The Need for and Specifics of a Retrofitting Project

(Technical Topic)

Determining What Constitutes Acceptable Disruption

(STS Topic)

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On my honor as a university student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Overall Introduction (Comprehensive Problem Frame)

Many of the buildings on grounds at The University of Virginia have existed for over a hundred years and were originally built well before anybody was concerned about operational sustainability. Now that human technology and engineering have advanced and climate change has become a legitimate threat, it is time to upgrade old systems to help reduce the impact UVA's resource use has on the environment. The public has recognized in recent years that temperatures have been rising and storms have been getting worse. The overall lack of action up to this point can be attributed to the uncertainty behind climate change. The uncertainty lies in just how much worse climate change will get and whether or not humans will be able to sufficiently reduce emissions to avoid disaster, and even though UVA's contribution won't be nearly enough to solve the larger problem, its sets a good example for the community at large. UVA specifically will not face the worst of climate change as it's not located in a coastal area or particularly close to the equator and nothing UVA does regarding its own operational use of energy will change global trends, but the University still wants to contribute to the worldwide solution. Other areas of the world will suffer significantly if action is not taken everywhere "Flooding is expected to get worse unless we adapt" (Forster May 4, 2020). Humans as a whole have to eliminate wasteful and damaging behaviors and UVA reducing emissions and water use is part of that. Replacing outdated equipment such as HVAC systems and insulation will translate to substantial savings over the next several years and beyond in terms of carbon emissions, utility bills, and could even provide social benefits (Congedo 2 12-13 May 2017).

The Need for and Specifics of a Retrofitting Project (Technical Topic)

It is necessary that the public recognizes climate change as a serious problem, as well as understand that it is caused by excessive greenhouse gas emissions across the globe. As can be

seen in Figure 1 (Lindsey Aug 14 2020) the atmospheric level of carbon dioxide has skyrocketed as a direct result of human emissions coming from all kinds of different sources. There is not one big thing to be done but a large number of small things that each serve a specific purpose all working together and, in that way, the University's project reflects the overall global effort to combat climate change. The carnage that will come as a result of the global population not addressing climate change could be some of the most significant damage mankind has ever seen. Global warming means ice melting, which means oceans rising, which will cause flooding in coastal cities and dramatically increase storm surge (Ralston April 26 2017) meaning thousands if not millions of deaths and billions in damages. It's also helpful to understand that newer equipment for HVAC and other systems are more efficient and generate less emissions than equivalent technology developed decades ago. Keep in mind however, that even if UVA's project blows away expectations, it will not be nearly enough to stabilize the global climate. From a practical standpoint, the greatest goal of de-carbonizing the university will be that it inspires other universities, organizations and citizens to act more sustainably, carrying on and furthering the global initiative.

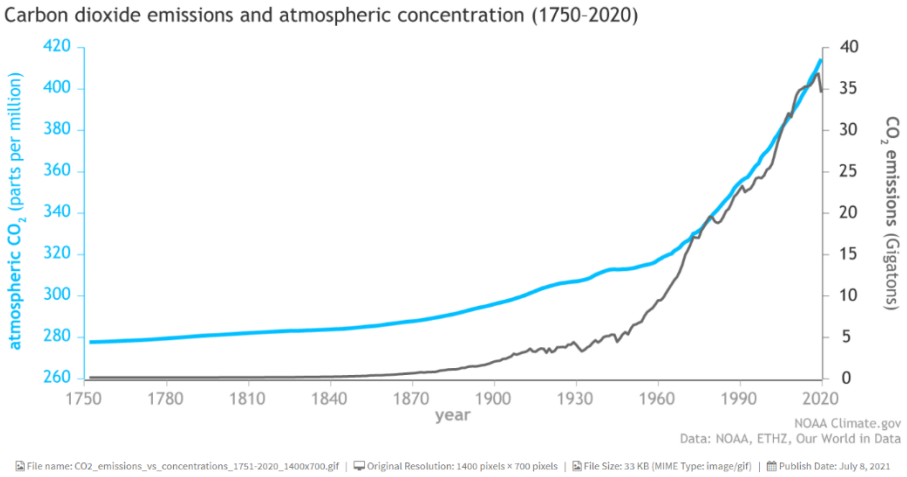

Figure 1: CO_2 emissions and their effect on the atmospheric levels since 1750

Our team plans to take some of the most successful points of various similar projects that have been carried out at other universities or cities and implement them here to deliver a smaller

UVA carbon footprint. This will include things like new energy efficient windows, modern HVAC systems to replace oil and gas heating, energy monitoring systems for distinct buildings or even distinct rooms, improved insulation and more (Paradis August 15 2016). The most significant of these potential changes is certainly a modern HVAC system with chilled water systems and heat recovery (Nandi August 2 2017) or possibly a dual duct system with variable fan speed (Ligade, 2019, 2) as HVAC systems have advanced very significantly in the time since these buildings were last equipped. A study was done in 2016 where a variety of buildings were retrofitted in terms of HVAC systems and insulation upgrades and as figure 2 (Cai, 2016, 5) shows certain buildings saw a 30% reduction in electricity use. If a complete HVAC overhaul is determined to be out of the scope of this project, reducing the strain on the HVAC system through other means is another potential goal. In areas with a lot of concrete and lacking in greenery experts have observed and urban heat island effect (Ralston April 26 2017) in which the paved area heats up significantly more than surrounding areas. In order to alleviate HVAC systems having to combat that increased heat, urban greening (which in this case would consist of transforming areas like roofs into gardens) would prevent the heat island from ever forming. There are also some newer technologies that have been implemented in recent retrofitting projects, specifically the Empire State Building's recent overhaul. Two particularly advanced and interesting solutions included electrochromic glass, which can automatically lighten or darken to control the amount of light being let into the

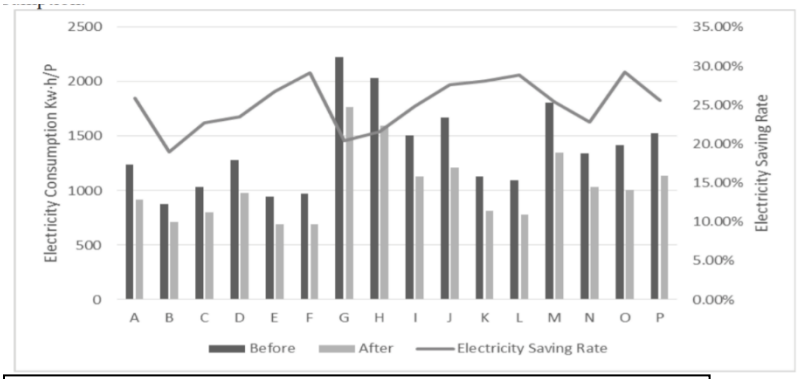

Figure 2: Per capita electricity consumption and electricity saving effect by building

building, as well as energy capture flooring tiles that harness the small amount of kinetic energy they receive when being walked on and convert it into electricity (De la Garza 1, May 10 2021). These kinetic tiles are just one form of clean energy production that the university could implement in order to offset the inevitable demand for energy. Installing solar panels to go with (or in place of) the green roofing or erecting wind turbines in areas of grounds where wind tunnels form would both be valid investments that would provide green energy. On average homeowners have reported that the cost of solar panel installation is covered in electricity savings in anywhere from 6-10 years (Deters, Feb. 16 2021) and there is no indication the University should expect any complication.

Determining What Constitutes Acceptable Disruption (STS Topic)

Buildings at the University of Virginia have individuals working in them every day, whether it's classes, research, or something else entirely. Those individuals are capable of dealing with minor disruption, especially with good cause, but do need a suitable environment to be able to work properly. A full renovation could displace or at least disrupt those who normally use the space being retrofitted. The two questions this project aims to answer are "What are the most efficient modifications to increase sustainability (specifically applied to the UVA building in question)?" as well as "What level and type of disruption are University personnel willing to put up with in order to retrofit sustainability?".

It can be agreed at least among the UVA community that climate change is not an if problem, but a when problem (assuming we don't take appropriate actions to prevent it in time) and the sooner we can start to combat it, the less severe the climate will be in the immediate future. Learning how to effectively retrofit old buildings in cost effective ways that minimize disruption to those who are using the space being retrofitted could be extremely useful as the

process could be taken and applied elsewhere. Just about everyone at the University wants to see these outdated buildings become more sustainable as it is undeniably beneficial in the long run and the University could expect to see recurring savings of anywhere from two to seven dollars per square foot of the building in operating costs (Lockwood 1, Dec 2009), so they will accept a non-zero level of disruption to achieve this goal.

The key to success in this endeavor will be to collaborate and communicate with the people in the space being retrofitted as it happens far too often that actions taken to solve one problem (in this case the minor building renovations) create new, sometimes worse problems that in turn must be solved themselves. The more information we can gather on the system as a whole and how all the different actors interact, the more problems we can avoid creating. Different types of disruption will inevitably result from different renovations and while some types of disruption may be deemed acceptable others could be too much trouble. For example, one aspect of the project may be to install energy meters and all the disruption that comes with that would be that a maintenance worker would have to enter each room of a building (possibly interrupting a meeting or class) and that would probably be deemed acceptable. However, if it was determined a part of the project would be to reinsulate entire wings of the building and they would have to be closed for extended periods of time, the people who normally use those rooms might not be so accepting of the project. Some disruptions will be affected by the environment as well. If the HVAC systems were being replaced and a building did not have AC/heat for a day or two, the residents' attitudes toward the situation would be dependent on the weather during that time. Different project aspects will cause different disruptions of varying degree and type and all the consequences of each course of action must be considered in the planning stages.

Conclusion

Ideally, this project will be able to design a process for retrofitting sustainability into these old buildings, then it will actually be applied and UVA will be able to reduce its carbon footprint and resource use. This will clarify how to minimize disruption to residents while retrofitting so that the knowledge can be implemented in similar future projects. Hopefully, in the future other groups and organizations will look to this project as an example to follow much like we have observed a number of other similar projects in our own preliminary research. As explained before, even if this project is wildly successful and UVA becomes completely net zero carbon, on the global scale that is still just a drop in the bucket. The ultimate goal of the project is to both inspire other entities outside the university to “go green” themselves as well as giving them a roadmap for how to go about such a project in the most efficient and least disruptive way possible.

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