Energy Efficiency at Science Leadership Academy

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Abstract:

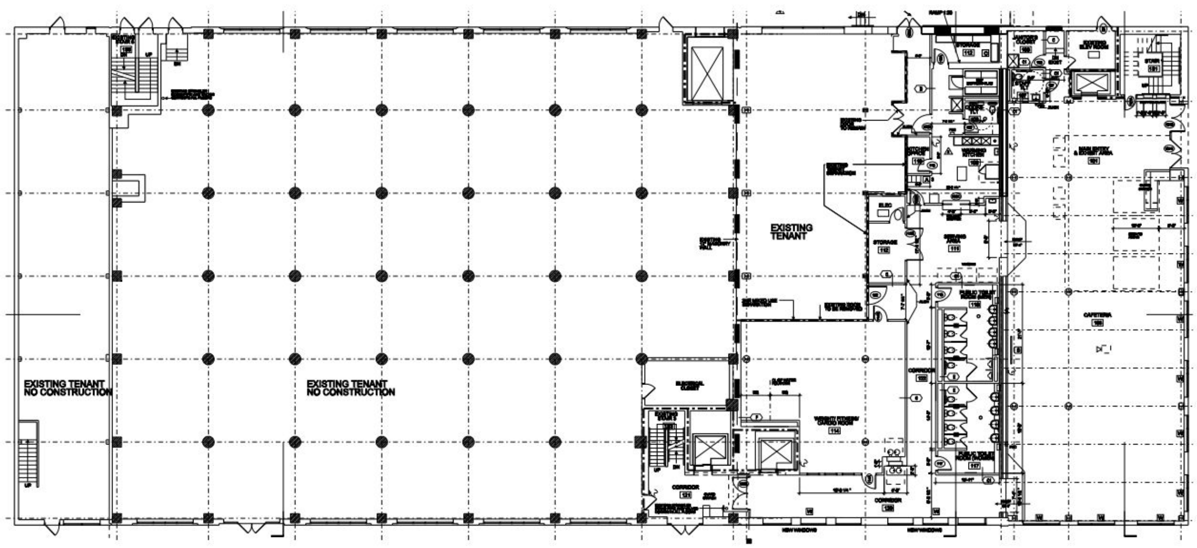
Energy use is guaranteed to happen within SLA. Students and staff need lights, heat, and every other essential electrical application. However, the community is unaware of how much energy is being used and how much it is actually costing the city of Philadelphia. This Capstone project outlines the energy usage of Science Leadership Academy and the cost of that usage, but also has implementations and other proposals to bring down these numbers.

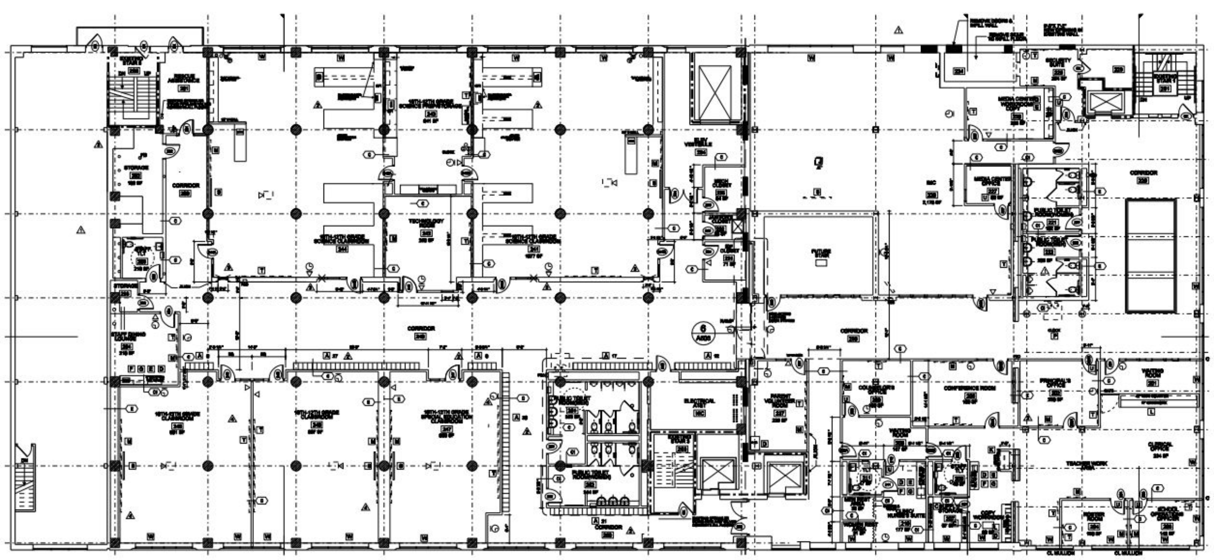
How Much Energy Is Being Used:

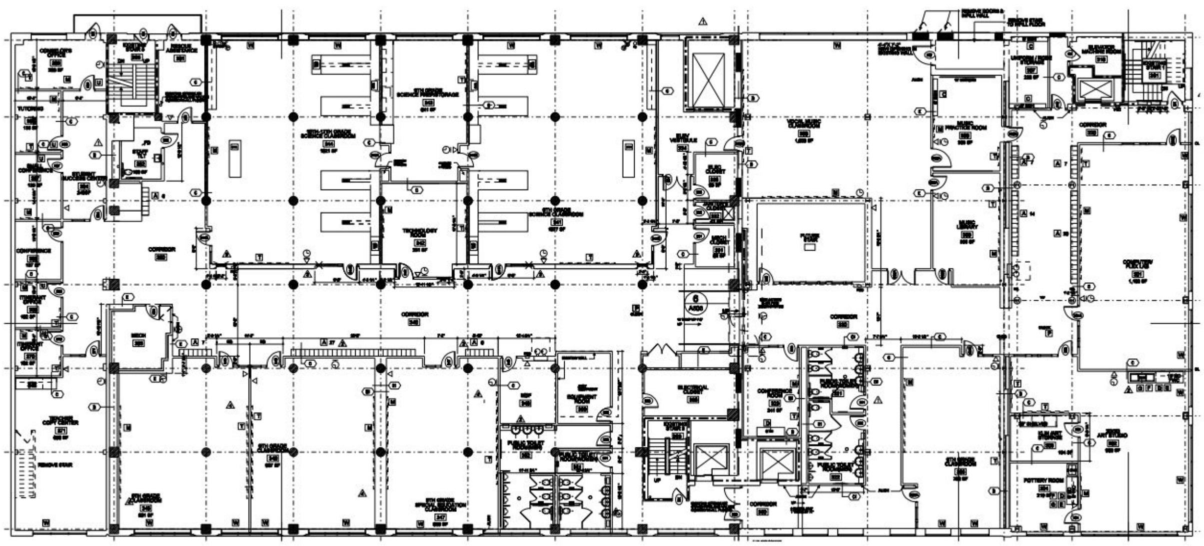
An essential question is how much electricity is SLA actually using? And the answer is a little more complicated than one might think. Since I could not get the concrete data, I ran several tests and can safely estimate how much power SLA is consuming. These numbers will not be exact, but an estimate is just as valuable to have as it still gives us a projection while we can rely on real data collected.

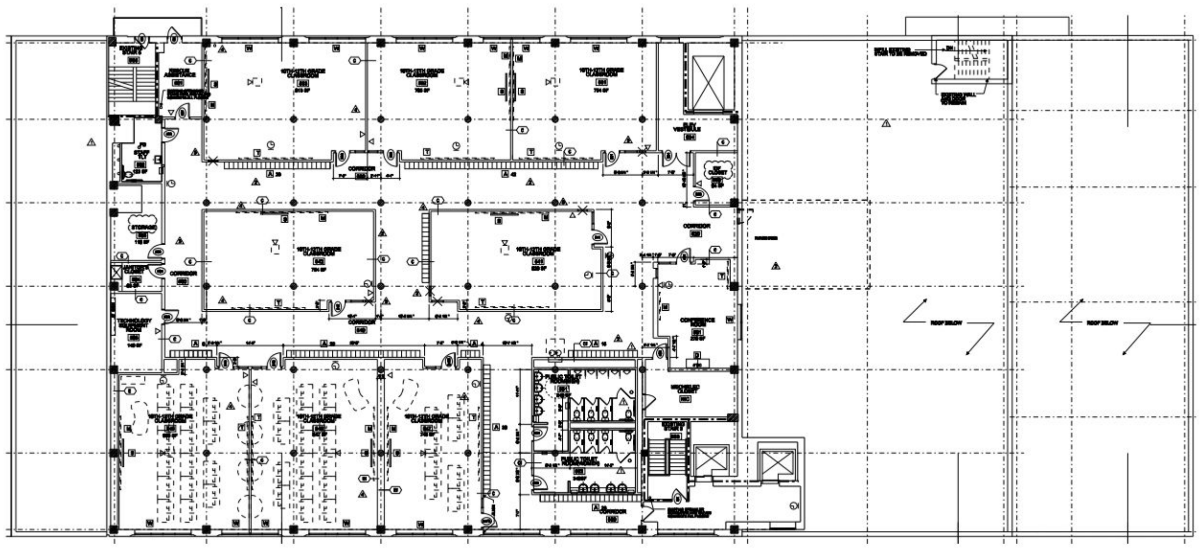
Based on my research and discussing my idea with multiple experts I decided to focus more on heating and cooling systems. This area of usage is so much larger than the other areas (like appliances, lights, etc.) that the small things would hardly make a dent in the analysis. However, I did collect some data on the light usage. This lighting data will also be included as it is still important to look at.

To break heating a building down there are some essential units to understand. First, there are BTUs, or British Thermal Units. BTUs are essentially a traditional way of measuring heat. I am using BTUs for this project because that is the standard US convention. In order to find how many BTUs are needed to heat a room, we need to know the square footage of the space. Luckily, I know the square footage of every floor due to SLA's blueprints. They are included below and ordered by floor (1, 2, 3, 5). The scale I discovered is every 2 cm is equal to 17 ft.









Based off these drawings, the square footage of floor one is 5527.125 square feet. The square footage of floor two is 13980.375 square feet. The square footage of floor three is 13980.375 square feet. And the square footage of floor five is 7477.875 square feet.

Now that we know the square footage of each floor of SLA, we can determine the BTUs we need to heat the following floors. Now, this number will change based on where you live (North, East, West, South, etc.) and since we live in the northeast we are in temperate zone 4 (45-50 BTUs per square foot). This is just essentially showing us our general outside temperatures and factors that can lead to heat differences.

Now that we know all of these factors, the BTUs needed can simply be calculated. Here is the BTU breakdown

Floor	BTUs
1	276,350
2	699,000
3	699,000
5	373,850
TOTAL	2,048,200

And to understand this in terms of Wattage (a unit of electrical power) we can simply convert the total BTU figure into watts.

2,048,200 BTUs = 600,268.16557 Watts

Now that we are a little familiar with collecting data, let’s collect the light data. This is significantly easier as we don’t have to worry about BTUs. Lights are measured just in watts, so all there is to do is count how many lights SLA has and how many work and how long they are on for. SLA has two types of light fixtures. Long lights and shorter lights. These use different wattages, so I broke them up as well. Since I already have collected this data, here is the total number of lights below broken down:

Floor	Lights
1	61 Long Lights 21 Shorter Lights
2	209 Long Lights 51 Shorter Lights
3	109 Long Lights 23 Shorter Lights
5	105 Long Lights 14 Shorter Lights
TOTAL	556 Long Lights 140 Shorter Lights

Now that the total number of lights are known, we can find the total wattage they are using. The longer lights are 28 watts per light bulb and the shorter lights are 14 watts per light bulb. This means we simply take our final light numbers and multiply them by their corresponding wattage. This means the total wattage for the longer lights is 31,136 Watts and the shorter lights are 3,920 Watts. Adding them together gives you the total wattage lights use at SLA, and this number is 35,056 Watts.

How Much is the Bill:

To understand how much we are spending, we have to look at how much we are using. And to calculate how to save we have to look at how much electricity use is unnecessary and to make change.

To estimate the costs of an electricity bill we need to know the wattage of an appliance and how long that appliance is on.

This is the section of my data collection where it probably has the most holes. I simply could not stay at SLA until the lights and such were turned off, but I have some educated estimate based on the pattern of the school.

For example, the heat is on 24 hours a day during the five month period of winter. We can estimate this for a 150 day period. Since we live in Pennsylvania, the rate of electricity bills is $0.14 kilowatts per hour. This would mean heating the school for just the winter months costs $302535.07. As we can see, this is a lot of money

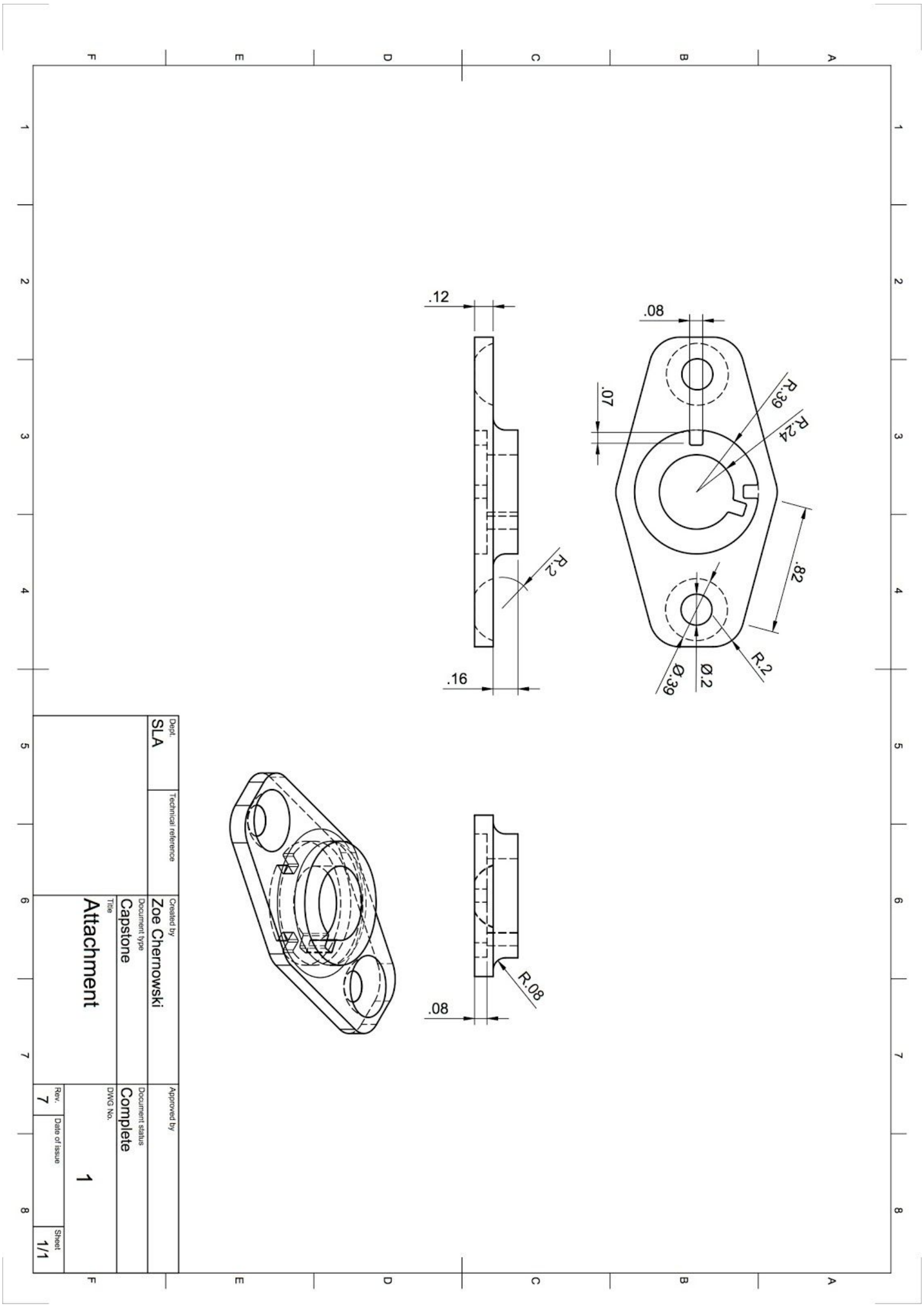
In terms of lights it would cost around $11,955.50 per year. This is calculated using the data that lights would be on about 203 days out of the year for 12 hours a day.

Reducing Usage and Cost:

When reviewing the numbers, the way to make the most impact on SLA's power consumption is to target the heating and cooling units. Even when changing temperature by a sudden one degree can make the electricity cost jump up. Based on the research done (Desjardins, Jeff) heating and cooling takes up the largest chunk by far for energy used, but it was also a field where there were some obvious problems to solve. For example, all of the windows that were broken (due to having no handle) would let the heat and cool air escape the building rapidly, causing thermostats to work twice as hard for the same temperature in different areas of the school. This was the first stepping stone, I knew fixing the windows was the best tangible application after some of my other ideas didn't pan out so nicely.

The first step for fixing these widows was to observe and understand them. What about them were broken? What was missing? Who would open or close these windows? I came to understand how these handles work, are attached, and how they can last through multiple attempts using the design process and simply just observations.

The next step was to start brainstorming designs and materials. I knew I wanted to 3D print my handles so they would be cheap and easy to replace. Once the design is final, staff or other adults can easily print a handle at the press of a button and attach it the same day. There was no need to wait for shipping and handling and other time consuming tasks. There were lots of drafts of the design, but at the end these pieces below functioned the best.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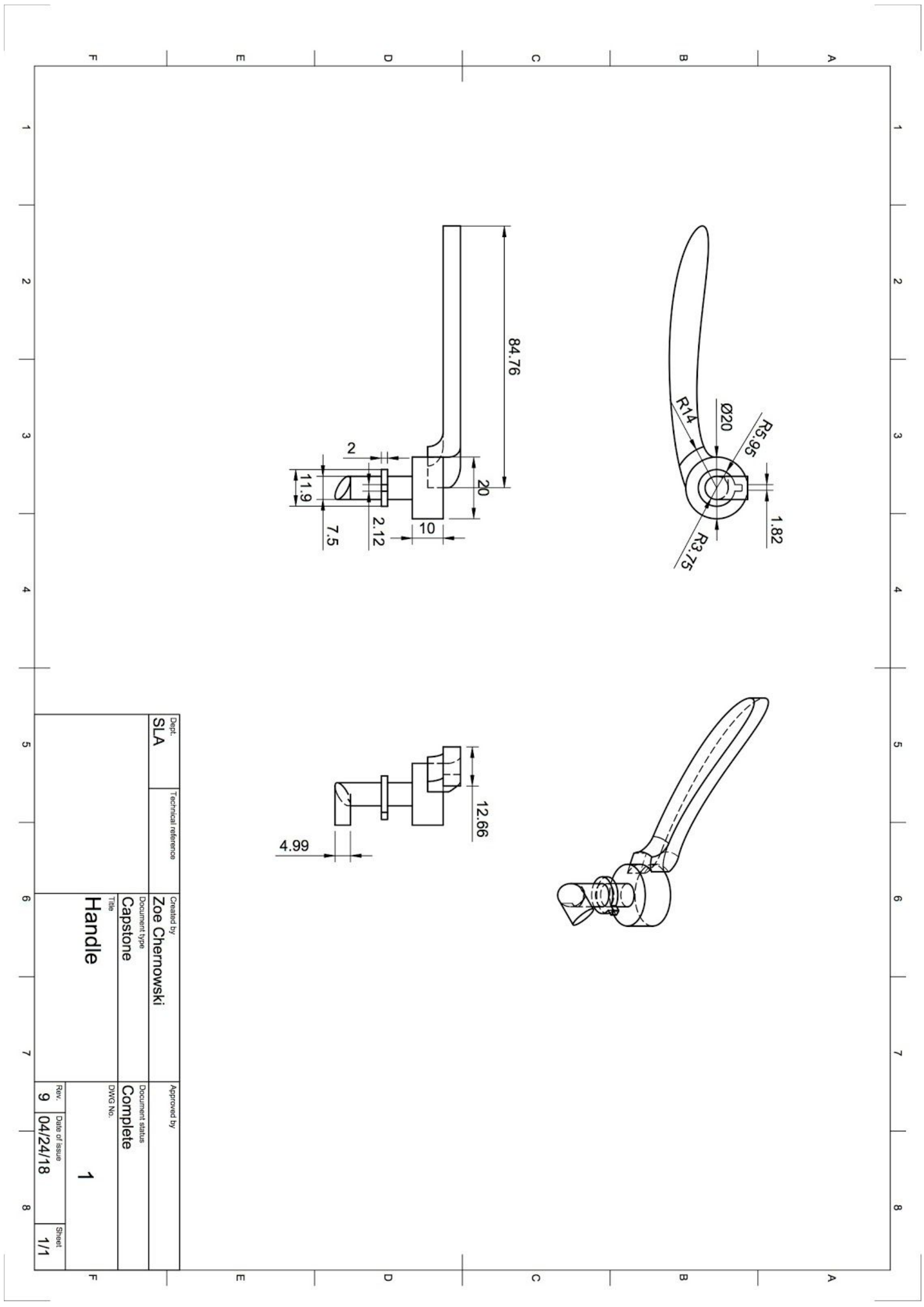
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As seen above, there are two pieces for the new handles. One, the actual handle that would turn and close the window and two, the piece that would screw this on the window itself so it won't move. I printed out a prototype of the design with just standard PLA filament on one of SLA's 3D printers. I applied it to the window and everything worked for some time. However, as I was testing the design over an extended amount of time, the plastic handle snapped and I knew my initial idea of carbon fiber filament was a must. Below are images of the prototype PLA handle.

The carbon fiber filament final design picture is also included on the next page.

The handle design, redesigns, printing, and implementation took longer than I wanted to so I knew that other physical tools may be hard to install. I also knew that printing out all the handles at once would take so much time that I thought about incorporating the skills that I have learned back into the classroom. I propose that learning how to 3D print be apart of the mechanical engineering curriculum and that students' first print can be these handles and they can learn to attach them.

Now, one might be wondering, how do handles solve the efficiency of energy? Well having heat not escape the building as easily can actually help SLA save a maximum of $30,253.61. This number is based off the range of a maximum and minimum BTU estimate for how much energy is actually used to heat the building (Sexton, Joe). Once the BTU value is known, we can once again estimate the cost through conversions of BTUs and watts.

Now, while physical change is necessary to save power, human change is also needed. A human way of solving this problem is simply understanding when it is necessary to have heat or air conditioning on. One suggestion I strongly encourage is that teachers and staff should simply turn off their heating/cooling system during the period of late March to early May. This is because the outside temperature is not in either extreme cold or heat. If even one classroom would do this it would save an upwards of $4031.90 if the system would stay completely off.

This same $4031.90 can be saved per classroom if the air conditioning was left off over the summer months since no one would be at SLA. This would also mean no one would be really in danger if a certain room's AC is off.

Reflection:

I would say that overall, this project was far from easy. Collecting data took a while and a lot of time that I would rather be spending on designing and installation. I simply ran out of time during implementation because I would need to stay at SLA to do all of my work. I also had a hard time working with 3D printing. I first had to learn CAD completely in a very constricted time limit. So I had designs ready that I couldn't really finish until I got past the roadblock of learning a new software. I also encountered the issue of actually printing. This was one of my first times printing a design I created and was totally helpless when two out of three of our machines were down. Printing was also tedious and waiting more than an hour for one handle had me rolling over in anguish. However, I pushed through and I found a solution by creating this report and having my designs be public so that installation can continue even after the capstone deadline.

I would say this project really helped me learn how to manage not only my time, but my skills and outlook on a project. I am very much a perfectionist, so it was very enlightening showing I just didn't need to know everything all at once.