

ABSTRACT

Title of Thesis: BLOOM: A REGENERATIVE MODEL FOR URBAN DEVELOPMENT

Donald Benjamin Plugge, Master of Architecture, 2025

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The buildings we design make up our urban ecosystems, yet it is increasingly clear that these ecosystems need to become more compatible with the natural environment. The climate crisis is evidence that our cities are not performing sustainably on the urban scale. Natural ecosystems manage to be both delicate and resilient by balancing resource allocation optimally. We can learn from the systems that have been developed for billions of years in different plant communities and natural habitats. Natural ecosystem regeneration holds the keys to understanding how our cities can learn to adapt to change. With this set of design principles borrowed from nature, we can create sustainable cities that unite communities as co-contributors to a cohesive ecosystem.

Keywords: Urban Ecosystem Ecology, Building Cooperation, Building Optimization, Biomimicry

BLOOM:
A REGENERATIVE MODEL FOR URBAN DEVELOPMENT

by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Architecture
2025

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Acknowledgements

This project was made possible by the support of my loving family, inspiring mentors, loyal friends, gracious colleagues, and viewers like you.

Table of Contents

Acknowledgements.....	ii
Table of Contents.....	iii
List of Figures.....	v
List of Illustrations.....	vii
Chapter 1: Project Outline	1
Thesis Question:.....	1
Introduction.....	1
Chapter 2: Literature Review.....	4
Introduction.....	4
Research Categories.....	5
Ecosystems.....	5
Biomimicry	6
Kinetic Architecture.....	7
Sustainability.....	12
Chapter 3: Research Methodologies	14
Introduction.....	14
Explorations	14
Energy Efficiency	15
Water Reclamation.....	16
Social Impact	16
Precedent Selection.....	16
Passive and Kinetic Buildings	16
Scale.....	17
Synergetic Strategies.....	17
Site Selection and Analysis.....	18
Site Analysis Methods	18
Climate.....	19
Resource Balancing	19
Impact	20
Chapter 4: Precedent Studies	22
Introduction.....	22
Precedent 1: Natural Ecosystems.....	23
Permaculture Layers	24
Precedent 2: Lloyd Crossing Sustainable Urban Design Plan.....	25
Design Process	26
Precedent 3: Heliostat	26
Symbiotic Collaboration	27
Resource Distribution	27
Lessons.....	28
Precedent 4: Edith Green-Wendell Wyatt Federal Building.....	28
Adaptive Re-use.....	30
Passive Design	31
Lessons.....	31

Precedent 5: Omega Center	32
Omega Center Values	32
Community Integration.....	33
Eco Machine	34
Lessons.....	34
Conclusions.....	35
Chapter 5: Zones and Program	36
Introduction.....	36
Building Type Identification.....	37
Ecology Center.....	37
Existing Ecosystem.....	37
Introduction.....	39
Site Selection Matrix.....	40
Criteria	40
Wells Fargo Parking, Albuquerque, NM	41
Strengths	41
Weaknesses.....	42
Cityfront Plaza, Chicago, IL	43
Strengths	43
Weaknesses.....	43
Lloyd Crossing, Portland, OR.....	44
Strengths	44
Weaknesses.....	45
Hopkins Plaza, Baltimore, MD.....	46
Strengths	46
Weaknesses.....	46
Chapter 7: Conceptual Testing.....	48
Introduction.....	48
Scheme 1	49
Scheme 2.....	50
Scheme 3.....	52
Literature Review.....	53
Precedents	54
Site Analysis	55
Conclusion	55
Chapter 8: Conclusions.....	56
Introduction.....	56
Scales of change.....	57
Bibliography	67

List of Figures

Figure 1 – Four different categories of kinetic facades. Classifications and definitions by Author	10
Figure 2 - Map of US climate zones overlaid with initial site options.....	19
Figure 3 - Residential electricity use daily average distribution.....	20
Figure 4 - Ecosystem diagram overlaid with architectural equivalents.....	23
Figure 5 - Input and output distribution diagram by author.....	25
Figure 6 - Lloyd Crossing site section perspective with water treatment diagram.....	25
Figure 7 – Building network water treatment diagram by author.....	26
Figure 8 - Heliostat kinetic mirror system and naturally lit atrium space	27
Figure 9 - Natural light redistribution diagram by author.....	28
Figure 10 - Edith Green-Wendell Wyatt building before and after renovation images	29
Figure 11 - Total embodied emissions for existing operation, renovation, and total replacement.....	30
Figure 12- Reskinning existing building diagram by author	31
Figure 13 - Omega Center floor plan and section perspective sustainability and water treatment diagram	32
Figure 14 - Water treatment sequence diagram by author.....	35
Figure 15 - Initial concept 'scope of work' diagram by author	36
Figure 16 - Site selection criteria venn diagram by author.....	39
Figure 17 - Map of US climate zones overlaid with initial site options.....	41
Figure 18 - Chicago site plan and aerial axon Source: Google Earth.....	43
Figure 19 - Portland site plan and aerial axon	44
Figure 20 - Baltimore site section and aerial axon	46
Figure 21 - Site matrix rating sites from 1-5 based on site criteria by author	47
Figure 22 - Scheme 1 massing sketch and plan diagram by author.....	49
Figure 23 - Scheme 2 massing sketch and plan diagram by author.....	50
Figure 24 - Scheme 3 massing sketch and plan diagram by author.....	52
Figure 25 - View over constructed wetlands, community garden, and Hopkins Plaza	56
Figure 26 - Pioneer integration	58
Figure 27 - Mid-Succession optimization.....	58
Figure 28 - Mature Cooperation	58
Figure 29 - Vision for the future.....	58
Figure 30 - Floor plan in block context	58
Figure 31 - Baltimore Desirability Index.....	59
Figure 32 - Baltimore vacancy rate map.....	59
Figure 33 - Retain existing use	60
Figure 34 - Increase Density	60
Figure 35 - Promote mixed use.....	60

Figure 36 - Optimize kinetic facade.....	61
Figure 37 - Facade energy generation.....	61
Figure 38 - On-site grid.....	61
Figure 39 - Energy Use Intensity Comparison with three façade shading options.....	62
Figure 40 - Cost comparison with three facade shading options	62
Figure 41 - Rain water capture.....	63
Figure 42 - Wastewater Treatment	63
Figure 43 - Process city water.....	63
Figure 44 - Add green space	64
Figure 45 - Increase biodiversity	64
Figure 46 - Extend Eco-tones	64
Figure 47 - Pathway connecting ecology center with mixed use building featuring kinetic facade and bio pond	65

List of Illustrations

Figure 5 - Input and output distribution diagram by author.....	25
Figure 7 – Building network water treatment diagram by author.....	26
Figure 9 - Natural light redistribution diagram by author.....	28
Figure 12- Reskinning existing building diagram by author	31
Figure 14 - Water treatment sequence diagram by author.....	35
Figure 15 - Initial concept 'scope of work' diagram by author	36
Figure 16 - Site selection criteria venn diagram by author.....	39
Figure 22 - Scheme 1 massing sketch and plan diagram by author.....	49
Figure 23 - Scheme 2 massing sketch and plan diagram by author.....	50
Figure 24 - Scheme 3 massing sketch and plan diagram by author.....	52

Chapter 1: Project Outline

Thesis Question:

How can we take inspiration from nature to create optimized and collaborative urban ecosystems that express the value of urban renewal to the local community?

Introduction

It has been evident for several decades that the built ecosystem is incompatible with the natural ecosystem in its current state. Population¹, CO2 emissions², average global temperature³, and energy consumption from all sources⁴ are constantly increasing. In order to achieve a symbiotic relationship with our environment, we are going to need to enter an era of providing more than we take. The changes required to achieve this are too numerous to list, but the fact that roughly 40% of energy consumption is used by buildings⁵ shows us that changing the way we think of building energy use is a good start.

We often discuss the environment as if it is one thing, and in a way, Earth's ecosystem is a whole made up of many natural and artificial systems. This ecosystem can be broken down into its parts, and each of those can be broken down further, what

¹ "World Population by Year - Worldometer." Accessed December 13, 2024.

² Ritchie, Hannah, and Max Roser. "CO₂ Emissions." Our World in Data, January 22, 2024.

³ Counts, The World. "Average Global Temperature." Accessed December 13, 2024.

⁴ "World Energy Consumption, 1965-2020 | The Geography of Transport Systems," 2017.

⁵ PAGES 2k Consortium (2019). "Consistent multidecadal variability in global temperature reconstructions and simulations over the Common Era". Nature Geoscience. 12 (8): 643–649.

matters is that the system as a whole is working towards equilibrium, not disorder. Though it is true that there have been and will always be phases in the resting state of the planet, we can measure and reasonably explain how the outputs of our societies have effects that ripple through the planet's systems. One of the strongest pieces of evidence for this theory is that we are able to estimate average global temperatures to the beginning of the Common Era⁶, and up until the late 1900s it was between -0.5 and $+0.5^{\circ}\text{C}$ ⁷. Today the average temperature is $+1.17^{\circ}\text{C}$ and each of the last 10 years has been hotter than the last. It is currently 1.36°C warmer than the preindustrial average as measured between 1850-1900.

In order to reach the goal of providing for the environment rather than disrupting it, the first step is to define tangible sub-goals. One way this can be done is by investigating what the inputs and outputs of built environments are. Currently, our inputs are largely non-renewable resources that generate the energy we use to complete our different processes, and our outputs are 'waste' materials in whatever form they took when we finished with them, ie. plastic, CO₂, infertile soil, building ruins, etc. We are currently in the process of changing the forms of our inputs (solar, wind, and hydroelectric power) and outputs (biodegradable materials and clean chemicals) to integrate better with the natural world. There are still some major roadblocks keeping us from being able to reach a true symbiotic relationship though. Currently, there are not enough clean energy sources to meet the demands of our

⁶ PAGES 2k Consortium (2019). "Consistent multidecadal variability in global temperature reconstructions and simulations over the Common Era". *Nature Geoscience*. 12 (8): 643–649.

⁷ Counts, The World. "Average Global Temperature." Accessed December 13, 2024.

society, so we are forced to rely on non-renewable resources. However, that is a very temporary solution to a long-term problem.

This project proposes a way to increase the efficiency of an ecosystem of buildings by optimizing the use of natural resources like sunlight, air, and rainwater. Taking inspiration from vernacular architecture which relied on responding to the environment out of necessity, this solution coordinates a diverse community of buildings with different needs and functions. Using Kinetic design and passive strategies, the resource load of the system can be optimized and the community can collaborate to reduce energy loads and reduce the environmental impact.

Chapter 2: Literature Review

Introduction

This project builds on both old and new concepts in resource management and efficiency, from passive design strategies used in vernacular architecture, to modern innovations in energy production. The primary background for this project, however, predates architecture and humanity entirely. The project was inspired by the tested efficiency of natural ecosystems. Their ability to work symbiotically to improve efficiency and create a globally balanced system is something we should be replicating in our urban ecosystems. Taking inspiration from natural processes is a practice that has been essential to Architecture since its inception. Passive design is an example of this in which architects use assets of the local environment to optimize ambient conditions for comfort. The more modern concept of Kinetic Architecture can be seen as an evolution of passive design in which building components move to react to environmental changes in real-time and can help optimize the benefits of passive design. Biomimicry is the scientific field studying design solutions inspired by natural models, systems, and elements. “Using nature as a guide can enhance sustainability or even go beyond that and generate a regenerative approach”⁸.

⁸ Verbrugghe, Nathalie, Eleonora Rubinacci, and Ahmed Z. Khan. “Biomimicry in Architecture: A Review of Definitions, Case Studies, and Design Methods.” *Biomimetics* 8, no. 1 (March 2023): 107.

This project builds upon the existing framework of biomimetics, building optimization, and collaborative ecosystems to create an integrated and sustainable urban ecosystem. To create a clear image of what this might look like, a comprehensive definition of the given parts must be established. Starting with the applicable aspects of natural ecosystems including symbiotic collaboration, resource reallocation, permaculture layers. Followed by a description of Biomimicry, and façade optimization including the history, concepts, applications, terms, approaches, systems, and benefits of the theory and practice.

After defining the component principles of the project, a clear, measurable goal must be defined. Though the findings will produce diverse results, the project's primary goal is sustainability and energy efficiency in the pursuit of reducing CO2 emissions. The problem as it has been described is that, despite green building efforts, our cities are not sustainable. Before we can expand our city infrastructure to account for growing populations, we must look at them through a wide lens and determine how to reduce their environmental impact.

Research Categories

Ecosystems

An ecosystem can be defined as “a biological community of interacting organisms and their physical environment.”⁹ This system of symbiotic coordination is

⁹ Oxford English Dictionary, s.v. “ecosystem (n.),” July 2023, <https://doi.org/10.1093/OED/4710651519>.

a naturally occurring form that stems from the observed diversity-stability¹⁰ relationship between different biological species. This relationship is defined by the limited resources available within any given climate, meaning that species competing over the same resources will form an unstable relationship. However, if species can coexist or cooperate by modifying their resource requirement or acquisition methods, the ecosystem will become more stable.

The laws of the natural ecosystem apply to human communities as well, our resources tend to be abstracted into money and time instead of food, water, and sunlight like natural ecosystems, but a diverse community results in less competition when cooperation is achieved. This thesis argues that this analogue can be drawn to the built environment as well. Buildings intake water, air, and sunlight and expel waste or byproducts.

Biomimicry

Biomimetic design is a concept that is inherent in the field of architecture, it became globally defined in the mid-20th century, and is experiencing a renaissance with modern Green and Natural building styles. Biomimicry uses nature as a basis for design, applying principles from natural structures and systems to solve architectural problems. Similar to the traditional architectural design process, biomimetic design involves defining a problem in abstract terms so that an applicable case study can be adapted and applied as a solution. The difference in the two processes is that Biomimetics studies plant and animal functions as case studies to be applied to

¹⁰ Anthony R. Ives, Stephen R. Carpenter, Stability and Diversity of Ecosystems. *Science* 317, 58-62 (2007). DOI:10.1126/science.1133258

human issues. Pavan Velivela proposes a design process inspired by Biomimicry called Domain Integrated Design¹¹.

Biological functions are unique in their ability to adapt to diverse situations through the transmission of advantageous genetic traits. This process is seen in both plants and animals and equates to intelligent design. The adaptive traits that are found in nature can be applied to architecture to create timeless buildings that can mold to new functions and changes in the environment.

Our structures can also benefit greatly from the resilient structures found in nature. One of the primary metrics for biological success is the ability to survive adverse conditions. Especially with the unpredictable changes in the global climate today, surviving adverse conditions is becoming more essential in our building design.

Biomimicry is a powerful tool in regenerative design for our urban ecosystems, taking inspiration from self-healing systems in nature can allow our cities to repair themselves and the environment. Jemimah Asamoah defines regenerative design as “Designing to promote a symbiotic relationship between a local community and the natural environment” in their thesis on biophilia and biomimicry.

Kinetic Architecture

Although the idea of ‘Kinetic Architecture’ is considered a new practice in architecture, this mostly refers to the specific term. In many ways, architecture has

¹¹ Velivela, Pavan Tejaswi, and Yaoyao Fiona Zhao. “A Comparative Analysis of the State-of-the-Art Methods for Multifunctional Bio-Inspired Design and an Introduction to Domain Integrated Design (DID).” *Designs* 6, no. 6 (December 2022)

been kinetic since its conception, nomadic societies used temporary tensile membrane structures¹² before any of the ancient stone ruins that we consider the earliest architecture. However, there are notable milestones in the development of kinetic architecture. The first operable doors seem to have been created around 3000 B.C. both in ancient Egypt and Europe in tombs and shelters respectively¹³. This development of a movable element that blocks light and views, keeps out the elements and intruders and changes the definition of a space evolved through the ages and is still growing. In the 19th century, the Industrial Revolution brought about another significant development, the safety brake elevator. This was revolutionary to the field of architecture as a whole and had cascading effects on urban development. This progress continued into the early 20th century with proposals for a revolving house, first by Thomas Gaynor in 1908, then in 1935 by Angelo Invernizzi in which a Villa rotated on a 44-meter base to follow the trajectory of the sun, this was called Villa Girasole¹⁴, which means sunflower in Italian. The invention of the computer began the next era in reactive building components, and in 1970 the term “Kinetic Architecture” was coined by William Zuk and Roger H. Clark in their book of the same name. It was now possible to create building components that could move in reaction to environmental stimuli using Sensors, Actuators, Controllers, and Motors. This is what was used in what some consider an early example of Modern Kinetic

¹² R. Kronenburg, *Architecture in motion: the history and development of portable building*. Routledge, London, 2013.

¹³ Muraflex. “A History Lesson in Doors Shows Us How They Have Evolved over the Centuries.,” June 20, 2022. <https://muraflex.com/en/blog/the-history-of-doors>.

¹⁴ Elmokadem, Dr Ashraf, Dr Magda Ekram, Dr Ahmed Waseef, and Basma Nashaat. “Kinetic Architecture: Concepts, History and Applications” 7, no. 4 (2016).

Architecture, the Institut du Monde Arabe designed by Jean Nouvel'¹⁵. This building used sensors and motors to automatically close apertures on the facade to keep consistent light levels and solar exposure on the interior.

Kinetic interventions can take a variety of forms, but they can be generally sorted into three categories; Kinetic Facades, Interior, and Structure Systems¹⁶. Kinetic Facades are cladding elements that move by scaling, transitioning, deforming, rotating, or shifting in another way, generally, these components deal with energy efficiency and visibility on the skin of the building. Kinetic Interiors include elements that change the spatial quality of a building, like a kinetic wall or transformable room. Finally, there are Kinetic Structure Systems, which often deal with the building's resilience. Some examples of these are embedded moving systems like tuned mass dampers, deployable temporary structures like tents, or dynamic kinetic structures that can be added, changed, or moved like sliding partitions.

¹⁵ J. Moloney, *Designing kinetics for architectural facades: state change*, Taylor & Francis, New York, 2011.

¹⁶ Elmokadem, Dr Ashraf, Dr Magda Ekram, Dr Ahmed Waseef, and Basma Nashaat. "Kinetic Architecture: Concepts, History and Applications" 7, no. 4 (2016).



Figure 1 – Four different categories of kinetic facades. Classifications and definitions by Author

The rich history of applications leaves defining the term Kinetic Architecture quite difficult. Luckily there is a wealth of theory on the subject and each interpretation has its own slightly different definition, the contemporary state of the art is well summarized by Fox and Kemp¹⁷: “Kinetic architecture is defined generally as buildings and/or building components with varied mobility, location, and /or geometry”. They go on to describe the different ways that this variation is performed “folding, sliding, expanding, and transforming in both size and shape through pneumatic, chemical, magnetic, natural, or mechanical” means. However, the listing of vehicles of movement, while helpful as an inspirational tool, is limiting to the definition and has already been outdated since its conception.

Under the umbrella concept of Kinetic

Architecture, there are a myriad of typologies that

have been explored in theory and practice, Megahed

defines and categorizes the typologies on the basis of some of the influential works

surrounding Kinetic architecture¹⁸. Adaptable structures are designed to be altered by

¹⁷ Fox, M., & Kemp, M. (2009). Interactive architecture. New York, NY: Princeton Architectural Press.

¹⁸ Megahed, Naglaa Ali. “Understanding Kinetic Architecture: Typology, Classification, and Design Strategy.” *Architectural Engineering and Design Management* 13, no. 2 (March 4, 2017): 130–46.

users for different functions. Deployable structures are transportable structures that are capable of mostly autonomous change. Intelligent architecture responds in time to information measured from its environment. Mobile structures are designed to move on an integrated chassis. Performance-based buildings use digital technology to change to improve their impact on the environment. Responsive architecture reacts to predetermined stimuli in a specific place at a specific time. Transformable structures are designed to quickly take a new form to fulfill functional requirements. These typologies create a kit of parts that can be used to address unique architectural problems with site-specific solutions.

In many ways, Kinetic design is the natural evolution of passive design. They both utilize environmental influences to improve the built environment, but Kinetic designs transform to optimize the results. Kinetic systems also act similarly to Active systems. Both process environmental information and perform a function based on the results, but Kinetic systems supplement their energy requirements with site-specific assets.

One of the inciting inspirations behind kinetic architecture was its unique ability to affect users by changing form to match function. “Groups like Archigram took this new kind of knowledge and used it in architecture so that spaces could be changed in order to match the changes in the user’s wishes and needs”¹⁹.

¹⁹ Megahed “Understanding Kinetic Architecture” (March 4, 2017): 130–46.

Sustainability

Creating reactive architecture through Kinetic architecture and Biomimicry will allow buildings to function more efficiently and users to feel more in control of their environment. However, the ultimate application of these concepts is to improve sustainability in our urban ecosystems and make the environmental impact of our cities positive.

The path to net-positive cities has already begun, it started with net-positive buildings. Buildings that have such low energy consumption and so much on-site production that they supply power back to their local infrastructure. If this practice was universalized, it would completely change the toll that we are imparting on the planet, and could lead to the positive change that our ecosystem desperately needs. But this is not feasible with all buildings using current technologies. The remedy to this issue is allowing buildings to function together in a system through “heat sharing and load diversity”²⁰.

It is not enough for us to reduce the built environment's energy load. Cities need to simultaneously reduce their impact, which means water runoff, CO2 emissions, light pollution sound pollution, and more. Site impact can be measured in a number of ways, but in the end, it comes down to the resources being used on a site. There will always be valuable resources imported into an urban context, energy consumed to enable the completion of actions and processes, and waste material

²⁰ Kallushi, Abi, Jeffrey Harris, John Miller, Matt Johnston, and Ab Ream. “Think Bigger: Net-Zero Communities,” n.d.

expelled from the site. Reducing the inputs and maximizing useful outputs reduces the measurable impact on a site.

Chapter 3: Research Methodologies

Introduction

Not only does this thesis inquiry have a strictly defined goal to reach, but the premise revolves around the public being able to see the results of the intervention compared to that goal. The research has to be thorough enough so that even the messiness of the real world will not stop the project from reaching its goals.

When it comes to research methods for the distinct parts of the project, this will require an iterative process. The first level of research will be precedent study and reviewing research papers. This process is the most time-efficient and gives general information to start as a foundation for any part of the project. For example, the site is chosen with consideration for the Lloyd Crossing case study (which will be studied more in-depth in Chapter 4) integrated with lessons learned from literature review. The next level of research should take more time, but produce more accurate and applicable results. An example of this is performance experiments with physical and digital models to test kinetic and biomimetic systems. Being familiar with the process of testing a prototype will shine additional light on feasibility and constructability.

Explorations

The research methodologies used in this project emphasize technical data and comparative analysis. The primary method of data collection is through the scientific method involving thesis and synthesis. The explorations of the project can fall into

one of the following categories: Can existing high-rise buildings be adapted to reach net zero energy consumption in an urban ecosystem? What infrastructure is required to reach goals related to water treatment? How can this project improve user experience and integrate sustainability into the community? Each of these topics will have a different approach to finding sufficient data, but they are also all essential to the success of the project.

Energy Efficiency

To identify the viability of the energy goals of the project, research had to be done into how existing buildings can be adapted to net zero energy consumption. This process started with reviewing scholarly articles, from which it was determined that environmental factors play a commanding role in the ability of buildings to reach net-zero energy consumption. Research into the New Building Institute's list of net zero buildings was crucial for getting an overview of what types of buildings tend to be successful in reaching net zero as well as providing a list of precedents. From that list, ideas could be generated on possibilities and ideals for passive buildings. After determining an appropriate program that would match the thesis, a single precedent was chosen from the list to study, the Omega Center. Though it is a passive building, investigation into the project revealed a greater aspect to the building: Its water reclamation system.

Water Reclamation

The integration of water reclamation as a core principle of the project stemmed from the idea of optimizing the inputs and outputs of the urban system. The idea surfaced multiple times in the precedent study phase, first in the study of plant communities and permaculture, then in the theoretical Lloyd Crossing project, and more formally in the Omega Center project. Similar to improving energy efficiency, improving the quantity of water reclamation can result in costs to the user experience. The performance goals of the project will be weighed against goal of being an asset to the community.

Social Impact

In the same way that the project intends to give back to the natural environment, it also intends to support the social climate of the area. The way this was done was by offering the core of the project as a public space for the community to enjoy, investigate, and learn from. Jemimah Asamoah's thesis (source) on biophilia counteracting urban blight was a great tool for using inspiration from nature to improve community psychology.

Precedent Selection

Passive and Kinetic Buildings

After the research phase, the project was focused on mimicking the kinetic aspects of nature and the use of a natural ecosystem was being applied at the building scale. This inspired extensive investigation into kinetic and passive architectural precedents, because they embody bioclimatic design that responds to nature. As the

project progressed it was decided that passive and kinetic strategies can improve how buildings work with their environment, but they do not address how buildings react to each other. In the end, these strategies are best integrated as a moving parts that work together in a system with a wider view.

Scale

Initial precedent research seemed to be resulting in individual ideas will vastly different purposes, until the intended scale of the project was determined. With an initial focus on kinetic buildings, the extent and quality of implementation on different scales was studied through a series of precedents, starting with small, movable structures, into larger structures with kinetic spaces, and larger still with buildings whose facades moved for performance and security reasons. But once the concept moved past the study natural kinetics into the study of natural systems in general, another scale was introduced which was the urban ecosystem. Precedents were selected from categories that represented key concepts of the project: Passive Design, Kinetic Façades, Kinetic Spaces, Urban Ecosystems, and Net Positive buildings.

Synergetic Strategies

It was not until the third round of precedent studies that the core concepts and scope of the perspective project began to become evident. A breakthrough in the methodology came when it was acknowledged that kinetic architecture was not the core of the thesis, but rather a part, the larger idea of a synergetic urban ecosystem. At this point, it was decided that the project would involve a number of context buildings

being re-skinned in order to retain their carbon sequestration while improving their performance. It was also determined that the primary intervention would be a central ecology center that hosted water treatment, energy storage, and learning facilities where the community can track the performance of the ecosystem. New methodologies were developed and a wider range of precedent criteria were implemented. The criteria of a net zero building was specified to net zero façade renovations. The kinetic categories were changed to a broader resource manipulation category in which buildings and building components are used to change the conditions of natural resources to be more usable. The category of water reclamation was added because this topic required much more research. Finally the Ecosystem precedent criteria was split into a natural ecosystem precedent and an architectural ecosystem precedent. In the end, these changes allowed for a selection of precedents that represented the implementation of ideas, rather than simply applicable practices.

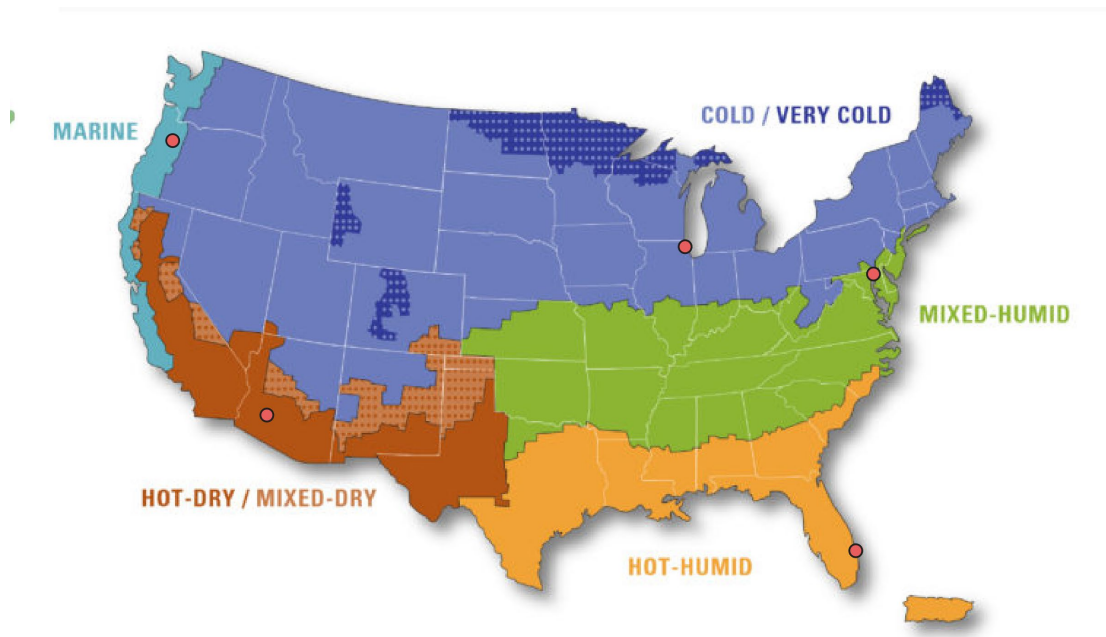
Site Selection and Analysis

Site Analysis Methods

Once site analysis began, the program parti was established for a rather identifiable site. It was already determined that the context should be a high-rise urban environment because these buildings have the most sequestered carbon, and they have the most envelope surface area to test skin adaptations. This gave options of vertical additions or a new building on a baren site, there is a world where this project would work as a rooftop addition to an existing building, but that added an unnecessary level of complexity.

Climate

Working backwards, it was important to determine an ideal climate for this specific site. The first decision was if this project will be in the United States or not, for many reasons including the fair climate, familiarity with codes and regulations, prominence of the US in the Paris agreement, and access both to sites and site information, it was determined that the US would be the best region for the project. Within that context, candidates from each of the applicable climate zones was chosen, between the site analysis and the climate analysis, a group of possible sites was selected and information was gathered to be analyzed through a site matrix.

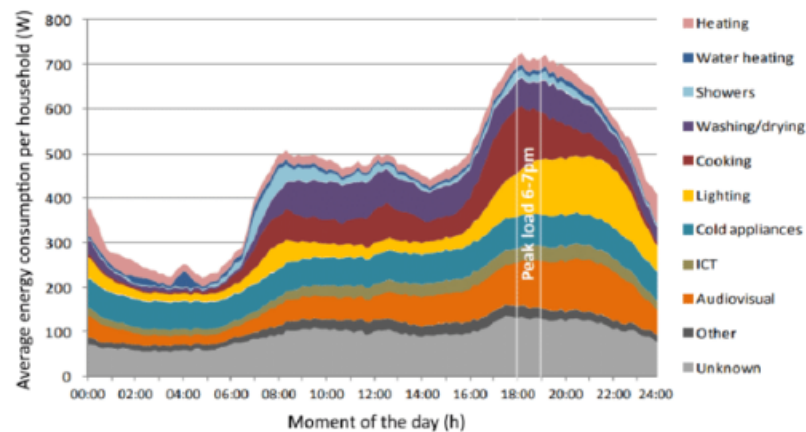


*Figure 2 - Map of US climate zones overlaid with initial site options.
Source: <https://basc.pnnl.gov/images/building-america-climate-zone-map>*

Resource Balancing

Comparing specific sites brought into focus an important aspect of the research process which was the resource consumption by different use groups and

how that will need to be balanced in the proposed ecosystem. The reason that a system of buildings has an advantage in terms of sustainability is that each building has its own strengths and weaknesses, when buildings share resources, it is possible to offset shortcomings, similar to the reason that humans live in communities. This concept was first explored through the lens of use groups. Buildings with different uses have different needs and if this project is able engineer those needs to compliment each other, it will have a much better chance of success. For example, the typical daily energy consumption per person in a residential buildings look like the figure below (this section needs more research on how the load balancing of different uses can be optimized)



Average electricity use profile (in W) per 24 h in a typical household in the United Kingdom. The data is taken from 250 households of varying size and age groups. Reproduced and modified from [33].

Figure 3 - Residential electricity use daily average distribution.

Source: https://www.researchgate.net/figure/Average-electricity-use-profile-in-W-per-24-h-in-a-typical-household-in-the-United_fig2_341286330

Impact

The goal that addresses the social impact of the project is hard to define, and at the same time, it must be addressed at every level of research and design. When it came to site selection, the methodology behind social impact investigation was

related to what level each site needed a project like this on a social level. Evaluating the level of need started at a qualitative level, which city needs updated buildings and improved energy performance? which communities will adopt the project and take stock in the value of the upgrades and how well the project is performing? There were qualitative responses to these questions, but in order to evaluate them against each other, they needed to be quantitative, so the questions were rephrased to be more specific and measurable: What are the prices of electricity and water in the area? Which states have the best baseline energy performance? What sustainability programs are already implemented in the area? These criteria were now in a format that could be input into a decision matrix to reduce the number of sites down to the one.

Chapter 4: Precedent Studies

Introduction

In a technical project such as this one, precedents provide jumping-off points when connecting one idea to another. The considerations for this thesis vary in scale, starting from the climatic, this project relies to its climate by utilizing every asset and addressing every challenge possible. It relates to the urban scale by introducing a new layer of infrastructure to complement the existing systems between buildings. On a contextual site scale, the project's success lies in the ability of neighboring buildings to support each other with choreographed interactions. At the building scale, the project works to optimize performance while allowing for human comfort. The smallest building scale in the proposal is the heart of the project, whose function emanates outward facilitating the buildings and context, powering the infrastructure and, most importantly, touching the community and displaying the impact of thoughtful collaborative design.

Each of these scales was developed using a precedent as a grounding point that can be adjusted to match the thesis concept. The precedents that inspired the project were natural ecosystems, as the concept became focused, the layers of permaculture emerged as the primary precedent. Similar ideas of symbiotic collaboration were explored in the Lloyd Crossing sustainable urban design plan. In order to dive deeper into the interrelationships between buildings, the Heliostat in Sydney, Australia was studied for its kinetic re-distribution of natural resources like light and air. To investigate the possibilities of improving the performance of existing

buildings through the renovation of the envelope, the Edith Green-Wendell Wyatt Federal Building was studied. As the primary provision for the general public, the heart required a thorough case study. The Omega Center for Sustainable Living is a great example of a building that provides resources for the public infrastructure while supplying communal educational space that displays its innovative practices.

The following precedents are presented in order from broad to specific, starting with the most large-scale, theoretical inspiration moving to the most specific, functional example.

Precedent 1: Natural Ecosystems

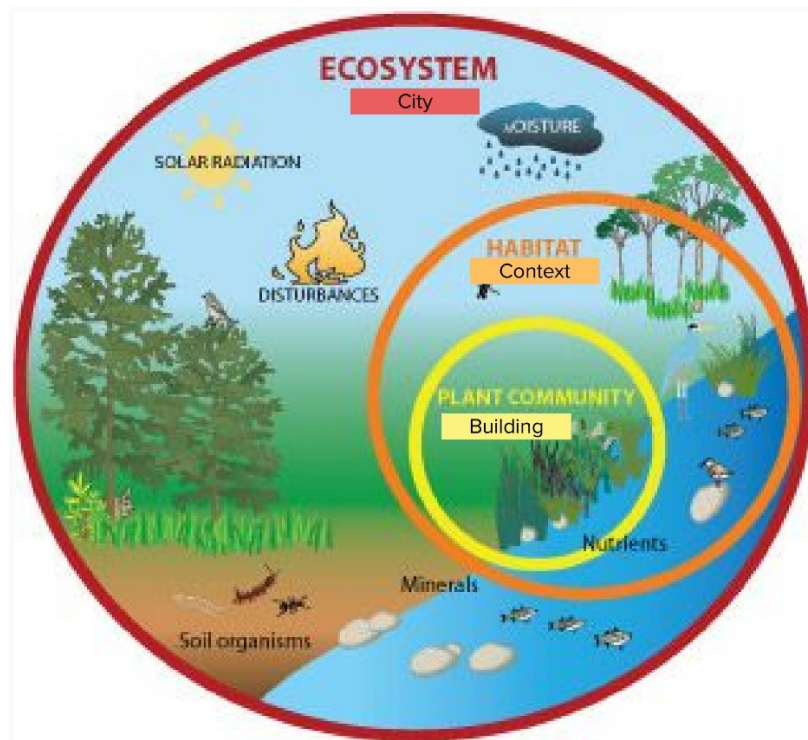


Figure 4 - Ecosystem diagram overlaid with architectural equivalents.
Source: <https://blog.prosono.com/blog/ecosystem-overview>

Permaculture Layers

Inspiration from nature is a thematic thread that has carried through the project from the beginning, and though it may not offer many architectural solutions, we still have a lot to learn from plan communities about resource allocation²¹. This abstract concept is great in theory, but to apply it in this project, there will need to be specific examples. That is why the first precedent is the layered permaculture of a “Food Forest”. This is a designed system that is made to get the most out of its resources by integrating different plant types in the same system resulting in less waste and preservation of the surrounding environment. The layers include the Canopy/ tall tree layer, which provides structure to the system. Then there is the Sub-Canopy/ large shrub layer, which reduces sunlight intensity to lower layers. The Shrub layer fruits which invites animal species and increases biodiversity. The Herbaceous layer provides habitats for beneficial insects. The ground cover/ creeper layer protects the soil against erosion, and the underground layer supports fungi which recharge the soil and reallocate resources. The Vertical/ Climber layer helps to start the decomposition process on dead or dying members²².

²¹ Tilman, David. *Plant Strategies and the Dynamics and Structure of Plant Communities*. Monographs in Population Biology 26. Princeton, N.J: Princeton University Press, 1988.

²² Hirschfeld, Sarah, and Rene Van Acker. “Review: Ecosystem Services in Permaculture Systems.” *Agroecology and Sustainable Food Systems* 45, no. 6 (July 3, 2021): 794–816. <https://doi.org/10.1080/21683565.2021.1881862>.

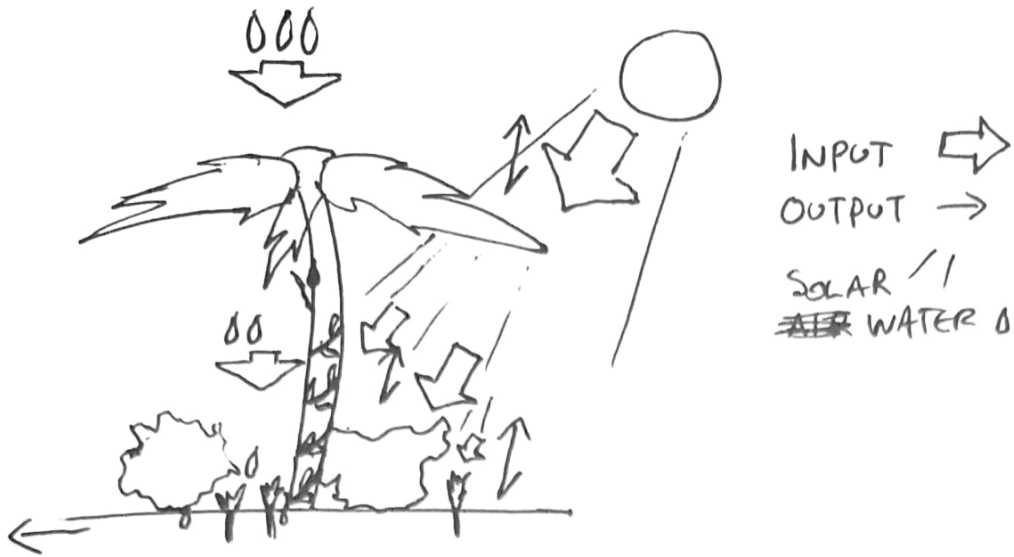


Figure 5 - Input and output distribution diagram by author

Precedent 2: Lloyd Crossing Sustainable Urban Design Plan

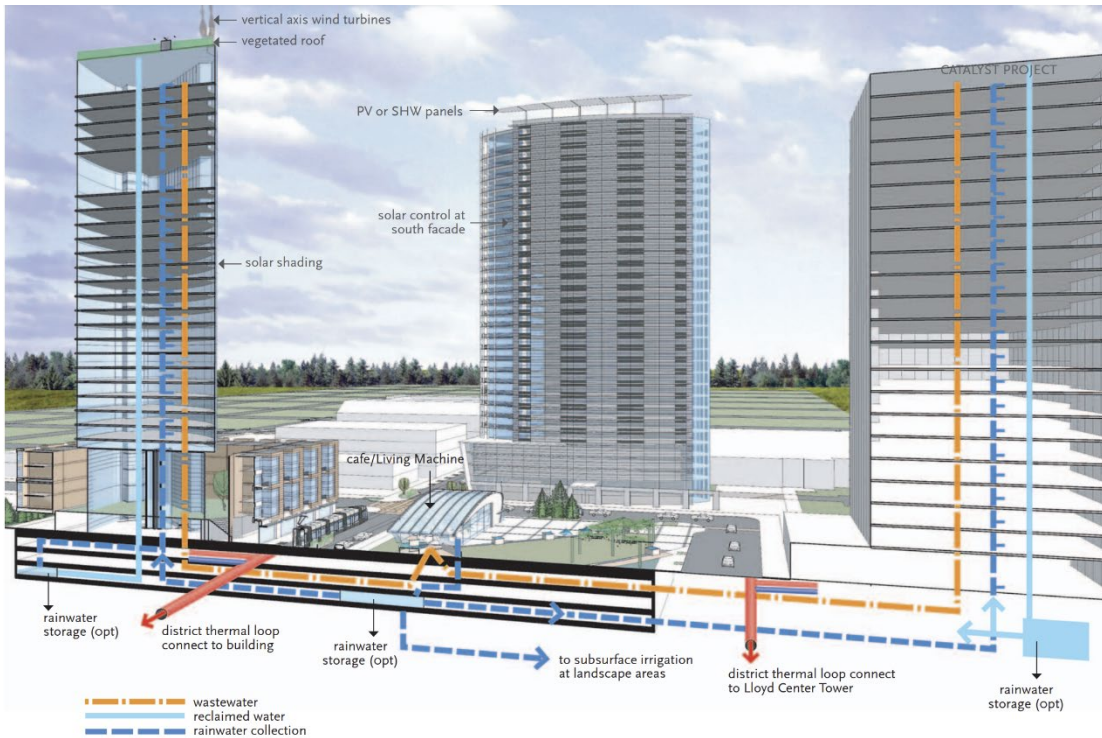


Figure 6 - Lloyd Crossing site section perspective with water treatment diagram
 Source: <https://prosperportland.us/wp-content/uploads/2016/07/Lloyd-Crossing-Plan.pdf>

Design Process

The aspect of this project that speaks to this thesis is the design process behind the analysis of a gradient of Inputs vs. Outputs. The project started with an analysis of the site if it had never been built on, the site used all of the rainwater that it needed and created a balance of light exposure. They then compared that to how it could be built with modern principals of siteless, timeless architecture, this was considered the worst case scenario. From there a matrix was made that showed the cost associated with a variety of levels of intervention. They then explored the two most cost efficient options for viability.

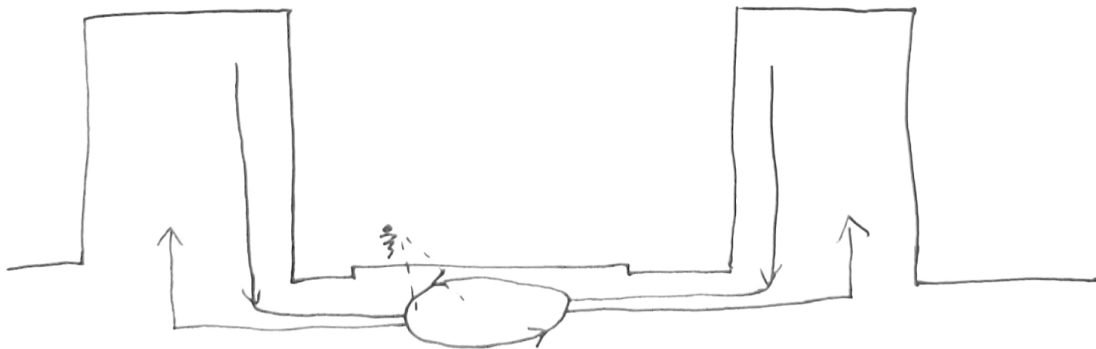


Figure 7 – Building network water treatment diagram by author

Precedent 3: Heliostat

The Heliostat at One Central Park in Sydney Australia was design for Frasers property by Ateliers Jean Nouvel & PTX Architects²³. The highlight of the project is the cantilevered array of mirrors between the two towers which redirects light into the central atrium space that would otherwise be a dark space. The mirrors are motorized to precisely direct light into he courtyard without it reflecting on unintended targets. This unique design not only solves an age old problem in courtyard buildings, but it

²³ Tilt. "Heliostat - One Central Park." Accessed December 17, 2024.

also uses a glass reflecting pool and LED art exhibit to create a memorable experience for users during the day and at night.



Figure 8 - Heliostat kinetic mirror system and naturally lit atrium space
Source: <https://good-design.org/projects/one-central-park-heliostat-and-reflector-system/>

Symbiotic Collaboration

The Heliostat speaks to a specific type of building intervention that does not get as much exploration as passive design or kinetic architecture. That is Symbiotic collaboration. The way that this building interacts with natural resources relates to the project in that it involves the two taller buildings working together to provide for the courtyard between them. In return, the courtyard provides an amenity space that occupants can enjoy in the space.

Resource Distribution

This creative distribution of resources is a great example of what this thesis could achieve. Jean Nouvel's mastery of modern technology and bioclimatic design resulted in a project that utilizes natural resources to create quality spaces where others would consider impossible. Not only did he push through what must have been ruthless skepticism and doubt to do something so out of the ordinary, but he made it the centerpiece of the building, and it makes the project unforgettable. A criticism of

this project is that it may be considered an object building, and it is difficult to make a city out of projects like this. However, the methodology of designing creatively with respect for place and time are essential pieces to create efficient and beautiful architecture.

Lessons

The primary lessons gained from this study were in the thoughtful approach to creative design. Not only was the concept of the Heliostat a thoughtful solution to a common problem, but it was also carefully designed and fully developed on an experiential level. Nouvel paired an issue (lack of light in the courtyard) with a new technology (motorized heliostat) to not only redirect resources, but also create a unique experience.

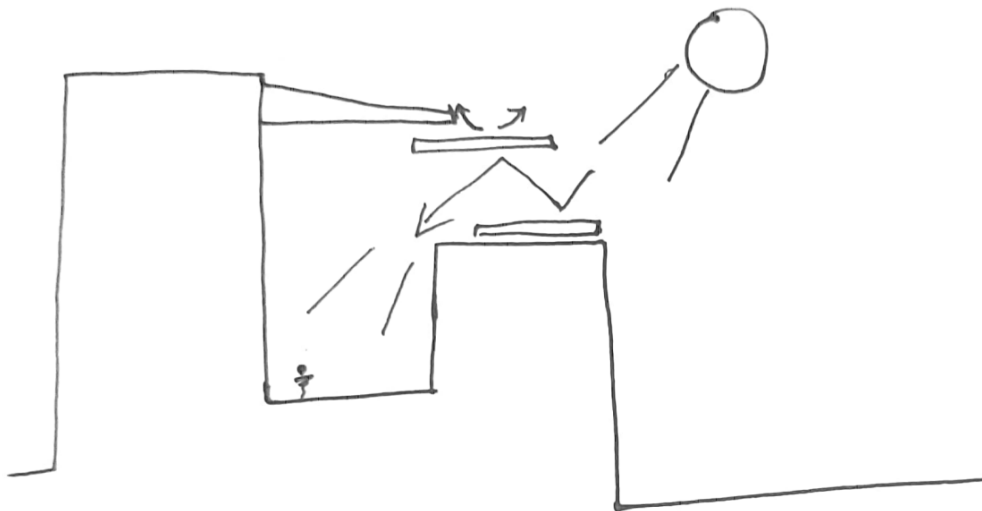


Figure 9 - Natural light redistribution diagram by author

Precedent 4: Edith Green-Wendell Wyatt Federal Building

The Edith Green Wendell Wyatt (EGWW) Federal Building modernization was designed by AERA architects in 2013 as a redesign of the original 1974 building.

It is an adaptive reuse project for the existing 18 story, 512,474 square foot office tower. The project proposed updates to the exterior of the building, the outdated building systems, and some interior updates. The performance goal of the redesign was to meet the energy and water conservation requirements of the Energy Independence & Security Act (EISA), and it did just that with 60% reduction in potable water use, 46% energy use savings, and 4% renewable energy generated by onsite Photovoltaics.²⁴ One of the reasons that this type of project is so important for the future of sustainable design is that they retain the existing structure of the building, which accounts for approximately 57% of a building's embodied carbon.²⁵



Figure 10 - Edith Green-Wendell Wyatt building before and after renovation images
Source: <https://www.aiatopten.org/node/354>

²⁴ “Edith Green Wendell Wyatt Federal Building Modernization.” Accessed November 24, 2024.

²⁵ Building Reuse = Climate + Justice + Urban Action Carl Elefante FAIA FAPT - The University of Maryland School of Architecture, Planning, and Preservation, ARCH 678J Adaptation, 10.22.2024

Adaptive Re-use

“Building Re-use almost always yields fewer environmental impacts than new construction when comparing buildings of similar size and functionality”²⁶

In the effort to reduce environmental impact, reduction of carbon emissions is a primary consideration. The EGWW building is an example of excellent carbon reduction, starting with adaptively reusing a large portion of the existing building. Over half of embodied carbon in modern era buildings is stored in the structure of the building, which often outlives the services and the skin of the building five times over. After considering the reduction in operational emissions, renovating a building can elapse total CO₂ emissions from the existing building after 8 years, as opposed to replacing the building, which will not payback emissions for about 20 years.

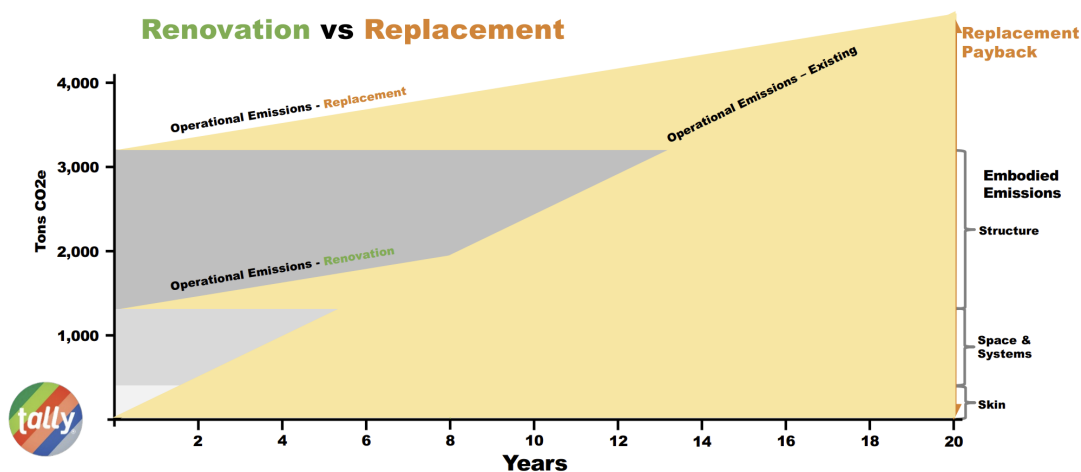


Figure 11 - Total embodied emissions for existing operation, renovation, and total replacement
Source: Building Reuse = Climate + Justice + Urban Action Carl Elefante FAIA FAPT

²⁶ Frey, Patrice, Liz Dunn, Rick Cochran, K. Spataro, J. F. McLennan, R. DiNola, and B. Heider. "The greenest building: Quantifying the environmental value of building reuse." *Preservation Green Lab, National Trust for Historic Preservation* (2011).

Passive Design

The primary update that improved the operational emissions of the building was adding a bioclimatic shading system to make a high-performance curtain wall. The new shading system takes into account orientation, elevation, depth, and visibility in attempts to optimize solar heat gain against user experience. On the roof of the building, there is a rainwater collection canopy that supports a 180-kW photovoltaic array.

Lessons

This project displays the possibilities available within the bounds of an existing building, and gives hope that we can progress our cities towards becoming net neutral and reaching our vow in the Paris Agreement. This building did not reach net zero, but it is one of the first existing renovations that has achieved LEED platinum, and as technology improves these benchmarks will only improve. Comparisons to this project will check the reality of conservation proposals for the thesis, and the shortcomings of this project (like the sub-optimal 29 kBTU energy usage intensity) can be challenged or avoided by the Bloom thesis.

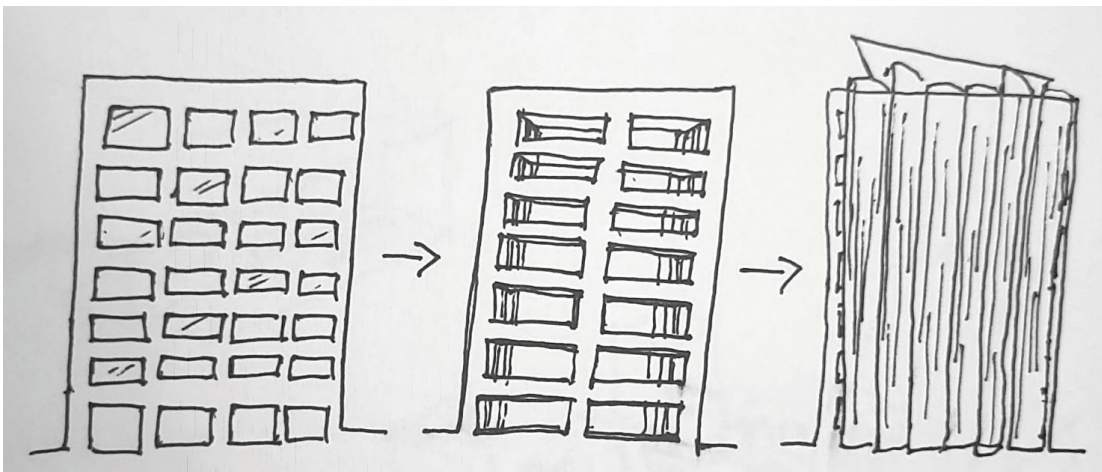


Figure 12- Reskinning existing building diagram by author

Precedent 5: Omega Center

The Omega Center is the closest one-to-one precedent study made during the development of the project. Between communicating a message to the community, healing the human impact on the environment, and learning about nature to find the answers to human problems, Bloom has a lot in common with the omega center. In order to learn more about the project, the Omega Center CEO Robert “Skip” Backus was interviewed in order to learn more about the project. Skip explained the project in terms of values/ goals, community interaction, and technical details in order to provide a wholistic view of the project.



Figure 13 - Omega Center floor plan and section perspective sustainability and water treatment diagram
Source: <https://www.aiaatopten.org/node/109>

Omega Center Values

The primary goals of the Omega Center are to illustrate the community’s place in the water system and to create a high standard for sustainable living. The full name of the program is the Omega Center for Sustainable Living (OCSL) and wholistic studies. This name describes the values of what the Omega team is trying to accomplish. Starting with holistic studies, they try to not only continue learning from the building as a large-scale science experiment, but they also bring communities into the experiment and encourage visitors to investigate as well. The center has over

20,000 visitors a year, and the water used by all of them is processed on-site and returned back to the aquifer. The project is not simply a learning center though, they also put themselves in a position to set the standard for sustainability in the future. Not only was the building awarded LEED Platinum status, but it was foundational in the creation of the Living Building Challenge²⁷. This project is a success story of how setting lofty goals when it comes to environmental stewardship can lead to buildings that grow and learn with the community.

Community Integration

Using architecture to engage the community is a major consideration for this project, and when asked about how this is done in the Omega Center, Skip described two ways that the project engages the community. First, he talked about how the project became deeply rooted in its home. Before the project even began, Skip had established relationships with governing officials, board members, and created an idea of what the project could be. He also mentioned that when a project and organization can achieve new accomplishments, people become interested, even outside of the local community. Between the reputation that the project has made for itself by accomplishing its goals, and the confidence and understanding that the team has for what is being done, they have to do very little marketing to encourage people to come visit.

²⁷ omega.org. "The Living Building." Accessed December 3, 2024

Eco Machine

There are certainly differences between Bloom and the Omega Center from a technical perspective, most notably that Omega uses the space that they have available to complete a full water treatment cycle, from black water to potable water²⁸. This will not be possible in the small footprint of a city block, but Skip gave some insight into this in his interview, he said that the components used in the Omega system can be used as an extensive kit of parts, each performing a certain job in the water treatment process. This thesis attempts to integrate aspects of the Omega Center as they apply to the specific context of the project, similar to the treatment of other precedents.

Lessons

Insights from Skip and the research done on this revolutionary project have shown that when sustainability goals are built into the premise of our project, buildings perform better and can even work to heal the damage done by unsustainable projects. It also acts as proof that people are attracted to excellent design, and environmental design is no different, in many ways designing for the future is its own investment.

²⁸ omega.org. "The Eco Machine." Accessed December 15, 2024.

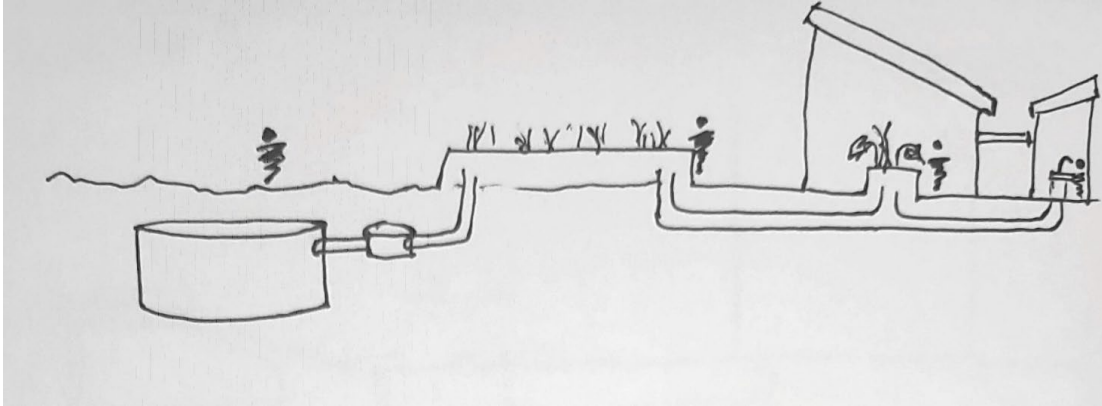


Figure 14 - Water treatment sequence diagram by author

Conclusions

These precedent studies have provided ideas, insights and methodologies to follow going forward. They act like a road map of projects that started from a similar place with similar goals and contain both essential ingredients to a successful project and unique enhancements that inspire creativity in this project. The study of natural ecosystems has outlined how biological communities distribute resources evenly to improve the success of the ecosystem as a whole. The Lloyd Crossing plan created a methodology for comparing an urban system to a natural system in order to measure efficiency. The Heliostat was an example of creative resource redistribution which reworked the problem of a resource deficit into an opportunity for a unique experience. The Edith Green-Wendell Wyatt building exemplified how to improve the existing performance with minimal carbon investment. Finally, the Omega Center is a role-model for community engagement through excellent sustainable design. By combining the applicable aspects and values of these successful projects, the Bloom thesis will result in a thorough and realistic investigation into the questions, goals, and aspirations of the thesis.

Chapter 5: Zones and Program

Introduction

The programmatic design of this project can be broken down into two parts, the ecology center at the heart of the project and the program of the existing buildings within the ecosystem. The ecology center is part of the project that has an opportunity to inspire the community and restore hope in our cities and their ability to reverse global climate change through symbiotic collaboration. The renovation of the surrounding buildings is not intended to change their program, any programmatic changes will be towards the goal of optimizing the system with minimal disruption to its current functionality. As an investigative process to test the limits of modern technology in a synergetic urban ecosystem, precedent research has directed the selection of an ecology center for the ultimate program category.

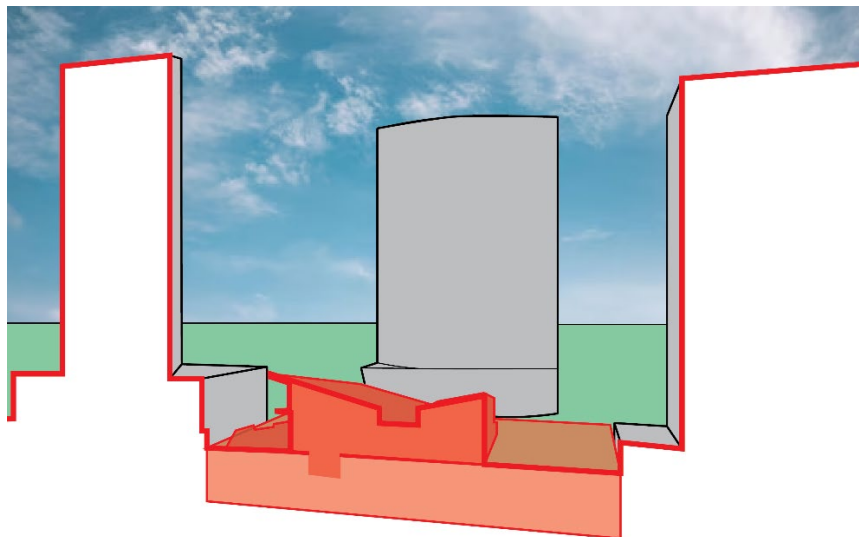


Figure 15 - Initial concept 'scope of work' diagram by author

Building Type Identification

Research on the climate crisis related to energy consumption, carbon emissions, and population trends quickly suggested that the project would be best served in the urban context. Cities are our greatest consumers of resources and our primary producers of pollutants, so this is where this work can have the greatest impact. Today, more than half of global population lives in cities, and by the end of the century, nearly nine in ten people will (New Urban Agenda). Next, a meta-analysis of net-neutral buildings was used to identify what types of buildings have successfully reached net neutrality. Based on the following information, a conclusion was reached: The most successful net-neutral building types are educational, offices, and multifamily buildings and the buildings with the highest proportional success rate are between 10k and 25k square feet. (NBI 2019 list of ZE projects) Working backward from an educational building in the mid-to-low size range that can satisfy the projects goal of displaying the state of the art in net-neutral building design, the program of an environmental center emerged.

Ecology Center

One of the reasons that the Omega Center is a perfect precedent for this project is its scale. The scale of intervention for this thesis has been developed through literature review, meta-analysis, and precedent study.

Existing Ecosystem

The programmatic precedent study for this project was driven by the type of precedents that were already being investigated and the type of site that the literature

review seemed to suggest. After looking into the Lloyd Crossing project, water reclamation was added as a goal for the project under the larger umbrella of a low-impact project, this investigation led to the Omega Center. With its on-site water reclamation and biological wastewater treatment and its focus on community involvement and education, it seemed like a good fit. The parti for the project was born from overlaying these two projects on top of each other and finding that the Omega Center fits nicely on the site of the Lloyd Crossing water treatment building, in the end, both of these projects were reverse-engineered to create a contextualized estimate of the final product of the thesis.

Chapter 6: Site Selection and Analysis

Introduction

In looking for a site for the Bloom project to occupy, a list of criteria became evident from the part of the thesis which would help narrow down the search. These criteria stemmed from environmental conditions, user experience, and surrounding context that would be integrated into the ecosystem. These categories were broken down further into Applicable Bioclimatics, Seasonal Comfort, Accessibility, Mix of Uses, Adaptability of Context Buildings, the Current Carbon Investment, and the Need for this kind of project.

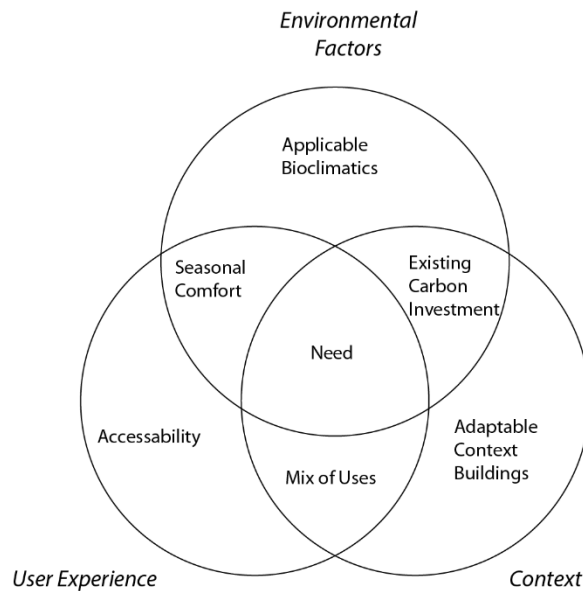


Figure 16 - Site selection criteria venn diagram by author

Site Selection Matrix

Criteria

These criteria each relate to a different aspect of the thesis question. Starting with the identified problem of the thesis the Environmental factors address the climate crisis. Applicable bioclimatic speaks to the means by which the site can allow the project to reach its goals, and how effectively the integration of passive and active design can improve building performance. Existing Carbon transitions from the problem to the opportunities of the context, carbon reduction is one of the primary metrics that will define the environmental impact of the project.

The context that is going to matter most to the project is buildings that can be adapted W and integrated into the ecosystem, the context must be suitable for renovation. It should be reiterated that even if the project is able to perform to meet expectations if it is not a usable, enjoyable space, it is a failure in the architectural sense.

The site can aid the project in meeting user requirements by having a mix of uses that naturally work in a synergetic environment. As a program that is being provided to the public, accessibility will allow more recognition and use. Seasonal comfort begins to talk about how users will experience the space and the resources required to make buildings comfortable. All of these factors come together under the more abstract concept of need. I included need as a criterion because it ties the users, environment, and context together and views them through the lens of outcomes and program.

“Are the outcomes from this program needed on this site?”

In order to judge this aspect objectively, I assigned quantitative measurements like the price of water and energy in the area, the proximity of educational and ecological facilities, and the density of green spaces in the city.

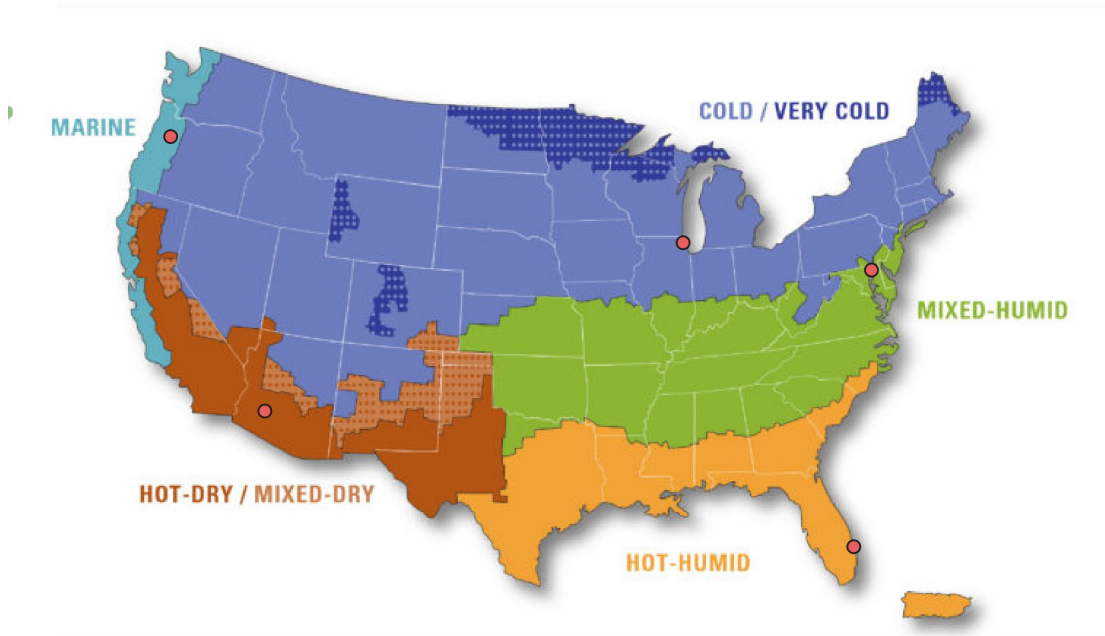


Figure 17 - Map of US climate zones overlaid with initial site options.

The following site choices will be presented in increasing order of project compatibility

Wells Fargo Parking, Albuquerque, NM

Strengths

When initially looking at possible sites, the pros and cons of each general climate zone were weighed against each other because these generalities would help narrow the site selection in broad strokes to start. At first glance, a hot, dry climate found in the southwest of the US seemed like a great choice. Albuquerque, New Mexico was studied because the average yearly temperature was closest to a

comfortable internal temperature and New Mexico has the highest average household energy usage in the climate zone²⁹. In the summer natural ventilation could be used to reduce temperatures and, in the winter, solar radiation could be used to heat the buildings. This site is strong compared to somewhere like Miami, Florida, because the hot, humid climate zone is not ideal for natural ventilation. The humid air will create an uncomfortably humid internal environment. With the specific ideals of this project, it was determined that this site was not ideal

Weaknesses

The initial assumption that the hot and dry climate zone was ideal was later reconsidered once applicable bioclimatics were considered. The focus of this project in terms of energy reduction is through façade optimization, restricting and allowing solar radiation to heat the building throughout the year. This method of passive temperature control become much less effective in warm climates because the need for heat is less. Cold climates already use more energy on heating than warm climates do on heating³⁰. Therefore, locating the project in a cooler climate will allow it to do the most good. Though warmer sites could be considered on a similar thesis that put more focus on natural ventilation and less on daylighting, ultimately, sites in the southern portion of the country were not chosen.

²⁹“U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.” Accessed December 17, 2024.

³⁰“Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA).” Accessed December 16, 2024.

Cityfront Plaza, Chicago, IL

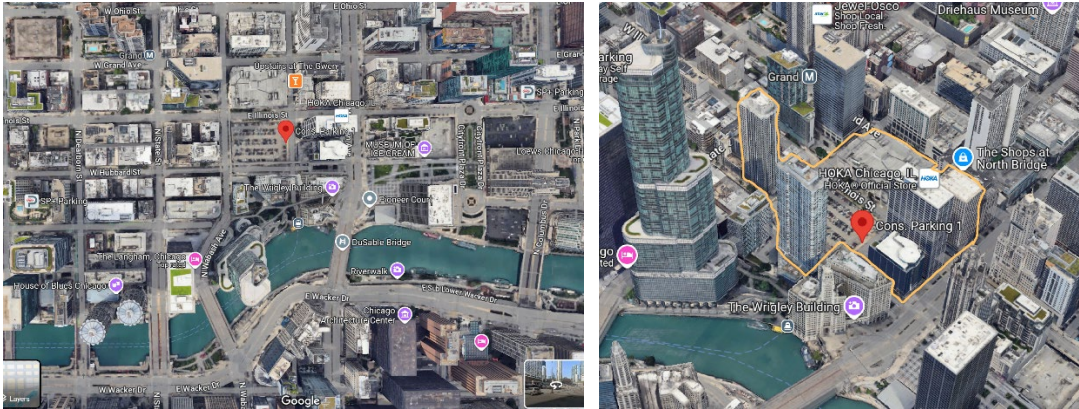


Figure 18 - Chicago site plan and aerial axon Source: Google Earth

Strengths

Chicago is one of the cities that lies in an ideal climate zone for sustainable urban renewal because it has the lowest average temperature of all the selected sites and thus has the highest heating load of all sites. The city is also full of high-rise buildings that would usually benefit greatly from modernized façade design. However, downtown Chicago also has the highest property value of the selected sites³¹.

Weaknesses

The high property value in downtown Chicago causes a few issues with the implementation of this project. High value buildings are often well kept, this means that the necessity for façade renovations is very low. Expensive cities also do not have open area for development, the sites that are within the search criteria are either parks valued by the community, public plazas, or host existing parking garages.

³¹ “Mapped: The Top 30 Most Valuable Real Estate Cities in the U.S.” Accessed December 17, 2024.

Finally, the urban fabric of the city is almost completely high-rises, which works for the urban ecosystem, but this does not leave much access to light and air and can cause bioclimatic issues in the more fine grained scale. Due to the specific characteristics of the urban fabric and the lack of need for this type of renovation project, Chicago was not chosen for this project's site.

Lloyd Crossing, Portland, OR

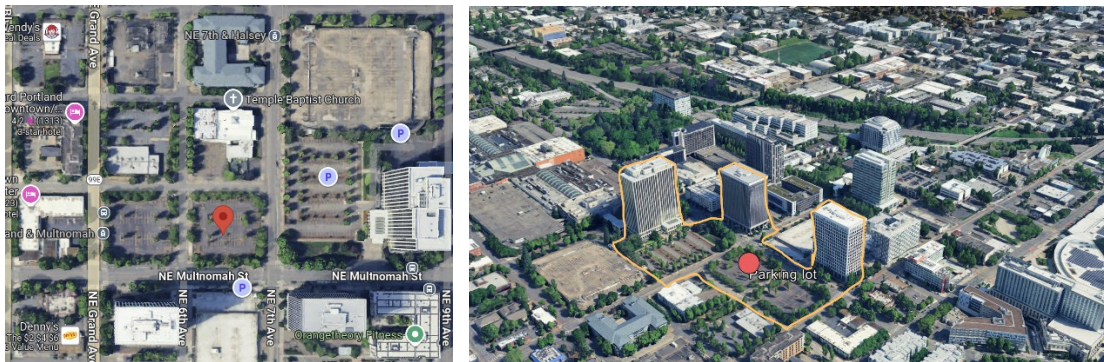


Figure 19 - Portland site plan and aerial axon

Strengths

This site was chosen because one of the formative precedents of the projects is a sustainable urban design plan of the area. Being that the sustainability goals of Mithun Architects' plan align closely with this project, the environmental conditions of this site were nearly perfect. The area is in a good climate zone for seasonal comfort, the average temperature is not too hot which means that internal temperatures can be controlled by solar access. It is not too humid, meaning that natural ventilation can be utilized in the summer to improve thermal comfort.

At the site scale, this area of the city works well because it has lots of access to light and air, and there are still some high-rise buildings nearby to be incorporated into the ecosystem. Portland also has a good mix of different building uses which

allows opportunity to have buildings offset each other's energy consumption throughout the day to keep a consistent energy load.

Culturally, this city is the ideal choice for an urban development project focused on sustainability because of their industrial history, avid community involvement, thoughtful urban planning, and environmental stewardship³². Because of projects like this, Portland has become an example of urban integration of sustainable practices.

Weaknesses

While Lloyd Crossing has suitable environmental conditions, it was lacking in compatible context. The city is mostly low to mid-rise office and residential buildings, but this project works best with larger context that can experience greater changes in façade optimization. In the downtown area, there are high-rise buildings, and though the area is not lacking in green spaces, there are not many opportunity sites large enough to satisfy the water filtration needs of the project.

Paradoxically, the reasons that made Portland perfect for this type of project, are the same reasons that show why it does not need this type of project. It is a beacon of environmental awareness and thoughtful urban planning, but the goal of this project is to improve building performance and show the community how that can affect climates

³² Olsson, Roxanne M. "Revealing Human-Nature Relationships: The Case of Portland, Oregon," June 2014.

Hopkins Plaza, Baltimore, MD



Figure 20 - Baltimore site section and aerial axon

Strengths

The factors that set the Baltimore site above the Portland site were the quality of the specific site and the general need that Baltimore has for this type of project that Portland is lacking. Starting with site accessibility, Hopkins Plaza is far superior. The site is directly on top of a metro station, in the heart of the city, and located just blocks from some of the major points of interest of the city such as the Inner Harbor, Camden Yards, the Convention Center, the Aquarium, and more. Not only is the site accessibly by the community, making it a great place for an educational institution, but it is also close enough to research in person from the University of Maryland, and this personal connection to the project is important for many reasons.

Weaknesses

Some of the weaknesses of the city as a whole end up being in support of an urban renewal project such as this one. The fact that there are inefficient, early modernist buildings that are in need of repair works well into the needs of the project. Since the city has aging and unsustainable infrastructure, improving the existing buildings and systems has the potential to do a lot of good for the city and more

clearly show the effects that this project is capable of. The combination of a solid base condition and ample improvement opportunities makes Baltimore a great candidate to host the Bloom thesis project.

	Site A Portland, OR	Site B Baltimore, MD	Site C Chicago, IL
Seasonal Comfort - Ease of achieving thermal comfort	4	3	3
Mix of Uses - Diversity of surrounding use groups	2	4	4
Applicable Bioclimatics - Ease of bioclimatic application	4	3	3
Accessibility - Ease of access to the site	3	5	4
Need - Adaptation opportunities and need for green infrastructure.	4	4	3
Access to Light, Air and Water - Solar exposure, clean air, and local aquifer	4	3	2
Existing Carbon Investment - Quality of usable existing structures	3	4	3
Adaptable Context Buildings - Age and deterioration of context buildings	3	4	3
Total:	27	30	25

Figure 21 - Site matrix rating sites from 1-5 based on site criteria by author

Chapter 7: Conceptual Testing

Introduction

The first concepts for the design were inspired by bioclimatic and context. These two influences held the highest importance because the project is based on performance optimization and urban collaboration. The tectonics of this project all work towards accomplishing the primary goal of the thesis: display how carbon emissions are reduced by optimizing resource utilization. That means that the mass is driven by bioclimatics, the construction is driven by carbon sequestration, and the experience is driven by transparency of information.

The initial approaches to construction mostly revolve around facade optimization of context buildings focusing on both the utilization of sunlight and the connection between new and old. Creating ideal solar infiltration through layered facades will require in-depth study of the existing facade conditions compared to the thermal comfort of inhabitants throughout the year. The more a facade is able to adapt to environmental conditions, the better it will perform, which is why kinetic shading systems are a strong consideration. This solution cannot be applied to every building, however, which is why additional options should be considered. Passive facades with ideal shading for average yearly conditions which can be implemented in more subtle circumstances than kinetics. In conditions like the two historic buildings within the

ecosystem, solutions that preserve the historic facade will be required including material updates like energy efficient windows.

Scheme 1

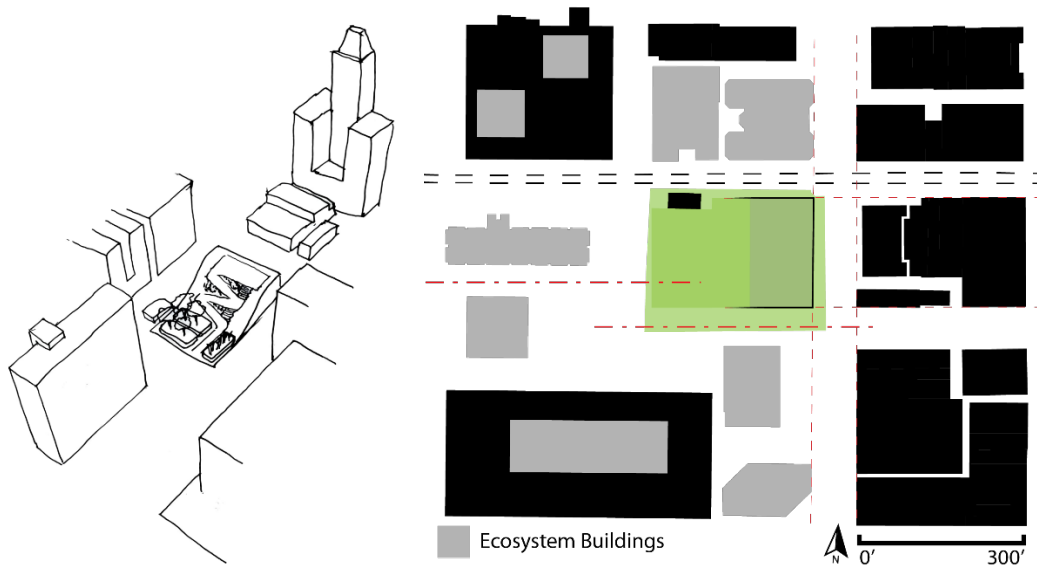


Figure 22 - Scheme 1 massing sketch and plan diagram by author

The first scheme attempts to maximize area for water reclamation and provide an amenity for the community. The design features a green space that covers the entirety of the site which will include constructed wetlands and an aerated lagoon above, with anaerobic tanks and subsurface dispersal tanks below. The site is then lifted on the eastern side and the program is placed underneath the landscape. This is done for a couple of reasons.

First, this scheme follows the thematic tie to the rest of the thesis by allowing users to descend into the site and see what is happening under the surface. Second, it responds to the context in a few ways, on the eastern side it continues the established street edge, on the north and south sides it transitions the street walls down, and on the west it is still able to address Hopkins Plaza. Finally, this scheme gives back to

the community as a whole, it provides a public green space that offers reprieve for metro travelers, convention center attendees and Inner Harbor visitors.

The drawbacks with this scheme are that it may not be a financially ideal solution for the site and the unique massing creates some geometric complexities. Though the financial aspect is not the most important part of the thesis, the finances of a project are as real as the structure or performance and should be considered as such. This site is optimal real estate, it is on top of a metro station, in the heart of downtown, blocks away from the Inner Harbor, Camden Yards, the Convention Center, and the CFG Bank Arena, this makes it a great candidate for densification. The other issue is one of massing, this scheme has some great moves like transitioning the flat plaza into the high-rise massing, but the sloped side walls may create a confused streetscape at the ground level.

Scheme 2

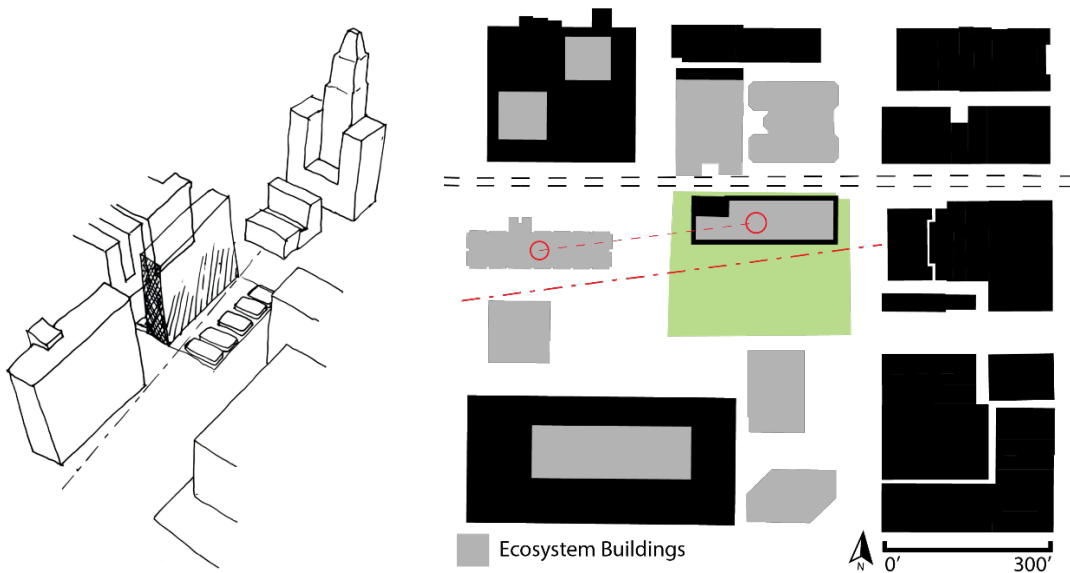


Figure 23 - Scheme 2 massing sketch and plan diagram by author

The focus of the second scheme is to maximize solar energy generation. This design features a mixed-use bar building with the ecology center at the ground floor and residential above similar to the neighboring building 2Hopkins. The rest of the site is used for water reclamation and outdoor green space that acts as a counterpart to the hardscaped Hopkin's Plaza. The first driving factor of this design was to capture sunlight that is inaccessible to the ecosystem because it lands on the two historic buildings to the north. The tall bar building would give a new surface that could absorb that light and use it to provide power for the rest of the system. The second driving factor was to increase density in the area, this was addressed as a drawback of the previous scheme. The apartment building to the west, 2Hopkins, is near full capacity, with only 4 available units(<https://www.2hopkinsapts.com/floor-plans/>), which suggests that there is demand for residential units in the area. From a massing standpoint, this scheme is a potent response to the existing site, where the existing 2Hapton and Hampton plaza are hard, inefficient, brutal stone, this site mirrors the massing, but shows how this can be modified for the future, with green, optimized organic forms cleaning up the 'mess' that modernism exacerbated.

The obvious drawback of this scheme is that it eclipse the existing historic buildings and creates a street canyon on the north side. However, this creates a great opportunity to use some of the creative resource manipulation tools that have been studied previously like the heliostat or light wells which could allow light to pass through while still utilizing the solar radiation that provides energy for the system as a whole. The scheme also restricts the amount of space dedicated to water reclamation, but this may be unavoidable when testing different quantities of program.

Scheme 3

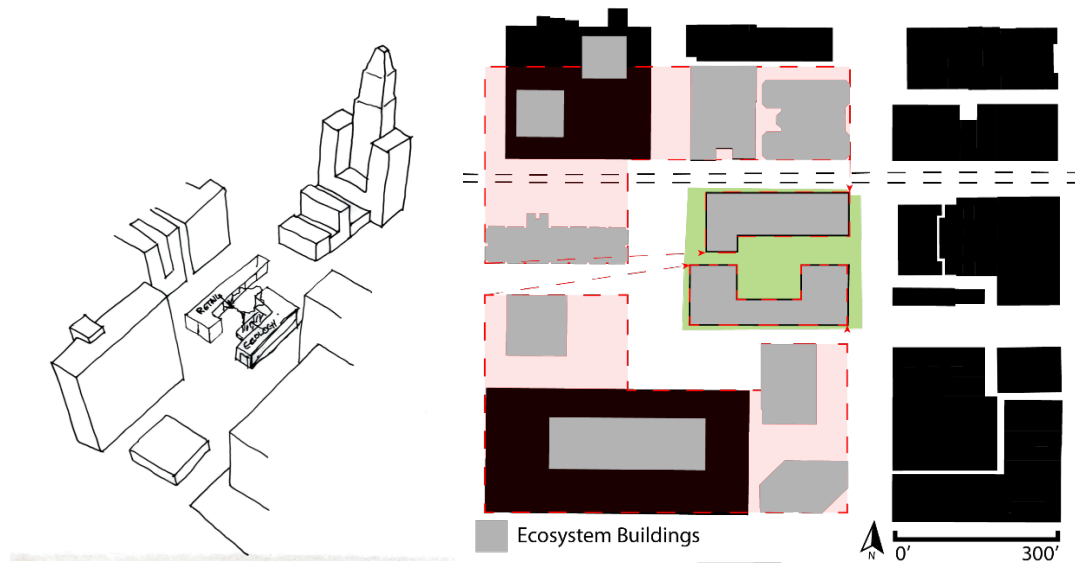


Figure 24 - Scheme 3 massing sketch and plan diagram by author

The third scheme is meant to conceptualize the thesis by scaling down the context to the human scale while balancing solar gain and water reclamation. This scheme places the program for the ecology center below a ground-level retail strip around the perimeter of the site with a sunken central courtyard in the center, which would act as a display space for the performance of the system. This scheme creates an internal space for reflecting and learning while still relating to the surrounding context. It also takes advantage of the symbiotic relationship between retail and cultural institute facilities. The ecology center will draw in new audiences from outside of the city to visit the retail, while the nearby retail will encourage local visitors.

An issue with this scheme is that in searching for a common ground between focusing on energy generation and water reclamation, it does not perform either to the preferred extent. It uses the roof of the norther building to catch extra solar exposure,

but it is not nearly as much as scheme 2, and by sinking the central courtyard, it attempts to build on the idea from scheme 1 in which observers descend into the site to see how the water reclamation is done, again not as effectively as the initial scheme.

Literature Review

Initial conceptual testing has been used to apply the theory gained by studying nature and reviewing concepts like facade optimization, water reclamation, and bioclimatics. In order to keep a cohesive design and thesis, it is essential that the schematic design clearly expresses the values of the project.

When trying to optimize building performance, the base principals are building form and envelope design (“A Morphological Approach for Kinetic Façade Design Process to Improve Visual and Thermal Comfort: Review.”). Things to consider when designing building form optimally for performance are maximizing solar access, reducing surface area, and allowing space for a layered facade. Envelope design is investigated on a much smaller scale, but can be conceptualized per facade based on solar orientation.

When it comes to water reclamation, there are many considerations determining what treatment systems are applicable “Of these considerations, often the most limiting is the soil resource or site and space limitations” (“Onsite Wastewater Treatment Systems | Onsite Wastewater Treatment | Health & Senior Services.”). While in schematic design, leaving as much area for water treatment as possible matches the objectives of the project, and where program takes up site space, intensive green rooves are added to further improve performance.

Big-picture scheme ideas can be gleaned from biomimetic and ecological study. The main idea here is that there are inherent tradeoffs between gathering resources below and above ground (Plant Strategies and the Dynamics and Structure of Plant Communities) and the fact that these two sources are not mutually exclusive means that they should both be considered. This is also an opportunity to communicate the possibilities of sustainable design to the community through comparison, that is why each scheme addresses its above ground and below ground aspect and can relate to the ecological system analogy that has been used to describe the system.

Precedents

Due to the varied nature of the massing and additional program of initial schemes, various precedent studies are explored and specific features are implemented. A consistent precedent throughout the schemes has been the Omega Center, which has given a framework for the eco-machine and water treatment on site. Depending on availability of space, design promenade, and topography changes for each design, different parts from the Omega Center are used to most effectively treat water on site. Counterintuitively, sections of the water reclamation system are integrated starting with the last steps and working backward depending on available space. These features include dispersal fields, sand filters, the aerated lagoon, constructed wetlands, and any applicable underground infrastructure (eomega.org. “The Eco Machine.”)

Site Analysis

Site analysis lead to a lot of concept generation related to urban fabric integration, conversation with context, and bioclimatic opportunities. The site's environmental factors have been known since initial site selection, and are continuously being refined as schemes are being developed. Reflection of the urban condition resulted in the acknowledgment of existing street walls, contextual scale, proximity to amenities, and views.

Conclusion

As the project develops in the conceptual stages, it is clear that there are a number of balances that need to be reached. The balance between solar energy and water treatment, human scale and urban scale, openness and density, and more generally: expression and efficiency. It is likely that the answers to these questions do not lie on either side of the spectrum, it will require critical investigation, data analysis, precedent and literature study, and design thinking to create a harmonious environment in the urban context.

Chapter 8: Conclusions

Introduction

This thesis demonstrates that modern buildings are not equipped to adapt to the city's changing needs, resulting in structures that live to serve their function and eventually vanish, leaving gaps in the urban fabric. Moving forward, our architecture must go beyond sustainability and work to regenerate built ecosystems. As a model of this new urban development, Bloom proposes a solution inspired by nature's regenerative design process to create lively, energetic, and adaptable buildings and cities.



Figure 25 - View over constructed wetlands, community garden, and Hopkins Plaza

Scales of change

Applying these natural principles, the lifespan of a building was broken into major milestones: Pioneer integration, Mid-Succession optimization, and Mature cooperation. These phases are measured on both a physical and temporal scale because as a building ages, its effect on and its environment should expand. The pioneer phase of a building involves the design and initial integration of a building. The goal of this phase is to reduce the impact on the flow of energy within the city ecosystem. The building should respond to the natural and built environment and use responsible materials and construction methods. For example, Bloom's active solar shading reduces energy consumption by 7% (Figure 39) throughout the year. The Mid-Succession phase is the predictable lifespan of the building. The goal here should be to operate efficiently and effectively within its immediate context. At this time, the building should optimize itself based on changes in the site, use, environment, building technologies and practices, etc. Bloom's structure is designed so that the use proportion can change based on the current market. Finally, in the Mature phase, the building is a working, cooperative member of a complex and diverse building ecosystem. Unpredictable changes will happen to the building, but the established framework and sustainable values of the architecture will guide the change without predetermining the outcome. Bloom's water treatment facility can be expanded upon to process and provide water for nearby buildings and street trees. The design of these phases is driven by a vision of a future with productive cities where buildings can work together to save, generate, and emanate energy for the greater ecosystem.

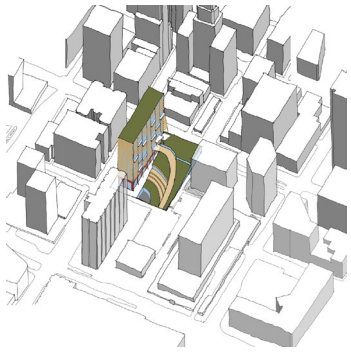


Figure 26 - Pioneer integration



Figure 27 - Mid-Succession optimization



Figure 28 - Mature Cooperation optimization



Figure 29 - Vision for the future

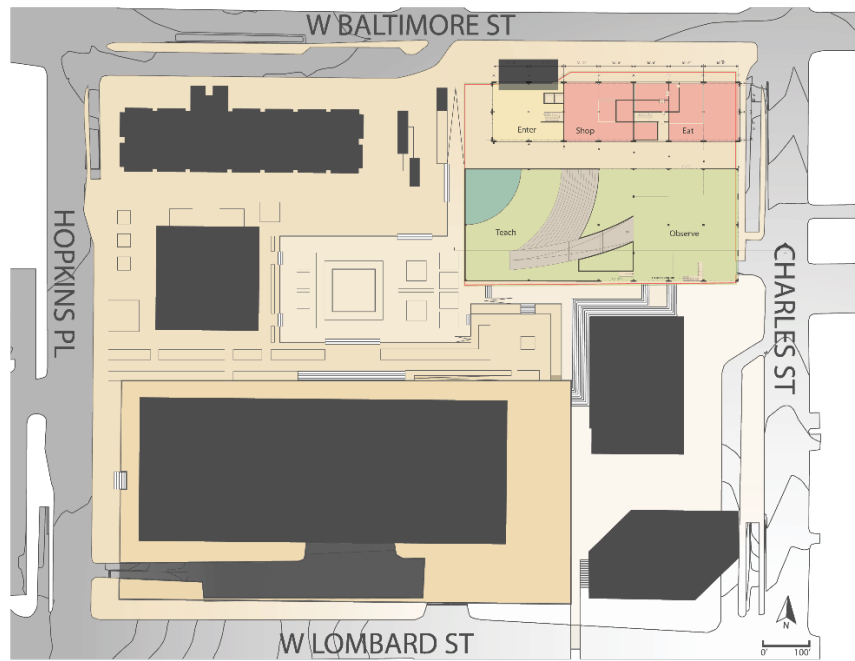


Figure 30 - Floor plan in block context

Dimensions of design

Four dimensions of design became evident in the development of the project. Stemming from the primary goals of the project to improve efficiency and user experience, the project allows for planned and unplanned change in these dimensions: Use, Energy, Water, and Habitat. Use being the specific function of any given space in the building. Energy refers to how the building optimizes the site's energy and becomes an energy source within the city. Similar to energy, the project reduces the water load on city infrastructure by reusing every drop of water that enters the site. Finally, the building creates a restorative habitat for plants, animals, and humans within the city, hoping to inspire the city to grow to reflect these regenerative aspirations.

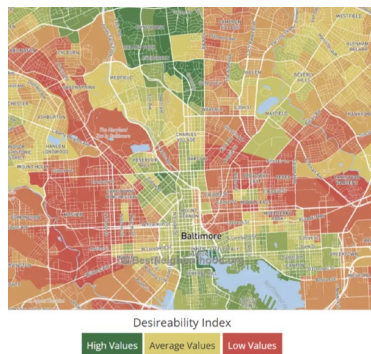


Figure 31 - Baltimore Desirability Index

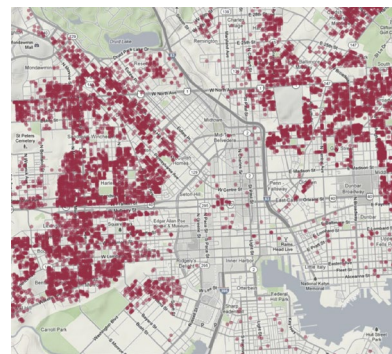


Figure 32 - Baltimore vacancy rate map

Use

The ideology behind the project's use was to create a building that could house the changing needs of the city, while also providing an architectural expression of the city's values. Due to the conflict between expressive and efficient architecture, the decision was made to create two forms that worked together to provide a well-

rounded project. The 24-story high-rise building was inspired by modern Japanese mixed-use architecture, however unlike the influential Metabolism movement, this building uses traditional techniques and layouts with modern material improvements to allow for undictated spatial change³³. The project's use progression begins by retaining the entertainment function of the original site, and adding density and apartments as this area in Baltimore has some of the highest value units with the lowest vacancy rates in the city (Figures 31 and 32). As the building enters Mid-Succession, the use will change, either in proportion or type of use, allowing for more interpersonal interactions and generation of energy in the form of information. As the system matures, this mix of people will create more opportunities for financial growth, softening the edge between locals and visitors and inspire a more complex system of uses in the city.

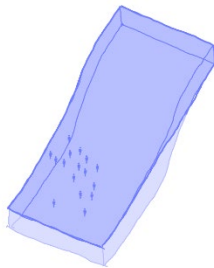


Figure 33 - Retain existing use

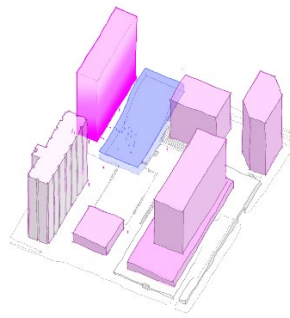


Figure 34 - Increase Density

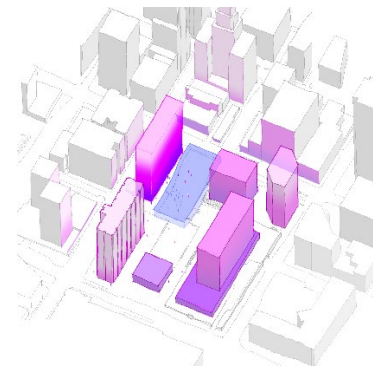


Figure 35 - Promote mixed use

³³ Schalk, Meike. "The Architecture of Metabolism. Inventing a Culture of Resilience." *Arts* 3, no. 2 (June 2014): 279–97. <https://doi.org/10.3390/arts3020279>.

Energy

When viewing a building from an energy accounting lens, there is no limit to the factors that can be considered in an energy analysis of the city, but for this design standpoint, considerations are limited to solar and electrical energy. In a city like Baltimore, there are about 180 kBTU/Ft²/Year³⁴ of energy hitting the site on average. Compare this to the approximately 25 kBTU/Ft²/Year³⁵ is being used in buildings, and it becomes evident that it is possible to power our cities on solar power alone. Bloom takes advantage of solar access to the south by implementing a kinetic shading system that creates a comfortable environment throughout the year and reduces energy costs up to \$43,568 a year (Figure 27). The kinetic system is able to optimize building performance throughout the year and it allows for energy generation if the shades are upgraded to a solar panel system. Ultimately, this building can act as an on-site grid, generating as much power as possible and storing it in the allocated battery bank to create a more resilient block that is independent from the city grid.

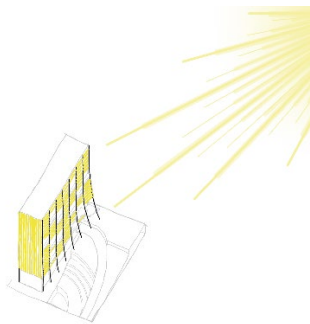


Figure 36 - Optimize kinetic facade

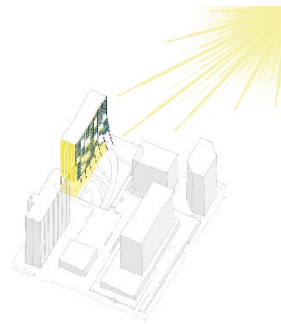


Figure 37 - Facade energy generation

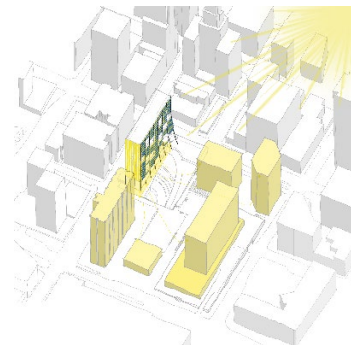


Figure 38 - On-site grid

³⁴ Gates, Ashley. "US Solar Insolation Maps." NAZ Solar Electric. Accessed May 23, 2025. <https://www.solar-electric.com/learning-center/solar-insolation-maps.html/>

³⁵ EnergySage. "Electricity Cost in Washington D.C.: 2025 Electric Rates." Accessed May 23, 2025. <https://www.energysage.com/local-data/electricity-cost/dc/>. "Housing Inventory: Median Home Size in Square Feet in Baltimore County, MD," May 1, 2025. <https://fred.stlouisfed.org/series/MEDSQUFEE24005>.

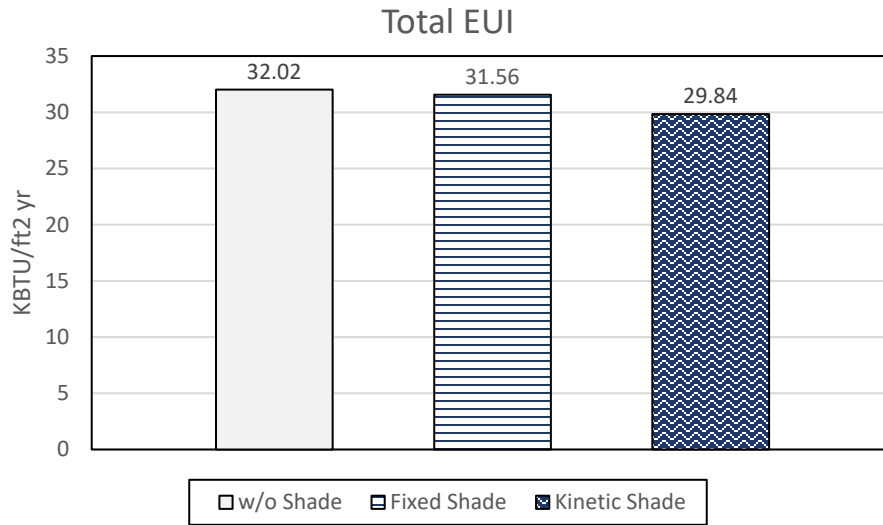


Figure 39 - Energy Use Intensity Comparison with three façade shading options

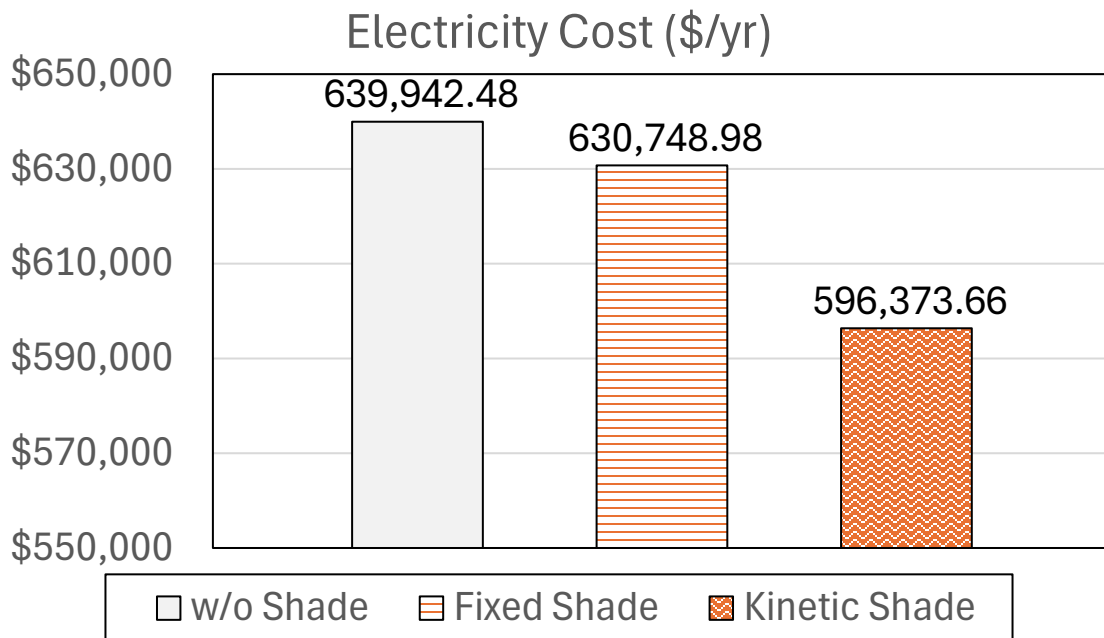


Figure 40 - Cost comparison with three facade shading options

Water

Just as the project carefully considers and optimizes its inputs, it also maximizes the use of its waste. A large part of this comes with water reclamation. This project can use every drop of fresh water that enters at least twice before sending it to a water treatment plant, thus reducing utility costs and wear on the city's water infrastructure. First, the integrated water treatment can process and store rainwater to be used to feed the community garden and to recharge the groundwater. Bloom also gets the most out of the fresh water that it imports by filtering grey and black water with the constructed wetland and water filtration systems. Eventually, the facility will have more water than it can use, and this water can be distributed to neighboring buildings and street greenery to spread the influence of naturally cleaned water throughout the city. In addition to the monetary benefits, creating a greener, more knowledgeable, sustainable, and resilient city will result in a regenerative city.

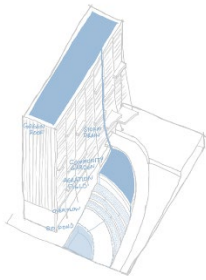


Figure 41 - Rain water capture

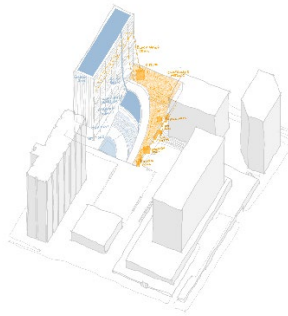


Figure 42 - Wastewater Treatment

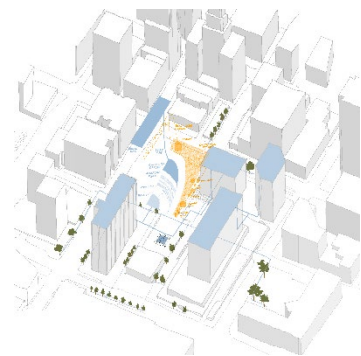


Figure 43 - Process city water

Habitat

The building should also provide a sense of place in the city, not only for the residents and users, but for the community, wildlife, and even plant life. Any time a diverse green space is added to a city, it is an opportunity for increased biodiversity in a space that desperately needs it, especially in places like the constructed wetlands that is visible, but not accessible, or the community garden which invites germination from the community. With the implementation of new plants, new wildlife like insects, birds will follow, and new aquatic life in the bio pond, this space becomes infused with sound, life, and movement. The long-term effects on the community of a natural habitat within the urban environment are numerous³⁶ and is a priceless amenity space for the building. Above all else, this space creates the identity of a green core within the city for Hopkins Plaza, and this sense of community will spread to influence the rest of the city, creating a lasting legacy for the community that will outlive the building.

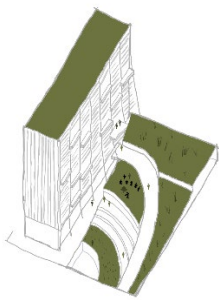


Figure 44 - Add green space

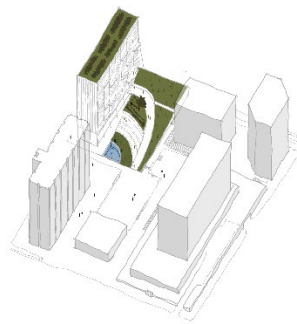


Figure 45 - Increase biodiversity

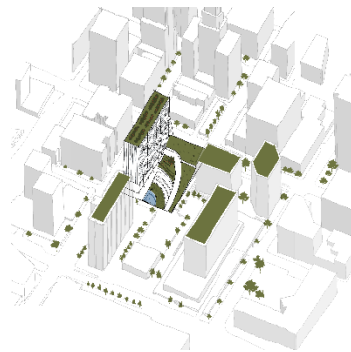


Figure 46 - Extend Eco-tones

³⁶ Nguyen Dang, Hoai-Anh, Rupert Legg, Aila Khan, Sara Wilkinson, Nicole Ibbett, and Anh-Tuan Doan. "Social Impact of Green Roofs." *Frontiers in Built Environment* 8 (November 10, 2022). <https://doi.org/10.3389/fbuil.2022.1047335>.

These four components come together in a supersystem that is designed to optimally provide for the inhabitants of this site with energy to give back to the city more than it takes. In this way, Bloom can start a regenerative process in Baltimore, Maryland and grow with the city.

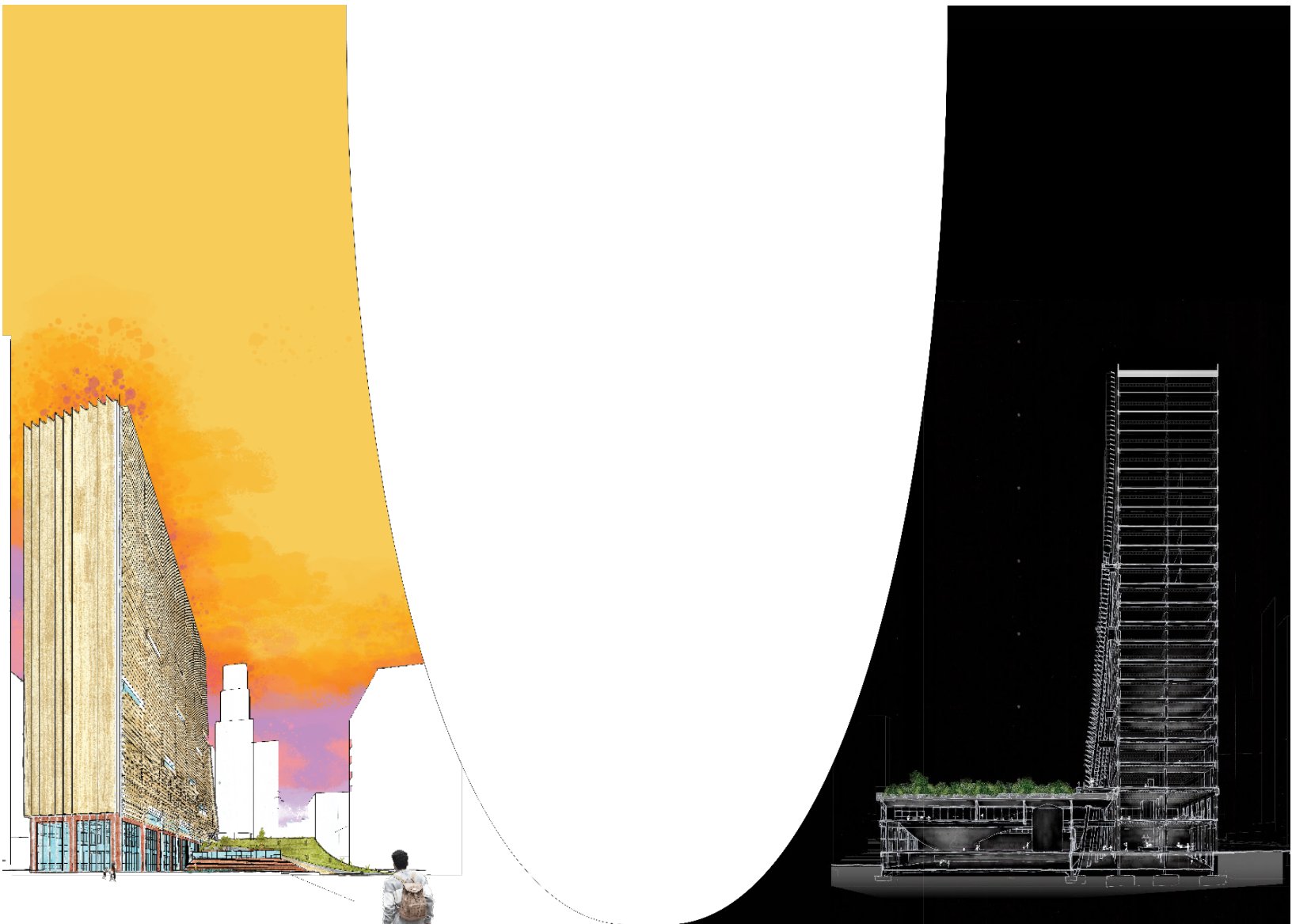


Figure 47 - Pathway connecting ecology center with mixed use building featuring kinetic facade and bio pond

Synthesis

Similar to the analogies this project draws to natural systems, the project itself is an example of how the design process can be applied. The regenerative process of natural ecosystems is well documented and accepted within the ecological science community, and applying this to architecture is how we can begin to create urban ecosystems that work like natural ecosystems. That means designing for change like the layered structure within a living system, rather than a single building within a city. In his book *Cradle to Cradle*, William McDonough held the belief that “Being less

bad is not being good.”³⁷ This means that meeting requirements and doing what is expected is not always the same as being a responsible designer. Bloom shows that regenerative design is not only possible—it is necessary. The next generation of cities will depend on architecture that gives more than it takes and lasts longer than its form.



³⁷ McDonough, William, and Michael Braungart. *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press, 2002.

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