3-2018

Worcester Community Clean Energy Project: A Preliminary Assessment of Project Aims and Potential

Gabe J. Epstein
gepstein@clarku.edu

Worcester Community Clean Energy Project:

A Preliminary Assessment of Project Aims and Potential

Gabriel Epstein

May, 2018

A Master's Research Paper

Submitted to the faculty of Clark University, Worcester,

Massachusetts, in partial fulfillment of the requirements for

the degree of Master of Arts in the department of

International Development, Community and Engagement

And accepted on the recommendation of

Kathryn J. Madden, AICP, M.C.P., S.M.Arch.S., Chief Instructor

Abstract

E4TheFuture is orchestrating two pilot Community Clean Energy Projects (CCEP) in the state of Massachusetts. This paper is a preliminary analysis of the Worcester CCEP and is commissioned by E4TheFuture. The CCEP incorporates multiple types of renewable energies and a cooperative energy approach to provide clean energy access to any community member regardless of income level or homeowner status. The paper examines the CCEP's mission statement and project estimates, using data provided by E4TheFuture and academic literature. The analysis seeks to determine the feasibility of the Worcester CCEP, its potential impact on underserved communities, and the potential for project replication.

Kathryn Madden, AICP, M.C.P., S.M.Arch.S., Chief Instructor

Susan Buchan, M.Arch., Director of Energy Projects at E4TheFuture

Author's Background

Academic History

Bachelor of Arts in Geography, Clark University, Worcester, MA. May 21, 2017

Occupation and Academic Connection

Full Scholarship for an accelerated Masters of Arts in Community Development and Planning,

Clark University, Worcester, MA. Expected May 20, 2018

Energy Projects Associate at E4TheFuture, Framingham, MA, May 2017- May 2018

Senior Honors Thesis, Geography Department, Clark University, Worcester, MA

Table of Cofntents

Introduction

E4TheFuture is currently in the midst of designing and implementing two Community Clean Energy Projects (CCEPs) in Massachusetts. One project is in the town Tyringham, located in the Berkshires and the other is an urban project in Worcester, MA. The Tyringham project is intended to demonstrate the potential for rural clean energy utilizing existing barn roofs. The second CCEP is in primarily low-income neighborhoods of southern Worcester. The Worcester Community Clean Energy Project (CCEP) is a unique approach to community energy, which incorporates a multitude of stakeholders in underserved urban neighborhoods. The 501(c)3 non-profit, E4TheFuture, is designing the CCEP, and established a Board of Directors who will run the 501(c)12 Community Clean Energy Project upon its implementation. Set in the Main South, Piedmont, and South Worcester neighborhoods, the CCEP is a pilot project that seeks to provide access to clean energy and cost savings in traditionally underserved, low-income communities. The Worcester CCEP combines ideas of environmental resilience and environmental justice. By pairing these two different frameworks of sustainability the CCEP hopes to create a project which can increase Worcester's ability to withstand the impacts of climate change while focusing efforts towards populations that are typically left out of the clean energy market. The CCEP is intended to be a replicable project, implementing rooftop solar, anaerobic digestion, battery storage, and energy efficiency. While the CCEP is designed to be replicable, the specific renewable energy types implemented in new projects are likely to vary, depending on what resources are best suited to each project's local environment.

E4TheFuture is based in Framingham, MA, working on both state and national policy as well as developing two CCEP pilot projects in MA. The Worcester CCEP promotes E4TheFuture's mission which is to improve "residential clean energy and sustainable resource solutions to advance climate protection and economic fairness by influencing federal, state and local policies, by helping to build a resilient and vibrant energy efficiency and clean energy sector and by developing local innovative strategies" (E4TheFuture, accessed at e4thefuture.org). E4TheFuture is responsible for the CCEP's project design and implementation. Upon completion, the Worcester CCEP will be managed by its Board of Directors, with E4TheFuture acting as a partner to provide information and resources as needed.

This study is an exploratory assessment of the Worcester CCEP project principles and expected outcomes. Using literature and data gathered by E4TheFuture, the assessment will analyze project goals as well as barriers to best understand both the feasibility and relevancy of the CCEP. The assessment has a dual purpose to guide E4TheFuture in the Worcester CCEP's development and to inform newly emerging energy initiatives across the United States.

Literature Review

Definitions

The Worcester CCEP attempts to foster environmental resilience and environmental justice in a primarily low-income, diverse community. The CCEP is a pilot program meant to facilitate equitable access to the economic and environmental benefits of renewable energy resources in an urban setting. To do so, the CCEP intends to incorporate multiple factors which will make the project unique in comparison to existing community energy projects. Rather than focusing only on one type of renewable energy resource (i.e. community solar, or community wind farms), the Worcester CCEP will attempt to integrate energy efficiency, solar photovoltaic systems, anaerobic digestion, and battery storage. The CCEP also plans to make co-op membership free of charge for wider participation. So far, few community energy projects across the nation offer no-cost entry, none of which also integrate multiple energy resources in the same project. The literature review will establish definitions of environmental resilience and environmental justice. The exploration of these phrases is followed by understandings of low-income energy burdens, the potential for energy efficiency and renewable energy to mitigate environmental burdens, and summaries of various renewable technologies. The literature also examines case studies of similar community energy projects nationwide that will guide an understanding of the CCEP's ability to effectively meet its goals.

Environmental resilience is a loose term, with a wide range of definitions. Resilience is used regarding pollution, natural disasters, and public health. Stemming from the Latin root "resilio", the word's meaning is "to bounce back" (Meerow et al., 39, 2016). In a broad sense, the word resilience is a proactive response to both slow acting and sudden disaster, focusing on mitigation, preparedness, response, and recovery (Adil & Ko, 2016). Similarly, the common definition of urban resilience is "the capacity of a system to absorb disturbance and reorganize while undergoing change as to still retain essentially the same function, structure, identity, and feedback" (Meerow et al., 2016). The common definition is highly general, lacking any description of time frame, or the possibility that systems may require alterations in function as the climate changes. As a result, authors Meerow, Newell, and Stults offer a series of recommendations for an enhanced, comprehensive definition of urban resilience. The authors stipulate that resilience should focus on mechanisms that are "safe to fail", rather than "fail safe", focusing on a rapid response towards rebuilding and recovery. The essay chooses to use the newly proposed definition,

> Urban resilience refers to the ability of an urban system - and all of its constituent socio-ecological and socio-technical networks across temporal and spatial scales - to maintain or rapidly return to desired functions in the face of a disturbance, to

> adapt to change, and to quickly transform systems that limit current or future adaptive capacity (Meerow, et al., 45, 2016).

This definition folds in both urban systems along with environmental and social concerns, thus fitting the goals established by the CCEP.

The Worcester CCEP is intentionally sited in the Main South, South Worcester, and Piedmont neighborhoods to demonstrate the capacity for renewable energy to benefit low-income, high minority communities that are traditionally underserved. The CCEP's goal to reduce energy costs and improve public health fall in line with the Environmental Justice (EJ) movement. The concept of EJ arose from activist concerns in 1982 after the arrest of 500 people in Afton, NC for protesting the placement of a landfill that directly impacted the health and safety of the community (Bullard, 2005). Like resilience, environmental justice also suffers from a multitude of varying definitions. Upon evaluating multiple definitions from federal, state, and organizational levels, this paper uses that of the state of Massachusetts, which has the most pertinent and comprehensive definition. Environmental Justice can be understood as

> "the equal protection and meaningful involvement of all people and communities with respect to the development, implementation and enforcement of energy, climate change, and environmental laws, regulations, and policies and the equitable distribution of environmental benefits" (Massachusetts Executive Office of Environmental Affairs, 3, 2017).

The Massachusetts definition insists upon the right of equitable benefits in addition to requiring the alleviation of harm. The definition asserts that low-income and minority communities must be provided with the same distribution of both environmental benefits, and hazards, as non-EJ communities (Edwards, et al. 2015). This distinction is important, as low-income, minority populations experience disparities in environmental hazards (Brulle & Pellow, 2006). Nationally, high-minority communities in the United States average twenty-seven hazardous waste sites per square mile, compared to only three hazardous waste sites for white, non-low-income communities (Faber in Sandler & Pezzullo, 2007). The Massachusetts definition specifically states that mitigating existing environmental burdens is not sufficient, but that these communities must also receive an equitable distribution of environmental benefits.

Energy, Wealth, and Health Disparities

Few low-income and minority households see the equitable distribution of environmental benefits as described by the state of Massachusetts. Rather, these households have little access to resources, and information pertaining to energy efficiency and renewable energy. Nationally low-income, minority, and renter populations all have disproportionately high energy bills compared to the national average (Sabol, 2016). High energy bills are often the result of low-income and minority populations living in older, aging housing stock with inefficient appliances and poor weatherization measures (Drehobl & Ross, 2016). The average low-income family pays bill averages ranging between 7.9% to 13% percent of annual income on energy costs (Drehobl & Ross, 2016; Sabol, 2016). An energy bill that costs 10% of annual income is four times the energy expenditure of the average American household and is defined as “energy poverty” (Moore et al., 2014). Not only are low-income households paying higher portions of their incomes, but those higher portions often amount to more actual dollars spent as well. In 2013 the median electricity bill was $114 per month. For low-income households the median was $200 per month (Sabol, 2016). When broken down by square footage, low-income populations are understood to pay $1.28 in energy costs per square foot, compared to $0.98 for middle to upper class households (Cluett et al., 2016; Drebohl & Ross, 2016). Energy costs are also higher for renters, African American, and Latino populations (Drebohl & Ross, 2016). This finding implies that low-income, minority, renters pay the highest percentage of their incomes on energy in the United States.

Energy burdens can have significant impacts on low-income, minority populations ranging from economic instability to heightened health risks (Sabol, 2016; Drebohl & Ross, 2016). Forty-four percent (44%) of low-income households struggle with energy instability, which is defined as an inability to meet basic household energy needs (Cluett, et al., 2016). The environmental organization, Groundswell, reported that high energy burdens are correlated to an increased likelihood of unsustainable debt, or purchase tradeoffs, such as foregoing groceries (Sabol, 2016). In addition to financial burdens, inefficient homes and appliances lead to discomfort, increased stress, and illness. Poor housing stock is linked to increases in respiratory illness, heart disease, mental health problems, and impacts on education among other challenges (Drehobl & Ross, 2016). These impacts are most severe for adolescents, putting them at twice the risk of respiratory illness and five times more likely to develop mental health problems (Drehobl & Ross, 2016). Through energy efficiency upgrades alone, households could save up to 55% on electricity costs, while also improving comfort and in-home air quality (Bird & Hernandez, 2012). Renters typically do not access energy efficiency measures due to cost and a lack of incentive for landlords. Eighty-eight percent (88%) of landlords pass energy costs to their tenants and are therefore unlikely to pay for energy efficiency measures without seeing any sort of financial return (Sabol, 2016). Due to the high sticker price of energy efficient appliances, low-income populations are less able to invest in efficiency measures, however, every dollar invested in utility energy efficiency generates $2 to $4 in benefits for customers, paying for themselves up to four times over the course of their lifespan (Molina, et al., 2016).

Renewable Energy Potential

Much like energy efficiency measures, renewable energies can also provide significant benefits to environmental justice communities. Not only are there numerous accounts of solar energy being economically efficient over the course of one to two decades, but solar also presents a viable option for mitigating both climate change and public health concerns. Despite the growth of the renewable energies sector, the burning of fossil fuels also continues to rise to meet energy demands (Panwar et al., 2011). Because of the continued burning of fossil fuels, humans are responsible for increasing carbon dioxide levels by an estimated 31% over the past two centuries (Panwar et al., 2011). As humans continue to emit greater levels of carbon dioxide and other greenhouse gases, average global temperatures continue to increase, which is correlated with more frequent and more intense natural disasters (Panwar et al., 2011). In addition to increasing rates of natural disasters there is also a concern of pollutants and toxins being emitted due to the burning of fossil fuels. These pollutants are shown to most impact EJ communities (White-Newsome, 2016). As air pollution continues to worsen, public health problems are also projected to increase. Increased pollution and health problems will cause greater human suffering, as well as contribute to massive public health costs (Bullard. 2005). Authors Peer Smet and Paul Van Lindert argue that taking ecology and energy into consideration are crucial in establishing sustainable low-income urban housing (Smet & Van Lindert, 2016). Solar and other renewables present a potential measure to reduce and eventually curb continued emissions of pollutants and in doing so offset the looming costs of both disaster relief and healthcare (Smet & Van Lindert, 2016).

At present, investment in solar can also be shown to strengthen local economies and job growth at a far greater rate than almost any other type of energy production. Peter Wenz states that gas and oil create 1.5 jobs, the coal industry 4.4 jobs, and solar 17 jobs with every million dollars spent in each industry (Wenz in Sandler & Pezzullo, 2007). In Massachusetts alone, there are 14,582 solar jobs, making it the seventh largest state for solar in the country (Solar Energy Industries Association, 2016).

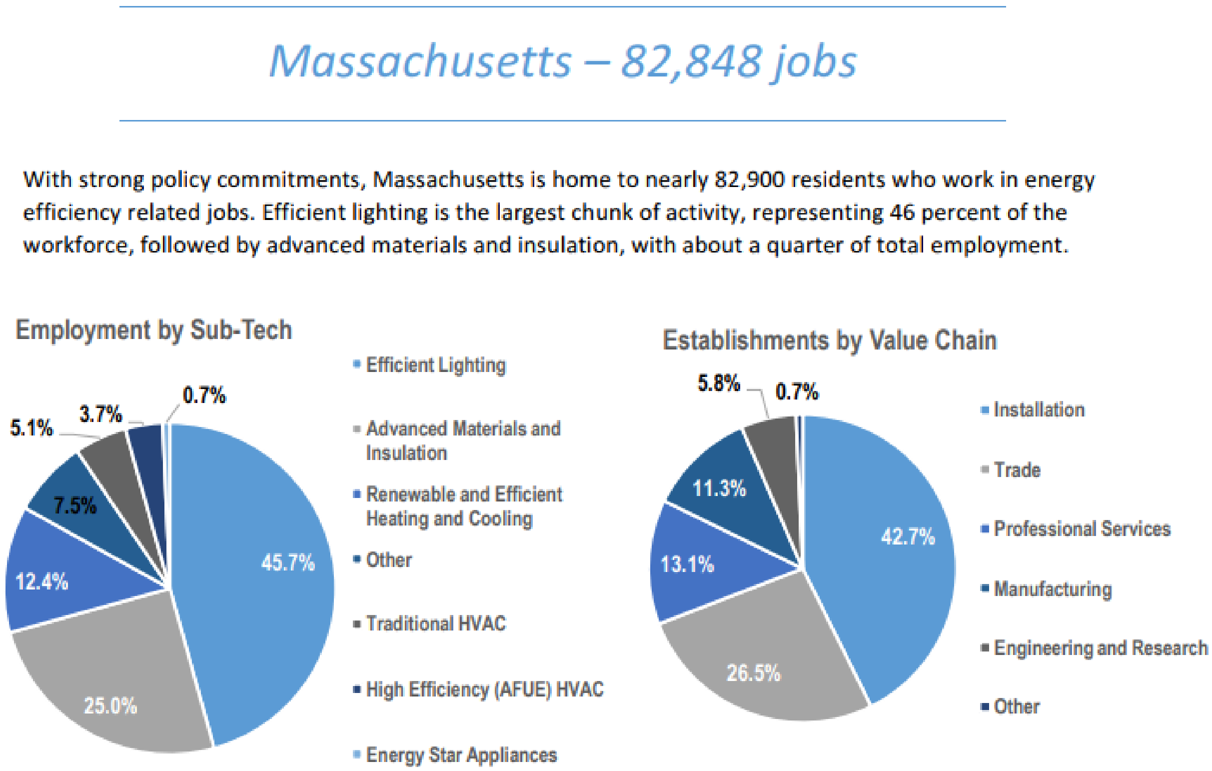


Figure 1, Energy Efficiency Jobs in America. Massachusetts Energy Efficiency Jobs

Massachusetts also has a total of 82,848 energy efficiency jobs (Lehmann et al., 2016). These energy efficiency and solar jobs range from manufacturing to installation and development, being projected to continue growing over the next five years (Lehmann et al., 2016). At present solar is the most affordable and accessible renewable energy, however, is not alone in its ability to mitigate environmental harms while generating significant energy and cost savings over time. Much like solar photovoltaics, wind energy, anaerobic digestion, battery storage, and an array of other energy sources can play a substantial role in creating a diverse, resilient energy system. At the same time, these alternative energy solutions can create economic savings and improve public health.

Technology Summaries

Perhaps the most pervasive of renewables energies, solar photovoltaics offer an increasingly affordable source of electricity. Solar photovoltaic cells operate by using semiconducting materials to convert sunlight into electrical currents (Kammen & Sunter, 2016). Due to the abundance of sunlight, solar panels can produce 5,000 times the Earth's current energy needs (Kammen & Sunter, 2016). Solar panel locations are highly flexible, capable of being mounted on urban rooftops, as canopies over farmland, and conceivably anywhere that direct sunlight can be encountered. Solar prices today are now less than one third of their cost in 1998 (Hagerman et al., 2016). These prices are continuing to drop, averaging a decline of 11.2% annually (Torani et al., 2016). As costs decrease, solar efficiency and lifespans continue to increase as well, with new solar panels now achieving a 40% efficiency rating in laboratory settings (Kammen & Sunter, 2016). Solar lifespans also continue to increase and are now expected to remain productive for approximately 30 years (Comello & Reichelstein, 2016). Despite rooftop solar's remarkable increase in efficiency and cost reduction, solar PV systems are not yet at "socket parity" without added governmental subsidy or incentives (Hagerman et al., 2016). The term "socket parity" is defined "as occurring when the lifetime cost from the rooftop array is less than or equal to the lifetime price of purchasing electricity from the local distribution utility" (Hagerman et al., 85. 2016). However, with government incentives, solar PV systems are at 98% market parity in the United States, including the state of Massachusetts (Hagerman et al., 2016).

Anaerobic digestion is a more recent renewable energy technology in the United States, offering the opportunity for combined heat and power (CHP) generation. Manure-based anaerobic digestion functions by storing large quantities of organic waste in a metal silo with a rubber dome. The organic waste is slurried, aiding the natural microbiomes from the waste in breaking down compost into biogas (Chen et al., 2008). As the organic waste decomposes, methane gas is a natural byproduct, which typically enters the atmosphere as a harmful greenhouse gas. By trapping the generated methane within the dome, anaerobic digestion can burn the naturally occurring biogas for energy. By burning the biogas, anaerobic digesters reduce greenhouse gas emissions by 85% (Vanguard, vanguardrenewables.com). In addition to energy generation, anaerobic digestion is also able to harness the heat created by the waste, which can be used to heat buildings. Other outputs of the anaerobic digestion process are water purification and digestate to be used, or sold, as fertilizer for agricultural purposes (Vanguard, vanguardrenewables.com). Unlike solar, anaerobic digesters are not an intermittent generation source, and are capable of running for 24 hours a day. Anaerobic digestion is reliant on a constant stream of organic waste rather than the sometimes elusive sun, providing constant and consistent energy (EPA, Accessed at: www.epa.gov/agstar/learn-about-biogasrecovery#adwork). While a versatile solution for waste management, energy production, and heat generation, anaerobic digesters also have drawbacks that make them difficult for widespread adoption at present. Of these barriers, the most challenging is waste acquisition. Anaerobic digestion requires substantial waste to generate power. Not only are large quantities of waste necessary, but the organic waste must also remain consistent in the amount and type of waste being fed into the digester with minimal contamination by non-organic materials. Frequent alterations in waste type will lead to inefficiency in power generation, and may also risk system instability (Chen et al., 2008). Typically, anaerobic digestion is found on cattle or dairy farms, with large quantities of manure for a consistent energy source. Consistent and sizable quantities of waste are less able to be found in urban settings. The other primary barrier to anaerobic digestion is the issue of construction cost. Anaerobic digesters are expensive and complicated machines, requiring millions of dollars to build. Small anaerobic digestion systems are especially difficult to finance but become more cost effective as they are built to larger scale. Despite the high investment cost, these systems can often be paid for in five to seven years through sale of energy and fertilizer, with low acquisition costs for organic waste (Renewable Waste Intelligence, 2013). These systems are expected to have a lifespan of over 20 years (Nemecek and Kägi, 2007).

Battery Electric Storage Systems (BESS) allow intermittent energy sources, like solar, to be stored and drawn upon as needed. There are a variety of storage models, ranging from flywheel to lithium-ion technology. Each different battery model comes with a different set of benefits and limitations. For example, some batteries are better suited for long duration energy flows, to be used off-grid, while other batteries are designed to provide short bursts of energy which can smooth grid intermittencies and reduce energy demand during peak energy use times on the electricity grid (Denholm et al., 2010). Lithium ion batteries are the most widely used, offering compact, lower cost, efficient battery storage that benefits grid resilience (Zipp, Solar Power World, 2015). Despite its value to reduce peak demands and improve grid resilience, the market has yet to catch up to battery storage being coupled with renewable energies. At present, Massachusetts does not allow for stored renewable energy to receive net metering credits (D.P.U, Massachusetts, 2017); however, this regulation is being adjudicated in a case currently before the DPU and may be resolved soon (Ibid, 17-146) Without any credit for the grid benefits and resilience for critical loads provided by storage, pairing renewable energy with battery storage provides little economic incentive for the inclusion of storage in a CCEP at this time.

Through this analysis it can be understood that renewable energies can mitigate harmful fossil fuel emissions and create greater economic stability for low-income families, creating local clean energy jobs, and keeping more dollars in the local economy. The implementation of solar panels, anaerobic digestion, and battery storage are projected to promote lucrative job growth in the energy sector, while also stabilizing rising energy costs and providing savings for low-income families, creating significant impacts on quality of life and creating environmental justice (Drehobl & Ross, 2016; Sabol, 2016).

Case Studies

As the Worcester CCEP intends to provide community energy using multiple types of renewable energies with a focus on low-income community members, the literature review also seeks to be informed by existing community energy case studies. E4TheFuture explores community energy projects, such as community solar and community wind projects across states that allow Virtual Net Metering. Virtual Net Metering allows for the distribution of net metering credits from off-site renewable energy sources, making community energy projects feasible. These credits are allocated virtually using a tool referred to as Schedule Z. Of these existing projects, however, few manage to successfully include low-income members, and no existing project has been found which incorporates more than one renewable energy type.

Perhaps the closest existing project to the CCEP is Delta-Montrose Electric Association (DMEA) and GRID Alternatives' (GRID) community solar initiative serving Montrose, Delta, and Gunnison counties in Colorado. This project constitutes of 151 KW of solar arrays for up to 43 low-income cooperative members. Subscribers must earn below 80% of HUD's area median income. The GRID project aligns with the Main South CCEP regarding its focus on low-income populations but differs in most other respects. While there are substantial differences between this case study and the Worcester CCEP, the GRID project is more successful than most national examples of community energy at subscribing low-income residents. Rather than requiring a buy-in fee or monthly payment plan, the GRID project instead has members contribute through 16 hours of donated labor in panel installation (CEO, 2017).

Other national examples include MN Community Solar and the South Dakota Wind Partners. While these are not the only community energy projects across the country they serve as representative case studies, demonstrating the broad scope and successes achieved by community energy developments across the U.S. MN Community Solar partners with the utility Xcel Energy, offering 10% energy savings in the first year with no upfront entrance fees and is made available both to commercial and residential customers (MN Community Solar, What We Do). MN Community Solar currently has six solar farms across the state, making it a larger, broader initiative than the Worcester CCEP. The project differs from the CCEP, using only one renewable energy type, with no focus on low-income customers, a lower annual energy savings rate, and a statewide geographic focus. While there is no buy-in fee, the project does mandate a credit score of 680+ and enforces buy out fees of up to $250 dollars for early contract termination (MN Community Solar, FAQs: Terms). MN Community Solar shows incredible success in Minnesota, currently at full capacity with more solar arrays in construction. The project, however, includes financial barriers that prevent the inclusion of low-income members. These financial limitations make the project more easily financeable but fails to address concerns relating to environmental justice and equity.

The South Dakota Wind Partners is included as a case study as it shows a community energy project that uses a resource separate from solar. The Wind Partners built seven wind turbines with a capacity of 100+ megawatts. This energy is shared by 600 farmers and residents around Crow Lake, South Dakota. The project was funded using both debt sharing and equity, as well as a $15,000 buy-in from each member (Farrell, 2017).

These existing community energy projects are instrumental in informing the Worcester CCEP as it develops. Yet, these case studies also demonstrate a lack of access for low-income customers who have the greatest need. Existing projects also show that no successful community energy venture has yet to incorporate multiple types of renewable energies, which allow for more consistent and resilient energy generation. By targeting a low-income, high minority community, and incorporating multiple renewable energies the Worcester CCEP offers an innovative opportunity to increase equity and reduce fossil fuel emissions through the strategic implementation of energy efficiency and renewable energy in Worcester's most underserved communities.

Methodology

The Worcester CCEP is still in the initial planning phases and has yet to enter into any formal construction contracts. Despite being in its infancy, E4TheFuture has conducted research, compiling data from the U.S government, energy utilities, renewable energy companies, and satellite imagery to create its own data models relating to cost predictions, and expected impacts. At present, the CCEP also incorporated its board of directors and maintains relationships with a variety of local organizations. As the Worcester CCEP develops, the project anticipates its initial rollout of solar and member acquisition to begin in 2018. This report is informed by data and findings coming directly from E4TheFuture, with full access to company documents. Similarly, the findings for the Worcester CCEP are informed by E4TheFuture information as well as from collaborating institutions both locally and nationally.

The CCEP is a pilot program, and an apt case study, to determine the feasibility of replicating community energy projects across Massachusetts and the nation at large. E4TheFuture is dedicated to climate protection and economic fairness, coming into being through the purchasing of Conservation Services Group's assets by ClearResult in 2015. As a result, E4TheFuture operates with an endowment that provides sufficient economic resources to engage in a financially risky and complicated pilot project. As the Worcester CCEP proceeds, E4TheFuture will be able to inform newly emerging projects, enabling community organizations to avoid pitfalls and achieve success.

While in the planning stages for the CCEP, E4TheFuture is currently engaged with the U.S Department of Energy's Solar in Your Community Initiative. As a participant, E4TheFuture is provided with a "solar coach", who plays a guiding role in answering questions and providing suggestions to improve the likelihood of success. In addition to providing a coach, Solar in Your Community offers ample research and templates for energy generation and cost estimates. Lastly, the Solar in Your Community Initiative is a competition, which will provide up to $1 million in grant funding to a select group of participants in January of 2019.

Community Partners

The CCEP is partnering with a series of local actors, many of whom are participants in the project's advisory board and board of directors who can provide data and community insight as they take the reins of managing the CCEP upon operation. CCEP partnerships and collaborators include:

> The Office of Congressman Jim McGovern, City Councilmember Sarai Rivera, National Grid, Eversource, RENEW, the Main South CDC, Worcester Common Ground, the Worcester Community Action Council (WCAC), The Southeast Asian Coalition, Clark University, Table Talk Pies Inc., and Vanguard Energy.

Of these organizations, Congressman McGovern's office, Clark University, National Grid, and Table Talk Pies provided letters of support for the project. Congressman McGovern's office also connected E4TheFuture with information regarding anaerobic digestion projects across Massachusetts. Councilmember Rivera is a CCEP advisory board member with an intimate knowledge of community need and key stakeholders. Both energy utility companies, National Grid and Eversource, are members of the advisory board and provide E4TheFuture with information relating to neighborhood utility accounts, average monthly bill expenses, kilowatt hours consumed, and details pertaining to grid interconnection. RENEW is a cooperative organization based out of Worcester's Stone Soup that is now collaborating with the CCEP. The Main South CDC and Worcester Common Ground are two community development corporations which focus on the Main South and Piedmont neighborhoods, respectively. The Main South CDC holds a seat on the CCEP's Board of Directors, but both CDCs are participating in the project, providing connections to the hundreds of families served through CDC initiatives. The WCAC is also represented on the advisory board and provides contact information through its Low-Income Home Energy Assistance Program (LIHEAP) services through Worcester as well as informing the CCEP through knowledge of community outreach best practices in the community being served. The Southeast Asian Coalition agreed to help engage with community members as well as offer translation services. Clark University is a longtime community stakeholder which commits resources to the betterment of the neighborhood. Clark University holds an advisory board seat and offers insight from professors such as Professor Chuck Agosta, as well as providing introductions to other neighborhood organizations. Table Talk Pies is partnering with the CCEP as a potential host for the proposed anaerobic digester and a rooftop solar array in the newly developed South Worcester Industrial Park. Table Talk Pies offers a viable solution to anaerobic digestion, offering an industrial space for construction, a significant source of organic food waste, and a large, flat rooftop that may be suitable for a solar array. Lastly, Vanguard is a company specializing in anaerobic digestion which provided E4TheFuture with models and estimates of systems costs, inputs, and outputs. Despite estimates presented by Vanguard, E4TheFuture is now pursuing an anaerobic digestion contract with Purpose Energy.

Data Projections

E4TheFuture pairs information gathered through community partners with its own preliminary goals and estimates to model the CCEP's expected cost, capacity for membership, and expected annual savings for members. E4TheFuture initially set goals of 15-20% of energy savings on electricity bills for members. Using this goal and data provided by National Grid E4TheFuture estimated the number of households feasible to serve as cooperative members, as well as the amount of renewable energy capacity to be built. Predicting the need for approximately 2-megawatts of solar and a 1-megawatt anaerobic digester, E4TheFuture used Google Earth and Google Sunroof to identify adequate rooftops in Worcester and the CCEP target area. These preliminary rooftop findings are being tailored as E4TheFuture gauges building condition, rooftop availability, and landlord interest. Potential rooftops are also visualized using the polygon tool in Google Earth along with number estimates of the number of solar panels which can fit along with their energy generation capacity.

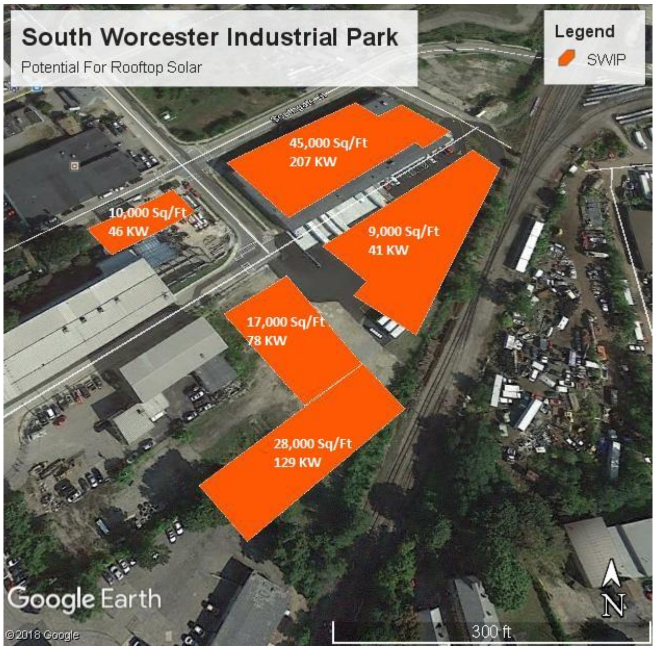


Figure 2, produced by E4TheFuture

[1]

Figure 3, produced by E4TheFuture

[1] These proposed rooftops are in no way final or assured but are intended to demonstrate rooftop solar capacity in the target area and provide the CCEP with a list of potential landlords to approach for a professional rooftop assessment by an outside organization.

The cost estimates and data projections resultant from E4TheFuture and collaborating organizations are also paired with a body of research pertaining to South Worcester, renewable energies, energy efficiency, and energy impacts on low-income households. This research includes U.S Census data, an EPA resilience study, and academic research. Through this synthesis of data, E4TheFuture provides a comprehensive strategy for its newly emerging cooperative.

CCEP Analysis:

To properly analyze the Worcester Community Clean Energy Project this paper will focus on the target area's history, demographics, and zoning to understand the context that the CCEP is operating in. With this background knowledge in hand, the CCEP's data projections and potential impacts on the community can be better understood. While the CCEP includes Main South, Piedmont, and South Worcester, the project's initial focus was solely on the Main South neighborhood. All three of these neighborhoods demonstrate similar needs, however, and fit the project's goals. Because of the project's primary focus on the Main South neighborhood this paper includes a history of Main South, however, neglects to provide explicit detail of the surrounding two neighborhoods.

The CCEP is a pilot project intended to provide clean energy and cost savings to a primarily low-income, urban community. The CCEP has manifold goals, seeking to combat climate change and provide an equitable distribution of wealth generated from community owned renewable energies. In doing so, the CCEP can reduce the disparities in environmental benefits and hazards between low-income, high-minority communities and their counterparts, bringing typically excluded communities into the clean energy economy. As a pilot project, the

Worcester CCEP is being implemented in a manner to be replicated by communities with access to Virtual Net Metering across the country as an alternative to current energy generation systems.

Study Area

The Worcester CCEP is intended to be a replicable project, focusing primarily on the Main South, Piedmont, and South Worcester neighborhoods of Worcester. These neighborhoods are similar in economic and racial makeup and are intended to demonstrate the feasibility of such a project despite a multitude of factors often viewed as barriers in the energy sector. Low-income status poses challenges to project finance, while urban settings prove difficult to find sufficient space for to-scale construction of renewable energies. These same factors are also what make the neighborhood ideal for the CCEP, attempting to prove that these projects can be done. In doing so, the CCEP hopes to provide significant benefits to low-income, minority communities which are often left out of the clean energy economy. By understanding the neighborhoods' all too common history, current demographics, and community needs, the Worcester pilot attempts to model adaptability, potentially able to be placed into almost any urban environment.

Figure 4, CCEP Boundary, Produced by E4TheFuture

Worcester was once a vibrant industrial city, with the CCEP's target area being home to Clark University and many of the factory owners during the turn of the 20th century (Chelsey & Peterson, 1995; Warshaw, 1990). Over time, the area morphed into a primarily blue-collar community, with the city's factory workers moving into triple decker housing nearby their jobs (Chelsey & Peterson, 1995; Warshaw, 1990). Worcester hit hard times, however, during the 1970's as factories and residents flooded out of the city in mass. As factory jobs vanished in Worcester, the Main South neighborhood became a hotspot for prostitution, drug trafficking, and robbery (McKie Jr., L. R., 1975; "Worcester's combat zone?", 1974). Neighborhood conditions continued to deteriorate well into the 1980's. In the mid-1980's Clark University helped to form the Main South Community Development Corporation (CDC), which worked to develop affordable housing and first-time homeowner programs (Warshaw, 1990). The CDC, Clark University, and a handful of other non-profit, as well as religious organizations, are committed to the revitalization to Main South and surrounding neighborhoods. While these efforts have done substantial work in stabilizing the neighborhood, the neighborhood still has a long way to go before achieving the economic and social stability that it had before the 1970s.

Zoning and Geography

As a result of the city's history, Main South, Piedmont, and South Worcester are home to triple decker households and old factory buildings, many of which remain underutilized or abandoned. For many of these triple decker households, renewable energy technologies like solar are infeasible. Worcester's triple deckers are primarily inhabited by multiple renters, meaning that solar production on their own roof would have to be split between multiple households. As renters, these households would also need rooftop solar to be installed by the landlord, who has little cost incentive to do so. Many of these triple decker houses have aging roofs as well, which can prevent installation, or seriously increase costs (Augustine & McGavisk, 2015). The prevalence of triple decker households make rooftop solar infeasible for most residents, without even considering financial constraints. Large factory buildings, however, offer a potential solution for community solar initiatives to be used by renters and homeowners alike.

As the Worcester CCEP involves rooftop solar arrays and anaerobic digestion, the placement of these technologies can be limited by urban zoning policies. South Worcester consists of RG-5 (Residence, General), IN-S (Clark University), BL-1.0 (Business Limited), BG-4.0 (Business, General), and MG-2.0 (Manufacturing, General) zoning ordinances (Zoning Ordinance & Map, City of Worcester, 2018). According to City staff, rooftop solar can be installed in any zoning district, so long as it complies with roof height, yard setbacks, and interconnection applications. Anaerobic digestion, however, is a more intrusive development project, fitting only the MG-2.0 ordinance, or special permission from the city.

In a recent resilience report, the Environmental Protection Agency (EPA) compared Worcester, MA with Washington D.C, examining both city's level of resilience and preparedness for inclement weather and changes in climate patterns. In this report, Worcester was noted to have hilly topography, which could exacerbate natural disasters such as severe storms, floods, and landslides (EPA, 2017). The report also notes low resilience grades in Worcester's energy capacity, lacking adequate alternative energies if natural gas or coal energy generation is impeded. From this resilience report the lowest resilience rating, and highest importance was given to the city's economic sector and providing for the city's vulnerable subpopulations (EPA, 2017). The Worcester CCEP aims to solve the exact challenges highlighted by the EPA's resilience report, improving the resilience of Worcester, through the benefit of the city's most underserved constituents.

Demographics

Table 1: Economic Demographics of CCEP Target Area

	Main South: Census Tract 7313	South Worcester: Census Tract 7330	Piedmont: Census Tract 7314	Greater Worcester Metro Area
Median Income ($)	33,053	40,897	27,115	64,368
Poverty Rate (%)	26.6	19.4	38.9	11.4

(American Community Survey, United States Census Bureau, 2016)

Table 2: Racial demographics of CCEP Target Area

	Main South: Census Tract 7313	South Worcester: Census Tract 7330	Piedmont: Census Tract 7314	Greater Worcester Metro Area
White (%)	56.7	50.8	43.7	77
Black (%)	11.3	11.7	17.1	4
Hispanic (%)	37.8	36.8	52	11
Asian (%)	11.8	12	8	5
Native American (%)	0.2	0	0.8	0

(American Community Survey, United States Census Bureau, 2016)

Main South, South Worcester and Piedmont are some of the lowest-income, highest minority neighborhoods in the city (Downs et al., 2012). Exceeding its poverty rate, Main South and South Worcester also have a youth poverty rate of 42%. In comparison to the greater Worcester area, these three neighborhoods all earn less than half the median household income and are home to a large composition of minority residents. Through economic and racial demographics, it is clear that each of these neighborhoods fits the status of being Environmental Justice Zones and could benefit from initiatives to increase financial savings and fit the EPA's resiliency report of the neighborhoods in need of improved climate resilience.

Evidence of Need

Through the city's history, economic, and demographics data gathered from the U.S census, the EPA's resilience report, and accompanying literature, community need for a project such as the CCEP is clear. The Main South, Piedmont, and South Worcester neighborhoods have high rates of poverty, sitting well below the city's median annual income. Similarly, as seen in the literature review, it is these low-income, minority, and renter populations that have the highest energy burdens, paying disproportionate amounts of income on their utility bills. Having high energy burdens further reinforces poverty, while also leading to public health concerns and added stressors to community members. A community energy cooperative poses a viable solution to reducing energy poverty, generating needed cash savings and improving air quality through renewables and energy efficiency improvements.

As is highlighted by the EPA resilience report, Worcester has few economic assets in these neighborhoods and is doing little to ensure neighborhood resilience in the event of economic or environmental downturn.

The CCEP also presents an opportunity for educational opportunities and increased community pride. Through partnerships with community organizations the CCEP can work to inform both adults and children in the community about renewable energies and the environment. Through informal conversations with the executive director of Worcester Common Ground, Yvette Dyson, and the Main South CDC's director, Steve Teasdale, they noted that residents were often too financially constrained and overworked to be involved in causes like the environmental movement. By placing visible renewable energies directly into the neighborhoods serviced, reductions in electricity bills, and educational initiatives, residents will witness first-hand the connection between their cash-savings, and renewable energies in their neighborhood. In doing so, the CCEP may lead to a communal sense of pride while also tapping into the environmental movement without added strain to residents' daily lives.

Project Description

The Worcester Community Clean Energy Project is a 501 (c) 12 cooperative (co-op). The CCEP is designed as an opt-in membership for residents of the Main South, South Worcester, and Piedmont neighborhoods. The goal of this project is to achieve replicability, generate cost savings, and reduce reliance on fossil fuels. Members can be individuals, organizations, or commercial businesses. The CCEP aims to build a total of 2-3 MW of renewable energy, providing co-op members with renewable energy credits as well as increased access to existing energy efficiency opportunities. The CCEP is a cooperative designed with the intention of community buyback and ownership of the clean energy resources over a 7-10-year period. Renewable energy systems will be financed through private investors using earned energy credits. Partial credits will be provided to investors, while retaining approximately half to be distributed as energy savings to co-op customers. Eventual community ownership of the renewable energy systems, as well as improved housing values through energy efficiency installations will create needed community assets while adding to the neighborhood, and the city's, overall resilience. The CCEP will be managed by an Advisory Board and Board of Directors, comprised of a mix between public officials, energy utilities, local non-profit organizations, small business interests, and community residents.

By implementing renewable energies in the target neighborhoods, the CCEP seeks to build replicable economic and environmental opportunities for traditionally underserved communities who would otherwise have no feasible access to these resources. By providing community members with energy efficiency measures and renewable energy credits, the CCEP's goal is to reduce energy bills by 15-20%, improve indoor air-quality, reduce reliance on fossil fuels, and create education opportunities. By partnering with local organizations and businesses the CCEP also expects to make meaningful connections within the neighborhoods, establishing trust and local ownership of the CCEP by community stakeholders.

After preliminary assessments of local geography, both built and natural, E4TheFuture identified potential sites for rooftop solar, anaerobic digestion, and battery storage. Incorporating wind turbines into the project proved infeasible, due to a lack of nearby locations with adequate wind speed to make a turbine financeable. The CCEP intends to incorporate 2 MW of rooftop solar panels and a 1 MW anaerobic digester for energy production that can be harnessed by co-op members. In addition, E4TheFuture found that the city of Worcester has no emergency shelters in the event of a disaster or extreme weather. E4TheFuture also seeks to install both rooftop solar and battery storage on a to-be-determined community hub in the target area which will be able to act as a microgrid if the area loses power. In the event of power outage, community members will be able to seek shelter, warmth, and triage services as the city responds to whatever cause may be responsible. While almost impossible to project quantitative benefits of a community shelter microgrid, this service would offer potentially life-saving services in the face of climate change. As natural events including blizzards, hurricanes, and floods increase both in frequency as well as intensity having a designated gathering space will increase community resilience and public safety.

While the community microgrid is one component of the CCEP, the primary aim is to supply cooperative members with 2 MW of solar and 1 MW of anaerobic digestion. Through E4TheFuture's relationship with National Grid, the organization was told that the average Worcester household uses 6,164 kWh of energy a year. Given E4TheFuture's estimates of solar and anaerobic digestion production and average household energy use, E4TheFuture estimates that the co-op can provide savings to the equivalent of 2,000 community residents. E4TheFuture's estimates suggest that 2 MW of rooftop solar would generate 2.5 million kWh of energy per year. A 2 MW system can offset 3,873,390 lbs. of carbon annually. Upon its completion in five years, the anaerobic digester would contribute an additional 7.621 million kWh annually, 120,000 BTU/h of heat and 8,000,250 gallons of fertilizer. E4TheFuture was given estimates of requiring approximately 100 tons of waste per day by Vanguard Energy (see appendix). While challenging, this urban anaerobic digester also poses an opportunity as a waste-management solution for urban industrial food waste. The newly constructed South Worcester Industrial Park (SWIP) is the home of Table Talk Pies second manufacturing plant, which offers a potential site for the anaerobic digester, and is a primary generator of industrial-scale organic waste. At present the Table Talk Pies company has provided an Intent to Lease form to E4TheFuture, along with a letter of support for the CCEP. If the pie factory proves adequate for the anaerobic digester, South Worcester should face no challenges resulting from city zoning.

The average household in Main South uses 6,164 kilowatt hours (kWh) of energy per year. National Grid charges a $5.50 monthly fee, along with 11.479 cents per kWh in delivery services, and an additional supply charge of 12.673 cents per kWh. Annual average costs can be calculated as (5.5*12) + (0.11479*6164) + (0.12673*6164) = $1,554.72. National Grid's low-income, R-2 fee provides a 29% discount on the delivery charge, changing the total cost to $1,349.53 for those registered. If it is assumed that the CCEP succeeds in providing 20% annual electricity savings to co-op members, the average member will save between $270 and $311 dollars a year. If co-op members are living in older housing stock with inefficient appliances and electric heating, their electricity costs, and potential savings, are likely to be even greater. While less easily calculated, the CCEP will also allow businesses and organizations in the target area to join the cooperative.

Co-op membership will be free of charge. Despite the lack of entry cost, the CCEP will require some time commitments and potential payments for monthly renewable energy bill credits. Upon entry into the cooperative, members will receive resources and educational opportunity to improve energy efficiency and reduce excess energy usage. The CCEP also hopes to provide members with information regarding the environment and environmental justice to bring members into the movement. Members will be granted the opportunity to receive net metering credits for 15-20% in energy savings. Depending on customer type such as low-income, residential, or commercial, members may be offered different percentages of savings. If a standard member were to receive 20% in bill savings, they would likely be granted 40% of their energy bill in net metering credits, being required to pay the CCEP 20% to pay off system financing. Members would, therefore, retain 20% in personal savings. At present, E4TheFuture intends to place the bill repayments and energy savings on a sliding scale, allowing for low-income members to receive the highest percentages, with commercial customers receiving the lowest percentage of cost savings.

Table 3, CCEP Energy and Savings Estimates

Avg. Main South Usage (kWh/year):	6,164

National Grid Rates		
Monthly Fee	$5.50	
Delivery Charge	$0.11479	** R-2 rate = 29% off delivery charge*
Supply Charge	$0.12673	
NMC Rate ($/kWh)	$0.18	

Member Savings				
Savings needed for discount of:	Annual Elec. Costs	10%	15%	20%
R-1	$1,554.73	$155.47	$233.21	$310.95
R-2	$1,349.54	$134.95	$202.43	$269.91

NMCs Allocated			
kWhs needed for discount of:	10%	15%	20%
R-1	864	1,296	1,727
R-2	750	1,125	1,499

(NMCs - Net Metering Credits Allocated)

If each co-op member were to receive a 20% bill reduction, the proposed rooftop solar alone could allow savings for approximately 1,014 members. Because the solar panels will be financed over a 7 to 10-year period, the CCEP will operate by paying customers 40% off their electricity bills. Co-op members would then repay the CCEP 20% for system payment, retaining 20% in savings for themselves. Upon installation of the anaerobic digester within an expected five years, the CCEP's electricity generation capacity would increase threefold, allowing for an increase in membership and future electricity savings. The anaerobic digester is expected to have a 6 to 8-year repayment period for the digester upon its construction. By transferring ownership of these renewable energies from private investors to the CCEP, the co-op will no longer be required to make payments to the energy financiers. Instead, the CCEP's elected Board of Directors will have autonomy to decide how to use the increase in savings, either opening the CCEP to additional members, or further increasing the savings received by existing members. As a hypothetical, the Board may decide that of the 40% annual savings generated for members, each member could be granted 35% instead of 20%, retaining 5% for operation and management fees, while residents receive an added 15% in savings. The heat and fertilizer from the anaerobic digester may also be sold commercially for additional savings. How these resources are handled will also be a long-term decision by the Board of Directors closer to the anaerobic digester becoming operational.

In addition to hundreds of dollars a year in annual savings for co-op members, the CCEP also brings more qualitative benefits, creating the potential for both youth and adult education regarding renewable energies and the environment. While site location of the solar arrays does not affect the project's ability to distribute energy credits, the CCEP intends for some solar arrays to be intentionally visible in the community, allowing residents to see exactly where their energy is being produced. Educational opportunities will be furthered due to community relationships already established. Clark University's Professor, Chuck Agosta, has offered resources and student participation from his renewable energies lab. Having college students available to participate in education opportunities with local CDCs, nonprofits, and businesses will provide a deeper understanding of how renewable energies operate, further strategies for reducing energy costs, and a deeper understanding of climate change, as well as how low-income, minority communities may be disproportionately impacted. These educational opportunities may lead to a greater sense of community between co-op members and can contribute to community empowerment.

The CCEP's development costs are also variable due to political changes, as Massachusetts transitions from its SREC II energy program to SMART, potentially reducing savings from renewable energies. Solar panel costs can also be anticipated to fluctuate due to the Trump administration's recent move to place a 30% tariff on foreign solar panels. The utility Eversource recently added a minimum monthly reliability charge (MMRC) approved for solar systems. The MMRC could also be adopted in National Grid territory, adding a monthly fee for the use of solar energy. E4TheFuture is currently applying for grants. The CCEP has received $120,000 in confirmed funding at present and received a grant from the MassCEC for solar rooftop site assessments. The MassCEC grant provides $75,000 for assessments along with the opportunity for up to $1 million in further project funding. E4TheFuture is also anticipating a second assessment grant from MassCEC for the anaerobic digestion system. The MassCEC Grants, the Solar in Your Community Grants, and various other foundations could provide E4TheFuture with no funds or provide the CCEP with upwards of $1.5 million in grant funding for the project. The anticipated response to the CCEP's Requests for Proposal and from potential grant funders will impact customer savings. The CCEP's funds will be used for system purchasing and installation costs, to pay for a full-time CCEP staff member, and to pay for data management.

The CCEP is intended to be both a scalable and a replicable project. It is the CCEP's goal to document each step in its development to enable other communities across the state, and nation, as a model for their own Community Clean Energy Projects. By compiling information about the project's successes, failures, and additional barriers, E4TheFuture will become a useful resource in increasing ease of access for new CCEPs. Additionally, the Worcester CCEP's Board of Directors will determine whether the Worcester CCEP should continue to scale up upon the completion of the anaerobic digester. If members choose to, the Worcester CCEP has the potential to include more members, construct more renewable energies, and expand through Worcester's most underserved communities.

Findings

Project Potential

The Worcester CCEP is the first of its kind. The project offers a multi-stakeholder cooperative model providing clean energy and cost savings to all types of customers, with a focus on low-income residents. By having a diverse range in project stakeholders, the CCEP positions itself to be a long-term, sustaining community venture. The Advisory Board and Board of Directors is composed of community members, with an elected Board of Directors. These boards will work to make sure stakeholder needs are voiced, while also engaging directly with public officials and energy utility companies who will be crucial in contributing added leverage to the CCEP. The utility representatives will also play an important role in ensuring that the CCEP's aims are put into action, seeing through the interconnection process while also providing a professional understanding of the electricity grid and renewable energies.

Through the project's intended implementation of rooftop solar, anaerobic digestion, battery storage, and increased energy efficiency, the CCEP is also the first known community energy initiative to incorporate multiple renewable energy types at once. As the CCEP progresses, it is evident that the primary reason no project has attempted to couple multiple energy types is due to difficulties in project financing. As E4TheFuture seeks financing for the Tyringham CCEP, and begins its search for the Worcester CCEP, the organization has encountered no energy developers willing to finance multiple types of clean energy. Instead, E4TheFuture will need to finance the anaerobic digester and rooftop solar arrays separately through two different developers. While the added complexity to project financing acts as a hurdle to the CCEP, the implementation of multiple energy types is an important pilot project. Literature on the subject asserts that the implementation of multiple energy types improves environmental resilience, with different energy types generating their peak loads in different daylight and weather conditions. By coupling multiple types of renewable energy, in addition to battery storage, electricity generation will be more consistent. Battery storage can then discharge electricity at peak energy hours when electricity prices increase, as well as creating a microgrid which can act as a shelter in the event of an emergency. Energy efficiency implementation will further the impacts of the multiple renewable energy types.

By reducing energy usage in homes, businesses, and organizations, energy efficiency allows the clean energy generated to have an even further reach. Energy efficiency will increase the impact of the renewable energy types, while further reducing utility bills for participants. Energy efficiency programs are also largely in place already, with programs through the Worcester Community Action Council and the CLEAResult MassSave program offering highly subsidized and free energy efficiency services. These services are available to both residential and commercial buildings, however, the programs are often underutilized. At little to no cost, the CCEP can aid residents in accessing these existing programs, which will lower electricity costs while increasing indoor air quality and comfort.

While the CCEP is centered on environmental sustainability and resilience, the project must also maintain long-term financial sustainability. While the added barriers in financing multiple renewable energy types poses a challenge, it is too early to say what financing opportunities will be presented to the CCEP. Much of the project's fiscal success will be determined by the amount of grant funding and financing rates that E4TheFuture will be presented with in the coming months. However, even without significant grant funding E4TheFuture believes the project to be feasible through traditional financing along with the $120,000 dollars of grant funding already awarded. If that is the case, however, the project will likely have to forego the implementation of battery storage. Differences in grant awards and financing options will primarily determine the scale at which the CCEP is built as well as the buyback time frame for the CCEP to flip ownership of the renewable energies from the developers to the Co-op. At present, E4TheFuture anticipates a 7 to 10-year buy back for rooftop solar and a 5 to 7-year buyback period upon the completion of the anaerobic digester in 5 years' time. Solar panels have an average lifespan between 25 to 30-years and approximately 20 years for anaerobic digestion. Because both systems would be paid off in comparatively short time periods compared to their lifespans, both technologies would offer over a decade of profitability which does not have to be shared with financiers but can instead be harnessed fully by CCEP members. The CCEP's Board of Directors will be able to determine how to spend the additional savings. The generated income from system ownership could potentially be used to increase co-op membership or provide increased savings to members. The Board may also decide to use the profits to construct further clean energy in the area.

As energy systems come online and the CCEP increases membership the project has potential to create community involvement in a multitude of ways. Due to its novelty, the CCEP may make for an excellent means of increasing community pride. While the city of Worcester just completed a large solar array on top of a nearby landfill, the city itself has very little in terms of visible renewable energy. By locating the CCEP in the Main South, Piedmont, and South Worcester neighborhoods, the CCEP will make these traditionally underserved neighborhoods a vanguard in the city, while providing financial assets to the community which will save community members hundreds of dollars a year. The CCEP also presents educational opportunities to residents which will increase knowledge of climate change and renewable energies while continuing to strengthen community bonds between stakeholders such as the CDCs, Clark University, and local businesses.

Barriers

At present, E4TheFuture established a working advisory board, a board of directors, and a series of community partners. E4TheFuture also compiled significant quantitative data regarding energy production and customer savings. Because the CCEP is still in its predevelopment phase, however, there remain many knowledge gaps and limitations as to how the project may operate. Perhaps the most significant limitation is lacking a complete project budget for Worcester as E4TheFuture does not yet have a precise knowledge of development costs for the Worcester CCEP. Given new changes in both State and Federal policies, E4TheFuture is working with renewable energy developers to determine new cost estimates for the projects. While financial barriers are common in almost any development project, the

CCEP's implementation of multiple renewable energies and focus on low-income residents will further complicate project funding.

Another anticipated limitation will be in member acquisition for the CCEP. While the CCEP established a goal of 2,000 residential members over a 5-year period E4TheFuture acknowledges the potential difficulty in signing on members in the Main South, South Worcester, and Piedmont neighborhoods. Through conversations with CDC directors and input from the advisory board it is evident that these communities are often the targets of frequent cold calling by private, for-profit, solar companies. Given that these neighborhoods have high rates of poverty and minority status, many community members may also work multiple jobs and may not speak English as their first language. These various barriers may pose a challenge in E4TheFuture's marketing of the CCEP. E4TheFuture's present strategy is to work through existing organizations such as the CDCs, local businesses, cultural organizations, and religious institutions to make connections with residents using trusted neighborhood organizations as an entryway into the community. The CCEP also intends to provide accessible membership materials with a variety of language translations to ensure clear messaging as trust is established with communities in the target area.

Low-income neighborhoods are known to have transient populations and are deemed less likely to pay their bills regularly. Both neighborhood traits pose a challenge to effectively run a community energy project. Month to month changes in residents and membership poses a challenge for securing membership and allocating net metering credits through Schedule Z. At present, Schedule Z allocations can only be changed every six months. If members move or opt out between six-month intervals their credits will go unused until their allocation of credits can be transferred elsewhere. Despite these potential risks, however, the CCEP believes in the importance of providing cost-savings to low-income communities that could most benefit from reduced energy burdens. The CCEP intends to operate strategically, seeking alternatives to long-term contracts or buy-in fees which are common in other community energy projects. Rather, the CCEP is weighing options to prevent barriers for low-income access. The CCEP also hopes to use its anchor tenants, such as the CDCs or Clark University, to purchase additional renewable energy from the CCEP if members leave and need to be replaced.

Conclusion

While still in its infancy, the Worcester CCEP offers great potential for a new, more equitable, community energy model. The CCEP has already and is expected to continue facing barriers throughout its implementation. Because E4TheFuture is primarily involved in public policy with expertise in renewable energies, E4TheFuture sees itself as being more able to pursue a riskier energy pilot than community organizations could achieve on their own. By creating the pilot program, E4TheFuture can pave the way for other community groups as the organization faces, and finds solutions to, the various barriers surrounding the CCEP. Low-income communities comprise a disproportionately small portion of renewable energy recipients, and often face the greatest concentration of environmental burdens and hazards. With the implementation of multiple renewable energies, free membership, and a diverse range of stakeholders, the CCEP seeks to demonstrate the financial and operational feasibility of providing underserved communities with cooperatively owned clean energy. In doing so, the CCEP will bolster Worcester's environmental resilience, preparing the city and its most vulnerable residents for the impending effects of climate change.

Due to its exploratory nature, and the infancy of the CCEP, this analysis cannot adequately demonstrate the feasibility of the project. Rather, the study demonstrates the vast potential of the CCEP and the need for increased environmental resilience to be paired with environmental justice initiatives. Pairing environmental resilience with environmental justice is exactly what the Worcester CCEP aims to accomplish. For these goals to be expounded upon and adopted in other communities the CCEP will require further analysis upon its completion. Additionally, the CCEP model as it stands now, the project is only possible in a handful of states which have implemented virtual net metering. Further policy relating to renewable energies, as well as low-income access requirements will be needed for the CCEP model to be widely adopted.

Works Cited

Adil, Ali M. & Ko, Yekang. "Socio-technical evolution of Decentralized Energy Systems: Acritical review and implications for urban planning and policy". *Renewable and Sustainable Energy Reviews*, 2016, vol. 57, issue C. 1025-1037.

American Community Survey (ACS) (2016) U.S Census.

Augustine, Paul, and Emily McGavisk. (2016) "The next Big Thing in Renewable Energy: Shared Solar." *The Electricity Journal* 29: 4. 36–42.

Bird, Stephen. (2012) "Policy Options for the Split Incentive: Increasing Energy Efficiency for Low-Income Renters." *Energy Policy*. 48: 506–514.

Bullard, Robert. (2005). "The Quest for Environmental Justice: Human Rights and the Politics of Pollution". *Sierra Club Books*.

Brulle, Robert & Pellow, David. (2006). "Environmental Justice: Human Health and Environmental Inequalities". *Annual Review Public Health*. 27:3.

Chen, Ye; Cheng, Jay; Creamer, Kurt. (2008). "Inhibition of Anaerobic Digestion Process: A Review". *Bioresource Technology*. 99, 10. 4044-4064.

Chesley, K., & Peterson, J. (1995). "New plan to revitalize main south". *Clark News*. 1.

Cluett, R; Amman, J; Ou, S. (2016). "Building Better Energy Efficiency Programs for Low Income Households". Washington, DC: *ACEEE*. Accessed at: aceee.org/research-report/a1601.

Colorado Energy Office (CEO). (2017) "Low-Income Community Solar Demonstration Project Case Study". Delta-Montrose Electric Association.

Comello, Stephen, and Stefan Reichelstein. (2016) "The U.S. Investment Tax Credit for Solar Energy: Alternatives to the Anticipated 2017 Step-Down." *Renewable and Sustainable Energy Reviews* 55. 591–602.

Denholm, Paul; Ela, Erik; Kirby, Brendan; Milligan, Michael. (2010). "The Role of Energy Storage with Renewable Electricity Generation". *National Renewable Energy Laboratory*.

Department of Public Utilities. Commonwealth of Massachusetts. October 3, 2017. "D.P.U Order 10-4-17"; DPU, 17-146.

Drehobl, A., and L. Ross. 2016. "Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities". Washington, DC: *ACEEE*. aceee.org/research report/u1602.

Downs, Timothy; Ross, Laurie; Goble, Robert; Subedi, Rajendra; Greenberg, Sara; Taylor, Octavia. (2012) "Vulnerability, Risk Perception, and Health Profile of Marginalized People Exposed to Multiple Built-Environment Stressors in Worcester, Massachusetts: A Pilot Project" *Risk Analysis*. 609-628

Edwards, G. A. S., L. Reid, and C. Hunter. (2015). "Environmental Justice, Capabilities, and the Theorization of Well-Being." *Progress in Human Geography* 40:6. 754–69.

Environmental Protection Agency (2017). "Evaluating Urban Resilience to Climate Change: A Multi-Sector Approach (Final Report)". *U.S. Environmental Protection Agency*, Washington, D.C., EPA/600/R-16/365F, 2017.

Environmental Protection Agency, AgSTAR. "How Does Anaerobic Digestion Work?". Accessed at: www.epa.gov/agstar/learn-about-biogas recovery#adwork

Executive Office of Environmental Affairs, Massachusetts. (2015) "The Environmental Justice Policy of The Executive Office Of Environmental Affairs". Accessed at: http://www.mass.gov/eea/docs/eea/ej/ej-factsheet english.pdf

Faber, Daniel in Sandler, Ronald; Pezzullo, Phaedra. (2007). "Environmental Justice and Environmentalism". *Chapter 5 A More "Productive" Environmental Justice*. MIT Press.

Farrell, John. (Jan 9th, 2017) "Beyond Sharing Report -Part 3: Exceptional Community-Owned Renewable Energy Projects". *Clean Technical*.

Sabol, Patrick (2016). "From Power to Empowerment: Plugging Low Income Communities Into the Clean Energy Economy". *Groundswell*.

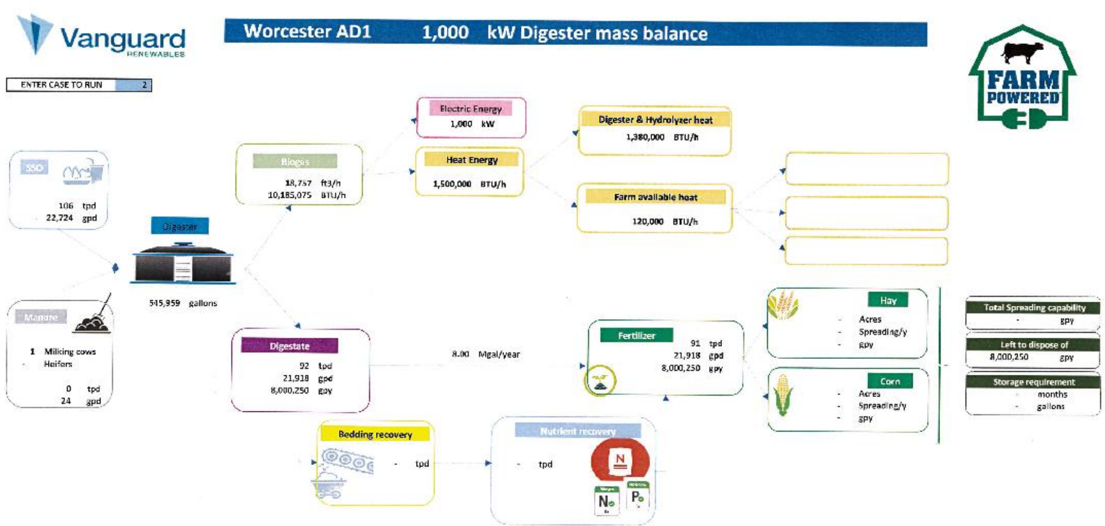
Hagerman, Shelly; Jaramillo, Paulina; & M. Granger, Morgan. (2016). "Is Rooftop Solar PV at Socket Parity without Subsidies?" *Energy Policy* 89. 84–94.

Kammen, Daniel, and Deborah A. Sunter. (2016) "City-Integrated Renewable Energy for Urban Sustainability." *Science* 352:6288. 922–28.

Lehmann, Sarah; Jordan, Philip; Nunez, Christina; Benzak, Jeff; Keefe, Bob; Carlisle, Grant. (2016). "Energy Efficiency Jobs in America". *E2 & E4TheFuture*.

McKie Jr., L. R. (1975, June 12). “Main south crime fight aid is pledged”. *Worcester Telegram and Gazette*, p. 1 & 30.
Meerow, Sara; Newell, Joshua; Stults, Melissa. (2016). “Defining Urban Resilience: A Review”. *Landscape and Urban Planning*. 147. P 38-49.
MN Community Solar. “What We Do; FAQs” Accessed at: http://mncommunitysolar.com/
Molina, Maggie; Kiker, Patrick; Nowak, Seth. (2016). “The Greatest Energy Story You Haven’t Heard: How Investing in Energy Efficiency Changed the US Power Sector and Gave Us a Tool to Tackle Climate Change”. *ACEEE*.
Moore, Trivess, John Morrissey, and Ralph Horne (2014). “Cost Efficient Low-Emission Housing: Implications for Household Cash-Flows in Melbourne.” *International Journal of Sustainable Development* 17:4. 374–86.
Nemecek T., Kägi T. (2007). “Life Cycle Inventories of Agricultural Production Systems”. *Ecoinvent Report* Version 2.0, Vol. 15 Zurich: Swiss Centre for LCI, ART.
Panwar, N. L., S. C. Kaushik, and Surendra Kothari. (2011). “Role of Renewable Energy Sources in Environmental Protection: A Review.” *Renewable and Sustainable Energy Reviews* 15:3. 1513– 24.
Renewable Waste Intelligence. (March, 2013). *Business Analysis of Anaerobic Digestion in the USA*.
Solar Energy Industries Association. (2016). “Massachusetts Solar*”.* Accessed at: http://www.seia.org/state-solar-policy/massachusetts
Smets, Peer, and Paul van Lindert. (2016). “Sustainable Housing and the Urban Poor.” *International Journal of Urban Sustainable Development* 8:1. 1–9.
Torani, Kiran Rausser, Gordon and Zilberman, David. (2016). “Innovation subsidies versus consumer subsidies: A real options analysis of solar energy”. *Energy Policy*. 92:C. 255-269.
Vanguard Renewables. “What We Do”. Accessed at: vanguardrenewables.com
Warshaw, M. (1990, December). “Mean Streets, my Streets”. *Inside Worcester*, pp. 44-48.
Wenz, Peter in Sandler, Ronald; Pezzullo, Phaedra. (2007). “Environmental Justice and Environmentalism”. Chapter 2 Does Environmentalism Promote Injustice for the Poor?. MIT Press.
White-Newsome, Jalonne Lynay. (2016). “A Policy Approach Toward Climate Justice.” *The Black Scholar* 46:3. 12–26.
Worcester's combat zone? (1974, March 21). *Worcester Telegram and Gazette*
Zipp, Kathie. (August 21, 2015). *Batteries: Which is Best for Solar Storage*. Solar Power World.

Appendix



Vanguard
RENEWABLES
Worcester AD1 1,000 kW Digester mass balance
ENTER CASE TO RUN 2
FARM POWERED
SSO
106 tpd
22,724 gpd
Manure
1 Milking cows
- Heifers
0 tpd
24 gpd
Digester
545,959 gallons
Biogas
18,757 ft3/h
10,185,075 BTU/h
Electric Energy
1,000 kW
Heat Energy
1,500,000 BTU/h
Digester & Hydrolyzer heat
1,380,000 BTU/h
Farm available heat
120,000 BTU/h
Digestate
92 tpd
21,918 gpd
8,000,250 gpy
8.00 Mgal/year
Fertilizer
91 tpd
21,918 gpd
8,000,250 gpy
Hay
- Acres
- Spreading/y
- gpy
Corn
- Acres
- Spreading/y
- gpy
Total Spreading capability
- gpy
Left to dispose of
8,000,250 gpy
Storage requirement
- months
- gallons
Bedding recovery
- tpd
Nutrient recovery
- tpd