Alcoa – Sustainability Project

EDSGN 100 Section 24

Submitted to: Professor Sven Bilen

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FINAL REPORT

Team 3
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Executive Summary:

The main objective of this project was to design a product/redesign an engineering system on campus that uses aluminum to satisfy consumer needs and complaints. We gathered this feedback to break down what is most important and what is out of reach. Our overall concentration of this design project is sustainability and we created an efficient way to improve the Hammond Building on campus. We implemented an aluminum curtain wall, aluminum doors and rails and aluminum window frames.

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1.0 Abstract

This project incorporates Aluminum in a system on campus to make it more sustainable. To do this, we vigorously tested every aspect of the Aluminum, such as strength, durability, weight, etc. After collecting our data, we assessed our data to see where in the building Aluminum could be used for the purpose of increasing the efficiency or sustainability of products and product systems.

We combined the proposed areas of improvement with our customer needs, brainstormed ideas to redesign the structure, and applied our designs to create a better Hammond.

1.1 Problem Statement (A.)

Our initial problem statement was based on Alcoa's statement of work which is to recognize an opportunity across the campus to take advantage of aluminum's intrinsic properties for the purpose of increasing the efficiency or sustainability of products and product systems.

2.0 Introduction

This project incorporates Aluminum in a system on campus to make it more sustainable. To do so, we vigorously tested every aspect of the Aluminum, such as strength, durability, weight, etc. Collected and assessed data to see where in the building aluminum could be used to increase sustainability in product systems and efficiency

Following this we:

- combined the proposed areas of improvement with our customer needs
- brainstormed ideas to redesign the structure internally and externally
- applied our designs to create a better Hammond

3.0 Mission Statement

To redesign the Hammond Building (College of Engineering) to be more sustainable. Our goal is to make it more convenient and efficient for students who use it whether engineering/non-engineering students or faculty. Our main objective is to involve the design and application of aluminum products to improve the efficiency of energy use and/or increase sustainability of the Penn State campus.

4.0 Customer Needs Analysis

In order to find out what aspects of the Hammond building our team was going to redesign or improve upon, we decided that making an online survey would be the best option. We used survey

monkey to make a survey that allowed for participants to answer our open ended questions and comment freely on their thoughts of the efficiency of the Hammond building. The best way to get our survey out there was through social media such as facebook. We shared the link to the survey by posting it onto various group pages like the engineering groups and organizations, as well as the class page so we can get comments from non engineering students who may use Hammond for other classes. There is a link to the survey on our homepage by clicking the survey monkey icon.

Table 1. Initial Customer Needs List

1)need new elevators
2)bad insulation
3)confusing layout
4)new water fountains
5)renovations to kunkle lounge
6)locations of entrances

4.1 Hierarchical Customer Needs List

Customer needs have been collected and placed in a table with a rating scale from 1 to 5. 1 being least important and 5 being most important.

Need Number	Need	Importance
1	New Elevators	4
2	Building Layout	5
3	Insulation	5
4	Water Fountains	2
5	Entrance Locations	3
6	Kunkle Lounge Renovation	3
7	Aluminum Windows	4
8	Green Roof	3
9	Non-toxic painting	3

4.2 Customer Interviews and Feedback

Questions used in our interview

1)Do you know where the college of engineering is ?
2)In your mind,What image do you have of the College of Engineering ?
3)What are some the things you could fix in this building? Or what would you like to see in the future college of engineering ?
4)Do you know about ALCOA?
If the answer is YES:
What do you know about it?Where have you heard of it ?
If the answer is NO:
Do you know where Aluminum is used on campus ?
5) where in a building is Aluminum used ?

Staff Interview

1.) Do you know where the College of Engineering building (Hammond building) is on campus?
2.) Compared to your College's building, how do you think the Hammond Building compares?
3.) What do you like or dislike about the Hammond Building?
4.) How do you think the College of Engineering building can be improved?
5.) What makes the building of your College recognizable?
6.) What would you expect out of a top quality engineering facility? Things that you would change in the Hammond Building?
7.) How do you think aluminum can be incorporated into the Hammond building when renovated?

College of Engineering Staff Interview

1.) What do you like/dislike about the Hammond Building?
2.) What do you think are the major flaws in the design of the building? How would you change/improve them?
3.) What are the major benefits of the design of the building?
4.) How do you think the Hammond Building compares to the buildings of the other Colleges around campus?
5.) How do you think the Hammond Building can be renovated to have a recognizable entrance?
6.) How can we incorporate a sustainable aluminum design to the building?
7.) What sustainable benefits do you think could be added as renovations to help the building?

Key points discussed with Clark Colborn, Facilities Administration Officers:

- 600 ft long steel curtain wall
- 10 million dollars in the money
- little decisions like diffusers
- store front entrances
- the main entrance

- recycled glass
- inner face and outer face of aluminum
- atrium in between the Engineering Units
- Insulated panels
- LEED

4.3 Metric Table

Metric Number	Need Number	Metric	Importance	Units
1	3,7	Weatherproof	5	inches, feet, yards
2	2,6	Aesthetics	4	scale
3	5	Convenience	4	scale
4	1,9	Safety	3	scale
5	8	Ecofriendly	3	scale
6	4	Systematical	2	scale

5.0 External Research

There a many buildings across the Penn State campus that we looked at to redesign the Hammond Building. One that comes to mind is the Business Building's entrance. It is the very large and stylish giving the College of Business a powerful presence. The windows of the IST Building give shade and prevent some sunlight from entering. For The Earth and Mineral Science Building, we liked the new and updated approach of the design. So we combined the main aspects from all of these buildings in our redesign of Hammond.

5.1 Online

Most of our online research came from other engineering institutions at various universities. We based the entrance of our design from the layout of the entrance for the University of Southern California's engineering building. We also looked at the Texas A&M's engineering building for the updated look and roof. The idea of aluminum windows was influenced by the University of Utah's aluminum approach. First we learned of the importance of aluminum windows through ALCOA's website. We also gained insight on curtain walls from various websites of engineering firms and building companies, in which we inquired how to incorporate aluminum.

5.2 Library Research

For other research, we gained most through interviews. We interviewed faculty and students. The most beneficial piece of information came through Clark Colborn, the Facilities Administration Officer of the Penn State College of Engineering. He gave us insight into future renovations of the Hammond Building. Also, he helped point out some flaws that will be fixed in the renovations, along with how we can incorporate aluminum into the design. We gained more knowledge into the history of the building too, which helped us understand the design aspects and how to change them properly to function.

5.3 Patent Research

Charles Martin Hall, the inventor of the aluminum making process had difficulty patenting his work. Paul Heroult of France had submitted a similar proposal at an earlier date. However, Heroult did not properly express his ideas. On May 22, 1886, the patent of Hall's was approved. Hall and his partners the Cowles brothers had disputed over these patents with countless lawsuits. The Cowles used the process patented by Hall without proper consent but eventually came to an agreement.

5.4 Product Dissection

i- Art Function Matrix for Hammond

Function		Art		
	Aluminum making process by electrolysis	Insulated aluminum windows	Extruded aluminum jamb moldings	A vertical square tube, a transverse square tube, an aluminum plate component and an aluminum alloy pressure block.
Aluminum	U.S. Patent 400,464			
Aluminum windows		U.S. Patent 2792090A		

Extrude Aluminum door frame			US 20090211184 A1	
Aluminum Curtain Wall				CN 102953474 A

5.5 Product Archeology/History

Hammond Building On Its Side?
Perhaps best known as the longest eyesore on campus, Hammond Building is at the center of another popular campus myth. Stretching for 609 feet and nearly three blocks along College Avenue, the popular folklore surrounding Hammond is that it was originally intended to be built vertically from its site. Legend has it that its long hallways were meant to serve rather as elevator shafts, but a conflict between architects and engineers resulted in it being constructed "on its side."

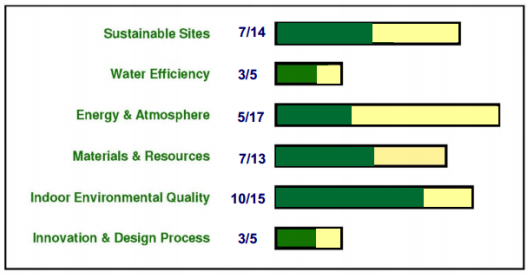
"Architectural follies and architectural acts of revenge are frequent campus legends," said Simon J. Bronner, Distinguished Professor of American Studies and Folklore at Penn State Harrisburg and author of Piled Higher and Deeper. Both Bronner and Penn State historian Michael Bezilla have investigated Hammond's original plans in an effort to dispel this myth. Records confirm it was designed as a horizontal building and never intended to be a skyscraper.

5.6 Benchmarking

i-Benchmarking Table

Since our project involves a building and not a product that we are comparing against a market. In this report, we have adapted the LEED program to benchmark against other Penn State Building on Campus,University Park. This idea was suggested to us by Mr.Clark during the interview. In the table below, We benchmarked Hammond to the Student Health Center, School of Arch Landscape Arch., the Alumni Center, and the Millenium Science Complex.

LEED Scorecard Illustration



Total Credits Expected: 35 LEED Certification pending

Overall LEED Performance

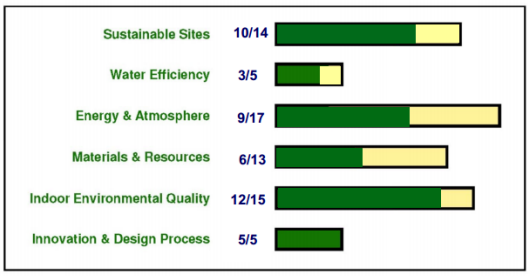
- Expecting Silver
- Integration of efforts by PSU, the GC and the design team
- Completed in May 2008

PENNSTATE

Student Health Center
The Pennsylvania State University, University Park, PA

Student Health Center

LEED Scorecard Illustration



Total Credits Received 45 LEED Gold Certification 2007

Overall LEED Performance

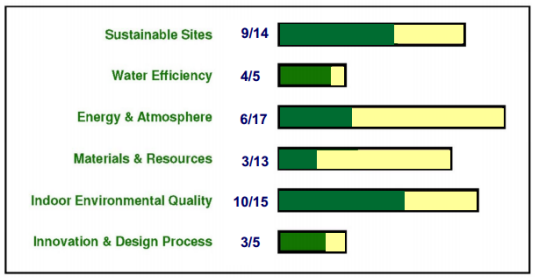
- Penn State's first LEED certified building
- 87% of facility materials were locally sourced
- 79% of construction "waste" was recycled
- Completed in Summer 2005

PENNSTATE

School of Architecture and Landscape Architecture
The Pennsylvania State University, University Park, PA

School of Architecture and Landscape Architecture

LEED Scorecard Illustration



Total Credits Expected: 35 LEED Certification pending

Overall LEED Performance

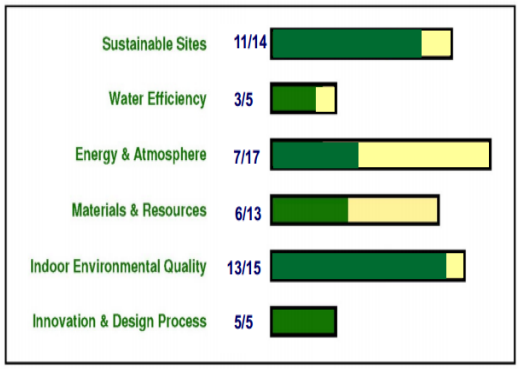
- Expect Silver
- Integration of efforts by PSU, the GC and the design team
- Expected Completion May 2010

PENNSTATE

Robert and Sally Metzgar Admissions and Alumni Center
The Pennsylvania State University, University Park, PA

Robert and Sally Metzger Admissions Alumni Center

LEED Scorecard Illustration



Total Credits Expected: 45 LEED Certification pending

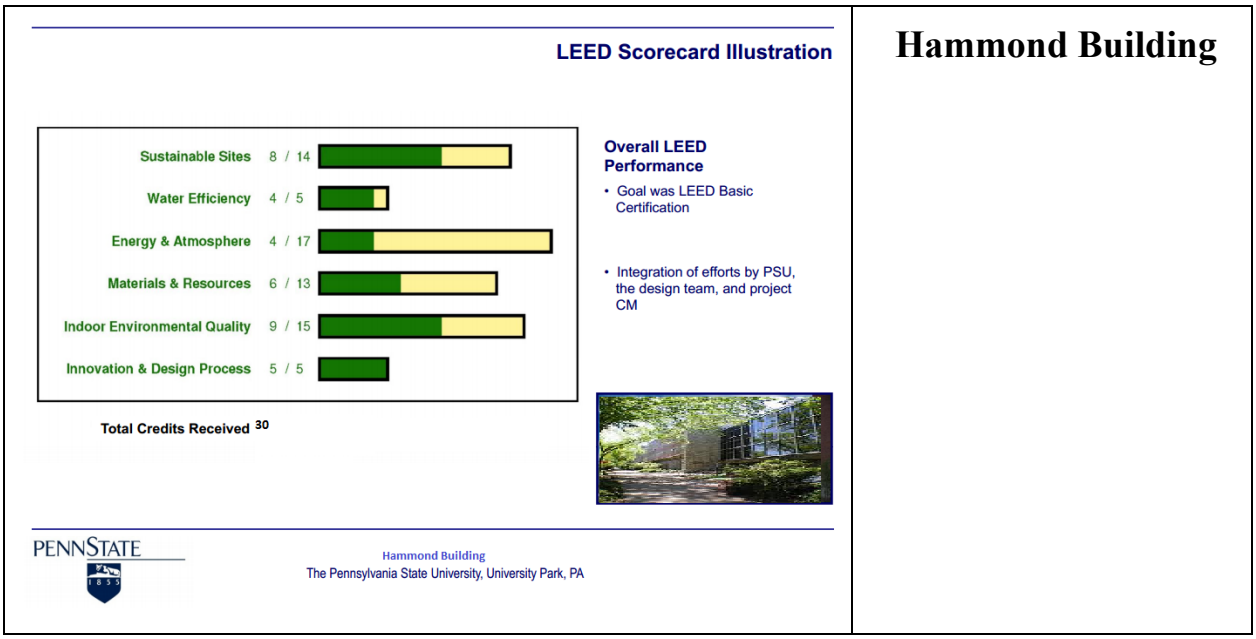
Overall LEED Performance

- Expecting Gold
- Integration of efforts by PSU, the GC and the design team
- Expected completion summer 2011

PENNSTATE

Millennium Science Complex
The Pennsylvania State University, University Park, PA

Millenium Science Complex



6.0 Concept Generation (B.)

We have five concepts that we generated based off of our needs and specifications. The following are our various ideas.

1. <u>New Aluminum Curtain Wall</u>

This design is based off of the current design but is however refined. We refined this design by using an all aluminum design, making the wall more efficient. The windows will be aluminum windows which can help generate heat and help deflect glare. The window panes can also be made out of aluminum to help with the material cost of not having to change the materials on the wall. This design is more efficient at holding a thin layer of insulation between the two walls than it was before.

2. <u>Aluminum Entrance</u>

To add to the new, updated style, we decided that adding a grand entrance to the building can help with a modern look. The sleek look of aluminum adds updated looks to the building and also makes the main building of the college stand apart from other buildings. We can build this out of recycled aluminum, making the design more environmentally efficient. This would also give the College of Engineering a signature look.

3. <u>Atrium</u>

There are plans for an atrium to be added on the side of the engineering units, in which the units will be removed. This atrium can be used for many things including studying or leisure activities, celebrating the College of Engineering. Aluminum can be used for benches to help with cost of materials. There can also be reflective aluminum panels used to redirect light within the atrium, saving electrical power to the

area.

4. Green Roof
Another addition that is plausible to the Hammond Building is to add aluminum panels to the roof that can be used as solar panels. The suns energy on these can either be used for heat or electricity. This woudl also have a garden on top around the panels for environmental friendliness. Either way, this design can save a great cost in the long run. This is also good for the environment because the panels can be made of recycled aluminum and be put to a very effective function.

5. Kunkle Lounge Renovation
Another concept that we generated was the renovation of the Kunkle Lounge. To add to the lounge, we can use larger glass windows to let light in held by aluminum frames to save money. The chairs and tables can be made to an ergonomic fashion out of aluminum. This would give the building a modern look to it and a nice feel. The framework for the steps and rails can also be used out of aluminum. This would make it possible to expand the lounge outward for a larger study area, in which we can add a library.

6. Underground Units
In the new design of the Hammond Building, the Engineering Units to the side of the building will be demolished in the process. To save room and allow for expansion of the building, we believe using very strong aluminum, build underground storage units to save room.

6.1 Concept Generation Table

Concept generation answers the question of "how" the product will satisfy the customer needs as mapped into the functional specifications.

In this Concept Generation Table, we portrayed the numerous ideas we came up with in analyzing the consumer needs and feedback. We have each design characteristic that was listed through customer needs, listed below with the ratings from 1-5. 1 being the least valuable and 5 being the most valuable to the customers.

Criteria	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6

Versatility	5	3	3	5	3	3
Durability	3	3	5	4	3	5
Style	3	5	4	1	4	3
Environmental	4	4	3	4	5	3
Cost	1	4	1	2	4	2
Efficiency	5	2	3	5	3	3
Aesthetics	3	5	3	3	3	3
Ease of Use	3	3	3	1	4	3

6.2 Design Selection (C.)

i-Concept Screening Table

In the concept screening table, a plus is used for a positive effect to the criteria, while a minus is used for a negative affect to the criteria. A 0 means that the design is not correlated to that criteria.

After taking into account for all of the positive and negative effects, we ranked them on a scale from 1 to 6.

Selection Criteria	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6
Versatility	+	0	0	+	0	0
Durability	0	0	+	+	0	+
Style	0	+	+	-	+	0
Environmental	+	+	0	+	+	0
Cost	-	+	-	-	+	-
Efficiency	+	-	0	+	0	0
Aesthetics	0	+	0	0	0	0

Ease of Use	0	0	0	-	+	0
Sum +'s	3	4	2	4	4	1
Sum -'s	1	1	1	3	0	1
Rank	3	2	5	4	1	6
Continue?	Yes	Yes	No	Yes	Yes	No

ii- Concept Selection Matrix Table

		Concepts											
		A		B		C		D		E		F	
		Design 1		Design 2		Design 3		Design 4		Design 5		Design 6	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Versatility	5%	5	0.25	3	0.15	3	0.15	5	0.25	3	0.15	3	0.15
Durability	15%	3	0.45	3	0.45	5	0.75	4	0.6	3	0.45	5	0.75
Style	8%	3	0.24	5	0.4	4	0.32	1	0.08	4	0.32	3	0.24
Environmental	15%	4	0.6	4	0.6	3	0.45	4	0.6	5	0.75	3	0.45
Cost	20%	1	0.2	4	0.8	1	0.2	2	0.4	4	0.8	2	0.4
Efficiency	22%	5	1.1	2	0.44	3	0.66	5	1.1	3	0.66	3	0.66
Aesthetics	12%	3	0.36	5	0.6	3	0.36	3	0.36	3	0.36	3	0.36
Ease of Use	3%	3	0.09	3	0.09	3	0.09	1	0.03	4	0.12	3	0.09
	Total Score	3.29		3.53		2.98		3.42		3.61		3.10	
	Rank	4		2		6		3		1		5	
	Continue?	yes		yes		no		yes		yes		no	

7.0 Review of Design Features (D.)

7.1 Problem Identification

The main problems with the Hammond Building are the curtain wall and the entrance to the building. There is no main and captivating entrance to the Hammond Building. Without the signature entrance, people will have a difficult time finding the building. The curtain wall facing College Avenue is very thin, but is yet a good idea. However, it is outdated and starting to wear away to an extent. The windows are very old and along with the alloy wall, insulation, and wood panels, are not very effective anymore.

7.2 Product Specifications

We determined to improve the design of the Hammond Building by modernizing, making more

efficient, and incorporating a versatile metal of aluminum. To accurately find our specifications, we used our surveys, analyzed customer needs, used research, and interviewed staff. Some of the specifications that we drew from our information are an environment friendly design, that is durable, aesthetically pleasing, stylish, efficient, and that has high aluminum use. Through the surveys and customer needs assessments, we determined that efficiency and location of key features is very important to students and faculty. Due to the fact there is a budget, cost is also a specification of the design. Cost can determine the type and grade of aluminum used and the amount. We can fix the problems by incorporating these qualities.

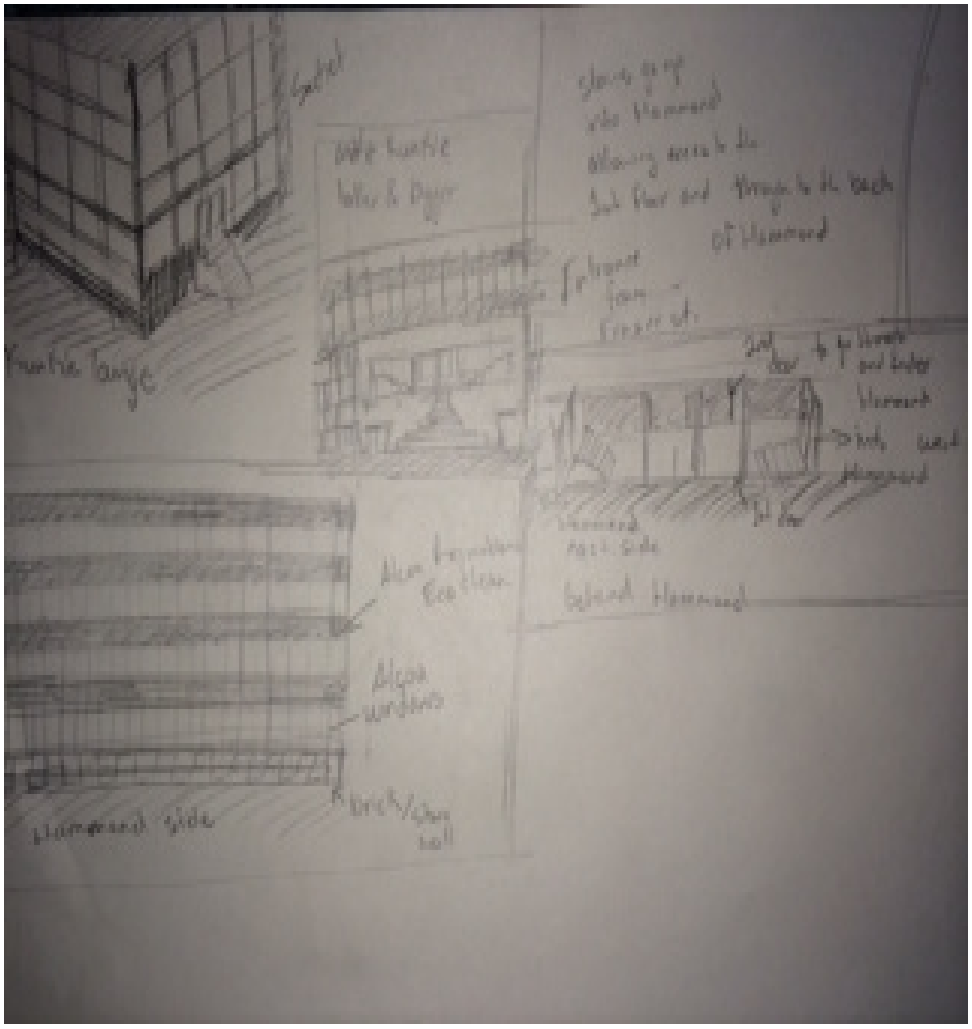
7.3 Selection Criteria

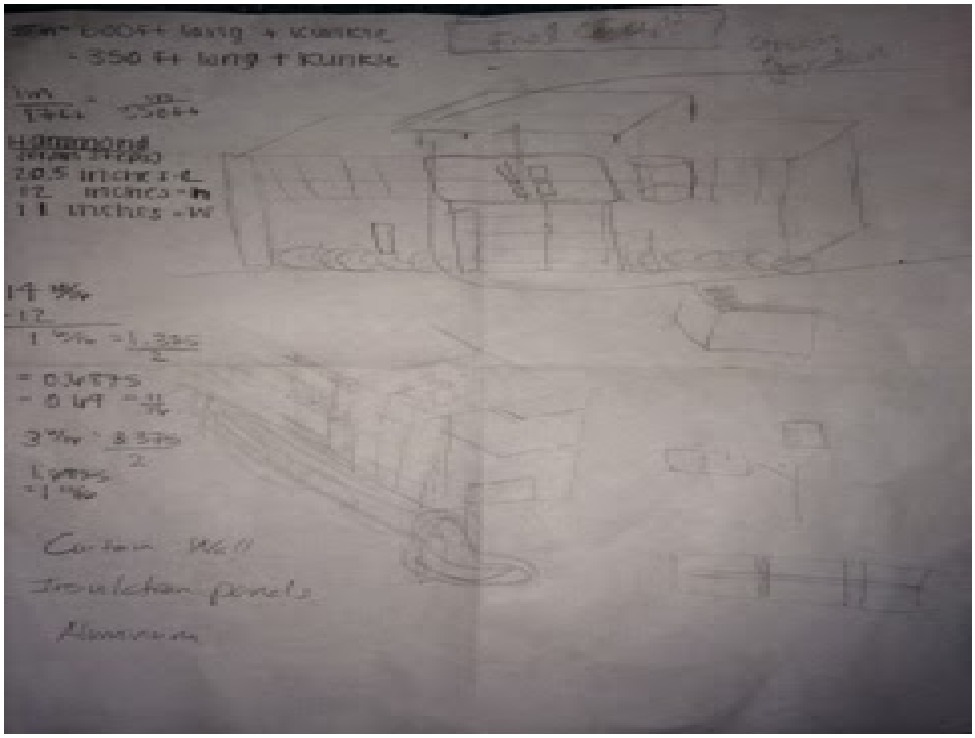
The criteria we used to determine the specifications of the design were based off of customer needs and research. These criteria include:

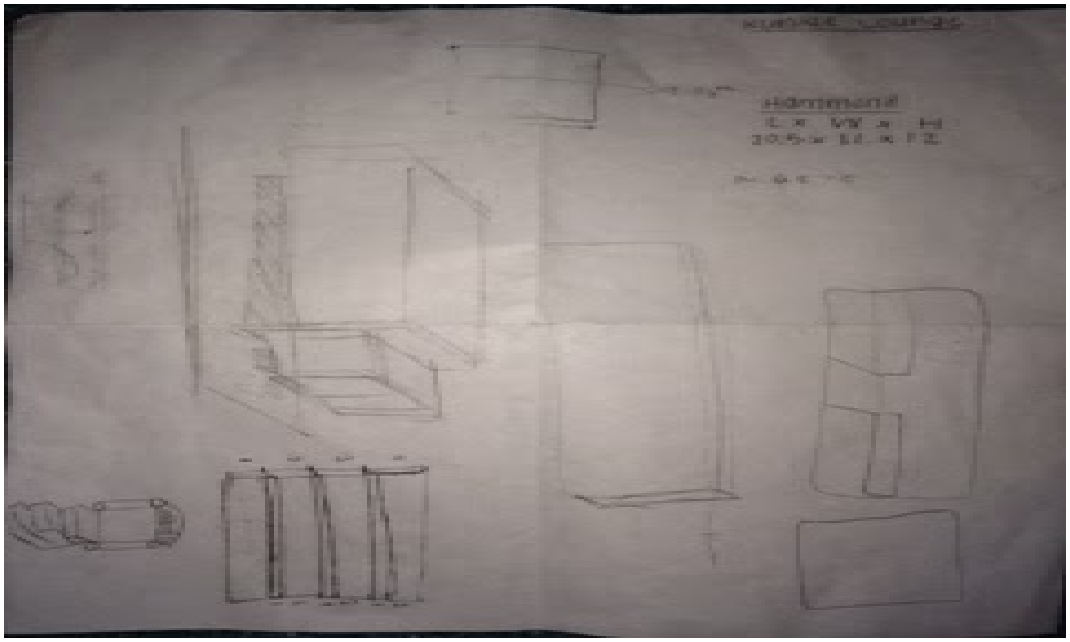
1. Versatility
2. Durability
3. Style
4. Environmental Friendliness
5. Cost
6. Aesthetics
7. Efficiency
8. Ease of Use/Application

8.0 Analysis & Testing (E.)

8.1 Design Sketches and Prototype Scale Measurements


Hammond side
Behind Hammond

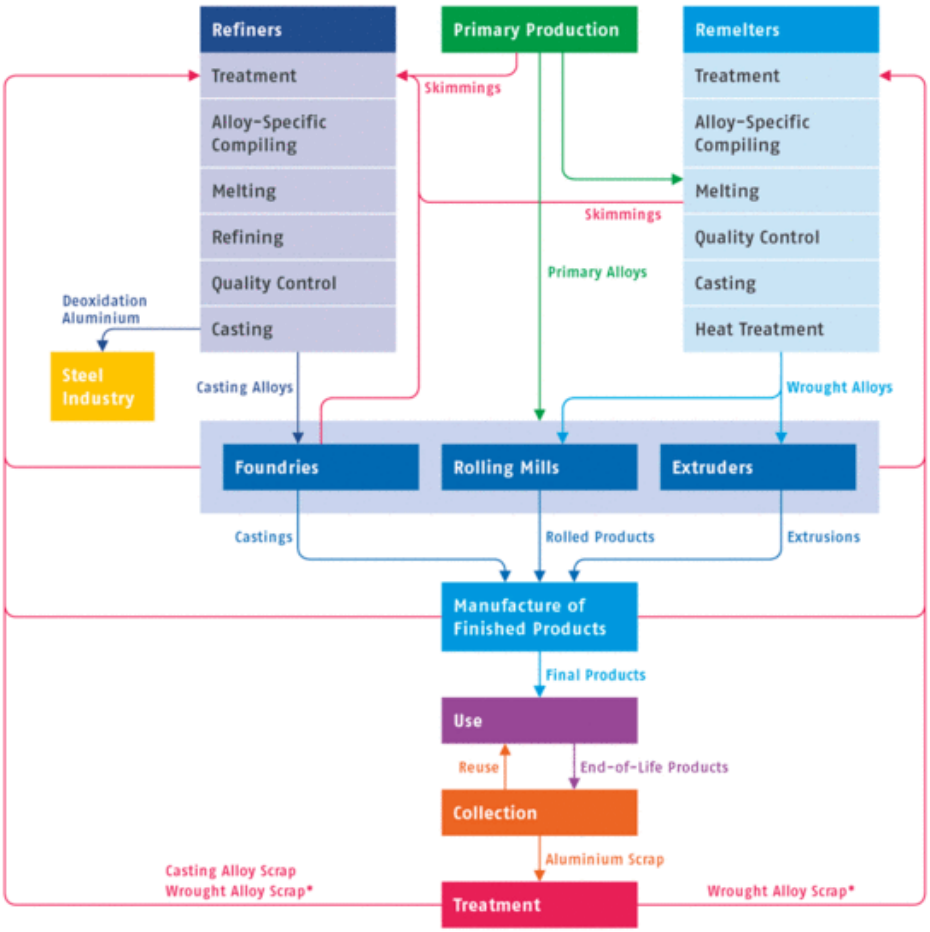

Hammond
20.5 inches - L
12 inches - h
11 inches - W
Carton Mill
Insulation panels
Aluminum



9.0 Description of Design Operation (F.)

The building is renovated with three key components to the new design. There is a curtain wall which is made thicker to provide more insulation. This helps keep in heat better and is cheaper and more viable with the aluminum feature. The grand entrance is made out of aluminum to provide a captivating look and is relatively inexpensive. An aluminum roof is very self sustaining. Iit doesn't need regular care like a tar roof or replaced as much as a single one. The aluminum makes the building overall more sustainable.

10.0 Life Cycle Analysis (G.)



** Wrought alloys used by remelters have a different chemical composition from those used by refiners.*

Aluminum Processing

Aluminum originates as an oxide called alumina. Aluminum itself does not occur in nature as a metal, the processing of aluminum took a giant leap forward with the use of electricity in it's process. Deposits of bauxite ore are mined and refined into alumina. Then alumina and electricity are combined in a cell with a molten electrolyte called cryolite.The molten aluminum collects at the bottom of the cell and is tapped into a crucible and cast into ingots.

Fabricated Products

The automotive industry is the largest market for making aluminum castings, and more than half of the aluminum used in cars is made from casting products. Cast aluminum transmission housing and pistons have been almost universal in cars and trucks throughout the world for many years.

Extruded aluminum is the material of choice for countless applications. Various alloys can be readily formed into complex shapes using extrudes that designers and materials specifiers choose

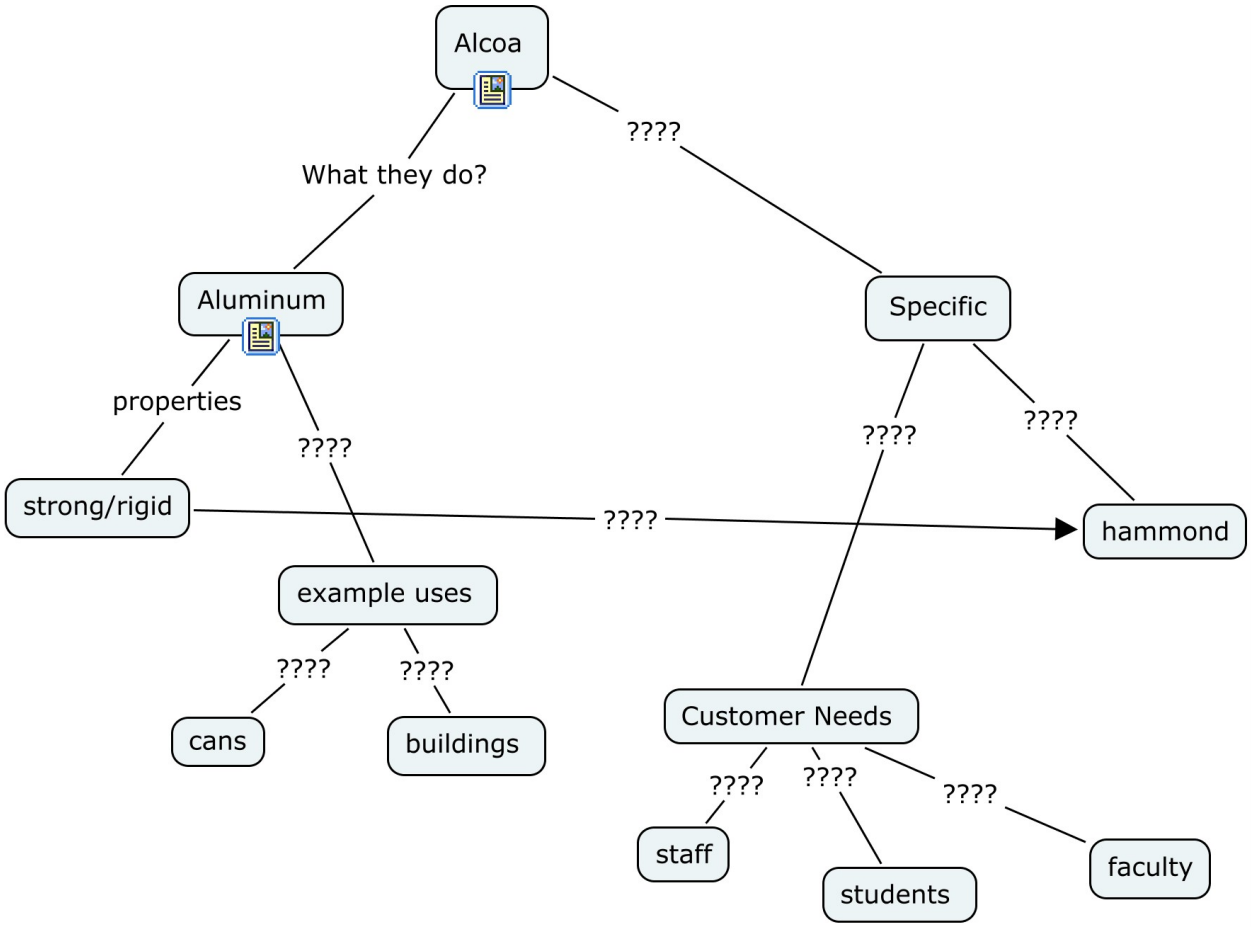
aluminum profiles. For one the extrusion tooling is inexpensive; lead times for custom shapes or prototypes are relatively brief; many different finishes are available; and the life-cycle value of the product remains high due to aluminum's recyclability.

Aluminum mill products are semi-fabricated products such as sheet, plate, foil, extruded products, insulated/covered wire and cable, drawing stock, bare wire, bare cable, pigments and powder, and forgings. In 2005, shipments of aluminum mill products totaled 12.69 billion pounds, or 71.1 percent of total aluminum demand.

Recyclability

Recycling is a critical component of the industry, it's role in the industry has a huge impact on its contributions to the environment and because of its favorable economic impact on production. Not only does the aluminum used in the building and construction industry contain a high percentage of both post-consumer and post-industrial recycled content, at the end of its long, useful life in your building application it is 100% recyclable. This is what would happen to the aluminum that may be in use on the Hammond building's current curtain wall. Aluminum building components can be repeatedly recycled back into similar products with no loss of quality.To produce aluminum from recycled material requires only ~5% of the energy required to produce aluminum from bauxite ore, and every ton of recycled aluminum saves 4 tons of bauxite. Additionally, using recycled aluminum instead of raw materials reduces air pollution generation such as CO2, SOx, and NOx by 95% and water pollution by 97%.

11.0 Ihmc-mindmapping (Screenshot)



12.0 Conclusions

We hope that others will enjoy our vision of the new Hammond. It will be more sustainable with a longer and more efficient "lifespan." Now people be able to identify the Engineering Building with an updated, modern engineer design and look.

12.1 Project Summary (H.)

This project is very feasible. It uses aluminum effectively making the Hammond Building more sustainable. The idea of the renovation will greatly improve the building at a less expensive price. The

aluminum curtain wall and the grand entrance and aluminum roof are very innovative ideas that can help the look and function of the building.

13.0References

Clark Colborn
Facilities Administration Officer
101 Hammond Building
University Park, PA 16802
Phone: 814-865-7137 | Fax: 814-863-4749
Email: cwc2@psu.edu
Website:www.engr.psu.edu/facilities

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