HEALTHY BUILDINGS: A COMBINATION OF NATURE AND TECHNOLOGY CAN SECURE A SUSTAINABLE FUTURE

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ABSTRACT

Can buildings be designed to provide people who work in close proximity to each other with physical and emotional comfort or safety, while minimizing the risk of increased viral infection? COVID-19 had a major impact on our country with increased infection rates/deaths, mask mandates, and building occupancy limitations. With the vaccine, mandates were relaxed, including building occupancy levels. Despite this progress, many people are still anxious to work in close proximity to each other in public buildings. This paper seeks to address how healthy building ideals can set the precedent for future public buildings. Healthy buildings are key to bringing back full access to positive communal interaction. Healthy buildings provide for human comfort via advanced building systems, sustainable design thinking, and the utilization low emissive natural materials. Technical innovation and mechanical stability, focusing on indoor air quality and low emissive materials, guarantee occupant safety, while safeguarding a sustainable future. The researcher's proposition was explored through a graduate design thesis project. The building type utilized was a laboratory research center for contagious diseases. Pfizer, Moderna, and the Center for Virology and Vaccine Research were studied as precedents for their current practices related to viral infectious research. Drawing from nature, the geometry and molecular makeup of the atom was used to derive the building form. The design process focused on a combination of natural flora and sustainable technology to eliminate social and psychological fears, while facilitating the required security levels. The results are presented as both an architectural design proposition and related technical and statistical data for a net-zero design. The paper's contention is that research design proposals of this nature help promote healthy building ideals, while ensuring a healthy sustainable future.

Keywords: healthy buildings, critical regionalism, post 9-11 theory, occupancy levels, comfort, safety, connection, proximity.

1 INTRODUCTION

The COVID-19 pandemic has had a major impact on our country with increased infection rates/deaths, brought mask mandates for public settings, and building occupancy limitations. With the rollout of the vaccine, mandates were relaxed including building occupancy levels. Despite all of this, people are still afraid to work in office buildings and return to occupancy levels. So, the question now is, how can buildings be designed to provide people with the comfort and safety of being indoors again while minimizing the risk of infection? My position is to utilize a research center for contagious diseases specifically focusing on viruses to embody the ideals of this question. With this facility, researchers will be able to study and develop more effective vaccines/treatments in a safe controlled environment. Ultimately setting a precedent for what research facilities and buildings in general can become designing with the ideals of a healthy building. Healthy buildings are the key to bringing back the comfort of being indoors. Specifically creating healthy indoor environments through indoor air quality and low emissive materials. Addressing these key elements within the building design can address this question directly while providing the region and the world with a solution to further our understanding of viral infectious diseases and fight against them.

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2 INSPIRATIONAL QUOTES

"I pictured myself as a virus or a cancer cell and tried to sense what it would be like" [1]. There has always been viruses and diseases spreading around from person to person for centuries. Many people have gotten sick and even died from contracting something as small as a cold in the early years of human civilization. It has not been until recently that early forms of vaccinations were invented to help fight against viral pathogens and diseases. Due to vaccines being so new, there was limited understanding on how they worked and helped protect the human body from infection rather than infecting it. The first vaccine was invented in 1800 by Benjamin Waterhouse and has evolved over time with many other medical professionals trying to help develop more vaccines for other viruses and diseases. This includes developing vaccines for polio just as Jonas Salk successfully did. Jonas Salk was the first American virologist to develop the first successful polio vaccines. The quote above shows how he put himself in the shoes of the virus and diseases to see if he could experience what it is like as these cells. Jonas Salk's mindset of trying to sense what it is like to be viral infectious cells can be utilized for many different applications including aiding in the design of a viral infectious research center.

"Sustainable design is a collective process whereby the built environment achieves ecologic balance in new and retrofit construction toward the long-term viability and humanization of architecture" [2]. The integration of architecture into the surrounding landscape has been a big motive in the past few years and is rapidly becoming the norm in the architecture and construction world. There has been a push for designing buildings as "healthy buildings" increasing indoor environmental quality, sense of place, and well-being. Providing a comfortable and safe place to occupy and conduct daily activities is important when it comes to "healthy buildings". With the presence of the COVID-19 pandemic, "healthy buildings" are in high demand right now and there are not a lot of buildings that have the capabilities of becoming or classifying as a "healthy building". People are afraid to spend time indoors and would rather be outdoors because they feel safer. Integrating the program of viral infectious research with the aspirations and goals of becoming a "healthy building", keeping this quote in mind will help guide what a "healthy building" strives to achieve while mitigating the fears of a facility like this, creating a sense of comfort, and setting a precedent of what buildings should strive to be.

3 BUILDING TYPE

The purpose of current viral infectious research centers is to research and educate people about viruses and diseases while also protecting people from health threats. Developing methods and recommendations such as personal protective equipment (PPE) and basic healthy habits can help limit infection. These centers research viable and safe medications, treatment methods, and vaccines for a multitude of viruses and diseases. Expanding the presence of these centers, not only on a regional scale but on a worldwide scale, can limit the risk of viral outbreaks. The three primary areas of research that are vital to perform viral infectious research are neuro-virology/immunology, researching/developing treatments for neurological disorders, Translational Immunology, researching immune system in relation to new concepts for anti-viral therapy, and viral pathogenesis, understanding how viruses can cause disease in humans to create more effective treatments and vaccines. These three areas of research will be the primary focus of this research center. Physical, computer, and data security are taken into consideration for the occupants/research safety and security.

4 PRECEDENT ANALYSIS

Throughout precedent analysis there were five types of precedents analyzed. Research precedents, looking at the building typology providing information on how existing research centers function and how architects responded to those functions through architecture. Building type precedents, learning about how different projects utilized varied materials, building techniques, systems, and structure to inform the design of the building and site relationships. Technical precedents, studying how other projects integrated advanced building systems, sustainable design methods, and building materials. Abstract precedents, studying a non-building object that has nothing to do with architecture but can relate to the typology of the project and inform the design intent. Anti-precedents, determining what this project does not want to be in terms of design, materials, building techniques, what is deemed to be a failure.

4.1 Precedent utilization

Pearl River Pfizer Headquarters Campus: Pfizer's headquarter campus and the company gave me a better understanding on what types of research they are working on, research methods, and most importantly their vaccine research. *The Center for Virology and Vaccine Research:* The research programs and research processes at this hospital helped expand my knowledge on viral research and provide different options when it comes to what viral research methods I will be utilizing. *Moderna Manufacturing Facility:* Analyzing key elements that Moderna utilizes for their research helped me understand what exactly mRNA is and how mRNA pertains to the development of vaccines. *The Lerner Research Institute:* Understanding their research programs, research processes, and the relationship between the building and the courtyard. *Salk Institute:* Analyzing spatial sequence between the laboratories and the central gathering space, designing for natural light, and open space. Natural lighting was important for productivity in my research center and how to design for natural light utilizing light wells, Northern light, and fenestration methods. *Purdue University Bioscience Innovation Building:* Since this building type is not exactly what my building type is, I was able to pick out certain spaces in the program that helped me start formulating a program. Looking at the structural elements of this building, they exactly resemble what my structural elements are going to look like in the form of lateral cross bracing. Analyzing these elements at this scale was beneficial. *Kenwood Interdisciplinary Research Complex:* Studying the intricate facade and fenestration design. It is interesting to look at the facade and see a primary, secondary, and tertiary facade all within one. Also, the fenestration adding horizontality with shading. *Symbiosis University Hospital and Research Centre:* Analyzing envelope design, solar orientation, and passive design methods. These three elements when combined can create an efficient and sustainable performing building. *Bioprocess Innovation Center:* Understanding the relationships between the surrounding landscape and the built form as well as how the axial circulation works within this building in relation to the surrounding landscape. *Kyushu University Biolab:* Analyzing what a basic research lab layout consists of as well as the necessary ductwork that is required for the equipment in the lab. *Viruses/Antibodies:* Looking at the geometry of virus cells and antibodies for conceptual design inspiration to create architectural/scientific relationships within the center. *Science Research Facilities:* This design is baron, undesirable, region specific materials, essentially looking at how this building design is unsuccessful to use as a precedent compared to what this research center wants to achieve.

5 PROGRAM ANALYSIS

The goal of the program for this project is to provide the necessary and supporting spaces to perform viral infectious research in an efficient and successful manner while also providing the opportunity for sustainable design. Before defining the specific spaces within my program, I looked at my precedents to determine what categories of spaces in each program could work with my building type. After looking at all my precedents, I determined that breaking up the program into categories will help define the use of a cluster of spaces within a specific category. This was when I broke down my building type into five main categories and five supporting categories. The program is broken up into five main categories and five supporting categories. The main categories are research, experiment, green space, meeting space, and visitors space. These categories define how the research center will be utilized and designed for researchers. The supporting categories are mechanical, administration, services, support, and building core. These categories define spaces that will help researchers in the research process get answers and the most efficient methods to go about the research. These spaces also provide necessary security and data management of the research center. Within the program analysis, these categories form the first diagram that could become the parti of the design (Fig. 2). The parti could be used creatively or literally depending on design decisions and goals. Main spaces are listed on the periodic table diagram with their square footages and notation. Below that is a space/major components analysis breaking down the program (Fig. 1).

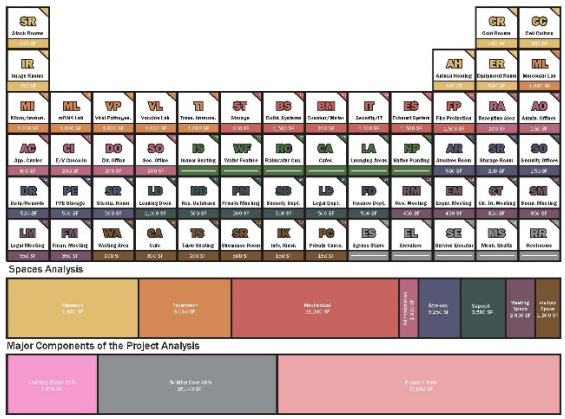

Figure 1: Program periodic table/program scale.

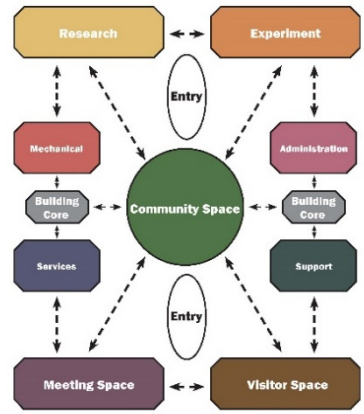

Figure 2: Conceptual parti diagram.

Through this program analysis I have successfully created a program that could work for my chosen building type and benefit the goals and aspirations of what my thesis efforts are striving to be. This program defined the size of the building to be roughly 60,000 SF. After some revisions and program integration, the program developed required double the original square footage with a program square footage requirement of 130,000 SF. The bars signify research/experiment spaces, the spaces between the bars signify support/services, the West side of the building includes meeting/visitors' spaces/administration with mechanical below. From looking at the precedents studied, there were multiple floor plans, space types, and necessary adjacencies referenced to formulate this program. Based on the original program

square footage and the revisions of the program, the increase in square footage will benefit the daily spatial needs of researchers.

6 SITE ANALYSIS

The site for this project is located on the eastern coast of the United States in the state of New York. Within New York State, this site is located in Orange County in the town of Wallkill, New York. In the town of Wallkill, there is an existing medical center named Garnet Health Medical Center which specializes in emergency services, healthcare, hospital services, and cancer treatment. Within the Garnet Health campus is the project site just west of the existing medical center. The size of the parcel is nine acres surrounded by trees creating a very secluded parcel which is great for this building type to limit fear of accidental outbreak. This site was previously cleared and flattened but then utilized as a storage location for the dirt that was excavated from the installation of the existing medical center foundation. This has created a big dirt mound that was compacted and had grass planted on the surface to try and make it look natural. Looking at the zoning for the town of Wallkill, New York, there are multiple zones that surround the zone that Garnet Health Medical Center and the project site is in. The zone that these two elements are in is the office and research zone for the town. Since the site and the existing medical center are within the zoning boundaries, it is confirmed that per zoning the building type of a viral infectious research center is feasible in this location. Currently, this parcel does not have a designated street address due to there being no plans for future development currently in this parcel. The closest street address available to locate this parcel was 200 Midway Park Drive which is the parcel across from the project site.

While formulating and compiling the most essential information from the site and the surrounding area, there are a lot of site elements and environmental factors that could contribute or affect the outcome of the project. This graphic is meant to give all the necessary information needed to keep in mind while designing in one place so there is no guessing when designing. The graphic will help make informed design decisions that will benefit the project overall. Smart and effective design decisions based on viable information is key for designing this research center to the best that it can be (Fig. 3).

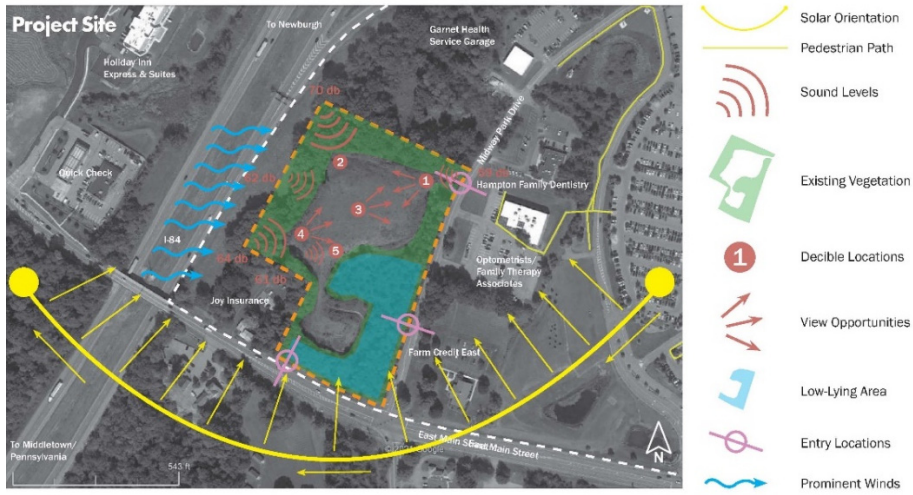

Figure 3: Composite site analysis showing relevant site elements and existing conditions.

7 CONCEPTUAL DESIGN

For concept number one, the idea is to create a functional and productive research environment for all researchers within the facility. There are views from the laboratories, administration, and support areas of the front green space as well as views towards the hospital. The idea of having constant views of the hospital and the green space is to boost the motivation/productivity of the researchers. For concept number two, the idea is to create a highly functional research center with a symmetrical floor plan with four main entrances with access to different program quadrants of the building all surrounding a centralized courtyard. This courtyard provides not only views from the laboratories when researchers are working, it also acts as a space where researchers can get away from research and take a break. For concept number three, the idea is to integrate the building more with the surrounding site and existing topography while providing views towards the existing hospital. The building will be divided into three blocks for three distinct types of research to be performed in these blocks. Laboratories as well as administration and support have views of the rear courtyard as well as the hospital to boost productivity. For concept number four, the idea is to create a building that interlocks together like an antibody creating a strong reference to the natural defense in the human body against viruses and diseases. Since there is a central green space, this concept acts as an active atom with the green space being the nucleus, adjacent spaces being the protons/neutrons, and unique site elements being the electrons. For concept number five, the idea is to reference the Caduceus symbol representing medical practice all over the world creating a sense of hope within the building design as well as the scientists who occupy this building. There are three laboratory sectors based on CVVR research ensuring that the laboratories have an adequate connection/view to nature helping to increase productivity and motivation. For concept number six, the idea is to create a research facility that is more campus like encouraging as much collaboration as possible between researchers with a central collaborative space while also providing research specific laboratories that provide privacy for experiments. An abundance of green space creates an excellent connection with the site and helps the research facility blend in (Fig. 4).

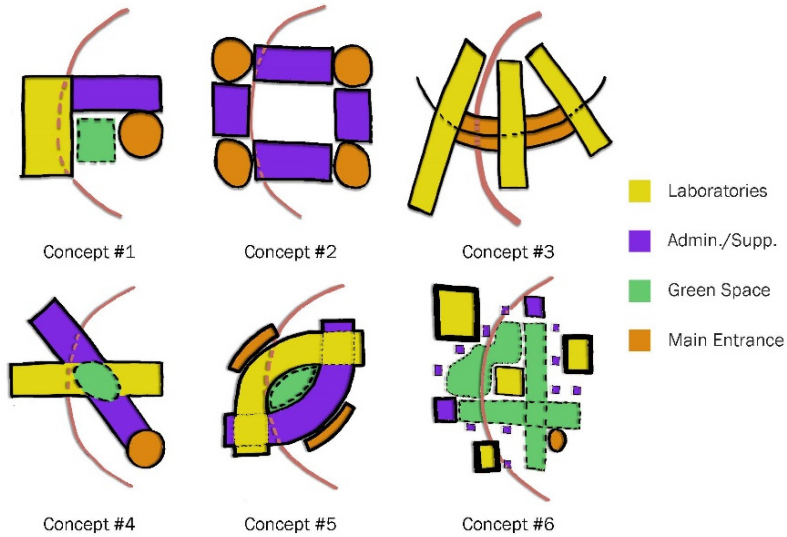

Figure 4: Conceptual design diagrams.

8 SCHEMATIC DESIGN

The concepts that were chosen out of the six from conceptual design for further development were concept #3 and concept #4. Instead of further developing these two concepts separately, they were combined to create three new concepts for the project, concept #7, concept #8, and concept #9 (Fig. 5). For concept number seven, the idea is to also continue exploring concept number three and concept number four together. From further exploration, adding a block towards the back of concept number three created an administrative block. Another block can enclose the green space creating more of a Winter Garden accessible year-round providing a fantastic opportunity for social interaction and entry. For concept number eight, the idea is to continue exploring concept number three as well as combining ideas from concept number four to see if there are any potential opportunities between the two. Taking the bar from concept number four facing East Main Street and putting it behind concept number three allows for an administration block and use of space across the main green space. For concept number nine, the idea is to further explore concept number four to see if there are more opportunities within this concept that can provide a more successful conceptual design. This concept was refined into one main concept but was also explored as two other concepts in terms of building form. Overall, there are three schemes in one concept that can all function the same way. Once these three concepts were developed, concept number seven was further explored to respond to the site analysis accordingly. Concept number seven seemed to have the most potential for the building type and the occupants I will be designing for. Looking at concept number seven, there was something about the rear of the building that did not match the front curve of the building. The rear block of the building was then curved for further exploration of this concept and seeing what the curve in the rear could provide for the building overall. With the refinement and expansion of concept number seven, it helped in the development of the concept for the project. This concept was further explored in terms of curving the administration block to the same radius as the laboratory branches creating the "nucleus" of the laboratory as well as a branding opportunity for the adjacent highway. By creating this "nucleus" promotes the idea of a working atom/cell while also providing researchers an escape from the rigidity of research spaces.

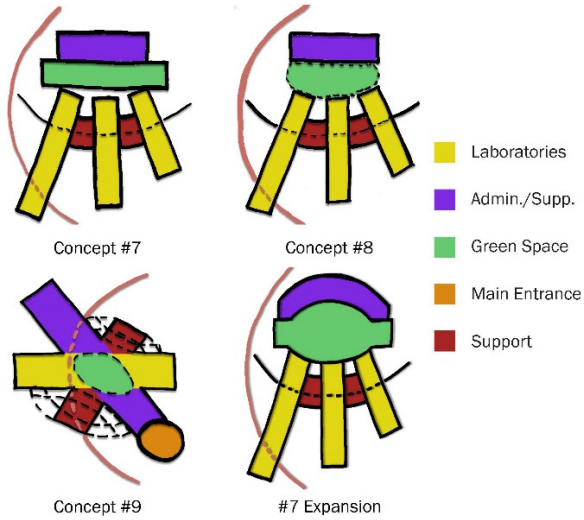

Figure 5: Schematic design diagrams.

9 DESIGN DEVELOPMENT

After thorough refinement and expansion of concept #7, this concept was chosen as the driving force for design development. This concept and building form were developed to show my thoughts and aspirations for this project. Having the concept developed extensively helped in obtaining feedback on the building and design decisions based off a solid concept to back the design. The design development phase included explaining and diagramming the concept of the project, site analysis, proposed floor plans, connections of each branch of the building to different points of the existing medical center adjacent to the site, exploded axonometric drawings, elevations, renderings, and technical drawings such as wall sections to show wall assembly. Once feedback was received, refinements needed to be made to ensure that the building design was showing the overall concept of the design. Sustainable design strategies were analyzed early in the project to be integrated in the design development phase. The feedback provided showed that there needed to be a further exploration on how sustainable design strategies will benefit the overall design based on research and analysis.

Figure 6: Design development rendering of the west elevation facing I-84 highway.

Figure 7: Rendering of chosen concept #7 expansion overall during design development.

10 FINAL DESIGN

Once the schematic design phase was complete, the final development of concept #7 was underway. The final design of this project revolves around the concept of a fully functioning atom with the central atrium space being the nucleus, the laboratories being the protons, the supporting spaces being the neutrons, and the exterior site elements being the electrons. These elements are key for an atom to be an atom and the same thing goes for this building design. Without one or the other, there is no building or "atom". The west side of the building towards the highway has a radial curve to allow for a branding opportunity for the building along the highway (Figs 6 and 8). Creating a more dynamic architectural experience on this side of the building is important to create a separation from the rigidity of viral infectious research within the building. The atrium space acts as the transition space between rigidity and dynamic creating a wonderful place for social interaction within the staff community (Fig. 13). This project aspires to be a LEED Platinum net-zero building (Figs 9 and 14).

Figure 8: final design rendering of the west elevation facing I-84 highway.

Figure 9: Final design rendering of the chosen concept #7 expansion overall.

11 SUSTAINABILITY

Since this building aspires of becoming a LEED Platinum net-zero building there were an abundance of calculations that needed to be performed in order to prove that this building is truly a LEED Platinum net-zero building. Going through the LEED v4.1 BD+C: Healthcare checklist, the project obtained 100 points achieving LEED Platinum certification. There was an energy analysis performed on the building as well as building system metrics done for rainwater collection, collecting 844,302 gallons of water annually, wind turbines, saving $27,000 per year with twelve turbines, geothermal, saving $56,000 annually, and an off-site PV array, saving $149,000 annually. Since the annual energy cost after the energy analysis is $148,376 (Fig. 12), the off-site PV system puts the building at net-zero. Adding a combined savings of $66,000 to the savings from the off-site PV array puts the building at $83,000 in total annual energy cost essentially proving that this building is not only net-zero, but it is in fact a net-positive viral infectious research center. Cooling load calculations were also done to prove that the tight envelope being utilized instead of a loose envelope is decreasing the cooling load of the building essentially limiting cost to the owner and the carbon footprint of the building. A typical laboratory has an air changes per hour rate of 15. Between fan coil units and fume hoods, this laboratory achieves 22 ACPH. Daylighting was also analyzed for fenestration placement to increase sDA and limit ASE (Figs 10 and 11).

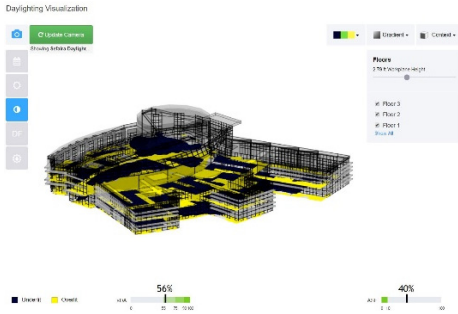

Figure 10: Daylighting with shades.

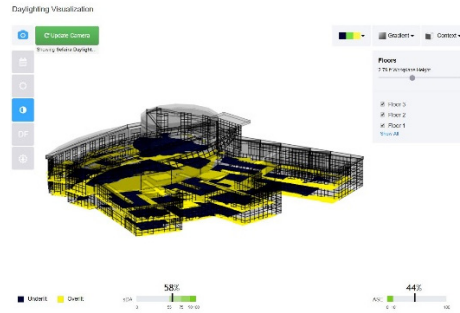

Figure 11: Daylighting without shades.

		AHU Design Airflow	Cooling Equipment ...	EUI	Annual Energy Cost
Baseline Concept 130,076 ft²	HVAC System Type: VAV - 100% OA Central Plant	**270,138** (cfm)	**1,758.3** ton	**170** kBTU/ft²/yr	**$665,790**
Fan Coil Units	Fan Coil Units and Central Plant	118,545 -56%	1,088.8 -38%	171 -0%	$699,001 -4%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,545 -56%	1,059.1 -39%	172 -1%	$690,438 -3%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,545 -56%	1,037.6 -40%	167 -1%	$681,908 -2%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,545 -56%	1,043.9 -40%	158 -7%	$672,893 -1%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,545 -56%	862.5 -50%	141 -17%	$558,849 -16%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,545 -56%	1,047.6 -40%	115 -32%	$477,823 -28%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,577 -56%	862.9 -50%	141 -17%	$559,168 -16%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,545 -56%	1,047.5 -40%	92 -45%	$338,327 -49%
Fan Coil Units, Exterior Ve...	Fan Coil Units and Central Plant	118,545 -56%	1,047.3 -40%	61 -64%	$148,376 -77%

Figure 12: Energy analysis through multiple iterations of different design decisions.

12 CONCLUSION

There has been an extensive amount of research conducted on topics relating to viral infectious research. Throughout this thesis effort, there were deep dives into understanding the medical and research processes in conducting such research as well as the important terminology that goes with it. Analyzing different methods of developing vaccines and fighting against viral infectious diseases expanded the knowledge about how this type of research is conducted and how it works within the human body. Combining the analysis on viral infectious research and the analysis on the building/site side of the research as well as the aspirations of becoming a precedent for "healthy buildings", this research helped direct this thesis effort and ultimately created an amazing design response for the world.

Figure 13: Rendering of V.I.R.C. atrium space.

Figure 14: Rendering of V.I.R.C. researcher entrance.

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