Reducing Residential Greenhouse Gas Emissions in Easton, PA

EGRS 451 Capstone Project, Fall 2022

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Introduction

We are four Lafayette College Engineering Studies majors, and in this report, we suggest that the City of Easton, supported by the Housing Authority of the City of Easton (HACE), use microgrids to reduce the emissions from residential energy consumption while prioritizing equity.

Energy consumption is and will remain central to everyday American life. The problem arises in the type and *quantity* that is consumed. Heating, cooling, and generally maintaining and living in a house require a lot of energy. A vast majority of global energy is supplied by fossil fuels such as coal, oil, and gas. When these are burned to generate electricity and heat, greenhouse gasses are released to create the *'greenhouse effect'*, or trapping of the sun's heat in the atmosphere. This results in a plethora of negative consequences for the environment, public health, the economy, etc. According to the EPA, burning fossil fuels for electricity is one of the largest sources of GHG emissions in the US. Not only does energy consumption contribute to climate change, but it is also challenged by climate change. Climate change is increasing the frequency and severity of hot and cold days; to manage it, Americans will have to spend more money and use more energy to heat and cool their houses with air conditioning.

Energy is central to climate change not just as a cause but also as a solution. In December 2015, a historic global agreement was made at the UN Climate Conference: The Paris Agreement. Behind the legally binding agreement are 193 nations and the EU. The Paris Agreement defined that for the Earth to stay inhabitable, increases in global temperatures cannot rise more than 2 degrees Celsius above pre-industrial levels and ideally would not rise more than 1.5 degrees Celsius. To achieve this, countries must take action to reduce their greenhouse gas emissions in line with the Paris Agreement's goal that global emissions will be at net zero by ‘mid-century’. The legally binding agreement acts as a framework for social and economic transformations in the coming decades but does not dictate to nations how they should go about reducing their emissions. Instead, governments should formulate policy solutions that are tailored to their specific economic, geopolitical, and environmental characteristics.

The City of Easton is attempting to do just that and has spent years researching and planning after signing on to the Global Covenant of Mayors for Climate & Energy in 2016. The plan sets goals for 2030 and 2050 – importantly greenhouse gas emissions will be reduced by 80% in 2050 compared to 2016 levels. The CAP outlines objectives in 10 areas that will aid in meeting this goal but does not provide a timeline for when each action item will occur. Given the severe scarcity of employees, time, and capital that Easton currently has to dedicate to climate action, it would be greatly beneficial to pursue an intermediary policy option to address the largest emitting sector *before* a plan to meet all objectives is materialized.

The largest emitting sector in Easton, accounting for nearly half of emissions, is residential energy (Easton CAP). In the Climate Action plan, there are two broad objectives to address residential energy. The first, RB1, is to support retrofits and energy efficiency measures in existing residential buildings and homes. This objective is supported by four action items – expanding existing home energy efficiency programs; establishing a program for replacing appliances and systems with high-efficiency electric options; providing incentives for rental property owners to increase energy efficiency; and educating homeowners about the benefits of energy efficiency measures. The second objective, RB2, is to ensure that new residential buildings and homes are built to maximize energy efficiency. There are two action items connected to this – encouraging or requiring net-zero emissions building standards and reviewing and updating building codes to increase efficiency.

Other objectives that relate to residential energy consumption emissions are found within Chapter X: Energy Production. The CAP has three objectives in this sector – EP1: educate residents and businesses about the benefits of renewable energy and the options available to them; EP2: maximize energy generated by small-scale renewable energy systems within the city; and EP3: support policy changes that expand renewable electricity options for all Easton residents.

Energy consumption does not happen in a vacuum, but rather is deeply embedded in the context of any given region. In Easton, social context is particularly important. Approximately 18.9%[1] of Eason residents live under the poverty line, and many of these residents rent their housing instead of buying. The city had received federal grants to increase the amount of affordable housing,[2] yet this worsened the equity issue of energy consumption. In efforts to keep costs low, these contractors built the housing cheaply and inefficiently. This means low-income residents spend more on their energy bills but cannot afford to make efficiency changes to their homes. They also might not be able to afford air conditioners which becomes a public health concern in extreme heat.

Widespread poverty and a high population of renters pose a challenge to policies that incentive homeowners to make energy efficiency adjustments in their homes. Many Easton residents do not own a home to retrofit, and if they do they might not be able to afford these measures. Even if Easton were to get the funding, technology, and outreach programs together to roll out their RB1 objective, and if they were to maximize the efficiency of all of the homes in Easton, there would still be efficient homes being powered by fossil fuels. It would be greatly beneficial for Easton to power residential buildings with renewable energy *before* the rest of the

[1] Census Profile: Easton City, Northampton County, PA, 2021
[2] TRIAD Associates, 2018

city as it is the highest GHG sector, instead of focusing solely on efficiency measures for now. An effective way to do this is through Microgrids.

We propose that the City of Easton connect a microgrid, powered by renewable energy, to the public housing units owned. We suggest public housing units because firstly, there is currently not a strong economic incentive for private owners to opt into the plan. Secondly, this choice would reduce the costs of energy and the frequency of energy blackouts for these residents. Disconnecting this segment of the population from the macrogrid would allow Easton to make significant strides toward reducing GHG emissions and promoting equity. Lastly, this plan would exert Easton as a leading Pennsylvania city in the fight against climate change. As Easton has received a federal Housing and Urban Development (HUD) planning grant and is applying, and likely to get, for a multimillion-dollar redevelopment grant,[3] we suggest that the microgrid be established in proximity to the North Union Street and Bushkill apartments. As determined in the draft plan produced with the HUD grant, these apartments will be among the first to be redeveloped, and their proximity to one another makes it feasible for both to be connected to one microgrid.

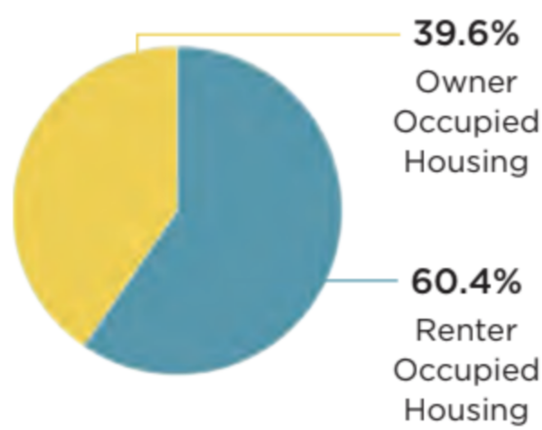
In this report, we provide evidence that a microgrid would be an effective intermediate policy option to make significant progress in reducing residential energy emissions while prioritizing equity. We will delve into the context that makes microgrids an appealing option for the city and why the N. Union Street and Bushkill apartments are ideal locations. Then, we will provide a technical analysis of how a microgrid works and a discussion of what the local source of energy could be. We will offer case studies of cities that have successfully used microgrids to reduce GHG emissions, and we will end the report with an economic analysis of funding options and costs.

[3] Admin, 2022

Social and Political Context

Located at the junction between the Delaware and Lehigh Rivers, Easton, PA is well connected to water and rail transportation routes and is less than 100 miles from both Philadelphia and New York City. These factors made the city one of the nation's prominent industrial centers in the mid-19th century through the early 20th century, with flourishing steel and silk industries. The City also physically grew as new water, gas, and transit lines were extended to create new neighborhoods. Today, Easton, PA is broken into four neighborhoods – College Hill, Downtown, Southside, and West Ward.

Easton prospered culturally and economically until the mid-20th century when the decline of industry, post-WWII 'urban renewal projects', and increasing urban sprawl towards the suburbs transformed Easton from a strengthening to a struggling community. For example, many units in the West Ward neighborhood were converted from family homes to multi-unit apartments in the 1970s (West Ward Choice Neighborhood Draft Plan, 2022). This reinforced the shift of population and growth to suburbs, and the effects of these shifts in infrastructure are still felt heavily by the city today. The West Ward in particular faces high rates of crime, transience, and an aging housing stock.



In addition to the older housing stock, the West Ward has a disproportionately high population density and poverty rate compared to the rest of the city. With 1.27 square miles and approximately 9,794 residents, the West Ward houses approximately 36% of Easton's population. Median household income is

$46,835 for Easton as a whole, but only $35,025 in the West Ward. 60% of housing units are renter-occupied, and 58% of households spend 30% or more of their income on rent which qualifies them as 'cost-burdened' by the U.S. Department of Housing and Urban Development. Put together, 25.8% of West Ward residents live below the poverty line compared to 18.6% of the city as a whole (West Ward Choice Neighborhood Draft Plan, 2022).

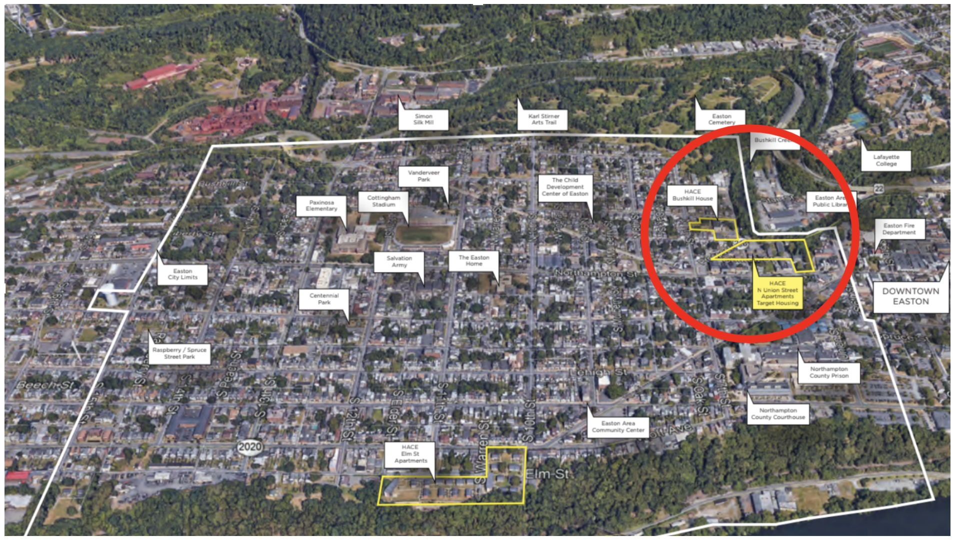
The social and physical qualities of the West Ward make residents more vulnerable to climate change's effects, such as extreme heat events or flooding. This is because vulnerable groups such as the elderly, children, people with disabilities, people living alone, and people living in poverty are less equipped to respond to hazards effectively. In the realm of energy usage, climate change increases both the frequency and intensity of extreme heat events. In turn, this greatly increases the demand for energy to cool buildings and makes it more likely for the energy grid to be overwhelmed and for blackouts to occur. For some, this would be an inconvenience, but for socially vulnerable groups it can cause significant disruptions to their lives and even injury or death.[4]

The West Ward neighborhood is disproportionately at risk of high energy bills and energy blackouts due to the physical and social vulnerabilities present. As aforementioned, 60.4% of housing units in the West Ward are renter-occupied. Therefore goals surrounding retrofitting homes to increase energy efficiency will be particularly hard to incentivize in this area. This is compounded by the poverty of the neighborhood – a resident could be incentivized to make adjustments but not be able to afford it.

The disparate socioeconomic qualities of the West Ward make it a priority for government support. This priority status is reflected in the West Ward Choice Neighborhoods Draft Plan, published in June 2022. This plan was the result of a $450,000 grant from the

[4] Nurture Nature Center, 2018

Housing and Urban Development (HUD) agency of the federal government and is a comprehensive plan for neighborhood transformation. The grant went into a thorough community engagement process which has resulted in the core goals of People, Neighborhood, and Housing. Most relevant to this report is the Housing section, which has the objective of creating "high-quality, energy-efficient housing that meets resident needs for affordability and a healthy living environment."[5] To that end, the plan identifies three locations of severely distressed housing that are priorities for redevelopment – N. Union Street Apartments, Elm Street Apartments, and the Bushkill House. The N. Union Street Apartments and Bushkill House are in very close physical proximity to one another (see image XXX). For this reason, we argue that it should be these two units be connected to a microgrid powered by renewable sources. As they are being demolished and rebuilt, time and money will be going towards creating the infrastructure to reconnect these housing units to power. A more socially, environmentally, and economically efficient choice is to use these resources to connect the new housing units to a renewable energy source through a microgrid.



[5] Admin, 2022

Microgrids

One promising and reliable solution is a microgrid. Microgrids are not mentioned in the Easton Climate Action Plan but are a natural fit for the issues and goals of the city. Microgrids are small-scale power grids that work independently or in collaboration with the 'macrogrid' (i.e. the standard grid supplying energy). Microgrids have a wide range of benefits for energy infrastructure and the environment. They allow for local management of power supply and demand, which increases energy efficiency and prevents waste. The local nature of the grid increases energy reliability and security in case of macrogrid outages, as well as reducing transmission losses (also known as line losses) that come with sending energy over long distances. They also provide resilience against extreme weather or cyber attacks focused on the macrogrid. Because of these benefits, microgrids tend to reduce outage frequency and duration, while reducing cost by anticipating and accommodating peak loads. Most notably, these benefits reduce greenhouse gas emissions, which is the primary focus of the Easton CAP

As a relatively new technology, microgrids have undergone significant testing to determine their feasibility. The creation of the Microgrid Research and Development Team under the Department of Energy in 1999 represents the first government examination of the technology, which was funded by the Consortium for Electric Reliability Technology Solutions, which came from the DOE's Office of Electricity Delivery and Energy Reliability and the California Energy Commission's Public Interest Energy Research program.[6] MIT, in collaboration with the Masdar Institute, has also done substantial research into microgrids and how to make them most effective. They found that one of the most appealing features of the microgrid lies in its flexibility- it can act as an isolated power grid, or be connected to the central power system. This

[6] Low-Income Community Energy Solutions, 2011

flexibility is also appealing when considering energy generation: these systems can incorporate renewable energy sources like wind and solar power in tandem with diesel generators to ensure reliable energy when it is not sunny or windy enough for green energy sources and can purchase energy from the central power system if all else fails.

Because of this flexibility, microgrids serve to fulfill a few of the goals established in the Easton CAP, specifically concerning EP3. While separate from residential goals in the CAP, production and consumption are part of the same system and must be considered interconnected aspects of the energy infrastructure of Easton, which is why our focus is not limited to the RB aspects of the CAP. The stated goals of EP-3 are as follows:

EP-3A- Support proposed legislation that would enable community solar projects, where multiple parties share ownership of a central solar generation site if they cannot install renewables on their own property

EP-3B- Explore Community Choice Aggregation (CCA) as a means of increasing local control over electricity sources to receive lower carbon electricity at a lower price.

EP-3C- Prioritize local renewable electricity options. Consider options for financing a renewable power project that could sell power to a retail supplier and then to consumers at a low cost. An RFI could explore developer interest in this type of project. Consider any renewable energy sources (wind, solar, geothermal)

These goals are directly aligned with the functions of a microgrid, which would integrate more renewable energy options into our energy infrastructure for a reduced price, encourage further renewable energy investments, and increase community involvement by catering the microgrid portfolio and output to the needs of the citizens.

Technological Context of Microgrids

A grid is an electricity network that connects consumers (homes, business establishments, and industries), infrastructure (wires and poles), and power plants. It can be divided by scale into macro and microgrids, and both can be owned by the government or a private group. Grids generally operate by producing energy using gas generators, which are then distributed to a wider area using transmission lines. Someone who is connected to the macrogrid can send or consume energy directly to/from the grid, and microgrids operate on this same principle. Microgrids are localized versions of the grid system that can operate on their own or in tandem with a macrogrid. Because of their size, they have a more limited range and can power at most a small city. Despite this, the unreliable nature of macrogrids through power outages and energy insecurity can lead one to choose to be connected to a community microgrid rather than a standard macrogrid. In this way, a solid, local system provides a building with a reliable power supply generated from renewables such as wind, geothermal, hydropower, or solar energy in tandem with gas generators.

Microgrids essentially perform like macrogrids but are tailored to the needs of a specific area. They can range in size from 100 kilowatts to multiple megawatts, which enables them to power anything from a single building to an entire community. From a technical standpoint, they are constructed similarly to the macrogrid but with greater emphasis on renewable energy and storage. Microgrids do commonly contain natural gas generators, but in tandem with renewables such as solar, wind, and hydropower. Therein lies another of a microgrid's strengths - the energy production capabilities of these sources are catered to the requirements of the area it will be supplying, and a microgrid manager controls this output depending on the load. In being able to reduce energy production and transmission when necessary, microgrids reduce greenhouse gas emissions at the source by only producing the required energy load for the city and with more carbon-neutral energy sources. Alternatively, a microgrid controller can focus on profits by selling excess energy to third parties for credit. Generally, microgrids are connected to the macrogrid and serve as a failsafe if the macrogrid suffers an outage, as demonstrated in some of the case studies included in this report.

Case Studies

Microgrids can come in different forms, including general-purpose and community-focused. These impact the energy production of the microgrids by powering different things- general-purpose microgrids provide energy much like the macrogrid where needed, while a community microgrid serves a more public focus, powering emergency services, cell towers, and water pumping. For residents of Easton, a general-purpose microgrid would better address emissions issues because it would focus on residential infrastructure and replace the entirety of the energy currently being consumed from the macrogrid, which primarily consists of fossil fuels. Whether 100% on renewable sources or not, powering a community with a microgrid makes great strides toward reducing emissions and increasing grid resilience. As such, microgrids have been found to garner more community involvement in the process because communities can limit the impact of costly power outages and support the continuity of service at affordable costs.[7] Furthermore, in being tailored to the energy needs of a city's residents, the community would have the opportunity to learn about their energy consumption, and why this is relevant to the health of the community and the climate.

Microgrids can also mitigate energy losses by reducing transmission distance and thus line losses. Since microgrid electricity is produced locally, line losses are minimized and there is less power required to meet general demand. Additionally, the locality of the microgrid can allow

[7] Community Microgrids from All Angles, 2021

for the heat produced during energy production to be captured and repurposed for other energy needs. which could be beneficial to the lower-income renters of Easton that use more heat on account of their poorly constructed and maintained homes and apartments.[8]

Because of current financing structures, a microgrid would only be able to power publicly-owned residential infrastructure, which limits our implementation areas. Many microgrids across the nation use solar energy as a renewable power source as it only requires access to sunlight to function. Using solar as the power source for a microgrid aligns with goals set in EP-2 of Easton's climate action plan, as they seek to expand and support solar installations on new projects. While renewable energy production is generally focused on solar, Easton's geography as bordered by the Delaware River could also allow for a unique integration of hydroelectric power. An Easton resolution[9] has determined that hydropower along the canal system could be a feasible source of renewable energy for the city and is working with New England Hydropower LLC to develop these facilities, so this could be a significant aspect of the renewable energy portfolio of an Easton microgrid, but more research is needed. The amount of energy generated is also important, as it must reliably support the buildings that we have chosen.

This is one of the most significant challenges faced by MIT and the Masdar Institute- determining the components that will enable sufficient power generation for the needs of the community. Naturally, finding the optimal ratio for cost vs. emissions is difficult as the two are contradictory, but systems and techniques were developed to assist in this decision. The Masdar Institute has developed an "analytical tool to help designers create the best possible microgrids for their needs, given the relative importance they place on minimizing emissions versus minimizing cost… For a defined level of demand and reliability of service, this powerful tool can

[8] Cohn, 2017
[9] Edinger, 2020

determine the mix of devices and the strategy for operating them that will best meet the needs and preferences of the designer."[10] One aspect of this analysis of particular importance is the Pareto front, which graphs emissions and costs to demonstrate the best possible solutions in any combination of design and operating choices. While this tool could be an integral part of establishing a microgrid within Easton, we must first determine the balance of emissions and costs that is acceptable for Easton and perform more research into the energy demands of the city. It should be noted that in performing these emission/cost analyses, one must include the emissions created during the manufacturing and installation of these technologies to produce the most accurate analysis.

In summation, microgrids generally consist of renewable energy sources such as turbines and solar panels alongside generators to produce the necessary energy for a given area. They are flexible in that they can be catered to the energy needs of any area, and their employment of renewable energy reduces greenhouse gas emissions. In addition to using more renewable energy, the locality of the grid makes use of energy that would otherwise be lost when traveling from a centralized power station, known as "line losses." It would also enhance grid resilience during extreme weather conditions as its relatively small service area is significantly less susceptible to damages, preventing further energy-intensive blackouts. These benefits are emphasized by the real-world case studies where microgrids have been implemented.

Microgrids are being implemented in cities across the country to deal with various energy-related issues, and with notable benefits in many areas. In addition to playing an essential role in removing planet-warming emissions from utilities, the advancement of microgrids can also assist in providing climate resilience to frontline or marginalized communities. This is of particular importance because these people are often the most impacted by climate change.

[10] Stauffer, 2012

Because of this, many communities view microgrids as a key solution to building climate resilience. Two such Boston communities that are attempting to establish microgrids are Chinatown and Chelsea, each of which is heavily burdened by climate change.

Following the efforts in Chinatown and Chelsea, neighborhoods, cities, and community groups, such as Roxbury and Cambridge, have expressed significant interest in microgrids themselves. This expansion of microgrids lays the foundation for enabling residents to take control of their energy and creating communities that identify as climate-resilient, an issue that low-income residents in Easton need to improve their energy efficiency. Below are a few brief descriptions of case studies where the benefits of a microgrid were realized in other ways.

Chelsea, Massachusetts[11]

Chelsea, Massachusetts is another such city that is designing a microgrid with a specific focus on the compromise between city officials and the community. This “microgrid without borders” is designed to power a couple of critical buildings, and then as many citizens as can be supported by the remaining power. As a small industrial city located near Boston, Chelsea is only 2.2 square miles, causing it to be one of the state’s most dense populations. Although the city has numerous reasons for wanting a microgrid, the main one is Hurricane Mario in Puerto Rico. The storm decimated the vast majority of the island’s grid in 2017, which created the largest blackout in United States history. This felt incredibly close to home for many of Chelsea’s residents, as the community has an exceptionally large Puerto Rican population. One of the main reasons why the microgrid in Chelsea is so successful is due to how small the town is. The microgrid is located right in the center of the city, allowing it to power numerous significant buildings. Another reason why it succeeded is that the project was centered around the existing community, which

[11] Gellerman & Greene, 2021

isn't normally the case. One of the biggest pullbacks for why microgrids are difficult to implement is the immense cost. Luckily the project received a $200,000 grant from a nonprofit organization called Green Communities. This not only allowed them to build the microgrid but also helped the city strive to decrease its carbon emissions and save money on energy. This is yet another example of the flexibility of microgrids and the benefits that they can bring to a community.

Bronzeville, Illinois[12]

Bronzeville, Illinois is another unique case of microgrids in which a community microgrid is connected to another at the Illinois Institute of Technology, creating a microgrid cluster that increases efficiency and reliability. This cluster will allow the city of Bronzeville and the University of Illinois to share power in the case of an outage. Additionally, the microgrid cluster allows either party to cut back on its nonessential loads and share power with the other, which is a huge deal in today's power world. The Bronzeville microgrid consists of 750 kW of PV, a 500 kW/2 MWh battery energy storage system, and a 5 MW of dispatchable natural gas generation. Essentially, this means that the microgrid cluster could keep both the city and the university powered for up to four hours. The Bronzeville microgrid project will be completed sometime this year and will be located just south of Chicago. It is incredibly difficult to find the proper funding for a project of this magnitude, which is why the $4,000,000 grant from the DOE's Solar Energy Technologies Office was such an immense help. The microgrid will save the Illinois Institute of Technology a whopping $200,000-$1,000,000 per year, so they should have a phenomenal return on their investment in no time. This efficiency and reliability are why the Bronzeville microgrid should be a model for other microgrids around the country and even

[12] Bronzeville Microgrid- Chicago, Illinois Adaptation Clearinghouse, 2019

the world. Additionally, it is why Hamden, Connecticut is planning to build one microgrid by 2025 and another by 2030, to provide power to the 62,000-person town as well as its schools, shopping centers, emergency services, and town center.

Princeton University[13]

Princeton University's campus microgrid is an example of a smaller-scaled microgrid that has proven to be beneficial to the school. The microgrid draws electricity from a gas-turbine generator and solar panel field and can work alongside the existing utility grid or be completely disconnected when energy from the utility grid is threatened. This specific microgrid is capable of producing 15 megawatts of energy. Normally, Princeton's microgrid operates while synchronized with the local utility, which benefits both the university and local ratepayers. In the case where the price of utility power is lower than Princeton's cost to generate it, the microgrid automatically transitions to draw from the utility grid. When Princeton's microgrid produces power less expensively, it will only run in the university's most highly demanded areas. On the other hand, when Princeton's microgrid generates more energy than the university needs at a given time, or when the utility grid's price of power is high, Princeton exports some of this power to earn revenue while also lowering the average power price for grid participants. The microgrid has proven to be reliable after the power outages caused by Hurricane Sandy, as it provided the school with access to electricity after only 20 minutes of no power. In addition, this microgrid on Princeton's campus allows them to have a much lower carbon footprint and higher reliability associated with behind-the-meter CHP. In addition, Princeton's microgrid offers itself as an example of what it takes to build a successful microgrid. This includes economic dispatch,

[13] Barter & Borer, 2015

underground power distribution, full commissioning and periodic resetting of critical components, testing using realistic conditions, designing systems with multiple fuel and water supply options, regularly practicing the use of emergency response teams, and planning for human needs during regional emergencies.

Blue Lake Rancheria, California[14]

Located in California, the Blue Lake Rancheria Tribe invested in the implementation of a microgrid for their hotel, casino, and Tribal buildings with hopes of increasing their power reliability and resiliency. With the ability to control their energy source, the microgrid saves them over $200,000/year in energy costs and cuts 200 tons of GHG/year. This allows the microgrid to serve about 10,000 people (or about 10% of the country's population) in an outage. The implementation of this microgrid shines a light on how badly resources are needed during an extended power outage. Even excluding the power shortages, the Blue Lake Rancheria microgrid served as an example of how all microgrids should be. The project received a Microgrid Greater Good Award from Microgrid Knowledge at Microgrid 2019 in San Diego. It was selected due to both its environmental and economic benefits. Microgrids are incredibly expensive to implement, which is why the $5,000,000 grant from the California Energy Commission's Electric Program Investment Charge was so beneficial.

Colleges are establishing microgrid systems as well, such as Las Positas College in California. Their project began by determining the project needs, the goals of the microgrid and the power demand of the College to frame the issue and advance with the details of energy-producing technologies and the necessary storage for a reliable system. Upon the implementation of this microgrid, Las Positas College demonstrated a potential 10-12 year

[14] Siemens, 2022

financial payback, operational benefits to the college, and social and environmental benefits. The projected savings from the microgrid were $100,000 to $150,000 per year, which represents a similar cost/benefit ratio to that of installing PV cells.

Economic Analysis

The issue raised by the considerable share of greenhouse gas emissions produced by the consumption of residential energy is a concern to many stakeholders in the City of Easton – which includes the Nurture Nature Center, residents, the city's government, and us. As many states take on the responsibility to implement plans in hopes of reducing the future impacts of climate change, local governments are making sure they are doing their part to help reach the common goal. In Easton's case, the local government has tasked the Nurture Nature Center with the initiative of acting on a climate action plan, and as students in the Engineering & Society Capstone, we have looked to microgrids as the solution for the city of Easton to consider. Initially, we looked at ways solutions could be implemented at the individual level. We considered tasks such as the use of incentives like tax credits to encourage individual actions. However, we noticed that there were existing policies in the state and country that are already aimed at encouraging actions on the individual/household level (i.e. WAP, LIHEAP, etc.). Additionally, because of issues and limitations regarding the social element of the project, we scaled up our solution to account for individuals in the city that may have limited access to resources. Because climate change has impacted cities across the country, it's feasible to adopt an existing practice, and through research analysis and evaluation, we landed at microgrids.

Without a doubt, a major barrier for low-income individuals when it comes to becoming more energy efficient is money. Low supplies of oil and gas resulting from the pandemic coupled with the return of energy consumption to pre-pandemic levels have caused energy costs to rise. According to some reports, the average electricity pricing rate has increased by nearly 8% from its levels in 2021.[15] Additionally, studies have shown that on average, low-income households

[15] US Energy Information Administration, 2022

have an energy burden percentage that is at least three times higher than non-low-income households.[16] Furthermore, the war in Ukraine has also caused supply instability in oil and gas markets globally, causing this issue to be reflected in energy prices in the US as well. With multiple factors forcing the rise of energy prices, utility companies have to charge increasing rates. This economic burden is affecting lower-class households, causing them to put more focus on paying bills rather than prioritizing energy efficiency. Taking on the initiative to reduce greenhouse gas emissions in the City of Easton requires us, as well as the Nurture Nature Center, to consider all aspects of the city's community. Regarding the social aspect, it is in our best interest to make the project feasible and accessible to all Easton residents as projects like this can easily exclude viewpoints from lower-class individuals and vulnerable communities. As stated earlier, nearly 19% of Easton residents fall below the poverty line and are most vulnerable to the impacts of climate change for various reasons. Additionally, many of these residents tend to rent and reside in buildings that do not utilize energy efficiently. Considering that these individuals lack resources, individual measures would put financial stress on a great percentage of Easton's population. However, with microgrids, it is possible to decrease the economic burden on residents. The local aspect of a microgrid would give end-users more agency and independence from utilities and increase energy savings. Microgrids would take up the burden of investing in energy-efficient technologies off of the individual, as it is a systemic solution that will benefit the community as a whole.

[16] Low-Income Community Energy Solutions, n.d.

Funding Easton's Microgrid

When constructing a microgrid, there are a couple of investments that would need to be made. No microgrid looks the same, but the key components of a microgrid system include space for construction, an island inverter, a control unit, an energy storage unit (i.e. battery), and the source of (renewable) energy. To provide numbers for how much construction may cost, let's consider two microgrid systems. Located in Washington, D.C. is the public housing property of Maycroft Apartments.[17] For comparison, the newly proposed Bushkill and North Union Street properties will have a total of 173 units. The Maycroft Apartments has 100 units. This means that when evaluating pricing, we do not expect costs to fall below the costs of the energy project in DC. For the equipment located in the control center (inverter, battery storage, control unit, etc), equipment cost was around $90,000 and installation cost was around $40,000. It is also key to note that the system runs on solar energy and has used the roof as the space to house the solar panels. For solar panel installation, the cost was around $197,000, and is expected to produce 75MWh a year. Overall, $327,000 is what was spent on the microgrid system for the Maycroft Apartment complex. On the other hand, there is the Marcus Garvey Apartments solar microgrid located in Brooklyn, New York.[18] This microgrid can work in tandem with the traditional macrogrid to increase the efficiency of energy consumption, or it can work in island mode for up to 12 hours in the case of a power outage. In terms of size, it provides power for 32 buildings with 625 units, which exceeds the amount of power Easton would need for this 2-building proposal. Because the cost of this project totaled $1.3 million, we do not expect the cost of a microgrid powering the Bushkill House and N. Union St. apartments to surpass this price point.

[17] Clean Energy Group, 2019
[18] Wright & Hanley, 2017

Thus far, it can be expected for microgrid costs to fall anywhere between $327,000 and $1.3 million – favoring the cheaper price point.

Despite the notable financial benefits of these microgrids, one of the greatest difficulties in establishing microgrids is acquiring the funding necessary for such a project. Public funding for microgrids can come in the form of tax credits, grants, green banks, revolving funds, and power purchase agreements (PPAs) among many other options. In Easton's case, there are a few existing programs that can aid in financing such a project. First, Easton is in the works of applying for a federal HUD planning grant that could promise $30-50 million towards West Ward redevelopment. Allocating some of those funds toward the microgrid could be one way to fund it. Considering the microgrid price should not exceed $1.3 million, the price of a microgrid in Easton would not take up more than 4.3% of the planning grant.

Additionally, the city could utilize Pennsylvania's Guaranteed Energy Savings Act (GESA).[19] Passed in 1998, GESA has been providing PA public institutions the enabling legislation needed to cost-effectively streamline all energy-based project development, procurement, implementation, and post-construction services without requiring any capital dollar outlay. Essentially, through financing (up to a 20-year term), generated savings would financially support the project. Additionally, other public-private partnership (P3) contracts could be incorporated into GESA to enhance its economic value as the provider (and not the public institution) sources the investment for implementation. These P3 contracts include "Energy as a Service" (EaaS), "Design-Build-Own-Operate-Maintain" (DBOOM), "Power Purchase Agreement" (PPA), and "Master Service Agreement" (MSA). With careful planning and consideration, the use of GESA in conjunction with other contracts could provide for an economically beneficial, budget-neutral investment.

[19] Energy & Resource Management, n.d.

In addition to GESA, the United States recently passed the Inflation Reduction Act[20] which could also provide capital and incentives toward a microgrid project in Easton. This act invests $369 billion in energy/climate solutions and environmental justice, and could potentially be a source for grants to fund the project. Additionally, there are 2 types of tax credits within the act that can be advantageous. First is the Investment Tax Credit (ITC). With this, a 30% base tax credit is provided for investment in renewable energy projects. This has the potential to be beneficial since the microgrid would generate electricity from a renewable source. Additionally, 10% is added to the base tax credit if the project is implemented in a low-income community. Because of GESA, we propose that the microgrid be placed in the vicinity of or on public housing property. This placement would allow for the utilization of this bonus incentive. In addition to the ITC, there is also a Production Tax Credit (PTC). This would provide an annual credit based on the amount of energy produced and sold by a project over a 10-year period (2.5¢/kWh in 2021 dollars).

A microgrid can provide financial benefits for Easton and its residents, but for the city to capitalize on the available programs and incentives, project costs need to be defined. A rough estimate of project costs has been given based on the analysis of similar projects in the United States. However, an energy assessment needs to be done on the Bushkill House and N. Union St. apartments before moving forward in this process. The assessment would be the first step towards microgrid implementation as it would allow the city to understand where energy improvements are needed, as well as how much energy a microgrid would need to provide. Upon completion, a more detailed economic analysis can be conducted.

[20] Fact Sheet: Four Ways the Inflation Reduction Act's Tax Incentives Will Support Building an Equitable Clean Energy Economy, 2022

Conclusion

In sum, poor residential energy efficiency in Easton is an issue that can be amended with the proper tools, and one such tool is microgrids. Microgrids have proven to be beneficial in many other locations throughout the United States, and have provided varying communities with local, reliable, and relatively inexpensive energy. Microgrids have also been a major factor in cutting greenhouse gas emissions and meeting energy goals. On account of technical, social, and economic factors, microgrids are a solution that the City of Easton should consider in the face of climate change pressures. It is because of this that we suggest that the City of Easton Housing Authority and the Nurture Nature Center work together to rebuild the Bushkill and North Union Street housing complexes with maximum energy efficiency and connect them to a renewable energy source. We propose that Easton's Environmental Advisory Council help to facilitate increased coordination between Easton housing authorities and the Nurture Nature Center during this period.

For this to be successful, further research and work must be done to determine the energy load required for these buildings which could be determined by the energy companies that supply Easton– PPL Corp and Met-Ed. Once these companies carry out an energy analysis for Bushkill and North Union complexes, the more specific details of the microgrid can be determined. It would also be beneficial to create an "Energy Efficiency and Renewable Energy", or a more general "Climate Change" chapter of the Choice Neighborhoods plan, which currently makes no reference to climate change or what will need to be done to address it as an issue for the West Ward specifically.

Generally, this project has identified a gap in Easton's coordination. Given that the city is eight years out from the first deadline for major climate goals, there should be no new development projects that do not strongly consider their environmental footprints and long-term sustainability. To this end, we suggest that the City of Easton supports the formation of an 'Energy Efficiency Housing Council' which can solely focus on connecting the goals of the Climate Action Plan and all housing development plans, not just in the West Ward. For example, objectives EP-2A and EP-2E of the Climate Action Plan discuss rooftop solar on existing and new residential buildings. However, the Nurture Nature Center does not have the resources or authority to follow through with these objectives at this time. If granted the proper resources and authority, an Energy Efficiency Housing Council could coordinate efforts and ensure that no new housing units are built without rooftop solar.

If this proposal were to be implemented, it would advance the goals of not only the Climate Action Plan but also the West Ward Choice Neighborhoods plan. This plan discusses actions that will be taken to rebrand the neighborhood and change its perception. There is an unutilized opportunity here – to use climate action *as* a rebranding opportunity. If the N. Union and Bushkill House units were to be built with maximum energy efficiency and on renewable sources, and the West Ward could exert itself as a 'Progressive Energy Neighborhood'. This would advance the goal of advancing West Ward's reputation in Easton, but it would also advance Easton's reputation in PA and hopefully inspire other regions to create their own Progressive Energy Neighborhoods.

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