How going green impacts a school's long-term sustainability

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Abstract

Sustainability is a broad concept that has been gaining a lot of popularity over the past years as it encompasses ways to make usage of energy more efficient and less wasteful. Despite seeing implementation of more green technologies in the world around us, specifically construction, there are still many questions regarding how we can make technologies and infrastructure more efficient. After interning at LEAF Engineers, I began to question how much energy we are saving now compared to previous years and what that means in the long-term. This original research endeavor was conducted to evaluate how going green has impacted Dulles High School's long-term sustainability. This research was conducted using mechanical, electrical, and plumbing (MEP) floor plans, panel schedules, and fixture schedules from Dulles High School to use as a baseline for number and types of fixtures that are installed in public high schools. I will first be evaluating sustainability within the mechanical discipline, specifically HVAC systems. Second, I will evaluate sustainability within the electrical discipline, specifically lighting fixtures. Lastly, I will evaluate sustainability within the plumbing discipline, specifically toilet fixtures. After calculating the amount of energy saved from old fixtures and systems to newer ones we conclude that our energy usage in terms of EER for mechanical systems decreased by 64.73%, decreased by 61.46% in terms of wattage for electrical fixtures, and decreased 73.33% in terms of gpf for plumbing fixtures. The results were that ultimately we do save a lot of energy in terms of electrical and plumbing but not in terms of mechanical. Since the EER shows a decrease this means that the efficiency of older AHU is more efficient than that of a newer one. Overall, the results show that new technologies should be implemented in schools because currently a lot of energy is being wasted by keeping old models in use in terms of electrical and plumbing. To see if this is possible a future research endeavor could consist of comparing the amount of energy saved by school to that of a stadium which may lead to different results for mechanical.

Introduction

As we know, sustainability is a topic that has recently been gaining a lot of interest due to its great impact in creating an environmentally healthy future. The concept of sustainability is applicable within many different contexts, but I focused on its relevance within mechanical, electrical and plumbing (MEP) engineering. MEP engineering is the core foundation of the construction industry. These three engineering disciplines have evolved over the past years in terms of technology, fixtures, and most importantly energy/resource usage. Making sure that each system does not waste energy in terms of heating, cooling, lighting, and water usage is key to increasing efficiency and saving financially in the long-term within MEP and construction. A building's sustainability lies within the design of the materials and systems that are being used [1]. In previous years, we would use and apply materials that were easily available and in large supply, but now we are able to use materials that provide the least amount of wastage and are more advanced. This means that overtime our buildings and MEP systems have simultaneously become more efficient and less wasteful. For the mechanical discipline this means that we waste less in terms of heating and cooling. For the electrical discipline this means we are wasting less watts of energy within our lighting fixtures. Lastly, for plumbing this means we are wasting less water per flush in our bathroom fixtures. The reason shifting to more sustainable methods is so important is because it makes efforts in mitigating negative anthropogenic effects on the environment. Approximately 39% of the world's CO_2 emissions are caused by the construction industry [2]. Knowing this, we can see how important it is for this specific sector of our society to make massive efforts in lowering this statistic.

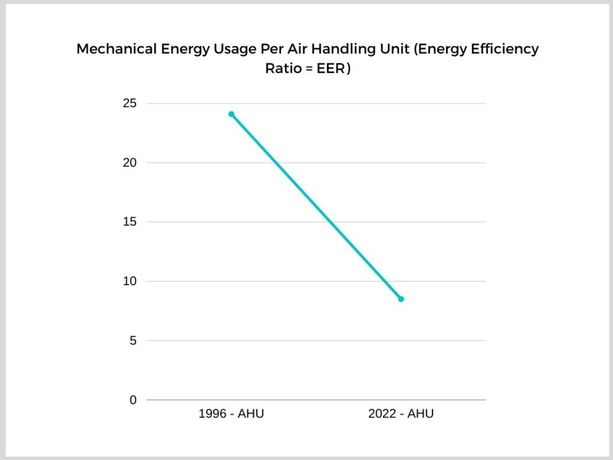
Summary

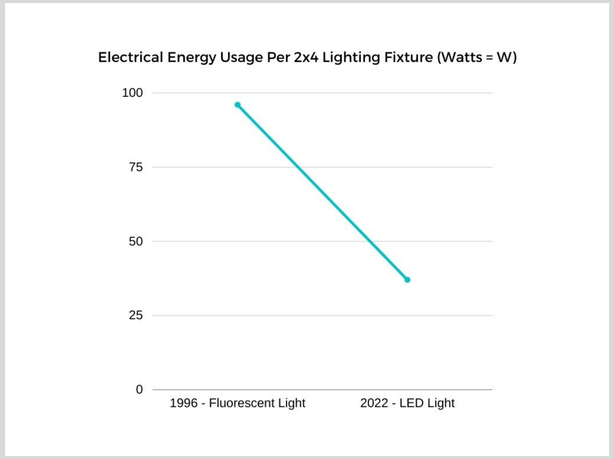
Seeing differences in high schools' technology, infrastructure, and systems made me question the differences within MEP systems specifically. Specifically, as a Dulles high school student, there are many changes that have taken place in terms of infrastructure because the school was built in 1959. I have noticed how in some areas of the school there are more advanced structures compared to other areas, for example, renovated lighting fixtures or bathroom hand dryers that run at higher speeds. These changes made me want to evaluate if we would save energy and how much energy we would save by implementing more advanced infrastructure in Dulles High School in terms of MEP. The focus of this research endeavor is to understand how going green can impact Dulles High School's long-term sustainability in terms of energy usage. The research conducted in this paper is an original research endeavor as no one has previously conducted this research on Dulles High School floor plans. I predict that we will be saving more energy by implementing new HVAC systems, lighting fixtures, and plumbing fixtures.

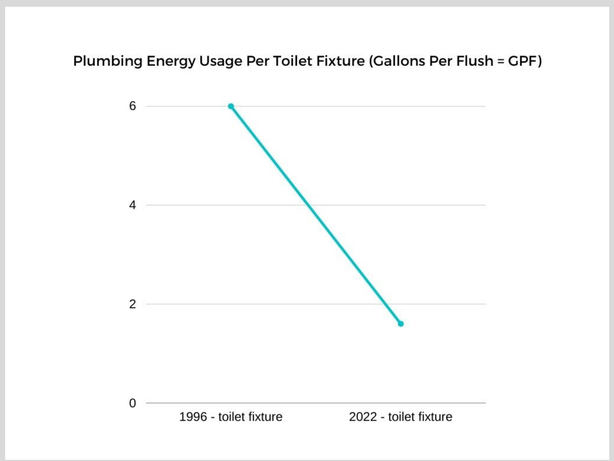
Methodology

This research endeavor will be threefold. I will first be evaluating sustainability within the mechanical discipline, specifically HVAC systems. Second, I will evaluate sustainability within the electrical discipline, specifically lighting fixtures. Lastly, I will evaluate sustainability within the plumbing discipline, specifically toilet fixtures. The data collected from this study will help schools similar to Dulles High School consider more energy-efficient design and structure options when building or renovating a school. This investigation will include using Dulles High School floor plans and panel schedules for MEP design. The calculations based on the Dulles High School floor plans and panel schedules will use quantitative components as a means of measurement. For the mechanical discipline, based on the HVAC load of a Dulles High School R-One Line Diagram, I will be evaluating the energy efficiency ratio (EER) and comparing it to the EER of an advanced HVAC system/load. For the electrical discipline, based on the Dulles High School electrical panel schedules, I will be evaluating the amount of watts needed by fluorescent lighting for a basic classroom and comparing it to the amounts of watts needed by light-emitting diode (LED) lighting. For the plumbing discipline, I will evaluate how many gallons per flush (GPF) an average bathroom uses and compare it to that of more efficient toilet fixtures. I will quantify mechanical efficiency in terms of EER, electrical in terms of wattage, and plumbing in terms of GPF. Quantifying these numbers will help ensure consistency within my results. I chose to evaluate these specific disciplines because they are the building blocks of the construction industry. After completing calculations for all three disciplines I will evaluate the amount of energy (based on each discipline's respective units for calculations mentioned above) saved or lost.

Results







Findings

Based on Figure 1 we can see a decrease in EER when looking at the 1996 AHU which is approximately 24.1 EER compared to that of a 2022 AHU which is 8.5 EER. Based on Figure 2 we can see the drastic change in the amount of watts used based on the change in lighting fixture. According to Figure 2 we can see that approximately 96w were being used by a 2x4 fluorescent light fixture and the shift to LED dropped the amount used to 37w. This means that we are saving approximately 59w per lighting fixture by switching from fluorescent light to LED. When we look at the bigger picture and compare how much wattage we are saving per classroom we can look at the average number of light fixtures in a Dulles classroom which is 9. The fluorescent lighting would require 864w whereas the LED lighting would require 333w. This means that we would be saving 531w per classroom by shifting to LED lighting. This automatically shows that for the electrical discipline we are saving a lot more energy by shifting to LED lighting which is the new and more advanced technology for this discipline. Based on figure 3 we can see the drastic change in the amount of gpf used by an average toilet fixture. In 1996 the gpf for an average toilet was 6 and in 2022 the average gpf for a toilet is 1.6. When looking at the bigger picture we can calculate how much gpf we save based on the average number of toilet fixtures in an average Dulles bathroom which is 6. The 1996 toilets would require approximately 36 gpf and the 2022 toilets would require approximately 9.6 gpf. This means per flush an average bathroom at Dulles using 2022 toilets saves 26.4 gallons.

My original hypothesis was proven correct for electrical and plumbing but not for the mechanical discipline through this research endeavor. I predicted that we will be saving more energy by implementing new more sustainable HVAC systems, lighting fixtures, and plumbing fixtures. After looking at the calculations we can see that our energy usage in terms of EER for mechanical systems decreased by 64.73%, decreased by 61.46% in terms of wattage for electrical fixtures, and decreased by 73.33% in terms of gpf for plumbing fixtures. This means that by switching to newer technologies we would be saving a significant amount of energy in terms of watts and gallons per flush but not in terms of EER. A decrease in the EER means that the current AHU system is actually significantly less efficient than that of one used in 1996.

Discussion

One possible limitation of this research could be that the units in which energy was calculated was different for each discipline. This could be a possible limitation when comparing the bigger picture and how much energy each discipline saved in reference to another discipline. For example, although we know we decreased the amount of watts used per 2x4 lighting fixture by 61.46% and the amount of gpf usage by 73.33%, we cannot compare the percentages themselves as they are representations of different units for their respective discipline. Another possible limitation is the type of fixture that was used. Since the fixtures for some of the disciplines changed entirely we cannot compare that specific fixtures efficiency increase. For example, the lighting fixtures in electrical systems switched from fluorescent lighting to LED so we cannot find the increase in fluorescent lighting's efficiency specifically. To fix this limitation I should've compared the exact same fixture models from previous years to current years.

One of the biggest successes of using Dulles High School as a baseline for my research is that the knowledge gained from my research can be applicable to other similar public schools. I realized that Dulles high school was built in 1959 and therefore much has changed through renovations in areas of the school, but also in newer technologies created in the field of construction. The statistics found from my research will be somewhat applicable on a bigger level in the realm of sustainability. One of the failures of this methodology was that I was unable to get Dulles fixture schedules for the plumbing discipline, so I had to use gpf of an average toilet from the year 1996. This was a failure because it is possible that Dulles' toilets may have required less than or more than 6 gpf based on how advanced the toilet fixtures were.

Through this research endeavor I was able to learn that implementing a variety of new fixtures within the field of electrical and plumbing at Dulles High School could ultimately help the school's long-term sustainability by wasting less energy. I also learned that the current fixtures and systems that are being used have decreased energy wastage by a very significant amount within electrical and plumbing. On the other hand, in the mechanical discipline, the AHU that was used in 1996 is actually significantly more significant than the current AHU. One reason for this could be that engineers are not focusing on the overall EER of newer units and instead focusing on loads. This means that my research endeavor shows that engineers should focus more on the overall EER of the AHU they are building to ensure higher levels of EER and overall energy efficiency. This shows us that when we calculate for bigger numbers like schools, the amount of energy that is saved is amplified. I calculated energy usage for a basic high school hvac system, a basic high school classroom, and a basic high school bathroom. These numbers themselves show how much we save but they give us insight on how much an entire building like a school can save in the long-term. A future research endeavor should be calculating the amount of energy that can be saved by buildings similar to a high school, like a stadium, by implementing the newest fixtures and systems. Since these two buildings require different amounts of energy within each discipline of MEP, we can compare the two buildings' overall amount of energy saved over a certain period of time. The new research endeavor will be a way to see how the size and type of building affects the overall energy usage within each specific field of MEP. We will also be able to see if we see a change in the mechanical discipline's results and if the EER of the AHU for a stadium is more efficient than that of a school's. If we see a positive trend in the new study we will have more concrete evidence to support the idea that all buildings should switch to less-energy wastage fixtures and systems because it will allow them to save more in the long-term.

References

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