

ABSTRACT

Title of Thesis: GENERATING SYNERGIES: REIMAGINING
POST-INDUSTRIAL WATERFRONT AS A
SUSTAINABLE LIVE-WORK-PLAY
COMMUNITY

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Planning, and Preservation

The Earth's climate has changed throughout history, but the current rate of change is unprecedented and largely driven by human activities like fossil fuel combustion, deforestation, and industrial processes. These release greenhouse gases, such as carbon dioxide and methane, trap heat from the sun, causing the planet to warm. Power plants, particularly those fueled by fossil fuels like coal, oil, and natural gas, are major contributors to climate change. Their operations emit a significant amount of greenhouse gases, primarily carbon dioxide, and they are responsible for around 27% of global greenhouse gas emissions. Such environmental concerns and the comparably short lifespan of the infrastructure has led to an increasing number of abandoned facilities. In response to these issues, this thesis proposes a radical transformation: repurposing abandoned power plants as an epicenter of clean energy innovation and environmental research. Transformed from symbols of pollution, the structures now serve as catalysts for change, unpacking the narrative shift from degraded wastelands to a seed of a

sustainable future. The key lies not just in technology but in the collective efforts of diverse minds and backgrounds. Through a vibrant co-working space, interconnecting engineers, scientists, and community members, their expertise harmonizes to create synergies, leading to solutions that mitigate the severity of climate change.

GENERATING SYNERGIES: REIMAGINING POST-INDUSTRIAL WATERFRONT AS A
SUSTAINABLE LIVE-WORK-PLAY COMMUNITY

by

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Research Question

How can the presence of abandoned infrastructure pose opportunities to restore the environmental degradation caused by previous non-renewable energy reliance?

Preface

“For we have always understood that when times change, so must we, that fidelity to our founding principles requires new responses to new challenges, that preserving our individual freedoms ultimately requires collective action.”

– President Barack Obama

Dedication

To my parents, whose unwavering support and encouragement fueled my passion for education and ultimately led me to this journey in architecture.

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Introduction

Throughout history, the development of industrial-scale power generation facilities, or power plants, has been inevitably linked to the expanding needs of a burgeoning global population. This dynamic interplay between technological advancements in energy production and socio-economic demands has yielded diverse forms of power plants, evolving from initial coal-fired stations to advanced nuclear reactors. The reliance on fossil fuels, particularly during the Industrial Revolution, had a profound impact on the landscape of power generation. To meet the ever-increasing demand for energy, especially in newly industrialized nations, the number of land-based power plants doubled, primarily utilizing coal and oil combustion technologies. However, this rapid expansion came at a cost, contributing significantly to environmental degradation and climate change due to the inherent emissions associated with fossil fuel use. Electric power generation is the second largest emitter of carbon dioxide pollution, contributing to climate change.¹ Fossil fuel-fired power plants are threatening public health and affecting ecosystems at multiple levels, from the biological communities that make up ecosystems to the services they provide to communities, economies, and people.² In 2022, the U.S. electric power industry

¹ “Human Health & Environmental Impacts of the Electric Power Sector | US EPA,” *United States Environmental Protection Agency (EPA)*, last modified December 18, 2023, <https://www.epa.gov/power-sector/human-health-environmental-impacts-electric-power-sector#:~:text=Electric%20power%20generation%20is%20the,communities%2C%20economies%2C%20and%20people.>

² Ibid.

accounted for about 33% of total U.S. energy-related CO₂ emissions, while the electric power sector accounted for about 31%.³

Most of the power plants serve the urban environments and cities are major contributors to climate change. According to UN Habitat, cities consume 78% of the world's energy and produce more than 60% of greenhouse gas emissions.⁴ High population density in urban environments exacerbates their dependence on fossil fuel-based energy systems, increasing their vulnerability to the impacts of climate change, including heat stress, air pollution, and infrastructure disruptions. Mounting pressure to address climate change, combined with the short lifespan of fossil fuel-based power plants, has resulted in a dramatic increase in the number of abandoned infrastructure in recent years. As the footprint of abandoned power plants expands, so do concerns about public health risks, economic stagnation in affected communities, and the burden these sites place on local authorities. The problem associated with abandoned infrastructure is that the presence of abandoned infrastructure causes significant environmental, social, cultural, and economic impacts on the surrounding community. Collected data from the research indicates that abandonment poses a threat, leading to environmental degradation, reduced business activities and increased health concerns.⁵ Additionally, vacant and abandoned properties are highly

³ “How Much of U.S. Carbon Dioxide Emissions Are Associated with Electricity Generation?,” *Energy Information Administration (EIA)*, last modified November 30, 2023, <https://www.eia.gov/tools/faqs/faq.php?id=77&t=11#:~:text=In%202022%2C%20the%20U.S.%20electric,sector%20accounted%20for%20about%2031%25.&text=Data%20source%3A%20United%20States%20Electricity,7%3A%20Emissions%2C%20November%202023.>

⁴ “Generating Power ,” *United Nations*, last modified 2023, <https://www.un.org/en/climatechange/climate-solutions/cities-pollution>.

⁵ Emmanuel O. Abdul, Kazeem O. Raimi, and Abayomi S. Ibisola, “Effects of Abandoned Urban Infrastructure on Environmental Development in Ogun State,” *Geomatics and Environmental Engineering* 12, no. 3 (2018): 5–15.

associated with elevated crime rates and contribute to a decline in property values of the surrounding area. The study shows a strong correlation between abandoned buildings and increased criminal activity, and 83% of abandoned properties in a neighborhood more likely attract various types of crime.⁶

Addressing the pressing global challenges of climate change and environmental degradation, this thesis looks beyond the benefits of adaptive reuse as a carbon-mitigation and heritage-preserving tool. It proposes a theoretical framework for the adaptive reuse of abandoned power plants as a dynamic epicenter of clean energy innovation and collaborative environmental action. This thesis reveals a comprehensive set of programs serving as a practical prototype for the adaptive transformation of abandoned power plants, an ever-growing concern across the nation. These programs aim to catalyze collective action and knowledge production on multiple fronts, paving the way for a more sustainable future. Transformed from symbols of pollution, the structures now serve as catalysts for change, unpacking the narrative shift from degraded wastelands to a seed of a sustainable future.

⁶ Lauren C. Porter et al., “Understanding the Criminogenic Properties of Vacant Housing: A Mixed Methods Approach,” *Journal of Research in Crime and Delinquency* 56, no. 3 (November 14, 2018): 378–411.

Chapter 1: Power Plant: Energy Generator

The History of Electric Power Generation: Technological and Industrial Transformations

The Dawn of Electric Power: Early innovations in electricity

Throughout the 19th century, European and North American inventors worked to develop electrical lighting. Electric arc lighting was first introduced by British chemist and physicist Sir Humphry Davy in 1808. Arc lighting had the best suitable characteristics for outdoor use or very large indoor spaces. It had an open electric arc leaping between two carbon electrodes, the frequent need to renew the carbon tips, and brilliant and glaring light.⁷ Although arc lighting gained commercial success on both sides of the Atlantic Ocean by the 1870s, incandescent electric lighting was recognized as indispensable for homes and most other indoor applications early in the 1800s. In 1870, The first development of an electrical generator (dynamo) to produce enough power for a commercial scale industry was invented by a Belgian inventor, Zenobe Gramme. A dynamo refers to “a device for maintaining constant voltage, lamp technology, and other individual components needed to provide incandescent electric light.”⁸ A dynamo that Zenobe Gramme invented was able to produce a constant direct-current (DC) source which was optimally suited for powering motors.

⁷ Carl Sulzberger, “Thomas Edison’s 1882 Pearl Street Generating Station,” *IEEE Global History Network* (2010), 1.

⁸ Ibid.

This invention led to the stage of using arc lighting which had become the predominant form of public lighting in many cities around the world by 1877. However, its excessive brightness rendered it unsuitable for indoor use. Then, the most reliable dynamo design was developed by Charles F. Brush, and it promised large-scale electricity distribution. By the time of 1879, Thomas Edison invented a less powerful incandescent lamp, and in September 1882, he established the first commercial central power station in the world at Pearl Street in lower Manhattan.⁹ The power station that Edison introduced at Pearl Street opened the era of DC electric service. The Pearl Street power station utilized the 27-ton “Jumbo” constant-voltage dynamo that Edison and his team developed.¹⁰ Six dynamos had been installed to supply enough power within Pearl Street’s service area, and each dynamo had a capacity of about 100kW and could supply about 1,200 lamps.¹¹ The six dynamos were energized by Armington & Sims through reciprocating steam engines, which were fueled by four coal-fired boilers. Edison’s first power station, which was capable of supplying the energy needs of the Pearl Street area, demonstrated feasibility and potential of comprehensive electrification, and the station itself represented a successful prototype for the central-station electric utility system.

Edison’s direct current (DC) system did not last long due to the development of alternating current (AC) systems in the mid-1880s. The invention of the AC

⁹ “History of Power: The Evolution of the Electric Generation Industry,” *POWER Magazine* (POWER Magazine, October 2022), last modified October 2022, accessed November 16, 2023, <https://www.powermag.com/history-of-power-the-evolution-of-the-electric-generation-industry/>.

¹⁰ Carl, “Thomas Edison’s 1882 Pearl Street Generating Station,” 2.

¹¹ Ibid.

transformer addressed the major disadvantage of low-voltage DC systems.

Technology implemented in the AC system made it possible to transmit electric power at high voltage over long distances, which was more cost-effective and efficient at that time. People started to prefer more of the AC system, and by the end of the 19th century, the use of DC systems eventually began to decline gradually and inevitably. Then, in 1884, Sir Charles Parsons constructed the first turbine generator and two years later, he enhanced its efficiency by introducing the first condensing turbine, which drove an AC generator. Toward the end of the 1800s, a different turbine was introduced to the General Electric Corporation (GE) by American inventor, Charles Curtis. By 1901, GE had made significant steps in the development of turbine generator technology, introducing a 500-kW Curtis turbine generator that utilized high-pressure steam to drive the rapid rotation of a shaft-mounted disk.¹² Two years later, the Curtis turbine generator was able to deliver the world's first 5-MW steam turbine to the Commonwealth Edison Corporation of Chicago. The range of development in coal-fired power units had been developed to generate outputs in the 1MW to 10MW by the early 1900s. Throughout the historical trajectory of power unit development, various electricity generation methods have emerged, including steam turbines, gas turbines, and nuclear power plants. These diverse technological approaches have contributed to shaping the modern power generation landscape, and as the system has evolved over time, distinct advantages and challenges in meeting the world's growing energy demands have been indicated in our society.

¹² "History of Power: The Evolution of the Electric Generation Industry."

The Development of Steam Turbine: Water-based Cycle

The improvement and development of the coal-fired power plant cycle kept growing rapidly along with the establishment of the turbines with steam extractions for feedwater heating and steam generators equipped with air preheaters, which increased net efficiency to about 15%.¹³ By introducing pulverized coal steam generators at the Oneida Street Station in Wisconsin, it allowed bigger boilers in 1919. In 1927, Benson boiler was introduced, and such boiler applications helped to reheat steam and improve large-scale steam generation in power plants. This led to the point that reheating steam turbines became the industry standard in the 1930s. A pioneering milestone was achieved in 1972 when the world's first integrated coal gasification combined cycle power plant initiated its operations. Then, there was a turning point for the industry when environmental concerns gained prominence, leading to the Clean Air Act in the 1970s. Response to the regulation, the industry began to invest in technology to mitigate sulfur dioxide emissions, and in 1979, the innovative commercial fluidized bed combustion plant was successfully completed at Georgetown University in Washington D.C. During the early 1980s, emissions control technologies continued to advance, leading to the completion of the first large-scale coal-fired power unit equipped with carbon capture and storage (CCS) technology in 2014 at Boundary Dam in Saskatchewan, Canada.¹⁴ Steam turbines have undergone continuous evolution by building up to the development of increasingly advanced and larger-scale technological systems that are capable of

¹³ Ibid.

¹⁴ Ibid.

providing society with an abundance of reliable and efficient energy, which was effectively supporting economic growth.

The Development of Gas Turbine: Compressed Air and Fuel

English inventor John Barber first suggested the foundation for the gas turbine concept in 1791, however, it wasn't until much later that these principles were successfully translated into practical applications. In 1903, the first gas turbine, producing more power, was developed by Norwegian engineer, Jens William Aegidius Elling. He also played a major role in the evolution of the gas turbine system that incorporates a separate turbine unit and compressor in a series configuration, and his design is still widely used today. Then, the first gas turbine for electric power generation was installed by Brown Boveri Corporation in Neuchatel, Switzerland in 1939, and 10 years later, a gas turbine-electric locomotive was further developed. GE implemented the first gas turbine into practical use for power generation at the Belle Isle Station, owned by Oklahoma Gas & Electric in July 1949. Furthermore, to revolutionize energy production and enhance efficiency and output, the synergistic combination of steam turbines and gas turbines in combined cycle power plants was invented in 1968. It was the integration of the first combined cycle gas turbine (CCGT) with a heat recovery steam generator (HRSG).¹⁵ Over time, several other innovative developments had been introduced in various forms to handle large heavy-duty energy production. The invention of the gas turbine system reached the point where they have enough capability to offer highly flexible and

¹⁵ Ibid.

efficient power through combustion of multiple fuels, including high volumes of hydrogen.

The Development of Nuclear Power Plant

Despite a comprehensive understanding of the atom's fundamental structure, scientists faced the challenge of harnessing the immense energy potential contained within these microscopic entities. Furthermore, most of the atomic research had been done to develop weapons technology due to World War II. It was not until after the war that the U.S. government started to focus on developing nuclear energy for peaceful civilian purposes. Then, they paid attention to inventing a self-sustaining chain reaction. In 1942, a group of scientists, led by the Italian physicist Enrico Fermi, constructed the world's first nuclear reactor at the University of Chicago, called Chicago Pile-1. In 1951, Experimental Breeder Reactor I, the first reactor producing electricity from nuclear energy, was introduced in Idaho. A few years later, the first commercial U.S. nuclear power plant, Shipping port Atomic Power Station was successfully integrated into the Pennsylvania power grid on December 18, 1957.¹⁶ The station provided a light-water reactor with a 60-MW capacity, and this momentous development marked the inauguration of a new era in nuclear energy production while paving the way for advancements and innovations that transformed the global energy industry. The industry grew rapidly during the 1960s and 1970s when other countries including the UK, Germany, Japan, and France were getting on board with developing nuclear power plants. There was the steady development of

¹⁶ Ibid.

nuclear plants especially in the U.S, during the 1960s. Less than ten reactors were installed before 1966, however, the number of reactors quadrupled in 1966-67 when GE and Westinghouse Electric Corporation competed with each other for turn-key contracts.¹⁷ The growth of nuclear power plants peaked in 1973-73, and by that time, the U.S. ordered 41 new units of nuclear construction projects in 1973 alone.

However, the momentum of the nuclear plants industry was soon impeded by a consequence of financial challenges, safety incidents, and environmental and health concerns, caused by the presence of nuclear power plants. In 1970, to prevent the harmful impact of nuclear plants, the Environmental Protection Agency (EPA) created regulations that made nuclear plants more expensive to build. Consequently, approximately half of all planned nuclear power plant projects in the U.S. were canceled, which led to a substantial decline in the reliance on nuclear energy. Despite the aforementioned challenges, nuclear energy still remains a significant contributor to the electricity supply of various countries, including the U.S. However, the presence of numerous decommissioned nuclear power plants across the U.S. raises concerns regarding their management and potential environmental impact.

The Downfall of the Power Plant

Environmental Concerns and Regulations

The environmental toll of coal-fired and nuclear power plants, primarily resulting from their operation processes, has been a major driving force behind the

¹⁷ James Chater, "A History of Nuclear Power," *Focus on Nuclear Power Generation* (2005), 31.

decline in their demand. When fuels are burned for electricity generation, massive amounts of certain gases are inevitably released to the air which produce emissions. The Energy Information Administration (EIA) published emission factors for energy-related carbon dioxide (CO₂) emissions as well as for sulfur dioxide (SO₂) and nitrogen oxides (NO_x) emissions related to U.S. electricity generation. SO₂ and NO_x are criteria pollutants regulated by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act and subsequent amendments.¹⁸ To measure how much carbon dioxide emission is produced from electricity generation, EIA collected annual data about total annual U.S. electricity net generation by utility-scale electric power plants of about 4.23 trillion kilowatt-hours (kWh) from all energy sources, and it resulted in the emission of about 1.65 billion metric tons (1.82 billion short tons) of carbon dioxide (CO₂).¹⁹ Furthermore, in 2022, utility-scale electric power plants that burned coal, natural gas and petroleum fuels were the source of about 60% of total annual U.S. utility-scale electricity net generation, but they accounted for 99% of U.S. carbon dioxide emissions associated with electric power generation.²⁰ Due to the critical amount of emission released from power plants, the Clean Air Act of 1970 was signed into law by Richard Nixon to regulate the coal combustion process for electricity generation.²¹ The Clean Air Act has posed significant operational

¹⁸ “What Are the Greenhouse Gas and Air Pollutant Emissions Factors for Fuels and Electricity?,” *U.S. Energy Information Administration (EIA)*, last modified August 2, 2023, accessed November 16, 2023, <https://www.eia.gov/tools/faqs/faq.php?id=76&t=11>.

¹⁹ “How Much Carbon Dioxide Is Produced per Kilowatthour of U.S. Electricity Generation?,” *U.S. Energy Information Administration (EIA)*, last modified November 7, 2023, accessed November 16, 2023, <https://www.eia.gov/tools/faqs/faq.php?id=74&t=11>.

²⁰ *Ibid.*

²¹ Charles D. Kolstad, “What Is Killing the US Coal Industry?,” *Stanford Institute for Economic Policy Research (SIEPR)* (March 2017).

challenges for the coal-fired and nuclear power plant industry. The law enacted stringent regulations on sulfur dioxide emissions emanating from newly constructed coal-fired power plants. The prospect of stricter greenhouse gas (GHG) mitigation policies in the future could also pose a substantial downside risk for the U.S. coal-fired generators.

In addition to adhering to stringent environmental regulations to minimize pollution, nuclear power plants have also attracted considerable scrutiny due to their potential adverse effects on human health. The major reason for the decline of nuclear power plants began with the Fukushima Daiichi nuclear accident in 2011. In the aftermath of the Fukushima accident, Japan initiated the closure of 48 nuclear reactors, and Germany followed suit by decommissioning 11 of its 17 operational reactors. Several other European countries including Belgium, Spain and Switzerland are also shutting down their nuclear programs. The United States maintained its status as the world's largest producer of nuclear electricity, operating a network of 94 reactors across 28 states until the late 1970s. However, public support for nuclear energy began to wane following the Three Mile Island accident in 1979, when a reactor partial meltdown occurred near Middletown, Pennsylvania.²² Subsequent to the Three Mile Island incident, concerns regarding the potential adverse effects of nuclear power plants on human health have prompted the decommissioning of numerous nuclear power plants in the United States. As of June 2023, there were 209

²² Lois Parshley, "The Controversial Future of Nuclear Power in the U.S.," *Environment* (National Geographic, May 4, 2021), last modified May 4, 2021, accessed November 16, 2023, <https://www.nationalgeographic.com/environment/article/nuclear-plants-are-closing-in-the-us-should-we-build-more?loggedin=true&rnd=1700021338253>.

nuclear reactors permanently shut down worldwide. The United States recorded the largest number of shutdowns with 41 units.²³

Financial Challenges and Retirement

The Clean Air Act not only resulted in significant operational challenges for the industry due to strict environmental regulations, but it also exacerbated financial difficulties for many power plants, ultimately leading to the closure of several facilities. Recent federal policy changes, such as lifting the coal-leasing moratorium, ending the royalty rate review, and expanding tax credits for carbon capture and sequestration (CCS), have undermined coal's competitiveness in the domestic electricity market.²⁴ As a result, the maintenance of the facilities became challenging, and the availability of more affordable power sources made it more expensive to operate the facilities. The cheaper price of natural gas is available in the market which led to displacement of coal in existing power systems. Moreover, renewable energy, generated from solar and wind have made substantial remarks in the electricity generation sector, which also causes a renewed competitive threat to coal-fired power plants.²⁵ The combined impact of aging infrastructure, rising operational costs, low demand growth, and the increasing competitiveness of renewable energy sources has contributed to the operation of the power plants becoming increasingly

²³ "Global Nuclear Reactors Permanent Shutdowns 2023, by Country," *Statista* (Statista, June 9, 2023), last modified June 9, 2023, accessed November 16, 2023, <https://www.statista.com/statistics/513639/number-of-permanent-nuclear-reactor-shutdowns-worldwide/#:~:text=As%20of%20June%202023%2C%20there,of%20shutdowns%2C%20with%2041%20units.>

²⁴ Howard Gruenspecht, "The U.S. Coal Sector," *The Brookings Institution* (January 2019).

²⁵ Charles D, "What Is Killing the US Coal Industry?" 6.

challenging that is leading to early retirement and delay the viability of new or planned facilities, ultimately playing a significant role in the downfall of the coal industry.

As the construction of new power plants dwindles, the retirement of aging power plants becomes increasingly prevalent in the United States. With most coal-fired power plants built in the 1970s and 1980s, approaching the average lifespan of 40-50 years, these aging facilities are reaching the end of their operational life and being decommissioned. The oldest four of the plant's seven coal-fired units were retired in 2020, and the last three units are expected to shut down in 2023. The largest coal-fired power plant, Sammis Power Plant in Ohio, is also expected to retire in 2023.²⁶ The anticipated retirement of a significant number of aging power plants necessitates careful consideration of strategies for managing their abandoned infrastructure.

What is it today: Abandoned Infrastructure

Today, abandoned power plants are a common sight in many parts of the world. The problem is that the presence of abandoned infrastructure causes significant environmental, social, cultural, and economic impacts on the surrounding community. Collected data from the research indicates that abandonment poses a

²⁶ "Coal and Natural Gas Plants Will Account for 98% of U.S. Capacity Retirements in 2023," *U.S. Energy Information Administration (EIA)*, last modified February 7, 2023, accessed November 16, 2023, <https://www.eia.gov/todayinenergy/detail.php?id=55439#:~:text=As%20these%20aging%20coal%2Dfired,power%20plants%20are%20being%20retired.>

threat, leading to environmental degradation, reduced business activities, and increased health concerns.²⁷ Furthermore, vacant and abandoned properties are highly associated with elevated crime rates, and contribute to a decline in property values of the surrounding area. The study reveals a strong correlation between abandoned buildings and increased criminal activity, and 83 percent of abandoned properties in a neighborhood more likely attract various types of crime, such as prostitution and drug dealing.²⁸ Vacant properties provide an opportune environment for the concealment of drug use and the clandestine gathering of individuals engaged in criminal activities.

The abandoned property also leads to a decrease in property value in the neighborhood. In a 2001 study, researchers from Philadelphia found that residential properties within a 150-foot radius of a vacant or abandoned property exhibited a net depreciation in value of \$7,627, and properties within 150 to 300 foot radius experienced a decline in value of \$6,819 while those located within 300 to 450-foot radius encountered a loss of \$3,542.²⁹ Moreover, the maintenance or demolition, especially large-scale infrastructure places a financial burden on municipalities. Addressing such challenges is essential for fostering and cultivating a sustainable urban environment and enhancing community well-being while taking into

²⁷ Emmanuel O. Abdul, Kazeem O. Raimi, and Abayomi S. Ibisola, “Effects of Abandoned Urban Infrastructure on Environmental Development in Ogun State,” *Geomatics and Environmental Engineering* 12, no. 3 (2018): 5–15.

²⁸ Lauren C. Porter et al., “Understanding the Criminogenic Properties of Vacant Housing: A Mixed Methods Approach,” *Journal of Research in Crime and Delinquency* 56, no. 3 (November 14, 2018): 378–411.

²⁹ National Vacant Properties Campaign, “Vacant Properties: The True Costs to Communities,” *National Vacant Properties Campaign* (August 2005), 9

consideration the use of substantial land area occupied by decommissioned power plants. Therefore, the compelling need to repurpose abandoned infrastructures into vibrant community spaces necessitates the development and implementation of comprehensive strategies. Such a transformation would effectively alleviate the detrimental impacts of these derelict structures and cultivate safe, thriving neighborhoods.

Chapter 2: Adaptive Reuse

What is Adaptive Reuse?

Adaptive reuse is “the repurposing of buildings that have outlived their original purpose. Its main goals include preserving architectural and cultural heritage, transforming urban light, and igniting social change.”³⁰ Throughout history, the concept of adaptive reuse has been used since the Roman Empire when structures like the Colosseum were transformed into housing, workshops, and fortresses.³¹ The strategy of adaptive reuse in the past only focused on repurposing existing buildings into new programs to accommodate the changing needs of society. However, historical preservation and environmental sustainability has become a more prominent consideration alongside function change in terms of the contemporary framework of adaptive reuse.

History of Adaptive Reuse

In the beginning of the 20th century, new developments on architecture and urban planning that came out across Western countries reflected the promise of industrial production and cheap energy, and this new era of urban development

³⁰ Sarah Jones, “How Adaptive Reuse Gives Defunct Buildings New Leases on Life,” *Design & Make with Autodesk*, last modified February 18, 2022, accessed November 17, 2023, <https://www.autodesk.com/design-make/articles/adaptive-reuse>.

³¹ Andrea Neculae, “The Adaptive Reuse Movement: From History to Home,” *RentCafe Rental Blog*, last modified October 10, 2023, accessed November 17, 2023, <https://www.rentcafe.com/blog/apartmentliving/the-adaptive-reuse-movement-from-history-to-home/#:~:text=Throughout%20history%2C%20communities%20have%20adapted,architectural%20heritage%20of%20a%20building.>

embraced a *tabula rasa* approach, favoring the construction of new buildings over the reuse of existing buildings.³² Many urban industrial sites demolished unused infrastructures without taking into consideration adapting the existing structure in the process of deindustrialization. By that time, the concerns about preservation of industrial heritage had gained significant attention. A wave of public disagreement against the ‘clean sweep’ planning approach had increased, which also led to the environmental movements. David Lloyd and Matthew Dalbey of the U.S. Environmental Protection Agency (EPA) once mentioned that “the first approach to the environmental recovery of industrial sites dating back to the mid-1970s was dominated by an emergency, large-scale, top-down approach that had as its first, and often only, goal the elimination of an environmental hazard, often under huge pressure from public opinion.”³³ In recognition of these interconnected challenges, the EPA started to expand their scope of research on incorporating clean-up and redevelopment processes with preservation and community involvement in the late 1990s. The perception of industrial areas has radically shifted from a view of risk to potential opportunity, and adaptive reuse appeared as a practical approach rather than a theoretical framework.

³² Francesca Lanz and John Pendlebury, “Adaptive Reuse: A Critical Review,” *The Journal of Architecture* (September 20, 2022): 441–462.

³³ Matteo Robiglio, “THE ADAPTIVE REUSE TOOLKIT: How Cities Can Turn Their Industrial Legacy into Infrastructure for Innovation and Growth,” *The German Marshall Fund of the United States* (2016), 3.

First Adaptive Reuse Case Study: SoHo Urban Renewal Project

The first implementation of the bottom-up process in adaptive reuse was Soho's revitalization, led by Chester Rapkin, New York City planning commissioner from 1969 to 1977.³⁴ In the early 1960s, South Houston in New York City was heavily involved in industrialization. The area was characterized by a cluster of small factories and warehouses, mostly occupied by Puerto Ricans and African Americans. The dominant industrial character of the neighborhood contributed to a sense of abandonment and quietude during nighttime and on weekends. The area was referred to as "Hell's Hundred Acres" due to its frequent accidental fires, which reflected an image as a decaying industrial remnant characterized by unappealing buildings. However, by the mid-1970s, South Houston had changed to SoHo, and the demographic composition and socioeconomic conditions of these neighborhoods have experienced significant transformation since their zoning as manufacturing districts, accompanied by the implementation of unique zoning regulations as a part of revitalization plan.³⁵ This remarkable change attracted young professionals who are interested in the loft lifestyle and diverse artistic community, establishing the area as one of the world's art centers. Today, SoHo has transformed into a vibrant tourist destination and a prominent shopping hub, leading to a perpetually crowded urban environment even during nighttime and on weekends. Despite its transformation, SoHo stands as a successful precedent of historic preservation, demonstrating its

³⁴ Ibid.

³⁵ "SoHo/NoHo Neighborhood Plan: Overview - DCP," *NYC Planning*, last modified December 15, 2021, accessed November 17, 2023, <https://www.nyc.gov/site/planning/plans/soho-noho/soho-noho-overview.page#:~:text=The%20SoHo%2FNoHo%20Neighborhood%20Plan%20seeks%20to%20establish%20a%20new,by%20local%20and%20citywide%20stakeholders.>

ability to conserve significant historic landscapes and preserve their cultural landscape for the city and beyond.³⁶ The majority of buildings in SoHo retain their original cast-iron architecture, seamlessly adapted to mixed-use programs with commercial strips at street level and residential or office spaces above, which fosters SoHo's distinctive identity.

Benefits of Adaptive Reuse

Environmental Impacts

Adaptive reuse can be used as a powerful instrument for restorative justice, not only by addressing environmental concerns but also by fostering opportunities to revive a city's heritage and identity through the promotion of local culture. Reuse is often better than demolition and reconstruction by reducing embodied carbon since “the greenest building is the one that is already built” as claimed in a 2005 National Trust for Historic Preservation campaign.³⁷ The process of demolishing and reconstructing new buildings requires more time and resources, which also contributes to more building carbon footprint. According to the data, building construction emissions, related to the manufacturing of building materials, amounted to a further 11 GtCO₂ in 2018, for a total of 39% of global energy-related

³⁶ Susie Ranney, “SoHo: Beyond Boutiques and Cast Iron the Significance, Legacy, and Preservation of the Pioneering Artist Community’s Cultural Heritage,” *Columbia University* (2012).

³⁷ Robiglio, “THE ADAPTIVE REUSE TOOLKIT: How Cities Can Turn Their Industrial Legacy into Infrastructure for Innovation and Growth,” 5.

emissions.³⁸ Furthermore, the process of the demolition and re-building has been estimated to cause 40,000 tons of CO₂ emissions.³⁹ Based on the analysis of the carbon emissions throughout the entire life cycle of buildings, the proportion of carbon emissions during the production and transportation stages of building materials is 22.89%, 0.91% during the construction stage, 76.07% during the operational stage, and 0.31% during the demolition stage.⁴⁰ Adaptive reuse can achieve substantial reductions in embodied carbon emissions, reaching up to 23.93% compared to new construction, by avoiding the transportation, construction, and demolition stages. Additionally, reuse aligns with sustainability principles by mitigating waste production and conserving natural resources. Adaptive reuse presents itself as a compelling solution for reducing the construction industry's carbon footprint, and paving the way for improvement on green buildings through a transformative approach to construction that minimizes environmental impact, braces resource conservation, and supports long-term sustainability.

Cultural Preservation and Economic Catalyst (Case Study: The High Line, NYC)

Adaptive reuse also serves as a key component of cultural preservation and community cohesion. It helps to strengthen a sense of belonging in the community, bridging the city's historical narrative into its unfolding future while addressing the

³⁸ 2019 Global Status Report for Buildings and Construction towards a Zero-Emissions, Efficient and Resilient Buildings and Construction Sector, International Energy Agency: IEA (Global Alliance for Buildings and Construction, 2019), 15

³⁹ Roger Harrabin, *Climate Change: MPs Say Building Demolitions Must Be Reduced*, BBC News (BBC News, May 26, 2022), accessed November 17, 2023, <https://www.bbc.com/news/science-environment-61580979>.

⁴⁰ Meijing Liu et al., "Analysis of the Impact of Photovoltaic Curtain Walls Replacing Glass Curtain Walls on the Whole Life Cycle...", *Energies* (October 2023), 17.

community's emerging needs. Isolation of abandoned buildings often leads to harmful effects on public health, while the repurposing of obsolete infrastructure alleviates these negative impacts and provides opportunities for encouraging community engagement and socialization. One of the remarkable adaptive reuse projects that shows the transformative power of such initiatives in revitalizing communities and enhancing socioeconomic status is the High Line in New York City. The High Line's metamorphosis from an abandoned railway into inviting public space radically flipped the narrative of urban landscape, reshaping transportation infrastructure into a pedestrian-oriented design while preserving the existing structure that absorbs the essence of its industrial heritage. The place was once called "an ugly eyesore," prompting Mayor Giuliani to even sign a demolition order.⁴¹ However, recognizing "the beauty of this hidden landscape," the project seamlessly integrated vernacular and harmonious landscape features to breathe new life into the once-neglected West Side rail corridor, converting it from a forgotten relic into a vigorous hub of activity. The overall redevelopment of the High Line also has catalyzed a wave of economic development in the surrounding area. This linear park, as a public space, has not only increased the property values and improved retail and commercial activity in the surrounding neighborhoods, but has also attracted tourism and hospitality, further promoting local economics. Based on the successful case study, the High Line, the concept of adaptive reuse has proven and highlighted the numerous positive impacts of this approach, making it a valuable strategy to incorporate into urban renewal

⁴¹ "History," *The High Line*, last modified June 27, 2023, accessed November 17, 2023, <https://www.thehighline.org/history/>.

plans, especially in the post-industrial districts. It encourages community revitalization, socioeconomic enhancement, and cultural preservation, all while embracing sustainable and eco-friendly urban development principles.

Challenges and Opportunities

Design Approach

To successfully implement the concept of adaptive reuse, it is important to know how to approach this strategy to a specific location. First and foremost step of finding potential reuse opportunities is to explore possibilities through available information and assets such as mapping services.⁴² Many of the cities have private and public mapping tools that provide several different layers of information, including vacant properties information. The Urban Redevelopment Authority of Pittsburgh, for example, regularly updates an online map of vacant properties based on tax foreclosures.⁴³ These resources are usually accessible to the public, enabling individuals to gather data and identify potential sites for adaptive reuse and redevelopment projects. During site analysis, it is crucial to pay attention not only to “cold” knowledge from a public database but also to “warm” local experience that reflects their lived experiences and perspectives on the site and its surroundings as a part of community engagement.⁴⁴

⁴² Robiglio, “THE ADAPTIVE REUSE TOOLKIT: How Cities Can Turn Their Industrial Legacy into Infrastructure for Innovation and Growth,” 12.

⁴³ Ibid.

⁴⁴ Ibid.

The next step is to understand the site conditions and access potential. “The success of the reuse will depend on a mix of factors, including location, the scale of the property, and the extent to which the building(s) can support certain activities.”⁴⁵ Abandoned industrial sites and buildings possess a unique set of characteristics that require careful consideration to fully comprehend the structural anatomy. It is essential to assess and mitigate potential risks, especially those related to contamination from previous production. The information about past production processes can be accumulated through local knowledge by retired workers or neighbors, interviews with residents, and public walks as a part of site visit. Local knowledge also provides opportunities “to reconnect to the history and culture of a place.”⁴⁶ Prudent assessment of the appropriate scale of intervention is also necessary in the process of adaptive reuse projects, ensuring that the size and form of the interventions align harmoniously with the specific context and objectives.⁴⁷ Moreover, the continuous cultivation of a compelling narrative throughout the project plays a predominant role in providing the positive and aspirational vision for the selected sites. Overall, a comprehensive understanding of the site’s physical conditions, historical context, and community needs is uppermost to consider for developing successful adaptive reuse projects.

⁴⁵ Ibid, 13.

⁴⁶ Ibid, 14.

⁴⁷ Ibid, 13.

Potential Gentrification

Another critical consideration in employing adaptive reuse strategies is the potential for gentrification and displacement. Revitalization projects often initiate rapid growth in property value, leading to the displacement of low- and middle-income residents who can no longer afford housing in the redeveloped area. This displacement disproportionately affects marginalized communities, aggravating existing patterns of urban social inequity. The revitalization project should provide benefits to everyone as possible. To mitigate these negative consequences, it is essential to develop and implement appropriate planning strategies that prioritize equitable and inclusive development. Such strategies should incorporate structural interventions that address the underlying causes of displacement, such as income disparities and access to affordable housing⁴⁸. Additionally, supporting community engagement and empowerment can ensure that the revitalization process benefits all residents, not just a select few. Thus, adaptive reuse projects require a holistic approach that integrates overarching planning strategies, structural interventions, and community engagement to offer equitable designed space in the community where all residents are able to share in the benefits of transformation.

⁴⁸ Helen Cole et al., “Determining the Health Benefits of Green Space: Does Gentrification Matter?,” *Health & Place* 57 (May 2019), 1.

Chapter 3: Environmental Cleanup and Remediation: Gray to Green

Environmental cleanup and remediation involve the procedures and methods that the United States Environmental Protection Agency (EPA) develops. The purpose of these procedures and methods is “to contain and mitigate contamination and to remediate the environment following public health and environmental incidents and disasters.”⁴⁹ Such contamination incidents often require the process of decontamination of building infrastructures and landscape conditions. The implementation of environmental cleanup and remediation strategies constitutes a critical intervention in protecting human health and the environment. These strategies aim to restore contaminated areas to their natural state, thereby promoting long-term sustainability.

Climate change continues to generate a growing number of emerging challenges, intensifying in severity as time progresses. This phenomenon is primarily driven by human activities that disrupt the delicate balance of the Earth’s natural systems, and the responsibility for finding solutions rests squarely on our shoulders. In a response to such issues, this thesis adopts a conceptual approach to environmental cleanup and remediation by applying the idea of decontamination and

⁴⁹ “Cleanup and Remediation,” *United States Environmental Protection Agency (EPA)*, last modified June 26, 2023, accessed December 7, 2023, <https://www.epa.gov/emergency-response-research/cleanup-and-remediation>.

restoration to address past and present environmental degradation, ultimately paving the way for a sustainable future. As part of the recovery phase, the infrastructure that had once contributed to global warming through fossil fuel power generation is undergoing a transformative narrative shift. It is now being repurposed to mitigate climate change and facilitate the investigation of clean energy and ecological solutions.

Response to Climate Change

Current Condition

Global warming is “a phase that refers to the effect on the climate of human activities, in particular the burning of fossil fuels (coal, oil and gas) and large-scale deforestation, which cause emissions to the atmosphere of large amounts of ‘greenhouse gases’, of which the most important is carbon dioxide.”⁵⁰ This is primarily observed in the industrial era, especially over the last six decades.⁵¹ Humanity’s relentless pursuit of resources to fulfill ever-expanding needs has reached a critical point, where confrontation with the unavoidable consequences of its harmful activities is becoming increasingly imminent. It is necessary to address this unsustainable trajectory, driven by the insatiable demand for resources. Based on the computer models of Earth’s climate system, scientists were able to explore the effects of both natural and human factors.⁵² The graph (Figure 3.1) clearly indicates that

⁵⁰ John Houghton, “Global Warming,” *Reports on Progress in Physics* 68, no. 6 (2005): 1343.

⁵¹ Katharine Hayhoe et al., “Our Changing Climate.,” ed. Linda O. Mearns, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment 2* (2018): 72–144.

⁵² Ibid.

human activities, particularly greenhouse gas emission, are the dominant contributors to current environmental conditions. These human-induced factors are collectively driving a warming trend, leading to progressively higher global temperatures. Observed warming over the period 1951-2010 was 1.2°F (0.65°C), and the studies demonstrated that the range of the human contribution to the global average temperature increase over the period 1951-2010 is 1.1°F to 1.4°F.⁵³

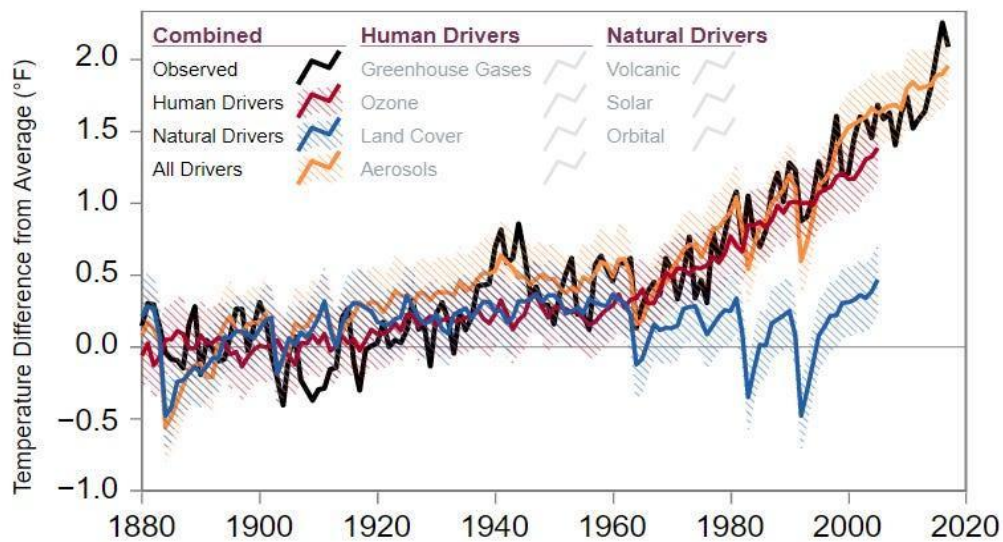


Figure 3.1: Human and Natural Influences on Global Temperature
(Source: U.S. Global Change Research Program)

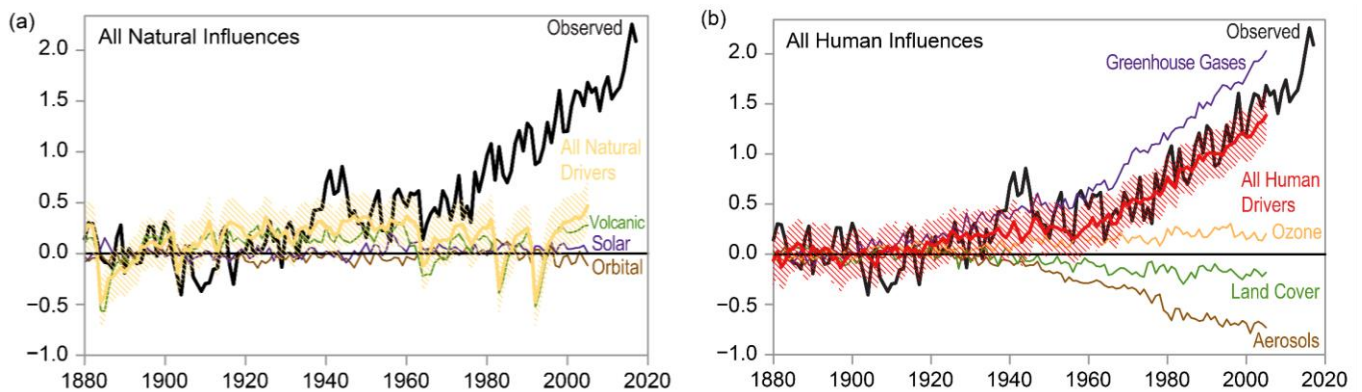


Figure 3.2: Natural Influences vs. Human Influences
(Source: Fourth National Climate Assessment)

⁵³ Ibid.

The global mean near-surface temperature in 2023 was around 1.40 ± 0.12 °C above the 1850-1900 average.⁵⁴ The data to October demonstrated that 2023 will be the warmest year in the 174-year observation record, surpassing the previous joint warmest years, 2016 at 1.29 ± 0.12 °C above the 1850-1900 average and 2020 at 1.27 ± 0.13 °C.⁵⁵ NOAA Chief Scientist Dr. Sarah Kapnick mentioned that September 2023 was warmer than the average July from 2001-2010.⁵⁶ Warm temperatures covered 20% of the world's surface in September 2023, which was the highest percentage of any month since the start of records in 1951.⁵⁷ The data indicated that the September 2023 global surface temperature was 2.59°F (1.44°C) above the 20th-century average of 59.0°F (15.0°C) and this was 0.83°F (0.46°C) above the previous record from September 2020.⁵⁸ North America, South America, Europe and Africa all experienced record-breaking warmth during September 2023.

⁵⁴ *Provisional State of the Global Climate 2023*, World Meteorological Organization, November 30, 2023, <https://wmo.int/files/provisional-state-of-global-climate-2023>.

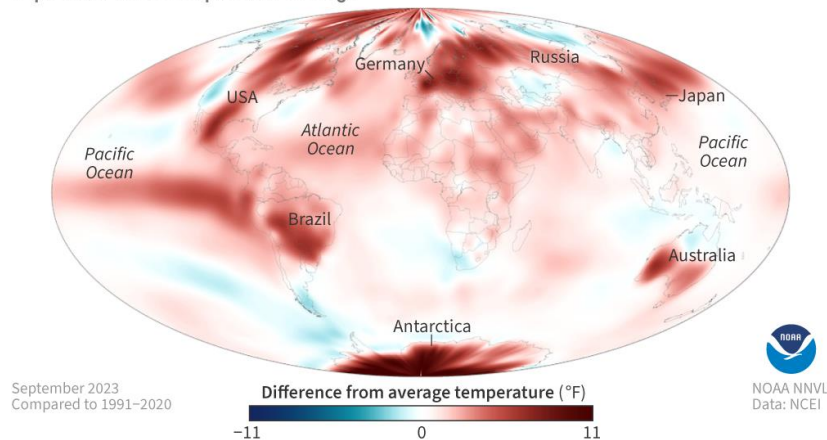
⁵⁵ Ibid.

⁵⁶ “Global Climate Summary for September 2023,” NOAA National Centers for Environmental Information, last modified October 16, 2023, <https://www.climate.gov/news-features/understanding-climate/global-climate-summary-september-2023#:~:text=For%20the%20sixth%20consecutive%20month,in%20NOAA's%20174%2Dyear%20record.>

⁵⁷ Ibid.

⁵⁸ Ibid.

September 2023 compared to average



September global temperatures compared to average (1850-2023)

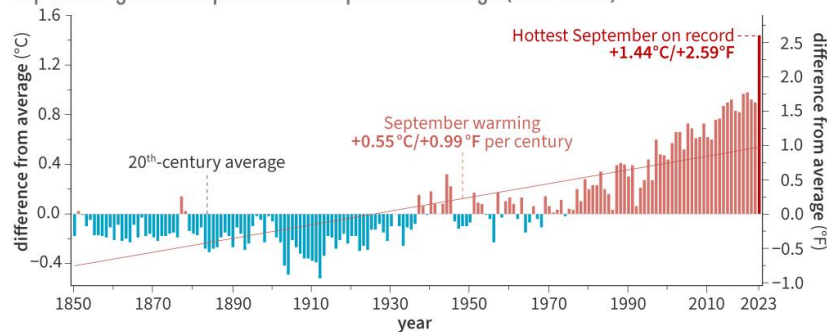


Figure 3.3: Surface temperature in September 2023 compared to the 20th century average (Source: NOAA)

Furthermore, observed concentrations of the three main greenhouse gases: carbon dioxide, methane, and nitrous oxide reached record high levels in 2022, and the levels of these three greenhouse gases continued to increase in 2023.⁵⁹ Global averaged concentrations of carbon dioxide in 2022 was a full 50% above the pre-industrial era for the first time and methane concentrations and levels of nitrous oxide also showed the highest year-on-year increase on record from 2021 to 2022, according to the Greenhouse Bulletin.⁶⁰ Carbon dioxide accounts for approximately

⁵⁹ *Provisional State of the Global Climate 2023*.

⁶⁰ “Greenhouse Gas Concentrations Hit Record High. Again.” *World Meteorological Organization*, last modified November 15, 2023, <https://wmo.int/news/media-centre/greenhouse-gas-concentrations-hit-record-high-again>.

64% of the warming effect on the climate, and methane accounts for about 19% of the warming effect of long-lived greenhouse gases while nitrous oxide accounts for 7% of the radiative forcing by long-lived greenhouse gases.⁶¹ Figure 3.4 is also showing how each three main greenhouse gases increase every year, which means rapid increase in warming effect on the climate as well. World Meteorological Organization (WMO) Secretary General Professor Petteri Taalas mentioned, “the current level of greenhouse gas concentrations puts us on the pathway of an increase in temperatures well above the Paris Agreement targets by the end of this century. This will be accompanied by more extreme weather, including intense heat and rainfall, ice melt, sea-level rise and ocean heat and acidification. The socioeconomic and environmental costs will soar. We must reduce the consumption of fossil fuels as a matter of urgency.”⁶²

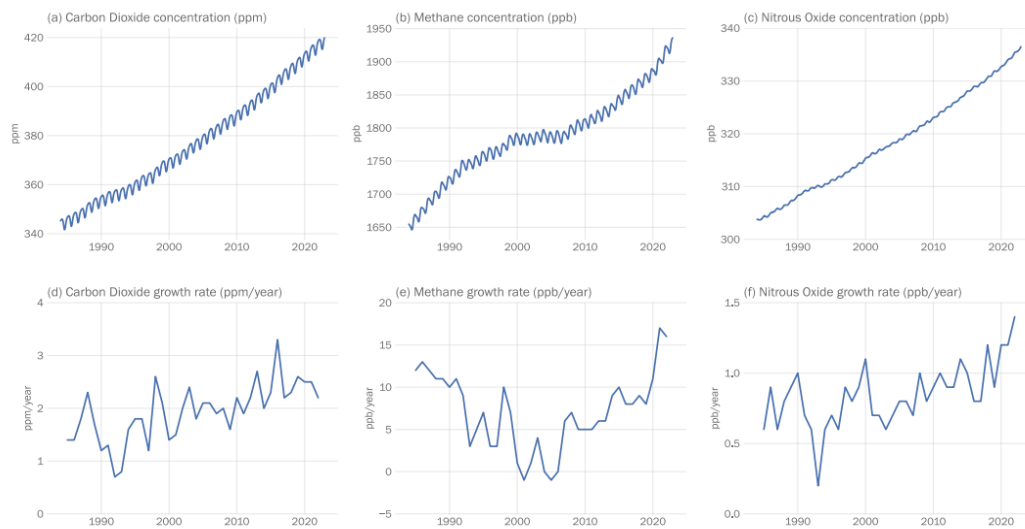


Figure 3.4: Top row: Monthly globally averaged mole fraction from 1984 to 2022. Bottom row: The growth rates represent increases in annual means of mole fractions. (Source: World Meteorological Organization)

⁶¹ Ibid.

⁶² Ibid.

The ocean acts as a heat sink, absorbing a significant portion of the heat generated by global warming. The rate of ocean warming has significantly increased in the past two decades, which impacts all depths. This warming leads to thermal expansion, causing sea level rise that threatens coastal and island communities. The ocean also absorbs carbon dioxide to mitigate its atmospheric concentration, however, this increased CO₂ absorption leads to ocean acidification which endangers marine life and coral reefs.⁶³ Ocean heat content (OHC) reached its highest level in 2022, and global mean sea level in 2023 reached a record high in the satellite record, reflecting continued ocean warming as well as the melting of glaciers and ice sheets.⁶⁴ The rate of global mean sea level rise in the past ten years of 2013-2022 is more than twice the rate of sea level rise in the first decade of the satellite record from 1993 to 2002.⁶⁵

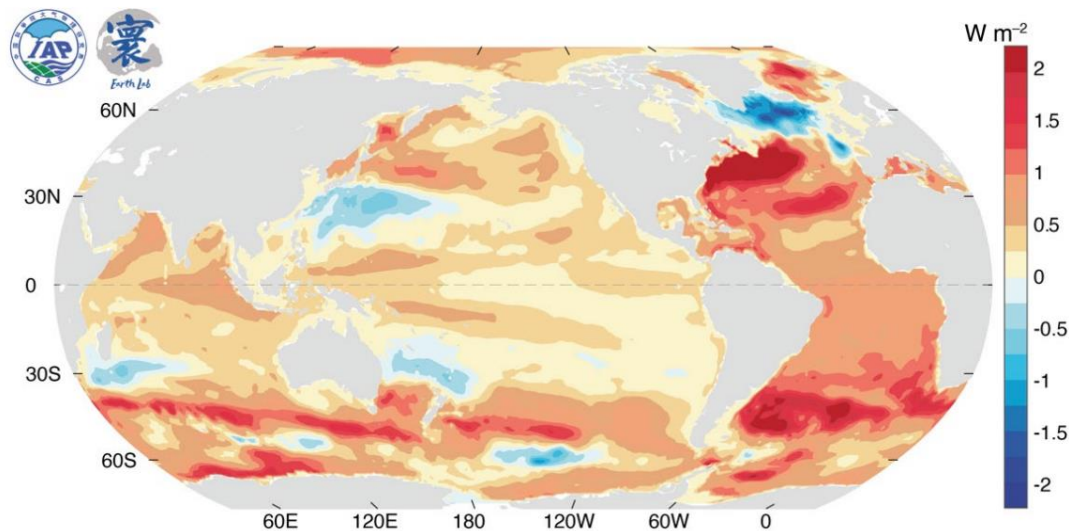


Figure 3.5: Observed upper 2000 m OHC trend from 1958 to 2022.
(Source: World Meteorological Organization)

⁶³ “Causes and Effects of Climate Change,” *United Nations*, last modified 2023, <https://www.un.org/en/climatechange/science/causes-effects-climate-change#collapseOne>.

⁶⁴ *Provisional State of the Global Climate 2023*.

⁶⁵ *Ibid.*

Intraseasonal sea level anomalies

E.U. Copernicus Marine Service Information (CMEMS). Marine Data Store (MDS). DOI: 10.48670/moi-00149

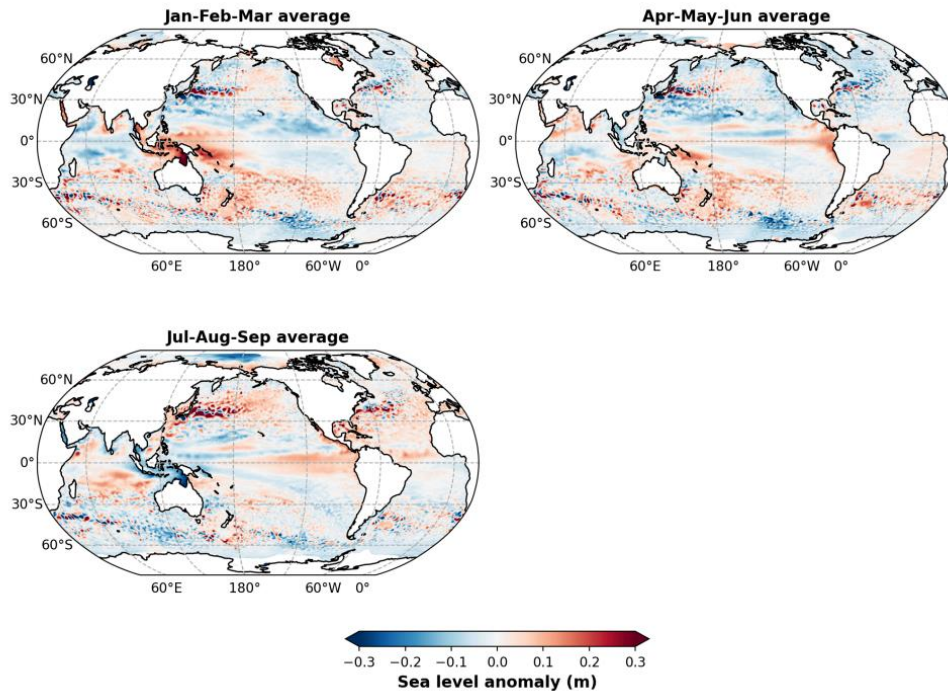


Figure 3.6: 3-month averages of altimetry-based sea level anomalies.
(Source: WMO, Copernicus Marine Service)

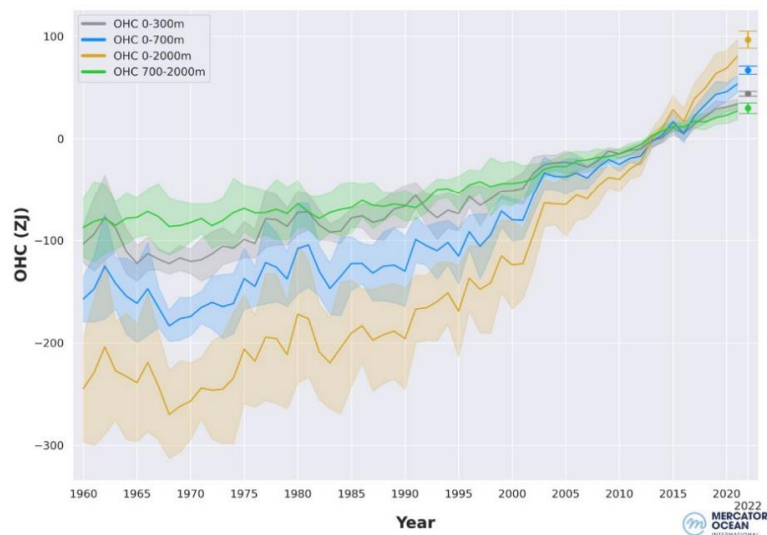


Figure 3.7: 1960-2021 global ocean heat content anomalies relative to 2005-2021 average for the 0-300m (gray), 0-700m (blue), 0-2000m (yellow) and a 700-2000m depth layer (green).
(Source: WMO)

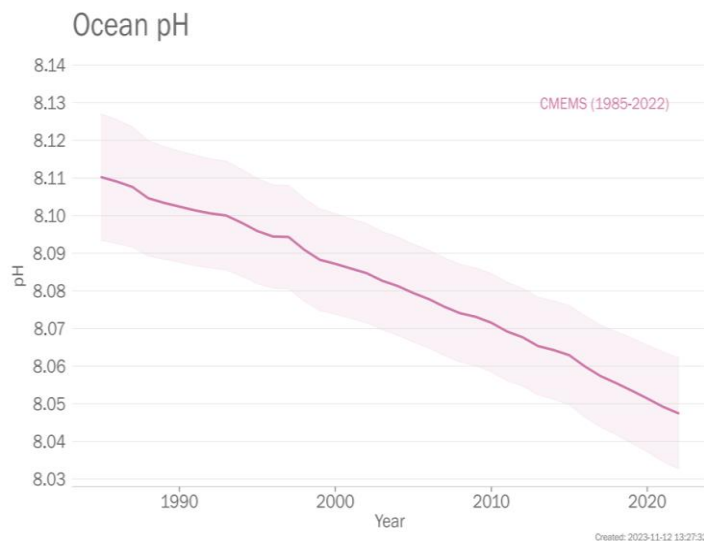


Figure 3.8: Global annual ocean surface pH covering the period 1985-2022.
(Source: WMO)

Future Projection

Future climate projections indicated continued and significant alterations of Earth's climate throughout the 21st century and beyond. The results might vary depending on global emissions of greenhouse gases and on the response of Earth's climate system to human induced warming.⁶⁶ Analysis of the data indicated a direct correlation between the ongoing trend and a potential for rapid intensification. The projected sea level rise over the next 30 years would be 10 to 12 inches as much as the rise measured over the last 100 years.⁶⁷ Additionally, about two feet of sea level rise along the U.S. coastline is increasingly likely between 2022 and 2100 because of emissions to date.⁶⁸ Unchecked future emission threatens an additional 1.5 to 5 feet of

⁶⁶ Katharine Hayhoe et al., "Our Changing Climate."

⁶⁷ "Climate Change Predictions," NOAA, last modified 2023, <https://coast.noaa.gov/states/fast-facts/climate-change.html>.

⁶⁸ Ibid.

sea level rise, bringing the total projected increase to 3.5 to 7 feet by the end of this century.⁶⁹ Without adapting to the changing climate, some Midwestern and southern countries could see a decline in yields of more than 10% over the next 5 to 25 years, with a 1-in-20 chance of losses of crops by more than 20%.⁷⁰ Moreover, unmitigated climate change will increase existing economic vulnerabilities, triggering substantial financial losses through increasingly frequent extreme weather events and catastrophic disasters. Accounting for potential shifts in hurricane frequency and intensity, average annual losses are projected to rise by \$7.3 billion, bringing the total cost of hurricanes and other coastal storms to \$35 billion.⁷¹ A concerning scenario with a 1-in-20 probability, twice as likely as an American developing melanoma, envisions more than \$1 trillion in coastal property submerged or at risk from high tides by the end of this century⁷². If this current path continues, the average American will likely experience 27 to 50 days over 90 degrees (in Fahrenheit) each year by the middle of this century.⁷³

⁶⁹ Ibid.

⁷⁰ Ibid.

⁷¹ Ibid.

⁷² Ibid.

⁷³ Ibid.

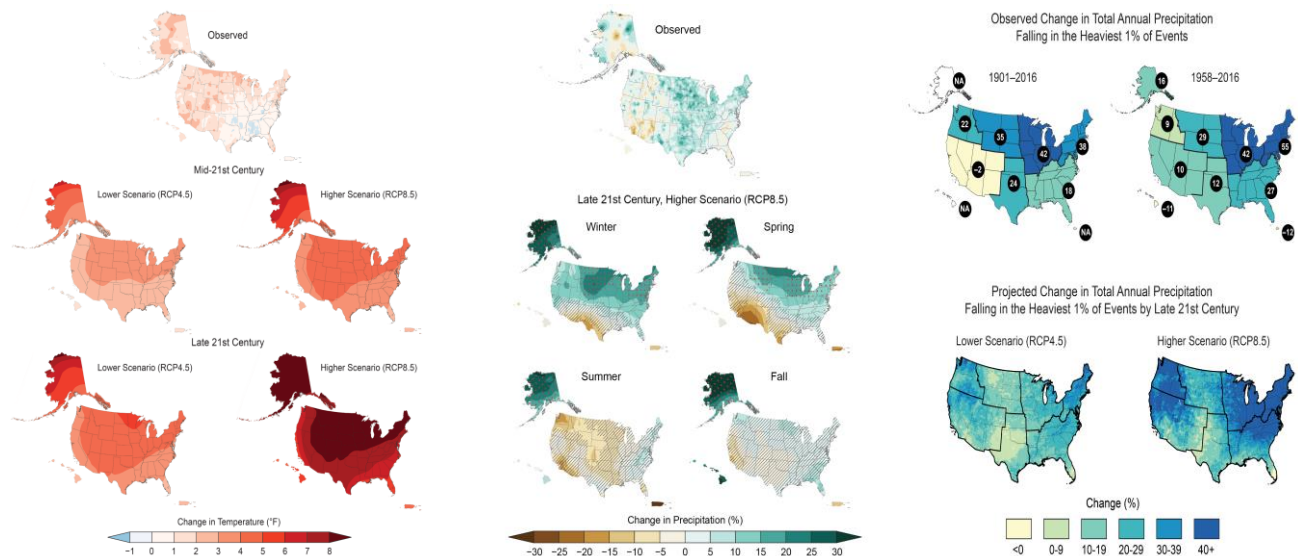


Figure 3.9: Observed and Projected Changes in Annual Average Temperature (Left), Seasonal Precipitation (Middle), and Heavy Precipitation (Right).
(Source: Fourth National Climate Assessment)

The future of our climate beyond mid-century is a crossroads shaped by two critical factors: the choices humans make about greenhouse gas emissions and the Earth's inherent response to the warming humans have already set in motion. By aggressively reducing emissions, global temperature increases can be held below 3.6°F (2°C) or less compared to preindustrial levels.⁷⁴ However, a failure to act decisively could unleash a scenario where annual temperatures exceed by 9°F (5°C) or more by the end of the century, posing unprecedented challenges for humanity.⁷⁵ Figure 3.10 illustrates the variation in global carbon emissions and their ultimate impact on global average temperatures across different scenarios. If emissions follow the higher scenario (RCP8.5), the world faces a future of continued fossil fuel

⁷⁴ Katharine Hayhoe et al., "Our Changing Climate."

⁷⁵ Ibid.

dependence and escalating temperatures. Models predict a global average increase of 4.2°- 8.5°F (2.4°-4.7°C) by 2080-2099 compared to the 1986-2015 average (shown by the burnt orange shaded area).⁷⁶ In contrast to the higher scenario, RCP4.5 provides a path toward mitigating climate change. Lower scenario envisions fossil fuel emissions peaking mid-century and subsequently declining, leading to a projected global average temperature increase of 1.7°- 4.4°F (0.9°-2.4°C) compared to the 1986-2015 average.⁷⁷ Lastly, an even lower scenario (RCP2.6) offers the most optimistic outlook, with the assumption that fossil fuel emissions have already peaked. This trajectory suggests the possibility of limiting global average temperature increases to a narrow range of 0.4°- 2.7°F (0.2°-1.5°C) compared to 1986-2015, as depicted by the green shaded area.⁷⁸ Therefore, while the future path of our climate rests upon a web of complex forces, our own response holds the strongest thread. The success of our mitigation efforts, the speed of our transition to clean energy, and the resilience we build will fundamentally determine the warmth of our future. The choice is ours, to write a story of: rising seas and scorching summers, or a narrative of adaptation and a stabilized planet.

⁷⁶ Ibid.

⁷⁷ Ibid.

⁷⁸ Ibid.

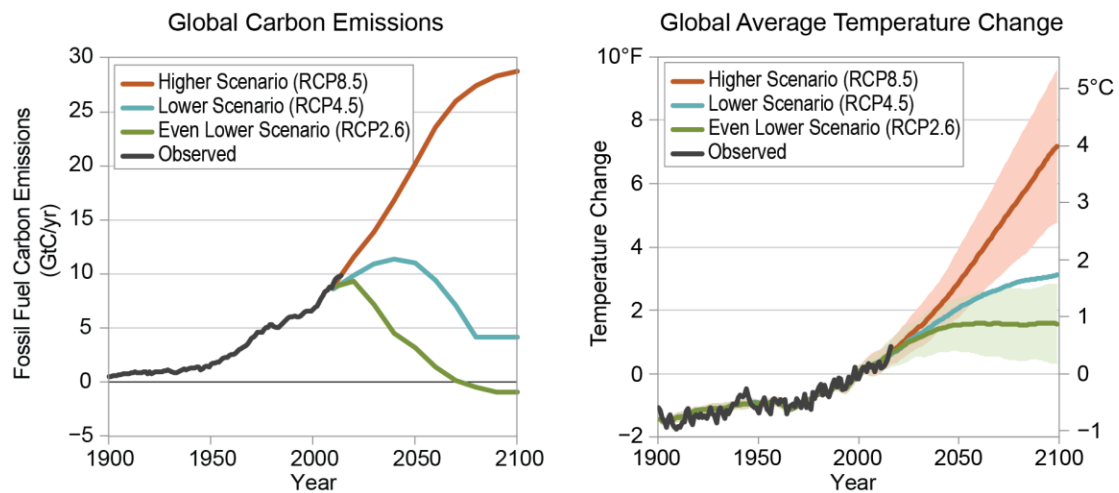


Figure 3.10: Observed and Projected Changes in Carbon Emissions and Temperature in different scenarios. (Source: Fourth National Climate Assessment)

Then, What's Next: Regeneration

In a powerful act of redemption, the former symbol of environmental degradation has been regenerated as a symbol of hope. The abandoned power plant, once responsible for fueling climate change, has been thoroughly reshaped into a hub for clean energy advancements and environmental research while actively reversing the damage it caused and striving to guide to a future of sustainable energy.

Optimizing the facility's impact requires thoughtful site selection and architecture that seamlessly integrates sustainability measures. Additionally, the effectiveness and implementation of potential and proposed solutions to climate change will depend heavily on the specific site characteristics.

Focus Area: Urban Regions

The pre-existing challenge of the urban heat island effect renders urban areas disproportionately vulnerable to the intensifying impacts of climate change. "One of the most pressing challenges to the prevention and mitigation of climate-change

impacts is the dramatic increase in urban populations. Currently, the world’s human population is growing by a net increase of about 83 million people per year.”⁷⁹ The rapid urban population increase aggravates unsustainable consumption and production patterns, undeniably leading to a trajectory of rising CO₂ equivalent emissions in cities. Effective climate change mitigation necessitates prioritizing sustainability concepts and approaches within urban areas. Focus areas include reducing energy and water consumption, minimizing waste across all societal levels, and enhancing waste prevention, reduction, and management.⁸⁰ Recent studies further highlight the critical role of quality of life, societal well-being, and healthy biodiversity in achieving sustainable development goals.⁸¹

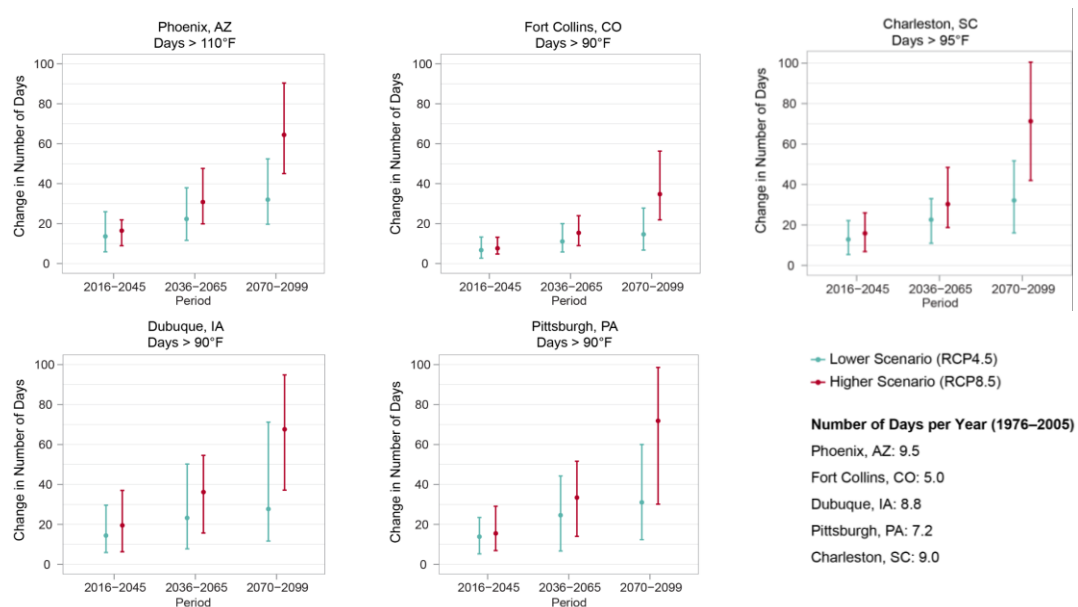


Figure 3.11: Projected Change in the number of very Hot Days.
(Source: Fourth National Climate Assessment)

⁷⁹ Boğaçhan Bayülken, Donald Huisingh, and Peter M.J. Fisher, “How Are Nature Based Solutions Helping in the Greening of Cities in the Context of Crises such as Climate Change and Pandemics? A Comprehensive Review,” *Journal of Cleaner Production* 288 (March 15, 2021).

⁸⁰ Ibid.

⁸¹ Ibid.

As the frequency and intensity of extreme weather events increase, the vulnerabilities of built environments come into focus. From the fundamental infrastructure that supports daily lives in the city-such as housing, transportation, communication, energy and water systems-to the spaces that foster recreation, learning, and community-such as parks, streets, and landscapes-the built environment becomes a battleground where human resilience is tested. Recognizing these vulnerabilities and investing in adaptive infrastructure is critical for ensuring a secure and sustainable future, especially in urban environments. “The way city residents respond to incidents [such as heat waves and heavy rainfalls] depends on their understanding of risk, their way of life, access to resources, and the communities to which they belong.”⁸² Conceptualizing interactive wayfinding as a tool for climate change awareness and engagement provides a promising avenue for fostering public awareness and motivating collective call for action. By integrating climate realities into urban navigation experiences, such designs can bridge the gap between knowledge and action through prompting city residents to contribute to a more sustainable future. Infrastructure built for past climate patterns is inadequately prepared for the future weather extremes and shifting climate realities. Forward-looking design principles offer a critical solution, ensuring acceptable performance and resilience under changing climate conditions.⁸³

⁸² Susan Julius et al., “Built Environment, Urban Systems, and Cities,” ed. Jesse Keenan, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment 2* (2018): 438–478.

⁸³ Ibid.

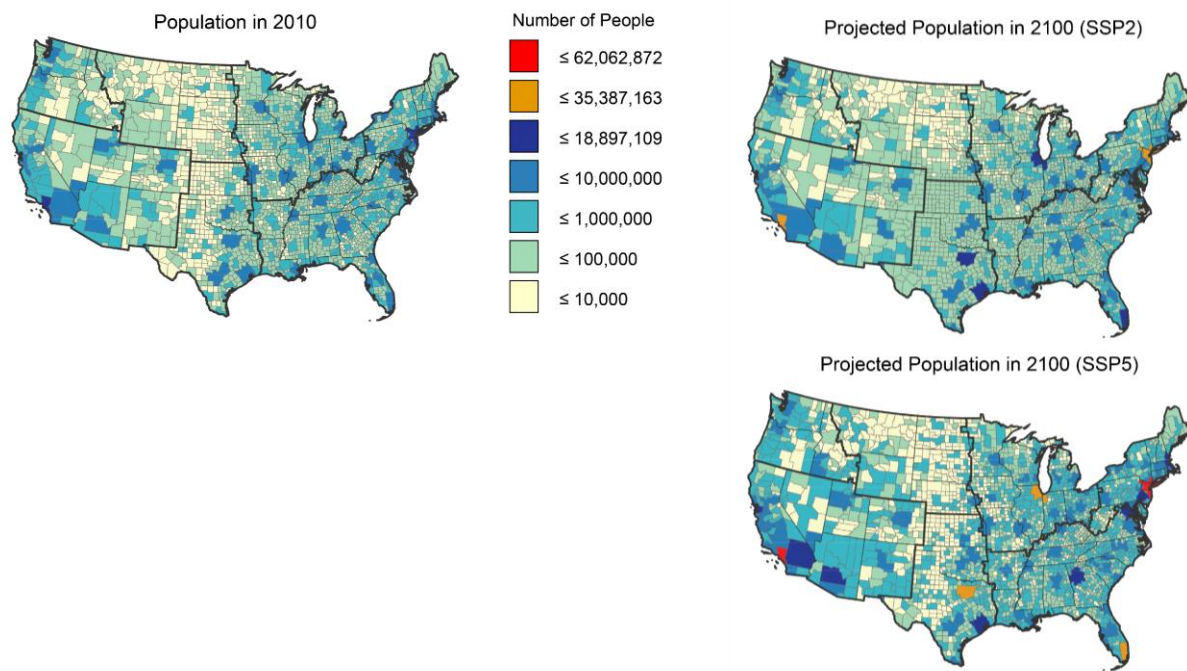


Figure 3.12: Current and Projected U.S. Population (Source: Fourth National Climate Assessment)

Self-sufficient Building: Integration of Sustainable Strategies

Embracing the imperatives of forward-looking design, the repurposed power plant can become a prototype for climate resilient infrastructure. By promoting self-sufficient building models, it provides a tangible response to the challenges of a changing climate. Furthermore, the facility's capability to generate positive-net energy presents potential avenues for innovative research, serving as an aspirational model for renewable energy adoption in surrounding communities. The Seaholm Power Plant Redevelopment in Austin, Texas stands as a prominent case study demonstrating the successful implementation of adaptive reuse on abandoned power plants and the integration of energy-efficient technologies. The renovated power plant

was made 24.3% more energy efficient by updating the walls and glazing.⁸⁴ Moreover, underground parking minimized the heat island effect and helped reduce the energy use in the low-rise building by nearly 30%.⁸⁵ The rainwater is harvested from all buildings on site into storage tanks which have a 325,000-gallon capacity, and it is used to irrigate the entire site and surrounding streetscape vegetation.⁸⁶ The redevelopment of this abandoned power plant exemplifies the successful integration of sustainable strategies, including energy conservation and waste minimization, with the preservation of historical features and site identity.

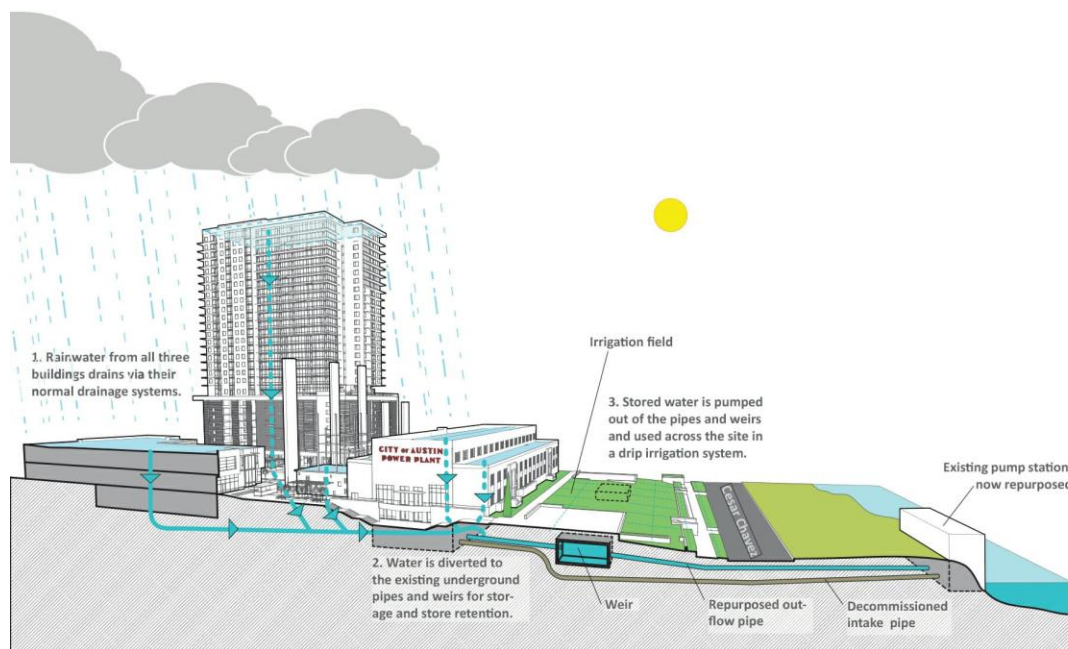


Figure 3.13: Seaholm Power Plant Redevelopment rain water harvesting diagram
(Source: Casey Dunn Photography)

⁸⁴ John Caulfield, “Adaptive Reuse Juices up an Abandoned Power Plant,” *Building Design + Construction*, last modified November 11, 2016, <https://www.bdcnetwork.com/adaptive-reuse-juices-abandoned-power-plant>.

⁸⁵ Ibid.

⁸⁶ Ibid.

Similar to the Seaholm Power Plant, Beloit College Powerhouse, designed by Studio Gang, breathes new life into an old power plant. Nestled in Wisconsin, this former coal plant embraces sustainability, demonstrating that history and green solutions can go hand in hand. Transforming the hundred-year-old structure into an energy-efficient building posed significant challenges. New insulation was developed to regulate heat flow in the historic portions of the building, while the polycarbonate facade of the new field house provides advanced thermal insulation and abundant, diffuse natural light throughout the day.⁸⁷ Moreover, insulation of a radian panel and slab system controls energy from the Rock River for most of the Powerhouse's heating and cooling needs.⁸⁸ This strategy helps improve comfort within the building and maintain the highest air quality, while also minimizing total energy use.⁸⁹ The project establishes a successful precedent for the adaptive reuse of power plants, while also demonstrating the utilization of existing water infrastructure, with the Rock River serving as one of the key sustainable strategies employed.

⁸⁷ Paula Pintos, "Beloit College Powerhouse / Studio Gang," *ArchDaily*, last modified March 2021, <https://www.archdaily.com/957717/beloit-college-powerhouse-studio-gang>.

⁸⁸ Ibid.

⁸⁹ Ibid.

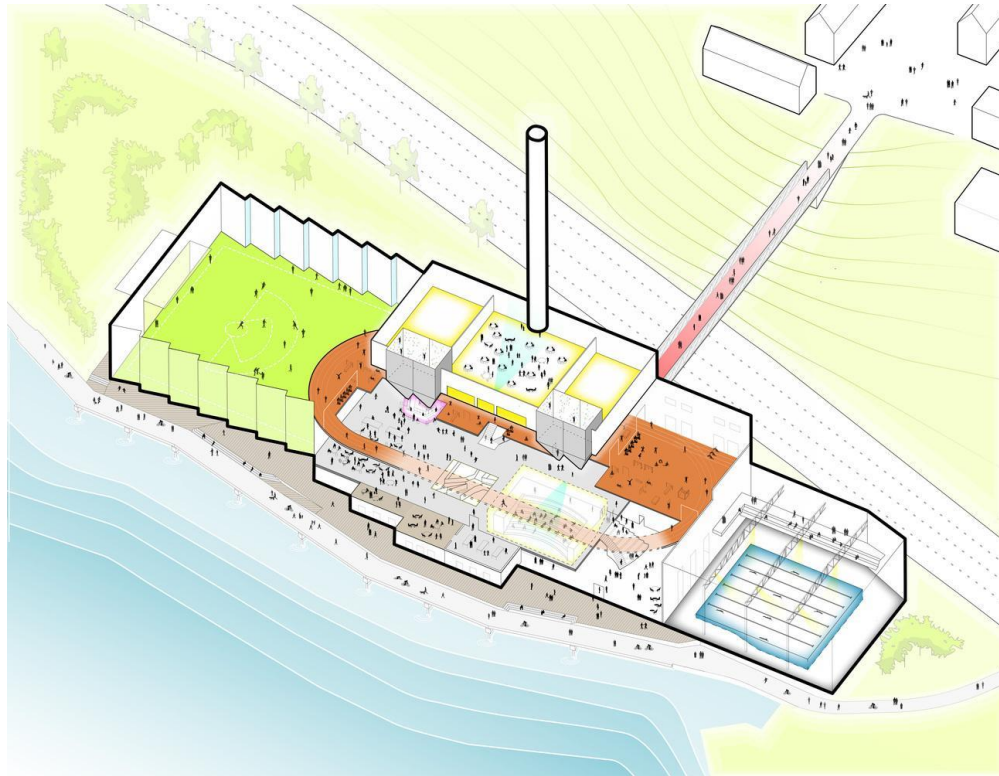


Figure 3.14: Beloit College Powerhouse Axonometric Diagram, the relationship between building and site. (Source: ArchDaily, Photographs: Tom Harris)

Chapter 4: Sustainable Future: Generating Synergies

Passive reliance on external solutions cannot mitigate climate change.

Proactive collective action driven by our shared responsibility towards future generations is crucial. Only through proactive and sustained collective action can we achieve a sustainable future not only for ourselves but for all living beings.

Addressing climate change with urgency and determination is imperative, as the future of our planet and all its inhabitants' rests on our shoulders. While acknowledging potential discrepancies in individual impact, encouraging universal participation in climate action remains essential. Every contribution, regardless of scale, holds value in mitigating the collective challenges. Through the strategic design of spaces that foster synergistic interactions, architecture can contribute to the development of sustainable solutions to address pressing global challenges: global warming. As the climate clock ticks faster with each passing moment, we must transform collective apprehension into collaborative action. Individual awareness, when synergistically combined, forms a potent force for change, capable of rippling through the strata of society, from local communities to global governance. The

future belongs not to those who passively await miracles, but to the architects of a sustainable tomorrow.

Community Engagement: Human Interaction

Co-working Space

Co-working space, through architecture that fosters interaction and cross-pollination, provides fertile ground for diverse minds to connect and co-create solutions that redefine the future. Within this shared space, people coming from very different backgrounds: entrepreneurs, associations, artists, students, researchers can interact as “co-workers,” which offers space for everyone to bring their own talent to a project, improving the outcome.⁹⁰ The important values that the co-working space possesses are participation, sharing and open-mindedness.⁹¹ “Commercial ‘desk share’ spaces already exist since a large time. But co-working space is a different concept. ‘Co-workers’ want to make connections, fostering collaboration and sharing knowledge. Co-working gathers people who work independently but who share values and look for the synergies that a common space shared with talented people can bring.”⁹² By fostering a sense of communal identity and shared purpose, co-

⁹⁰ Anne Leforestier, *The Co-Working Space Concept* (CINE Term project, February 2009).

⁹¹ Ibid, 3.

⁹² Ibid, 4.

working spaces act as catalysts for collaborative innovation, simultaneously diminishing unproductive competition and maximizing individual potential.

The research has shown that individuals employed within traditional organizational structures are susceptible to not only psychological stress but also a sense of boredom arising from unchallenging and repetitive work environments.⁹³ On the other hand, “new collaborative practices imply rethinking their own competences and prospects, often leading to fundamental life changes.”⁹⁴ The communities created by co-working work environments, through their multifaceted focus on practical skill development, provide professional identity formation and emotional support to address loneliness and sense-making.⁹⁵ Furthermore, co-working spaces foster a sense of professional belonging characterized by project-driven collaboration and skill-based participation, which leads to unlocking the potential for knowledge diffusion and cross-disciplinary innovation. Motivated by a desire for increased networking and collaborative opportunities, contemporary workers are increasingly gravitating towards co-working spaces, a trend contributing to their significant growth. The collected data indicate that “the main motivations for co-workers to work in a co-working space were that they were looking for a workspace outside their home that allows them to work in an inspiring work environment where the accommodation is affordable.”⁹⁶ The synergy generated within co-working spaces empowers individuals

⁹³ Nathalie Mitev et al., “Co-Working Spaces, Collaborative Practices and Entrepreneurship,” *Progress in IS* (July 20, 2018): 15–43.

⁹⁴ Ibid.

⁹⁵ Ibid.

⁹⁶ Minou Weijts Perrée et al., “Analysing User Preferences for Co-Working Space Characteristics,” *Building Research & Information* (May 4, 2018): 534–548.

to transcend traditional disciplinary boundaries and leverage their collective expertise, accelerating the development and implementation of effective climate change mitigation strategies.

Learning Center for Future Generations

Community learning centers serve as crucial catalysts for social capital formation, providing platforms for diverse individuals to interact, share knowledge, and co-create solutions, therefore, weaving a vibrant tapestry of community engagement. Community learning centers can also become dynamic knowledge hubs, empowering individuals to all ages with access to quality education and fostering a culture of lifelong learning that benefits future generations. Building on this foundation of engaged communities and continuous learning, the Harvard Graduate School of Education's climate change curriculum focuses on developing critical skills like critical thinking, problem solving, and collaboration in future education leaders.⁹⁷ These skills are essential for navigating the complexities of climate change and fostering collective action within communities. Despite exhibiting a strong engagement with climate change issues, young people frequently express a deficit in the knowledge and educational resources necessary to address these complex challenges effectively. Australian research conducted in 2020 by the Australian Institute of Disaster Resilience (AIDR) and World Vision on almost 1500 10-to-24-year-olds found that 90% expressed that they were not sufficiently educated in school

⁹⁷ Annie Hyokyong Nam and Sueyoon Lee, "Students as Partners. Implementation of Climate Change Education within the Harvard Graduate School of Education," ed. Fernando M. Reimers, *National Library of Medicine* (December 4, 2020): 153–180.

about climate change.⁹⁸ Bridging the knowledge gap for young people regarding climate change is an urgent societal obligation. Empowered with understanding and agency, they hold the key to shaping a sustainable future. Climate education for young people has also become an area of focus for UNESCO's global Education for Sustainability Development 2020 framework, where it has been recognized that “education is key to empowering and mobilizing young people across the world to take action.”⁹⁹

Additionally, the nascent understanding of climate adaptation among certain individuals and organizations underscores the critical need for comprehensive and accessible education in this domain. “Adaptation takes place at many levels-national and regional but mainly local-as governments, businesses, communities, and individuals respond to today’s altered climate conditions and prepare for future change based on the specific climate impacts relevant to their geography and vulnerability.”¹⁰⁰ Localized implementation of climate adaptation strategies, informed by specific geographic vulnerabilities and community needs, demonstrably fosters effective collective action and catalyzes deeper engagement with climate change challenges within communities. Engaging public awareness and cultivating deep understanding of the intricate tapestry of potential and unknown cascading effects, from global change to local and regional impacts, is an imperative.¹⁰¹

⁹⁸ Madeleine Hohenhaus et al., “Engaging Young People in Climate Change Action: A Scoping Review of Sustainability Programs,” *Sustainability* 15, no. 5 (February 27, 2023): 4259.

⁹⁹ Ibid.

¹⁰⁰ Jeffery Arnold et al., “Reducing Risks through Adaptation Actions,” ed. Mary Ann Lazarus, *Impacts, Risks and Adaptation in the United States: Fourth National Climate Assessment 2* (2018): 1309–1345.

¹⁰¹ Ibid.



Figure 4.1: Five Adaptation Stages and Progress

(Source: Fourth National Climate Assessment, adapted from National Research Council, 2010.¹ Used with permission from the National Academies Press, ©2010, National Academy of Sciences. Image credits, clockwise from top: National Weather Service; USGS; Armando Rodriguez, Miami-Dade County; Dr. Neil Berg, MARISA; Bill Ingalls, NASA)

Integration of Green Infrastructure: Environmental Design

As green infrastructure becomes the keystone of modern urban planning and community development, its significance is extending towards its potential as a multifaceted community resource. By incorporating features such as parks, green spaces, outdoor research space, and sustainable technologies into urban landscapes, communities are leveraging the power of nature to enhance the well-being and quality of life for their residents. There are diverse ways in which green infrastructure can serve as a dynamic community asset, promoting social cohesion, and supporting public health. Moreover, incorporating green infrastructure as an integral component

of climate adaptation strategies provides communities with nature-based solutions for managing a range of climate impacts, including drought, sea-level rise, and extreme weather events. There is also a significant potential of green infrastructure to support community resilience and foster adaptive capacities through mechanisms such as flood water retention, heat island mitigation, and ecosystem restoration, solidifying its role as a crucial tool for climate adaptation.

Social/Cultural Impact

Green infrastructure holds the possibility of transforming urban environments into inviting gathering spaces that encourage community cohesion and well-being. These green gathering spaces invite residents to connect with nature and one another. Picnic areas, playgrounds, and open lawns become natural meeting points, motivating neighbors to come together for recreational activities and shared experiences. Additionally, the deliberate incorporation of green gathering spaces promotes physical and mental well-being. Studies have shown that access to green areas improves mental health, reduces stress levels, and enhances overall quality of life.¹⁰² Researchers also suggest that the layout of buildings and the quality of common outdoor spaces in residential neighborhoods substantially affect the use of these spaces and the social interaction among residents.¹⁰³ By creating gathering spaces that are harmoniously integrated with nature, communities are not only investing in the

¹⁰² Daniel Nutsford, Amber L Pearson, and Simon Kingham, “An Ecological Study Investigating the Association between Access to Urban Green Space and Mental Health,” *Public Health* 127, no. 11 (November 19, 2013): 1005–1011.

¹⁰³ Naceur Farida, “Effects of Outdoor Shared Spaces on Social Interaction in a Housing Estate in Algeria,” *Frontiers of Architectural Research* 2, no. 4 (December 2013): 457–467.

physical health of their residents but also nurturing a sense of social cohesion that is essential for the vitality and resilience of urban environments. Beyond enhancing physical landscapes, effectively designed green infrastructure empowers communities through participatory planning and management, promoting social cohesion and collective ownership, which in turn strengthens community resilience and facilitates proactive engagement with environmental challenges.

Green infrastructure, when thoughtfully integrated into urban planning, also creates potential for vital venues for social interaction, recreation, and cultural events. Parks and green spaces often serve as venues for community events, from outdoor concerts, festivals, and art exhibitions to yoga classes and farmers' markets.¹⁰⁴ These events not only promote a sense of belonging but also stimulate local economies, as they draw in residents and visitors alike, generating a sense of vitality within the community. Additionally, these events can contribute to the formation of a sense of community identity. Providing a platform for local businesses and artisans to showcase their products stimulate economic activity within the community and promotes a sense of unique local identity.¹⁰⁵ Green spaces also serve as versatile educational tools, enabling the facilitation of workshops and events that address diverse thematic areas, such as gardening practice, biodiversity conservation, and the health benefits of spending time outdoors, therefore, enriching resident's knowledge and promoting healthy lifestyles. Investing in the educational functionalities of green

¹⁰⁴ Dmitri Chitov, "Cultivating Social Capital on Urban Plots: Community Gardens in New York City - Dmitri Chitov, 2006," *Humanity & Society* 30, no. 4 (November 2006): 437–462.

¹⁰⁵ Kimberley Hodgson, *Community Heritage and Culture* (Michigan, Chicago: American Planning Association, May 5, 2011).

spaces develops active citizenship and allows residents to be aware of environmental stewardship, contributing to a more sustainable and equitable future for the community.

Environmental Impact

Increased levels of greenhouse gas emissions released into the atmosphere, a legacy of the industrial revolution, population growth pressures, and consumerist lifestyle choices, are the main contributors to human-induced climate change.¹⁰⁶ Climate change is equivalent to the rising temperatures, reductions in rainfall, increased frequency of extreme weather events, and contribution toward declining public health trends. Green infrastructure provides diverse opportunities to mediate adverse effects, while delivering human health, well-being, environmental, economic, and social benefits to contemporary urban dwellers.¹⁰⁷ First, green infrastructure wields a transformative influence on air quality in urban environments, offering a natural counterbalance to the often adverse effects of urbanization. Trees, shrubs and other vegetation within green spaces act as nature's air purifiers filtering harmful pollutants from the atmosphere.¹⁰⁸ Through the process of photosynthesis, plants absorb carbon dioxide and release oxygen, effectively mitigating greenhouse gas levels. Additionally, vegetation acts as physical barriers, intercepting particular matter

¹⁰⁶ Jacqueline Parker and Maria Elena Zingoni de Baro, "Green Infrastructure in the Urban Environment: A Systematic Quantitative Review," *Sustainability* 11, no. 11 (June 6, 2019): 3182.

¹⁰⁷ Ibid.

¹⁰⁸ Kathleen Wolf, Sarah Krueger, and Katrina Flora, "Reduced Risk - a Literature Review," *Green Cities: Good Health, College of the Environment, University of Washington* (2015).

and reducing its dispersion in the air.¹⁰⁹ This not only leads to a reduction in respiratory ailments among urban inhabitants but also contributes to a cleaner and fresher atmosphere.

Green infrastructure also plays a critical role in efforts to reduce urban heat island effects, a phenomenon characterized by rising temperatures in densely built urban areas.¹¹⁰ The strategic placement of trees and greenery provides shade and lower ambient temperatures through a process called evapotranspiration, where plants release moisture into the air.¹¹¹ By tempering the urban microclimate, green infrastructure lessens the demand for energy-intensive air conditioning systems, thus curtailing the releases of greenhouse gases associated with electricity production.¹¹² The resulting decrease in energy consumption has a cascading effect on air quality, as it reduces the reliance on fossil fuels, further diminishing emissions of pollutants that contribute to air pollution. In this manner, green infrastructure stands as a powerful ally in the pursuit of cleaner and healthier urban environments.

Green infrastructure, as nature-based solutions, helps reduce stormwater quantity and improves surface water quality while providing a multitude of other

¹⁰⁹ Arnt Diener and Pierpaolo Mudu, “How Can Vegetation Protect Us from Air Pollution? A Critical Review on Green Spaces’ Mitigation Abilities for Air-Borne Particles from a Public Health Perspective - with Implications for Urban Planning,” *Science of The Total Environment* 796 (November 20, 2021): 148605.

¹¹⁰ Alexandra Price, Erick C Jones, and Felicia Jefferson, “Vertical Greenery Systems as a Strategy in Urban Heat Island Mitigation,” *Water Air Soil Pollution* 226, no. 247 (July 8, 2015).

¹¹¹ Elżbieta Szopińska et al., “Spatial Form of Greenery in Strategic Environmental Management in the Context of Urban Adaptation to Climate Change,” *Polish Journal of Environmental Studies* 28, no. 4 (2019): 1–12.

¹¹² Udayasoorian Kaaviya Priya and Ramalingam Senthil, “A Review of the Impact of the Green Landscape Interventions on the Urban Microclimate of Tropical Areas,” *Building and Environment* 205 (November 2021): 108190.

environmental, economic, and social benefits.¹¹³ Traditional gray infrastructure, such as concrete drainage systems, often struggle to handle surges of stormwater, leading to flooding and overwhelmed sewage systems. However, green infrastructure employs nature features like rain gardens, permeable pavements, and vegetated swales to absorb, filter, and store rainwater. These elements act as natural sponges, allowing water to percolate into the soil and replenish groundwater supplies. Thus, green infrastructure reduces the burden on conventional stormwater systems, curbing the risk of urban flooding and alleviating strain on municipal infrastructure while preserving the integrity of local ecosystems and biodiversity.



Figure 4.2: Greenway in Dubuque, Iowa - in response to a history of flooding, Dubuque, Iowa, installed the Bee Branch Creek Greenway to control flooding and provide recreational space. (Source:Fourth National Climate Assessment, Photo credit: City of Dubuque, Iowa)

¹¹³ Andrea R. McFarland et al., “Guide for Using Green Infrastructure in Urban Environments for Stormwater Management,” *Environmental science: Water research & technology* 5, no. 4 (2019): 643–659.

Chapter 5: Program

Program Abstract

With the preservation of existing structures and space, this adaptive reuse program envisions four primary zones, breathing new life into these industrial infrastructure through **community** engagement, **co-working** space for collaboration, **energy** innovation, and **environmental** research. The first zone, dedicated to the community, supports a sense of ownership and shared purpose. Beyond passive engagement, local residents are invited to actively co-create the space, shaping its purpose and programming through diverse programs and events focused on climate adaptation strategies. This zone also attracts visitors from other areas, fostering collective action and knowledge exchange towards a more resilient future. The co-working zone promotes a vibrant ecosystem of collaboration and ingenuity. Open floor plans and shared resources provide cross-pollination of ideas, while workshops and conferences facilitate knowledge exchange and networking opportunities. This zone becomes a breeding ground for innovation, attracting diverse minds and talents to tackle the pressing challenges of climate change and environmental degradation.

The energy and environmental zones explore more specialized disciplines, offering dedicated spaces for research, innovation, and education within the realms of clean energy technologies and environmental restoration. The primary goal for the energy zone is to investigate the ways of transforming the former source of fossil fuel

emissions into a hub for renewable energy generation and research. Educational exhibits showcase the inner workings of these technologies, while interactive labs allow visitors to experiment and learn about renewable energy production. Energy zones serve as a tangible demonstration of the transition from polluting past to sustainable future, inspiring both local communities and the broader public. The environmental zone transforms the surrounding landscape into active research and education spaces. Polluted soils are remediated, and native plants are introduced, creating a habitat for diverse species. Indoor and outdoor research labs within this zone focus on ecological restoration, water conservation, and sustainable farming practices, contributing to the knowledge base essential for building resilient communities.

Precedent Analysis

Typological Precedents

One of the typological precedents is Enabling Village, designed by WOHA. It is located in Singapore and was built in 2016. The project is “a demonstration of heartland rejuvenation and community building, through Master planning and adaptive reuse of Bukit Merah Vocational Institute built in the 1970s.”¹¹⁴ The property was repurposed as the Enabling Village, which provides an inclusive space that integrates education, work, training, retail and lifestyle through connecting people with disabilities and the society.¹¹⁵ The project integrates natural and

¹¹⁴ “Enabling Village / WOHA,” *ArchDaily*, last modified December 21, 2016, https://www.archdaily.com/801850/enabling-village-woha?ad_medium=gallery.

¹¹⁵ Ibid.

landscape elements effectively, employing biophilic design principles to create an innovative promenade that fosters a seamless transition from interior spaces to outdoor areas and ultimately deepens engagement with the surrounding natural environment.

Another typological percentage is O·POWER Culture & Arts Centre, designed by Shenzhen Huahui Design. The project is located in Shenzhen, China and was built in 2022. The Huazhong Power Plant is located in the northern part of the Overseas Chinese Town area in Nanshan District, Shenzhen. In 2006, the power plant was officially retired due to urban development and environmental protection requirements.¹¹⁶ The Huazhong Power Plant was repurposed as a cultural center yet preserved the memories of many old residents of the Overseas Chinese Town and embodied the collective spirit of the era. Throughout the entire redesign process, the focus was on “how to excavate and recreate the spirit of the place on the existing foundation, how to balance the constraints of the site’s environment with the practical functional requirements, and how to coordinate and integrate with the landscape elements.”¹¹⁷

¹¹⁶ “O·POWER Culture & Arts Centre / Shenzhen Huahui Design,” *ArchDaily*, last modified June 11, 2023, https://www.archdaily.com/1002113/o-star-power-culture-and-arts-centre-shenzhen-huahui-design?ad_medium=gallery.

¹¹⁷ Ibid.

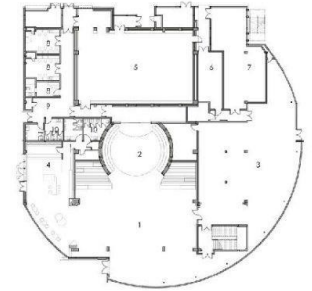
Enabling Village

Singapore

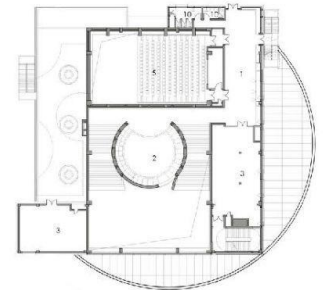
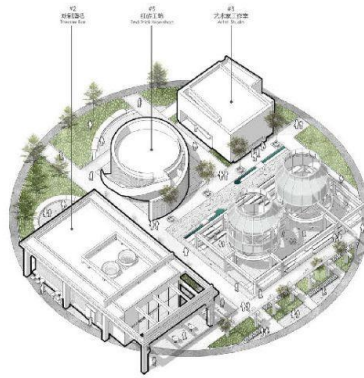
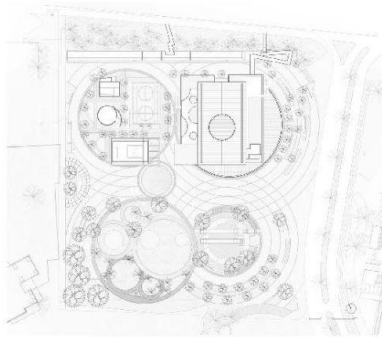


Figure 5.1: Enabling Village.
 (Source: ArchDaily, Photographs: Patrick Bingham Hall, Edward Hendricks)

Shenzhen, China



1 廚房 kitchen	6 供電系統電線 electrical wires
2 鋼琴室鋼琴 room	7 中央配電房 central electricity substation
3 育嬰室 nursery	8 候機室 waiting lobby
4 文娛園地 cultural and creative landscape area	9 候機區域 waiting area
5 POWER 對台 POWER theatre	10 卫生间 toilet



1 箭牌 Lotrey 2 西替立隆 Citipace 3 爱慕 Kaili 5 POWERR 爱地 POWER thease 10 卫生洁具 Toxet

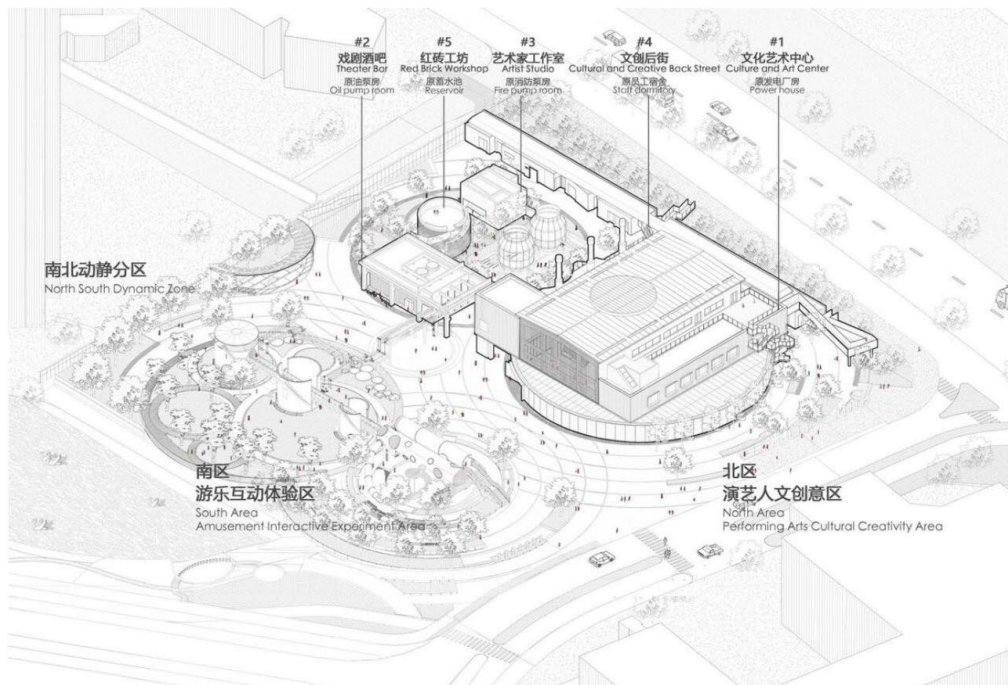


Figure 5.2: O Power Culture & Arts Centre
(Source: ArchDaily, Photographs: ZC Architectural Photography Studio)

Programmatic Precedents

One of the programmatic precedents that this thesis got inspired by is Semans-Griswold Environmental Hall, designed by Ayers Saint Gross. This is home of the Washington College Center for Environment and Society, commands a picturesque site on the Chester River. The most interesting aspect of this project is the use of surrounding natural resources. The river is physically and programmatically integrated in every aspect of its design.¹¹⁸ The river serves as a living laboratory that provides students with an immersive, hands-on experience in support of the building's programs in environmental science and wetlands ecology.¹¹⁹ Additionally, the project fosters the net-positive building that relies on renewable energy sources to operate pollutant-free. The building itself expects to produce 105% of its energy needs on site utilizing rooftop photovoltaic panels and a ground-source heating and cooling system.¹²⁰

Another programmatic precedent is Roux Center for the Environment, designed by CambridgeSeven. The building is located in Brunswick, Maine and was built in 2018. The Roux Center for the Environment provides an extended platform for environmental studies at Bowdoin College in rural Maine.¹²¹ The project provides communal space that is well-designed with the grand stairs, incorporating the space

¹¹⁸ "Washington College — Semans-Griswold Environmental Hall," *Ayers Saint Gross*, last modified October 31, 2023, <https://ayerssaintgross.com/work/project/washington-college-semans-griswold-environmental-hall/>.

¹¹⁹ *Ibid.*

¹²⁰ *Ibid.*

¹²¹ "Roux Center for the Environment / CambridgeSeven," *ArchDaily*, last modified January 29, 2020, https://www.archdaily.com/932718/roux-center-for-the-environment-cambridgeseven?ad_source=search&ad_medium=projects_tab.

with the vertical circulation. This building acts as a teaching lab of sustainable and innovative construction technologies, including a rooftop photovoltaic array, gray water reclamation system and high-efficiency mechanical systems, while the site features a bioswale to manage stormwater runoff.¹²²

¹²² Ibid.

Semans-Griswold Environmental Hall

Washington College, Chestertown, MD

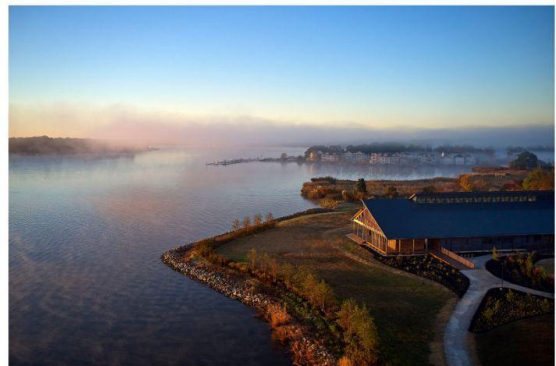
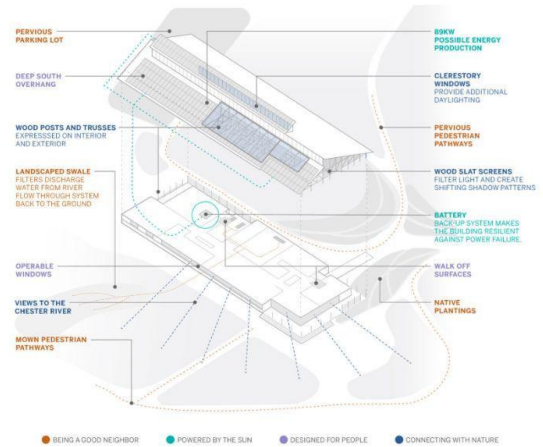
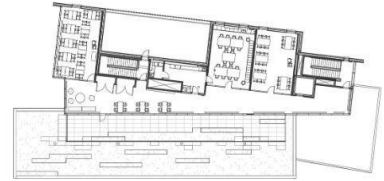
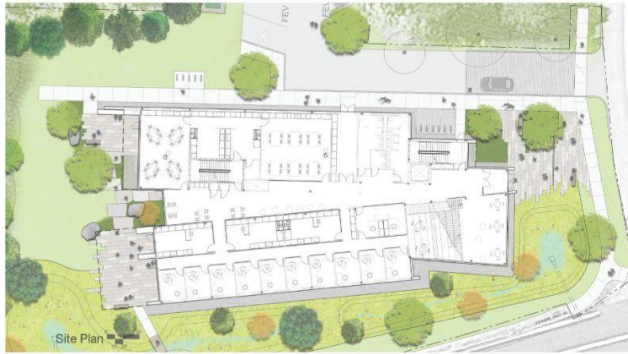


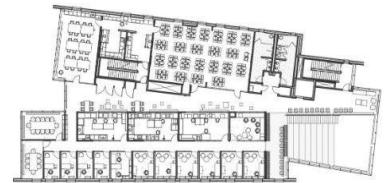
Figure 5.3: Semans-Griswold Environmental Hall.
(Source: Ayers Saint Gross)

Roux Center for the Environment

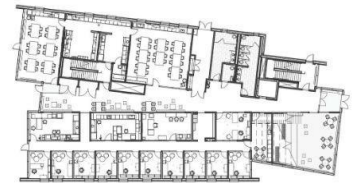
Bowdoin College, Brunswick, Maine



Third Floor Plan



Second Floor Plan



First Floor Plan



Figure 5.4: Roux Center for the Environment.
(Source: ArchDaily, Photographs: Jeff Goldberg/Esto)

Reverse Engineering Documentation

Semans-Griswold Environmental Hall, Chestertown, MD

The project accommodates a diverse research program through a carefully configured spatial hierarchy. Dedicated indoor laboratory spaces offer controlled environments for analytical work, while open-air research areas provide opportunities for in-site observation and experimentation. Closed and open work spaces provide users flexibility and privacy, while dedicated communal space fosters collaboration and knowledge exchange. Analysis of the tabulation reveals a significant presence of research space within both the site and building. This finding informs the development of the thesis program by providing a concrete foundation for the spatial allocation and program elements dedicated to research activities. Additionally, while communal space constitutes only 15% of this project's overall building area, its strategic allocation aligns with the thesis program's emphasis on collaborative research and knowledge production. This prioritization reflects a deliberate intent to promote synergistic interactions and facilitate cross-disciplinary exchange among researchers and community members.

This project embraces the opportunity to create a creative promenade and dynamic spatial experience through the strategic integration of green infrastructure and connection with surrounding natural elements. The semi-outdoor space: an outdoor deck with overhang facilitates a seamless transition between indoor and outdoor realms, fostering biophilic design principles and promoting occupation well-being.

Semans-Griswold Environmental Hall				
Washington College, Chestertown MD				
SITE	Description	Quantity	Size	Total
	Semi-Outdoor Space			
	Outdoor Deck	1	3,548	3,548
				3,548 (2%)
	Outdoor Research Space			
	Geothermal Well Field	1	31,605	31,605
	Shrub Nursery Bed	1	3,790	3,790
	Upland Shrub Bed	1	1,610	1,610
	Foraging Meadow	1	5,880	5,880
	Pollinator/Medicinal Meadow	1	5,588	5,588
	Low-Grass Meadow	1	3,257	3,257
	Habitat Meadow 1	1	5,233	5,233
	Habitat Meadow 2	1	20,540	20,540
	River Flow-through Swale	1	3,260	3,260
	Woodland Planting	1	9,434	9,434
	Mesocosms	1	1,107	1,107
	Vegetated Swale	1	7,100	7,100
				98,404 (68%)
	Other Landscape Features			
	Gravel Lot	1	22,624	22,624
	Crushed Stone Paths	1	5,495	5,495
	Open Lawn	1	12,134	12,134
	Mulch Paths	1	1,800	1,800
	Bike Racks	1	845	845
				42,898 (30%)
	Total			144,850

BUILDING	Description	Quantity	Size	Total
	Research Lab Space			
	Environmental Research Lab	1	524	524
	Lab Prep Room	1	200	200
	Mud Room	1	218	218
	Watershed Innovation Lab	1	1,125	1,125
	Wet Lab	1	1,061	1,061
				3,128 (30%)
	Work Space			
	Office 1	1	269	269
	Office 2	1	178	178
	Office 3	1	180	180
	Breakout Room	1	123	123
	Open Office	1	1,478	1,478
	Work Station	1	258	258
				2,486 (23%)
	Communal Space			
	Lobby	1	550	550
	Common	1	432	432
	Classroom	1	666	666
				1,648 (15%)
	Support			
	Men	1	192	192
	Women	1	192	192
	Restroom	1	80	80
	Storage 1	1	207	207
	Storage 2	1	154	154
	Janitor	1	116	116
	Mechanical Room	1	269	269
	Electrical Room	1	213	213
	MDF Room	1	205	205
	Stairs	1	226	226
				1,854 (17%)
	Circulation			1,592 (15%)
	Total			10,708

Figure 5.5: Reverse Engineering Exercise in Tabular Format (Source: Author)

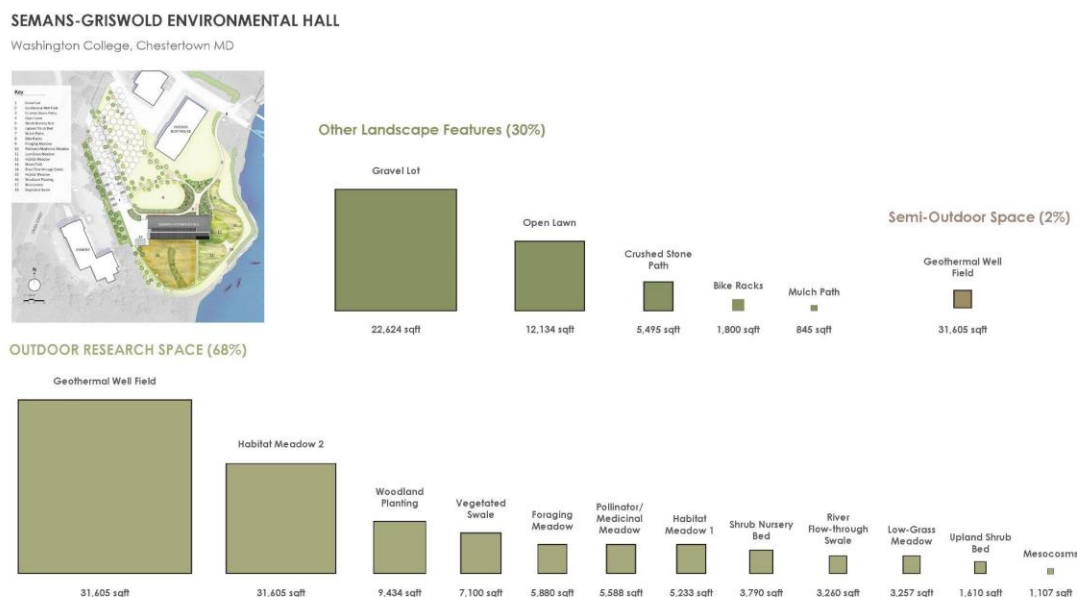
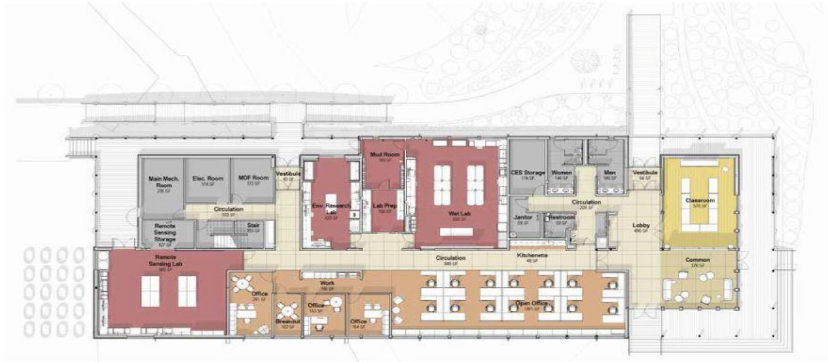


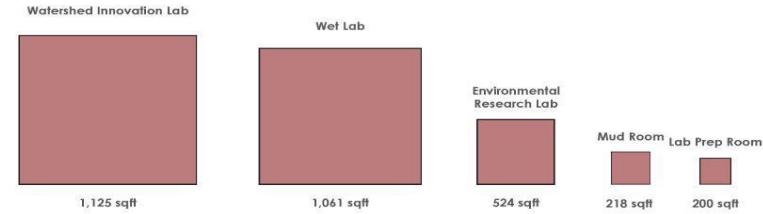
Figure 5.6: Reverse Engineering Exercise in Graphic Format, Site (Source: Author)

SEMANS-GRISWOLD ENVIRONMENTAL HALL

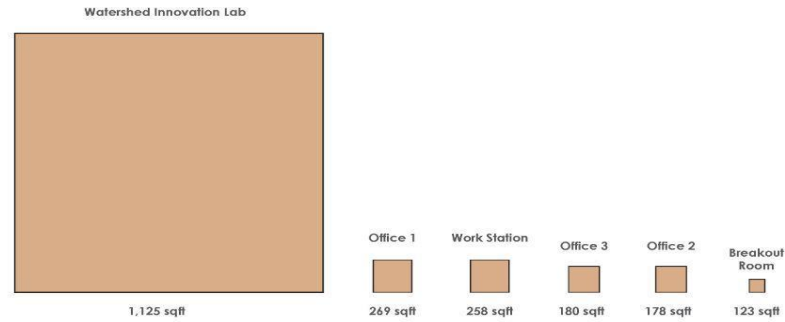
Washington College, Chestertown MD



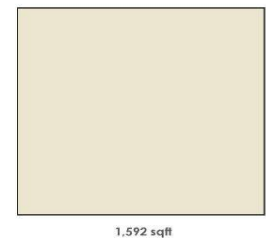
RESEARCH LAB SPACE (30%)



WORK SPACE (23%)



Circulation (15%)



Communal Space (15%)



Support (17%)



Figure 5.7: Reverse Engineering Exercise in Graphic Format, Building (Source: Author)

Thesis Program in Tabular and Graphic Formats with Program Zones

SITE	Description	Quantity
	Semi-Outdoor Space	
	Shaded zone	3
		14,243 (5%)
	Outdoor Research Space	
	Zone1	3
	Zone2	3
	Zone3	2
	Zone4	2
	Zone5	1
	Zone6	1
	Zone7	1
	Zone8	1
	Zone9	1
	Zone10	1
		185,159 (65%)
	Outdoor Learning/Recreational Space	
	Zone1	1
	Zone2	1
	Zone3	1
	Zone4	1
	Zone5	1
		85,458 (30%)
	Total	284,860 (100%)

ENERGY (3rd Floor)	Description	Quantity
	Research Lab Space for Energy Zone	
	Lab 1	1
	Lab 2	1
	Lab 3	1
	Lab 4	1
	Lab 5	1
		30%
	Work Space for Energy Zone	
	Enclosed Offices	5
	Open Office	2
	Breakout Rooms	5
	Conference Rooms	3
	Classrooms	5
	Lecture Hall	2
	Kitchens	2
	Common	3
		40%
	Service	
		15%
	Circulation	15%
	Total (Floor)	100%
	Total (Entire Building)	15%

ENVIRONMENT (4th Floor)	Description	Quantity
	Research Lab Space for Environmental Zone	
	Lab 1	1
	Lab 2	1
	Lab 3	1
	Lab 4	1
	Lab 5	1
		30%
	Work Space for Environmental Zone	
	Enclosed Offices	5
	Open Offices	2
	Breakout Rooms	5
	Conference Rooms	3
	Classrooms	5
	Lecture Hall	2
	Kitchens	2
	Common	3
		40%
	Service	
		15%
	Circulation	15%
	Total (Floor)	100%
	Total (Entire Building)	15%

OTHERS (5th Floor)	Description	Quantity
	Research Lab Space for Other Zones	
	Lab 1	1
	Lab 2	1
	Lab 3	1
	Lab 4	1
	Lab 5	1
		30%
	Work Space for Other Zones	
	Enclosed Offices	5
	Open Offices	2
	Breakout Rooms	5
	Conference Rooms	3
	Classrooms	5
	Lecture Hall	2
	Kitchens	2
	Common	3
		40%
	Service	
		15%
	Circulation	15%
	Total (Floor)	100%
	Total (Entire Building)	15%

CO-WORKING (2nd Floor)	Description	Quantity
	Research Lab Space for Co-working	
	Lab 1	1
	Lab 2	1
	Lab 3	1
	Lab 4	1
	Lab 5	1
		15%
	Work Space for Co-working	
	Open Offices	3
	Conference Rooms	5
	Classrooms	5
	Lecture Hall	2
		25%
	Recreational Space for Everyone	
	Kitchens	3
	Cafe	2
	Common	5
	Play Area	3
	Grand Stairs as sitting area	1
		30%
	Service	
		15%
	Circulation	15%
	Total (Floor)	100%
	Total (Entire Building)	25%

Figure 5.8: Thesis Program in Tabulation Format with Four Program Zones, Community, Co-working, Energy, and Environmental (Source: Author)



Figure 5.9: Thesis Program in Graphic Formats (Source: Author)

Chapter 6: Site Selection and Analysis

Site Selection Abstract

Along with the intensifying reality of climate change, urban regions face a growing burden of vulnerabilities. This thesis aims to identify suitable sites for implementing targeted climate adaptation strategies within urban fabric, focusing specifically on areas with emerging needs and high susceptibility to climate-related risks. In site selection process, this thesis prioritizes five key site criteria: 1) Proximity to Schools; 2) Level of Carbon Emission Rate; 3) Level of Climate Change Risks and Hazards; 4) Source Energy Production; 5) Level of Isolation from Surrounding Areas. A dense concentration of institutions surrounding the site creates a wealth of potential partnerships and collaborative learning opportunities. This proximity not only allows for strategic collaborations with research institutions, but also creates flexible learning pathways for students, enabling them to engage with diverse academic disciplines and perspectives on climate change.

The multifaceted criteria including carbon emission rate, climate change vulnerability, and energy source provide an insightful understanding of the site's current environmental sustainability and potential needs. This allows for a holistic assessment of challenges and opportunities for treated interventions. The carbon emission rate reveals the current environmental pressure, while climate change vulnerability exposes potential future risks. The criteria about energy sources identifies existing infrastructure and opportunities for transition. This comprehensive

approach synergistically integrates various features to increase the potential for positive environmental change and drive a sustained transition from existing negative conditions. The interplay of these features creates a virtuous cycle of environmental improvement, fostering resilience and ecological restoration.

Site Selection Criteria Matrix with Scoring System

Site Criteria

- 1) Proximity to Schools
- 2) Level of Carbon Emission Rate
- 3) Level of Climate Change Risks and Hazards
- 4) Source of Energy used to produce electricity
- 5) Level of Isolation from Surrounding Areas
- 6) Access to Renewable Energy
- 7) Availability and Quality of Water Infrastructure
- 8) Size of Land
- 9) Proximity to Research Institution/Environmental Centers
- 10) Proximity to Green Infrastructure
- 11) Population Density
- 12) Existing Presence of Cultural and Historical Heritage

Scoring System

		Delaware Generating Station 1325 N Beach St, Philadelphia, PA 19125	Brunot Island Power Station Brunots Island Trail, Pittsburgh, PA 15233	NRG Potomac River Generating Station 1400 N Royal St, Alexandria, VA 22314
Scale: 1 (Least Ideal) - 5 (Most Ideal)		Oil-fueled electricity	Gas-fired electricity	Coal-fired electricity
Criteria				
Priority	Proximity to Schools	4	5	2
	Level of Carbon Emission Rate	5	2	3
	Level of Climate Change Risks and Hazards	5	2	3
	Sources of Energy used to produce electricity	5	4	3
	Level of Isolation from surrounding area	4	5	3
	Access to Renewable Energy (Less % is more ideal)	5	4	3
	Availability and Quality of Water Infrastructure	3	5	5
	Size of land	5	3	4
	Proximity to Research Institutions (More looking for Environmental Centers)	5	5	5
	Proximity to Green infrastructure	4	3	5
	Population Density	5	4	3
	Existing presence of Cultural and Historical Heritage	3	4	3
	Total (60 possible points)	53	46	42
Percentage		88%	77%	70%

Figure 6.1: Site Selection Criteria Matrix (Source: Author)

Three Selected Sites

Site 1: Delaware Generating Station, Philadelphia, PA



Figure 6.2: Delaware Generating Station. (Source: Google Earth Underlay)

Site 2: Brunot Island Power Station, Pittsburgh, PA



Figure 6.3: Brunot Island Power Station. (Source: Google Earth Underlay)

Site 3: NRG Potomac River Generating Station, Alexandria, VA

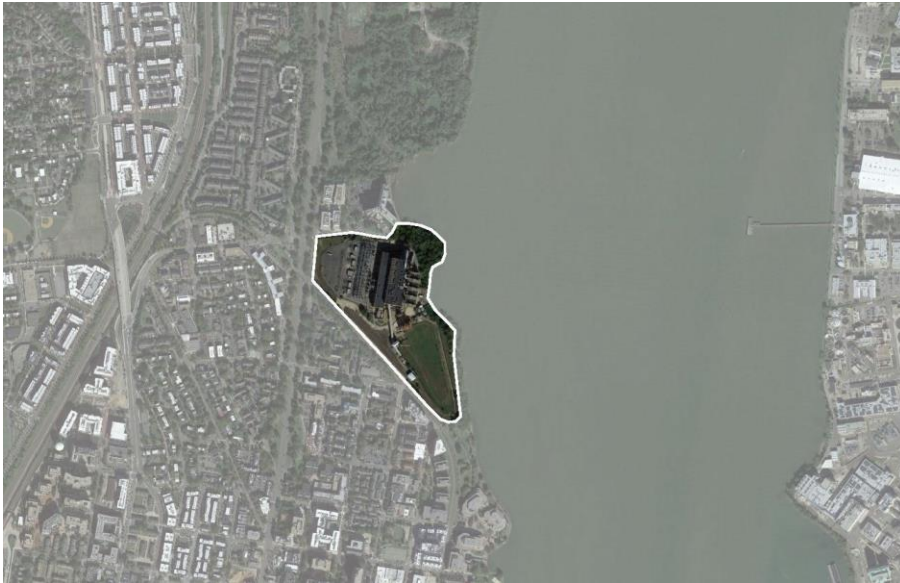


Figure 6.4: NRG Potomac River Generating Station. (Source: Google Earth Underlay)

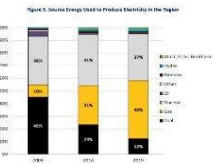
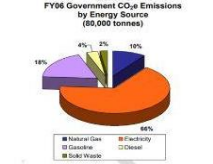
	Delaware Generating Station 1325 N Beach St, Philadelphia, PA 19125	Brunot Island Power Station Brunots Island Trail, Pittsburgh, PA 15233	NRG Potomac River Generating Station 1400 N Royal St, Alexandria, VA 22314
Type of Power Plant	Oil-fired electricity	Gas-fired electricity	Coal-fired electricity
Criteria			
Proximity to Schools	Within 1.5 mi. - 6 Elementary Schools - 1 Middle School - 2 High Schools Nearby University - Temple University	Within 1.5 mi. - 5 Elementary Schools - 5 Middle Schools - 3 High Schools Nearby University - Carnegie Mellon University - University of Pittsburgh	Within 1.5 mi. - 1 Elementary School - 1 Middle School - 1 High School
Level of Carbon Emission Rate	Annual GHG Emissions (MTCO2e) 20 million	Annual GHG Emissions (MTCO2e) 877,442	Annual GHG Emissions (MTCO2e) 1.47 million
Level of Climate Change Risks and Hazards			
Sources of Energy used to produce electricity		- nuclear power, natural gas, and coal as their main energy sources - Pennsylvania ranks second in the nation in nuclear power consumption - Coal-fired plants produce 33% of the total energy generation in the state	
Level of Isolation from surrounding area	Medium - There is public park right next to the facility.	High - No pedestrian/vehicular bridge to go to the island - Only railroad tracks	Low - Near residential area and there is a trail going across in front of the building - Tidal Lock Park right next to the site
Access to Renewable Energy	- 3% in Pennsylvania - About 9% renewable electricity, mainly from local solar RECs - Available sources: solar, geothermal, wind, hydropower and biomass	- 3% in Pennsylvania - 8% renewable energy but have plan for 100% renewable energy use by 2035 - Available sources: solar, geothermal, wind, hydropower and biomass	- 9% renewable energy uses in Virginia, mainly solar in Alexandria - Available sources: hydroelectric, wind, solar, and geothermal
Availability and Quality of Water Infrastructure	Delaware River - No swimming - Upper part contains some of the highest water quality in the eastern United States	Ohio River - One of the most polluted rivers in the U.S. - Served as dumping ground for local cities and industries for generations	Potomac River - Not safe for swimming and fishing - Not safe to eat fish from the river - Health "B" grade
Size of land	12.8 acres	129 acres	18.76 acres
Proximity to Research Institutions (More towards Environmental Centers)	Total 7 research institutions within 3.0 mi. - 5 Medical Related Research - 1 Education Related Research - 1 Science History None related to environment/climate change	None within 3.0 mi. - 1 care management related research in 4.0 mi. - Several research centers for University of Pittsburgh in 7.0 mi. None related to environment/climate change	Total 2 research institutions within 3.0 mi. - 2 Science related research None related to environment/climate change
Proximity to Green infrastructure	Total 10 parks within 1.5 mi. 1. Penn Treaty Park (5min walk, 0.2mi): Right next to station 2. Palmer Park (17min walk, 0.7mi) 3. Liberty Lands (23min walk, 1.0mi) 4. Orkney Park: Community garden (27min walk, 1.2mi) 5. Benson Park (29min walk, 1.3mi) 6. Konrad Square (26min walk, 1.2mi) 7. Towey Playground (25min walk, 1.1mi) 8. Norris Square Park (31min walk, 1.3mi) 9. Cione Playground (27min walk, 1.2mi) 10. Tezzi-Reitz Veteran's Memorial Park (31min walk, 1.4mi)	Total 5 parks within 1.5 mi. 1. Sheraden Park (31min walk, 1.3mi) 2. McGonigle Park (43min walk, 1.8mi) 3. Marshall - California Parklet (2hr walk, 5.2 mi) 4. Manchester Park (1hr 46min walk, 4.6mi) 5. West End Overlook Park (1hr 7min, 2.8mi)	Total 16 parks within 1.5 mi. 1. Mt Vernon Trail right in front of the station (in-between river and station) 2. Chetworth Park (16min walk, 0.7mi) 3. Tide Lock Park (8min walk, 0.4mi) 4. Promenade Classique Sculpture Garden (10min walk, 0.5mi) 5. Montgomery Park (13min walk, 0.6mi) 6. Rivergate City Park (13min walk, 0.6mi) 7. Alexandria House Park (15min walk, 0.7mi) 8. Oronoco Bay Park (14min walk, 0.7mi) 9. Powhatan Park (20min walk, 0.9mi) 10. Eugene Simpson Stadium Park (27min walk, 1.2mi) 11. Portner Park (24min walk, 1.1 mi) 12. West's Point Park (21min walk, 1.0mi) 13. Founders Park (22min walk, 1.0mi) 14. Helen Miller/Bernard Hunter Park (35min walk, 1.5mi) 15. Neighborhood Park (29min walk, 1.3mi) 16. Potomac Greens Park (21min walk, 1.0 mi)
Population Density	Philadelphia - 11,936.9 per square mile Region (Philadelphia City School District) - Total population: 1,603,797 - Total housing units: 726,797	Pittsburgh - 5,471.3 per square mile Region (Pittsburgh School District) - Total population: 306,350 - Total housing units: 159,458	Alexandria - 4,800 per square mile Region (Alexandria City Public Schools) - Total population: 159,467 - Total housing units: 80,479
Existing presence of Cultural and Historical Heritage	- Fishtown was an American industrial powerhouse before WWII	- Natural elements (the majority of the island is wildlife and animals) - The land was used for farming - Old race tracks	- Residential district - sight of the Washington Monument - near Alexandria Old Town - High-value riverfront land

Figure 6.5: Three Selected Sites Analysis (Source: Author)

Preferred Site Selected and Analysis: Delaware Generating Station, Philadelphia, PA

History

The Delaware Power Station was built by the Philadelphia Electric Company in 1920, to prevent a predicted power shortage.¹²³ It operated steadily from then on, with an expansion in 1953, until its last two turbine units were silenced in February 2004.¹²⁴ The building was designed by architects John T. Windrim and W.C.L. Englin in 1917, and the station provides the great public buildings of its time, with similar massing and classical details.¹²⁵ Once the largest power plant in the city of Philadelphia and the source of most of its electricity, the Delaware Station was first conceived as a solution to the patchwork of over 25 electrical services in Philadelphia that provide power to businesses, streetlights, industries, and homes.¹²⁶ However, by the 1950s, coal powered plants were considered obsolete, dirty, and insufficient when compared to the new innovative generator in the energy industry: nuclear power.¹²⁷ Despite the construction of the nuclear power plants in Peach Bottom and Limerick, Delaware Station still remained online. By 1969, the main turbine hall and original boiler houses were inactive and only the 1953 expansion was still online. The National Register of Historic Places (NRHP) form states by 2000 the plant's

¹²³ Matt Blanchard, "How the Exelon Delaware Power Plant Came to Be," *WHYY PBS*, last modified January 1, 2007, <https://whyy.org/articles/677/#:~:text=The%20Delaware%20Power%20Station%20was,Windrim%20and%20W.C.L>

¹²⁴ *Ibid.*

¹²⁵ *Ibid.*

¹²⁶ Matthew Christopher, "Delaware River Generating Station," *Abandoned America*, last modified September 24, 2021, <https://www.abandonedamerica.us/delaware-river-generating-station>.

¹²⁷ *Ibid.*

expansion was only used to balance out times of peak demand and the entire station was mothballed in 2008.¹²⁸ In 2015, the property was sold to developers Bart Baltstein and Joseph Volpe, who planned to turn it into a hotel and high-end event space complete with restaurants and ballrooms.¹²⁹

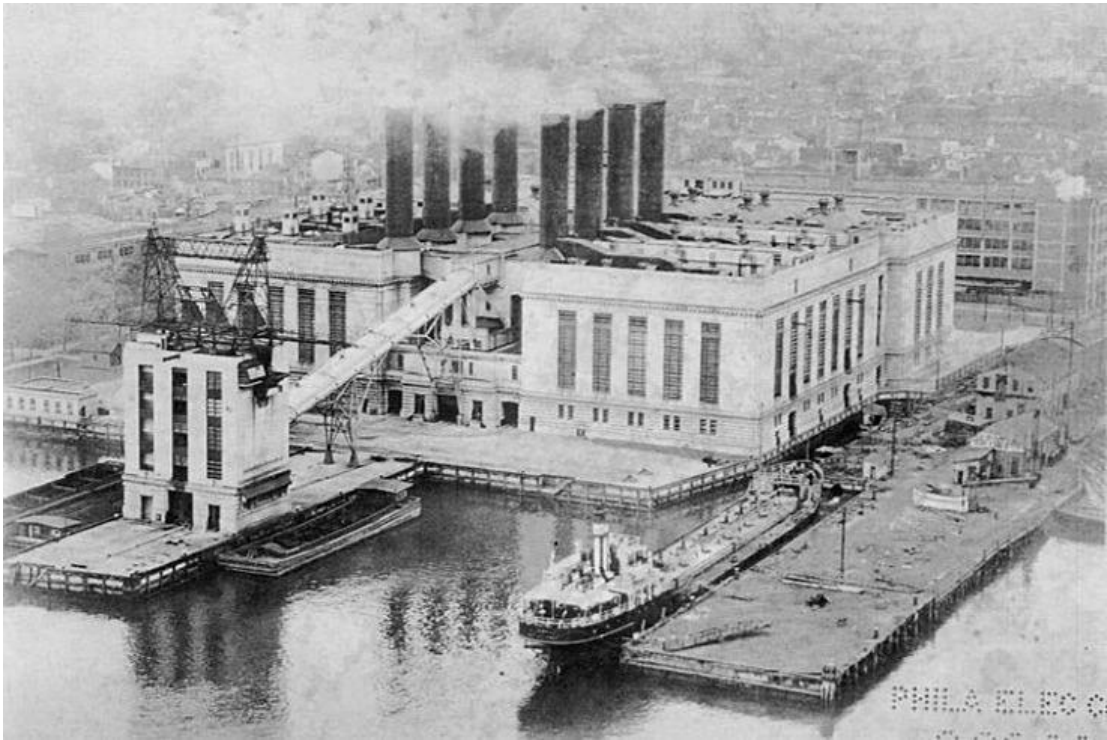


Figure 6.6: Historical Photograph of Delaware River Generating Station in Philadelphia.
(Source: Abandoned America, Matthew Christopher)

Vulnerability to Climate Change

Among the three selected sites, Philadelphia emerges as a clear focal point for intervention based on its concerning environmental metrics. The site exhibits the highest recorded carbon emission rate and the greatest reliance on non-renewable

¹²⁸ Ibid.

¹²⁹ Ibid.

energy sources, indicating a pressing need for decarbonization and clean energy transitions. The data indicates that the annual GHG emissions in Philadelphia is 20 million metric tons of carbon dioxide equivalent (MTCO₂e).¹³⁰ Figure 7.4 illustrates how the use of different Global Warming Potential (GWP) values affects the overall emissions and the contribution by gas. Moreover, Figure 7.5 shows the mix of fuels used to produce electricity in the region, based on data from the EPA.

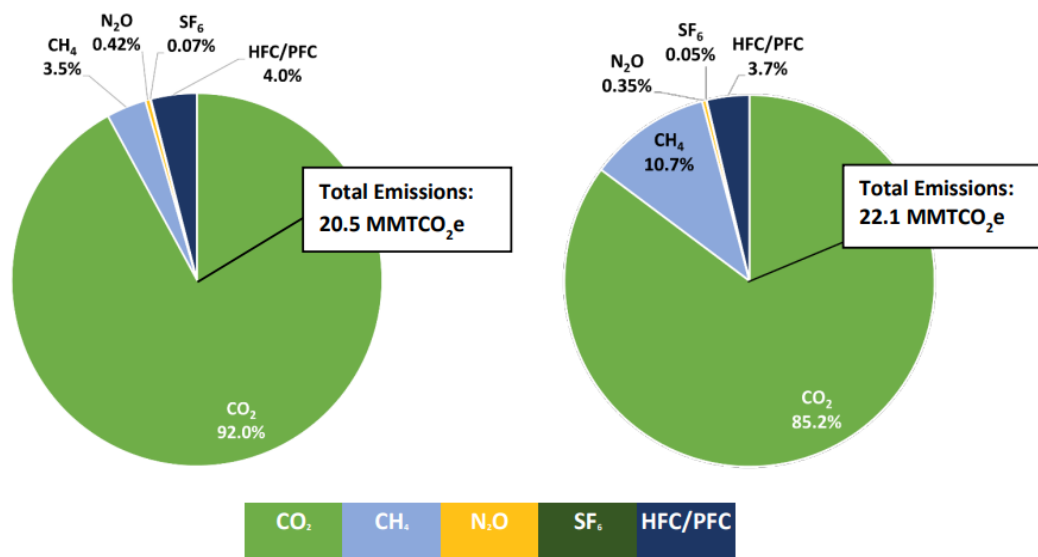


Figure 6.7: 2019 GHG Emissions, Contribution by Gas. (Left) Using 100-year GWP and (Right) Using 20-year GWP. (Source:2019 Greenhouse Gas Inventory Results and Methods)

¹³⁰ 2019 Greenhouse Gas Inventory Results and Methods (City of Philadelphia, Office of Sustainability, 2022), <https://www.phila.gov/media/20220418144709/2019-greenhouse-gas-inventory.pdf>.

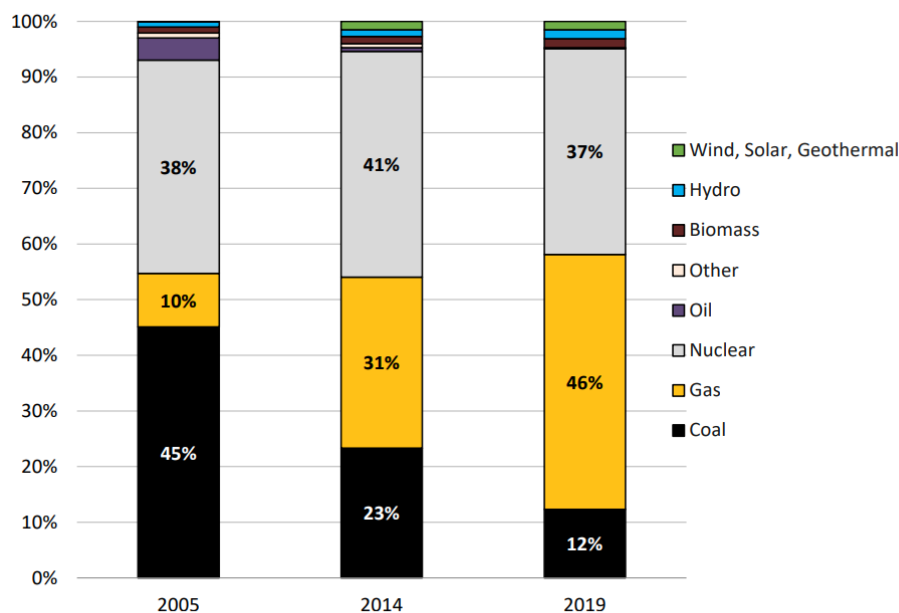


Figure 6.8: Source Energy used to produce Electricity in the Region, Philadelphia.
(Source: 2019 Greenhouse Gas Inventory Results and Methods)

Compelling data paint a concerning picture of Philadelphia’s future, revealing heightened climate change risks and hazards. Projections indicate a significant increase in risks associated with precipitation, heat and drought, demanding proactive adaptation strategies to ensure the city’s resilience. Precipitation risks in Philadelphia are a risk of flooding and the risk level for these buildings is significant. About 19% of buildings are at risk of flooding.¹³¹ An extreme storm for Philadelphia is a 48-hour rainfall total greater than 1.0 inches. Historically, about 18.3 inches of rain fell over about 11 storms each year, and by 2050, about 22.2 inches of rain are projected over about 13 storms each year in Philadelphia.¹³² The annual precipitation in the region is

¹³¹ “Philadelphia, PA Top Climate Change Risks: Precipitation, Heat, Drought,” *ClimateCheck*, last modified 2022, <https://climatecheck.com/pennsylvania/philadelphia#:~:text=Get%20an%20Instant%20Risk%20Assessment&text=Precipitation%20risk%20in%20Philadelphia%2C%20PA,for%20these%20buildings%20is%20significant.>

¹³² *Ibid.*

projected to increase from about 45.7 inches to about 49.5 inches.¹³³ Climate change increases the potential for extreme rainfall or snowfall. Additionally, people in Philadelphia experienced about 7 days above 93.6 °F in a year in a typical year between 1985-2005. However, by 2050, people are projected to experience an average of about 36 days per year over 93.6 °F.¹³⁴

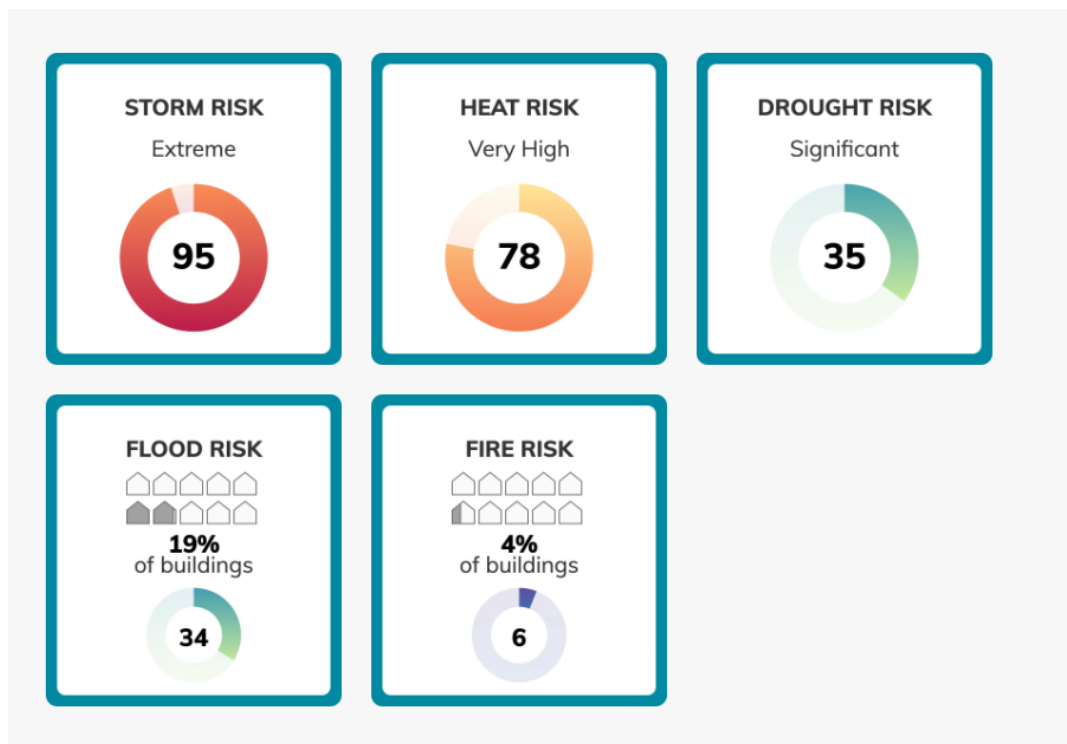


Figure 6.9: Climate Change Hazard Ratings for Philadelphia, PA. (Source: ClimateCheck)

¹³³ Ibid.

¹³⁴ Ibid.

Chapter 7: Convergence

Concept Explorations: Blocking and Stacking

Building Scale

There is a positive correlation between level and perceived privacy, suggesting that individuals occupying on higher levels experience greater privacy. The two lowest levels function as designated collaborative hubs, fostering uninhibited interaction and synergy among all occupants. Through open floor plan layouts, flexible furnishings, and integrated spatial division, the ground floor and lower level are intentionally designed to encourage collaboration, which also provides easier and more comfortable access to the building.



Figure 7.1: Placement of Program Zones from Level 1 to Level 5. (Source: Author)

From the third to fifth floors, a standardized spatial organization prevails, offering a sense of predictability and efficiency. This consistency in layout is punctuated by variations in research lab typologies and dimensions, catering to diverse research needs. The majority of office spaces combine enclosed and open areas, fostering both focused work and collaboration within individual teams. The second floor reconfigures itself as a dedicated coworking zone, featuring an expansive and inviting communal area. This strategically distributed open space encourages spontaneous encounters, informal knowledge sharing, and a dynamic exchange of ideas, promoting a collaborative and interdisciplinary research environment and community center.



Figure 7.2: Detailed Program divisions per Floor. (Source: Author)

Chapter 8: Thesis Design Solution

This thesis design solution investigates the potential of post-industrial cities to transform into sustainable live-work-play communities. It proposes a paradigm shift from prioritizing solely economic profits and mass production reliant on non-renewable energy sources. The focus instead becomes fostering a sense of community within these spaces while supporting the development of innovative methods for implementing renewable energy. This approach aims to normalize these sustainable strategies in our daily lives. The proposed design solution transcends the implementation of renewable energy systems. It additionally focuses on the adaptive reuse of post-industrial waterfront, aiming to elucidate the connectivity between these revitalized spaces and the existing urban fabric.

Existing Site Condition: Challenge

Post-Industrial Waterfront: Delaware River

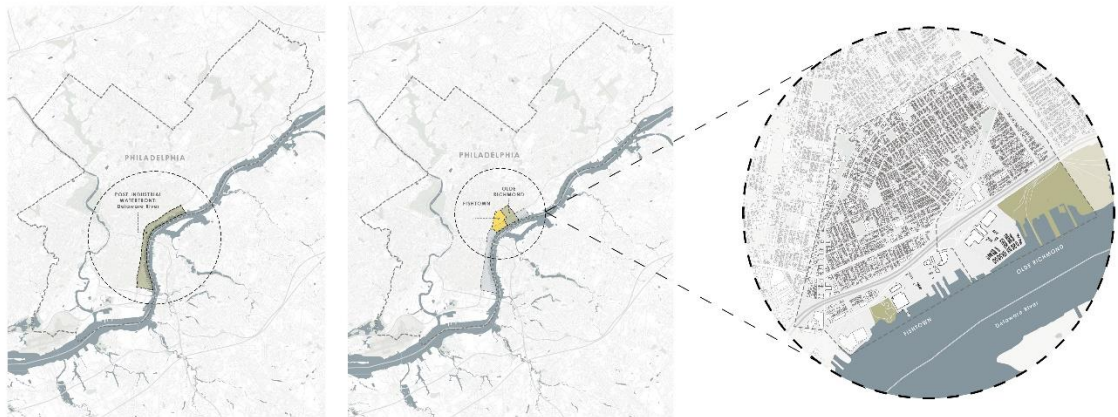


Figure 8.1: Site Location. (Source: Author)

The proposed site is situated along the Delaware River, at the confluence of Fishtown and Olde Richmond. This area formerly housed the Delaware Generating Power Station, which ceased operation in 1969. Due to its waterfront location, the site falls within the Federal Emergency Management Agency's (FEMA) 100-year and 500-year floodplains. Data indicates that 175,996 properties in Philadelphia face a greater than 32.2% chance of experiencing severe flooding over the next 30 years.¹³⁵ This significant flood risk in Philadelphia necessitates a comprehensive approach to mitigate its potential impact on the envisioned community's daily life.

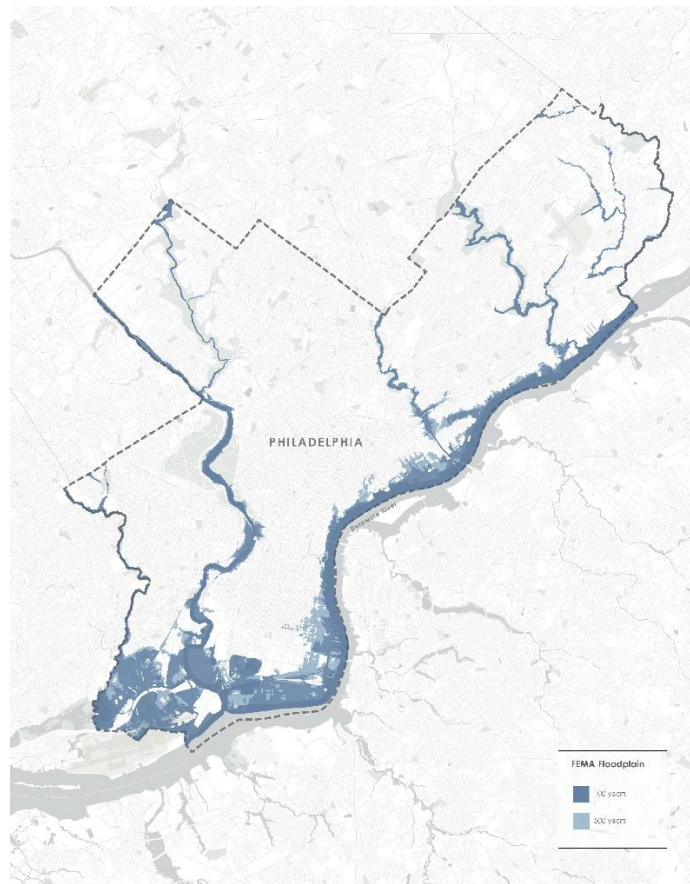


Figure 8.2: Philadelphia FEMA 100-year and 500-year Floodplain.
(Source: Author, ArcGIS underlay)

¹³⁵ "Philadelphia Flooding Risk," *RiskFactor.Com*, accessed May 17, 2024, https://riskfactor.com/city/philadelphia-pa/4260000_fsid/flood.

The Delaware Riverfront's development commenced in 1682 with the arrival of Willam Penn in Philadelphia. The area rapidly transformed into the pivotal center of the Port of Philadelphi, encompassing maritime, commercial, and political activities¹³⁶. Throughout history, the Delaware Waterfront has primarily served as infrastructure. However, with the passage of time, these piers have outlived their original purpose. Consequently, approximately three centuries after Penn's landing in Philadelphia, numerous abandoned piers have undergone adaptive reuse for purposes such as residential spaces and entertainment venues, serving as amenities.



Figure 8.3: An illustration of the Delaware waterfront at Front Street and Market Street in 1702. (Source: City of Philadelphia Archive)

¹³⁶ "History," *Pier 3 Condominium - History of Pier 3*, accessed May 17, 2024, <https://www.pier3.net/history>.



Figure 8.4: An aerial drawing of Philadelphia in 1908. (Source: City of Philadelphia Archive)

Likewise, the area where the Delaware Generating Power Station is located has also started to redevelop. However, despite nascent redevelopment efforts in the vicinity of the former power station, a significant disconnect persists between the waterfront area and the broader urban fabric. This lack of cohesion extends from Penn Treaty Park, the power station itself, and to the recently constructed townhomes. Furthermore, a critical challenge lies in the absence of essential amenities to support the residents of these new townhomes.



Figure 8.5: Existing Land Use Diagram. (Source: Author, ArcGIS underlay)

The existing urban grid also fails to integrate the waterfront area into the broader city fabric, indicating a sense of isolation. A significant contributor to this issue is the I-95 that acts as a physical barrier between the city and the waterfront. While some connecting streets exist, they do not provide easy accessibility, hindering pedestrian and vehicular movement to the area.



Figure 8.6: Post-Industrial Urban Problem Diagram. (Source: Author)

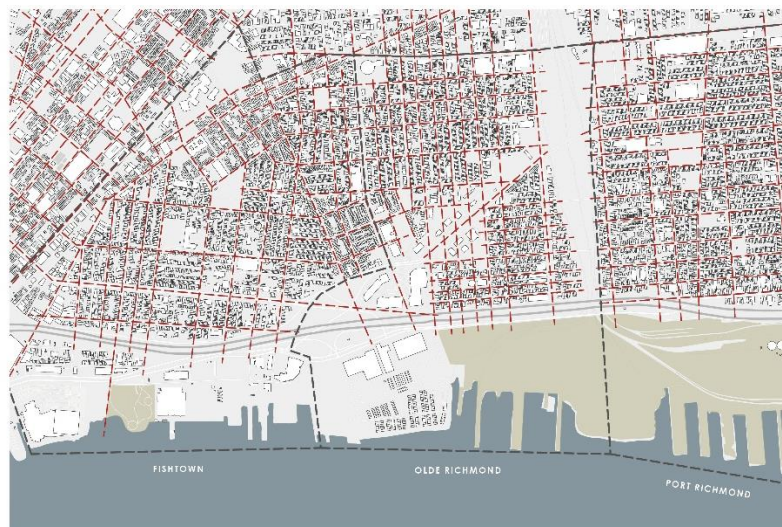


Figure 8.7: Existing City Grid. (Source: Author)

Furthermore, the vast expanse of vacant lots situated between Penn Treaty Park, the power station, and the newly developed townhomes exacerbates the feeling of abandonment. The decommissioning of the power station often leads to the decline of surrounding areas. Even the introduction of new developments, such as the townhomes in this case, would not be able to overcome a fundamental lack of connectivity, resulting in a persistent perception of desolation.



Figure 8.8: Existing Major Streets. (Source: Author)



Figure 8.9: Vacant Properties. (Source: Author)

Post-Industrial Waterfronts Precedents

Brooklyn Bridge Park

Brooklyn Bridge Park is a 1.3-mile-long public waterfront landscape, exemplifies the successful transformation of a neglected industrial area. Prior to its redevelopment, this section of Brooklyn’s shoreline had become isolated and underutilized. The park’s creation not only reconnected the city to its waterfront but also established a benchmark for sustainable waterfront projects around the world. This project primarily aims to achieve a dual purpose: fostering community access and recreation along the water’s edge, while also providing crucial storm protection in the face of rising sea levels due to climate change.¹³⁷



Figure 8.10: Abandoned Waterfront, 1990 to Brooklyn Bridge Park, 2021.
(Source: Michael Van Valkenburgh Associates Inc)

¹³⁷ “Brooklyn Bridge Park,” *Michael Van Valkenburgh Associates Inc*, accessed May 17, 2024, <https://www.mvvainc.com/projects/brooklyn-bridge-park>.

A key aspect of Brooklyn Bridge Park's success lies in its innovative water edge interventions. These interventions address the previously failing sea walls, which were susceptible to breaching during storms. To improve flood resilience, the failing structures were replaced with flood-tolerant stone rip-rap shoreline. This new shoreline provides a more robust defense against rising water levels. The park's designers also strategically incorporated a variety of naturalized and newly constructed shorelines. This variety promotes not only enhancing the ecological health of the waterfront habitat but also creating diverse spaces for visitors to connect with water in different ways. In some areas, deconstruction efforts involved removing partial concrete platforms and excavating the upland areas. This process facilitated the creation of natural living shorelines that better integrate with the surrounding landscape.¹³⁸



Figure 8.11: The Water's Edge.
(Source: Michael Van Valkenburgh Associates Inc)

¹³⁸ Ibid.

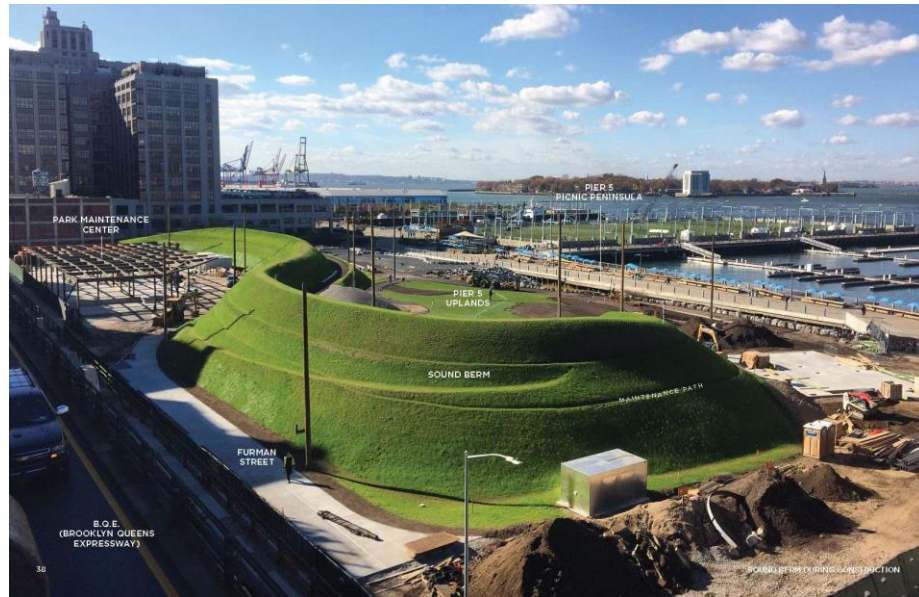


Figure 8.12: The Sound Berm.
(Source: Michael Van Valkenburgh Associates Inc)

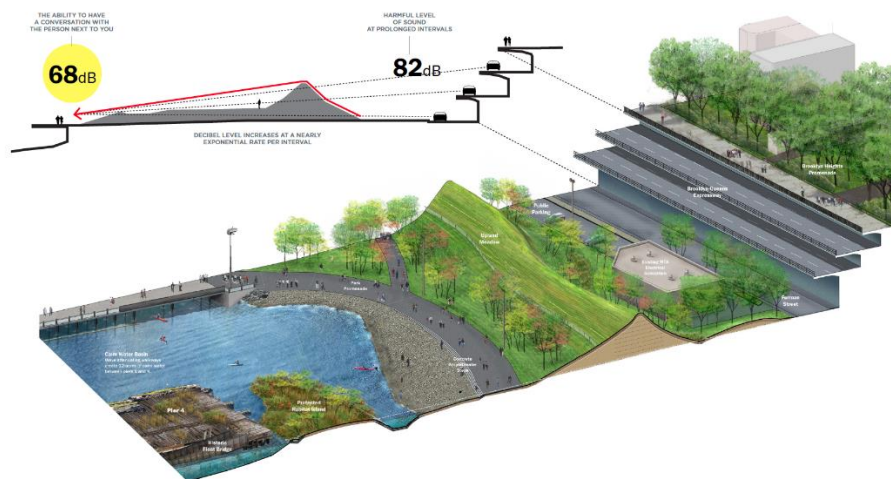


Figure 8.12: The Sound Berm Transect Diagram.
(Source: Michael Van Valkenburgh Associates Inc)

India Basin Waterfront Park

India Basin Waterfront Park in San Francisco proposes a 1.7-mile network of trails and green spaces, and this proposal presents a unique opportunity to not only revitalize a abandoned waterfront but also to implement innovative water edge interventions. Currently, the shoreline is likely dominated by industrial infrastructure, potentially hindering public access and ecological health. The development of the park provides a chance to rethink the relationship between the city and the bay.



Figure 8.13: India Basin Waterfront Park Site Plan. (Source: GGN)

Sustainable and resilient solutions should be at the forefront of the water edge design. Replacing existing bulkheads with a “living shoreline” could be explored. This natural approach utilizes native plants, rocks, and other materials to create a more ecologically beneficial habitat. This living shoreline can act as a buffer against rising sea levels while providing improved water quality and habitat for marine life. Additionally, incorporating tidal pools or gently sloping shoreline could enhance

public access to the water's edge, supporting a deeper connection between the community and the bay.¹³⁹



Figure 8.14: Before and After Development. (Source: Emily Gosack LinkedIn Post)

Design Approach

The thesis proposes a comprehensive masterplan for the redevelopment of an abandoned Delaware riverfront area, fostering a sustainable live-work-play community and promoting resiliency. The proposal prioritizes the integration of the site into the existing urban fabric, stitching it back to the existing city grid through the introduction of diverse programs. Previously vacant spaces between the power

¹³⁹ “India Basin Waterfront Park,” *San Francisco Recreation and Parks, CA*, accessed May 17, 2024, <https://sfrecpark.org/1153/India-Basin-Waterfront-Park>.

station, townhomes, and further to existing green space are filled with new functions, promoting a sense of place and encouraging community interaction.



Figure 8.15: Illustrative Site Plan. (Source: Author)



Figure 8.16: Proposed Grid Diagram. (Source: Author)

The proposed land use program strategically zones the area for a variety of uses, creating a dynamic and well-integrated community. The power station and surrounding area are designated for institutional purposes, potentially housing research and development facilities focused on innovative energy systems. This zone transitions seamlessly into a commercial corridor, offering a vibrant mix of retail stores, theaters, and other amenities to cater to the needs of residents and visitors alike. The heart of the masterplan lies in the central plaza, acting as a focal point for circulation and a hub for social interaction and environmental education. Flowing outwards from the plaza, a residential area offers a mix of townhomes and mixed-use housing options. This residential zone sits adjacent to a large green space, providing a tranquil escape and much-needed recreational space for residents and visitors. The green space also acts as a buffer zone, separating the residential area from the neighboring industrial zone. By strategically integrating a diverse range of uses, the masterplan fosters a cohesive and vibrant community while prioritizing environmental sustainability.



Figure 8.17: Proposed Land Use Diagram. (Source: Author)



Figure 8.18: Proposed Places Diagram. (Source: Author)

Water Edge Interventions: Resiliency

The proposed design emphasizes a resilient and sustainable approach to the waterfront. A key intervention involves replacing the existing man-made shoreline with a variety of natural edge configurations. The diverse water edge interventions not only showcase a range of adaptation strategies, promoting ecological resilience and public access, but also provide visitors with opportunities to learn about various methods for combating climate change through firsthand experience.



Figure 8.19: Key Site Plan for Water Edge Interventions. (Source: Author)

This includes:

- 1) **Preserved Pier:** One existing pier is retained to serve as a stop for water taxis, promoting sustainable transportation options.

Water Edge Condition (A)

Preserve Existing Pier for Water Transportation



Figure 8.20: Water Edge Intervention A. (Source: Author)

- 2) **Living Shoreline and Constructed Berm:** A combination of a naturalized shoreline with native plants and constructed berm provides a buffer against flooding, fostering ecological health while enhancing protection from rising sea levels.

Water Edge Condition (B)

Berm with Living Shoreline



Figure 8.21: Water Edge Intervention B. (Source: Author)

- 3) **Grand Staircase Access:** A grand staircase directly connects the central plaza to the water's edge, providing a deeper connection between the community and the water.

Water Edge Condition (C)

Direct View to Water

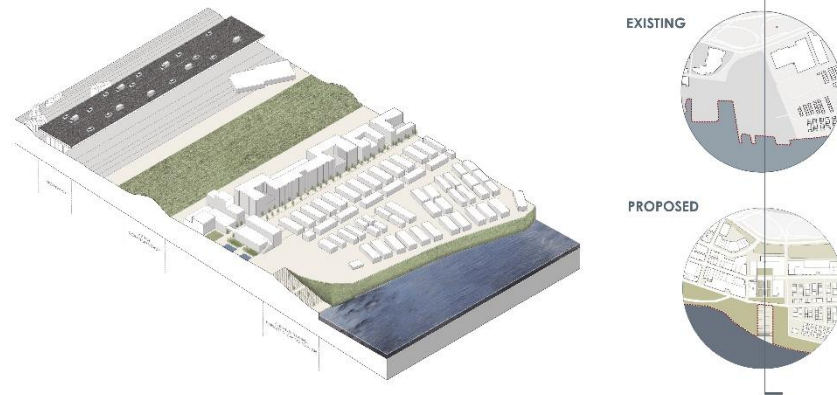


Figure 8.22: Water Edge Intervention C. (Source: Author)

- 4) **Preserved Pier with Living Shoreline:** One existing pier is partially preserved as a historical reference point, while the surrounding area is transformed into a natural living shoreline, highlighting the integration of

history with a sustainable future.

Water Edge Condition (D)

Existing Piers and Island

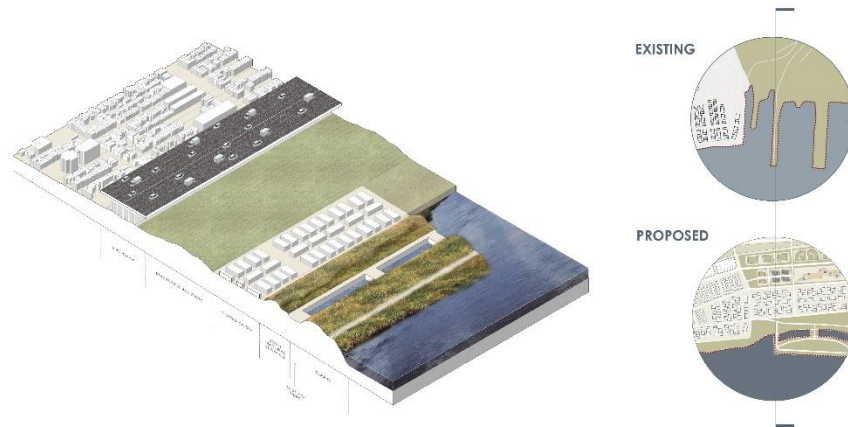


Figure 8.23: Water Edge Intervention D. (Source: Author)

Central Plaza

The Central Plaza serves as the heart of the development, acting as a vibrant gathering space and educational hub for the community. The surrounding buildings prioritize sustainable design principles. Here, the synergy between sustainability and enjoyment fosters a unique learning environment. The plaza integrates a climate change learning center, both indoor and outdoor exhibits showcasing the power of renewable energy. Visitors can explore interactive displays and even witness the process of waste-to-energy conversion in the integrated facility, highlighting the potential of alternative energy sources. Complementing this educational focus, the plaza offers opportunities for relaxation and social interaction. Restaurants and cafes shape the ground level, providing a variety of dining options, while an accessible rooftop offers stunning water views and a direct connection to the learning center. The upper floors of the surrounding buildings include office space, conference rooms,

and multi-functional event spaces, catering to diverse range of needs. Throughout the plaza, rows of trees and reflecting pools provide natural shading and cooling, creating a comfortable outdoor environment for dining and leisure activities.

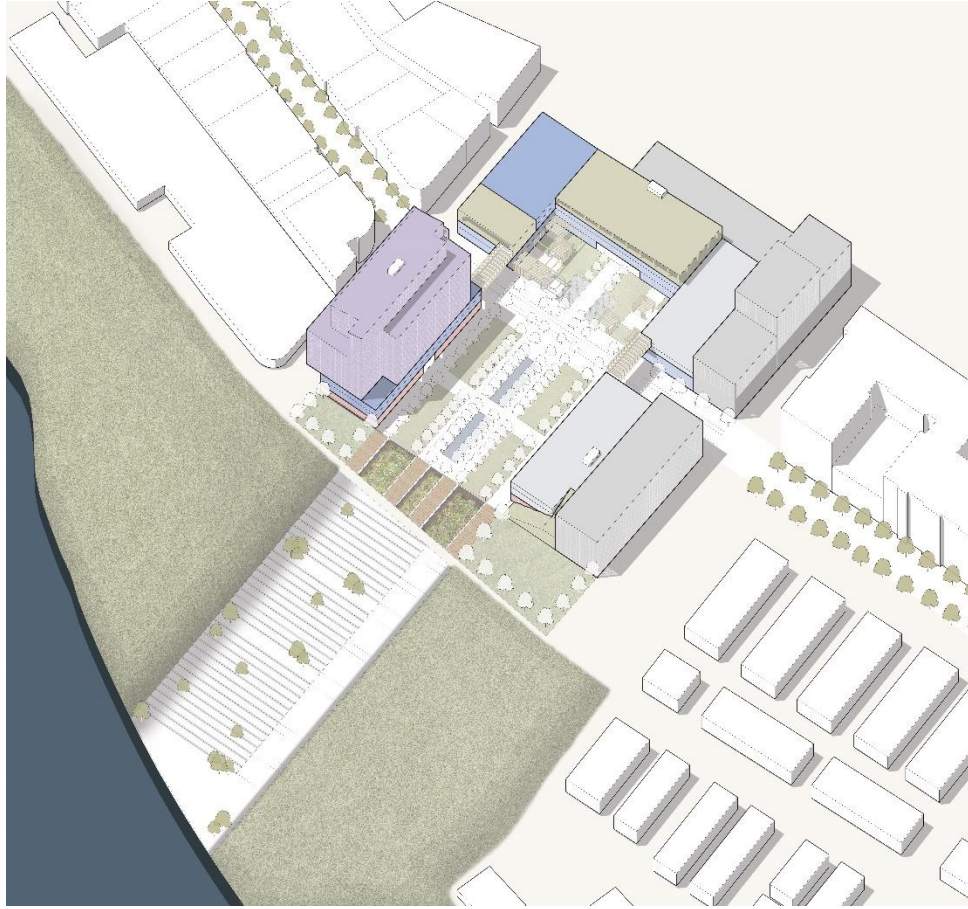


Figure 8.24: Central Plaza Axonometric Diagram. (Source: Author)

The buildings in the Central Plaza incorporate various types of sustainable strategies. A hotel building supports Building-Integrated Photovoltaics (BIPV) by implementing PV shade screens on the façade and roof-mounted PV system. Additionally, the building incorporates a radiant heating and cooling system that extracts water from the river for temperature regulation. The building that is located in front of the hotel also integrates with PV louvers as a shading device on the façade. Behind this building, there is a gravity energy storage that store the energy from the

renewable energy sources and distribute it when needed. The building for the learning center also integrates with PV cladding system on the façade and roof-mounted PV system.

Programs + Integrated Sustainable Strategies

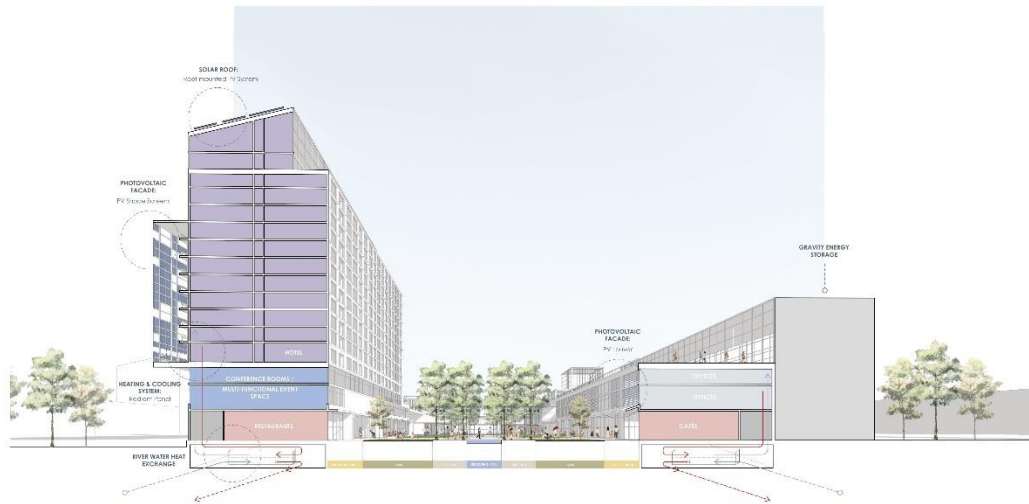


Figure 8.25: Programs and Integrated Sustainable Strategies Section Perspective.
(Source: Author)

Programs + Integrated Sustainable Strategies

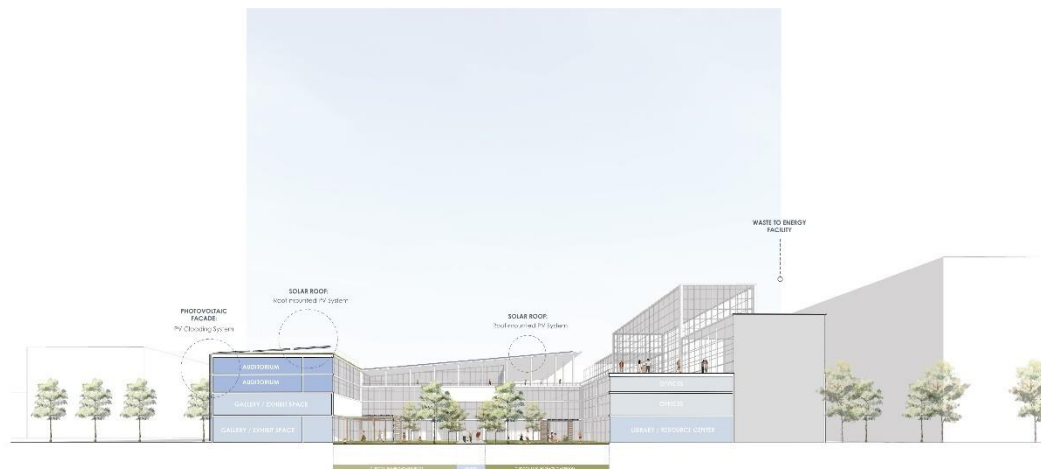


Figure 8.26: Programs and Integrated Sustainable Strategies Section Perspective.
(Source: Author)

This thesis overall proposes a transformative masterplan for a abandoned waterfront area. The proposal prioritizes reintegration with the existing urban fabric, fostering a vibrant and environmentally conscious community. A diverse program introduces new functions throughout the site, filling previously vacant spaces and promoting a strong sense of place.



Figure 8.27: Perspective of Entrance to the Central Plaza from Commercial Corridor.

(Source: Author)

Sustainable design principles are at the forefront, with a focus on natural shoreline interventions and renewable energy integrations. The Central Plaza serves as the heart of development, generating synergy through social interaction, education, and leisure

activities.



Figure 8.28: Perspective of Outdoor Learning and Exhibit Space. (Source: Author)

The surrounding land use program strategically zones the area, incorporating institutional research facilities, a dynamic commercial corridor, a well-connected residential area with access to a large green space, and a buffer zone separating the development from the neighboring industrial area. This comprehensive masterplan not only revitalizes the waterfront but also creates a model for sustainable and resilient urban development.



Figure 8.29: Perspective of Entrance to the Central Plaza from Residential Area.
(Source: Author)



Figure 8.30: Physical Site Model. (Source: Author)

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