Cultural Lifeboats: Distribution Network Facilities for Barrow, Alaska

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Committee:

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Abstract

Cultural Lifeboats: Distribution Network Facilities for Barrow, Alaska

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Architecture

Coastal Communities throughout the world are suffering from the effects of rising sea levels due to climate change and/or melting polar and glacier ice. This thesis focuses on an arctic community called Utqiagvik (Barrow), Alaska that is experiencing coastal erosion due to diminishing sea ice and rising sea levels. Because the communities proximity to the Chukchi and Beaufort Sea of the Arctic Ocean, the community makes heavy use of the resources the sea offers for survival. Barrow has served as a prominent settlement for the Inupiat for thousands of years, but it now faces many obstacles as sea levels continue to rise. The proposed thesis design of partially prefabricated community survival installations provides insight on technology and systems that are available locally and by ship or air. Two prefabricated design methods integrated with high performance technology systems are proposed as a possible survival model for the community. During day-to-day use the facilities are programmed to provide daily resources for the community.

Dedication

I dedicate this thesis proposal to the residents of Barrow who believe in the culture of their community, and provide the research and knowledge for the remainder of the world to understand the risks and effects of rising sea levels in arctic communities.

Acknowledgments

I would first like to say thank you to my committee members Jim Nicholls and Alex Anderson of the University of Washington for their commitment and unfailing support of my thesis proposal. Their continuous encouragement provided positive feedback and steered me in the right direction whenever the need for help arose.

I would also like to acknowledge my gratitude to the researchers who have conducted extensive research on arctic coastal communities. Their research was provided through scholar reports and publishings that I was able to access from the University of Washington Libraries.

And finally, I would like to say thank you to the members of Barrow, Alaska who continue to respect their local resources and support their heritage and culture.

Sarah Amundson

Table of Contents

Chapter I: Thesis Overview

No matter the location on Earth, climates are changing, sea levels are rising, and the human population is continuing to dominate the landscape. 71 percent of earth's surface is covered by water with only 0.3 percent of the surface water being fresh water, and the remainder of earth's surface is landmass. Seven billion people live on earth and approximately 3.2 billion of those people are living in coastal settlements. These coastal settlements are currently vulnerable to sea level rise and natural disasters related to global climate changes. As coastal climates transform, coastal settlements must develop unique resiliency models and distinct survival operations compatible with the culture, resources or settlement patterns of the community.[1]

To address the issues of resiliency, I am researching a particular community and proposing a pattern or model to allow it to reside in place during a natural disaster. Individuals ought to remain in a community where they have established their lives, family and work and not have to be displaced because of water level increase due to natural disasters and/or climate change. The community I have chosen is Utqiagvik (Barrow), Alaska. I have studied the location's culture, resources, and patterns of settlement to understand the community and to create a community model for sustainable infrastructure, building and material strategies. Although many tropical communities have been the focus of climate change research, few arctic regions have received similar attention. I have chosen Barrow, Alaska because of its unique coastal location in the Arctic Circle of northern Alaska, its relatively large population of 4,000 and its popularity as a tourist destination throughout the cool summer months. The settlement is particularly vulnerable to sea level rise and erosion due to melting sea ice, an important buffer for Alaska's coastlines.[2]

- *Title*: Cultural Lifeboats: Distribution Network Facilities for Barrow, Alaska.
- *Problem*: There is an arctic coastal population vulnerable to and affected by sea level rise and other climate-related disruptions.
- *What Ought to Be*: Individuals ought to remain in a community where they have established

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1 Droege, Peter. *Climate Design and Planning for the Age of Climate Change*. California: Gordon Goff, 2010. Print

their lives, family, and work and not have to be displaced because of water level increase due to natural disasters and/or climate change.

- *Position*: To research Barrow's culture, resources, and patterns of settlement to devise a network of community facilities that adapt to sea level rise and provide security.
- *Project*: Researching the social and environmental circumstances of Barrow and devising a system to allow the community to reside in its settlement location without displacing the members of the community.

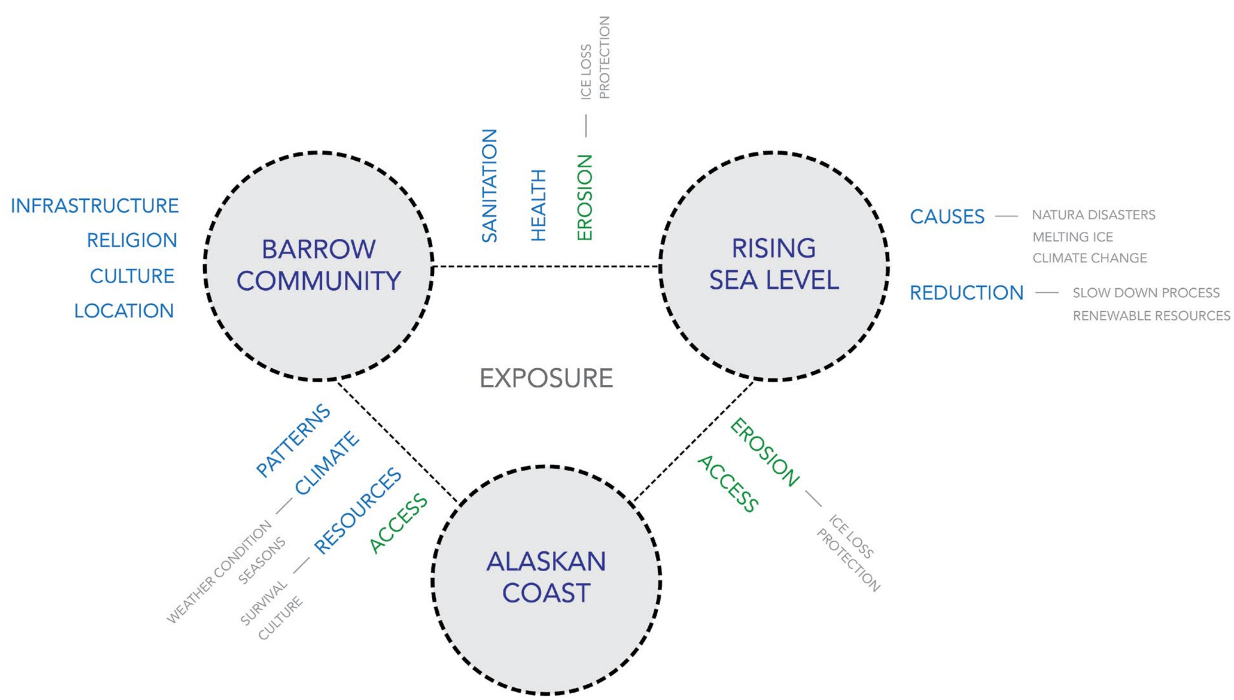

Figure 1 - A diagram I used throughout the thesis process to find relationships between rising sea levels, the Alaskan coast and Barrow community.

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2 "Ice Stories: Dispatches From Polar Scientists." Exploratorium. 2015. Web. 30 March 2017. <http://icestories exploratorium.edu/dispatches/big-ideas/barrow-alaska/index.html>

Chapter II: Theoretical Framework

Literature Review

I conducted research about weather and climate resistant resources that are available or commonly used in Barrow, Alaska. Through that research, I have catalogue the systems or resources used in the designs I proposed.

Water: Collection and Recycling

When designing in or near a site that has a complex water system, it is crucial to reduce major impacts that may become destructive. Communities benefit when water resources are respected, recycled and well-managed. If a hydrological process is miss-managed then a series of problems in the community can occur, such as flooding, water pollution, fresh water depletion, soil erosion and ecosystem degradation. It is important to allow natural cycles to occur including infiltration, evaporation, transpiration and undisturbed runoff locations. I integrated water supply, water storage, water use and water disposal into a specific building or site design can provide problem-solving techniques to communities that may suffer from fresh water supply resource limitations.[3]

The monthly water demand required from a specific design is determined by the number of occupants and the building's demand for potable and non-potable water use. The demand for the water can fluctuate as different seasons occur, as well as when the demand from the occupants changes. Potable water that has been cleaned and decontaminated can provide a fresh water resource to the occupants for consumption, hand washing, showering or ware-washing. Grey water, non-potable water, is water that has not had its contaminants removed and is beneficial to use in toilet systems or wetland and agricultural systems. Storage is a necessity for capture of precipitation that can ultimately determine how much a design is able to hold and maintain.

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3 Calkins, Meg. *The Sustainable Sites Handbook - A complete Guide to the Principles, Strategies, and Best Practices for Sustainable Landscapes*. New Jersey: John Wiley & Sons, Inc., 2012. Print.

Monthly rainfall x catchment area = monthly rainwater supply

To achieve a cost-effective design condition, storage systems should be designed to accommodate 75 to 95 percent the non-potable water systems demand.[3]

Materials: Timber

The use of wood is only as sustainable as the process it took to harvest from the forest and transform it into a building material and transport it to the building site. Although there are deforestation processes that can transform forests into development locations, there are forestry techniques that serve as sustainable and liable construction methods. Timber is a renewable resource that is grown with solar energy inputs, water and carbon. The carbon the timber sequesters into its growing process remains throughout its harvesting and processing into lumber products. This provides a sustainable method of reducing a design's carbon footprint that may otherwise add more carbon emissions to our environment's atmosphere.[3]

Timber has several potential benefits as a construction material:

- Durable
- Versatile
- Salvageable
- Reusable
- Recyclable
- Renewable
- Continues to sequester carbon until burned or decayed.
- Local resource availability (in some areas)
- Milling primarily uses biofuels for energy, thus embodying less energy than steel and concrete for fabrication.

However, timber does have Environmental impacts in construction:

- Chemicals in pressure treating can be toxic and energy intensive.
- Harvesting methods are not always sustainably managed and can create environmental degradation such as soil erosion, biodiversity loss, pollution, habitat alteration and deforestation.
- Production creates a large amount of waste.

When designing with timber materials in mind, it is important to design according to these factors:

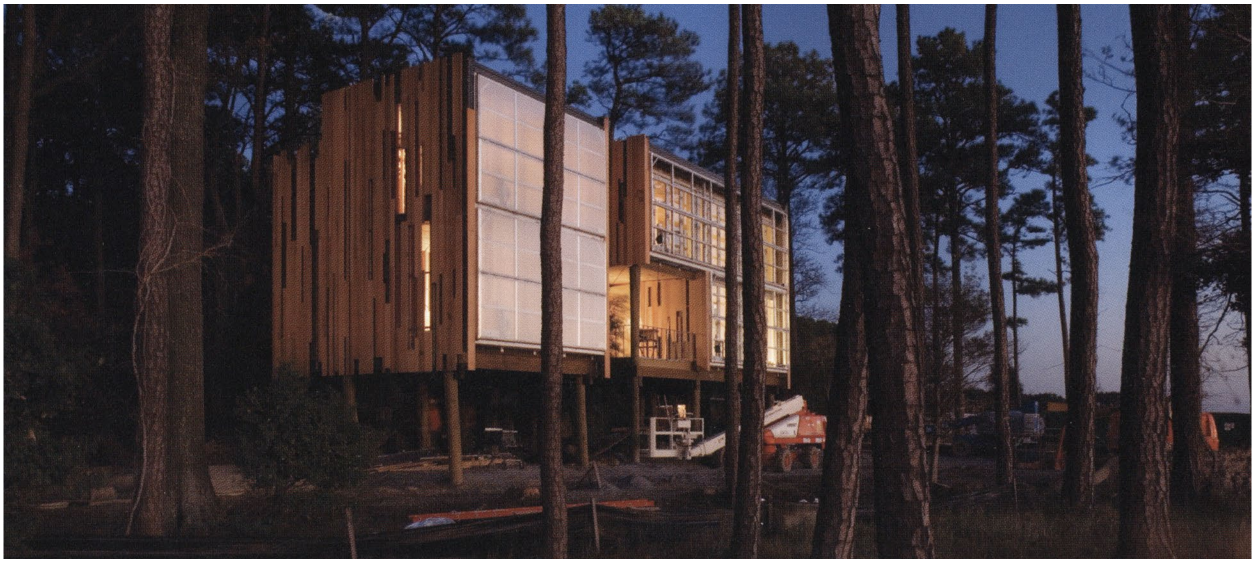
- Detail wood structures for durability.
- Build small.
- Design to reduce waste.
- Specify Endangered Wood Products.
- Specify decay resistant woods.
- Specify certified wood.
- Specify reclaimed wood.
- Design for deconstruction.
- Balance wood preservation needs with the toxicity of preservatives.
- Use the lowest quality of wood for an application.
- Specify engineered wood products.[3]

Precedent Review

Precedent reviews based off real building projects, systems and technologies provided useful information for the design of my proposal.

- *Loblolly House*: The Loblolly House was a useful precedent to understand the prefabrication of off-site structural insulated paneling systems that can be installed on-site for a quick installation process. The element of bringing parts together for rapid assembly is crucial for the community of Barrow.
- *Bullitt Center*: The Bullitt Center provided information on technologies focused on water collection, renewable energy, natural daylighting and waste management.
- *Makoko Floating School*: The Makoko Floating school demonstrated research in a community that is affected by sea level rise and the harmful pollutants and health effects members of the community can come in contact with if a dynamic floating system is not introduced.
- *Design Indaba*: The 10 x 10 Design Indaba focuses on how a community utilizes local resources by introducing them into a design that reflects the local climate and temperature

- *Vertical Indoor Farming*: Introducing a potential system that could be incorporated into a community that does not have a suitable climate or land available to grow their own food.
- *PlantLab*: A company that conducts research and provides appropriate growing systems and plants for a community that is unable to grow food outdoors as a traditional growing technique.



Loblolly House: Elements of Parts

The Loblolly House focuses on the idea of establishing a system of parts that can be used to create a structure and then be disassembled after the use of the structure has been exhausted. Similar to how the construction of a car works, a car is manufactured by a series of parts that work together to create a moving system. If one piece fails, the car piece can be disassembled and replaced by a duplicate piece so that the system will remain in operation. As a designer, the Loblolly House focuses on the use of the systems that can be generated and assembled off-site in mass quantities. Once the systems are created, assembly of a series of pieces provides a quick installation process that eliminates the use of on-site resources.[4]

The design of the Loblolly House has provided insight on how equipment of a structure not only has to be something that operates but can serve as the form. Form effects how wind, sun and precipitation react to the system. The Loblolly House uses an aluminum assembly frame that is integrated with panels and cartridges. The combination of the two allow the form to open up during different seasons and times of the day to allow the building to operate at a an optimal condition.[4]

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4 Kieran, Stephen and Timberlake, James. *Loblolly House: Elements of a New Architecture*. New York: Princeton Architectural Press, 2008. Print.

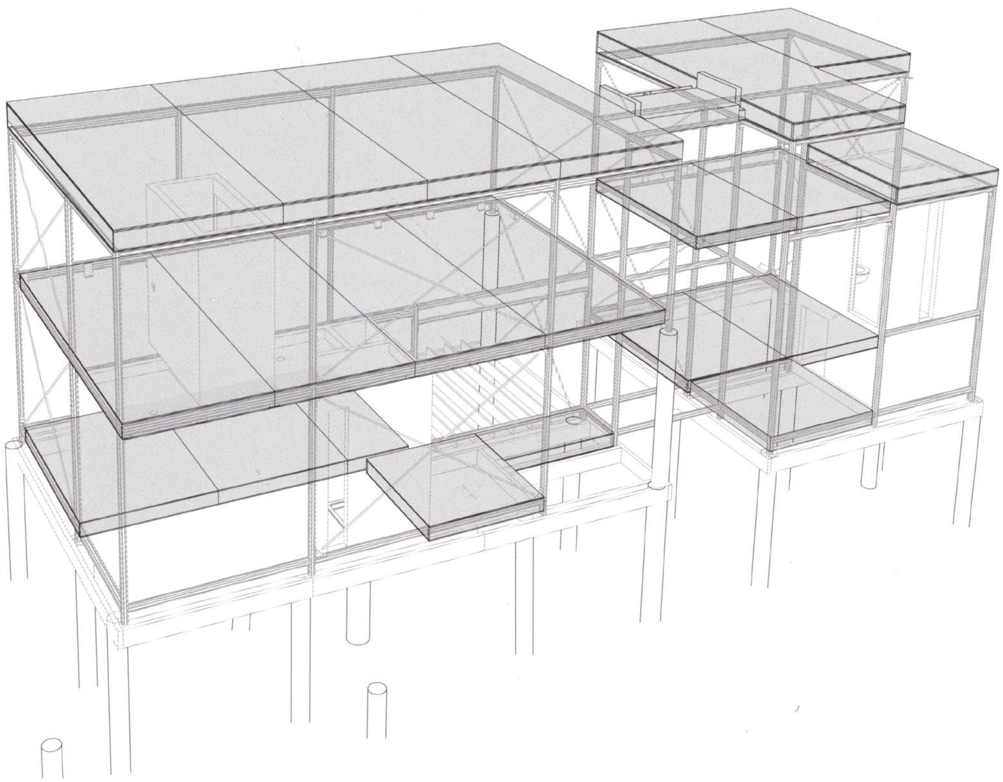

Figure 2 - A diagram of the aluminum frame structure of the house integrated with the floor panels.

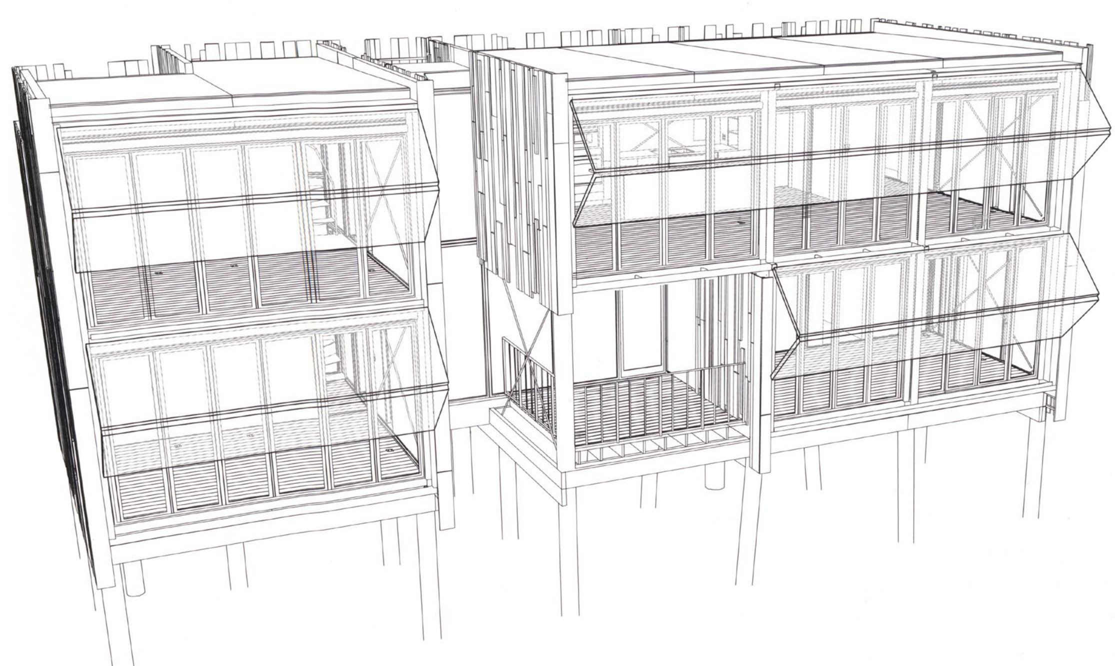

Figure 3 - A diagram of the convertible window systems attached to the aluminum frame and panels.

The Bullitt Center:
Building Efficiency, Water Collection and Waste Management

The Bullitt Center is a six story office building located in the culturally rich neighborhood Capitol Hill of Seattle, Washington. Owned by the Bullitt Foundation, developed by Point32, designed by Miller Hull Partnership, and contracted by Schuchart, the Bullitt Center was completed and opened in April 2013. Within the total cost of 32.5 million dollars, 18.5 million was spent directly on construction. The project was completed with 52,000 gross square feet with 356 dollar cost per square foot. The design of the structure designates a building lifespan of 250 years.[5]

The Bullitt Center's mission is to reduce its carbon footprint by focusing on issues impacting urban ecology and to protect the site's natural environment. To achieves its mission, the Bullitt Center's concept and design was based upon the Living Building challenge. The Living Building Challenge is part of the International Living Future Institute and focuses on twenty imperatives that condense into seven areas. Known as the seven petals, the Bullitt Center's design and performance was determined by:[6]

- *Site*: Restoring a healthy coexistence.

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5 Thomas, Mary. *The Greenest Building: How the Bullitt Center Changes the Urban landscape*. Portland: Ecotone Publishing, 2016. Print.

6 Pena, Robert. "Living Proof: The Bullitt Center." University of Washington Center for Integrated Design. 2014.

- *Water*: Creating water independent sites, buildings and communities .
- *Energy*: Relying only on current solar income.
- *Health*: Maximizing physical and psychological health and well-being.
- *Materials*: Endorsing products and processes that are safe for all species through time.
- *Equity*: Supporting a just, equitable world
- *Beauty*: Celebrating design that creates transformative change.[5]

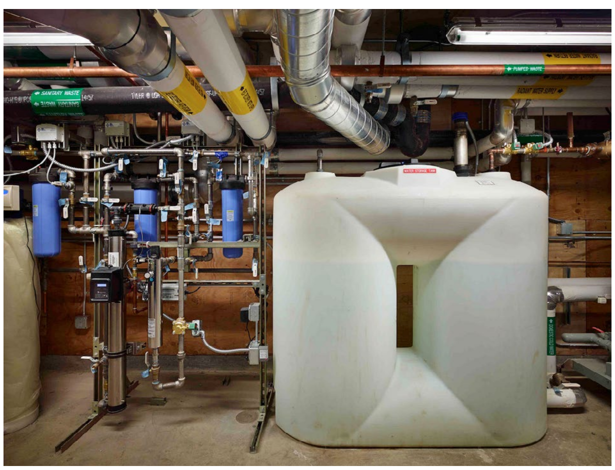

Figure 4 - Limestone and ultraviolet light water treatment technology to clean captured rain water and stored in the potable water tank in the basement of the Bullitt Center.

The Bullitt Center approached the site by building in a transit-friendly location where it is located close to downtown, residential areas, retail, restaurants and achieves a walk-score of 98/100. The water on the site restored the site hydrology to its pre-development condition, rainwater is collected and captured on the roof and stored in a 56,000 gallon cistern, goes through a purification processes without the use of chemicals, and uses a 500 gallon grey water system that is treated through the constructed wetland before returning to the eco-swell.[5]

One hundred percent of the energy needed for the Bullitt Center is produced on-site with 575 photovoltaic panels on the roof meeting the design of sixteen energy use intensity. The high performance envelope designed to last fifty years and be able to be replaced as technology changes and improves is designed with triple-glazed windows to reduce heat loss or gain. The windows are connected to an automatic system that is monitored through the local weather station and influenced by the current weather conditions. Twenty-six geothermal wells four hundred feet below ground that are approximately five inches in diameter are used to capture a fifty-three degree Fahrenheit water temperature kept constant in the ground and sent through the wells to a closed loop system. The closed loop system is attached to a heat pump located in the mechanical room to heat the water to 90 degrees Fahrenheit. The loop is then attached to another loop that is circulated throughout the building as radiant floor heating to heat the building. During warmer months, the process is switched and cooler water is used to cool the building.[5]

Health is promoted throughout the design of the Bullitt Center as walking is encouraged through the design of the timber "irresistible" staircase, and close proximity of fresh air and sunlight is available to all tenants through the large automatic operable windows. The materials of the Bullitt Center are all non-toxic, similar to a tree. 'Red list" items were forbidden from use within the site and building; red list items are hazardous materials that include toxic components used in building materials or are exposed to individuals making or installing the product and inhabiting the space. The Bullitt Center's team spent two years determining the product recipes for the building to ensure there were no hazardous materials being used and the list is available through the International Living Future Institute. The structure of the Bullitt Center is designed using concrete, steel, and mass timber. The basement, first, and second floor are made of concrete and timber of locally sources Douglas Fir is used as the structure for the remaining levels.[6]

The equity behind the design of the Bullitt Center ensures the employees are within thirty feet of natural daylight and have access to fresh air. Beauty is determined by the advisors who view the building and determine whether a living building challenge project has met this criteria. The Bullitt Center's beauty was determined by the constructed wetlands, innovated photovoltaic array, structural timber, the neighboring park and architecture. The Bullitt Center was able to provide data within the first twelve months of the building being over half occupied that is was able to meet all the criteria of the Living Building Challenge and was awarded certification.[5]

Other components of integrated systems that the Bullitt Center provides is waste management and monitoring of data. The composting toilet system uses a waterless foam-flush system that uses an automatic arrival sensor when a user is present to release biodegradable foam. The foam uses two tablespoons of water per use to lubricate the basin to ensure the slippage of waste towards the pipes that use gravity to drop the waste to the composters. The aerobic processes in the composters requires oxygen to decompose so a fan drives negative pressure down the piping to the composting units to provide the oxygen and create an odorless environment. The ten Phoenix Composters use wood chips and worms to decompose the biosoils and filter the excess liquids into leachate tanks. The leachate tanks are emptied once a month and the composters are emptied after every eighteen inches of build-up. The contents are packaged and used as GroCo Compost.[5]

Figure 5 - Ten composting systems located in the basement of the Bullitt Center

Data is continuously monitored throughout the Bullitt Center. A constant weather stream is available and used throughout the automatic window, shading and air systems. The energy supplied through the photovoltaic panels and energy used is compared side-by-side every hour to monitor energy consumption levels with current weather conditions. The cistern level, water collection rate and grey water usage is monitored as well. Currently, the Integrated Design Lab of the University of Washington is analyzing data of tenant usage as well as plug and phantom loads. Live stream data is available at the Bullitt Center and Online on its website any time of the day.[6]

Makoko Floating School:
Resistance to Sea Level Change

Lagos is located in Nigeria, Africa's most populated country of 170 million people, and houses 20 million people. Lagos is the smallest state of the country but has become the densest due to informal settlement patterns that have begun to take hold along the Lagos Lagoon. Lagos is a city of water. Its footprint is located within the Lagos Lagoon, which feeds into the Gulf of Guinea along the coast of the South Atlantic Ocean. Nearly thirty percent of the settlement of Lagos is covered by water, which is due to uneven settlement growth and the increase in rising sea levels. Flooding due to ocean surges and heavy rains often occupies the city thus causing significant damage and increased sanitation risks. The city of Lagos does not have any proper sanitation methods and has a poor drainage system set in place, often causing pollution and waste to enter the Lagos Lagoon. This affects the economics of the city that depends heavily on the nature of the water even though it's a resource that is highly under utilized.[7]

The city of Lagos is expanding at such a high rate that micro-infrastructure, informal buildings, and privately negotiated spaces have begun to over power the city. This boom has caused three major issues – fresh water supply, energy supply, and transportation. Urban planners and

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7 Gadanho, Pedro. *Uneven Growth - Tactical Urbanism for Expanding Megacities*. New York: Museum of Modern Art, 2014. Print.

strategies applied to the city have become nearly useless as the city continues to change without proper approval. The government is tackling this issue in two ways: an intervention of the large-scale infrastructure and the enhancement of small-scale community systems. This tackles the demand for transportation infrastructure while providing proper drainage systems and employment opportunities for members of the community.[7]

Figure 6 - A proposal of the Makoko Floating Community in Lagos, Nigeria.

The Lagos Water Community Project envision came into existence when Adeyemi noticed the issues occurring in his home country and wanted to make an impact and change the way the city has been expanding. He recognized the social injustice the district of Makoko was affected by, so he created a plan with his team at NLÉ Architects to attempt to improve the living conditions of the community. His vision was of an entire community of floating houses, education centers, and public places. The Lagos Water Communities Project proposal reached satisfactory reviews from the locals and expanded to creating a prototype named Makoko Floating School. Heinrich Boll Foundation, United Nations Development Program/Federal Environment Ministry, and local materials, labor, resources and expertise acquired the financial support for the project.[8]

The Makoko Floating School is comprised of local resources and recycled materials found within the community. The design is a floating structure comprised of 256 plastic barrels that were found in abundance within the city of Lagos. Sixteen wooden modules, each containing sixteen barrels were combined together to create the 100 square meter first level platform. Two anchors were connected to the platform to hold it in place as it performed as buoyancy to the raising and lowering of the tide levels. The A-frame triangle structure above the platform was of local bamboo and procured timber from the nearby forest and mills. The triangle framing was chosen because of the shape's low-lying cen-

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8 Cantz, Hatje. *Arfitecture - Building Social Change.* Munich: Architekturmusem der TU Muunchen, 2013. Print.

ter of gravity which helps resist tipping from a wave surge or uneven balance. Eight builders of the Makoko community were the work force behind the completion of the school.[9]

The the structure was intended to be used as a school, but was actually used by members of the community for other reasons. The structure stood at ten meters in height and the 100 square meter platform had become the only public space accessible to the community and began being used before completion. Fishermen would use it to sort their nets, it held as a gathering place for families, and even served as a trading and selling location for goods. The two upper levels were designed to fit one hundred students at a time, housing four classrooms on the middle floor and two workspace areas on the top level. The view from the top level of the prototype became the tallest observation point in Makoko, which drew an abundance of locals to enjoy the space. The prototype's intended use never became its actual use throughout is three year life span.[9]

NLÉ Architects incorporated high performance design methods into the design of the structure but failed to include them into the prototype. On the platform level a composting unit was proposed to address the sanitation issues of waste disposal within the lagoon. The human waste produced in Makoko is deposited into the lagoon, which contaminates the water and increases the likelihood of diseases such as cholera spreading throughout the water. A rainwater collection system capturing rain from the roof and storing in the barrels was imagined but unable to be carried out due to damage in the floating plastic barrels. The intention was to used the floating barrels as a storage device. Photovoltaic panels were also proposed in the design to allow the users to receive electricity since there is a lack of suitable, reliable energy throughout the community.[9]

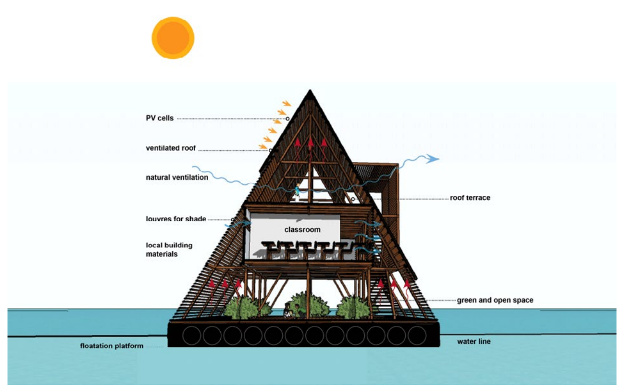

Figure 7 - A section diagram of the Makoko Floating School.

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9 NLÉ Architects. Makoko Floating School – Research Report. Amsterdam: NLÉ, 2012.

Design Indaba:
Local Resources and Thermal Control

In 1994, the Reconstruction and Development Program (RDP) was created by the South African government. The program was initiated to create 300,000 housing units a year for low income or poverty stricken families living outside urban centers. Two years after the founding of the RDP, Article 26 was adopted to warrant every South American citizen the right to housing. With the high demand for housing, over three million housing units have been constructed and sold at a low cost. With an intent to resolve a mass housing and informal settlement issue, the RDP created additional concerns with its poor layout and inefficient design strategies. This matter thus established a competition to improve the conditions and generate solutions to the housing problem. The 2007 Design Indaba Conference in Cape Town hosted the competition.[8]

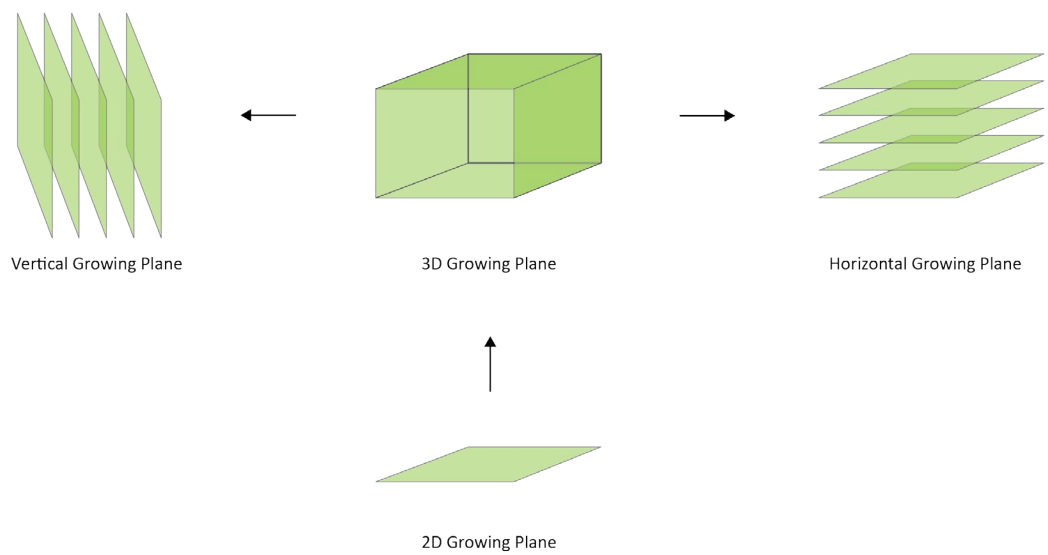
The competition focused on a township called Mitchell's Plains located outside the city center of Cape Town. Ten local architects designing ten low-cost housing units for ten disadvantaged families was the intent of the outcome for the competition. The RDP provided the funding for the competition, setting each housing unit's total cost at 7,000 dollars. A 112-square-meter plot of land was designated per dwelling with a 40-square-meter housing limit. However, due to the low-cost of the housing units, members of the community were still unable to afford to purchase a unit. To deal with the inability for members of Mitchell's Plain to afford the housing, each individual unit was raffled off to members of the community. The chosen families were then required to help with the assembly of their particular unit.[8]

Figure 8 - A construction view of a house showing the placement and density of the sandbags.

Luyanda Mpahlwa was an architect on the committee and he developed a housing strategy called the Sandbag House. His design consisted of wood-framed two story units with an infill of sandbags. His design was chosen due to the local advantages and efficiency of the design. The key efficiency components of the use of sandbags was the local availability at a low-cost, the insulation capabilities of the sand, the restriction to take in water, and the lack of electricity that is required during the installation process. The straightforward process of construction, guided the individuals occupying the dwellings to understand and participate in the construction process more effectively. This created opportunities for the members to relate more closely to their particular home and its unconventional construction method to provide adequate upkeep and maintenance.[8]

The two-story units are finished with bright color exteriors that distinguish them from past single-story government housing models constructed in the area. The two story structure was approved due to its narrow footprint and interior layout of spaces. Communal areas such as the kitchen and bath areas are located on the ground floor with the living and resting quarters on the second level. Space provided between the units allows for garden space or additions to be created in the future. Each unit is provided a veranda to relate to the local culture of merging the interior and exterior spaces.[8]

Figure 9 - A construction view of two window frames showing the placement and density of the sandbags.



Vertical Indoor Farming

Indoor farming is the technique of growing plants such as vegetables, fruits or herbs in an indoor highly controlled environment. Commonly referred to as controlled-environment agriculture (CEA) technology, indoor farming techniques such as vertical farming are becoming a more common practice in urban communities that maintain a high population of people with a lack of food production land use. Skyscrapers, abandoned buildings, warehouses, underground tunnels and shipping containers are just a few examples of places indoor farming can exist. Soil-based, hydroponics, aquaponics, mushroom culture and vertical farming are different indoor farming systems currently used throughout the world today.[10]

When the idea of indoor farming first began, it was commonly practiced among individuals who were growing in small amounts on a single two-dimensional surface. As techniques, processes and industry has evolved, three-dimensional ways of farming began to unfold to be utilized for production. Indoor growing in three-dimensional volumes requires the knowledge to understand the direct relationships of the specific needs of a particular plant, as well as the needs of the human population. These needs are the essential stepping-stones for the future of how

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10 Shimamura, Shigeharu, and Chieri Kubota. "Indoor Cultivation for the Future." Mirai. The University of Arizona, Tucson. 16 April 2017. Lecture

indoor growing systems will evolve.[11]

The expansion of indoor farming volumetrically from a single plane to multiple planes has increased production levels and provided evolutionary systems to be involved in the growing process. Vertical plane and horizontal planes have been introduced each providing their own challenges. Vertical growing methods affect how water can be used in the system and placement of artificial lighting but are not restrictive to airflow. Horizontal growing methods create barriers to adequate airflow, but by stacking the planes can provide convenient irrigation methods and uniform artificial lighting.[11]

Growing in volumes is the future of urban agriculture. By looking at the volumes, discovering the most efficient and cost effective way of production is key to a success of an indoor growing system. When growing indoors the main goal is space use efficiency from an economic viewpoint. Breaking this down, it is providing the most amount of produce in the smallest space in an efficient and economic manner. Understanding the valued cost of the infrastructure of the equipment in the scale required for adequate growing that can then be sold in a respected market.[10]

Figure 10 - A diagram demonstrating the potential sizes of indoor growing locations.

There are multiple benefits to indoor farming. The high efficient control of the indoor environment is one of the greatest benefits. The use of artificial lighting and controlled water, ventilation, humidity, carbon dioxide enrichment and temperatures creates the opportunity to grow a specific plant at its most efficient growing level. This creates a faster growing process and yields of the specific crop that could otherwise have suffered under outdoor or natural daylight conditions. Another benefit of controlling an indoor growing environment is eliminating nat-

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11 Storey, Amy. "The Beginner's Guide to the Indoor Farming Industry." Upstart University. 07 October 2016. Web. 16 April 2017. <https://university.upstartfarmers.com/blog/the-beginners-guide-tothe-indoor-far ing-industry>.

ural effects that could occur in an outdoor environment, such as drought, contamination and runoff. The high-intense human control over the indoor growing process creates opportunities to grow at different scales in different contexts of the world.[11]

For indoor farming to be successful, light is required to maintain optimal plant growth and health. When growing in a greenhouse, daylight is naturally available if sky conditions are sunny, but additional artificial light may be necessary if a plant requires it. Indoor growing in an enclosed, highly controlled environment requires artificial lighting that is cost efficient and sustainably powered. Sole-source lighting technologies that have been researched and used for the use of indoor growing systems are compact fluorescents, light emitting diodes (LEDs), high intensity discharges (HIDs) and sulphur plasmas. Understanding the plant type and its lighting need, the light sources quality, efficiency, heat production, placement, life span and the cost of the source are all primal criteria needed for light source selection.[12]

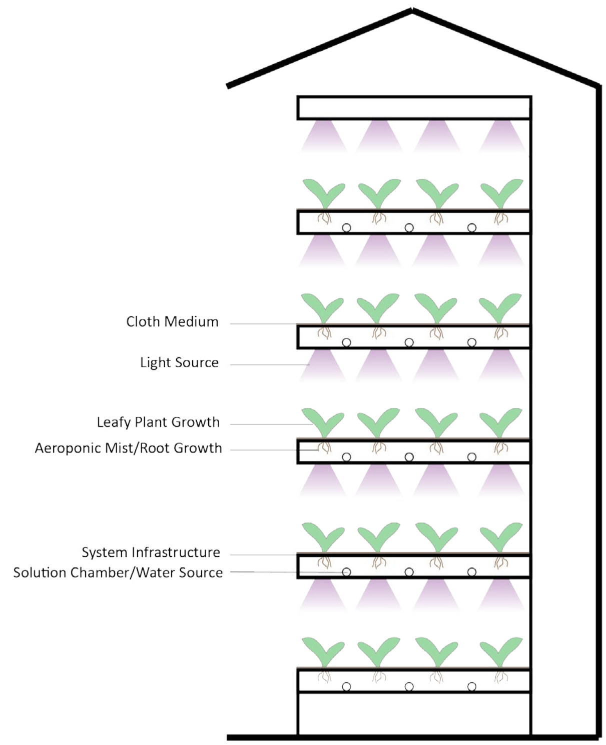

Figure 11 - A diagram demonstrating an aeroponic watering system of leafy plants with LED lighting.

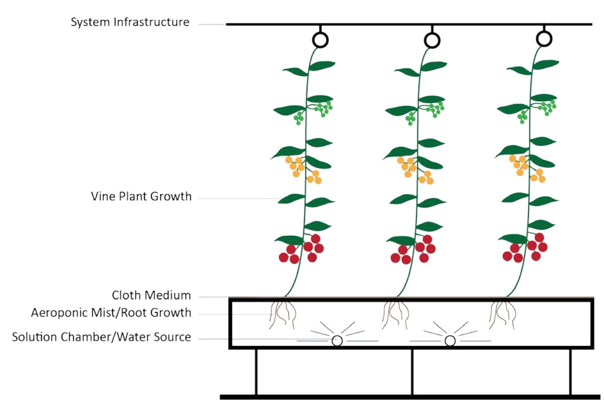

Figure 12 - A diagram demonstrating an aeroponic watering system of vine plants.

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12 Proksch, Gundula. "Environmental Resources." *Creating Urban Agricultural Systems: An Integrated Approach to Design*, 96-98. New York/London: Routledge, 2017.

When providing consistent crop production throughout the year with indoor farming, marketing strategies and branding relationships are created with valued customers. Adaptive reuse of existing buildings that are no longer used can serve as a sustainable platform to house an indoor growing system in communities that may not be able to support the construction of new facilities. A highly controlled environment combined with the considered lighting, watering and growth techniques creates a network of valuable food sources and the demands created by the market determines what is grown. Indoor growing serves as an opportunity for communities that do not have access to outdoor growing conditions and could highly benefit from the introduction of such system within the community. Each country and community throughout the world can look at different systems of how to introduce indoor farming into the market. With each market providing different resources throughout the world, communities that are in need of providing adequate nutrition to its citizens could adopt indoor farming techniques that lead the pathway to feeding the world.[13]

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13 Horton, Robin Plaskoff. “Indoor and Underground Urban Farms Growing in Size and Number.” Urban Gadens. 20 October 2015. Web. 17 April 2017. <http://www.urbangardensweb.com>

PlantLab:
Plant Production Unit

PlantLab is an indoor agriculture growing system technology company that focuses on future growing practices and uses a concept rationale to investigate existing agricultural practices to create innovative solutions. Located in Hertogenbsch, the Netherlands, the company was founded in 2010 by four engineers: Gertjan Meeuws, John van Gemert, Leon van Duijin, and Marcel Kers.[14] PlantLab focuses on the research and technology of plant growing systems that PlantLab calls Plant Paradise. PlantLab researches the required systems that are needed to succeed in indoor growing techniques and develops them to conform to the space limitations of the desired location and facility size. PlantLab's quest is to become the leader in three technological advances:

- Vertical farming
- LED lighting
- Applying mathematical models into plant cultivation

These Three technologies work together to form PlantLab's operating system called the Plant Production Unit. An additional location in Berkley, California provides a United States location for the expansion, research and marketing of PlantLab's systems. Research in Berkley is conduction

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14 Saenz, Aaron. "Dutch PlantLab Revolutionized Farming: No Sunlight, No Windows, Less Water, Better Food." 14 August 2011.

by staff members of the department of Plant and Microbial Biology at the University of California Berkley.[15]

Two decades prior to 2010 is when the formation of PlantLab began. In an interview with Laura Santamaria of Sublime, Gertjan Meeuws - founder and managing partner of PlantLab -discussed and reflected back on how PlantLab first planted its seeds towards becoming the innovative company it is today. In 1989, Meeuws described his role as a horticulturist that eventually developed into a plant physiologist. The beginning phase was to learn as much as possible about a variety of plants so that the team could begin developing their plant identification knowledge base. In the 1990s, Meeuws began looking at plants more in depth and his colleagues researched different plants growth speeds in relation to temperature, light, air and water and monitored behavior of light and photosynthesis. Meeuws and his team spent ten years studying plants until applying their discoveries in to a plan and action. Based off the transition that took place and the teams discoveries, Meeuws stated,"

"Plant organisms are so intelligent that they are prepared to adapt to every single circumstance, whether it is a dry, wet or hot summer."[15]

The first business plan Meeuws and his team had was to develop the next generation of a greenhouse. They believed a greenhouse provided an environment that could be tweaked to ensure optimal plant growth and happiness. However, in the 2000s, their idea changed. With the knowledge of global food production, environmental pollution, depleting fossil fuels, and food transfer at a global scale, local indoor growing systems became their business priority. They transition to developing indoor vertical growing systems while

Figure 13 - A rendering of an urban indoor growing location created by Shift.

maintaining plant growth and happiness from their previous greenhouse vision. This vision became the leading precedence in the development

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15 Santamaria, Laura. Interview with Gertjan Meeuws. "The Secret Life of Plants." Sublime. Issue 29, 2011.

Figure 14 - A diagram demonstrating the research process PlantLab undergoes for each plant.

of what is now known as PlantLab.[15]

To educate consumers, companies, and developers about their systems, PlantLab collaborates with Shift - Architecture Urbanism - to represent how the Plant Production Unit technology can be integrated into the urban environment. Shift has provided research for Frits van Dongen and his team on how PlantLab's indoor farming techniques can be used within government projects. The results of the research provided spatial strategies for indoor plant production within an urban environment, as well as, provided information on the global food network systems.[16] Shift also collaborated with Atelier Rijksbouwmeester on the spatial impact of PlantLab's vertical farming within an urban environment.[17]

Shifts reasoning for applying research towards PlantLab's vertical farming systems in an urban setting are to understand how and why it is becoming a global concern. Shift believes horticulture has taken a new form, and the ways of producing on a single-plane of land is becoming obsolete. Biological farming is unable to deliver local, high capacity food production for the growing urban communities. The pressure being applied to the current form of farm production is causing a transition of research and demand of urban vertical farm communities. With the future risk of diminishing fresh water supply and land nutrients depleting, vertical farming methods introduce solutions to such problems, as well as, climatologic, disease, and food crisis issues. The current process of growing is no longer sustainable and produces an enormous amount of food loss, up to fifty percent.[16]

PlantLab begins each collaborative discovery by saturating themselves with knowledge of a particular plant or growing type and researching the requirements that scenario would need to function at the most sustainable and effi-

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16 Shift Architecture Urbanism. "Indoor Farming." 2017. <http://www.shift-au.com/projects/>

17 Shift Architecture Urbanism. "High Tech Indoor Farming for the City." 2012 – 2013.

cient level possible. The researchers then apply a plant identification system and collaborate with a customer to form a recipe for the customer's desired growing business model. Once the recipe is selected PlantLab provides testing. If the testing provides positive results that the customer agrees to, then the plant growing identification is distributed to a facility that the customer has created using the recipes required ingredients and begins production.[18]

Currently, PlantLab is using nutrient research provided through past horticulture practices, but desires to incorporate their own research in the future. Without the need for pesticides to control pests and disease because of its highly intensive controlled indoor environment, PlantLab believes its current system provides the utmost 'happiest plant' on the market. With their own research into nutrients PlantLab considers an evolution of creating an 'even happier" plant if a newer system of nutrient control is possible.[15]

PlantLab has created its own system called the Plant Production Unit (PPU) to offer the convenience of any size for small microwave sized to multi-story building integrations. The PPU uses four areas of research and advancements: plant physiology, technology, multi-layer growing and mathematical modeling. The PPU system created allows for PlantLab to alter the environmental growing conditions by changing the indoor climate, humidity, ventilation, and lighting condition.[19]

In Meeuws interview with Santamaria he compared how a plant works to a factory; a plant will not succeed at its most optimal level if the tools are not adequately provided. PlantLab's system can operate as the 'factory' to provide the control of light, air, and temperature for the development of a plant-growing recipe. The recipes created in Plant Paradise are run through an Internet server system that controls the operating system and plant growth from seed to harvest.[15]

Water is a crucial role in the growth and production of a plant. PlantLab has tested its operating process of water control to be ninety percent more efficient than that of tradition-

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18 PlantLab. N.p., 2016. Web. 25 April 2017. <http://www.plantlab.nl/>

19 "PlantLab Could grow Fruit and Vegetables for the Entire World in a Space Smaller Than Holland." Inhabitat green Design Innovation Architecture Green Building. N.p., 17 March 2015. Web 25 April2017. <http://inhabitat.com/dutch-company-plantlabs-agriculture-revolution-could grow-the-worlds fruit-and-veg-in-a-space-smaller-than-holland/>

al horticulture methods. Different systems can be incorporated into the plant production unit's flexible design, such as hydroponic, aeroponic or aquaponic systems. PlantLab strongly argues through its research that fresh water will become a larger global problem than fossil fuels in the next twenty years. The issue of water usage in traditional agriculture methods needs to be addressed immediately and can be done so through the systems PlantLab has developed. PlantLab uses a process of capturing water in the plants themselves; water is absorbed through the plant's roots, progresses through the plant and evaporates through the leaves where it is captured and returned back to the water tank.[15]

PlantLab has created its Plant Paradise by providing LED lighting systems that provide red, blue and far-red lighting. Why these types of lights? Throughout research conducted in the 1990s and early 2000s, Meeuws revealed they discovered that the photosynthetic light absorbed by chloroplast in a plant is only the red, blue and far-red light waves. Plants react strongly to the far-red light even though humans are unable to see

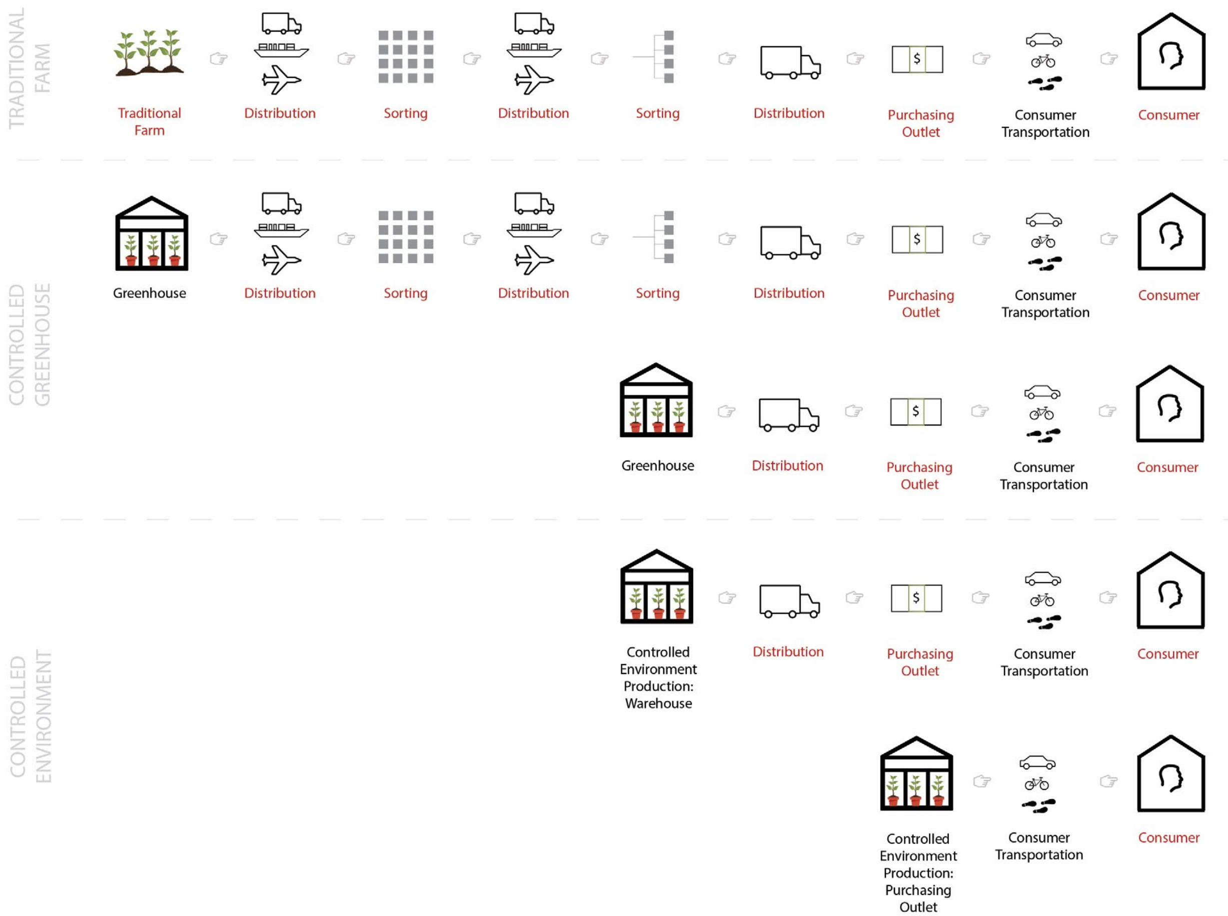

Figure 15 - A diagram demonstrating the transportation of food production.

it. Plants are green in hue due to their ability to absorb the red and blue light waves and inability to absorb green. Thus, that is why we see green, because it is reflected.[15]

Figure 16 - A photo of PlantLab's plant production unit with LED lighting.

PlantLab is revolutionizing the way that systems can be incorporated into existing structures to maximize growing potential and reduce the distribution chain. As a comparison to other growing techniques, systems and setting conditions, PlantLab does not compare its yield because of the constraints and limitations that other systems face. PlantLab focuses its attention on creating systems that can be integrated into any structure type. Attached to grocery outlets, integrated into the urban fabric, serving as a local location within a food desert community or the restoration of an existing abandoned indoor location all serve as integration locations for a plant production unit. Each unit is designed to maintain the most sustainable design approach in its unique environment.[15]

With each environment for an installation of a plant production unit differentiating, this poses the opportunity for different distribution options than what is currently occurring in the global food network. Currently food found in local super markets is produce that is grown or raised from everywhere in the world. This is not only an unsustainable approach to agriculture and marketing, but causes significant pollution from transportation and harvesting procedures. PlantLab's plant production unit provides the technology to incorporate systems in locations that provide fresh produce within a true local context. Supermarkets have the potential of providing produce grown from within the building and provided to the consumer within minutes. Food deserts in locations that may not have access to a supermarket are provided with fresh produce that is grown within an existing building. Sustainable energy practices and water capture techniques are great resources to integrate into possible indoor growing locations.[17]

If technology is the continuing wave of the future, then PlantLab's vision of an integrated indoor growing system is the innovation that our local communities will need to stand behind.

Chapter III: Methodology

Overview of Design Methods

Before applying a design method, I researched the community of Barrow and determined how individuals in the community lead their daily lives, the resources the community is able to receive, how waste is managed and electricity received. The existing conditions of the community were crucial research components in understanding the effects of past disasters and how future opportunities to reduce environmental impacts can be achieved. The design implements fourteen community centers that are distributed throughout the community to serve the population and existing community functions.

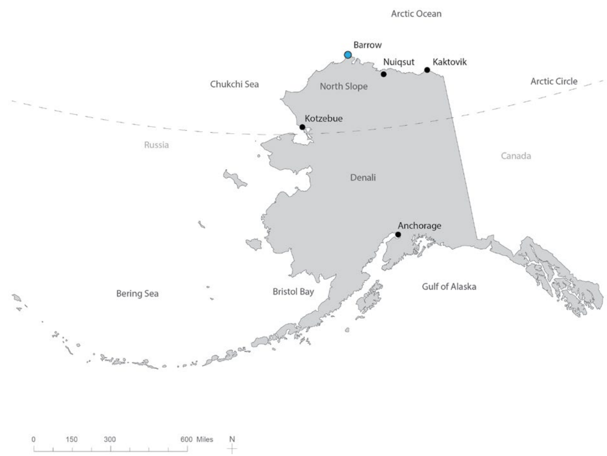

Figure 17 - A map of Alaska.

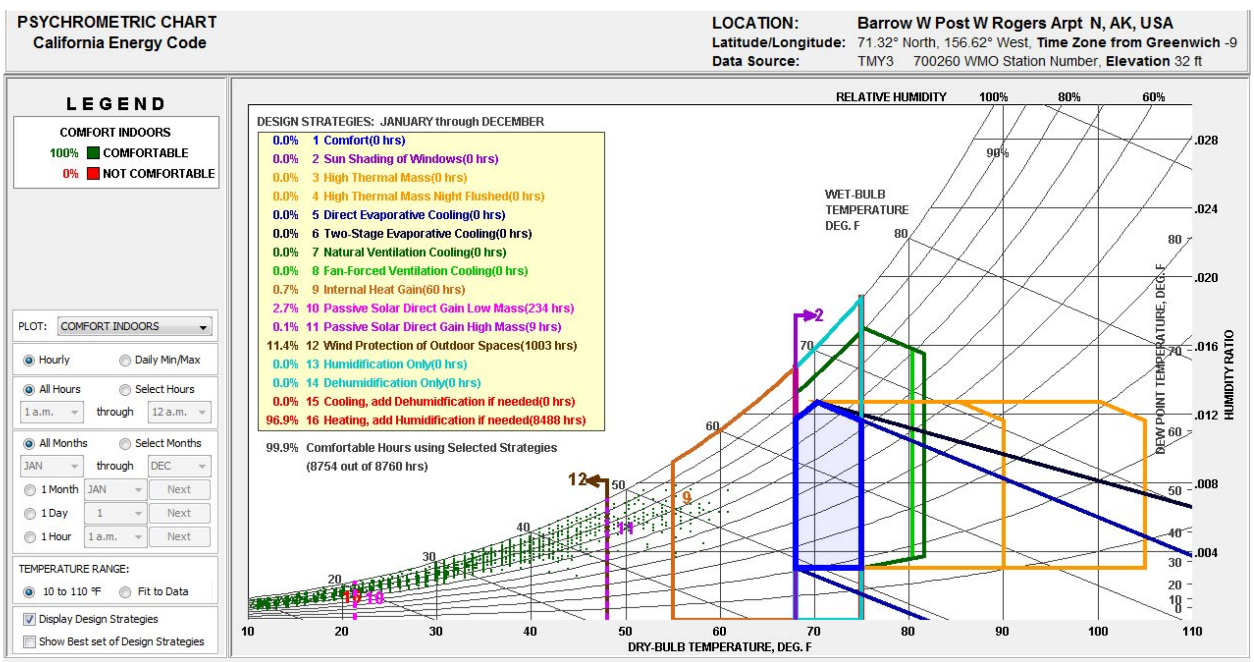

Figure 18 - The psychometric chart of Barrow, Alaska demonstrating ideal design strategies according to dry-bulb and wet-bulb temperatures.[20]

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20 Milne, Murray. Climate Consultant Department of Architecture and Urban Design, University of California. 2017.

Site Selection and Analysis

The Brooks Range, an extension of the Rocky Mountain System, separates northern Alaska from the remainder of the state. Within northern Alaska lies the mountain range, arctic foothills, and the Arctic Coastal Plains. The area totaling to 136,200 square kilometers, 70900 square kilometers of the area resides in the Arctic Coastal Plains. The arctic coastal plains lie north of the tree limit and are consumed by 40 percent arctic tundra ponds, large lakes, shallow ponds and old drained lake basins until reaching the Arctic Ocean. The remainder of the area is covered by grasses, mosses, lichens and sedges. Barrow is located at the northern tip of the coastal plain.[21]

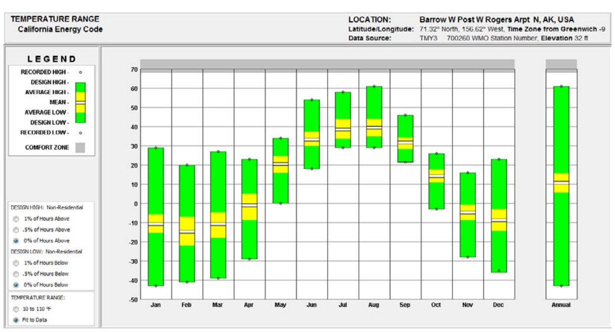

Figure 19 - The temperature chart of Barrow, Alaska demonstrating the range of temperatures throughout the year.[20]

The climate of Barrow consists of cool, short summers and long, cold winters. Between 18 November to 24 January, the sun is below the horizon level due to Barrows latitudinal location. During the winter months, the sky conditions are usually clear, thus lowering the temperatures and reducing the atmospheric insulation. Between 10 May and 2 August, 24-hour daylight is present as the sun never sets below the horizon. Nine months of the year there is consistent snow cover. In April and May, sun radiation is high but with 80 to 90 percent radiation reflection off the snow cover, very little snow is able to melt. This is called the Albedo Effect. Not until mid-June when the reflection levels reach 10 percent does the snow begin to melt. The consistent overcast sky conditions in the summer affect the solar radiation levels, and this occurs before the tundra ponds beginning to melt. The air temperatures in arrow average 9.68 degrees Fahrenheit annually and there are only approximately 40 days when the temperatures are above thirty-two degrees Fahrenheit.[21]

The Arctic Coastal Plain's annual air temperatures are below freezing, thus keeping a consistent ground temperature known as permafrost, which is 400 meters thick below Barrow with a

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21 Hobbie, John. *Limnology of Tundra Ponds: Barrow, Alaska.* Pennsylvania: Dowden, Hutchison & Ross, Inc.,1980. Print. Pages 2-4, 6, 25-26, and 32.

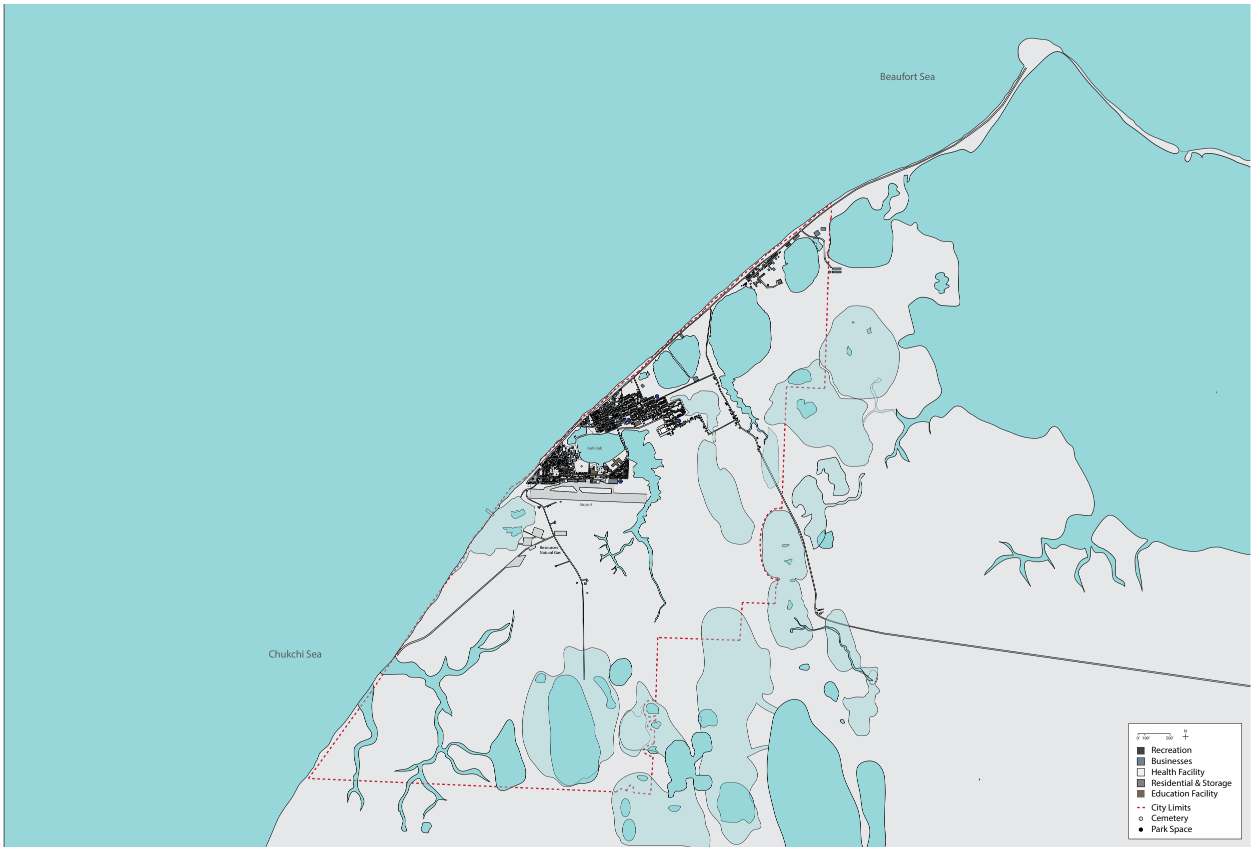


Figure 20 - A map showing the location of Barrow in proximity to the sea and surrounding tundra ponds.

top layer of soil 25 to 100 centimeters thick that does thaw each summer. The thaw depth is determined by the soil types and vegetation type present and how much insulation it provides. Melting in Barrow often occurs by tracked vehicles as they kill insulation vegetation. This causes the ice wedges to melt and create trough ponds.[21]

The area surrounding Barrow is tundra that experiences desert like conditions with only 12 centimeters of precipitation. Fifty percent of the precipitation falls between June and September. With the ground frozen as permafrost, no movement of water occurs below the ground or into sediment layers. The water flows between basins above ground during spring and creates tundra ponds approximately 0.5 meters in depth across the land. The tundra ponds range in size but are usually 30 by 40 meters in breadth and increase as spring melting and late summer precipitation occurs. Between each tundra pond are grasses and sedges that connect other ponds. Small ridges created by growth of underground ice push up the land and cuts off connection points from one pond to another.[21]

The shallow depths of the ponds reacts to temperatures from mid-June to September where they thaw and fluctuate in temperature. The cold temperatures of the environment creates a slow metabolism of the ecosystem. As the ice and sediment in the ponds begin to melt it only takes a few days and the temperatures can flux up to fifty degrees Fahrenheit in response to the sunlight, air temperatures and wind. Only the first 30 centimeters will thaw as the permafrost layers below ground keeps the remaining water and sediment frozen. The sediments in the ponds contain 80 percent organic matter. Very little salt is preset as ponds gain greater distance from the sea.[21]

With the permafrost and low evaporation levels in the area a great deal of fresh water is available in Barrow. 10.8 centimeters is the approximate precipitation each year with 50 percent of the being snow fall between October and November. Snow fall moves and drifts quite aggressively in the area due to its low elevation, flat landscape and ridge tops. The wind conditions

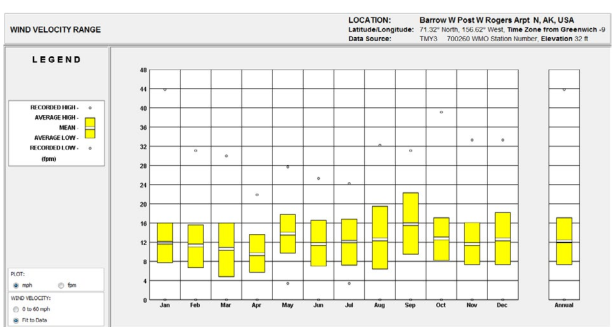


Figure 21 - A diagram of the annual wind velocity ranges in Barrow.[20]

in Barrow are consistently from the east. In October and September is when Barrow receives most of its coastal storms.[21]

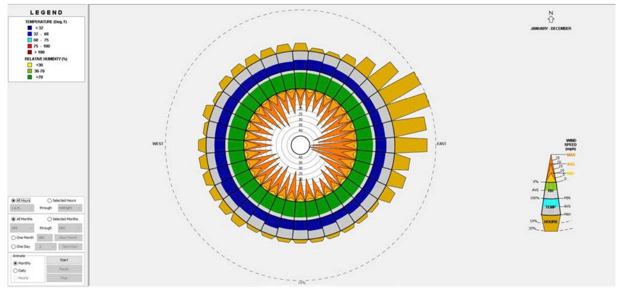


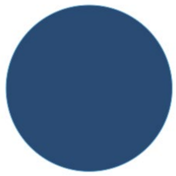
Figure 22 - A wind-rose diagram of the annual wind direction in Barrow.[20]

Goals and Objectives

I created a matrix of constraints based off the issues within the community of Barrow, Alaska. I programed a pattern language that reflects a program of resiliency the building models can use regularly for common purposes and adjusts to demanding needs as they are introduced. Overall, I'm designing two building patterns that serve as an off-grid community center and an emergency power-grid and resource center when a natural disaster strikes.

Program of Spaces

To begin the programming of the spaces, research based off the community building pat-



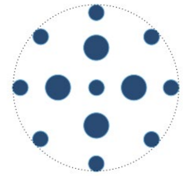


Figure 23 - A single dot demonstrating Barrow as one community.

Figure 24 - Several dots demonstrating Barrow as one community that breaks apart into several groups that work together to form a holistic unit.

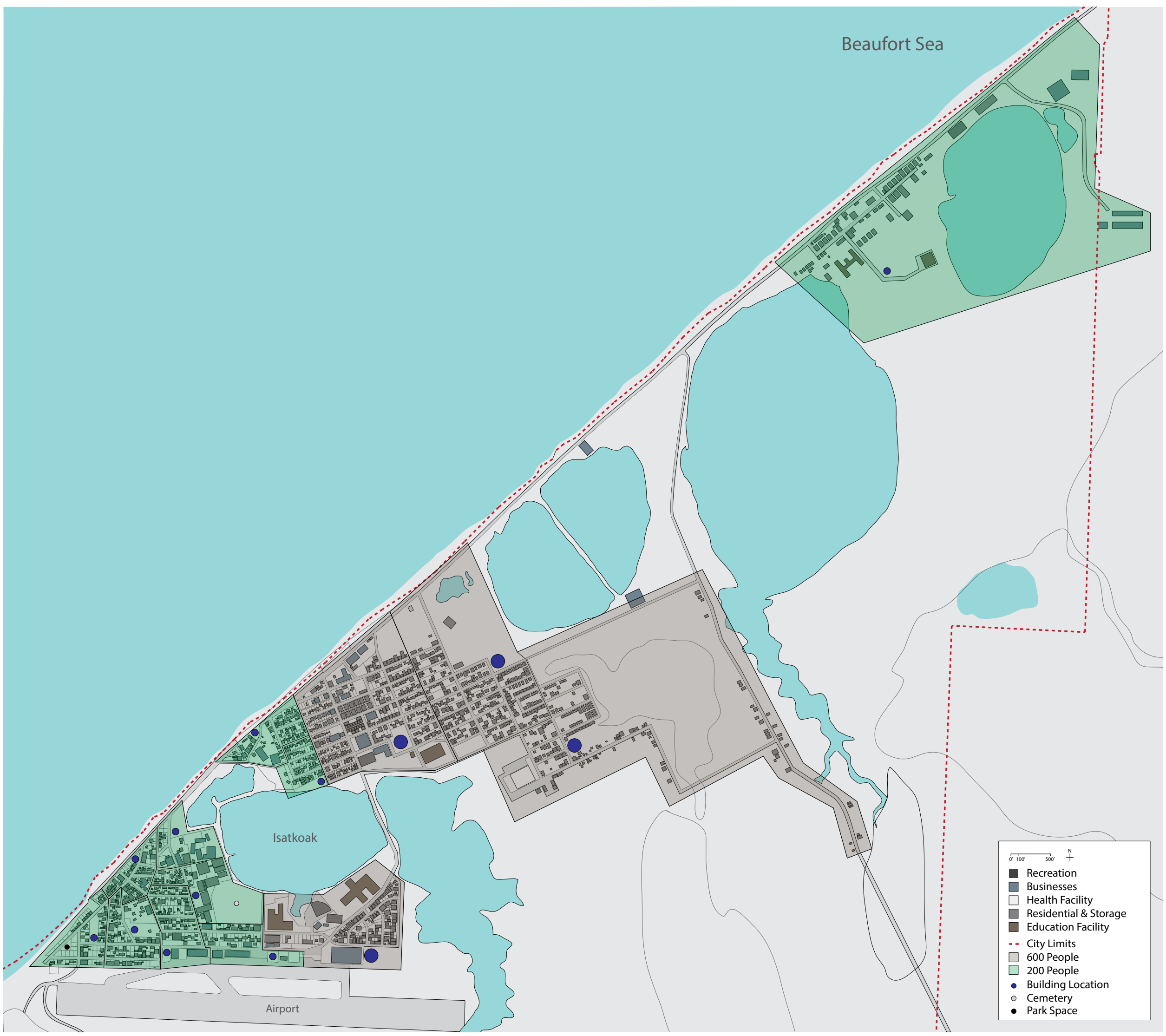


Figure 25 - A map of Barrow with designated zoning of program type and size. The community was broken down into two program sizes that accommodate fourteen separate facilities that work together as a unified whole.

tern was required. A different pattern language within different sections of the community creates a series of nodes in which different functions within the community occur. While designing a series of community spaces to accommodate current needs is important, a transformation of the spaces is crucial when resistance becomes urgent due to a risk of disruption. Resilient design in Barrow accommodates survival needs of in a local group of people affected by the moment of disruption.

The program of the design I am proposing considers the functional use of the spaces during idle and how they transform during disruption. To accommodate the population, a series of prefabricated buildings are designed according to local site constraints and daylight requirements and placed throughout the community. Each building will provide the basic amenity needs and a community attribute during day-to-day activities, but then will be able to transform to house a required amount of people during a length of disruption.

The current population of Barrow is around 4,300 people. To organize effective program layouts for each building in its desired node location, an increase in the number of people is required to accommodate future needs as well as people who may be visiting the area during a moment of disruption. Designing for 5,000 people is where the program begins and the study allows for expansion if the need arises.

The design of the structures are based off the International Building Code Special Detailed Requirements Based on Use and Occupancy - Community Storm Shelters. The International Building Code refers to the International Code Council Standard for the Design and Construction of Storm Shelters which goes more in depth on the requirements of storm shelter construction. The ICC requires a shelter design for wind speeds up to 160 miles per hour in Barrow, Alaska. Changes in internal pressures due to atmospheric pressure changes must be considered for the shelters. Flooding code in Barrow requires a minimum floor elevation of 6 feet. A maximum travel distance of 150 feet from an exterior door for occupied sheltered spaces with access within circulation and doorways to be of equal width to avoid the bottleneck effect. Community safe rooms within shelters require fire barriers with a minimum 2-hour assembly separating the safe zone from the remainder of the building. The safety shelter must be ventilated naturally and mechanically if accommodating more than 50 occupants at a given time.[22]

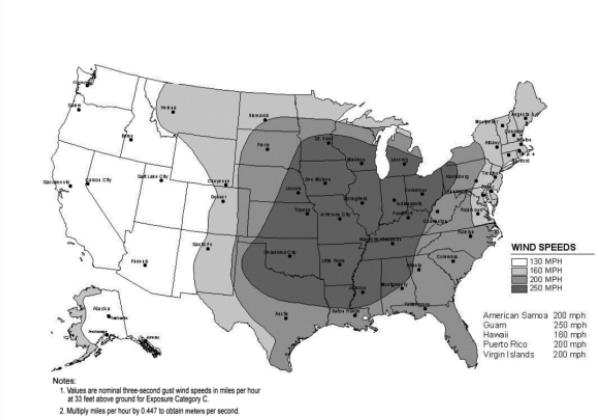


Figure 25 - A map of the United States with wind speeds to determine which type of force a design must design according to.

When programing the spaces required for the community centers, the International Building Code requires Assembly Group A-2 is used for spaces that are intended for food and/or drink consumption and the remainder of the space is designed according to the code Assembly Group A-3 for other intended assembly uses without fixed seating.[23]

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22 International Code Council 500-2014: ICC/NSSA Standard for the Design and Construction of Storm Shelters - American National Standard. Illinois: International Code Council Inc., 2014. Print.

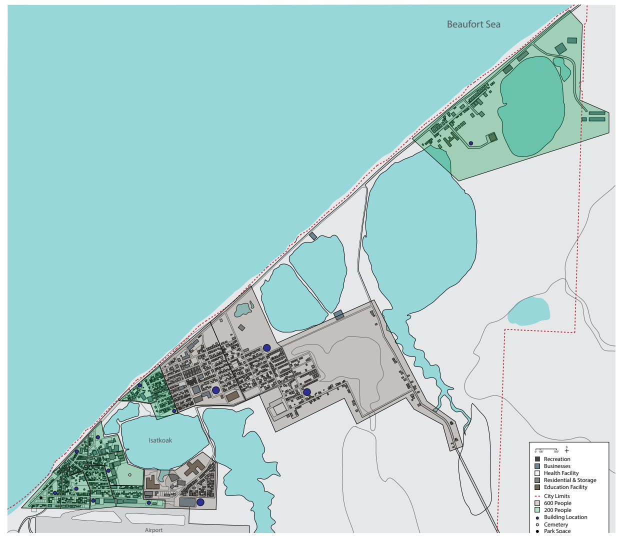
23 International Building Code. Illinois: International Code Council Inc., 2011. Print.

Scale: 600 People

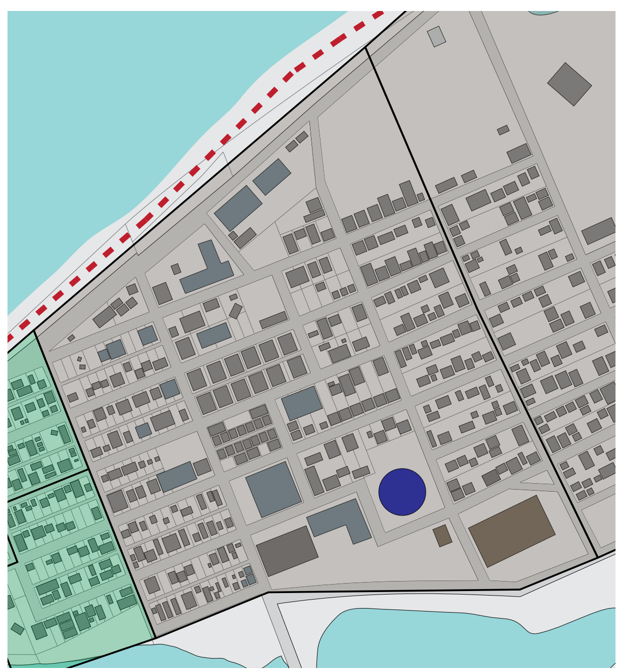
Daily: Recreation or Community Hall

During Disruption: Shelter

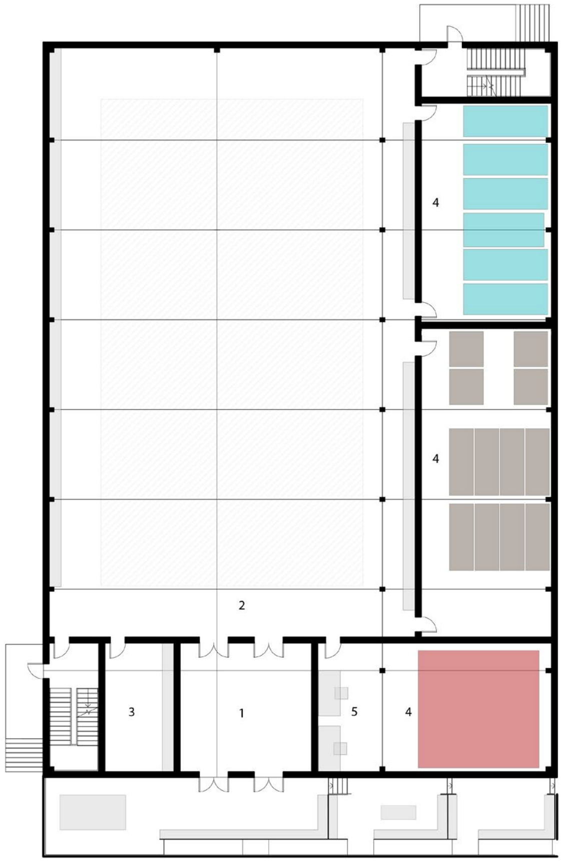
The facility designed for 600 people is programmed for the use of either recreation or community hall spaces. These programs are incorporated into the larger scale because of their proximity to schools and hospital facilities. There are four facilities at the 600 people per facility scale. They are located in the educational and healthcare locations where the greatest lot sizes in the community occur.



PROGRAM	MINIMUM SQUARE FOOTAGE	DESIGNED SQUARE FOOTAGE
NET BUILDING PROGRAM		
Lobby	550	630
Programed Space	9700 net	9700
Agriculture Growing Space	1000 gross	0
Office	200 Net	270
NET NECESSARY BUILDING COMPONENTS		
Water Closets Lavatories	7 Male, 7 Female 3 Male, 3 Female	840
Water Fountain	1	1
Showers	5 Male, 5 Female	600
Dry Food Storage	360	400
Water Storage	73,000 gallons	
Services	3000	3235
Kitchen	2015 net	2130
Means of Egress	400	400



Level One



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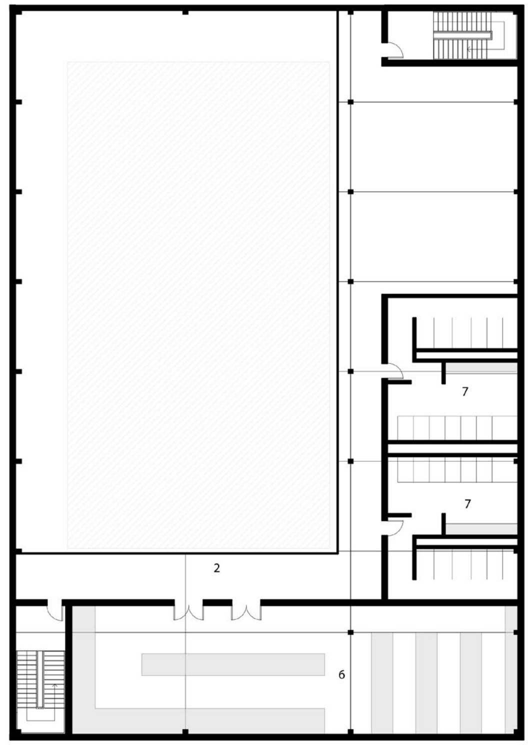
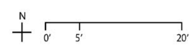


1 Lobby
2 Programed Space
3 Storage
4 Utility
5 Office
6 Kitchen /Dry Storage
7 Restrooms



Scale: 200 People

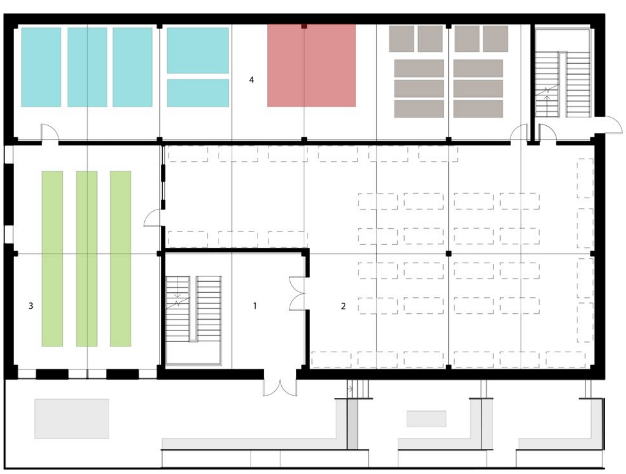
Daily: Library, Educational Space, Museum or Gallery

During Disruption: Shelter

The facility designed for 200 people is programmed for the use of either library, educational, museum or gallery spaces. These programs are incorporated into the smaller scale because of th dispersal opportunities of the programs that require less space and are on smaller sites. There are 10 facilities at the 200 people per facility scale. They are located in the residential and tourist locations where the greatest density of people within the community occurs.

PROGRAM	MINIMUM SQUARE FOOTAGE	DESIGNED SQUARE FOOTAGE
NET BUILDING PROGRAM		
Lobby	200	285
Programed Space	3000 net	4500
Agriculture Growing Space	1000 gross	1000
Office	200 Net	240
NET NECESSARY BUILDING COMPONENTS		
Water Closets Lavatories	3 Male, 3 Female 1 Male, 1 Female	220
Water Fountain	1	1
Showers	3 Male, 3 Female	60
Dry Food Storage	350	350
Water Storage	40,000 gallons	
Services	1500	1750
Kitchen	550 net	560
Means of Egress	400	400

Level One



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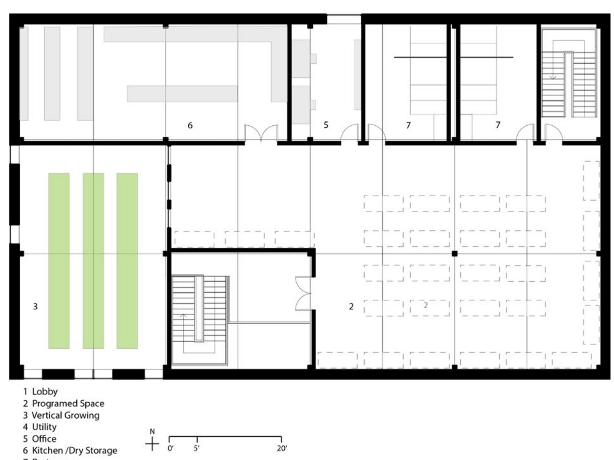
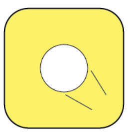


Performance Components

Modularity and Remote Construction

Wind Energy



Daylight Analysis

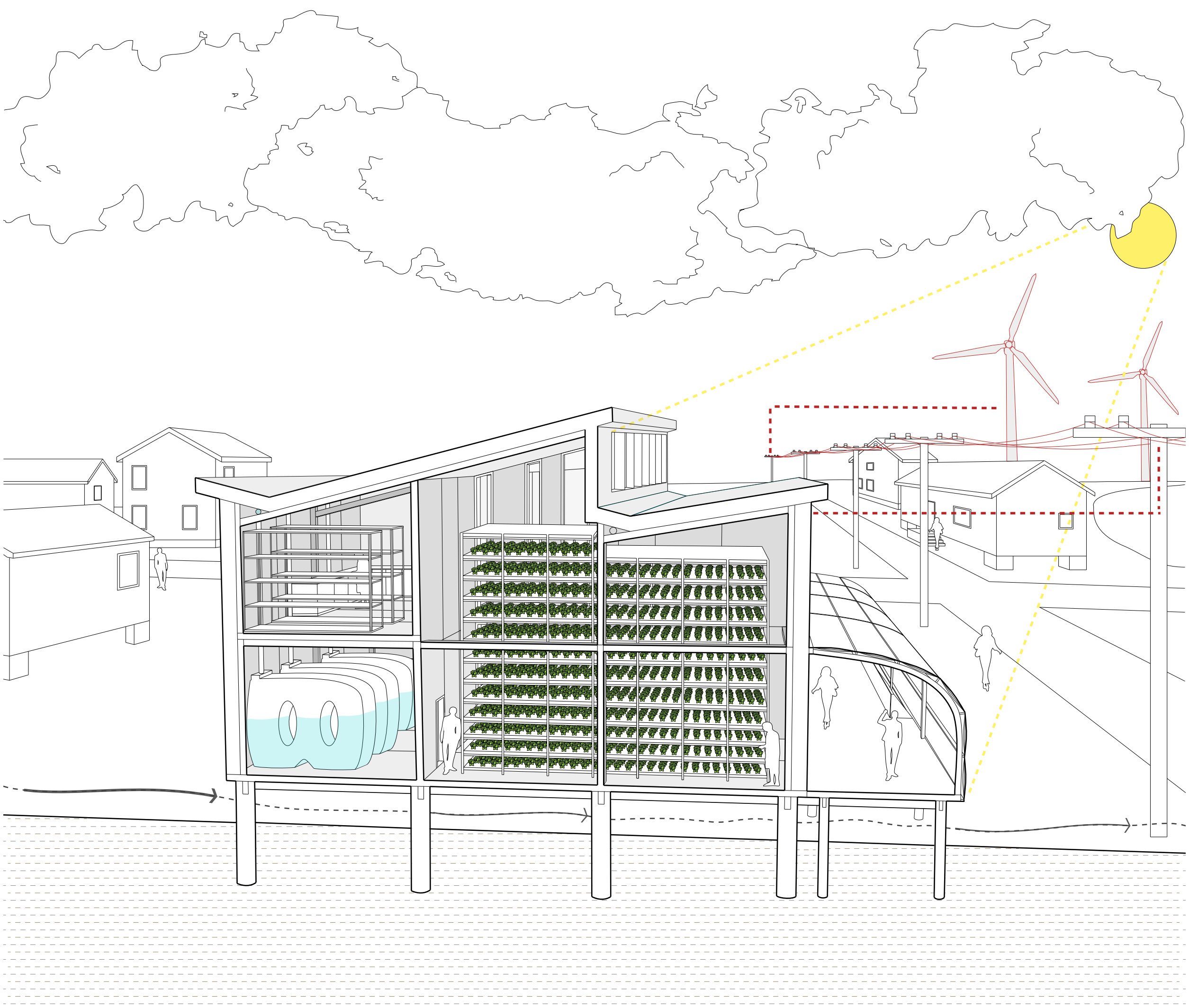
Snow Collection and Water Reuse

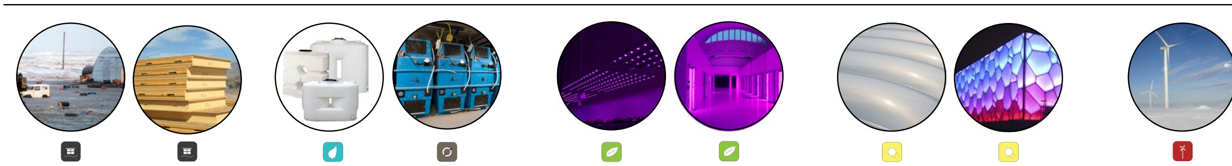
Vertical Indoor Agriculture

Waste and Composting

Section Perspective

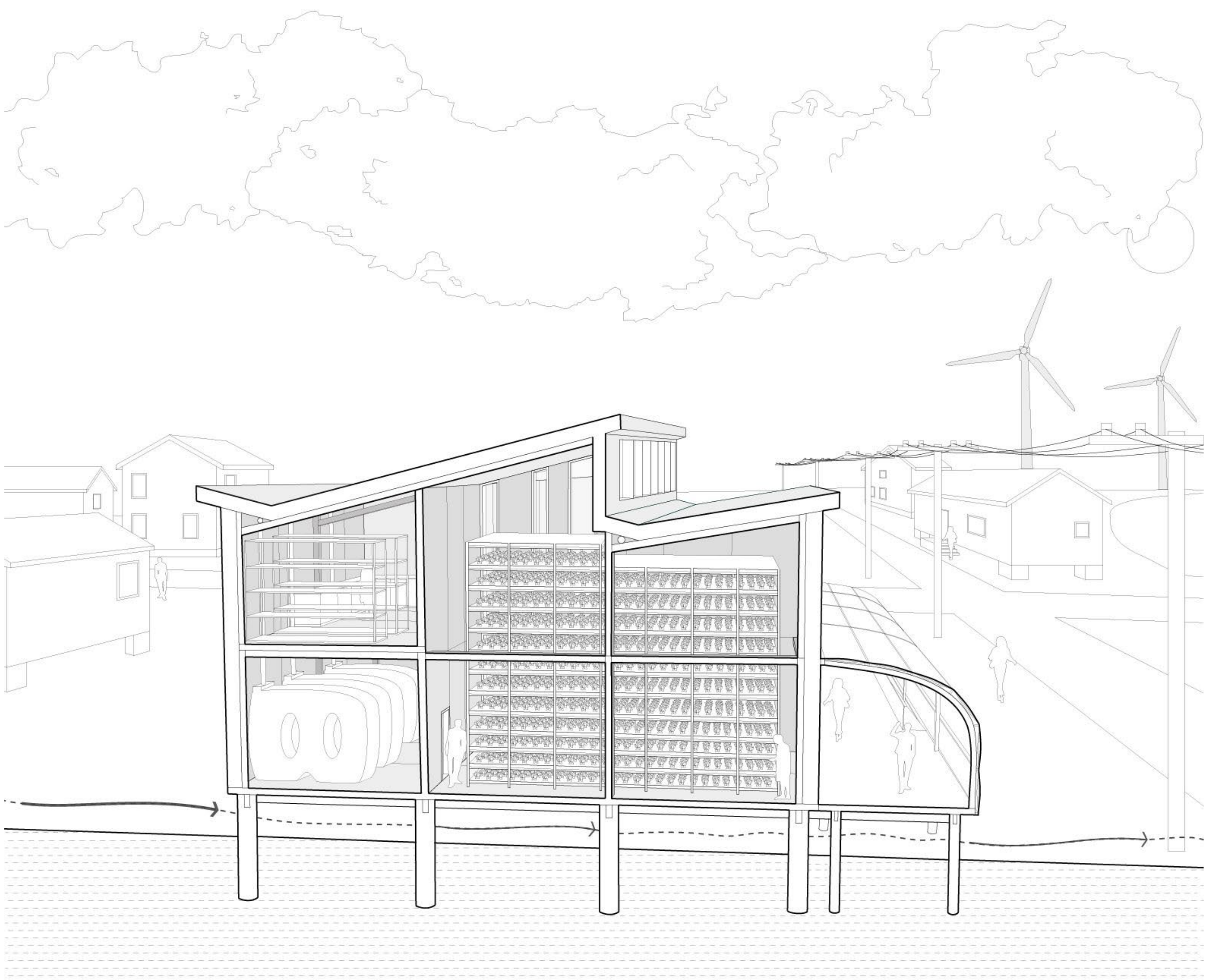
I created a section perspective of the 200 person capacity model as the main representation form. I used the section perspective to demonstrate how the high performance components are integrated into the entire facility. Below the section are images that highlight what each component could look like.



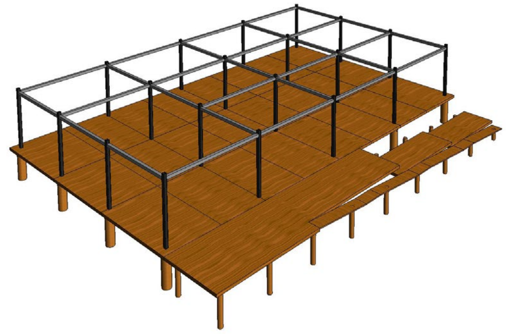


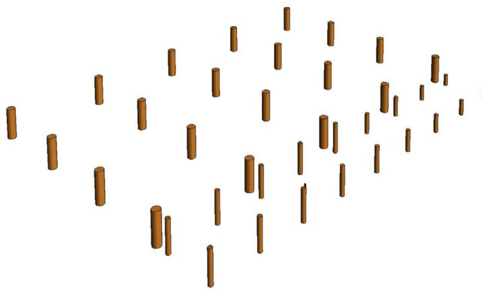
Modularity and Remote Construction

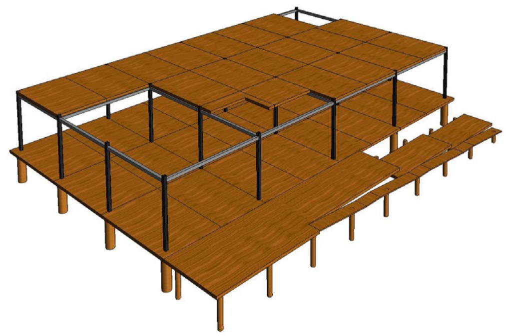
The modularity and remote construction component reflect the timber structural insulation panels that are made off-site and shipped to Barrow via a ship. The panels are 8 feet wide by 15 feet high (second level panels adjusted for height according to location) and are flat to accommodate shipping space. When brought on-site, the panels can easily be assembled and placed in their designed location around an aluminum framing system. The aluminum frame provides the support for attachment of the panels across horizontal and vertical surfaces. The building frame as a whole is designed on top of timber pilings that are 15 feet tall, nine feet into the ground and six feet above ground to accommodate for flooding and sea level rise.

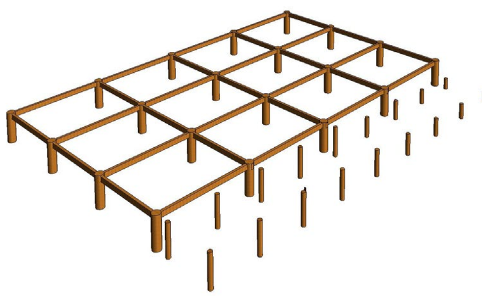


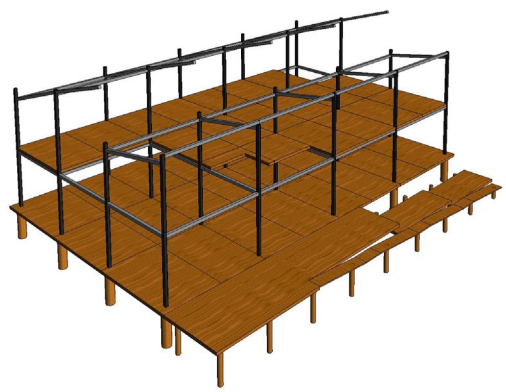
Below are diagrams of the breakdown of the materials used for the construction of the facility. Timber pilings for the footings, timber structural insulated panels for the floors and walls, aluminum framing for the interior column and beam support and ethylene tetrafluoethylane for the transparent polymer sheeting of the porch.

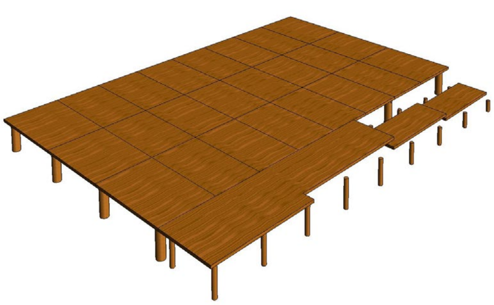


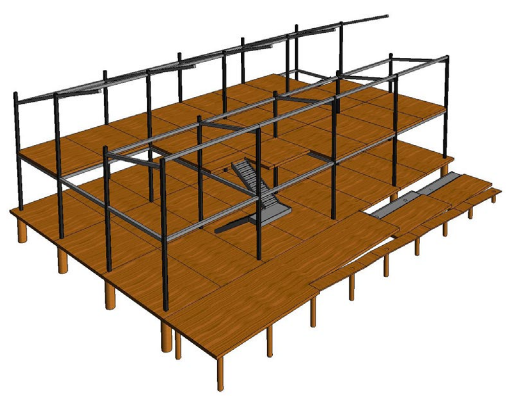


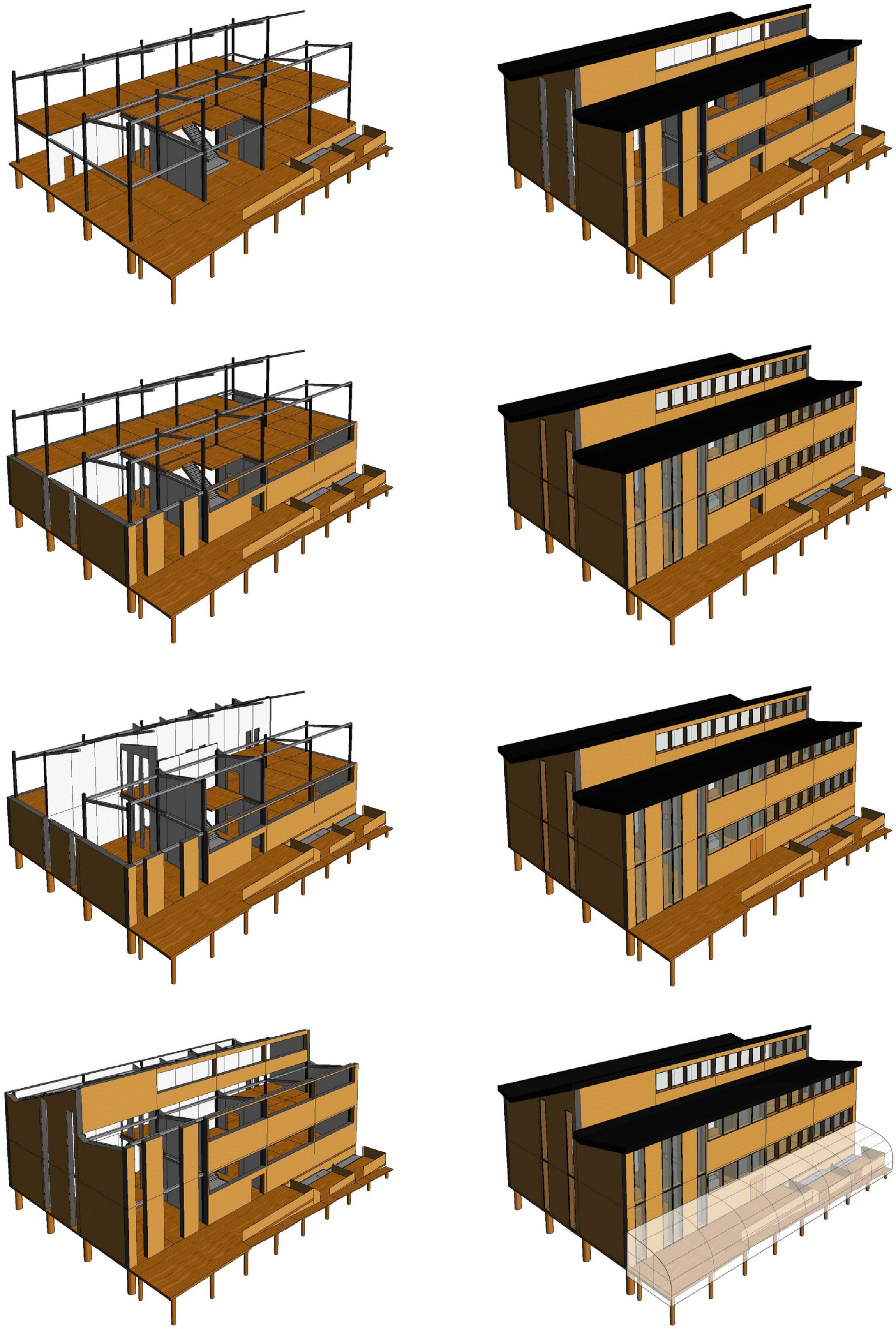






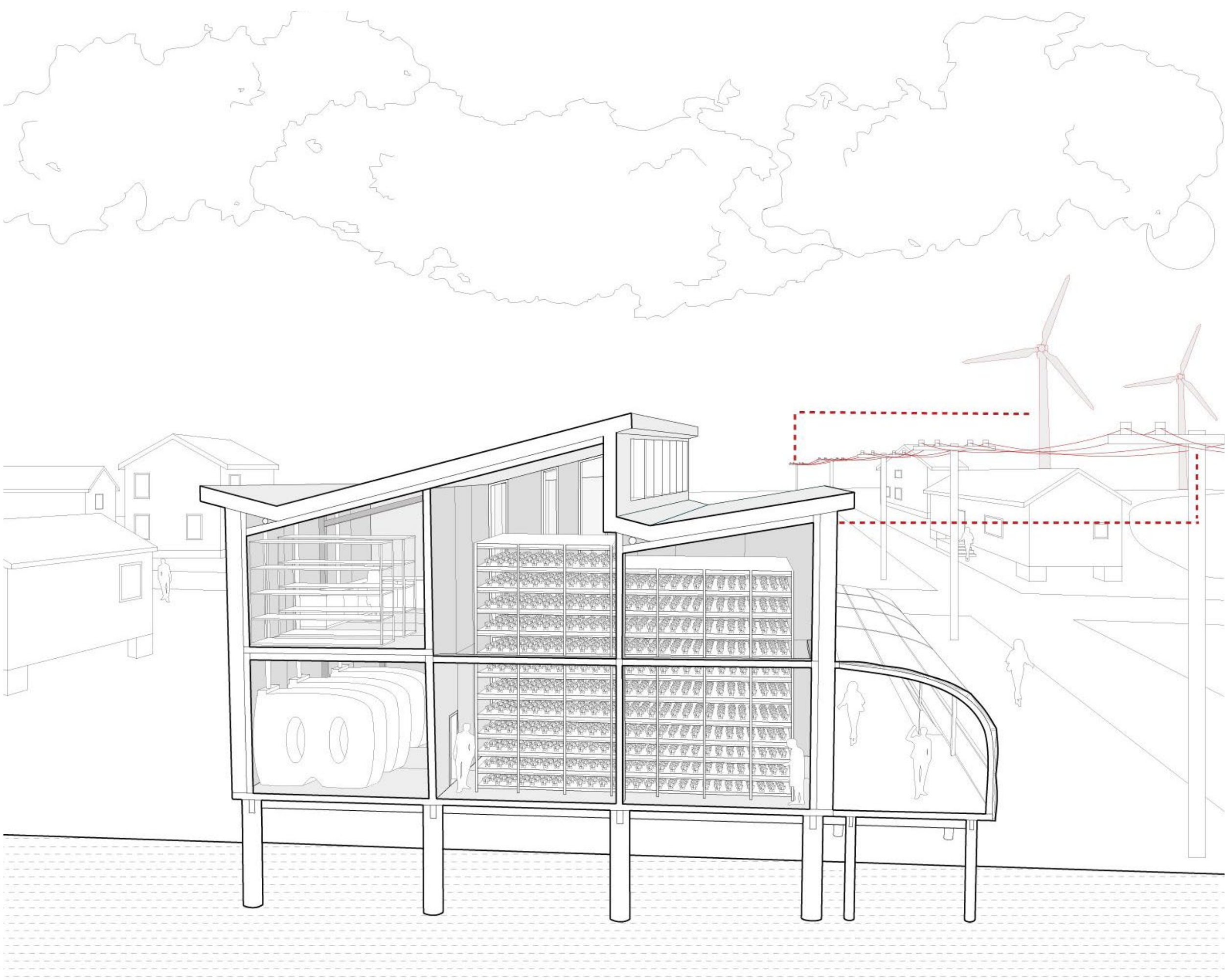






Wind Energy

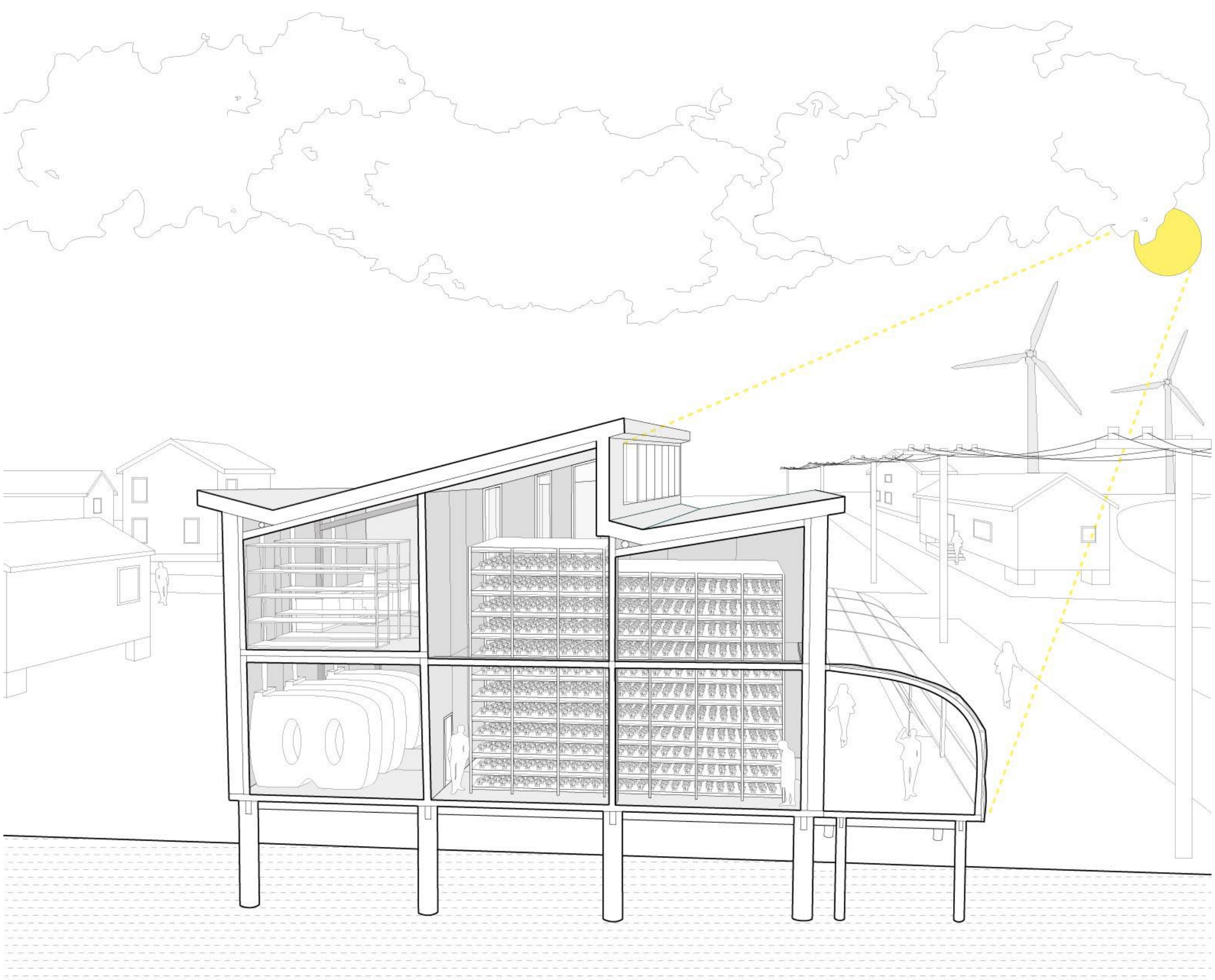
The current energy source in Barrow is natural gas which creates an immense amount of pollution that is released into the environment. Barrow is in a good location for the capture of wind energy. I proposed to provide wind energy for the entire community that can also serve as the energy source for all of the pro-
-gramed facilities. Solar energy was not a valid option for this location due to low temperatures and lack of solar radiation year-round.

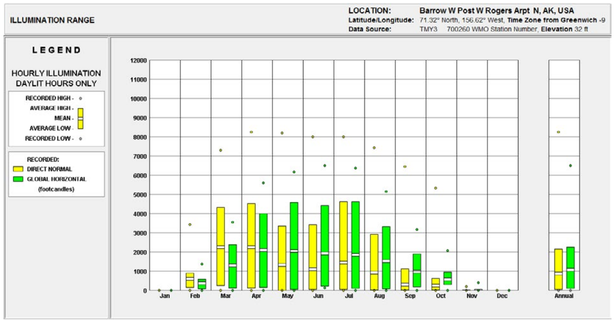


Daylight Analysis

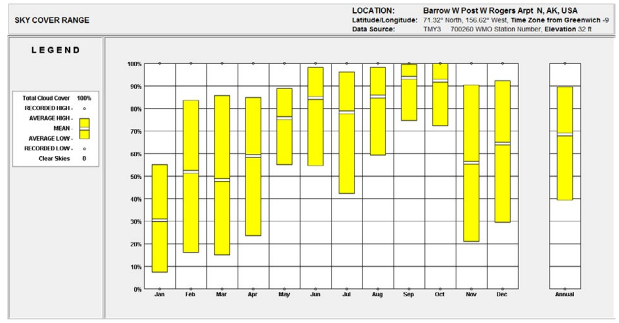
I provided daylight analysis on the design of the proposed facility to determine if adequate light levels were illuminating the interior space. I conducted the research by using Radiance and analyzing the light levels on two overcast days: March 21st at noon and June 21st at noon, the solstice and equinox.

A minimum of 300 lux is required for the illuminance levels of the interior space and the data provided (next page) provides the graphics that show the interior spaces meeting the minimum illuminance standard.

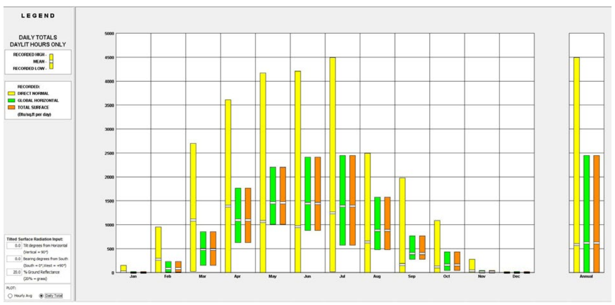




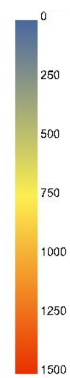
Figures 26 - The illumination range of annual lighting levels.[20]



Figures 28 - The annual sky coverage condition.[20]

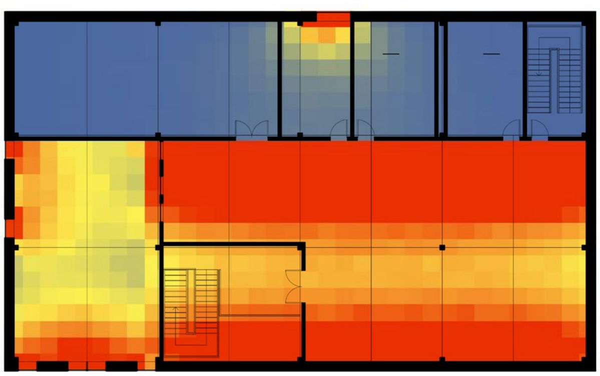


Figures 27 - The annual radiation levels.[20]



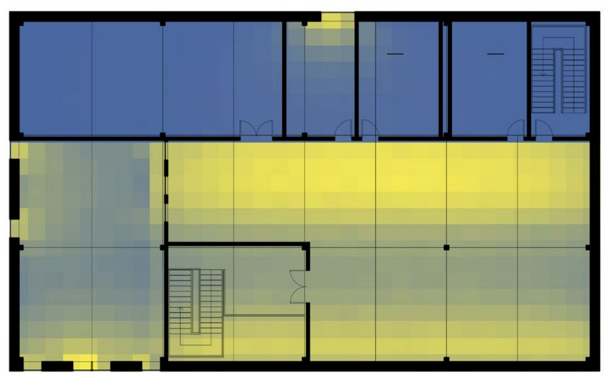
21 June at Noon - Overcast

Level Two

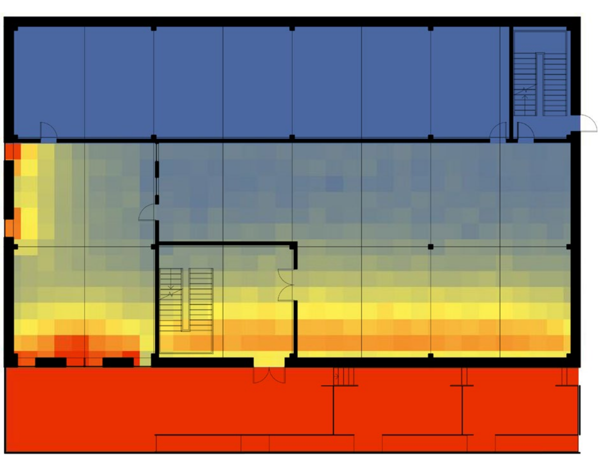


21 March at Noon - Overcast

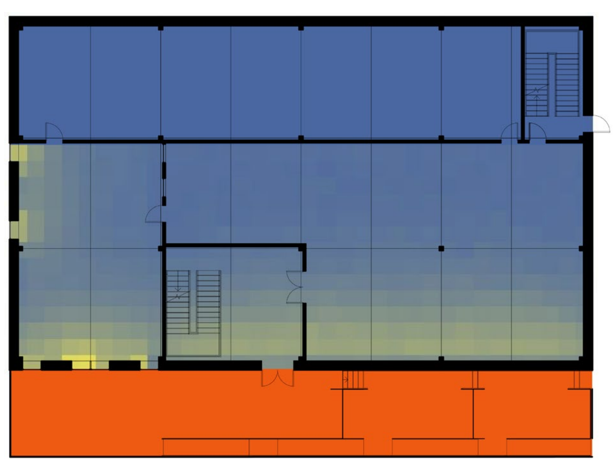
Level Two



Level One

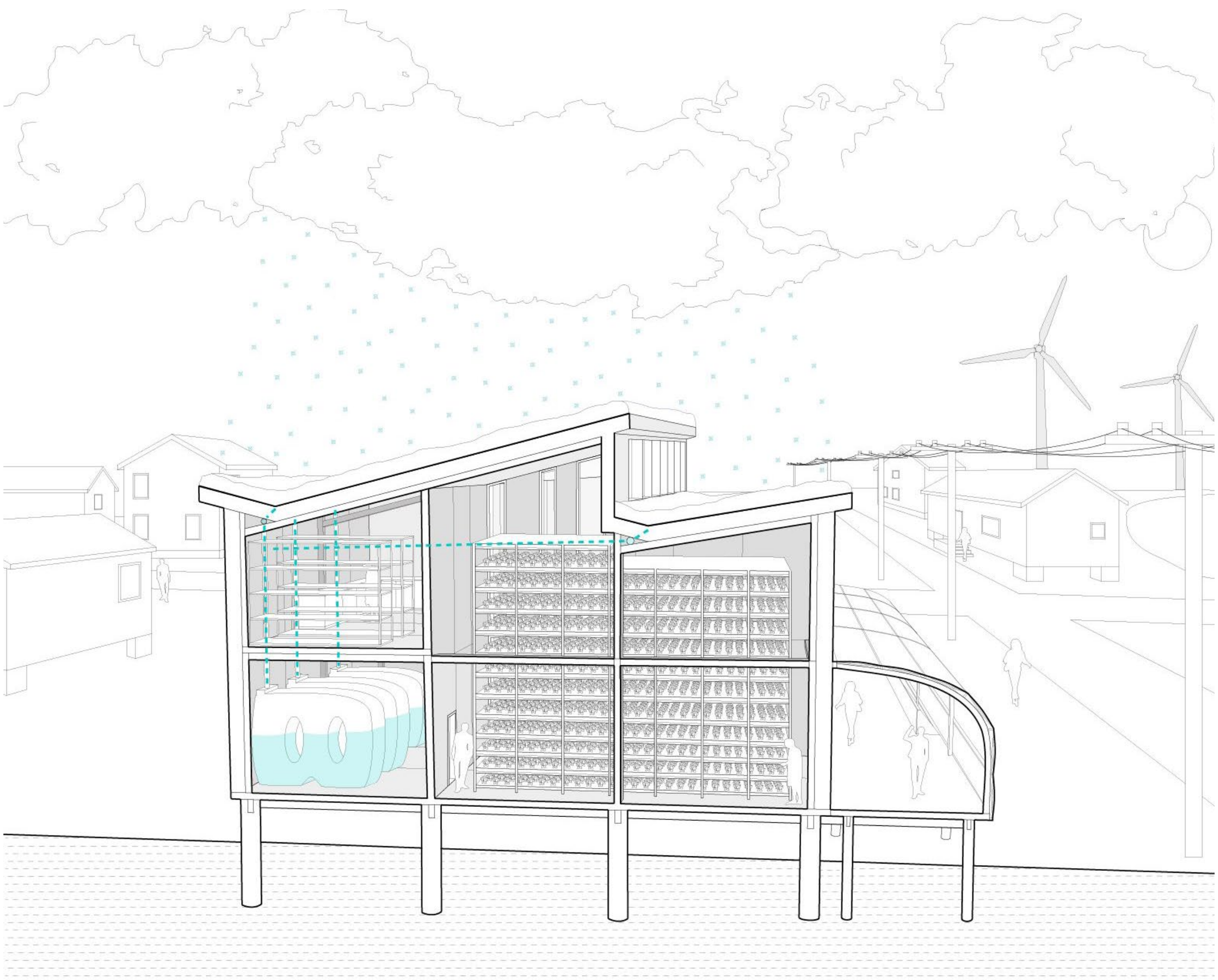


Level One



Snow Collection and Water Reuse

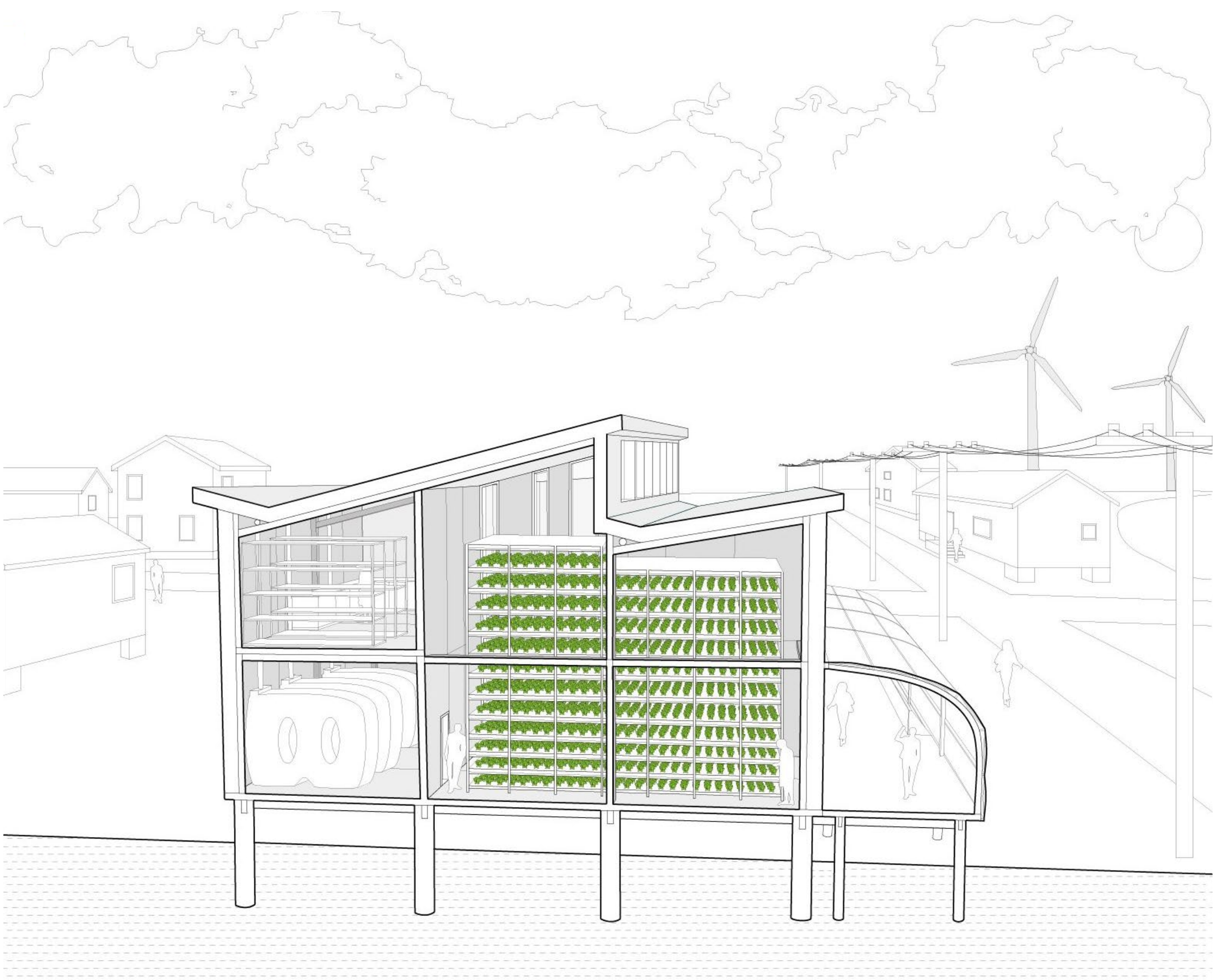
Fresh water supply is crucial for the design of a program that must maintain operation during a moment of disruption. The capture of potable water through the melting of the collected snow on the roof is beneficial and can be collected year-round. The double roofs are slanted in two locations that serve as melting collection points. I proposed the idea of warming and melting the snow at the roof's lowest points and distributing that water to the cisterns on the first floor. A system would clean the grey water and transfer it to a potable water tank that can then be used throughout the building. The grey water would be used in the toilets and as irrigation in the indoor vertical agriculture system.

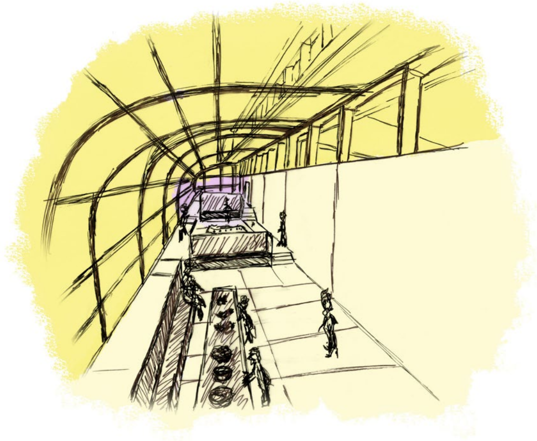


Vertical Indoor Agriculture

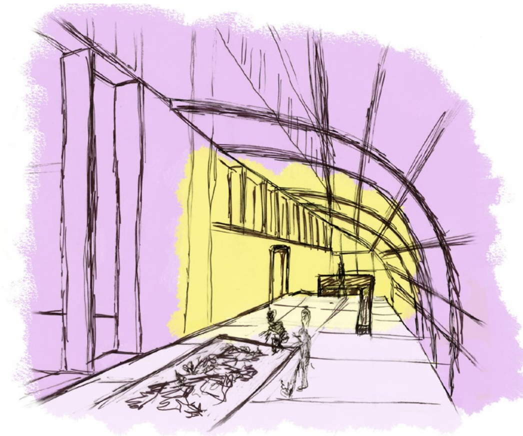
Waste and Composting

I proposed a vertical indoor agriculture system to provide the community with food resources that are difficult to grow and ship to Barrow. Also, the system provides an opportunity for members of the community to learn about plants and agriculture. Waste can be converted to a composting system that provides nutrients and the soil for the indoor vertical growing system.





Figures 29 - A preliminary sketch of the exterior porch that is illuminated by the interior light.



Figures 30 - A preliminary sketch of the exterior porch that is illuminated by the interior light.

Figures 29 - An image of the programmed facilities illuminating Barrow's horizon.

Chapter IV: Conclusions and Recommendations

Researching Barrow and how sea levels change the future of a community for generations to come is a topic that will continue to be researched at a global scale. Barrow has introduced me to a context of literature and research provided from individuals in arctic coastal communities that want other individuals to understand the risk of rising sea levels. My desire for the thesis submission was to educate myself about how architecture and a community can work together to provide solutions to a problem. The outcome of the solutions will not only affect a particular community but society as well. By educating myself on the risks of rising sea levels, I am able to bring that knowledge with me on my next adventure and share my research with the world.

After reviewing the proposal of the research I compiled and design I created, the next phase would be to react in a greater depth to the rising of the seawater. The solution I provided accommodates sea levels that increase and eventually subside. The next step I recommend would be to create a paneling system that could absorb the rising water as a storage system or to provide a system that allows the facility to float. A concept of providing a stationary facility on land during daily activities and can detach and float during a moment of disruption. The flexibility of movement with a wind generator attached tor integrated into the shape of the facility provides a sustainable resource for energy production as a facility becomes detached and floats above the seawater.

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