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Sustainability at East Halls

Alcoa

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EDSGN 100
Section 17

Our goal is to utilize the efficient use of aluminum and its properties in order to provide more of its benefits throughout the campus while ensuring that the solution meets all performance requirements, is economically viable, and corresponds with applicable regulatory codes. Keeping this in mind, we developed a three-pronged approach using aluminum keys and locks, aluminum fans, and aluminum take-out containers to reach our goals.

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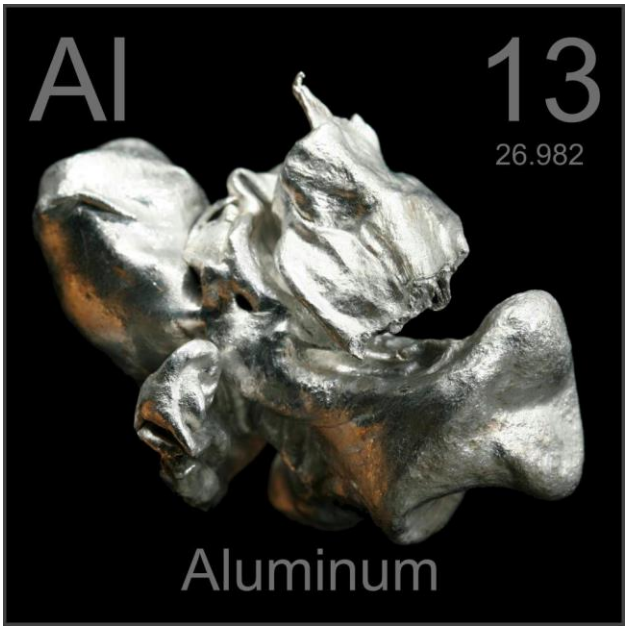
Recognize the Need

Aluminum has many properties that make it very unique. The silver, soft metal is very low density but durable and strong which makes it a good substitute to other metals. For example, it is a third of the weight of steel but can be just as useful. Also, one layer of aluminum is as effective as four inches of brick or ten inches of stone. In addition to its strength, aluminum is as ductile and malleable. Aluminum is also non-magnetic and non-corrosive which again makes it a good substitute. However unique, aluminum shares several properties with many metals which make it very useful. It is a good thermal conductor as well as a good conductor. Aluminum is actually twice as conductive as copper. Many of these properties make aluminum beneficial for packaging like cans, transportation, construction, household items, and electronics. Often aluminum alloys are used instead of pure aluminum to change its properties to make aluminum even more suitable for different functions. Some examples of important aluminum alloys include Alclad aluminum, Titanal, and Duralumin. Many of aluminum alloys make aluminum stronger under higher temperatures for use in aerospace and engine pistons.



Aluminum was discovered in the 1820s and is the most abundant metal on earth. The recycling of aluminum has great importance because of time and energy consuming process raw aluminum must go through to be ready for use. Making a new aluminum can from recycled cans takes 95% less energy than using raw aluminum. The recycling of aluminum is also a much

quicker process than refining the raw material. An aluminum can be recycled and put back on the shelf in a grocery store in as little as 60 days. The recycling process is fairly simple in that the aluminum is cleaned, undergoes moisture tests, is shredded, de-lacquered to remove inks and dyes, melted to molten aluminum again, and then put into large ingots which will then finally be flattened to be made into cans and other products. The production of aluminum from raw materials is a much more complicated process starting with the Bayer Process involving the bauxite. The Bayer Process removes the aluminum oxide from the bauxite and then the aluminum oxide is reduced to aluminum metal in the Hall-Heroult Process. Finally, the molten aluminum is mixed with the desired alloys and cast into ingots. Alloys are metallic materials consisting of two or more elements combined in a way that they cannot be physically separated. Alloys are designed for specific resistance to things such as corrosion, wear, fatigue, and temperature. Aluminum is an alloy with small amount of many different metals such as silicon, iron, copper, and magnesium.

Define the Problem

Everywhere, people are becoming much more aware of their impact on the Earth. The increase has caused a demand for more sustainable and efficient solutions to certain problems like energy and other resources. Campuses across the nation have become more of aware of their consumption and have turned towards more sustainable options. Penn State does very many things to help be more efficient like switch from the oil to natural gas. However, there are always ways to improve the sustainability. One of the best ways to do that is to look at the areas where Penn State

has large amounts of consumption. East Halls is without a doubt one of the busiest and highly populated residence areas on campus. Considering the number of people living in East Halls, there is a large amount of waste produced and energy consumed. The Eco-reps in the halls do their best but East halls as a whole need to put in a better effort. They use Styrofoam, large amounts of energy for heating, and much more. Considering this, East halls would make a good place to start to improve the efficiency and sustainability in energy usage and consumption.

The stakeholders are the students, teachers, faculty, and Alcoa. The students will be affected by any changes made on campus, making their opinions very important in the decision process. The teachers and faculty will also be directly affected by many changes that could be made. The way they will be affected must be taken into account when deciding how to solve the problem. Alcoa is also an important stakeholder. Alcoa provided the topic for the design project and they are paying to receive our ideas so their input is very important.

Specifications

Our first specification is cost efficient. The price of the solution cannot outweigh the benefits it will provide. One solution may seem really like the best choice but if the university cannot afford to implement the idea, then it cannot go into effect. Another specification is energy efficient. Aluminum must be used in some way to make east halls more energy efficient whether it be through power or recycling. Without energy efficiency, the solution will not fulfill the requirements of the project or construct a viable solution to the problem. Ease of installment is another specification the solution must meet. The solution must be easy to install and replacement or it will not be as cost effective. Also, the time it takes to install and replace must be taken into account for overall efficiency. The lifespan of the product or solution must also be

thought about. If the solution does not solve the problem for a large amount of time then it will not be very effective. In addition, long term sustainability is another specification. The solution must make the current situation more efficient while not damaging future use or materials. Our last specification is the usage of readily available materials, which would be aluminum in this case. Aluminum must be used because it is a requirement in the design prompt. If it is not used, then the requirements for the solutions is not met.

Table 1. Specifications

Specifications
1. Cost Efficient
2. Energy Efficient
3. Ease of Installment/Replacement
4. Long Term Sustainability
5. Usage of Readily Available Material(Aluminum)

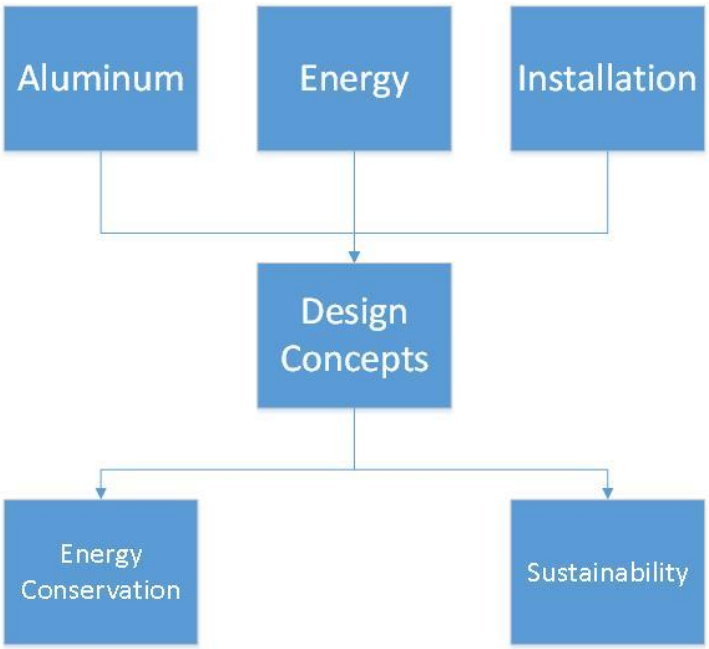


Table 2. Pairwise Comparison Matrix

Criteria	Cost Effective	Ease of Installment	Uses Aluminum	Energy Efficient	Sustainable (long term)	Total	Weights
Cost Efficient	1	1/2	1/6	1/5	1/2	2.367	**0.05**
Ease of Installment	2	1	1/8	1/8	1/6	3.417	**0.07**
Uses Aluminum Effectively	6	8	1	1/2	1/2	16	**0.31**
Energy Efficient	5	8	2	1	1/2	16.5	**0.32**
Sustainable (Long term)	2	6	2	2	1	13	**0.25**
					Total	**51.28**	

Brainstorming

Aluminum Take-Out Containers

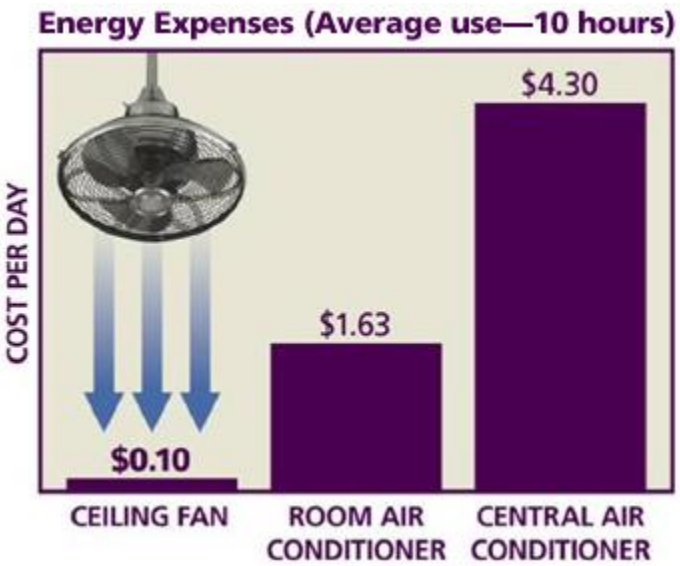
One of the many ways to improve East Halls is to stop the usage of Styrofoam containers as take out containers. Styrofoam never decomposes so all the take out containers will sit in a landfill forever. There is only a limited amount of space in landfills so there must be a better way to conserve space. We can effectively do this by using aluminum take out containers. Even though Styrofoam is a good insulator, aluminum can be recycled allowing the take out containers to go through the recycling process to be reused instead of going to the landfill. Also, using aluminum foil for packaging sandwiches and hoagies instead of paper will allow even more recycling to maximize the sustainability of East Halls.

Passive Water Heater

A passive water heater is a simple way to utilize efficient aluminum use. It is convenient and can be placed nearly anywhere outside. The water heater has a solar panel that converts the energy from the sun into heat that can be used to warm an entire building. East halls could benefit from these water heaters by cutting down on electrical costs. The aluminum provided is a good transfer component and allows both hot and cold water to flow in and out of the heater with ease. During cold winter months, the school would save more due to the fact that the solar heater is capable of enduring extreme conditions and they would not have to maintain such a high energy bill.

Aluminum Fans

Ceiling fans can be made from various materials with plywood being the most common. Recently, aluminum fans are starting to be more readily used. Aluminum when recycled, can be very inexpensive and is also very lightweight. Aluminum fans would be more cost efficient than the plywood fans becauses the price of a pound of aluminum is around $0.94 while a pound of plywood is around $1.13. In addition to be cost efficient, since the ceiling fans would be lighter they are more energy efficient. If installed in the Findlay Commons in



East Halls, they would decrease the energy and cost of cooling and circulating air. They would be installed in computer labs which are always extremely warm, even in the winter. The fans could also be installed in the dining hall, study lounges, and other areas throughout the commons.

Aluminum Keys

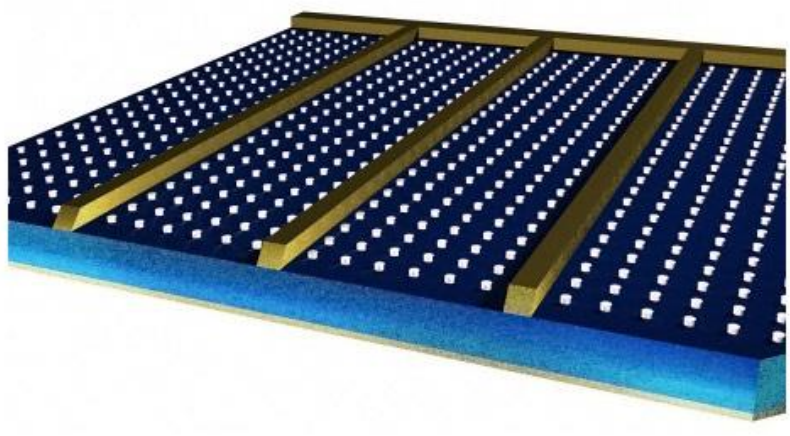
Every year, East Halls goes through so many keys when changing locks for the new freshmen moving in. After keys are used, they often just get thrown away. There must be a better way to change the locks without having to waste the keys from the previous year. By using aluminum keys, they could be melted and recycled into new keys so that not only does the campus stop wasting metal, it can save in the long run by not purchasing new metal for keys.

Aluminum window frames

Students have complained about the high temperature in the computer lab located at basement of the Findlay Commons. Since the windows installed in the computer lab won't allow the heat to transfer out efficiently, the heat is cumulated up to an uncomfortable level. By replacing the low heat conductive frame using the highly heat conductive aluminum window frame, the room temperature will decrease to a satisfactory level. Aluminum is a super effective heat conductor that can be used for different cooling system. The aluminum frame can efficiently transfer heat out from the room when the room temperature is high. The lightweight aluminum frame are also easy to install, to replace, and to recycle. The strength of the metal will also provide sustainability to the product.

Solar Panels with Aluminum Studs

Solar panels are already being used to provide energy for many buildings and homes. A new solar panel technology has been developed where cylindrical aluminum studs are placed on top of the panels. The aluminum studs reflect and scatter the light without absorbing it and greatly increase the amount of light trapped in the absorbing layer, increasing the electric current by as much as 22%. These solar panels could be installed in the Findlay Commons in East hall and well as on the dorm buildings to supply a more efficient and clean form of energy.



Evaluation

Table 3. Screening Matrix

Selection Criteria	Fans	Keys and Locks	Solar Panels	Passive Water Heater	Take-out containers	Window Frames
Cost Efficient	+	+	-	-	0	+
Ease of Installment	0	+	-	-	+	0
Uses Aluminum Effectively	+	+	0	+	+	+
Energy Efficient	+	+	+	0	+	+
Sustainable (Long Term)	+	+	0	-	+	+
+	4	5	1	1	4	4
0	1	0	2	1	1	1
-	0	0	2	3	0	0
Net	4	5	-1	-2	4	4
Ranking	2	1	3	4	2	2
Continue?	Yes	Yes	No	No	Yes	No

Table 4. Decision Matrix

		Ideas					
		Take out Containers		**Fans**		**Passive water Heating system**	
Selection Criteria	**Weight**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Cost Efficient	5%	2	0.10	4	0.20	1	0.05
Ease of Installment	7%	5	0.35	3	0.21	1	0.07
Uses Aluminum Effectively	31%	5	1.55	5	1.55	5	1.55
Energy Efficient	32%	3	0.96	2	0.64	2	0.64
Sustainable (Long Term)	25%	4	1.00	4	1.00	2	0.50
	Total Score	3.96		3.6		2.81	
	Ranking	2		3		6	
	Continue?	Yes		Yes		No	

		Ideas					
		Solar panels		Keys and Locks		Window Frames	
Selection Criteria	**Weight**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Cost Efficient	5%	1	0.05	4	0.20	3	0.15
Ease of Installment	7%	3	0.21	5	0.35	4	0.28
Uses Aluminum Effectively	31%	3	0.93	5	1.55	4	1.24
Energy Efficient	32%	4	1.28	3	0.96	2	0.64
Sustainable (Long Term)	25%	2	0.50	4	1.00	5	1.25
	Total Score	2.97		4.06		3.56	
	Ranking	5		1		4	
	Continue?	No		Yes		No	

Looking at the information we have collected, we used two different comparison matrices to decide which of the solutions should be implemented. The screening matrix helped eliminate two out of the six ideas but we felt that four would be too many so we used the weighted decision matrix. Utilizing that, we were able to narrow our choices better.

Table 5. Cost Analysis

Taking into account all the specifications, we were able to narrow down our ideas very effectively. Our solution to the problem is to implement a 3 pronged approach to make East Halls more efficient and sustainable using aluminum. We will change the take out containers from Styrofoam to aluminum, install ceiling fans in Findlay, and replace the keys with aluminum substitutes. That way we can help the university become more efficient and less wasteful with resources while also being cost efficient.

Cost Analysis		
Ideas	**Cost**	**Details**
Solar Panels with Aluminum Studs	$53,000	Price for one solar panel, including installation, parts, warranty, and labor
Keys and Locks	$0.68	Price per key there are 14 buildings in East Halls each with around 140 room so around 1,960 keys and locks would be need
Window Frames	$250-$300	Includes material and installation
Fans	$39.95	Price for one fan does not include installation
Containers	$350.00	Price for 2,500 9” containers
Passive Water Heater	$4,019.27	Price for 120 gallon tank. Eleven water heaters would be needed for each building.

Solution

After brainstorming and performing the evaluation the lock and key, take out containers, and fans were chosen for the solution to the problem. Through the screening matrix the lock and key met all of the specifications so this solution will be continued. The lock and keys would be cost efficient because the cost of using aluminum keys rather than the current keys is relatively the same. The benefits of using these keys are greater than using the current keys because of the amount of energy that will be conserved through the recycling process. The lock and key solution meets the energy efficient specification through recycling of the keys. At the end of each year the keys can be recycled to produce the new keys for next year. The recycling process will use much less energy than completely creating new keys. By recycling the keys 95% less energy will be used than producing new keys from raw materials. Currently the locks are already easily changed due to the fact that many residents lose their keys and the locks then must be replaced. The installment would take around an hour and can be done fairly easily so the lock and key solution readily meets the ease of installment and replacement specification. The lock and keys also meet the long-term sustainability because of the energy being conserved due to the recycling of keys; resources of aluminum and energy are being preserved for future generations.

Finally, the lock and keys meet the last specification of use of readily available material, aluminum. Since both the locks and keys will be made of aluminum, the material is being used its fullest in this case.

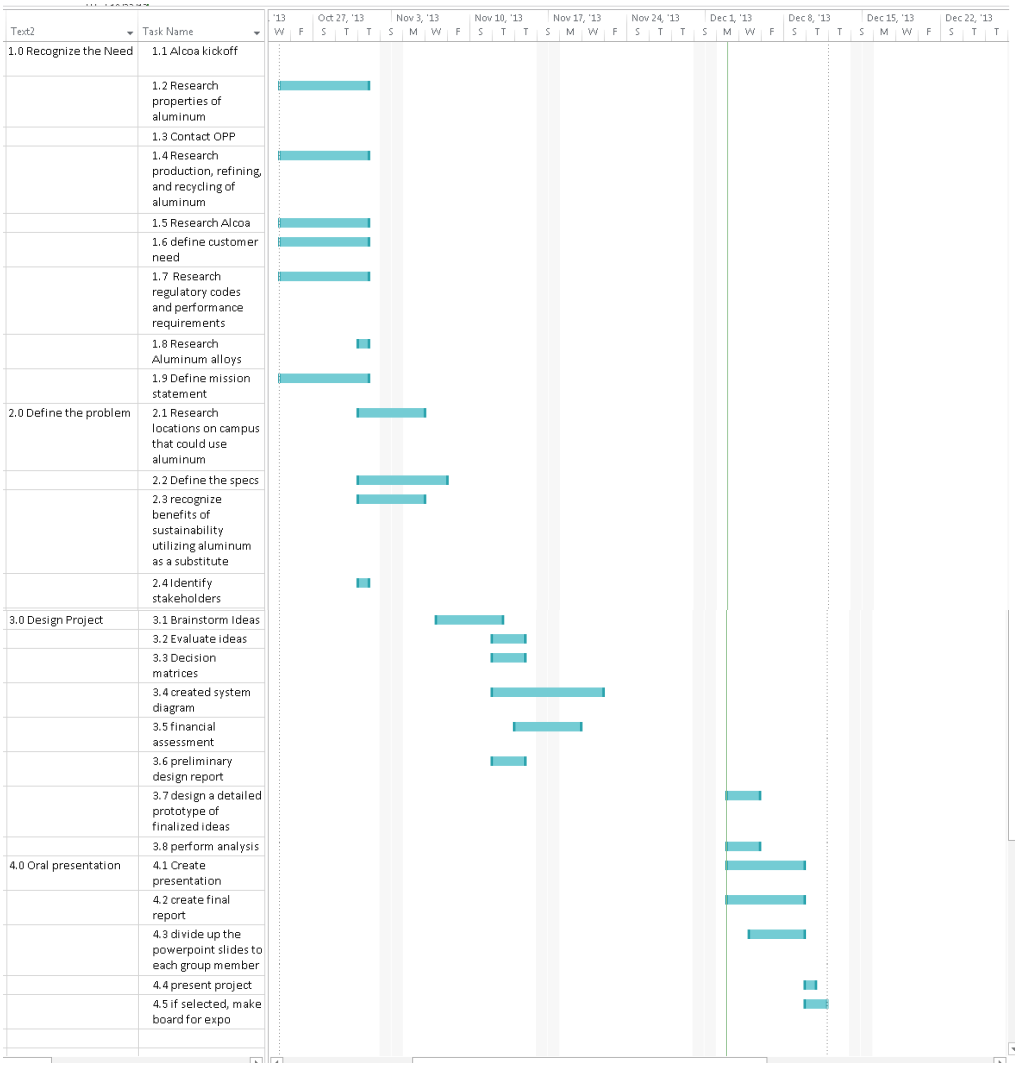
The fans are another solution to the problem, which met the designated specifications. The fans effectively meet the energy efficient specification due to how lightweight they will be due to the aluminum structure. Aluminum is lighter than the standard material ceiling fans are made from so less energy will be used to run them. A central air conditioner uses about 3,500 watts while a ceiling fan uses between 15 and 95 watts, demonstrating a drastic difference in energy use. The fans are also easily installed, meeting the ease of installment and replacement specification. Each fan will only take a couple hours and rarely have problems after installation. The fans are also cost efficient. A room air conditioning cost more than 15 times the amount of that the aluminum fans cost and the aluminum fan costs 40 times less than central air conditioning. Since the cost to run the fan is so much less than the cost of the air conditioning currently being used the fans would meet the required cost efficient specification. The fans also provide long-term sustainability through the energy large amount of energy saved. The fans will also last a long time so they will not need to be replaced very often. Since the fan will be made out of aluminum it meets the specification of use of readily available materials.

The take out container also meet the selected specifications. The current material being used is not easily recycled so switching to aluminum container would drastically change the energy consumed. Since the recycling of aluminum uses very little energy, less than 5% of the energy used to make it from raw materials, the take out containers meet the energy efficient specifications. The take out containers would be very easy to implement because the university would simply have to order the aluminum containers rather than the Styrofoam ones currently

being used. There would be no installation cost other than shipping which the university already must pay for when ordering the current Styrofoam containers. The replacement cost of aluminum containers would be slightly more expensive than the replacement cost of Styrofoam containers. Overall though, the containers meet the ease of installment and replacement specification. The take out containers also meet the cost efficient specification. After researching costs of Styrofoam and aluminum containers, the aluminum containers actually turned out to cost 28% less than the current Styrofoam containers. The take out containers would also provide long-term sustainability because of the amount of energy saved and aluminum being recycled. The more aluminum is recycled the less raw materials and energy will be used to produce more, ultimately conserving the limited resources for the future. Since the take out containers would be made from aluminum the use readily available materials specification would be met.

In conclusion, the lock and keys, fans, and takeout containers met all of the specification that were selected based on the customer needs Each of these solutions will make the campus more energy efficient and also provide long term sustainability while adequately using the desired material of aluminum.

Project Management



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