ABSTRACT

Title of Thesis:	SOLAR POWER FOR ALL: EXPLORING THE POTENTIAL OF SOLAR ENERGY IN BROADWAY EAST, BALTIMORE
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This thesis investigates how landscape architects can design multifunctional solar energy landscapes (MSELs) to support energy justice, ecological restoration, and community revitalization in Broadway East, Baltimore. Focusing on three vacant sites, the thesis evaluates their potential to support agrivoltaics, ecovoltaics, and solar parking canopies. Proposed designs integrate solar infrastructure with landscape elements such as shade trees, pollinator meadows, rain gardens, and public gathering spaces to improve environmental performance and neighborhood livability. Grounded in spatial analysis and site-specific design, the thesis demonstrates how solar infrastructure can be adapted to local social and ecological conditions, transforming underutilized land into multifunctional community assets. This work highlights the critical role of landscape architects in shaping energy transitions that are not only technically efficient, but also equitable, resilient, and responsive to place.

SOLAR POWER FOR ALL: EXPLORING THE POTENTIAL OF SOLAR ENERGY IN BROADWAY EAST, BALTIMORE

by

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To my family and my partner, Jimmy, thank you for supporting me in this crazy journey of becoming a landscape architect. I love you all!

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List of Abbreviations

LMI – Low-to-moderate-income

MSEL – Multifunctional Energy Landscape

PV – Photovoltaic

SDG – Sustainable Development Goal

UN – United Nations

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Chapter 1: Introduction

As cities around the world transition to renewable energy in response to the climate crisis, questions of equity, land use, and public acceptance are becoming increasingly urgent. In the United States, efforts to decarbonize the energy grid often neglect the voices and needs of historically underserved communities, especially in legacy cities like Baltimore, where systemic disinvestment has left entire neighborhoods with high vacancy rates, aging infrastructure, and unaffordable utility costs. This thesis explores how landscape architects can address these intersecting challenges through the design of multifunctional solar energy landscapes (MSELs), which are solar energy systems that provide ecological, social, and economic benefits in addition to renewable power generation.

Focusing on the Broadway East neighborhood of Baltimore, this project examines how vacant urban land can be repurposed to support community-driven energy solutions that are equitable, resilient, and place-based. Chapter 2 presents the research questions that guided this investigation while Chapter 3 provides context for the global and local energy transition. Chapter 4 reviews key literature on energy justice, multifunctional design, and emerging MSEL typologies such as agrivoltaics and ecovoltaics. Chapter 5 introduces case studies that offer real-world examples and lessons learned. In Chapter 6, these findings are synthesized to inform a framework for MSEL planning. Chapters 7 through 9 detail the site selection, inventory, and analysis process that led to the identification of three study sites within Broadway East. Chapter 10 presents design proposals for each site, aligned with economic, nature, and landscape goals. Chapter 11 evaluates the energy, environmental, and community benefits of the designs, followed by a discussion of implementation strategies and funding opportunities in Chapter 12. The paper concludes in Chapter 13 by reflecting on the broader implications of this work for landscape architects and the future of urban solar infrastructure.

Chapter 2: Research Questions

In 2024, I attended a presentation led by Naomi Davis, the founder of the nonprofit Blacks in Green, where she spoke about the potential of energy microgrids in disinvested neighborhoods throughout Detroit. At the same time, my studio class at the University of Maryland had partnered with Baltimore's Office of Sustainability to create innovative solutions for addressing vacant land. I chose to study the Broadway East neighborhood, which is characterized by large pockets of vacant land. Past planners proposed new housing, businesses, community centers, and parks as new uses for the land, but I realized there could be an opportunity to introduce a new land use – renewable energy infrastructure. I began my literature review with a broad question:

1. **How do landscape architects design solar energy landscapes in urban environments with vacant or underutilized land?**

The next two chapters, in which I describe various research papers and case studies, will address this question in further detail.

In the process of researching how other landscape architects and planners have approached solar energy landscapes, I developed a secondary question:

2. **How can landscape architects identify and design multifunctional solar energy landscapes (MSELs) within underserved communities like Broadway East?**

While the literature review and case studies offered a valuable foundation, the most significant insights emerged through the applied process of planning and designing solar infrastructure within a real-world context. By using Broadway East as a pilot site, I developed a site-specific methodology that improved upon existing solar design approaches.

Chapter 3: The Global Transition to Renewable Energy

Climate change is the defining crisis of the 21st century, with profound implications for public health, food security, economic stability, and ecological resilience, particularly among the world's most vulnerable populations. Its complexity lies not only in its scale but in its roots: the continued reliance on fossil fuels, which still provide most of the global energy and electricity today. Rapid decarbonization remains technically and economically challenging, and current mitigation strategies have yet to achieve the scale required.

With just over a 1°C rise in global temperatures since pre-industrial times, we are witnessing intensifying climate impacts – more frequent heat waves, severe flooding, expanding wildfires, stronger tropical storms, shifting pest ranges, disrupted agricultural cycles, rising sea levels, and ocean acidification. These global challenges demand new forms of spatial planning and design for renewable energy generation that acknowledge the urgency of mitigation while embracing the realities of adaptation (Larson et al., 2020).

The United Nations, a Leader in the Global Energy Transition

In 2015, the United Nations (UN) released the Sustainable Development Goals (SDGs) as part of a global effort to address climate change and other challenges associated with an increasingly changing world. They evolved from the earlier Millennium Development Goals (MDGs), which the UN established in 2000 to address poverty, hunger, disease, and other social issues. While the MDGs focused primarily on developing countries, the SDGs expanded this framework to apply universally to all nations, addressing the need for broader environmental, economic, and social dimensions of sustainable development ("Sustainable Development Goals," 2025).

The formulation of the SDGs began with the 2012 UN Conference on Sustainable Development (Rio+20), where member states agreed to develop a new set of goals. An open working group of 30 representatives from various countries collaborated to draft the goals and after extensive global consultation and negotiation, the final 17 goals and 169 targets were officially adopted on September 25, 2015 ("Sustainable Development Goals," 2025).

One of the SDGs, *Goal 7*, aims to ensure universal access to affordable, reliable, and modern energy by 2030 (*Goal 7*, n.d.). This goal emphasizes increasing renewable energy use, improving energy efficiency, and promoting international cooperation in clean energy technologies and infrastructure, especially in developing countries. Currently, 675 million people still live without electricity, and nearly 2.3 billion rely on harmful fuels for cooking ("Sustainable Development Goal 7," 2025). More equitable distribution of energy in remote areas or underserved communities is desperately needed, but the transition to clean energy can be an opportunity to begin addressing those needs.

Carbon Emission Reduction Goals in the United States

The United States is also committed to reducing carbon emissions by investing in clean and reliable renewable energy infrastructure. Under the Biden-Harris administration, the United States proposed an ambitious goal of 80% renewable energy generation by 2030, and 100% carbon emission free electricity by 2035 (Mai, 2023). The Inflation Reduction Act (IRA), which Congress passed in 2022, is driving a historic shift toward clean energy and creating economic opportunities across the U.S. It offers tax credits and incentives designed to benefit not just corporations, but also working families, underserved communities, and areas historically reliant on fossil fuels. These incentives support the domestic manufacturing of solar panels, wind turbines, batteries, and electric vehicles, while also adding new jobs by requiring projects to meet labor standards and encourage local hiring. The IRA also includes targeted bonuses for clean energy projects located in low-income or energy communities, and advances environmental justice goals by expanding access to renewable energy. Overall, the IRA supports economic growth and ensures that the benefits of a clean energy economy will reach all Americans (*FACT SHEET*, 2025).

Carbon Emission Reduction Goals in Baltimore, Maryland

Under Governor Wes Moore's leadership, Maryland is also joining the fight against climate change by committing to carbon emission reduction goals that align with those of the Biden Administration. In Baltimore's Climate Action Plan Update, published in 2024, the city committed to reduce fossil fuel emissions by 60% by 2030, and have net-zero emissions by 2045. Before 2024, over 50% of the energy powering Baltimore was generated by fossil fuels, with residential homes accounting for 34% of the energy consumption (Baltimore Office of Sustainability, 2024).

In order to meet these goals, Maryland will need to rapidly embrace emergent renewable energy infrastructure. Designers, planners, and residents must rethink how these technologies may fit within the urban fabric, especially in vacant or underutilized land where there is the potential for more productive uses.

Chapter 4: Literature Review

Addressing climate and energy challenges through landscape architecture requires a foundation rooted in justice. This chapter introduces key principles of energy justice, climate justice, racial justice, and energy burden that inform the design of equitable renewable energy systems. These concepts highlight how systemic inequities have shaped who benefits from clean energy and who bears its costs. By grounding the project in these frameworks, this chapter positions landscape architects as critical actors in advancing just, resilient, and community-centered energy landscapes.

Foundational Principles

Energy Justice

Vulnerable and historically marginalized populations have borne the brunt of the environmental and health impacts caused by the fossil fuel industry, yet they often receive the least investment when it comes to clean energy initiatives. These communities are frequently located near polluting facilities, experience higher rates of energy insecurity, and are more susceptible to the consequences of power outages or fluctuations in energy prices. Despite these heightened risks, clean energy development has not been equitably distributed, and these same populations are often left out of the decision-making processes that shape their energy futures.

Energy justice seeks to address these disparities by advocating for the fair distribution of energy resources and the restructuring of how energy is produced and governed. It calls for a shift away from traditional, centralized utility models toward more localized, community-driven systems that empower residents through ownership, control, and direct benefits from renewable energy projects. Research by Taylor et al. (2023) and Spurlock et al. (2022) underscores the importance of not only investing in renewable infrastructure within underserved communities but also ensuring their meaningful participation in planning and implementation.

Transitioning to local ownership models, such as community solar, energy cooperatives, and microgrids, can be a critical step toward achieving energy equity. As Finley-Brook and Holloman (2016) argue, these decentralized systems can help redistribute power – both literally and figuratively – by giving communities greater control over their energy sources, costs, and environmental impact. Such approaches not only promote resilience and self-sufficiency but also foster long-term social and economic benefits in communities that have long been excluded from the energy transition.

Climate Justice

Climate change reveals a stark imbalance between those who contribute most to the problem and those who suffer its most severe consequences. Wealthier nations and high-income communities tend to produce the largest share of greenhouse gas emissions due to their consumption patterns, industrial activities, and reliance on fossil fuels. In contrast, low-income communities (often communities of color) contribute the least to climate change but are disproportionately affected by its impacts, including extreme weather events, flooding, urban heat, and poor air quality (Catenacci, 2021).

This disparity underscores the need for a justice-centered approach to climate adaptation and mitigation. Interventions such as stormwater management systems, urban heat island mitigation, and renewable energy investments must be prioritized in communities that are on the frontlines of climate change. These areas often lack the infrastructure and resources needed to cope with increasingly intense climate stressors, making them especially vulnerable to displacement, health risks, and economic instability.

The fight against climate change must therefore begin in the communities most impacted. By directing climate investments to these areas, we not only address immediate vulnerabilities but also begin to rectify long-standing environmental injustices. Equitable climate action involves including frontline communities in decision-making processes and ensuring they receive the benefits like cleaner air, cooler streets, and lower energy bills, that come from sustainable infrastructure and resilient landscapes.

Racial Justice

Woven throughout the principles of energy and climate justice is a critical and urgent call for racial justice. Institutionalized racism in the United States – manifested through discriminatory housing policies, segregated urban planning, redlining, unequal access to employment, and exclusion from political power – has left Black Americans and other communities of color disproportionately exposed to the harmful impacts of climate change and the fossil-fuel industry. These systemic inequalities have led to greater rates of pollution exposure, heat vulnerability, flooding, and energy insecurity in Black and brown neighborhoods (Diallo et al., 2024; Spurlock et al., 2022).

To truly address the climate crisis, it is essential to acknowledge and rectify these intersecting injustices. Reparative justice demands more than technological fixes – it calls for intentional community investment in historically excluded communities and the active inclusion of Black, Indigenous, and People of Color (BIPOC) in the planning and decision-making processes that shape their environments. As Finley-Brook and Holloman (2016) argue, institutional racism is deeply embedded within environmental and energy systems, and dismantling these structures is necessary to achieve an equitable and sustainable future.

Centering BIPOC voices in climate and energy policy is not only a matter of fairness, but also a strategic necessity. These communities often have unique knowledge, cultural practices, and experiences that can inform more resilient and inclusive approaches to sustainability. Ensuring that BIPOC communities are at the forefront of the transition to renewable energy, resilient infrastructure, and ecological restoration is a vital step toward justice, healing, and transformative change.

Energy Burden

In Baltimore, we see what happens to vulnerable communities when racial justice, climate justice, and energy justice are ignored, especially when viewed through the lens of household energy burdens. Energy burden refers to the percentage of a household's income spent on energy costs, such as electricity and heating. When a household spends more than 6% of its income on energy, it is considered to have a high energy burden; if that share exceeds 10%, it is considered severe. High energy burdens are especially common in low-income communities, where energy costs consume a disproportionate share of already limited resources. In Maryland, these disparities are stark: low-income households experience energy burdens that are more than three times higher than those of non-low-income households (Figure 2.1).

In Baltimore, this problem is particularly acute. 23% of households (approximately 237,681) live with a high energy burden, while 11% (about 120,345 households) face a severe burden. These numbers point to a widespread issue of energy insecurity, where many families must choose between heating their homes and meeting other essential needs like food, healthcare, and rent. Moreover, the energy

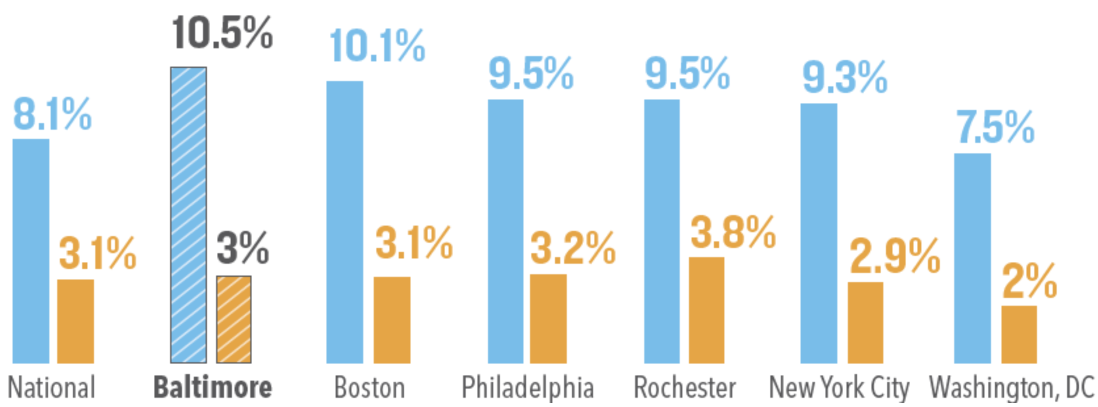


Figure 2.1 Median low-income energy burden (blue) vs. median energy burden (orange) (ACEEE, 2020).

burden is not distributed equally across racial lines. In Baltimore, the median energy burden for Black households is 36% higher than that of non-Hispanic white households, reflecting broader patterns of economic and racial inequality (American Council for an Energy-Efficient Economy, 2020).

Nationally, low-income households remain underrepresented in the clean energy transition. Between 2010 and 2018, they accounted for only 15% of solar photovoltaic (PV) installations, in part due to high upfront costs and the fact that many low-income households are renters and cannot install rooftop solar panels (ACEE, 2020). These structural barriers highlight the need for more inclusive clean energy programs and targeted investment strategies that prioritize energy justice. Expanding access to affordable solar energy, providing financial support for energy efficiency upgrades, and reforming utility programs can help reduce the energy burden in Maryland and across other high-need areas.

Rising Cost of Electricity in Baltimore

These disparities are especially alarming given that energy prices rose by approximately 30% over the past five years, with the most significant spike occurring during the recent winter season (Figure 2.2). For many low-income households, these cost increases translated into unaffordable electricity bills, exacerbating existing financial hardships and forcing difficult choices between heating, food, and other

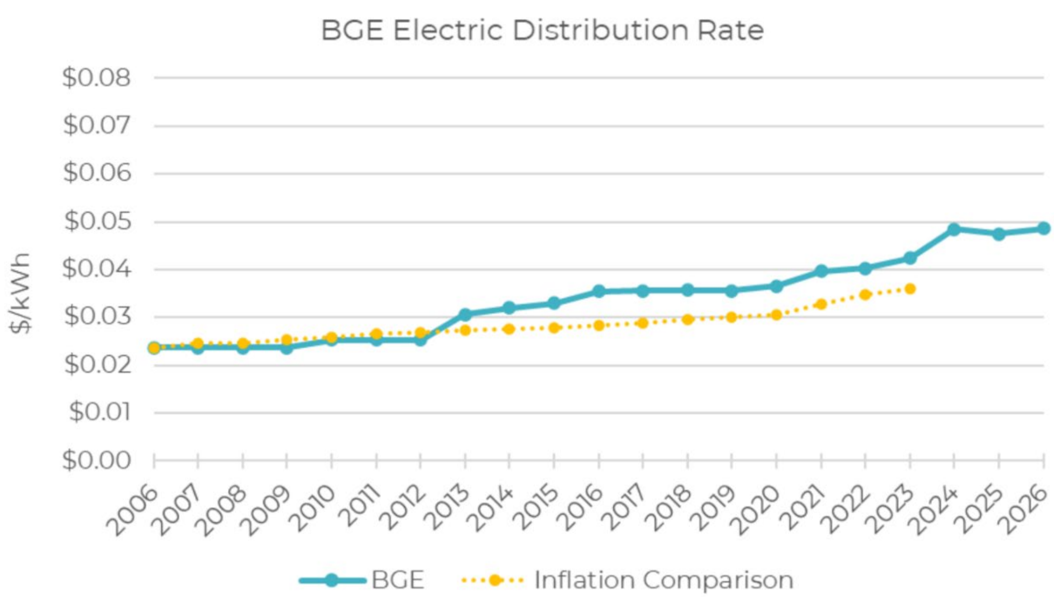


Figure 2.2 BGE electricity bills spiked over 30% the past 5 years, and many residents could no longer afford to pay their bills (Why Is My BGE Bill so High, n.d.).

essential needs. In Baltimore, the inability to keep up with utility payments led to a surge in shutoffs and sparked widespread public outcry, prompting official investigations and demands for greater regulatory oversight (Babb, 2025). Baltimore Gas and Electric Company (BGE), the largest supplier of electricity in the city, blamed recent rate hikes on the cost of replacing aging infrastructure, and the lack of enough energy supply to meet the demand. Maryland imports around 40% of its energy from other states, and investment in energy production is desperately needed (Babb, 2025).

These events underscore the urgent need for more equitable and resilient energy systems, particularly in historically disinvested neighborhoods where the cumulative burdens of poverty, aging infrastructure, and climate vulnerability intersect.

Community Solar

Community solar programs are an increasingly popular strategy for reducing the energy burden in low-to-moderate-income (LMI) neighborhoods, where traditional rooftop solar may not be feasible due to cost, rental status, or building conditions. These programs enable households to benefit from solar energy without needing to install panels on their own property.

Typically, solar developers partner with local utility companies to create a subscription-based model. Subscribers receive credits on their utility bills in proportion to the amount of solar energy generated by their share in the community solar array. While some programs come with a subscription fee, many providers have options designed specifically for LMI households, offering guaranteed energy savings, sometimes at no cost, to reduce financial barriers and promote equitable access to clean energy (*Community Solar Basics*, n.d.).

Despite their promise, community solar programs still face challenges. Utility companies often prioritize partnerships with large-scale providers that can deliver high volumes of electricity, which can limit the flexibility in the design, size, and siting of community solar installations. This can result in missed opportunities to integrate solar infrastructure into underutilized urban land or to pair solar development with community amenities like pollinator habitats or urban agriculture. For community solar to reach its full potential as a tool for energy justice, greater support is needed for small-scale, locally driven projects that center community needs in both design and delivery.

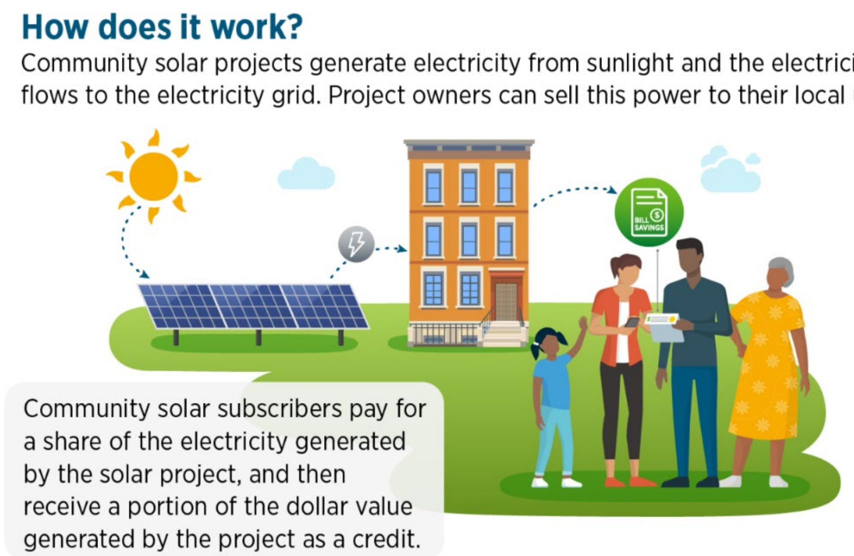


Figure 2.3 Illustration explaining how community solar energy distribution work, courtesy of the U.S. Department of Energy (Community Solar Basics, n.d.).

<u>*Solar Energy Microgrids*</u>

Solar energy microgrids offer a promising alternative to traditional utility-scale solar systems, particularly when it comes to addressing energy injustice and increasing community resilience. Unlike centralized solar production sites, which are often limited by utility partnerships and large-scale infrastructure requirements, microgrids are decentralized systems that generate and distribute energy locally within the same community they serve. These systems can either operate in connection with the main power grid or function independently by storing the energy generated in batteries, allowing them to provide power even when the larger grid fails (Wallsgrove et al., 2021).

One of the greatest advantages of solar microgrids is their ability to store energy in on-site batteries, which makes them especially valuable during emergencies or extreme weather events. As climate change increases the frequency and intensity of storms, heat waves, and power outages, microgrids provide a critical layer of protection for communities. Their ability to deliver continuous, localized power can make a life-saving difference for vulnerable populations, such as elderly residents, people with medical conditions requiring powered equipment, or low-income households that cannot afford to replace spoiled food or endure prolonged heat without air conditioning (Wallsgrove et al., 2021).

Installing renewable energy microgrids in underserved communities is not only a practical resilience strategy but also a foundational step toward addressing broader patterns of energy inequity. These systems can help correct historical disparities by ensuring that the communities most affected by power outages and rising energy costs are among the first to benefit from clean, reliable energy infrastructure. In this way, solar microgrids serve not just as a technological solution, but as a tool for energy justice—empowering communities with ownership, resilience, and long-term sustainability.

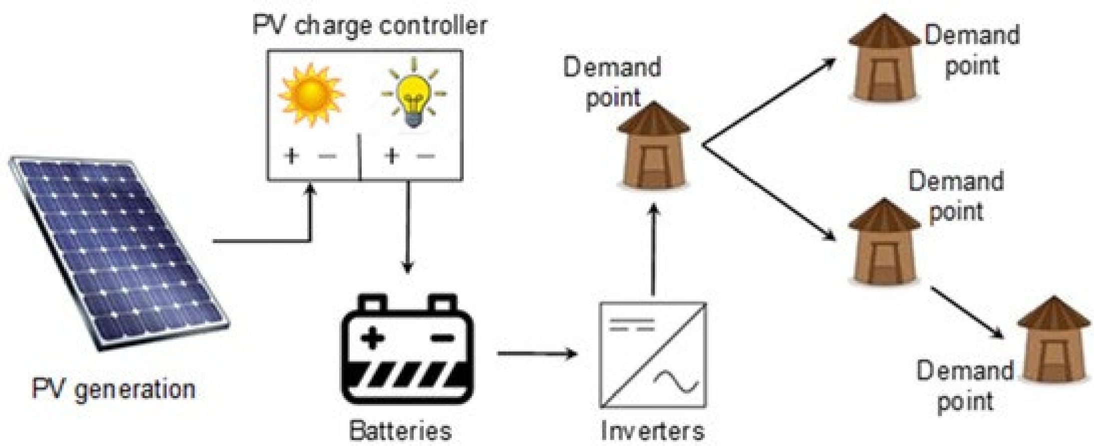


Figure 2.4 Diagram illustrating how solar energy is distributed directly to households in a microgrid system (Wallsgrove et al., 2021).

Multifunctional Solar Energy Landscapes

Despite the many benefits of solar energy, one of the greatest challenges to its future expansion is public resistance to the development of solar infrastructure. Critics often argue that land used for solar installations could be better utilized for agriculture, recreation, or environmental conservation. These concerns reflect broader land-use tensions and can significantly slow or block renewable energy projects. One promising strategy to address these concerns is through the concept of multifunctionality – designing solar installations that serve more than one purpose (O'Neil et al., 2022).

Multifunctional solar energy landscapes (MSELs), a term I will be using throughout this paper, refers to the co-location of solar energy production with other land uses. By integrating additional functions into solar sites, MSELs reduce land-use conflicts and make projects more appealing to the public. Designers play a crucial role in this process, using thoughtful planning and aesthetics to ensure that these projects contribute both visually and functionally to the landscape (Pevzner et al., 2021).

Agrivoltaics

There are several common types of MSELs. Agrivoltaics is the concept of co-locating solar photovoltaics (PV) with agriculture, allowing for the simultaneous use of land for both energy production and agricultural activities. By integrating solar panels above or alongside crops and grazing areas, this technology significantly reduces land use conflicts that often arise with traditional solar field projects, where vast areas of farmland or natural ecosystems are converted exclusively for energy production (Dawnbreaker, 2022). Agrivoltaic systems optimize land efficiency by enabling solar power generation while maintaining agricultural productivity. In large-scale agricultural farms, these systems can provide shade that helps reduce heat stress on crops, potentially improving yields in hot climates (Macknick et al., 2022). These benefits are especially relevant given the alarming rate at which average summer temperatures are increasing throughout the world.

There are many ways that agrivoltaic systems can be arranged, with multiple variations in the size, height, and spacing of the panels. Utility-scale projects (those generating around one MW of energy or more) typically try to maximize the amount of energy produced per square foot, therefore the configurations are more densely arranged. This type of configuration can sacrifice the amount of light that plants beneath or between the panels may receive. Farmers who wish to maximize plant growth may choose to implement a more open arrangement, but this choice sacrifices a portion of the total energy that could be produced on their property. A diagram illustrating several different configurations is pictured below:

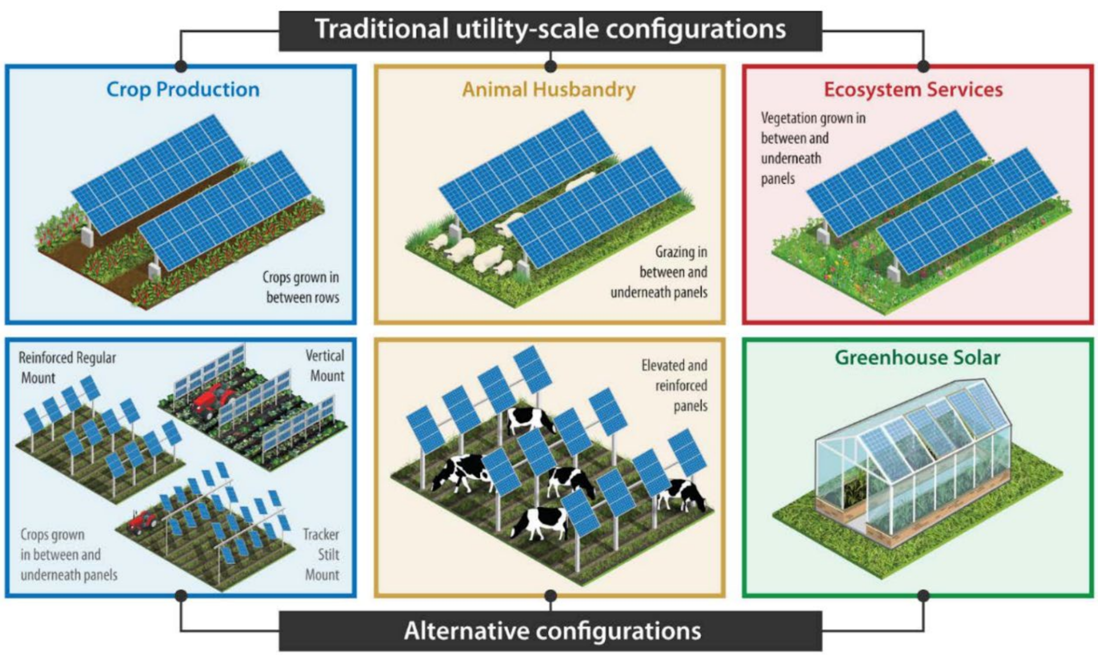


Figure 2.5 Illustrations of traditional utility-scale multifunctional solar farm configurations vs. possible alternative configurations (Macknick et al., 2022).

While most agrivoltaics projects are in rural agricultural areas, there is a growing opportunity for landscape architects to incorporate this technology into urban green space designs. By integrating solar panels into community gardens, rooftop farms, and urban parks, cities can enhance local food production, promote renewable energy use, and create multifunctional spaces that address climate resilience and urban sustainability goals. These strategies can not only reduce the urban heat island effect but could also provide communities with innovative solutions to address energy and food security challenges.

Ecovoltaics

Ecovoltaics refers to the integration of solar energy infrastructure with habitat conservation, creating multifunctional landscapes that support pollinators, native species, and broader ecological health. These systems range in form, from restricted conservation areas with minimal human access to expansive eco-parks designed to accommodate tourism and environmental education (Figure 2.6) (Oudes et al., 2022). Increasingly, research institutions such as Harvard University are engaging in ecovoltaic projects that implement and manage biodiverse habitats within solar arrays (Moran, 2023). These projects often

Figure 2.6 Solarpark Hemau in Germany, where restored wetlands co-exist with solar panels (Oudes et al., 2022).

include long-term ecological monitoring, such as post-occupancy studies that assess species diversity and habitat performance over time. In support of these efforts, states like Massachusetts and Maryland have established pollinator-friendly certification programs, which outline rigorous design, planting, and maintenance standards that site owners must meet to retain their designation and ensure ecological integrity (Power Plant Research Program, 2019).

Solar Parking Canopies

Solar canopies are elevated photovoltaic (PV) structures installed above existing impervious surfaces (most commonly over parking lots) to generate renewable electricity without requiring additional land area. Functionally, they serve a dual purpose: producing clean energy while offering environmental and experiential benefits such as shade, rain protection, and reduced urban heat island effects (Deshmukh & Pearce, 2021). In dense urban contexts where land availability is limited and competition for space is high, solar canopies present a practical strategy for integrating distributed energy infrastructure into the built environment. By utilizing underutilized surfaces such as retail parking lots, these systems avoid the land-use conflicts often associated with utility-scale solar development, making them particularly well-suited for urban adoption. Moreover, when combined with electric vehicle (EV) charging infrastructure, solar canopies help advance transportation electrification and local emissions reductions, reinforcing broader urban sustainability and resilience goals (Deshmukh & Pearce, 2021).

Evaluating Multifunctional Solar Energy Landscapes

In exploring contemporary approaches to energy landscape design, I identified a theoretical framework proposed by Oudes et al. (2022), which conceptualizes the design of Multifunctional Solar Energy Landscapes (MSELs) through three primary dimensions: **economic**, **nature**, and **landscape**. Nature considerations focus on the impacts of solar development on flora, fauna, and their habitats. Designers can address these concerns by either preserving existing ecological features or introducing new ones within the proposed MSEL. Another way to address nature considerations is by modifying the layout of the solar infrastructure. Designers can increase the distance between panel rows or reduce the number of panels (i.e., reducing patch density) to improve habitat quality. Economic considerations include potential losses of existing land uses, impacts on tourism and the local economy, and limitations related to grid capacity. To address these challenges, projects can incorporate commercial land use functions (such as agriculture, retail, or event spaces) within the solar site, thereby creating multifunctional landscapes that could generate additional revenue streams alongside solar electricity production. Finally, landscape considerations emphasize the relationship between solar infrastructure and the visual and experiential qualities of the broader environment. Careful integration of solar arrays is needed within the existing landscape, especially in more densely populated areas where conflict is more likely to arise. Strategies include minimizing visual disruption, enhancing viewsheds, and incorporating recreational and educational amenities to strengthen the connection between the solar site and the surrounding community (Oudes et al., 2022).

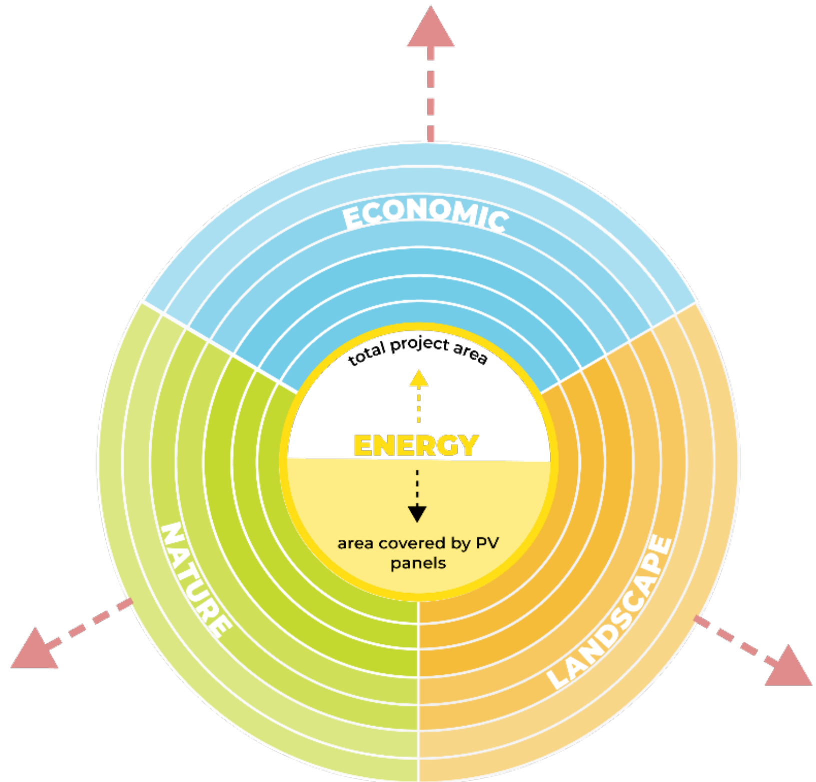


Figure 2.7 Diagram that illustrates the relationship between the economic, nature, and landscape dimensions of multifunctional solar energy landscapes (Oudes et al., 2022).

Figure 2.7 illustrates the interrelationships among these dimensions. Designs that prioritize *economic* outcomes typically allocate a greater share of the site to photovoltaic infrastructure, thereby maximizing energy yield and financial return. Conversely, prioritizing nature or landscape dimensions results in a greater emphasis on habitat restoration, recreational amenities, or public realm enhancements, often reducing the area available for solar production.

This framework reflects broader theories of trade-offs and multifunctionality in landscape architecture, where achieving diverse goals within limited space necessitates careful balancing among competing priorities. As such, the design of MSELs requires an intentional negotiation of spatial allocations, guided by the specific needs, values, and aspirations of the local community. Effective design outcomes hinge on the ability to integrate environmental, social, and economic objectives within a multifunctional landscape framework (Oudes et al., 2022; Oudes & Stremke, 2021).

Chapter 5: Case Studies

To ground this project in real-world applications, this chapter presents a series of case studies that explore the opportunities, challenges, and lessons learned from existing energy landscape projects. I selected each case study for its relevance to the theme of multifunctionality and its insight into designing solar sites. The Detroit project focuses on transforming underutilized vacant urban land into solar farms, an approach that models a potential future for Broadway East. The Temple University and Harvard University projects, both situated at research institutions, were selected for their novel integration of multifunctional solar design and the accessibility of detailed public documentation. Together, these case studies highlight best practices and inform a more innovative design strategy moving forward.

Neighborhood Solar Initiative in Detroit, Michigan

The city of Detroit, Michigan is currently in the process of converting nearly 165 acres of vacant land across three different neighborhoods into solar fields, which are designed to generate 33 megawatts of renewable energy that will power 127 municipal buildings. The project is expected to save the city $6.6 million annually, through a combination of $2.9 million in energy savings and $3.7 million in cost reductions across city departments (*Mayor Announces First 3 Solar Neighborhoods; Tells Residents, "You Have Not Been Forgotten"*, 2024). Despite $8.3 million in annual operating costs, the initiative results in a net cost of only $1.7 million per year (*Solar Neighborhoods*, 2025).

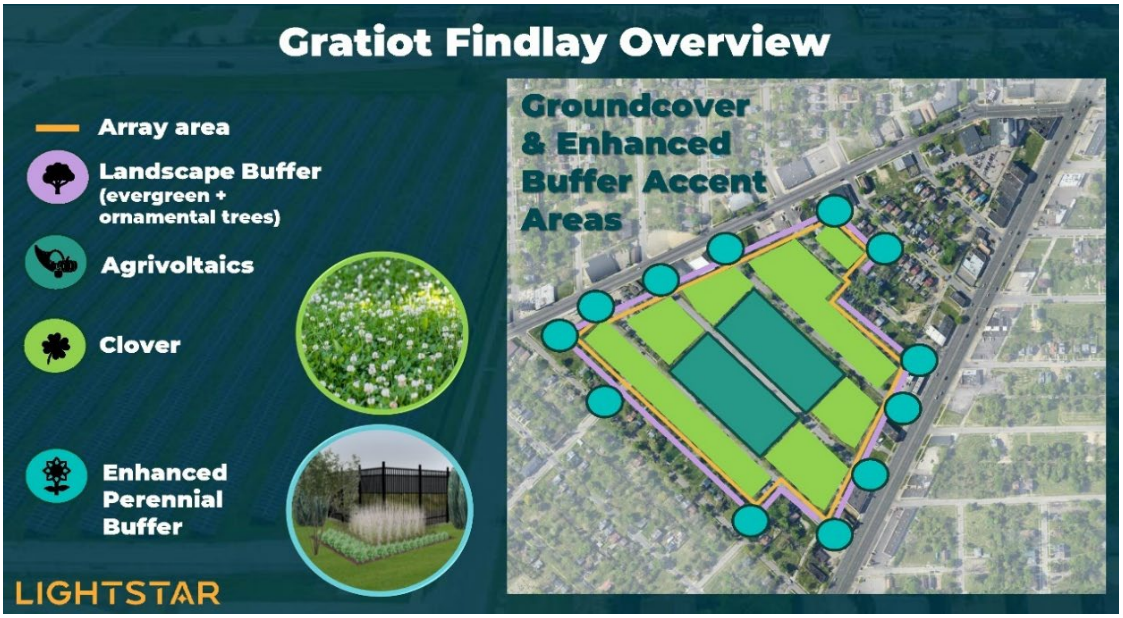


Figure 3.1 Master plan for the Gratiot Findlay neighborhood

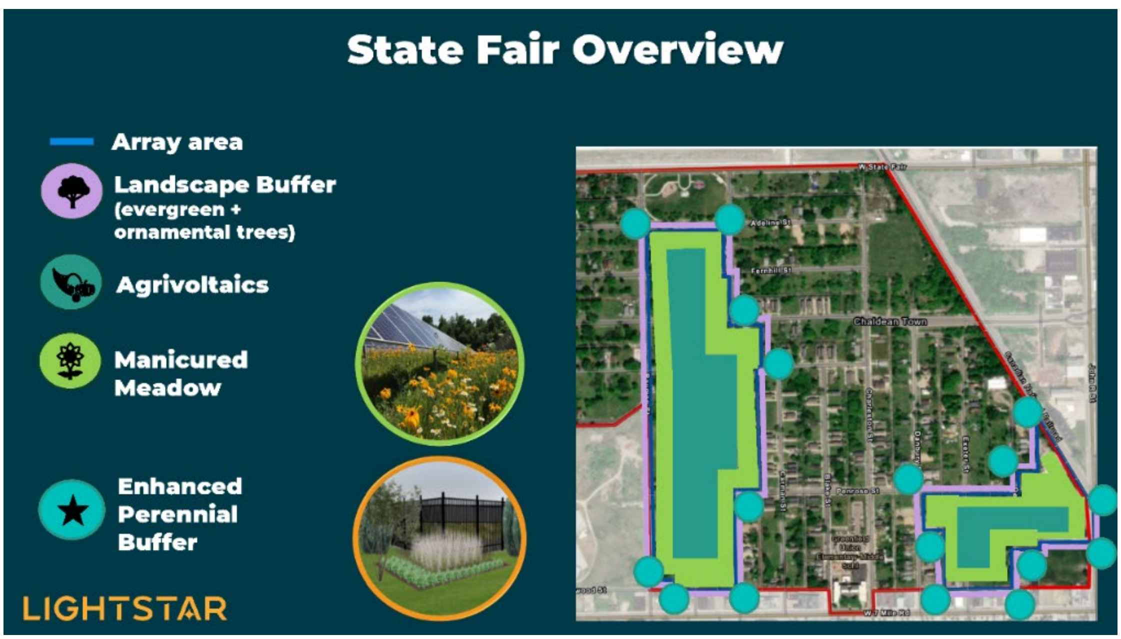


Figure 3.2 Master plan for the State Fair neighborhood

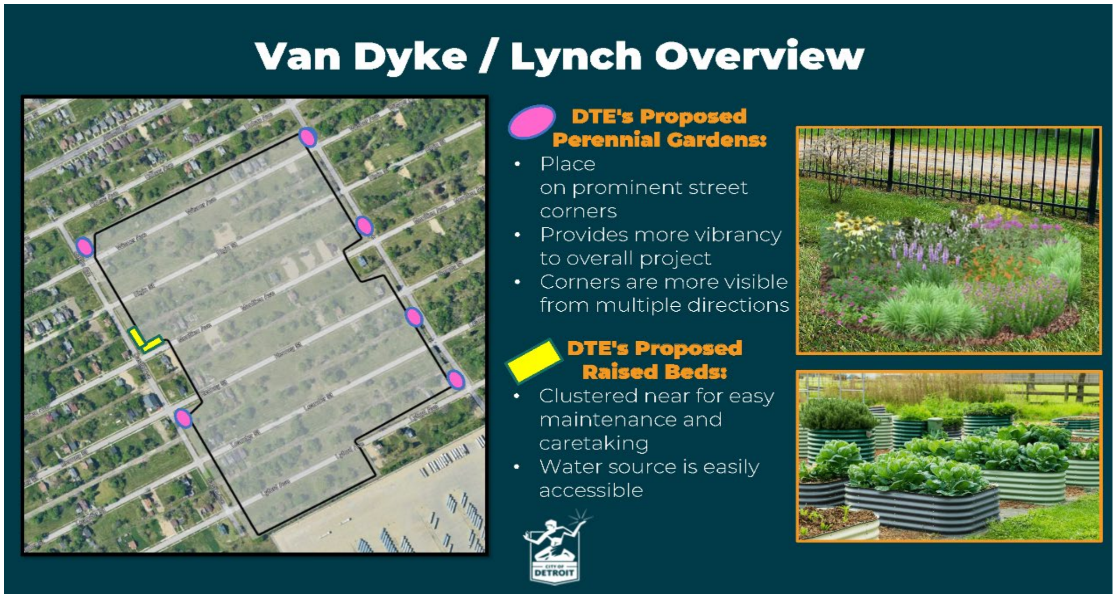


Figure 3.3 Master plan for the Van Dyke / Lynch neighborhood

The neighborhoods selected for this initiative are the Gratiot/Findlay, Van Dyke/Lynch and State Fair communities, which all have high vacancy and dwindling populations. The design for the solar fields is informed by community feedback and incorporates ornamental trees, pollinator meadows, and areas for urban agriculture. Owner-occupied homes surrounding the solar fields will receive $15,000 to $25,000 in energy-efficiency upgrades, while residents within the project boundaries who are displaced will be compensated with a minimum of $90,000 for relocation (*Solar Neighborhoods*, 2025). The solar farms are designed to have a lifespan of 35 years, after which the developers must decommission all solar PV equipment and restore the land as a greenfield. The city and community will then work together to figure out how the land should be used going forward (*Mayor Announces First 3 Solar Neighborhoods; Tells Residents, "You Have Not Been Forgotten"*, 2024).

Despite these benefits, some community members have raised concerns. There is a preference among some residents for alternative land uses, such as housing. Additionally, fears of vandalism have led to the inclusion of fencing in the design. Another point of contention is that the energy generated from these solar farms will go directly to the city, not to residents who need the cost-saving benefits the most (Allnut, 2024). Because of these concerns, several neighborhoods decided to opt out of the solar initiative, despite the potential for community-oriented amenities such as gardens that could otherwise improve the lives of residents.

Key Takeaways

This case study offers a valuable lesson for energy landscape planners working in underserved and disinvested communities. To align with the principles of energy justice, proposed energy infrastructure must provide direct and tangible benefits to local residents. Upholding these principles is critical to the success of future energy projects, particularly in areas with high vacancy rates and longstanding distrust of government-led initiatives.

My project improves upon the Detroit project by prioritizing small-scale community solar projects that directly benefit residents, not developers or other third parties. More importantly, my project will not displace current residents in order to build solar infrastructure. All proposed installations will be on currently vacant land that has no other plan in place, while land set aside for housing and other commercial purposes will remain unchanged.

Temple University Ambler Campus Agrivoltaics Project

At Temple University's Ambler Campus in Ambler, Pennsylvania, Dr. Sujith Ravi and Caroline Merheb are conducting research on the potential of agrivoltaics in urban environments (Ravi, 2024). Their work focuses on the dual use of land for both food production and solar energy generation, particularly in small urban spaces.

The research site spans just 610 square feet and features a 5.74 kW agrivoltaic system (Figure 3.4). Despite the compact footprint, the site supports a productive array of crops including buttercrunch head lettuce, red salad bowl lettuce, genovese basil, supersweet and sungold cherry tomatoes, burpee's stringless green pod and contender beans, and french breakfast and Donato F1 radishes (*Temple University Ambler Campus*, 2024).

Figure 3.4 Temple University agrivoltaics system built by Dr. Sujith Ravi and Caroline Merheb (Ravi, 2024)

This project highlights agrivoltaics as a promising solution to address both energy and food insecurity in densely populated areas. By integrating solar technology with edible planting, the system demonstrates how limited urban land can be optimized to meet multiple community needs.

Key Takeaways

This case study provides an invaluable example of small-scale urban agrivoltaic design and was the only publicly documented project of its kind available for analysis. As a landscape architecture student without formal engineering training, I drew upon the research of Dr. Ravi to inform my understanding of structural configurations that enable solar panels to be integrated above raised planting beds.

Harvard University Arnold Arboretum Pollinator Meadow

Harvard University's Arnold Arboretum in Boston, Massachusetts is home to a 1.2-acre solar pollinator meadow that demonstrates the potential for the co-location of renewable energy production and ecological restoration (Figure 3.5). Beneath an array of 1,152 ground-mounted solar panels, which generate over 542,000 kilowatt-hours of electricity annually, the Arboretum has established a lush meadow designed to support pollinator species and native biodiversity (Hetman, 2020).

This project maximizes the unutilized space beneath the solar arrays by creating a meadow habitat that attracts a variety of pollinators, including bumblebees, butterflies, moths, flies, and wasps. Birds have even been spotted on the site, drawn

Figure 3.5 The pollinator meadow at Arnold Arboretum several years after initial seeding (Hetman, 2020)

by the abundance of insects and native vegetation (Figure 3.6). The design demonstrates a commitment to multifunctional landscapes, where energy infrastructure can coexist with (and even enhance) urban ecosystems (Hetman, 2020).

The Arnold Arboretum's solar pollinator meadow is a model for how solar farms can do more than simply generate clean energy but actively help restore habitat in urban environments. It shows the potential for ecological planning and landscape architecture to work in tandem with renewable technologies, providing environmental as well as educational value to the public.

Figure 3.6 Bird nest found within one of the solar panel structures (Hetman, 2020)

Key Takeaways

While many examples of pollinator-friendly solar farms exist across Maryland, Washington, DC, and Virginia, I selected the Arnold Arboretum solar meadow as a primary case study due to the extensive publicly available documentation on its planning, design, and maintenance. Conservation specialists at Harvard University curated the plant palette based on species nativity and pollinator-host potential, and published their findings – including recommendations for solar panel height and spacing – on the Arnold Arboretum website. A post-occupancy study further demonstrated the meadow's success in attracting pollinators and other wildlife. Such transparency is uncommon, as private solar developers rarely share design plans. The publicly accessible information from the Arboretum and supporting independent articles allowed me to base my own meadow design on a rigorously studied and ecologically successful precedent.

Chapter 6: Lessons Learned from Literature Review and Case Studies

To summarize the previous two chapters, there were three main findings in the literature review and case studies that illuminate how landscape architects and planners should approach the design of solar energy landscapes in urban environments with vacant or underutilized land:

1. Planners should prioritize multifunctionality in solar landscapes to avoid land use conflicts with current residents.
2. Local energy production systems (microgrids) are a step toward developing equitable access to energy.
3. More energy investment is needed in communities of color.

In the previous chapters, I introduced the concept of multifunctional solar energy landscapes (MSELs) and how landscape architects can weave MSELs throughout the urban matrix. Despite numerous theoretical examples in universities and publications like Landscape Architecture Magazine (Pevzner et al., 2021), I could not find built MSEL projects in smaller pockets of vacant urban land. In order to incorporate MSELs in a neighborhood like Broadway East, I needed to develop my own methodology. And so, I began the design phase of my research by asking the following question:

How can landscape architects identify and design MSELs within underserved communities like Broadway East?

Chapter 7: Site Context and History

Understanding the historical context of a site is essential to shaping thoughtful and place-based design interventions. This chapter traces the layered history of the Broadway East neighborhood, examining how past patterns of land use, infrastructure development, disinvestment, and community resilience have shaped its present-day conditions. By situating the site within its broader social history, this analysis provides critical insight into past challenges and future opportunities within Broadway East.

Site Context

Broadway East is a 221-acre neighborhood located in East Baltimore, situated directly east of the Oliver neighborhood and north of the Middle East and Biddle Street neighborhoods (Figure 5.1). Its southernmost border is approximately a 15-minute walk from the Johns Hopkins Medical Center, a major institution that serves as a hub for healthcare, employment, and research in the region. Gay Street, which runs diagonally from the southwest corner of the neighborhood to the northeast corner, serves as a major route connecting west and east through the city. In recent years, there have been efforts to slow down the traffic speed along Gay Street by narrowing the roads and improving pedestrian safety. North Avenue, which constitutes the northern boundary of the city, is also a major road and bus route connecting Broadway East to the rest of the city. Washington Street, which runs perpendicular to North Avenue, is a one-way street with minimal street trees.

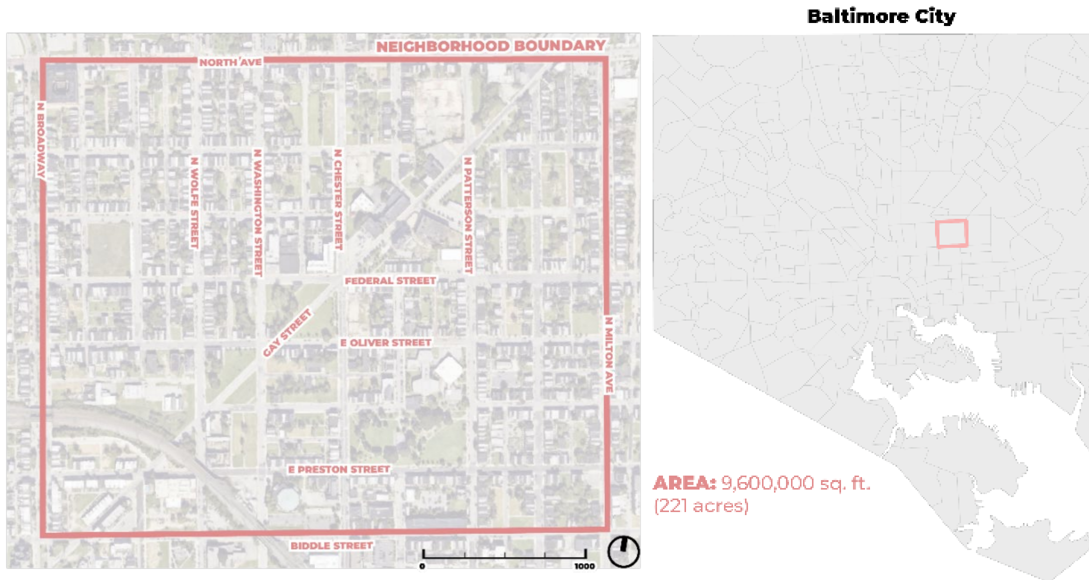


Figure 5.1 Broadway East site boundary and context.

However, there have been plans to connect Broadway East to Johns Hopkins Medical Center, Eager Park, and other major hubs through a green street plan along Washington Street (Ayers Saint Gross & First Baptist Church, 2017).

History

Redlining

Broadway East is one of several neighborhoods in Baltimore that experienced racial segregation during the early twentieth century. A southern portion of the neighborhood fell within a "red" area on federal Home Owners' Loan Corporation (HOLC) maps, which designated the least desirable areas for mortgage lending (HOLC Division of Research & Statistics, 1937). These redlined areas were

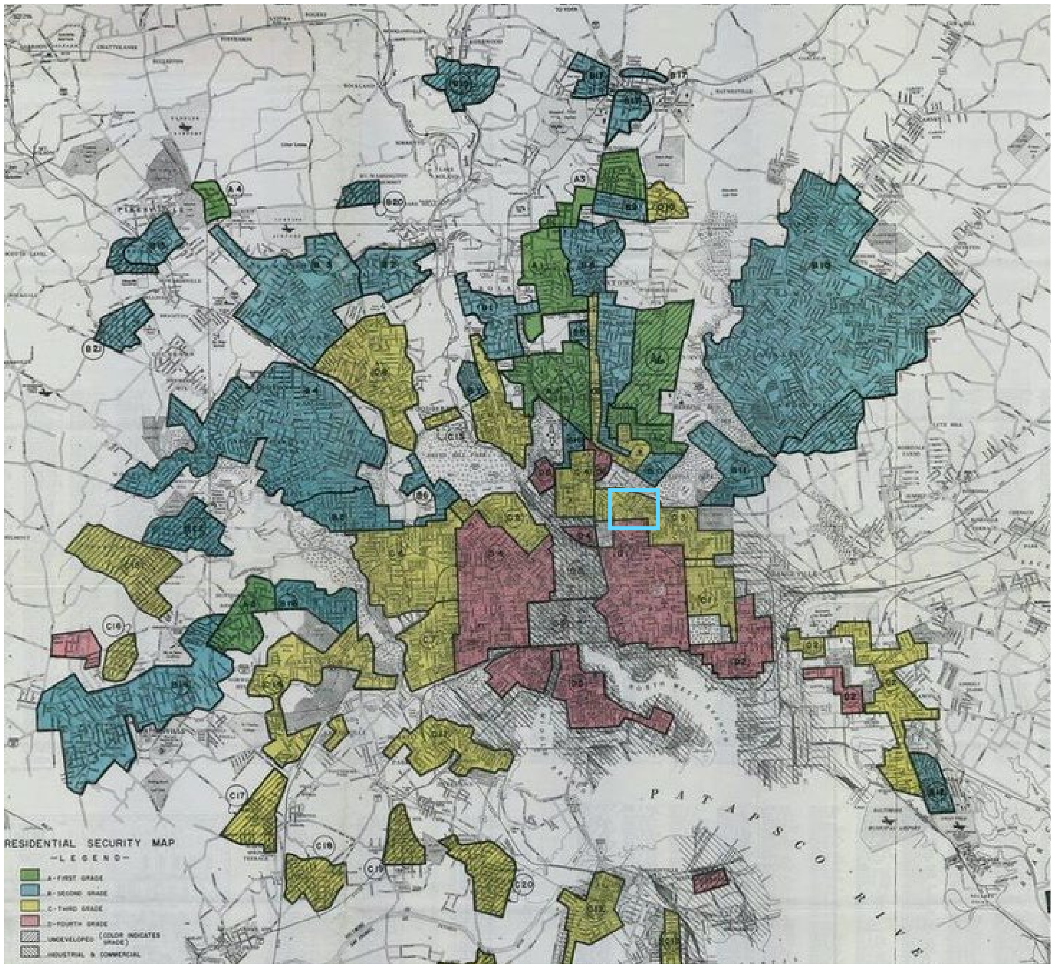


Figure 5.2 Federal HOLC map of Baltimore (HOLC Division of Research & Statistics, 1937)

predominantly inhabited by African American residents and recent immigrants, many of whom were employed in factory jobs near the city's waterfront. The majority of Broadway East, however, was classified as a "yellow" area, indicating slightly higher desirability (Figure 5.3). These homes were generally in better condition, closer to desirable jobs like Johns Hopkins Hospital, and the residents often held skilled labor positions, such as mechanics or clerks. Major roads within the neighborhood also supported vibrant commercial districts where small businesses flourished and residents did not need to travel far to find food, services, jobs, and lodging (Nelson et al., 2023; Ayers Saint Gross & First Baptist Church, 2017).

Figure 5.3 The Broadway East neighborhood boundary overlayed over the 1937 HOLC map. Image by author.

1968 Riots

The 1968 Baltimore Riot, which erupted in response to the assassination of Dr. Martin Luther King Jr., had a profound impact on Broadway East, resulting in the destruction of numerous homes and small businesses. Gay Street, in particular, felt the impact of these riots the most, with almost a third of its businesses lost in the fires that spread throughout East Baltimore's commercial corridors (Figure 5.4). This

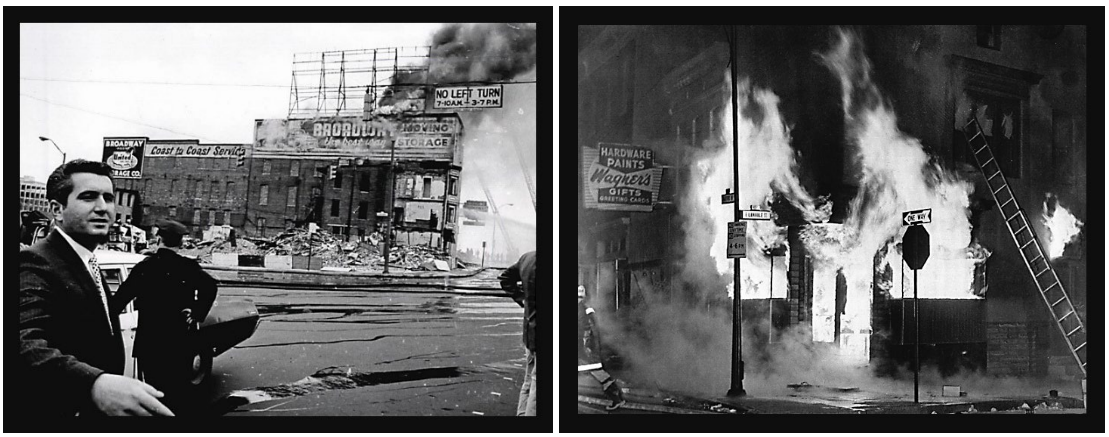


Figure 5.4 Photographs of the 1968 Riot showing burned and destroyed storefronts throughout Baltimore (Cassie, 2018).

event, combined with the decline of the manufacturing sector in the latter half of the twentieth century, led to a sharp decrease in the neighborhood's population. Over 100,000 manufacturing jobs disappeared over the course of 50 years, devastating the local economy and allowing criminal enterprises to take root in vulnerable communities like Broadway East. Ongoing Urban Renewal prioritized neighborhoods occupied by primarily white residents, while neighborhoods like Broadway East failed to receive similar investments that would rebuild the neighborhood after the destruction caused by the 1968 riots. Many residents began to flee from the city, pushed away by rising crime, crumbling infrastructure, and lack of employment opportunities (Cassie, 2018; Ayers Saint Gross & First Baptist Church, 2017; “Baltimore Riot of 1968,” 2025; “Broadway East, Baltimore,” 2025).

Preserving the Past

Despite subsequent increases in vacancy rates and crime, local leaders and community organizations led significant efforts to preserve the neighborhood's historical and cultural legacy. One prominent example is the American Brewery building, a landmark structure that operated as a brewery from 1887 to 1920 and

Figure 5.5 The American Brewery Building in Baltimore ca. 1900 (“American Brewery (Building),” 2025)

again from 1931 to 1973. It now serves as the headquarters for Humanim, a community-based nonprofit organization dedicated to social and economic empowerment. Additionally, the Duncan Street Miracle Garden, established in the 1970s, remains a vital community space through the ongoing support of nonprofits and volunteers (Round, 2020).

Today, Dr. Doris Minor-Terrell, a key figure in the community, leads the Broadway East Community & CDC. Her work focuses on fostering partnerships with local planners, nonprofit organizations, schools, and other stakeholders to drive positive change within the neighborhood. Notably, she recently collaborated with the Landscape Architecture Department at the University of Maryland to redesign a play area in Collington Square Park. Through her leadership, Dr. Minor-Terrell continues to advocate for the neighborhood's revitalization and to serve as a catalyst for future growth and development ((“About Us,” n.d.; Main Home, n.d.; Ayers Saint Gross & First Baptist Church, 2017)).

Demographics and Vacancy

The effects of decades of racist planning policies and systemic disinvestment

Figure 5.6 Images of vacant homes along Gay Street (left) and North Avenue (right). Images by author.

can still be seen in Broadway East today. Like many disinvested neighborhoods in Baltimore, Broadway East faces significant challenges related to housing vacancy (Figure 5.6) and population decline. The neighborhood's vacancy rate is approximately 27%, and the median home value is $120,000. Homeownership is relatively low, with only 37% of homes being owner-occupied, while approximately 63% are rented. Almost 50% of homes were built before 1939 and are in poor condition due to lack of maintenance (Ayers Saint Gross & First Baptist Church, 2017; Baltimore City, 2025).

Beyond housing issues, a substantial portion of the community experiences economic hardship, with nearly 29% of residents living below the federal poverty level (Baltimore City, 2025). Given these conditions, financial concerns are a pressing issue for many families in Broadway East. Efforts to reduce energy cost burdens, like my proposal for a solar-powered microgrid, could serve as an important strategy to address economic challenges in this community.

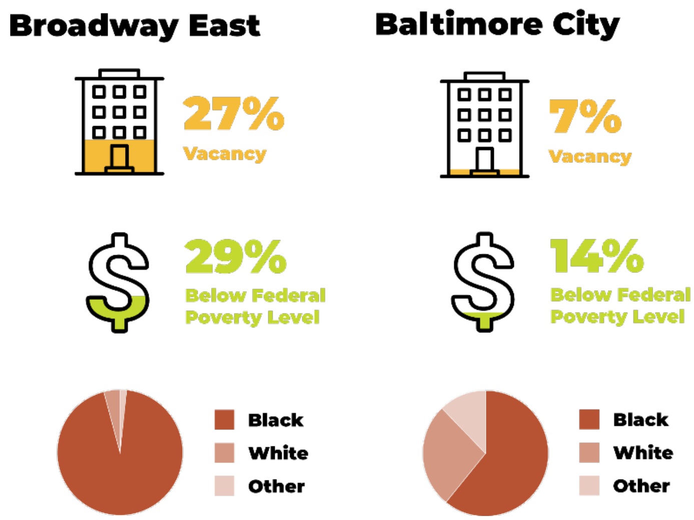


Figure 5.7 Vacancy, poverty, and racial demographic in Broadway East (Baltimore City, 2025).

Proposed Strategic Plans for Broadway East

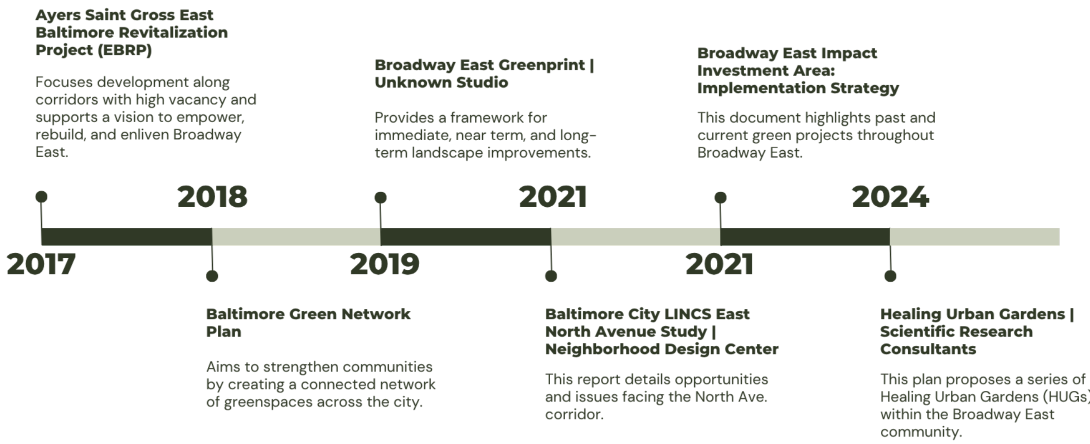


Figure 5.8 Timeline of proposed strategi plans for Broadway East.

Over the past seven years, a number of different planning and design firms worked with the community to develop strategic plans that address the challenges facing Broadway East (Figure 5.8). Given the theoretical nature of this project and time constraints, I drew upon two strategic planning documents to guide the development of my own design goals. The first was a plan developed by Ayers Saint Gross in collaboration with Israel Baptist Church, which envisioned a future for Broadway East grounded in community-driven priorities. Through a series of outreach efforts and design charrettes, the planning team worked with residents to co-create a vision centered on enhancing the neighborhood's natural beauty through the integration of parks, community gardens, and streetscape improvements. The plan also identified a strong community desire for improved access to public transportation

Figure 5.9 East Baltimore Revitalization Plan diagram illustrating increased activation along Gay Street and streets that run north-south like Washington Street (Ayers Saint Gross & First Baptist Church, 2017).

and a more comfortable pedestrian experience along major corridors such as Washington Street (Ayers Saint Gross & First Baptist Church, 2017).

The second resource that informed my design goals was The Greenprint Plan by Unknown Studio, which further explores the potential for green infrastructure within Broadway East. The plan outlines strategies to transform streetscapes and vacant lots into ecologically vibrant and socially supportive spaces. Key recommendations include increasing tree canopy coverage to 40% by planting along streets and alleyways, connecting fragmented greenspaces through green street improvements, and utilizing vacant parcels as multifunctional landscapes that serve children, adults, and local wildlife. Additionally, the plan emphasizes the importance of managing stormwater through the integration of rain gardens and vegetated road buffers. These interventions will not only mitigate flooding but also enhance the aesthetic and ecological quality of the neighborhood (Figure 5.10) (Unknown Studio, 2020).

Figure 5.10 Greenprint Plan diagrams for green street and vacant lot greening interventions (Unknown Studio, 2020)

Chapter 8: Site Inventory and Analysis

With this understanding of the history of Broadway East and key findings from previous planning initiatives, the next phase of the design process focused on identifying sites most suitable for solar energy infrastructure. This site selection process involved a layered spatial analysis of the neighborhood's vacant land assets. I began by reviewing maps of all vacant parcels within Broadway East and cross-referencing them with ongoing development projects, such as those designated for community use or greening. Special attention was given to lots enrolled in or eligible for Baltimore's Adopt-a-Lot program, as these sites offer community access and potential for stewardship. I also prioritized parcels located near existing community hubs and those with strong access to public transportation, recognizing that the success of solar energy landscapes depends not only on technical feasibility but also on accessibility and social integration. This multi-criteria approach helped narrow down a set of sites that aligned with both spatial opportunities and community-based priorities.

Vacant Land

There are close to 52 acres of open green space in Broadway East (Figure 6.1). The open green spaces supply sunny, varied lot sizes and corner lots that allow for excellent visibility and safety, making them ideal for community projects. Their proximity to residences encourages a sense of stewardship, and provides the opportunity to transform these underutilized blocks into vibrant, sustainable spaces with minimal infrastructure needs.

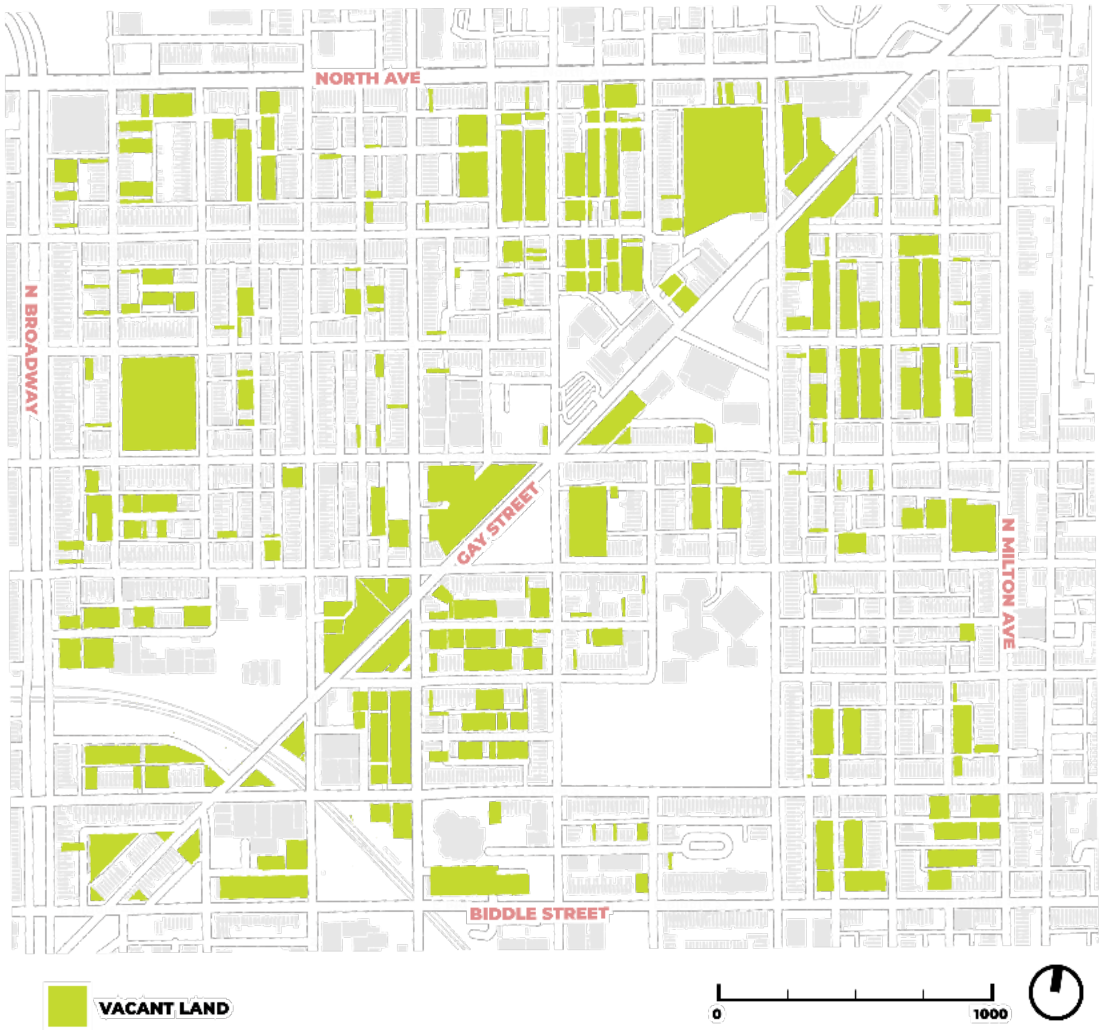


Figure 6.1 All vacant lots in Broadway East

<u>*Adopted Lots and Future Projects*</u>

To refine the list of potential project sites, I first identified areas with existing or planned development by consulting publicly available data from Baltimore's CoDeMap platform. Sites marked in orange indicated active community projects, such as the well-known Duncan Street Miracle Garden, while pink areas represented future development proposals, many of which are concentrated along the Gay Street

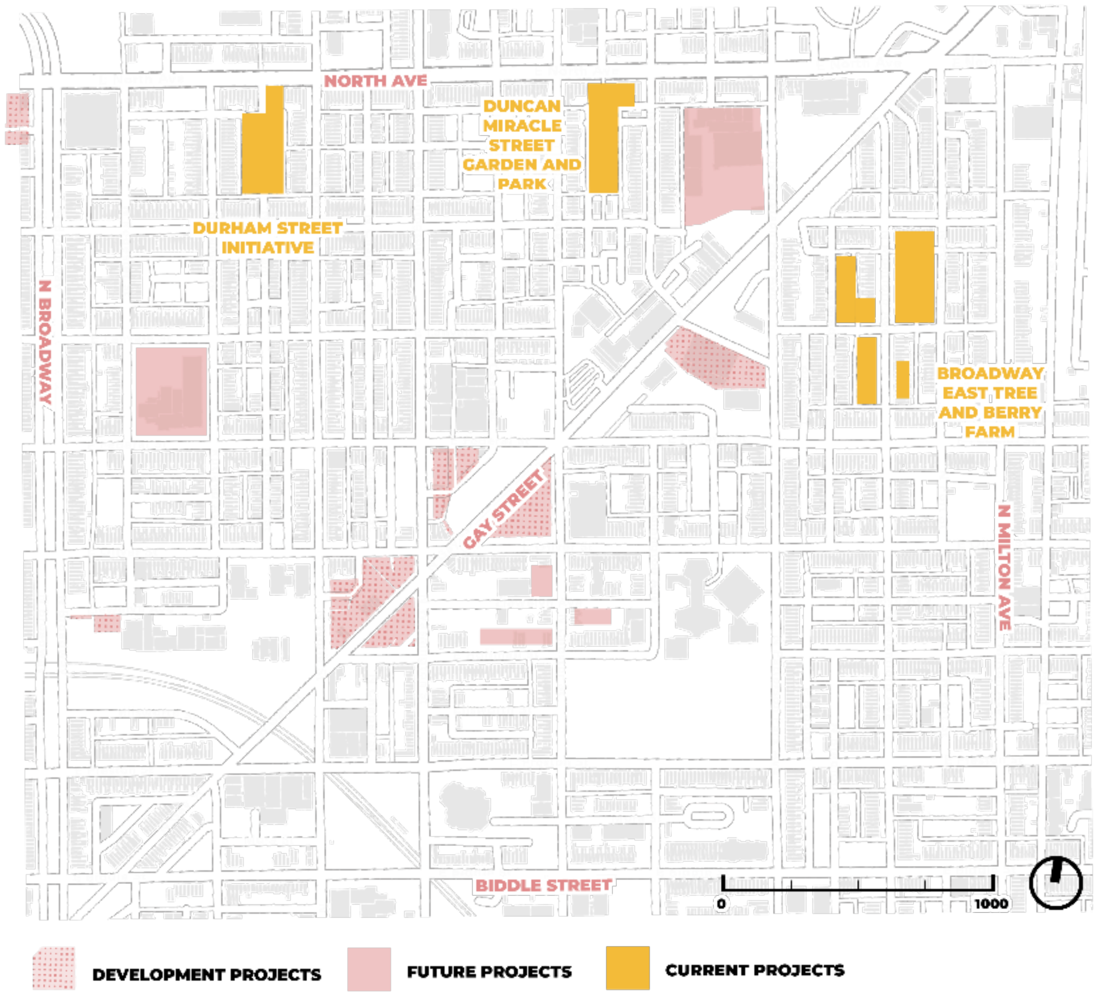


Figure 6.2 Map of current and future projects located on vacant land.

corridor (Figure 6.2). Although detailed information on these forthcoming projects is limited, a planner at Ayers Saint Gross confirmed that many will include mixed-use development. These forthcoming changes are likely to significantly reshape the neighborhood's spatial and social dynamics, making it important to avoid overlap and instead complement future land uses through strategic site selection.

Adoptable Lots

Figure 6.3 highlights parcels of vacant land that are either publicly owned or under partial city ownership and are available through Baltimore's Adopt-a-Lot program. These sites are of particular interest because they represent locations where

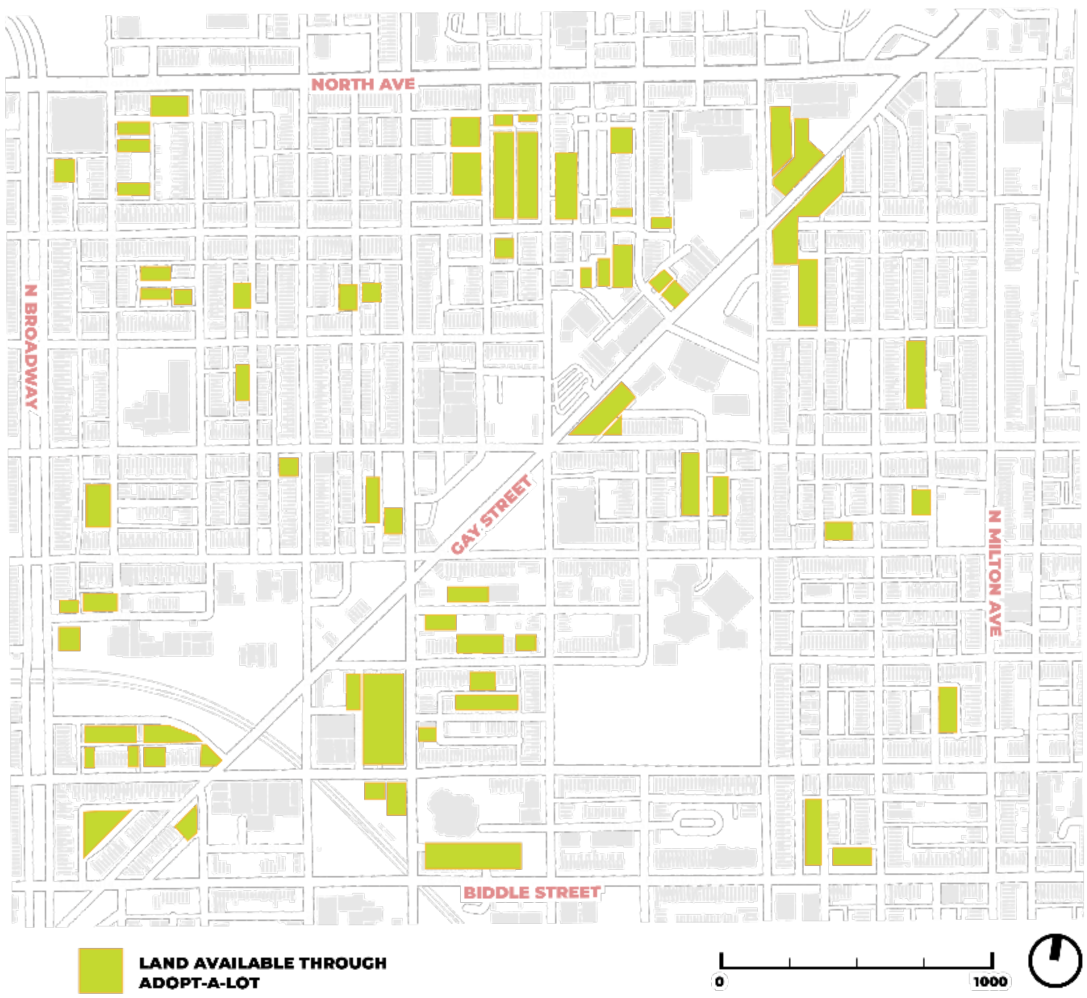


Figure 6.3 Map of currently vacant land that is owned or partially owned by the city.

the city is actively seeking design proposals from community members and partners. As such, they offer a practical and policy-aligned opportunity for implementing publicly beneficial landscape interventions, making them a central focus of my site selection and design process.

Community Hubs

Drawing inspiration from the East Baltimore Revitalization Plan, which strategically concentrated community investment around established neighborhood

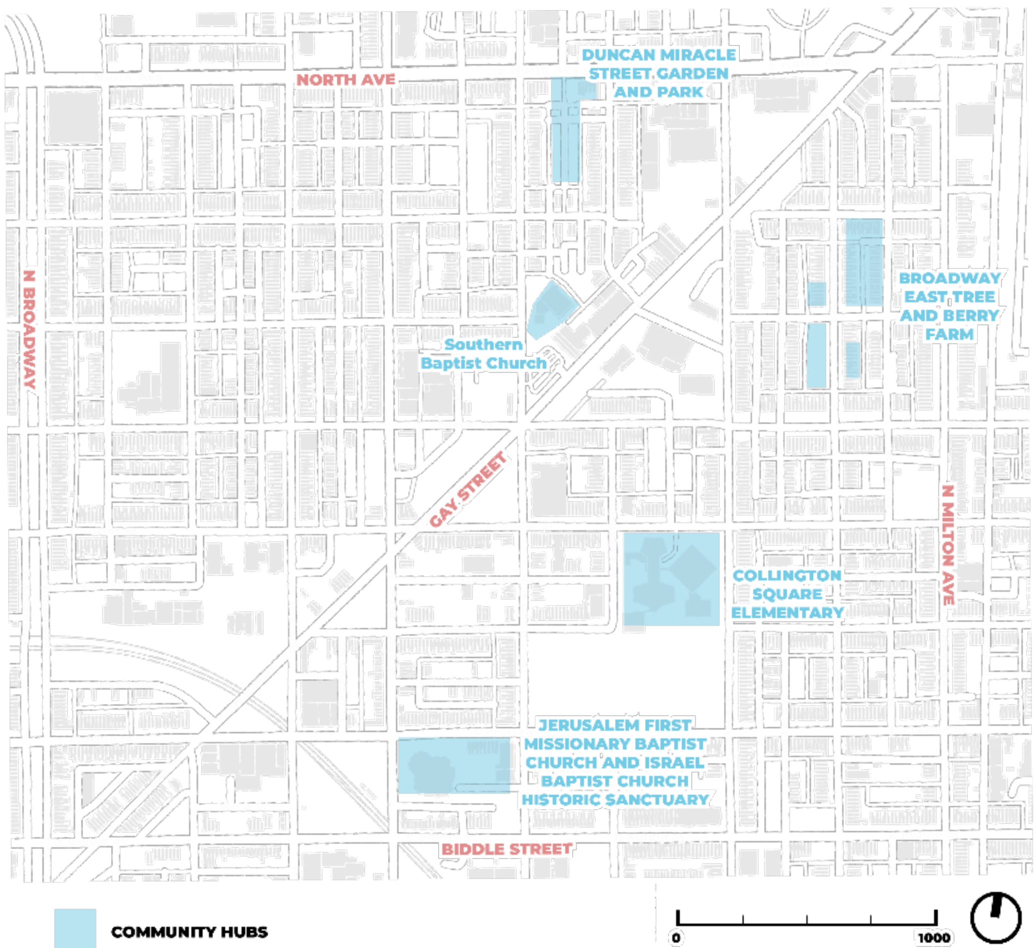


Figure 6.4 Map of community hubs within Broadway East

anchors, I conducted a similar analysis to identify community hubs within Broadway East (Figure 6.4). For the purpose of this study, I defined community hubs as churches, schools, and community gardens – spaces that serve as centers of social activity and local engagement. There are two large churches in the neighborhood – Southern Baptist Church and Isreal Baptist Church. There is also Collington Square Elementary School and two community gardens – the Duncan Street Miracle Garden and the Broadway East Tree and Berry Farm. By mapping these hubs and applying a proximity threshold of a five-minute walking distance, I was able to further refine my solar site selection criteria, limiting the pool of potential vacant parcels to those most likely to support and benefit from existing community networks.

Public Transportation

I also incorporated access to public transportation (primarily bus service) as a key site selection criterion. This consideration aimed to ensure that proposed Multifunctional Solar Energy Landscape (MSEL) sites would be easily accessible to neighborhood residents without private vehicles, as well as to visitors from outside Broadway East. As shown in Figure 6.5, several major bus routes run along North Avenue, Gay Street, Wolfe Street, and Washington Street, providing important transit corridors that informed the selection of preferred vacant parcels.

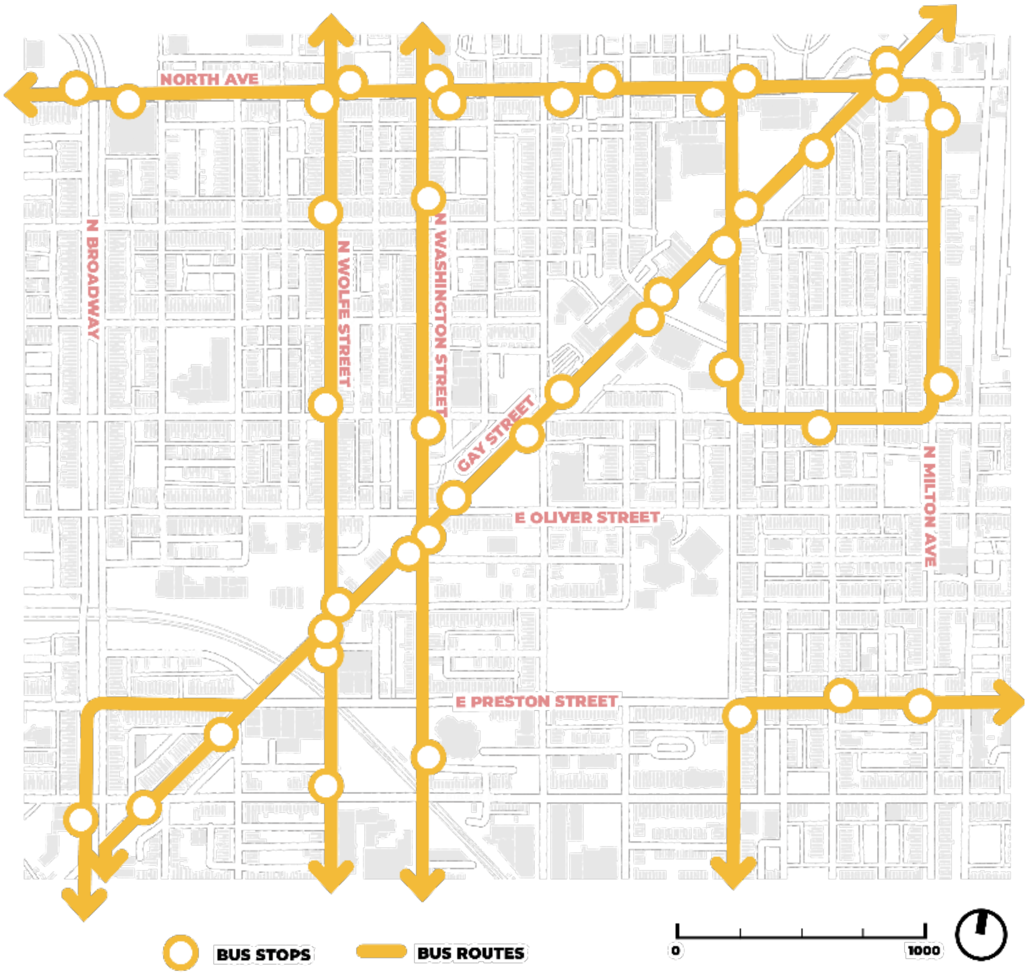


Figure 6.5 Map of public bus routes and stops in Broadway East.

Focus Areas

I compiled all spatial analysis layers into a composite diagram that identifies three potential focus areas, each approximately 687,000 square feet in size (Figure 6.6). I selected these areas based on their accessibility to public transportation, concentration of vacant land, and proximity to key community hubs. **Area 1** is anchored by the Broadway East Tree and Berry Farm and is within walking distance of both Gay Street and North Avenue, major transit and pedestrian corridors. **Area 2** is situated adjacent to Israel Baptist Church and Collington Square Elementary School, making it a strategic location for community-centered investment. **Area 3** lies

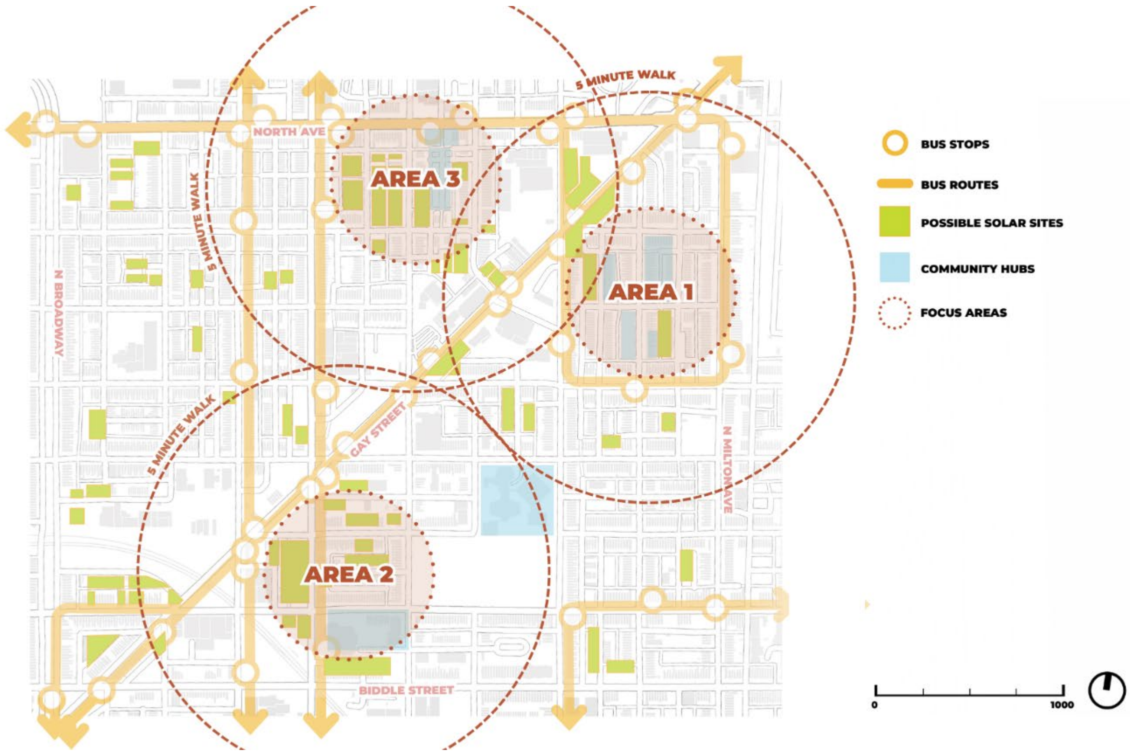


Figure 6.6 Composite map of all selection criteria used to identify three areas of interest.

along North Avenue and includes the historically significant Duncan Street Miracle Garden, a long-standing example of grassroots environmental stewardship in the neighborhood.

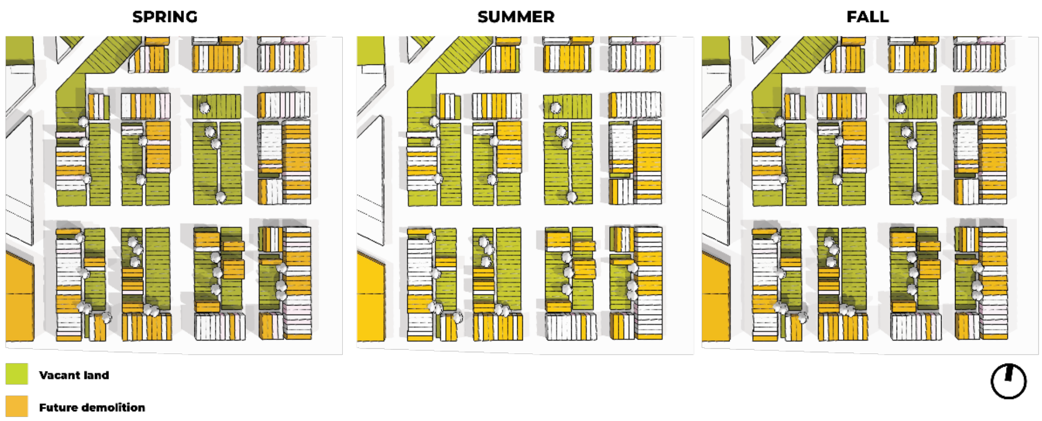
Chapter 9: Site Selection

After narrowing the study area to three focus neighborhoods, I conducted multiple analyses to assess the environmental and social characteristics of each site. I evaluated each focus area, approximately 687,000 square feet in size, based on direct sunlight availability, community land stewardship, tree cover, open space, and the percentage of owner-occupied housing.

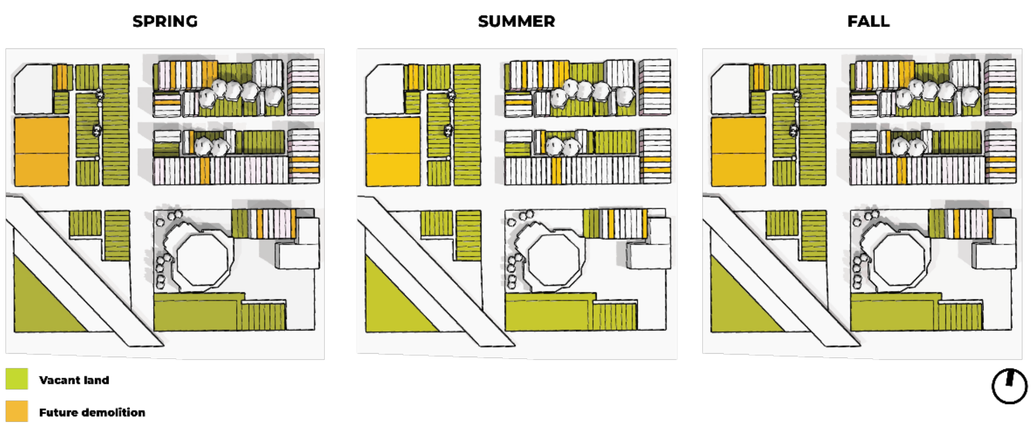
Shade Analysis

To perform the sun-shade analysis, I constructed a 3D model of the neighborhood in SketchUp and captured screenshots at three different times of the day – morning (9:00 AM), noon (12:00 PM), and afternoon (3:00 PM). These times represent a total of six peak sunlight hours. I conducted this analysis for the spring, summer, and fall equinoxes (Appendix A). By overlaying the seasonal shade diagrams, I developed annual shade diagrams for each site, which provided insights into optimal areas for solar panel placement (Figure 7.1). Area 2 received the highest levels of direct sunlight due to its large plots with minimal mature tree coverage. In contrast, Area 1 received the least sunlight, particularly in its unused vacant lots. Although there was greater sun exposure in the lots currently utilized for tree and berry production, I did not wish to propose construction that could risk ongoing agricultural activities. The remaining land in Area 1 is not suitable for the installation of large-scale solar panels. Lastly, Area 3 experiences a moderate-to-high level of direct sunlight. However, it lacks the expansive, continuous spaces present in Area 2 and contains a higher density of trees.

FOCUS AREA 1 ANNUAL SHADE ANALYSIS



FOCUS AREA 2 ANNUAL SHADE ANALYSIS



FOCUS AREA 3 ANNUAL SHADE ANALYSIS

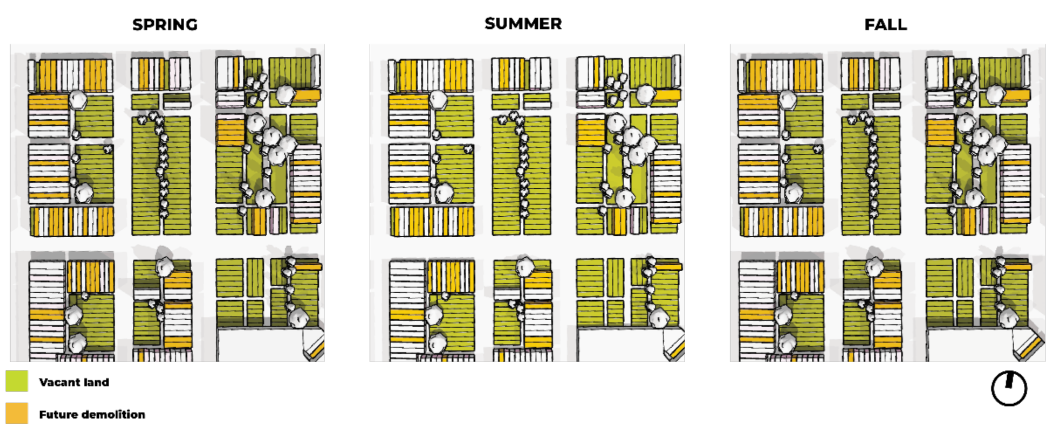


Figure 7.1 Annual shade diagrams for Focus Areas 1, 2, and 3.

Tree Cover

I analyzed tree cover using Geographic Information System (GIS) data obtained from Baltimore's CoDeMap and OpenGIS platforms (Figure 7.2), along with satellite imagery from Google Earth. I calculated the total tree coverage, including both street and canopy trees, within a 687,000 square foot area. From these measurements, I determined the percentage of tree cover in each focus area. Area 2 exhibited the lowest tree cover percentage at 5.7%, while Area 3 and Area 1 had the first and second highest percentages, respectively (Figure 7.3).

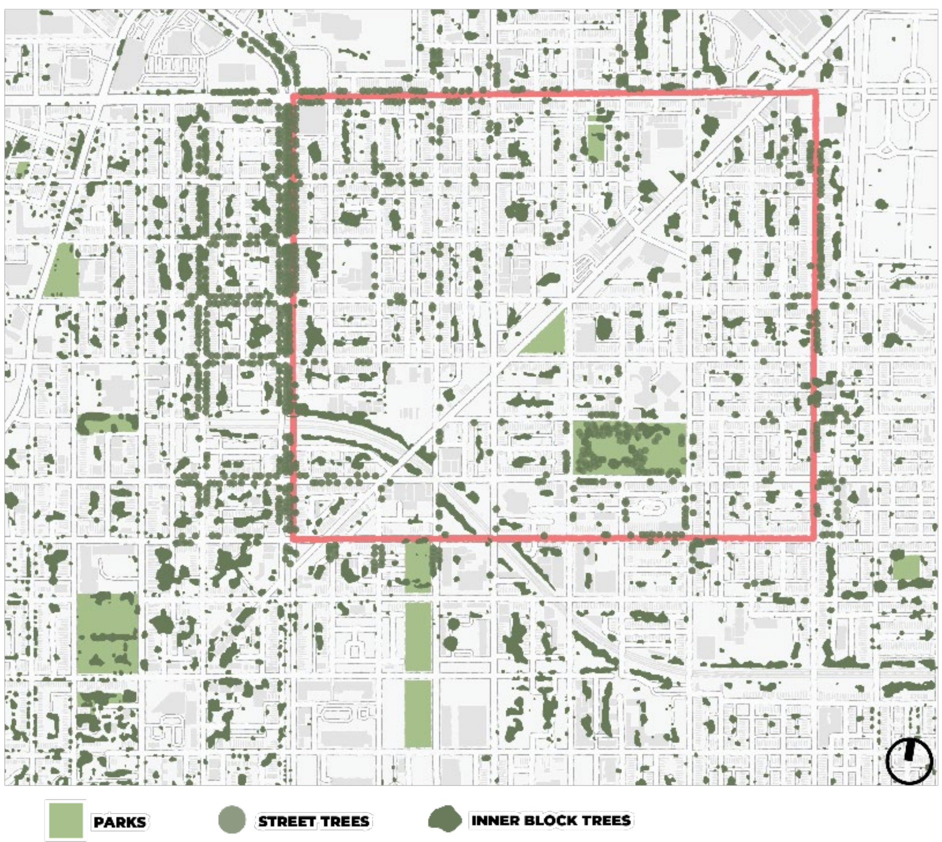


Figure 7.2 Parks, street trees, and canopy trees within Broadway East and the surrounding area.

Focus Area	Total Tree Area (ft.^{2})	Focus Area Size (ft.^{2})	Tree Coverage (%)
Area 1	58,742	687,000	8.6
Area 2	39,460	687,000	5.7
Area 3	71,264	687,000	10.4

Figure 7.3 Table showing the tree coverage percentages for each focus area.

Open Space

To analyze the available open space, I utilized the sun-shade diagrams I created previously to identify areas that receive the most sunlight over a six-hour period throughout the day. After importing these diagrams into ArcGIS, I outlined areas with the least amount of shading and calculated the total area of optimal land within each of the three focus areas. I excluded land that met either of the following criteria: (1) currently in use for other purposes, such as urban farming, or (2) parcels smaller than 500 square feet, as they were insufficient to support solar activities. The remaining land is referred to as the "Area of Usable Vacant Land." For simplicity, I rounded the total area calculations to two significant figures.

Focus Area	Area of Useable Vacant Land (ft.^{2})
Area 1	34,000
Area 2	80,000
Area 3	51,000

Figure 7.4 Table showing the area of usable land in each focus area.

Community Analysis

In this analysis, I aimed to assess the level of community engagement in land stewardship within each focus area. Specifically, I examined the extent to which community members participated in activities such as maintaining community gardens or organizing community outreach events.

Focus Area 1, located at 1600/1700 Montford Avenue, is home to the Broadway East Tree and Berry Farm, which was established by The 6th Branch in 2021 (*Our Farms*, n.d.). Collectively, The 6th Branch manages over 20 acres of green space in East Baltimore. Their farms produce a diverse array of vegetables, perennial fruits, herbs, and cut flowers, including tomatoes, peppers, squash, leafy greens, blackberries, blueberries, grapes, peaches, and figs. In 2023, they harvested approximately 6,500 pounds of produce. The farm also grows trees in containers that can be purchased by the city for sites around Broadway East or the rest of the city (Figure 7.5). The organization employs regenerative and sustainable farming practices, avoiding pesticides to maintain soil health and ensure safe, accessible green spaces (Quigley, 2024). Techniques such as low or no tillage, cover cropping, drip

Figure 7.5 Image of young trees growing in containers at the Broadway East Tree and Berry Farm (Quigley, 2024).

irrigation, and the use of landscape fabric help manage water usage and control weeds (*Our Farms*, n.d.). To support their operations, The 6th Branch relies on a dedicated team of staff, service corps members, community volunteers, and partners. Engaging with the community is a cornerstone of their mission. They distribute produce through weekly farm stands at no cost, without limiting quantities. Collaborations with local nonprofits enable the provision of food boxes to the elderly and those with dietary restrictions. The organization also hosts farming workshops, cooking demonstrations, open farm events, and educational programs for local schools, fostering a deep connection with the communities they serve. Through these efforts, The 6th Branch addresses food insecurity and promotes environmental justice by transforming underutilized urban spaces into vibrant, productive farms that benefit

Baltimore residents (Quigley, 2024). Based on the extent of these efforts, I gave Area 1 a community rating of 5 out of 5.

Focus Area 2 is home to the Israel Baptist Church, which serves as a significant community institution. The current church building was constructed in 2004 following the acquisition and demolition of 90 rowhomes that had fallen into disrepair. With a seating capacity exceeding 1,500 parishioners, the church functions as a central hub for community activities. According to the church's Facebook page, it hosts a variety of events throughout the year, including food banks, school supply drives, and communal potlucks (*Israel Baptist Church of Baltimore City Streaming*, n.d.). However, the extent of the church's involvement in land stewardship activities remains unclear. A review of the church's website did not reveal any evidence of participation in initiatives such as trash cleanups or community gardening, suggesting an opportunity to introduce such programs. Notably, many members of the congregation appear to be older, with a significant portion attending services via online streaming. This demographic consideration may present physical limitations, which should be taken into account during the planning and implementation of new community engagement initiatives. For these reasons, Area 2 received a community score of 3 out of 5.

Focus Area 3, which received the highest community score, features the iconic Duncan Street Miracle Garden, a neighborhood hub that has operated for almost 50 years. It was established in the 1970s by the Pharaoh's Social Club and served as a communal space for neighbors to gather and cultivate the land. In 1988, Mr. Lewis Sharpe revitalized the garden, transforming it from a neglected area into a vibrant urban oasis (Figure7.6). Drawing from his rural Virginia farming roots, Mr. Sharpe has dedicated himself to the garden, fostering a deep connection between the land and the community (*Duncan St. Miracle Garden*, n.d.).

Figure 7.6 Image of Mr. Sharpe who is the founder of the Duncan Street Miracle Garden (Round, 2020)

Along with a multitude of volunteers, he grows vegetables, fruits, and flowers that are given away to the community free of charge. Recently, there have been efforts to maintain the garden as a vital community hub amidst large-scale development plans. The Neighborhood Design Center (NDC) has been working with Mr. Sharpe to preserve the history and character of the garden, and in 2017, they unveiled a visual tribute to Mr. Sharpe in the form of a mural painted by the internationally acclaimed street artist Gaia (Figure 7.7) (*Duncan St. Miracle Garden*, n.d.). At 86 years old, Mr. Sharpe continues to be a fixture in the community, although his ability to keep up with gardening tasks is slowly declining. Community involvement and volunteer partnerships are needed now more than ever (Round, 2020).

Figure 7.7 Duncan Street Miracle Garden mural painted by the internationally acclaimed street artist Gaia (Duncan St. Miracle Garden, n.d.).

Owner-Occupied Housing

One of the biggest challenges when constructing ground-mounted solar infrastructure in urban settings is the opposition from people residing directly next to solar farms. Many people consider the solar panels to be visually unappealing and worry that their property could be devalued as a result of new solar infrastructure (Allnut, 2024). Therefore, I wanted to quantify the percentage of owner-occupied housing in each focus area. I created a map of all owner-occupied homes in the neighborhood (Figure 7.8) and divided the area of owner-occupied land by the area of useable land (Figure 7.9). Area 1 had the highest percentage of owner-occupation while Area 2 and Area 3 had much lower percentages.

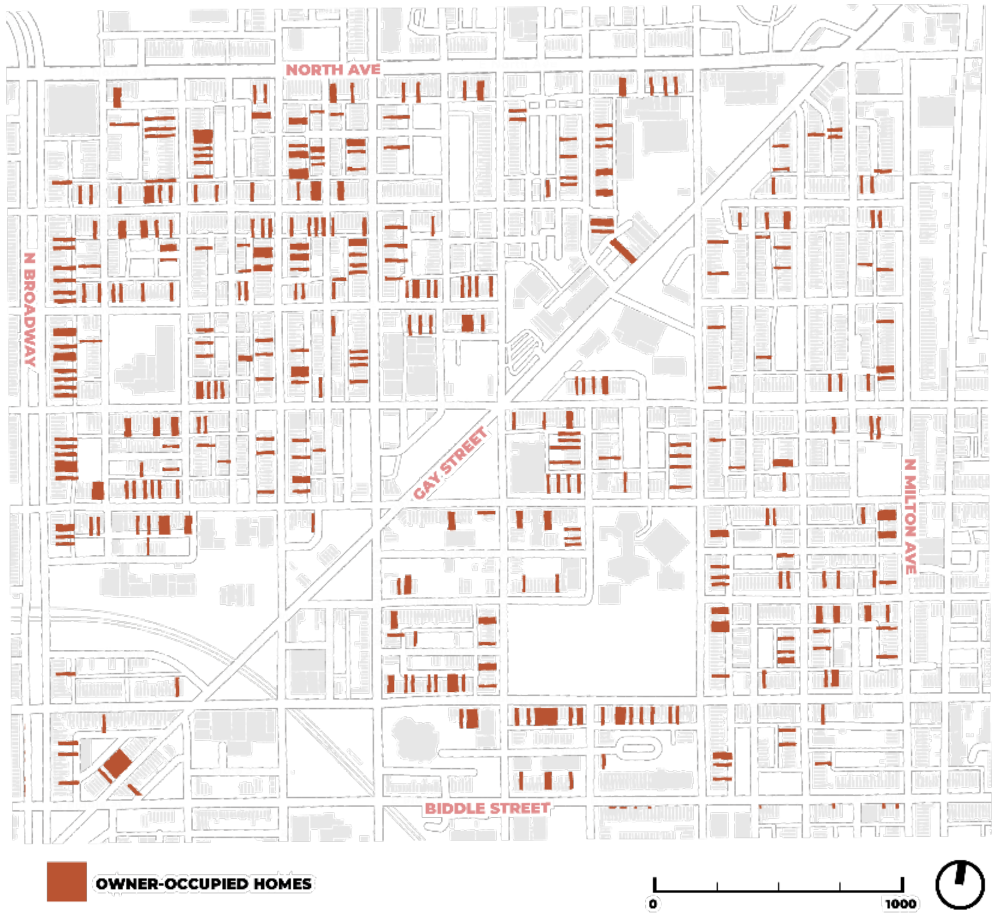


Figure 7.8 Map of owner-occupied homes and land within Broadway East.

Focus Area	Area of Useable Vacant Land (ft.²)	Area of Owner-Occupied Land (ft.²)	Owner-Occupied (%)
Area 1	34,000	24,000	70%
Area 2	80,000	24,000	30%
Area 3	51,000	18,000	35%

Figure 7.9 Table showing the percentage of owner-occupied land in each focus area.

Evaluating Design Potential in Each Area

To assess the design potential of each focus area, I applied a design framework developed by Oudes et al.(2022), which categorizes spatial properties according to three key dimensions: **economic**, **nature**, and **landscape**. I then used this framework to guide the creation of site-specific diagrams for each of the three focus areas (see Figure 7.11).

Each spatial property (rows) aligns with one or more of the three dimensions (columns) (Figure 7.10). While some properties clearly align with a single dimension, others may span multiple categories, requiring the designer to use professional judgment to determine the most contextually appropriate classification.

For example, the spatial property "Incidental patch configuration" refers to fragmented land patterns that arise due to existing obstacles (Oudes & Stremke, 2021, p. 6). These obstacles may be due to economic (e.g., land ownership), nature (e.g., habitat preservation), or landscape (e.g., aesthetic or historical considerations) reasons

Spatial Property	ECONOMIC	NATURE	LANDSCAPE	AREA 1	AREA 2	AREA 3
Incidental patch configuration	● (blue)	● (green)	● (orange)	● (blue)	● (orange)	● (green)
Decreased patch density		● (green)	● (orange)	● (orange)	● (green)	● (green)
Reduced visibility			● (orange)	● (orange)	● (orange)	● (orange)
Ecological features added beneath or between solar infrastructure		● (green)			● (green)	● (green)
Adjusted fence permeability		● (green)			● (green)	● (green)
Educational features			● (orange)	● (orange)	● (orange)	● (orange)
Vehicle storage or charging			● (orange)		● (orange)	● (orange)
Crop production beneath or between solar infrastructure	● (blue)			● (blue)	● (blue)	● (blue)
Fruit orchard and/or vegetable gardens		● (green)	● (orange)	● (orange)	● (orange)	● (orange)
Providing water storage capacity		● (green)			● (green)	● (green)
Access within MSEL			● (orange)	● (orange)	● (orange)	● (orange)
Reversibility to previous landscape conditions	● (blue)			● (blue)	● (blue)	● (blue)
Improvement of ecosystem services		● (green)			● (green)	● (green)
Continued synergy between PV and existing land use	● (blue)			● (blue)	● (blue)	● (blue)
Retaining existing vegetation	● (blue)	● (green)	● (orange)	● (green)		● (blue)
Retaining cultural-historical artifacts			● (orange)	● (orange)		

Figure 7.10 Table showing the relationship between spatial properties and social dimensions. Based off of the table by (O'Neil et al., 2022).

(Oudes et al., 2022). In Focus Area 1, the presence of the existing Broadway East Tree and Berry Farm represents an economic constraint. Removing farmland to make way for solar infrastructure could result in economic loss for the community. In Area 2, social and cultural sensitivities related to the proximity of Israel Baptist Church and major roadways could influence public acceptance, introducing landscape-based constraints. Area 3 is characterized by mature tree cover, which presents ecological limitations to solar siting.

The remaining rows (spatial properties) contain a simplified version of the spatial property table defined in Oudes et al. (2022). More detailed definitions can be found in the aforementioned paper, as well as an earlier paper published by Oudes and Stremke (2021). Using this framework, I determined the applicability of every spatial property to each of the three areas, then tallied the number of economic, nature, and landscape markers in each column. These tallies informed the development of the spatial diagrams shown in Figure 7.11. The results indicate that Focus Area 1 is most strongly aligned with landscape-driven priorities, while Areas 2 and 3 present a more balanced distribution across all three dimensions.

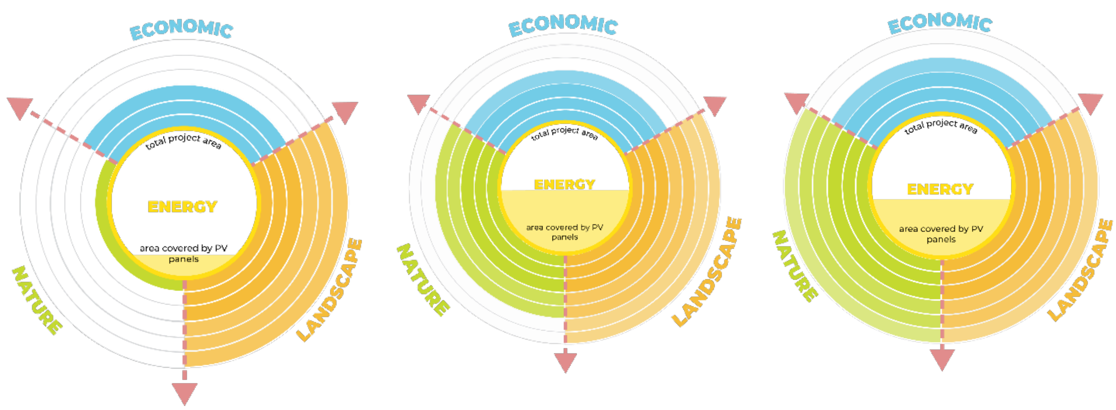


Figure 7.11 Social dimension diagrams for Area 1 (left), Area 2 (middle), and Area 3 (right)

Possible Solar Infrastructure Typologies

In addition to the social dimension diagrams discussed in the previous section, I employed a holistic site analysis to determine which Multifunctional Solar Energy Landscape (MSEL) typologies would be most appropriate for each focus area. The three typologies under consideration were agrivoltaics (the co-location of solar infrastructure with agriculture), ecovoltaics (solar infrastructure integrated with ecological restoration or conservation), and solar parking canopies.

To assess suitability, I evaluated a combination of spatial and social factors, including the extent of open space, existing tree cover, and the presence of established community assets or land stewardship practices. I then synthesized these criteria into a suitability map (Figure 7.12), which illustrates the typologies most aligned with the physical and social conditions of each site.

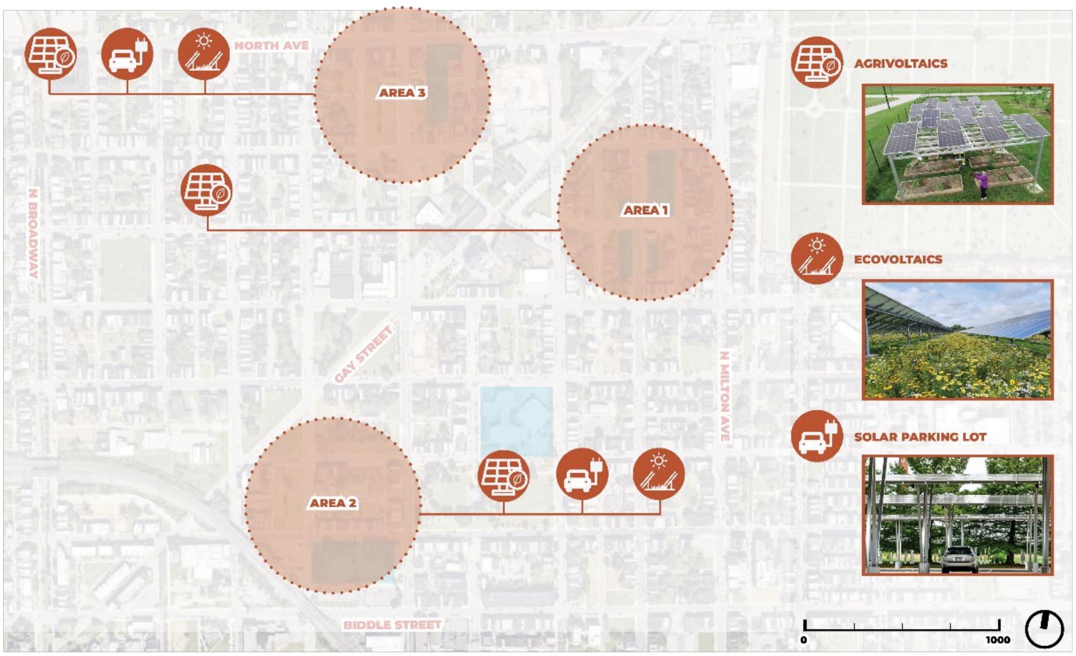


Figure 7.12 Diagram showing which MSEL typologies would be suited for each focus area.

Suitability Ratings

To further refine site selection, I developed a qualitative rating system based on five key criteria I examined above: solar availability, potential for community partnerships, extent of existing tree cover, amount of open space, and the percentage of owner-occupied housing. I created Figure 7.13 to summarize and compare the ratings of each focus area, which helped me make my final selection on which area would be best suited for MSEL design interventions. Based on this analysis, Focus Area 2 emerged as the most suitable site, offering the greatest balance of solar access, community engagement opportunities, and available land.

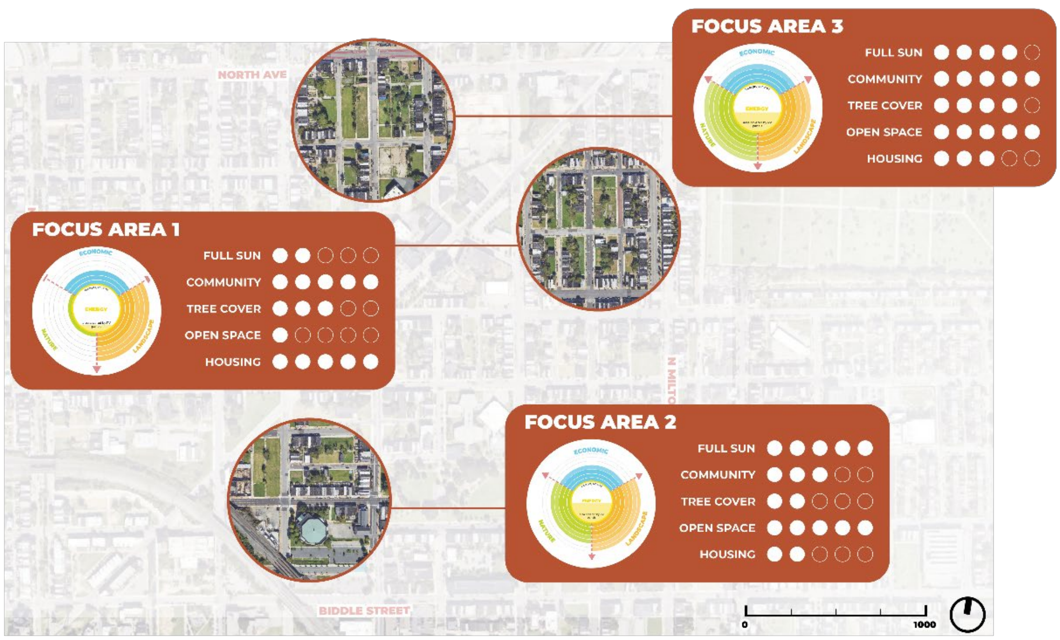


Figure 7.13 Site suitability ratings for Focus Areas 1, 2, and 3.

Area 2 Site Analysis

After selecting Focus Area 2 as the most viable site for an MSEL intervention, I conducted a more detailed site analysis to identify opportunities and constraints within the area. As shown in the accompanying imagery (see Figures 14-15), the site contains substantial vacant land, much of which is underutilized and lacks features that support the human experience.

Figure 7.14 Aerial image of Area 2 (left), image of the largest vacant lot at the intersection of Washington Street and Preston Street (top right), and image of temporary parking lot adjacent to the Amtrak line (bottom right). Images courtesy of Google Earth.

I identified several opportunities:

4. **Vacant Land**: The presence of large, contiguous parcels of vacant land provides flexibility for the installation of ground-mounted solar arrays.
5. **Community Anchors**: The site is adjacent to Israel Baptist Church and within short walking distance from Collington Square Elementary School, offering strong potential for community partnerships and co-programming.

6. **Public Realm Enhancements**: The area would benefit from landscape improvements such as ornamental plantings, shade trees, and outdoor gathering spaces to enhance walkability and create a more welcoming environment.
7. **Streetscape Modifications**: Narrowing certain street segments could create space for wider sidewalks and improved pedestrian infrastructure.

At the same time, a few constraints must be considered. Several mature trees may require removal or pruning to prevent shading on the proposed solar infrastructure, which raises ecological and aesthetic concerns. Additionally, portions of the site border owner-occupied housing, necessitating thoughtful design approaches that prioritize visual quality and minimize disruption to adjacent residents.

This analysis informed the development of design strategies that balance energy production with ecological enhancement and community enjoyment.

Figure 7.15 Perspective of a small block of vacant land located next to an alley street. Image courtesy of Google Earth.

Site analysis diagrams centered on Area 2 allowed me to further refine my design goals. I began by identifying three vacant areas that received a good amount of direct sunlight and were part of the Adopt-A-Lot prgram (Figure 7.16).

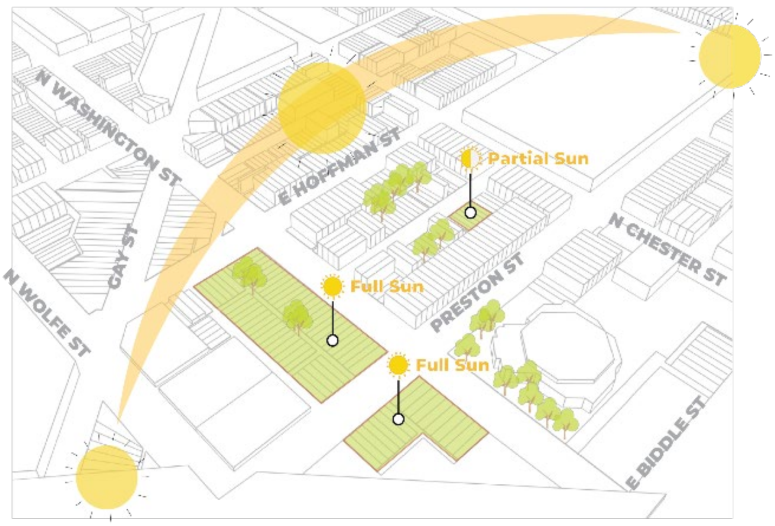


Figure 7.16 Area 2 sun analysis

I then assigned MSEL typologies to each lot, based on their size, location, and how much sunlight was available (Figure7.17). The largest lot (47,200 ft^2) would become

Figure 7.17 Area 2 MSEL typologies

the solar polllinator meadow, the medium-sized area (15,700 ft^2) would become the solar canopy parking lot, and the smallest area (8,000 ft^2) would become the agrivoltaic site.

Car, bus, and bike lanes played a key role in determining suitable locations for electric vehicle (EV) charging stations and micromobility infrastructure. Washington Street, a four-lane road that prioritizes vehicular traffic, serves as a major northbound corridor for both cars and buses (Figure 7.18), passing directly by the proposed

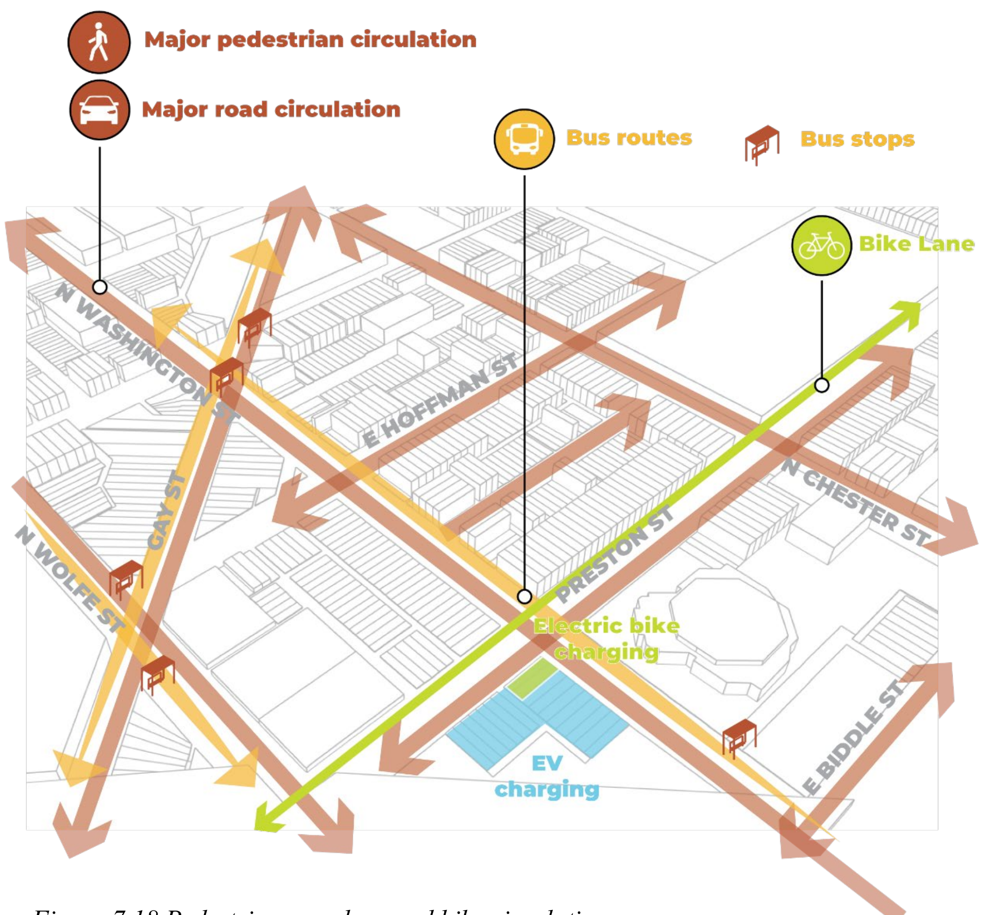


Figure 7.18 Pedestrian, car, bus, and bike circulation

parking and charging site. However, the street currently offers minimal pedestrian amenities, such as shade trees, resulting in a less inviting environment for those traveling on foot. A bike lane runs along Preston Street and conveniently connects

East Baltimore to West Baltimore. A charging dock for electric bikes at the intersection of Preston Street and Washington Street could provide a useful ammentity for those who frequently use that bike lane, and also encourage others to consider alternative modes of transportation powered by renewable energy.

To account for public visibility, I created a diagram that analyzed key sightlines from residential properties and high-traffic pedestrian corridors such as Washington Street, where views of the proposed solar infrastructure would be most frequent (Figure 7.19). In areas with greater visual exposure, I incorporated design strategies such as low-growing trees and decorative fencing to provide partial screening, ensuring that the infrastructure integrates more thoughtfully into the surrounding streetscape.

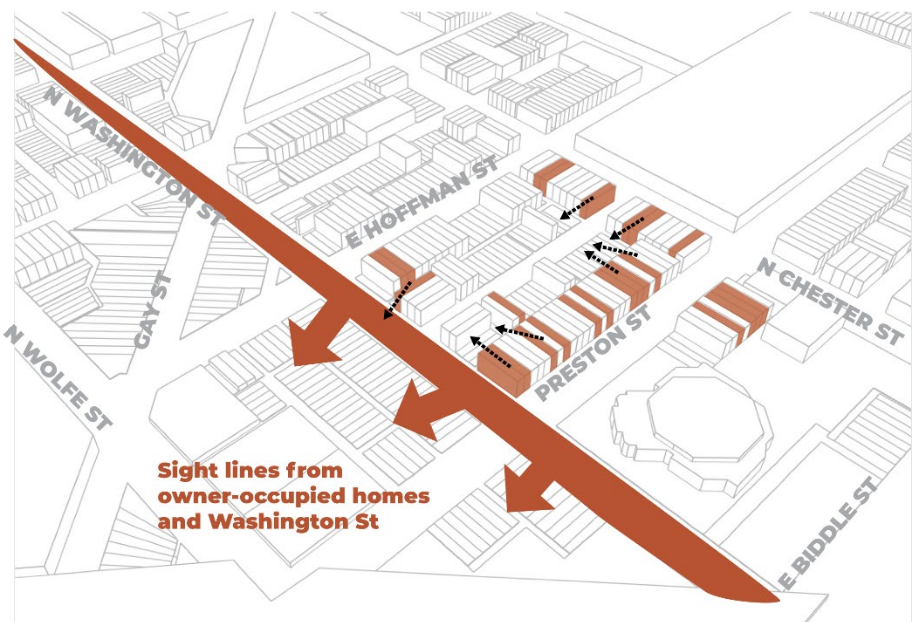


Figure 7.19 Sightlines from owner-occupied homes and Washington Street

Finally, I analyzed topographic maps to create a drainage diagram illustrating the flow of stormwater across the neighborhood (Figure 7.20). This analysis helped identify areas where water is likely to accumulate or cause erosion, particularly along the western and southwestern edges of the proposed sites. As a result, I prioritized these areas for the placement of rain gardens to manage runoff and mitigate potential soil erosion.

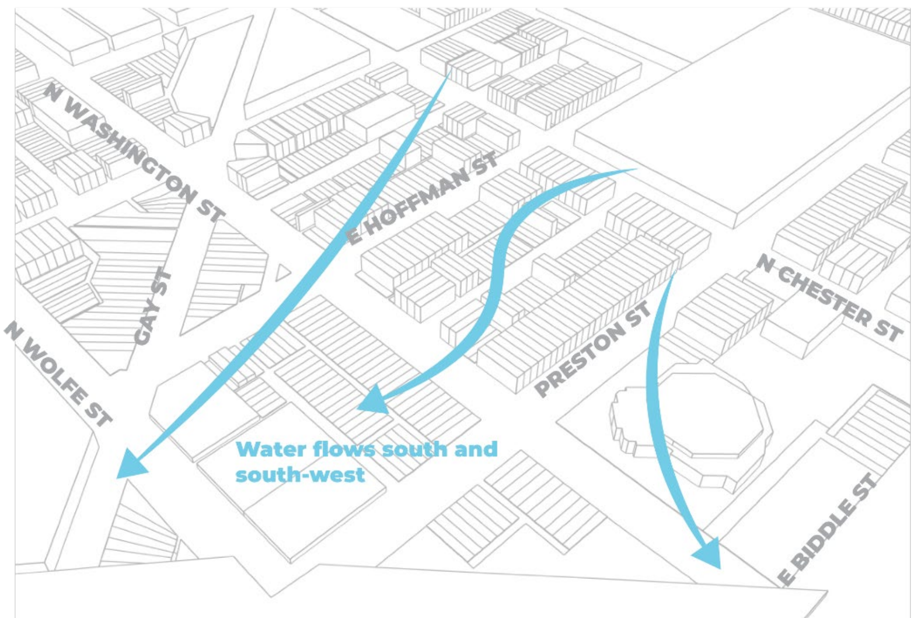


Figure 7.20 Direction of waterflow in Area 2

Chapter 10: Design

Design Goals

As a necessary preliminary step in my design process, I synthesized the findings from past planning proposals and the analysis discussed in the previous chapters to develop a list of design goals based on the three dimensions of solar energy: economic, nature, and landscape. Each of the three sites chosen within Area 2 will feature landscape strategies and solutions that respond to one of these three dimensions, with variations depending on local site conditions. Each of these dimensions corresponds to an icon (Figure 8.1), which is used to call out specific elements in each plan and their contributions to achieving the goals.

Figure 8.1 Icons associated with the three dimensions of MSEL design.

Economic

The economic design goals for this project were to:

1. Provide free or subsidized energy benefits to local residents;
2. Support the cultivation of vegetables or cash crops that can contribute to local food access and offer supplementary income for growers;
3. Attract tourism and outside visitors through multifunctional site design.

These objectives respond directly to the documented energy burdens faced by low-to-moderate income (LMI) communities such as Broadway East, where financial insecurity is a primary concern. They were also informed by the Detroit solar farm case study, which revealed that community acceptance of energy infrastructure increases when projects deliver tangible, localized economic benefits.

Nature

The nature design goals for this project are to:

1. Create new habitats that support pollinators and other urban wildlife;
2. Strengthen ecological connectivity by linking existing green spaces such as Eager Park, Collington Square Park, and Clifton Park;
3. Manage stormwater runoff from surrounding impervious surfaces.

These goals align with the broader greening priorities outlined in the East Baltimore Revitalization Project (EBRP) and the Broadway East Greenprint plan. Observations made during the site analysis, particularly the presence of erosion and pooling in the gravel parking area, further emphasized the need to incorporate stormwater management strategies into the design.

Landscape

The landscape design goals for this project are to:

1. Create inclusive public gathering spaces that foster community interaction and provide opportunities for events, rest, and recreation;

2. Enhance walkability and pedestrian comfort along Washington Street through the addition of shade trees, wider sidewalks, and traffic-calming features;
3. Support the use of electric vehicles and promote multi-modal transportation by integrating EV charging stations, bike infrastructure, and improved transit access;
4. Elevate the visual and experiential quality of the neighborhood through thoughtful planting design.

These goals reflect the social priorities outlined in the EBRP, which emphasizes the importance of public space and mobility in community well-being. They are also informed by firsthand observations during site visits, which revealed gaps in pedestrian infrastructure, limited access to inviting outdoor spaces, and opportunities to better connect residents with their environment.

Community Garden and Park

The first and smallest of the three sites, at approximately 8,000 square feet, is a community garden and park, which is conveniently located within short walking distance from Collington Square Elementary and Israel Baptist Church. The goal of this site is to prioritize social gathering opportunities and amenities for the community, with less emphasis placed on maximizing solar production.

In the site plan (Figure 8.2), owner-occupied houses are marked by the number "11" and existing trees are marked by the number "8." These two factors played a role in the decision to locate the agrivoltaics structure closer to Ellsworth Street and to add small trees around the border of the site to further screen the structure from neighboring residences.

Figure 8.2 Community Garden and Park master site plan.

A paved gathering space is located on the west side of the park, complemented by ample picnic seating along the south side (Figure 8.3). Visitors or volunteers can use these spaces to host community events or educational workshops centered around urban farming. An added swing set and open lawn on the east side of the park provide additional entertainment for younger visitors. Trees and ornamental plantings around the perimeter provide much-needed summer shade and enhance the overall vibrancy of the park.

Figure 8.3 Aerial perspective of the Community Garden and Park.

The agrivoltaic system consists of solar panels mounted on a metal structure, allowing sufficient sunlight to reach the raised garden beds below. The site produces approximately 12,744 kWh of electricity per year, which can power automatic irrigation systems and other maintenance equipment. Community members also have access to free phone charging stations located within the equipment shed, which houses both a battery and inverter as part of the site's integration into a microgrid.

Fences are a necessary and practical addition to the site (*Baltimore City Solar and Wind Zoning*, 2022). They help prevent vandalism and keep people away from high voltage solar energy equipment. Aside from its practical use, fencing can also serve aesthetic purposes. Most of the garden area is enclosed by simple metal fencing, but the side adjacent to Ellsworth Stret features a more ornamental design, inspired by a pattern of overlapping leaves (Figure 8.4).

Within the garden, there are 12 raised planting beds designated for food production. Based on findings from the Temple University case study, crops such as lettuce, cherry tomatoes, beans, and radishes are recommended, as they performed well under similar conditions (*Temple University Ambler Campus*, 2024).

A community farm in the Upton neighborhood of Baltimore is experimenting with growing indigo for dye, which has the potential to generate significant profit through sales to various companies (Edmunds, 2024). Plants like indigo may require more direct sunlight and in these cases, the spacing between solar panels can be widened to increase light penetration. Alternatively, semi-transparent solar panels, which allow light to pass through, could be used, although they are more costly and less energy efficient (Lozanova, 2025).

Figure 8.4 Perspective underneath the agrivoltaic structure.

To ensure ease of movement and accessibility throughout the site, approximately 4 feet of clearance is maintained between each planting bed (Figure

8.5). This spacing allows for comfortable pedestrian circulation, including access for maintenance activities and potential use of small equipment. A gravel maintenance road on the east side of the site allows maintenance vehicles access through the alleyway that is connected to Ellsworth Street.

Figure 8.5 Section drawing showing the heights of the fence and agrivoltaic structure, as well as other critical measurements.

In compliance with local zoning guidelines, the agrivoltaic structure is designed to remain under 10 feet in total height. It provides a minimum clearance of 8.5 feet underneath, allowing sufficient headroom for users to walk and work beneath the panels safely. Additionally, the structure is set back more than three feet from the property line to adhere to setback requirements and minimize any potential impacts on neighboring properties.

The solar panels are fixed-mounted and oriented directly south to maximize solar energy capture. The specific tilt angle for the panels will be determined in consultation with structural and electrical engineers to optimize both the energy production and structural integrity of the agrivoltaic system.

Parking and Charging Hub

At this site, energy production, stormwater management, and transportation are the primary design priorities. The area is currently covered in gravel and serves as a temporary parking lot for construction workers. It is located at the intersection of two major roads (Washington Street and Preston Street) where cars, buses, and bicycles share the roadway. The proposed design (Figure 8.6) will convert the site into a permanent parking lot and transportation hub, offering reduced-price electric vehicle (EV) charging and providing bikes and scooters (charged by on-site solar energy) for use by individuals without access to a personal vehicle.

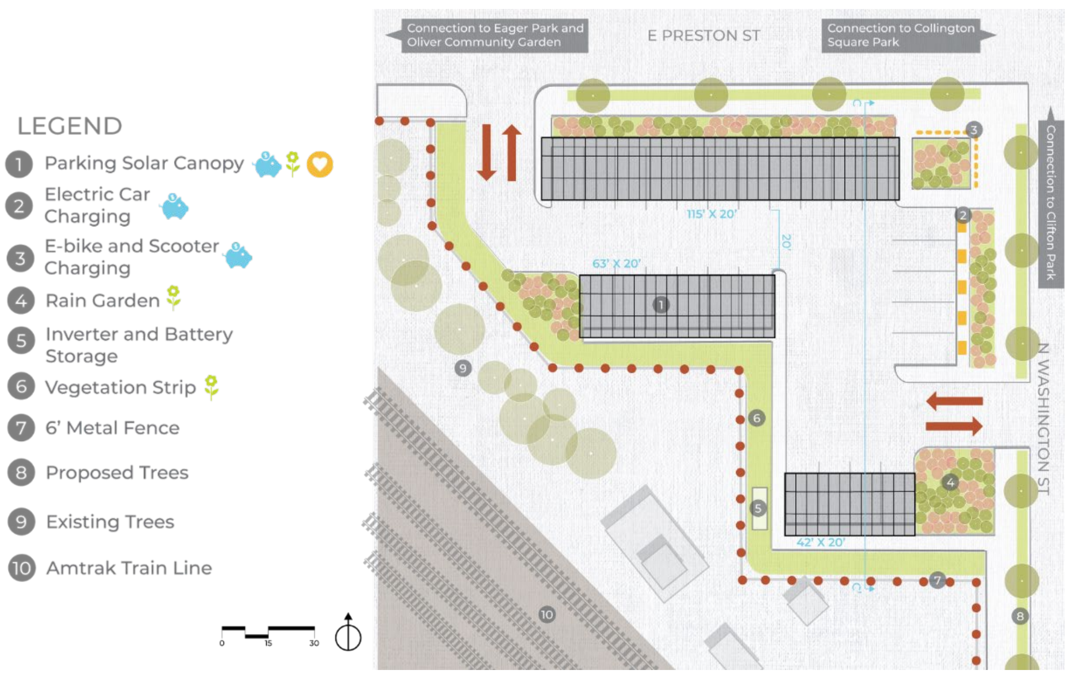


Figure 8.6 Site plan of the proposed Solar Parking and Charging Hub.

This site generates the second-highest amount of electricity among the project areas, producing approximately 83,000 kWh per year. In addition to energy production, the solar canopies provide much-needed shade for parked cars during the summer months (Figure 8.7).

The bus route travels north along Washington Street, a four-lane, one-way street that I narrowed to three lanes in the design proposal to allow for a wider sidewalk and the addition of street trees, improving pedestrian comfort and safety. A bike lane runs along the north side of Preston Street, providing easy access to the proposed e-bike and scooter charging stations.

Figure 8.7 Aerial perspective of the proposed Parking and Charging Hub.

These charging stations offer a valuable amenity to the community, where an estimated 14–18% of residents rely on buses to commute to work (Baltimore Neighborhood Indicators Alliance, 2024). Although this number has declined since the pandemic – largely due to service cuts that reduced bus frequency and reliability – many residents without access to a car still require affordable and convenient transportation options. By supporting electric bike and scooter use, this design aims to help bridge the transportation gap and improve local mobility.

As seen in Figure 8.8, the introduction of street trees and rain gardens enhances both the shade and visual appeal of the previously barren streetscape, supporting the City's broader goal of transforming Washington Street into a major pedestrian corridor.

Figure 8.8 Eye-level perspective of the proposed charging infrastructure.

The rain gardens can absorb approximately 1,874 cubic feet of additional stormwater runoff resulting from the increase in impervious surface area, thereby reducing the risk of localized flooding and improving water quality.

Beyond stormwater management, the rain gardens serve as ecological stepping stones, facilitating pollinator movement along Washington and Preston Streets. By providing habitat and food sources, they contribute to broader biodiversity goals and help strengthen the urban ecological network, while also mitigating urban heat island effects through the addition of vegetation.

Figure 8.9 Section illustration of the Solar Parking and Charging Hub.

In Figure 8.9, the solar canopy has a clearance height ranging from 12 to 15 feet, ensuring functional accommodation for vehicular access. The photovoltaic panels are oriented toward the south to optimize solar exposure throughout the year. The specific tilt angle will be determined in collaboration with the structural and electrical engineering teams, with considerations for maximizing energy efficiency, structural performance, and site-specific environmental conditions.

Pollinator Meadow

The final site features a solar meadow designed to prioritize both ecological function and renewable energy production (Figure 8.10). Currently, the site offers minimal shade for pedestrians walking along this extended stretch of vacant land, contributing to a harsh and inhospitable streetscape. To improve the pedestrian experience and create a more comfortable microclimate, one traffic lane was removed from Washington Street to accommodate low-growing street trees, providing shade, seasonal interest, and a more human-scaled environment.

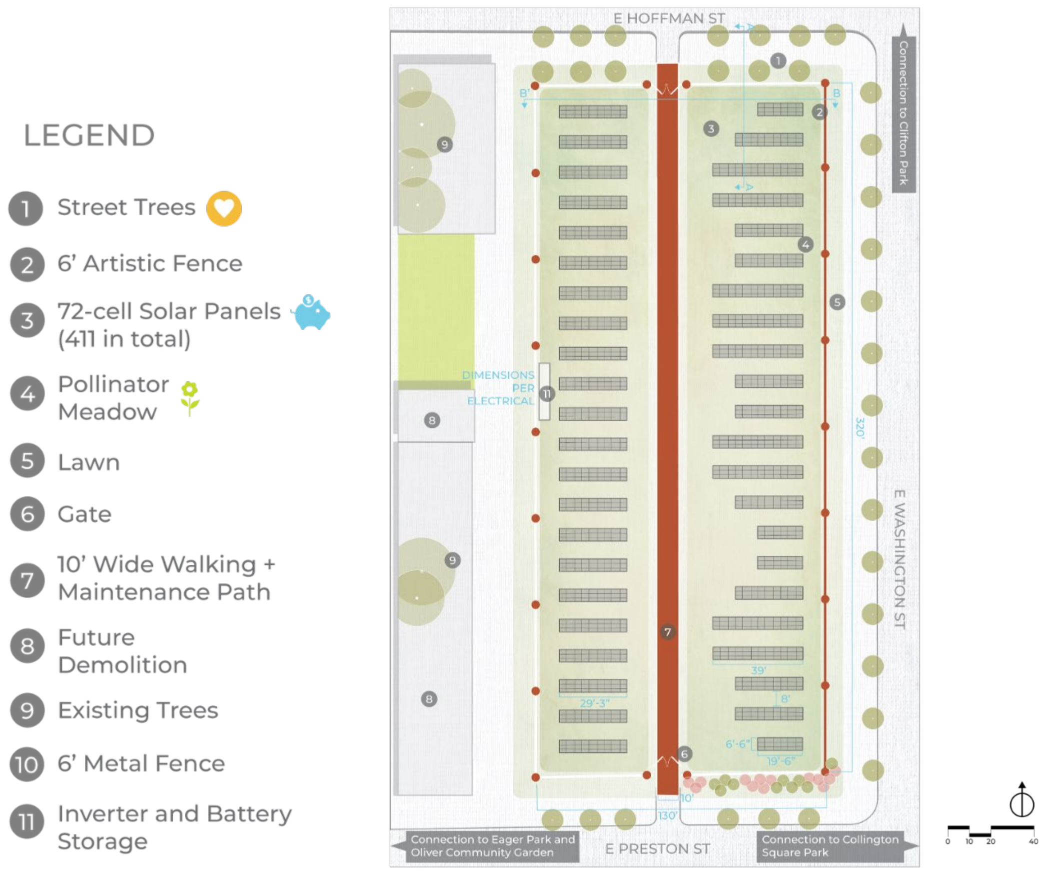


Figure 8.10 Site plan of the proposed solar pollinator meadow.

Along Preston Street, a palette of ornamental plantings introduces additional biodiversity and visual richness, while an artistically designed fence along Washington Street establishes a stronger sense of place and identity for the eastern edge of the meadow. Together, these interventions not only enhance the walkability and aesthetic character of the site, but also contribute to broader goals of ecological connectivity, community engagement, and urban placemaking.

The solar arrays are designed to optimize conditions for diverse plant growth beneath the panels, supporting both ecological function and energy production (Figure 8.11). To accommodate a variety of plant species, the arrays are elevated higher than typical ground-mounted systems, ranging from 2 feet at their lowest point to 6 feet at their highest. The panels are fixed-mounted and oriented southward at a 39-degree tilt angle, a configuration selected to maximize year-round solar energy production while maintaining sufficient light penetration for the vegetation below.

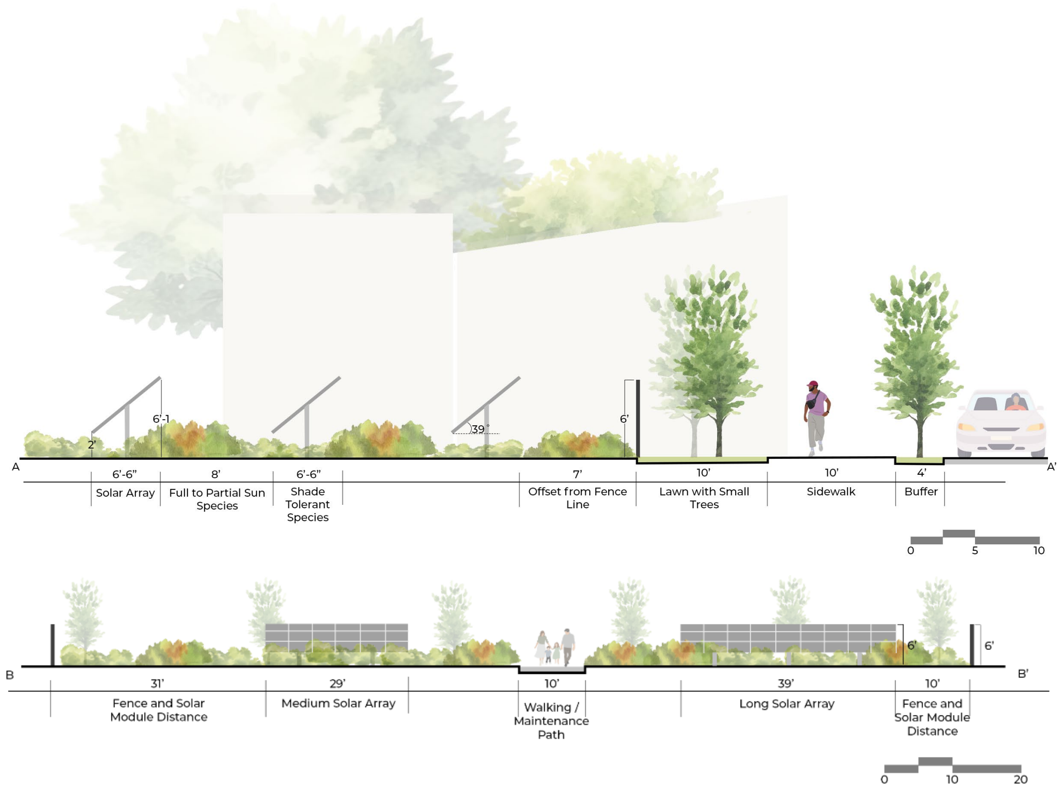


Figure 8.11 Section A (top) and Section B (bottom) show heights and spacing of the solar infrastructure.

The pollinator meadow generates the highest amount of solar energy across all project sites, producing approximately 180,618 kWh per year. On the eastern side of the site, the solar arrays are arranged in a subtly staggered pattern, allowing the infrastructure to integrate more seamlessly with the surrounding landscape while introducing a sense of movement and visual rhythm (Figure 8.12).

Aesthetic enhancements have also been incorporated adjacent to the solar equipment, where a combination of shrubs and grasses softens the site's edges and provides seasonal interest, particularly at the prominent intersection of Washington and Preston Streets. These plantings contribute to both the ecological value and the overall visual character of the site, further supporting goals of sustainable and context-sensitive design.

Figure 8.12 Aerial perspective showing the meadow at the corner of Preston Street and Washington Street.

Figure 8.13 illustrates the experiential quality of movement through the solar meadow, highlighting the intentional integration of ecological systems with renewable energy infrastructure. Rows of tall grasses and perennials emerge between the solar panel arrays, creating a landscape where natural and constructed elements are seamlessly blended. This design approach not only enhances the site's aesthetic value but also supports ecosystem functions such as pollinator habitat provision, microclimate regulation, and stormwater management.

Figure 8.13 Eye-level perspective of the pollinator meadow.

Situated between Eager Street and Collington Square Park, the meadow, along with supplementary pollinator plantings in the adjacent parking lot, lays the foundation for an emerging ecological greenway through Broadway East. This network of connected habitats contributes to broader urban biodiversity goals and strengthens ecological resilience within the neighborhood.

The site is also envisioned as an educational resource, offering opportunities for local elementary schools, such as Collington Square Elementary and Henderson-Hopkins Elementary, to engage students with nature-focused renewable energy systems. Proposed interpretive signage will support experiential learning by guiding visitors in identifying local pollinator species, bird populations, and other forms of urban wildlife.

In addition, the meadow offers potential for long-term research partnerships with academic institutions such as the University of Maryland, Baltimore County

(UMBC) and Johns Hopkins University. Collaborative monitoring programs could enhance the site's ecological performance over time while fostering community involvement in environmental stewardship initiatives.

The design of the pollinator meadow is informed by the guidelines outlined in Maryland’s Solar Site Pollinator Habitat Scorecard. In accordance with these standards, the planting design prioritizes achieving a composition of at least 50 percent native flowering plant species, with a minimum of 10 native species overall to support a diverse pollinator community. While not explicitly detailed in the site plan, the design allows for the potential inclusion of additional pollinator-supportive features such as watering bowls, bee boxes, and patches of bare soil to accommodate ground-nesting bees, thereby further enhancing the site's ecological function and biodiversity.

Chapter 11: Results

Energy Calculations

I calculated the estimated energy output for each of the three sites individually, as well as the combined total for all sites, to assess the overall energy production potential of the proposed infrastructure. The following formula was used to estimate energy output:

$$Energy = System\ Capacity[kW] \times Peak\ Sun\ Hours[hours/day]365days \times Derate\ Factor$$

The peak sun hours represent the average optimal hours of sunlight a given area receives in one year. In Baltimore, that value is about 4 hours/year (Schiavone, 2024). The derate value, which accounts for system inefficiencies, can vary, but a typical value of 0.86 will be used in my calculations (Schiavone, 2024). The system capacity is the amount of power that a solar panel can generate at any given time and is calculated using the formula:

$$System\ Capacity = \ (\#\ PanelsPanel\ \times Power[Watts/panel]) \div 1000[Watts/kW]$$

All proposed solar panels are modeled on 72-cell modules, which have output ratings ranging from 350 to 400 Watts. To provide a conservative estimate, a rating of 350 Watts (0.35 kilowatts) was used for the system capacity calculations. Thus, the system capacity results are as follows:

Pollinator Meadow: $System\ Capacity = (411 \times 350) \div 1000 = \mathbf{143.85\ kW}$

Parking Lot: $System\ Capacity = (189 \times 350) \div 1000 = \mathbf{66.15\ kW}$

Community Garden: $System\ Capacity = (29 \div 350) \div 1000 = \mathbf{10.15\ kW}$

With these system capacity values calculated, I then calculated the total energy output as follows:

Pollinator Meadow:

$$Energy = 143.85 \times 4 \times 411 \times 0.86 \ = \ \mathbf{180,618}\ \boldsymbol{kWh/year}$$

Parking Lot:

$$Energy = 66.15 \times 4 \times 189 \times 0.86 \ = \ \mathbf{83,058}\ \boldsymbol{kWh/year}$$

Community Garden:

$$Energy = 10.15 \times 4 \times 29 \times 0.86 \ = \ \mathbf{12,744}\ \boldsymbol{kWh/year}$$

The total combined energy output from the Pollinator Meadow, Parking Lot, and Community Garden was calculated to be **276,420 kWh/year**.

Energy Equivalencies

To calculate greenhouse gas equivalencies, I used the Greenhouse Gas Equivalencies Calculator provided by the United States Environmental Protection Agency (US EPA, 2024). According to the calculator, 276,420 kWh/year of renewable energy produced is equivalent to 186 metric tons of carbon dioxide. The complete equivalency results can be found in the screen captures below:

Fig 9.1 Greenhouse gas equivalencies for carbon dioxide emissions avoided by switching to solar energy (US EPA, 2024).

Annual Energy Savings

Annual energy savings can be calculated by multiplying the total amount of energy generated in a year by the average price per kilowatt-hour. In Baltimore, the average cost of electricity is around $0.181/kWh (Average Energy Prices, Baltimore-Columbia-Towson, 2024). By multiplying the average cost of electricity by 276,420 kWh/year, I found that the estimated cost savings associated with the proposed energy infrastructure would be $50,032.

$$Cost\ Saving = Energy \times Avg\ Price\ per\ kWh = 276{,}420\ kWh/year \times \$0.181/kWh$$

$$Cost\ Saving = \$\mathbf{50,032/year}$$

Rain Garden Calculations

The total volume of water treated by the rain gardens proposed on the Parking Lot site were calculated using the following equation (Rain Garden Guidance, 2023):

$$Volume = Area\ of\ Rain\ Garden \times [Depth\ of\ Ponding + (Depth\ of\ Filter\ Bed \times 0.25)$$

Where:

Area of Garden = 2,082 ft^2

Depth of Ponding = 0.5 ft

Depth of Filter Bed = 1.5 ft

The calculation for the total volume of water treatment is thus, as follows:

$$Volume = (2082 \times 0.5) + (2082 \times (1.5 \times 0.25))$$

$$Volume = (2082 \times 0.5) + (2082 \times 0.4)$$

$$Volume = \mathbf{1,874\ \mathit{cubic\ feet}}$$

<u>Predicting How MSELs Will Benefit Broadway East</u>

I began this design thesis project with the goal of understanding how landscape architects can identify and design MSELs within underserved communities like Broadway East. Through my research, site analysis, and site design, I found that MSELs offer a number of multifaceted benefits for Broadway East’s vacant lots. Collectively, the three sites are projected to generate approximately 276,420 kWh of solar energy annually, contributing to local energy resilience and reducing reliance on centralized utility infrastructure. Beyond energy production, the interventions enhance the neighborhood’s ecological and social fabric. New shade trees along sidewalks will mitigate urban heat island effects and improve walkability, while strategically placed rain gardens and pollinator meadows will provide essential habitat for native bees, butterflies, birds, and small mammals. These plantings will also offer critical ecosystem services such as carbon sequestration, erosion control, and stormwater management. Additionally, the proximity of project sites to local schools and churches creates rich opportunities for educational programming and community collaboration, fostering environmental literacy and empowering residents to take part in shaping a more sustainable and equitable neighborhood.

These benefits, sorted by social dimension, are summarized in Figure 9.2:

	Community Garden	Parking	Pollinator Meadow
Economic	• 12,744 kWh/year • (29) 72-cell solar panels • (12) 4'x10' raised planting beds equal to 480 sq. ft.	• 83,058 kWh/year • (189) 72-cell solar panels • Charging stations for 6 EVs, 6 e-bikes, and 6 micro-mobility devices	• 180,618 kWh/year • (411) 72-cell solar panels
Nature	• New trees provide shade and habitat for wildlife	• 1,874 cubic feet of stormwater treated by rain gardens • Flowering plants along Washington St serve as ecological stepping stones for pollinators	• 10 species of native vegetation • Habitat for pollinators, birds, and other wildlife • Solar panel height and spacing optimized for more plant diversity
Landscape	• Gardening opportunities for residents, church members, or elementary school children • Artistic fence and ornamental plantings add beauty	• New shade trees and colorful vegetation enhance the pedestrian experience along Washington St	• Opportunities to partner with local schools and universities to teach or conduct research • Possible ecotourism will attract more people to Broadway East

Figure 9.2 Table that summarizes the benefits of each MSEL site, grouped by social dimensions.

To further evaluate the proposed interventions, I revisited the social dimension framework developed by Oudes et al. (2022), as introduced earlier in this paper. Unlike the hypothetical diagrams constructed in Chapter 7, which were based on potential site conditions, the diagrams presented here are grounded in the actual spatial properties of the proposed MSEL designs (Figure 9.3). By analyzing each intervention through the lens of the framework's three dimensions (economic, nature, and landscape), I developed a set of diagrams that illustrate the relative emphasis of each design across these categories (Figure 9.4). These diagrams underscore the central premise of this work: solar infrastructure is not a one-size-fits-all solution. Instead, it can and should be tailored to the unique conditions and priorities of local communities. Through close collaboration with engineers and community stakeholders, landscape architects play a vital role in shaping energy landscapes that are not only functional, but also beautiful, people-centered, and environmentally responsible.

Spatial Property	ECONOMIC	NATURE	LANDSCAPE	COMMUNITY GARDEN	SOLAR PARKING LOT	POLLINATOR MEADOW
Incidental patch configuration	●	●	●	●	●	●
Decreased patch density		●	●	●	●	●
Reduced visibility through fencing or other screening			●	●		●
Ecological features added beneath or between solar infrastructure		●				●
Ecological features added adjacent to solar infrastructure		●			●	●
Educational features and potential for future research			●	●	●	●
Vehicle storage or charging			●		●	
Crop production beneath or between solar infrastructure	●			●		
Fruit orchard and/or vegetable gardens		●	●	●		
Provides stormwater treatment		●			●	●
Access within MSEL			●	●	●	●
Reversibility to previous landscape conditions	●					●
Improvement of ecosystem services		●			●	●
Continued synergy between PV and existing land use	●				●	
Produces more than 20,000 kWh annually	●				●	●
Improvement of social gathering space			●	●		

Figure 9.3 Table of the spatial properties associated with the three MSEL designs.

Figure 9.4 Social dimension diagrams for each of the MSEL designs.

Chapter 12: Discussion

Nonprofits and Other Community Partners

Successful implementation of the proposed MSEL projects will require collaboration with a range of local partners, each bringing expertise in community engagement, planting, and solar infrastructure. For community outreach and participatory design refinement, partnerships with the Broadway East Community Development Corporation (CDC) and the Baltimore City Department of Planning will be essential. The Broadway East CDC is a nonprofit dedicated to revitalizing the neighborhood through equitable development and resident engagement, while the Department of Planning works to shape Baltimore into a more vibrant, inclusive, and sustainable city (Baltimore Office of Sustainability, 2024; *Main Home*, n.d.). For planting installation, I could collaborate with Blue Water Baltimore, which specializes in designing and installing rain gardens to protect local waterways; the Baltimore Tree Trust, which works to expand tree canopy through planting and maintenance; and The 6th Branch (T6B), a veteran-led nonprofit that transforms vacant lots into productive green spaces and supports community farming initiatives (*Blue Water Baltimore*, 2025; *Our Farms*, n.d.; "Our Story," n.d.). Solar installation could be facilitated through Solar4Us, a Maryland-based nonprofit that helps design and install solar projects on rooftops, parking lots, and brownfields. Notably, Solar4Us has already completed a successful project at the nearby Henderson-Hopkins School and utilizes the Climate Access Fund to cover design and installation costs, ensuring that solar benefits are accessible to overburdened communities (*Solar4Us*, n.d.).

<u>Project Funding Opportunities</u>

As of 2024, there are a number of state and federal funding programs for renewable energy programs available in Maryland (Figure 10.1) (Maryland Energy Administration, 2024). Two grants in particular would be especially relevant for the designs proposed in this thesis: the FY25 Commercial Solar Grant Program and the Community Electric Vehicle Supply Equipment Grant Program.

FY25 Commercial Solar Grant Program

The FY25 Commercial Solar Grant Program, administered by the Maryland Energy Administration (MEA), offers a significant opportunity to support the implementation of community-based solar projects (Maryland Energy Administration, 2024). With a total program budget of $10 million, the initiative is designed to equitably expand access to solar photovoltaic (PV) systems, particularly for low-to-moderate income communities and those designated as overburdened or underserved under Maryland law (§1–701 of the Environment Article). The program operates under two Areas of Interest (AOIs): AOI 1 supports nonprofits and small, minority or veteran-owned businesses, offering grants of up to $1,700 per kW or 75% of the net project cost, whichever is lower; AOI 2 supports larger commercial entities and offers up to $1,000 per kW or 50% of net project costs. Eligible expenses include equipment, installation, and interconnection for both applicant-owned and third partyowned solar PV systems. However, solar canopy systems (like those mounted over parking lots) are excluded from this program and must be funded by a separate MEA initiative (Maryland Energy Administration, 2024). Given its alignment with goals of energy justice, economic development, and local sustainability, this grant program presents a promising funding source for implementing solar infrastructure in Broadway East and similar neighborhoods.

Community Electric Vehicle Supply Equipment Grant Program

The FY 2025 Community Electric Vehicle Supply Equipment Grant, administered by the Maryland Energy Administration, provides up to $1 million in funding to support the development of EV infrastructure plans in low-to-moderate income, overburdened, or underserved communities across Maryland (Maryland Energy Administration, 2025). This non-competitive, first-come-first-served grant offers up to 80% of total project costs (with a maximum award of $50,000) to eligible applicants, including Maryland-registered nonprofits, businesses, and state or local government entities. Funding may be used to hire consultants or engineers to prepare comprehensive EV infrastructure plans that address site conditions, permitting, utility coordination, ADA compliance, and community outreach (Maryland Energy Administration, 2025). Given the focus on EVs, this grant could be used to fund the solar canopies over the proposed parking lot site.

Chapter 13: Conclusion – Agrivoltaics in Vacant Urban Land

This thesis investigated how landscape architects can design multifunctional solar energy landscapes (MSELs) within vacant urban land in underserved communities. Using Broadway East in Baltimore as a pilot site, I developed a replicable landscape architectural methodology to help identify optimal locations for MSEL implementation based on vacancy, environmental suitability, and community context, and inform design solutions addressing nature, economy, and landscape/community. Although tailored to Baltimore, this approach holds relevance for other legacy cities such as Detroit and Philadelphia that face similar patterns of disinvestment and land vacancy.

As cities worldwide commit to net-zero emissions and allocate increased funding for renewable energy infrastructure, landscape architects have a critical role to play in shaping this transition. While engineers bring expertise in technical efficiency and performance, the integration of solar infrastructure into the built environment often lacks consideration for aesthetics, community identity, and spatial experience, areas in which landscape architects are uniquely equipped to lead. Most urban solar projects remain hidden on rooftops, disconnected from daily life. However, ground-mounted systems are increasingly being proposed for low-cost or degraded land located in historically marginalized neighborhoods. These projects raise legitimate concerns, from visual impacts to missed opportunities for more community-oriented land use. Greater involvement from landscape architects in the siting, design, and community engagement processes could transform these installations into multifunctional public spaces that reflect and benefit the communities they occupy. Without the input of designers, solar installations risk becoming visual and social liabilities rather than community assets.

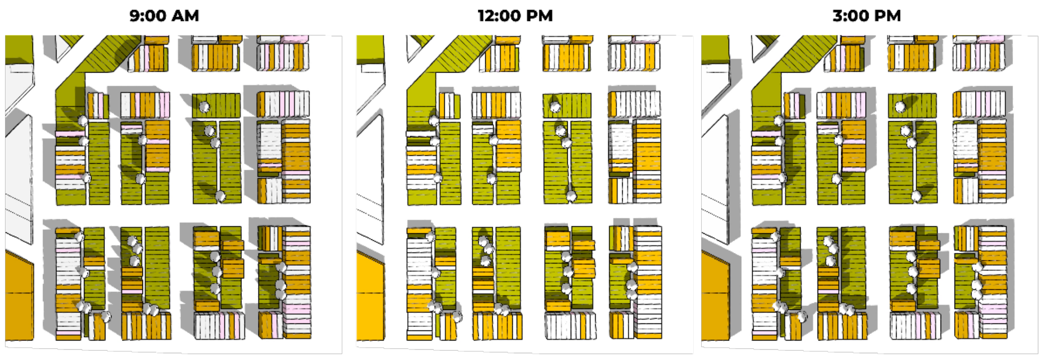
For solar infrastructure to be widely accepted in urban contexts, it must be more than efficient: it must also be equitable, context-sensitive, and socially engaging. This thesis sought to offer a model for future landscape architects seeking to advance multifunctional designs that balance ecological performance with community needs, and improve the livability and aesthetic qualities of the neighborhoods where they will be installed.

While uncertainty remains around the future of renewable energy funding, particularly in light of shifting global supply chains and rising infrastructure costs, efforts to build a more just and resilient energy future must continue. This thesis envisions energy infrastructure not only as a technical intervention but as a platform for equity, resilience, and regeneration. It also seeks to initiate a conversation about the role of landscape architecture in the ongoing clean energy transition and inspires future designers to push the boundaries of what solar energy infrastructure can be.

Appendices

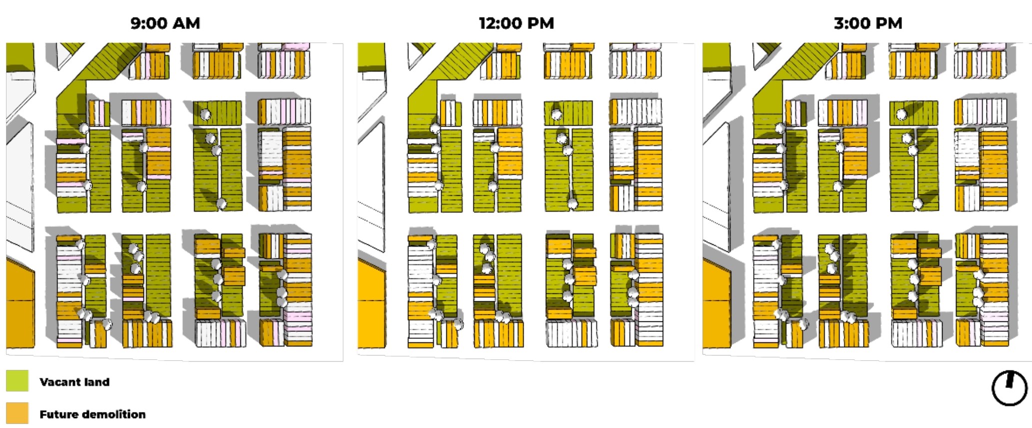
***Appendix A** – Individual Shade Diagrams for the Spring, Summer, and Fall*

FOCUS AREA 1 SPRING SHADE ANALYSIS



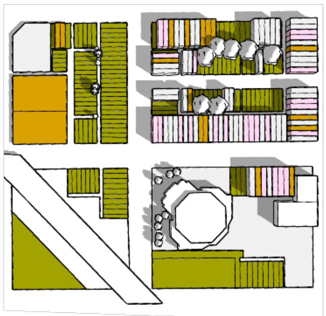
FOCUS AREA 1 SUMMER SHADE ANALYSIS

FOCUS AREA 1 FALL SHADE ANALYSIS



FOCUS AREA 2 SPRING SHADE ANALYSIS

9:00 AM



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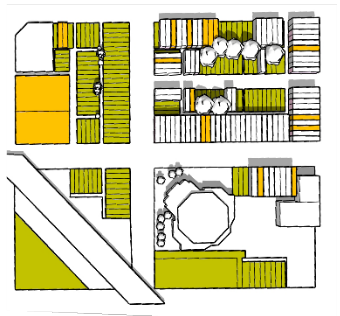

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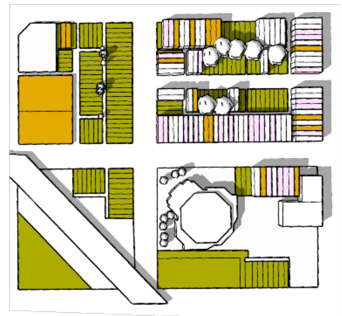

FOCUS AREA 2 SUMMER SHADE ANALYSIS

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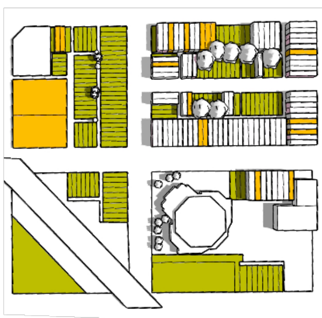

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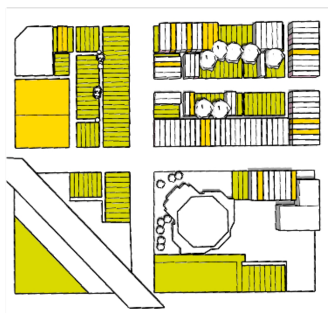

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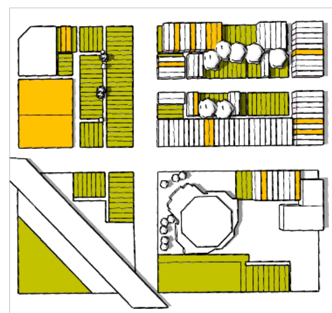

FOCUS AREA 2 FALL SHADE ANALYSIS

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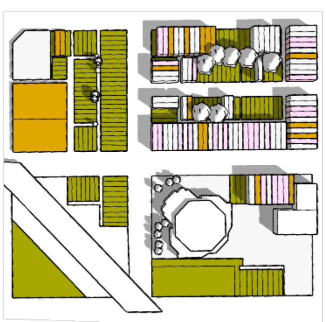

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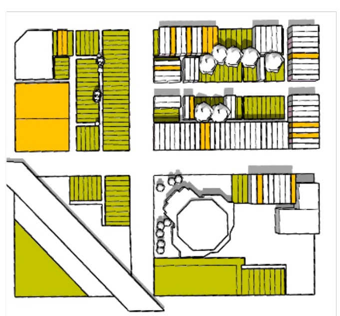

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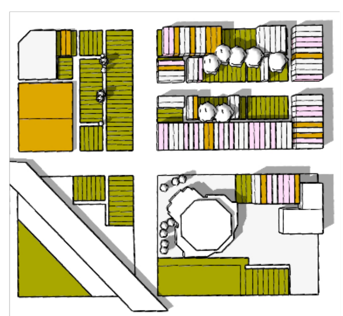
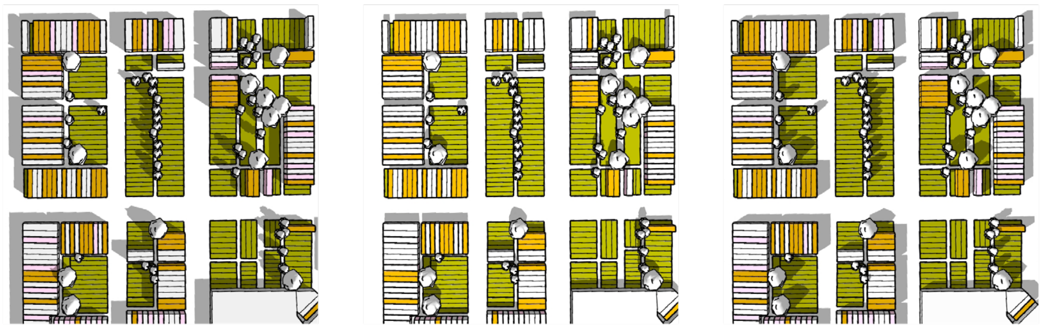


Vacant land

Future demolition

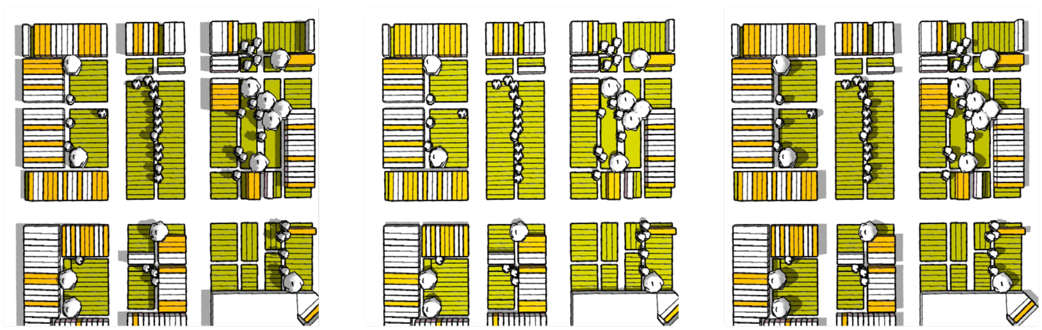
FOCUS AREA 3 SPRING SHADE ANALYSIS

9:00 AM | 12:00 PM | 3:00 PM



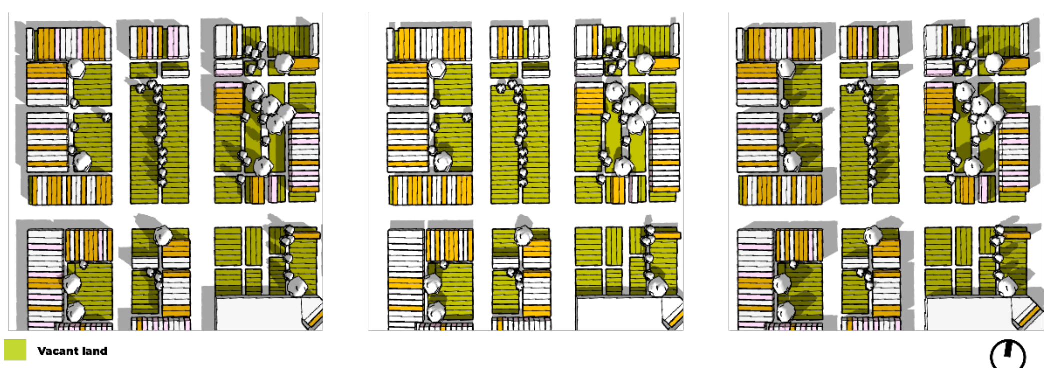
FOCUS AREA 3 SUMMER SHADE ANALYSIS

9:00 AM | 12:00 PM | 3:00 PM



FOCUS AREA 3 FALL SHADE ANALYSIS

9:00 AM | 12:00 PM | 3:00 PM



Vacant land

Future demolition

***Appendix B** – Maryland's Initial Solar Site Pollinator Habitat Planning and Assessment Scorecard (Power Plant Research Program, 2019)*

Maryland's INITIAL Solar Site Pollinator Habitat Planning and Assessment Scorecard

Circle each applicable point and then sum/minus.

1. Percent of facility to be planted, seeded or maintained with native plant species:

16-30 percent	5 points
31-50 percent	10 points
51-75 percent	20 points
76 percent or greater	30 points

2. Percent of facility to be planted, seeded or maintained with a mix of flowering plants including trees and shrubs:

16-30 percent	5 points
31-50 percent	10 points
51-75 percent	20 points
75 percent or greater	30 points

3. Flowering plant seed mix to be used includes ten or more plant species appropriate for the region or local habitat identified in the USDA-NRCS Maryland Native Grass and Wildflower Mixes for dry, mesic or wet sites (Mixes 15, 16 or 17): 5 points

4. Seed mix and/or plants used are pesticide-free, local ecotypes to the extent that it is possible to do so:

Yes	10 points
No	0 points

5. Amount of seed to be planted (lbs/acre) is determined according to seed provider's recommended application rate and/or planting density for planted species in the target area: 5 points

6. Pollinator seed mix includes species that bloom across spring, summer and fall:

Yes	15 points
No	0 points

7. The facility follows established best management practices for site preparation prior to seeding and planting (add all that apply):

Initial herbicide treatment (chemical burn) or scraping of weeds and annual grasses	5 points
Disking or tilling soil to promote weed seed germination with follow-up herbicide treatment	5 points
Follow up maintenance as needed to control weeds	5 points

8. Planned existing best management practices follow established USDA-NRCS Job Sheet Recommendation (Conservation Cover – 327, Herbaceous Plantings for Pollinator Habitat) and Implementation Requirements including (add all that apply):

Pre-establishment mowing of weeds and annual grasses as needed during initial planting period	5 points
Spot herbicide or mechanical invasive species control	5 points
Spot herbicide or mechanical woody species control	5 points
Overseeding or interseeding native wildflowers	5 points
Post-establishment mowing in dormant season only	10 points
Establishment of a detailed habitat maintenance plan	10 points

9. Additional facility practices to support pollinators include (add all that apply):

Water source	5 points
Ground nesting sites (small areas of bare ground)	5 points
Cavity nesting sites (fallen logs, shrubs, snags)	5 points
Woody stems for nesting left >2 years	5 points
Bee Boxes or Bat Boxes	5 points

10. Minimum panel height supports native flowering plants and grasses:

12-18 inches	0 points
24-30 inches	10 points
36 inches or higher	20 points

11. Vegetation buffer outside solar array (add all that apply):

At least 50% planted with native flowering plants	10 points
At least 50% planted with native plants	10 points

12. Education and Signage (add all that apply):

One or more "Pollinator Habitat" signs	5 points
Facility is used for pollinator research	5 points
Education Event regarding pollinator-friendly status	5 points

13. Pesticide Risk:

Routine on-site facility insecticide use	-40 points

Point Summary:

Meets Pollinator-Friendly Standards: 160
Exceeds Pollinator-Friendly Standards: 200
Maximum Points Available: 245

Developer:
Facility Location:
Facility Size:
Target Seeding Date:
Send Email or Completed Forms to:
MD Dept. of Agriculture, MD Dept. of Natural Resources, Power Plant Research Program, 580 Taylor Avenue, B-3, Annapolis, MD 21401

PPRP@maryland.gov

Comments:

***Appendix C** – Pollinator Meadow Plant Selection*

PLANT NAME		DIMENSIONS		
Scientific	Common	H	W	Notes
Panicum virgatum	Switchgrass	7'	3'	
Schizachyrium scoparium	Little bluestem	4'	3'	*Schizachyrium scoparium* var. *scoparium* is the variety native to MD
Eragrostis spectabilis	Purple lovegrass	1.25'	1.5'	
Euphorbia corollata	Flowering spurge	2'	2'	
Eutrochium dubium	Coastal plain Joe Pye	6'	4'	
Monarda fistulosa	Wild bergamot	4'	3'	*Monarda fistulosa* ssp. *fistulosa* is also native to Maryland
Rudbeckia hirta	Black-eyed Susan	3'	2'	For this species to persist, bare soil (no mulch) is needed for seed germination
Coreopsis verticillata	Whorled/threadleaf coreopsis	3'	2'	
Symphyotrichum prenanthoides	Crooked-stem aster	4'	2'	*Aster prenanthoides*
Asclepias verticillata	Whorled milkweed	18"		

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