willing	very likely	always	Slightly often (one to two times a week)
Female	Yes, full time as an undergraduate student	milk, juice, tea, lemonade	slightly willing	moderately likely	most of the time	never
Female	Yes, full time as an undergraduate student	milk, juice	just as willing	moderately likely	about half of the time	quite often (five times a week)
Female	Yes, full time as an undergraduate student	milk	just as willing	moderately likely	most of the time	never
Female	Yes, full time as an undergraduate student	milk, juice, lemonade	just as willing	moderately likely	about half of the time	Extremely often (Everyday)
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Male	Yes, full time as an undergraduate student	milk, lemonade	not willing	very likely	about half of the time	never

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Appendix II

Cost Analysis and Calculations

Year	First Cost	Annual Cost	Annual Income per Unit
0	$118,200	$220,000	$312,500
1		$218,362	$310,174
2		$216,737	$307,865
3		$215,123	$305,573
4		$213,522	$303,298
5		$211,932	$301,040
6		$210,355	$298,799
7		$208,789	$296,575
8		$207,235	$294,367
9		$205,692	$292,176
10		$204,161	$290,001
NPV	$118,200	$2,331,908	$3,312,369
Profit %			35.2%

Note: this example is working with aluminum bottles (16.9 oz.) assuming that one aluminum bottle estimates 2 aluminum soda cans for thickness

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Images

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