Spring 5-2020

A Benefit-Cost Analysis of Community Solar for Low to Moderate Income Residents of Mount Desert Island, Maine

Abigayle Hargreaves
University of Maine

A BENEFIT – COST ANALYSIS OF COMMUNITY SOLAR FOR LOW TO MODERATE INCOME RESIDENTS OF MOUNT DESERT ISLAND, MAINE

by

Abigayle Hargreaves

A Thesis Submitted to Partial Fulfillment
of the Requirements for a Degree with Honors
(Ecology and Environmental Science)

The Honors College

The University of Maine

May 2020

Advisory Committee:
Sharon Klein, Associate Professor, School of Economics, Advisor
Megan Bailey, Research Associate, Margaret Chase Smith Policy Center
Jordan LaBouff, Associate Professor of Psychology & Honors
Linda Silka, Senior Fellow, Senator George J. Mitchell Center for Sustainability Solutions
Timothy Waring, Associate Professor of Social-Ecological Systems Modeling

ABSTRACT

As we continue to feel the effects of climate change there is an increasing demand for clean energy to reduce the impact that the energy sector has on greenhouse gas emissions. An organization, A Climate To Thrive (ACTT), on Mount Desert Island (MDI) in Maine has made it their mission to make MDI energy independent by 2030 and are interested in the application of a community solar farm (CSF) as a means to help their low-to-moderate income (LMI) population transition to the use of solar power and reduce their energy burden. This study explores four scenarios, in conjunction with several financing mechanisms, to determine which CSF management scenario and financing techniques would be most accommodating of LMI needs that could otherwise inhibit this group from participating in renewable energy projects. These needs largely include a lack of financial flexibility, the inability to qualify for loans or tax credits, and the need to accommodate their homeownership status, which tends to be renters. To obtain these results a benefit-cost analysis (BCA) was done that showed the system owner and subscriber NPV, ROI, and Payback Periods. These results showed that, overall, the most accommodating scenario for LMI subscribers would be a lease-to-own scenario. This option provides flexible financing for both the system owner and subscriber and has great potential to be a worthwhile investment for both parties.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

It is undeniable that climate change is a very real and very challenging issue, but the means to combat it have long been reserved only for those who can easily afford the high upfront costs and lengthy payback period of residential solutions, such as solar power, up until now. The "energy burden," or percent of income spent on energy, rests more on people of low-income than people of high-income because energy consumption per household does not tend to vary as much as household income[1]. This means that people with low incomes spend a greater percent of their income on energy than people with high incomes. The primary goal of this project is to determine whether community solar can help low-to-moderate income (LMI) residents in the Maine community of MDI overcome the monetary limitations and concerns related to purchasing solar energy, an energy option with substantial potential for decreasing long-term energy burden. LMI individuals are anyone whose annual income is 50% or less (low income) or 51-80% (moderate income) of the area median for the community they live in[2]. Community solar may be more accessible for LMI individuals, as opposed to residential solar arrays, as many LMI residents are renters without the ability to install renewable energy on their homes[1]. Some community solar options can provide access to sustainably produced solar power without the higher upfront costs of an array installed on a home that they may not own.

This study focuses on the needs of an organization called A Climate To Thrive (ACTT), a non-profit organization from Mount Desert Island (MDI), Maine that is working towards achieving energy independence by 2030[3]. ACTT is facing difficulties when it comes to accommodating LMI residents with affordable energy options as LMI residents have less flexible incomes and make up roughly 8% of the total population on MDI[4]. Community solar may be a practical option for ACTT to accommodate their LMI residents for the reasons discussed above. The research questions (RQs) this study seeks to answer include:

1. Which community solar financing options have the most potential for improving solar affordability for low-to-moderate income individuals on MDI?
2. What are the limitations of using state or federal financing programs to fund an MDI community solar farm that includes LMI individuals?
3. What financing structures and approaches to engagement have the most potential for accommodating LMI needs?

A benefit-cost analysis (BCA) of different financing mechanisms for community solar addresses RQ1 (Section 4.3). Existing literature[1,5–11] identifies twenty-three solar PV financing mechanisms (Appendix A) but ACTT is most interested in[12]: On-Bill Financing (OBF), Low Income Home Energy Assistance Program (LIHEAP)/Weatherization Assistance Program (WAP), bulk purchasing (similar to Solarize), capital refinancing, and loans (Section 2.4). To answer RQ2, the BCA includes incentives, constraints, and other input parameters associated with different state and federal finance programs that could affect community solar for MDI's LMI residents. Finally, to address RQ3, I will be conducting a literature review of efforts to include LMI residents in different types of community solar projects. This review will help to better explain and target the LMI needs that can impact individual's ability to adopt solar technology and better understand ways in which LMI individuals have participated in

CSFs in the past. LMI needs typically include a lack of financial flexibility, the inability to qualify for loans or tax credits, and the need to accommodate their homeownership status with offsite methods of solar involvement[1,13]. I will then make recommendations based off this literature review and benefit-cost analysis for ways in which LMI-serving strategies and financing mechanisms can work in tandem to attain ACTT's goal of meeting the clean energy needs of their LMI residents.

2. BACKGROUND

This chapter contains a general overview of all the information relevant to this project including: the background of A Climate to Thrive, community solar farms, approaches to engage LMI individuals, financing mechanisms for community solar, and a review of other cost-benefit analyses for community solar. A wide range of background information is necessary to understand the importance of this project as it is seemingly the first of its kind and it is heavily specified in regard to the needs of A Climate to Thrive and their LMI community in conjunction with the currently available models of community solar.

2.1 - A Climate to Thrive (ACTT)

ACTT is a non-profit organization of MDI citizens concerned about climate change[3]. Formally launched in January 2016, ACTT strives to make MDI a leader in energy efficiency and sustainability through citizen engagement with the goal of becoming energy independent by 2030. To achieve their goals they set up six initial volunteer committees: Alternative Energy, Zero Waste, Building Efficiency, Transportation, Food Systems, and Public Policy[14]. They believe that their efforts towards energy independence and sustainability will improve the quality of their communities, economies, environment, and health[3]. To date, ACTT has implemented two community solar farms (CSFs) on the island, helped local organizations acquire Power Purchase Agreements (PPAs) to power local schools and town buildings with power from their solar PV efforts, and continues to encourage the education and involvement of their citizens through hosting events which offer free LED lightbulbs, home energy audits, and other ways to live more sustainably[3]. Since 2016 they have doubled the energy capacity of MDI by installing 76 solar projects on people's homes, businesses, and in their communities creating an additional 643kW of solar power[14].

I have been in communication with Gary Friedmann, a member of the Board of Directors for ACTT, to discuss how to best tailor this study to their needs. ACTT is interested in having their third CSF project focus on the involvement of LMI individuals because they make up about 8% of the total population on the island[4] and tend to be underserved by most of the other programs that ACTT has initiated to transition the island to clean energy. However, new legislation from January 2019 (LD 1711) requires that all new CSFs in Maine must give at least 10% of their energy generation to LMI individuals[13,15]. Studies show that it is common for LMI individuals to be underserved by community energy efforts due to their inflexible household budgets, homeownership status, and financial background[1,9]. In fact, there is a nationwide effort called the National Community Solar Partnership (NCSP) whose main goal is to make CSFs more accessible to LMI individuals[16]. Theoretically, CFSs allow residents to participate in solar energy adoption with less risk, compared to other options such as residential solar Photovoltaic (PV), where the individual is responsible for the full upfront cost of the solar array or the long-term loan that covers that cost. However, in practice, it has been difficult to tailor CSF programs to attract LMI involvement for several reasons like a lack of financial flexibility, LMI tendency to default on electric bills, and a lack of subsidies, state, or federal programs willing to cushion the costs of solar power[9,13]. In the case of a CSF, LMI individuals are only responsible for the panels they purchase (or rent), they don't have to own a home to participate, and the payback period is much shorter for CSFs, especially since the cost paid by LMI individuals may be subsidized by other panel owners[1]. Some CSF financing mechanisms don't require participants to pay anything upfront for their share of the solar array such as grant programs, loans, leasing models, and on-bill financing[1,5].

2.2 - Community Solar Farms (CSFs)

CSFs are solar photovoltaic (PV) arrays that are larger than residential arrays, often utility-scale, and are owned or rented by multiple people who do not necessarily own the property upon which the array sits; these people share some or all of the costs and benefits of the array[17]. Community solar first came about in Colorado in 2011 and became popular in 2017 when the threat of increasing taxes was limiting the growth of the solar industry[18]. Since 2016 community solar capacity has more than quadrupled from 300MW to 1,387 MW today[19]. Currently, 40 states have at least one active community solar project, 12 of these states, and Washington D.C., have developed or are developing programs that help make solar more accessible to LMI individuals[19]. Of the 40 states with community solar projects, Minnesota has the most installed community solar to date with 500 MW of installed capacity but the majority of that capacity is used by commercial clients, not residential[9,18]. Massachusetts follows with over 250 MW of installed capacity with a greater emphasis on residential use[9].

Typically, a CSF is purchased by a utility or third-party who then sells or rents portions of the generation or panels in the array itself to multiple subscribers. The utility then credits subscribers for this energy on their electric bill, though there is no standardized approach to the utilization of CSFs, meaning that each one can be managed or structured differently[20]. One of the ways that this energy sharing happens is through virtual and community net metering. Virtual net metering (VNM) is a bill crediting system for community solar that allows individuals to receive credits on their electric bill for excess energy production from an individual's share of an off-site solar project, like a CSF[1,21]. VNM is important to CSF implementation as it provides direct savings to the people that participate in an array, which can be a strong motivator for some people to participate in CSFs. Currently, 41 states have net metering programs for rooftop solar projects (where the property owner can receive credit for excess generation) while only 14 states and Washington D.C. offer VNM for off-site solar projects[1,21].

While Maine does offer virtual net metering, utilities are not allowed to own generation and per older legislation, replaced by LD 1711, all people benefitting from the generation of a CSF must have an "ownership interest" in the project, making it so that people were unable to rent panels in an array and instead had to buy them outright like a residential solar array[21,22]. Under this past legislation, CSFs in Maine were limited to 10 electric meters; 9 individual people and one meter for the array itself, limiting the maximum size of solar arrays to 50 kW or less. This law, however, was recently replaced in July 2019 by LD 1711 which allows those involved in CSFs to simply have a "financial interest" as opposed to just an "ownership interest" meaning that participants can lease panels from an array or pay off their panels over a longer period of time. LD 1711 also increases the maximum system size to 5 megawatts (MW), and includes a section mandating that all new CSFs in Maine must give at least 10% of their energy generation to LMI individuals[13,15]. Most community solar programs across the nation see a mix of local commercial and residential energy users with the larger arrays having more commercial customers, however, this is not true in Maine where the majority of CSFs are built for and by residential consumers[23]. A National Renewable Energy Laboratory (NREL) and Department of Energy (DOE) report estimates that nearly 50% of consumers and businesses are unable to host PV systems on their own buildings due to a number of factors, including the quality or position of their roof, whether or not they rent the property, and the high up-front costs of a single-owner, rooftop systems, which tend to be more costly on a per-watt basis than commercial and industrial scale systems[24].

ACTT is interested in CSFs as a way to get LMI residents involved in community energy because it minimizes the upfront costs of solar participation and people can participate regardless of the type of home that they live in[25]. Additionally, there are a number of programs that exist to help LMI individuals partake in renewable energy by way of CSFs like the National Community Solar Partnership (NCSP) and the Solar In Your Community Challenge (SIYCC). NCSP provides stakeholders with the tools and information that they need to implement community solar models in order to reach their partnership goal of expanding “access to affordable community solar to every American household by 2025”[16]. SIYCC is different from NCSP in that it is a $5 million prize competition designed to incentivize and expand solar adoption across the country[26]. Prizes are awarded to groups who focus on the needs of underserved citizens in their areas that have widely replicable and adoptable business models that expand solar access to underserved groups[26].

2.3 - Community Solar Financing Mechanisms

Table 1 shows a list of financing mechanisms that could potentially be used for a community solar farm (CSF) project and that are of particular interest to ACTT[12] (a full list of financing mechanisms can be found in Appendix A). In order of interest to ACTT these financing mechanisms are: On-Bill Financing, LIHEAP/WAP, Bulk Purchasing, Loans, and Capital Refinancing[12]. These mechanisms come from a variety of sources that discuss how to finance different types of solar projects like, CSFs and residential solar[1,5–11,20,23]. Some of the mechanisms may be geared toward LMI individuals (Bond and Grant Programs, LIHEAP/WAP, Direct Cash Incentives, etc.) due to low-income requirements for program qualification but may not necessarily be ideal for financing a CSF. The most prominent sources of information on these financing mechanisms were *Unlocking Solar for Low- and Moderate-Income Residents: A Matrix of Financing Options by Resident, Provider, and Housing Type*[1] and DSIRE[5], a database of state incentives for renewables created by the NC Clean Energy Technology Center and funded by the DOE. The first resource provides an overview and comparison of financing options geared toward LMI that are available nationwide to support PV adoption, not just CSFs[1]. The DSIRE database is a much broader resource that includes information on all (or nearly all) local, state, and federal policies and programs that support renewable energy and energy efficiency advancement. DSIRE helped me to better examine a broad range of incentives and policies (not just geared toward LMI) that are available to finance solar PV installations across the country.

Table 1: Community Solar Financing Mechanisms in order of interest to ACTT (see Appendix A for additional mechanisms not included in the ACTT study).

Name of Financing Mechanism	Description	Used in Maine?	Citations
On Bill Financing	Funding structure where a third party pays the upfront costs of a PV system and the residents pay for the investment through monthly electric bills	No	1 p. 5, 10 p. 11, 11
LIHEAP/WAP	Low income home energy assistance program/weatherization assistance program; DOE programs that allow states to use the program money to install cost-effective PV	Yes (but not for solar - used for weatherization)	1 p. 4
Bulk Purchasing	Allows multiple people to purchase systems together at a lower cost (not typically directed to LMI)	Yes (Solarize)	1 p.3, 6
Loans	Granted by public or private financial institutions, often under-subsidized terms, used to deploy PV; potentially may be combined with Loan Loss Reserve for people with low credit scores	Not for CSFs	1 p. 4, 23
Capital Refinancing	"A building owner negotiates a new mortgage rate and term to generate additional capital for building improvements including PV"[1] not used widespread for PV	Yes (not being used for PV though)	1 p. 3

On-Bill Financing is regarded by organizations like the Smart Electric Power Alliance as an effective option for financing LMI community solar projects as it does not require the participants to pay any upfront costs[10]. On-Bill Financing is particularly ideal for LMI residents as the panel ownership that is being paid back is typically tied to the home, not the resident, a more manageable situation for renters than traditional residential PV and CSF approaches[27]. This mechanism also tends to be cheaper and less risky for financial institutions as there is already a billing system in place (the electrical bill) and the payment is more reliable as utility bills have better repayment rates than other bills[27].

The Low Income Energy Assistance Program (LIHEAP) and Weatherization Assistance Program (WAP) are DOE programs that help LMI families to “cover their energy costs and keep their utilities running”[28] by providing direct monetary aid for energy bills or weatherization assistance to minimize the need for additional heating or cooling[27,28]. Recently, however, there have been interests and efforts to use money from these programs to install solar PV on LMI homes and in LMI neighborhoods as a means to allow states to use program money to install cost-effective PV for residents who fall below 150 percent of the poverty level[1,7,29]. LIHEAP/WAP have never been used to fund a community solar PV project (as of January 16, 2019) due to limitations in funding, but they have been used to install smaller solar projects on single-family, LMI homes in both California and Colorado[1,13,26,27]. The first of these programs was in California in 2010, as a pilot program where the state used $14.7 million from LIHEAP to install solar PV systems on 1,482 low-income resident's homes; this pilot program ended in 2012[30]. In Colorado, the DOE recently approved the use of WAP to work with other state incentives to "comprehensively address the energy burden through weatherization and solar for 300 low-income households by 2019"[30]. In order for LIHEAP to be used for any kind of solar PV project, state LIHEAP administrators must include solar PV projects as a measure in their state energy plans[27]. The WAP is available to be used for renewable energy, including solar PV, but those eligible for WAP services must first fill out a set of forms and send it to the housing authority for their state (MaineHousing) for approval before any further steps can be taken[27,31,32].

Bulk Purchasing is not typically directed at LMI individuals because of the high upfront costs involved for the subscriber[1]. Bulk purchasing is most often used in Solarize campaigns where many people within an area buy solar PV systems for their own homes and receive discounted rates on the installed cost of those systems through the program[1]. Although, according to Fortunat Mueller from ReVison Energy, bulk purchasing is essentially what CSFs of upwards of 1,000 people work out to be. In these cases, the price of the panels and the hardware for the system are equitably distributed amongst all the customers and since such a large quantity of materials is being purchased at once, these distributed costs are lower[13]. The discounts of bulk purchasing are usually due to a competitive request for proposal process or some other process that enables a group of people to select one or multiple installers willing to give tiered pricing based on increasing number of installations[1].

Loans have become newly available in the field of CSFs but they can be an issue for LMI citizens who often have lower credit scores than higher income citizens and are unable to qualify for most independent loans. However, there is an effort underway to make solar loans more accessible to LMI individuals, largely through programs like loan loss reserve (LLR), which makes it easier for low-credit score individuals to get loans for solar because the loaner is offered protection for the provision of the loan, and the use of state or private entities that are willing to help lower rates for LMI loanees[9,13,20]. There are five energy loan programs available in the state of Maine (see **Table 2**) but only one that could be used for an LMI-specific solar PV installation, due largely to restriction on building or beneficiary type[5]. The U.S. Department of Energy Loan Guarantee Program, which "is intended to encourage early commercial use of new or significantly improved technologies in energy projects"[5] would potentially be applicable to this new CSF if ACTT were act as the system owner or developer due to their nonprofit status. However, the direct impact of loans was not included in this model as applicable loans are limited in Maine and the ability to qualify for and utilize loans can be variable. Though, I did use loan rates from the property assessed clean energy (PACE) financing and Greensky as sample inputs for my subscriber Solar Project Financing Options. Greensky already offers loans that can be used for CSF participation and PACE loans could be used if the CSF is in Tremont (a PACE eligible town) and Maine legislation is updated to allow PACE loans to be used for CSF participation.

Table 2: Loans available in the State of Maine with the potential to be used for solar power.

Name of Loan Program	Income Level	Building Type	Used on Community Solar	Maine Resident Eligible	Maximum Loan	State Used in	Comments
Efficiency Maine	Any	Residential	No	Yes	$15,000	ME	
Qualified Energy Conservation Bonds (QECBs)	N/A	Government	No	No	N/A	U.S.	Discontinued (Tax Cuts and Jobs Act of 2017)
USDA - Rural Energy for America Program (REAP) Loan Guarantees	Low to moderate	Commercial, Agricultural	Possibly	Yes	$25 Million	U.S.	
Clean Renewable Energy Bonds (CREBs)	N/A	Government, Schools	No	No	Variable	U.S.	Discontinued (Tax Cuts and Jobs Act of 2017)
U.S. Department of Energy - Loan Guarantee Program	N/A	Commercial, Industrial, Local Government, Nonprofit, Schools, State Government, Agricultural, Institutional	Possibly	Yes (as non-profit)	Variable	U.S.	
FHA PowerSaver Loan Program	Low income	Residential, Low Income Residential	No	Yes	Variable	U.S.	
Energy-Efficient Mortgages	Any	Residential	No	Yes	$8,000	U.S.	

Capital refinancing, where "a building owner negotiates a new mortgage rate and term to generate additional capital for building" (3), is not typically used for solar PV projects as it tends to be used with large, multifamily housing that is undergoing new mortgage rate negotiations to free up capital for property improvements[1]. However, there is anecdotal evidence of it being used to deploy solar PV by way of using the additional income from the new mortgage to install PV to increase property value, which is of less concern to ACTT than obtaining an affordable CSF would be[1].

I was unable to truly model any of these financing mechanisms; the only exception would be bulk purchasing which I "modeled" by way of using a lower cost per watt for the total array to simulate a wholesale cost because of the size of the array. Otherwise, I was only able to include loans and on-bill financing by discussing (Section 4.4) how they may interact with different CSF management scenarios. Similarly, in my discussion (Section 4.4) I included the changes that would be necessary for LIHEAP/WAP to be used for a CSF and how funding from those programs could be used by subscribers. Finally, I was unable to model capital refinancing as it could only be used in a re-mortgaging of a building or an area of land and would not be applicable to ACTT's CSF.

2.4 - Approaches to Engage LMI

When planning a CSF for the benefit of LMI consumers, it is not enough to only consider financing mechanisms because LMI people are people first and don't always feel as if they have the financial freedom or flexibility to get involved with renewable energy, regardless of how it is financed[13]. Therefore, it's important to tailor financing mechanisms to their specific needs and to structure CSFs in such a way that it is easy for

LMI individuals to benefit, and understand how they are benefitting from, their involvement in a CSF. LMI individuals are anyone whose annual income is 50% or less (low income) or 51-80% (moderate income) of the area median for the community they live in[2]. It is important to engage LMI customers because they make up close to one third of households nationally and account for at least 20% of residential energy use in the U.S[33]. It is essential to engage LMI households in clean energy efforts if we want to see a complete transition away from fossil fuels to clean energy[33]. There have been issues with gaining LMI participation in CSFs as LMI consumers typically face a variety of barriers such as an inability to afford upfront costs or qualify for loans as is necessary for most solar projects. Even a hesitancy to participate in new programs because of the fear of scams or a lack of trust for the people heading said programs can discourage LMI participation[20,34]. Additionally, LMI individuals may not be in a position to think or care much about where their energy comes from due to the overriding necessity of meeting other basic needs. Because of this, many organizations will direct their program models at LMI citizens by subsidizing LMI participation, leveraging external funding, or creatively structuring the offer to maximize its benefits (Section 2.3) to make it more worthwhile for LMI individuals to get involved in clean energy programs[23].

The means to engage LMI consumers has been discussed by many organizations including the National Renewable Energy Laboratory (NREL), Clean Energy States Alliance (CESA), and the Rocky Mountain Institute. All these organizations encourage the same approach to engaging LMI consumers in solar projects. For example, The Sustainable Solar Education Project, run by the CESA and the U.S. Department of Energy created “A Guide for States and Municipalities” titled *Bringing the Benefits of*

Solar Energy to Low-Income Consumers[7]. This guide suggests basic principles for developing a successful low-income solar program; the program must be tailored toward low-income consumers, accommodating of their financial needs and housing situation, as well as being cost-effective and financially sustainable, and flexible enough to adapt to changing conditions and new learning[7].

An effective approach to gaining LMI participation would require the CSF subscription price to be at or below the prevailing cost of electricity[23]. This can be achieved through subsidized LMI participation or leveraging external funding to bring down the price that LMI individuals have to pay[23]. Other strategies that can help to increase LMI participation tend to involve establishing relationships with LMI community groups and/or government agencies that are designed to work with and serve the LMI community. Developing partnerships with these groups can help identify, recruit, and retain LMI customers in CSFs[35]. Additionally, there are two federal programs that aim to help increase LMI accessibility to solar power, NCSP and SIYCC (Section 2.2). Both of these programs aim to increase accessibility to solar power for LMI individuals, they also utilize the aspect of community involvement to encourage and increase LMI participation through involvement with organizations that already have a relationship with their local underserved communities[16,26]. I will do a more thorough literature on this subject in Section 4.2 as part of my results section to thoroughly summarize pre-existing methods to increase LMI engagement in CSFs and how ACTT can utilize those methods to better accommodate LMI need

2.5 - Existing Community Solar Cost-Benefit Analyses

There are very few studies or models that have tried to do a cost benefit analysis of community solar, especially with consideration of LMI needs and accommodation in CSF planning. One of these is a model called the Community Solar Business Case Tool[36], a "flexible financial model that projects the costs and benefits to the system developer and subscriber of a single community solar project"[36]. This model has outputs of costs, revenues, net benefits, and net present value after 25 years as well as the internal rate of return (IRR), modified internal rate of return (MIRR), return on investment (ROI), and payback period for both the system owner and subscriber. This model is a good basis for my research as ACTT is interested in of all these outputs. There is also a model from *Community Solar for the South East Implementation Guide* by the North Carolina Clean Energy Technology Center (NCCETC) that is similar to the Community Solar Business case tool that I will be using for my BCA[37]. NCCETC's model doesn't calculate MIRR or 25-year costs or revenues like the Community Solar Business Case tool but it does include both a sensitivity analysis and a section to reflect LMI subscriber's points of view of their investments in a CSF[37].

An example of a written paper that actually includes a BCA for community solar is *Financial and Social Implications of Community Solar in New England*, a Master's thesis by Stephanie Coffey from the University of Vermont[38]. This study compares the costs and benefits of a variety of solar typologies in Maine, Massachusetts, and Vermont to determine which typologies are cost competitive with retail electricity pricing and how state incentives may influence these costs[38]. This analysis is done by using net present value (NPV) and payback period to assess 553 community solar installations with the consideration of three different incentive scenarios: “1) no federal or state solar incentives; 2) currently available solar incentives; and 3) the reinstatement of recently lapsed incentives”(p. 80)[38]. This study ultimately concluded that the value of solar in each state, Maine, Vermont, and Massachusetts, is variable based off of the availability of solar incentives and the installed cost of solar, however, solar farms are still the most profitable type of solar project in all three states studied with net present values (NPVs) of $3.81per watt in Massachusetts, $1.13 per watt in Vermont, and $0.73 per watt in Maine with all applicable 2016 incentives. Coffey concluded that solar farms prove to be a valuable route for community solar development[38].

Another example of a BCA being used for a CSF is *Feasibility Study for Economic Viability of a Makah Community Solar Farm* by Eian S. Ray from Marylhurst University concerning a CSF on a Native American Reservation in Washington State. This author used four BCAs to determine whether or not it would be more cost-advantageous to delay construction of a CSF to a future date when solar technology would be cheaper[39]. The BCAs used considered the highest possible cost of $3.90 per watt of installed capacity and assumed the potential benefits to include electricity savings over the lifetime of the system and the value of employment when using locals to operate and maintain the facility[39]. Ultimately this study concluded that at the time this paper was written, it would not be cost-advantageous to build a CSF on the Makah reservation due to the lack of solar radiation at their particular latitude and the low cost of grid-derived electricity in Washington State[39].

Lastly, is in a small section of a report called *Community Solar Initiatives Opportunities for Brownfield – Community Solar Initiatives in the Commonwealth* written by a group from Boston University. This is a relatively ineffective BCA that only considers a very small portion of the actual costs and benefits of community solar. The report uses only a few numerical outputs, being limited to a simple list of benefits such as the ease of access to renters and the "obvious" environmental benefits with costs being listed as dependent upon contractor and location[40]. However, the document *Community Solar Power Obstacles and Opportunities* by John Farrell from the New Rules Project did something similar to a BCA by letter grading (A-F) nine community solar projects on their abilities to; overcome financial and institutional barriers to collectively-owned solar, increase the amount of people who can participate in decentralized solar power, offer affordable solar, disperse the economic benefits of solar power development, utilize unused urban space with close proximity to pre-existing grid connections, and be replicable[17]. Overall, this paper discusses a number of the costs involved with the development of community solar and lists some ways to potentially reduce those costs through the use of their *Community Solar Project Scorecard* (35)[17]. They found that only three of the nine community solar projects they evaluated came close to meeting the goals they set for community solar, and only one of these three projects seemed easy to replicate[17]. Otherwise, there were very few published cost benefit analyses of community solar that I could find.

There were some other notable documents that discussed aspects of my project but did not include a BCA. The U.S. Office of Energy Efficiency and Renewable Energy did an analysis in 2016 that highlights the opportunity presented by community solar to include LMI individuals in renewable energy projects, specifically mentioning the Solar in Your Community Challenge (Section 4.2) as a means to help increase LMI participation and ease of access to community solar[41]. The paper *A Probabilistic Portfolio-Based Model for Financial Valuation of Community Solar* by Shakouri, Lee, and Kim discusses a model that incorporates physical, environmental, and financial uncertainties in community solar projects to create a set of optimized portfolios, a maximum, minimum, and baseline[42]. They then use a Monte Carlo simulation to calculate the ROI and payback period of each scenario, both of which I will be using as outputs for my BCA[42]. They found that the portfolio with the maximum output had the highest ROI and shortest payback period and the portfolio with the minimum risk had the lowest ROI and longest payback period[42]. Finally, *Lazard's Levelized Cost of Energy Analysis* shows LCOEs for a variety of renewable energy technologies, five types of solar PV including community solar, and their sensitivities to U.S. federal tax subsidies and fuel prices[43]. Community solar was found to have a LCOE of $64-148 (unsubsidized) and $61-142 (subsidized), compared to rooftop residential solar PV with an LCOE of $151-242 (unsubsidized) and $139-222 (subsidized)[43].

There are many examples however of cost benefit analyses being done on other types of solar PV like the Maine Public Utilities Commission (PUC) Valuation Study (2015) which is a state-sanctioned solar economic and social cost-benefit analysis conducted by the Office of the Public Advocate and PUC[44]. This is not a cost-benefit analysis of community solar but of all solar energy and was designed to determine the value of distributed solar energy generation, evaluate implementation options, and create a report for the legislature[44]. This study found that the distributed value of solar was $0.182 per kWh in the first year and $0.337 per kWh for the 25 year levelized distributed value[44]. Additionally, 23 other states have publicly available BCAs on various aspects of solar PV such as distributed generation and the value of solar[45]. There are also no real cost benefit analyses of any type of solar for LMI individuals as that is still a relatively new sector.

2.6 - Additional Information

There have been several other programs that focus on community solar to increase local transitions from fossil fuels to renewable energy. A good example of this is in Victoria, Australia where the government started the Renewable Communities Program (RCP) to provide grant funding that supports community-led renewable energy projects, including several solar arrays and farms[46]. Other projects include Co-op Power in the Northeast that works with low-income neighborhoods and households to develop sustainable community solar projects[33] and the Colorado Community Solar Gardens Act which makes investor-owned electric utilities build community solar projects across the state, requiring at least five percent of the project subscribers to be LMI[7]. Additionally, there was a study done in May 2017 as a capstone project by seniors at Columbia University as a literature review and analysis of barriers of access to solar energy for low-income households[34].

3. METHODS

My methodology primarily consists of a cost-benefit analysis, using the Community Solar Business Case Tool, designed to produce results that aid organizations like ACTT in the development of CSFs by better understanding the benefits of several ownership scenarios, how those scenarios interact with different financing mechanisms, and what combinations thereof are most accommodating of LMI needs. The scenarios that I will be comparing using this model are; panel purchasing true ownership, panel purchasing with developer, panel leasing, and lease-to-own. The results that I will be comparing include net present value (NPV), modified internal rate of return (MIRR), and return on investment (ROI). The analysis of these results will be followed by a targeted literature review of LMI engagement approaches and CSF financing recommendations.

3.1 – Community Solar Business Case Tool

The Community Solar Business Case Tool was created by Emily McGavisk of West Monroe Partners and Vito Greco of Elevate Energy as part of the Cook County (Illinois) Community Solar Project, using a grant from the Solar Market Pathways Program through the DOE[36]. This tool was created in order to consider "community solar initiatives from the perspective of a subscriber or system owner"[36] and projects the costs and benefits to the system developer and subscriber of a community solar project in a flexible financial model[36]. This model already includes inputs that reflect industry averages, though I will be adjusting them to more accurately reflect the conditions on MDI and ACTT's plans for this CSF. Most of the data inputs that were specific to ACTT's plans were obtained via emails from Gary Friedmann, a member of ACTT's Board of Directors.

Though this model is thorough and quite comprehensive in its inclusion of many factors that could potentially impact a CSF I ultimately had to modify the model to accommodate alternative management scenarios. The Community Solar Business Case Tool has two primary management scenarios, panel purchasing and panel leasing, in this case, the pre-set panel leasing became my panel leasing scenario and the pre-set panel purchasing became my panel purchasing with developer scenario. The four management scenarios that I compared using this model were: panel purchasing true ownership, panel purchasing with developer, panel leasing, and lease-to-own. These scenarios were selected because panel purchasing true ownership, panel purchasing with developer, and lease-to-own all meet ACTT's ultimate goal of LMI individuals fully owning their share of a CSF while offering a comparison of how these different scenarios can accommodate LMI needs. I chose to use management scenarios in my modeling because the financing mechanisms that ACTT were interested in were dependent upon how the CSF was managed. For example, loans cannot be used in a lease-based management scenario because there is no upfront cost to cover and a loan would just cause the subscriber to incur an interest rate on top of covering the monthly lease price. Table 3 explains the structure of these four scenarios and how they affect the relevant financing mechanisms that ACTT is interested in, namely, loans as well as the modified accelerated cost recovery system (MACRs) and the investment tax credit (ITC), two potentially relevant federal programs that can reduce the cost of the CSF. All of these scenarios include the ITC as it provided a significant discount on the total cost of the system which can be reflected in the price that subscribers pay for their share of the array, it is not applicable if a non-profit covers the initial cost of the array, and has been successfully used on a CSF in the case of a man from Vermont. MACRs is a cost recovery system that is only applicable in the case of the CSF having one primary owner, any of the scenarios in **Table 3** other than panel purchasing true ownership. Finally, none of these management scenarios would be able to utilize the Federal Loan Guarantee Program, unless ACTT were to own the CSF initially as this Loan Program is only available to non-profits.

Table 3: Explanation of modeled financing scenarios

Scenario	Definition	Percent of Upfront Cost Financed by Subscriber	PACE loans or other individual loan	Federal Loan Guarantee	ITC	MACRs
Panel Purchasing (True Ownership)	Each person pays their share of upfront costs at the beginning and truly own their portion of the panels	50%	Y (subscriber)	N	Y (via permissions given in Vermont)	N
Panel Purchasing (with developer)	One entity or group of entities (the "developer") purchases the solar array and sells shares to subscribers who pay a large upfront cost to own their portion of the array.	50%	Y (subscriber)	N	Y	Y
Panel Leasing with On-Bill Financing	One entity (a company, group of companies, a person, or people) purchases the solar array upfront and the subscriber gets net metering credits on their electricity bill from their usual utility and pays the developer over time for the cost of electricity coming from the panels at a lower price than what they would otherwise pay to a utility.	0%	N	N	Y	Y
Panel Leasing to Own with On-Bill Financing	One entity (a company, group of companies, a person, or people) purchases the solar array upfront and the subscriber gets net metering credits on their electricity bill from their usual utility and pays the developer over time for the cost of electricity coming from the panels at a lower price than what they would be paying to the utility, plus a little more, so after a specified time they actually own the panels and don't have to continue paying the developer.	0%	N	N	Y	Y

3.2 – Model Inputs

Table 4 is an abbreviated list of inputs collected to populate the model with data that reflects the wants and needs of ACTT. These inputs included minimum, maximum, and default values but has been reduced to only include relevant inputs for the equations listed following the table and the basic, default values that were used to calculate subscriber and system owner NPV, MIRR, and ROI. A full table of inputs for the Community Solar Business Case Tool can be found in Appendix B. Minimum, maximum, and default values were used for each scenario to provide a range of outputs that reflect potential outcomes across the four scenarios modeled to account for the reasonable extremes of variable project funding, costs, and subscriber versus system owner participation in panel ownership and financing. These inputs were gathered from a variety of sources (cited in the full inputs table in Appendix B), and many came from Gary Friedmann of ACTT to help further specialize the scenario results to ACTT's LMI concerns and structural preferences. Other inputs were borrowed from the Community Solar Business Case Tool due to the difficulty of finding or generating certain inputs for a CSF, such as the labor hours, price escalators, and discount rates. I then varied these values by 20% in either direction or used the alternative values recommended in the model to find my minimum and maximum input values. In some cases, the maximum values were lower than the minimum values as "maximum" just represents the higher cost, most difficult to manage scenario while the "minimum represents the lower cost, easiest to manage scenario. The model also helped me to find Maine and MDI-specific inputs by recommending resources like the PV Watts tool and several CSF documents from NREL as well as the EIA documents that provided me with the Applicable

Subscriber Credit Rate data[47,48]. Other inputs were extrapolated from programs that exist to serve the LMI community that are available in other states, or through federal programs, but are not yet available or readily accessible in the State of Maine. This strategy was used to generate the Solar Project Financing Options for the subscriber based off of PACE loans, which are not currently available in Manset or Bar Harbor, two of the towns that ACTT is interested in installing this CSF but are available in Tremont, their other CSF option. PACE loans are similar to loan programs that are available and are in process of becoming available through other organizations like Greensky and Mosaic that work with individuals in Maine through ReVision Energy to use for CSF participation[49–52].

Table 4 (pg. 28-30): List of default value data inputs and key calculated parameters, a comprehensive list of inputs and their sources can be found in Appendix B.

Symbol	Name	Value	Units
$\mathbf{ACF_t}$	Annual Cash Flow by Year (Year 1)	Calculated	$/y
$\mathbf{B_{25YNetDev}}$	25 Year Net Benefits, Developer	Calculated	$
$\mathbf{B_{25YNetSub}}$	25 Year Net Benefits, Subscriber	Calculated	$
$\mathbf{C_{25YDev}}$	25 Year Costs, Developer	Calculated	$
$\mathbf{C_{25YSub}}$	25 Y Costs, Subscriber	Calculated	$
$\mathbf{C_{DevNetUpfront}}$	Developer Net Upfront Costs (one-time in Year 0)	Calculated	$
$\mathbf{C_{EquipLabor}}$	Cost of Equipment and Labor (one-time in Year 0)	Calculated	$
$\mathbf{Cf_{Dev}}$	Annual Cash Flow, Developer	Calculated	$/y
$\mathbf{C_{FinancingDev}}$	Total Annual Financing Costs, Developer	Calculated	$/y
$\mathbf{C_{FinancingDevLifetime}}$	Total Financing Costs, Developer Over Project Lifetime	Calculated	$
$\mathbf{C_{FinancingSub}}$	Total Annual Financing Costs, Subscriber	Calculated	$/y
$\mathbf{C_{FinancingSubLifetime}}$	Total Financing Costs, Subscriber, Over Project Lifetime	Calculated	$
$\mathbf{Cf_{Sub}}$	Annual Cash Flow, Subscriber	Calculated	$/y
$\mathbf{C_{GrossSysCapital}}$	Total Annual System Gross Capital Costs	Calculated	$/y
$\mathbf{C_{GrossSysCapital\ Lifetime}}$	Total System Gross Capital Costs Over Project Lifetime	Calculated	$
$\mathbf{C_{Land}}$	Annual Cost of Land, Upfront and/or Lease	Calculated	$/y
$\mathbf{C_{OM}}$	Annual Operations and Maintenance Costs	Calculated	$/y
$\mathbf{C_{OMAnnual}}$	Annual System Unit Operations and Maintenance Costs	14	$/kW/year

Symbol	Name	Value	Units
$C_{OMBilling\ Software}$	Ongoing Annual Billing Software Licensing Costs	0	$/y
$C_{OngoingTotalt}$	Total Annual Ongoing Costs	Calculated	$/y
$C_{OngoingTransBilling}$	Ongoing Annual Transactional and Billing Costs	Calculated	$/y
$C_{Operating}$	Total Annual Operating Costs	Calculated	$/y
$C_{OperatingLifetime}$	Total Operating Costs Over Project Lifetime	Calculated	$
$C_{PanelLease}$	Monthly Panel Lease Price (for panel lease management scenarios only_	5.34	$/mo
$C_{PanelPurchasing}$	Panel Purchase Price (for panel purchase management scenarios only)	709.65	$/panel
$C_{PVModule}$	Total Cost of PV Modules and Installation	2.02	$/Watt
C_{site}	Purchase Cost of Site (one-time cost in Year 0)	0	$
$C_{SiteLease}$	Annual Lease Payments for Site	0	$/y
$C_{SitePrep}$	Site/Land Preparation Costs	0.143	$
$C_{SubNetUpfront}$	Subscriber Net Upfront Costs (one-time in Year 0)	Calculated	$
$C_{SysRemoval}$	System Removal Costs (one-time cost in last year of cash flow)	0	$
$C_{UpfrontAdmin}$	Upfront Administrative and Billing Costs in Year 0	Calculated	$
i_{DEV}	Loan interest rate developer	6	%
i_{SUB}	Loan interest rate subscriber	7	%
$inc_{CapacityPayment}$	State/Local Capacity Incentive	0	$
$inc_{GenerationPayment}$	State/Local Generation Incentives	0	$
$ITC_{CashEquivalent}$	Cash Equivalent Value of the ITC (one-time payment in Year 0)	Calculated	$
$Loan_{Dev}$	Loan Amount, Developer (one-time cost in Year 0)	Calculated	$
$Loan_{Sub}$	Loan Amount, Subscriber	Calculated	$
$MACRS_{CashEquivalent(i)}$	Cash Equivalent Value of MACRS, Indexed by year for Years 2-7	Calculated	$/y
$MIRR_{Dev}$	Modified Internal Rate of Return, Developer	Calculated	%
$MIRR_{Sub}$	Modified Internal Rate of Return, Subscriber	Calculated	%
$N_{Cumulative}$	Number of Cumulative Subscribers in any given year	Calculated	subscribers
$N_{Dropped}$	Number of Dropped Subscribers in any given year	Calculated	subscribers
N_{New}	Number of New Subscribers in any given year	Calculated	subscribers
N_{Panels}	Number of Panels Per Subscriber	16	panels
p_{Anchor}	Percent of System Subscribed by Anchor Subscriber	20	%
PBP(i)	Payback Period	Calculated	Years
$P_{elecsold}$	Price of Unsubscribed Electricity	0.04	$/kWh
$p_{LoanDev}$	Percent of Costs Financed, Developer	50	%
$p_{LoanSub}$	Percent of Costs Financed, Subscriber	50	%
PMT()	Excel's "payment" function for calculating annual loan payments	N/A	N/A
$PRO_{SysBenefits}$	Total Annual System Production Benefits	Calculated	$/y
$p_{Salvage}$	Salvage Value	0	%
PV	Present Value of Annual Cash Flow	Calculated	$/y

Symbol	Name	Value	Units
$\mathbf{PW}_{\mathbf{SystemDC}}$	System Size (direct current (DC))	700	kW
$\mathbf{PYT}_{\mathbf{Annual}}$	Annual Developer Loan Payments	Calculated	$/y
$\mathbf{PYT}_{\mathbf{incDev}}$	Total Annual Incentive Payments, Developer	Calculated	$/y
$\mathbf{PYT}_{\mathbf{incSub}}$	Total Annual Incentive Payments (Bill Credits), Subscriber	Calculated	$/y
$\mathbf{PYT}_{\mathbf{Monthly}}$	Subscriber Monthly Payments	Calculated	$/mo
$\mathbf{PYT}_{\mathbf{SREC}}$	Annual SREC Benefits	Calculated	$/y
$\mathbf{PYT}_{\mathbf{Sub}}$	Total Annual Subscriber Payments	Calculated	$/y
$\mathbf{PYT}_{\mathbf{SubPanelLeasing}}$	Annual Subscriber Payments: Panel Leasing, Ongoing	Calculated	$/y
$\mathbf{PYT}_{\mathbf{SubPanelPurchasing}}$	Subscriber Payments: Panel Purchasing, Upfront (one-time payment in Year 0)	Calculated	$
$\mathbf{PYT}_{\mathbf{UnsubEnergy}}$	Annual Unsubscribed Energy Payments	Calculated	$/y
$\mathbf{R}_{\mathbf{Annualt}}$	Annual Electricity Generation Rate (obtained from PVWatts calculator)	888,049	kWh/y
$\mathbf{rC}_{\mathbf{Panel}}$	Panel Price/Lease Escalator	0	%
$\mathbf{r}_{\mathbf{DiscDev}}$	Developer Net Present Value Discount Rate	8	%
$\mathbf{r}_{\mathbf{DiscSub}}$	Subscriber Net Present Value Discount Rate	10	%
$\mathbf{r}_{\mathbf{itc}}$	Federal Investment Tax Credit	26	%
$\mathbf{ROI}_{\mathbf{Dev}}$	Return on Investment, Developer	Calculated	%
$\mathbf{ROI}_{\mathbf{Sub}}$	Return on Investment, Subscriber	Calculated	%
$\mathbf{R}_{\mathbf{Out(i)}}$	Generation Output	Calculated	kWh/y
$\mathbf{rP}_{\mathbf{elecEsc}}$	Annual Energy and Demand Cost Increase	1.64	%
$\mathbf{R}_{\mathbf{t}}$	Annual value of electricity from system	Calculated	$/y
$\mathbf{Sub}_{\mathbf{AnnualCumulativeRate}}$	Annual Cumulative Subscription Rate	Calculated	
$\mathbf{Sub}_{\mathbf{Expenditures}}$	Total Annual Participant Expenditures	Calculated	$/y
$\mathbf{Sub}_{\mathbf{ExpendituresLifetime}}$	Total Participant Expenditures Over Project Lifetime	Calculated	$
SysOwnerNPV	System Owner NPV	Calculated	$
$\mathbf{Sys}_{\mathbf{TotalPanels}}$	Total Panels in System	2333	
T	System Lifetime	25	Years
T	Year, Term	0-25	Year
$\mathbf{t}_{\mathbf{Dev}}$	Financing Term, Developer	10	Years
$\mathbf{t}_{\mathbf{Sub}}$	Financing Term, Subscriber	10	Years
$\mathbf{V}_{\mathbf{Salvage}}$	Salvage Value	0	$

*Additional equations related to this can be found in Appendix C

1.1 SysOwnerNPV=$(\sum_{t}^{T} PV) + C_{DevNetUpfront}$

1.2 PV=$\frac{Cf_{Dev}}{(1+r_{DiscDev})^t}$

1.3

$Cf_{Dev}=C_{GrossSysCapital}+C_{FinancingDev}+C_{Operating}+PYT_{incDev}+PYT_{Sub}+PRO_{SysBenefits}$

1.4 $C_{GrossSysCapital}=C_{Land}+C_{EquipLabor}$

1.5* $C_{Land}=C_{Site}+C_{SitePrep}*1000*PW_{SystemDC}+C_{SiteLease}$

1.6* $C_{EquipLabor}=C_{PVModule}*1000*PW_{SystemDC}$

1.7 $C_{FinancingDev}=Loan_{Dev}+PYT_{Annual}$

1.8* $Loan_{Dev}=p_{LoanDev}*C_{GrossSysCapital}$

1.9* PYT_{Annual}= PMT(i_{DEV}, t_{Dev}*12, $Loan_{Dev}$)

1.10 $C_{Operating}=C_{UpfrontAdmin}+C_{OngoingTransBilling}+C_{OM}+C_{SysRemoval}$

1.11* $C_{OngoingTransBilling}=C_{OngoingTotalt}+C_{OMBillingSoftware}$

1.12* $C_{OM}=C_{OMAnnual}*PW_{SystemDC}$

1.13

$PYT_{incDev}=ITC_{CashEquivalent}+MACRS_{CashEquivalent(i)}+inc_{CapacityPayment}+inc_{GenerationPayment}$

1.14* $ITC_{CashEquivalent}=(r_{ITC}*-(C_{EquipLabor}))$

1.15 $PYT_{Sub}=PYT_{SubPanelPurchasing}$ OR $PYT_{SubPanelLeasing}$

1.16* $PYT_{SubPanelPurchasing}=C_{PanelPurchase}*N_{Panels}*(N_{New}-N_{Dropped})$

1.17* $PYT_{SubPanelLeasing}=(N_{Cumulative}*N_{Panels}*C_{PanelLease}*12+p_{Anchor}*Sys_{TotalPanels}*C_{PanelLease}*12)*(1+rC_{Panel})^{(t-1)}$

1.18 $PRO_{SystemBenefits}=PYT_{UnsubEnergy}+PYT_{SREC}+V_{Salvage}$

1.19* $PYT_{UnsubEnergy}=(1-Sub_{AnnualCumulativeRate})*R_{Annualt}*P_{elecsold}*(1+rP_{elecEsc})^{(t-1)}$

2.1 $SubNPV=(\sum_t^T PV)+C_{SubNetUpfront}$

2.2 $PV=\frac{Cf_{Sub}}{(1+r_{DiscSub})^t}$

2.3 $Cf_{Sub}=Sub_{Expenditures}+C_{FinancingSub}+PYT_{incSub}$

2.4 $C_{FinancingSub}=Loan_{Sub}+PYT_{Monthly}$

2.5* $Loan_{Sub}=(-Sub_{Expenditures(i)})*p_{LoanSub}$

2.6 $PYT_{Monthly}= t_{Sub}-PMT(i)*12$

2.7 $PYT_{incSub}=\frac{R_t*N_{Panels}}{Sys_{TotalPanels}}$

3.1 $MIRR_{Dev}=\sqrt[t]{\frac{Cf_{Dev}*r_{DiscDev}}{ACF_t*r_{DiscDev}}}-1$

4.1 $MIRR_{Sub}=\sqrt[t]{\frac{Cf_{Sub}*r_{DiscSub}}{ACF_t*r_{DiscSub}}}-1$

5.1 $ROI_{Dev}=\frac{B_{25YNetDev}}{-C_{25YDev}}$

5.2 $B_{25YNetDev}= C_{GrossSysCapitalLifetime}+C_{FinancingDevLifetime}+C_{OperatingLifetime}$

6.1 $ROI_{Sub}=\frac{B_{25YNetSub}}{-C_{25YSub}}$

6.2 $B_{25YNetDev}= Sub_{ExpendituresLifetime}+C_{FinancingSubLifetime}$

The equations used to generate the contents of the Output Snapshot for the CSBCT were very complex equations, as seen in the case of equations 1.1-1.19 where the inputs for the equations were based off a series of other equations. Most of these inputs were also all constructed to be products of logic trees, denoted by an asterisk (*) next to the equation number, with each input being the result of at least one If-Then statement which was too complex to include in the above section and can be best described by viewing the CSBCT model itself, directions to this will be available in Appendix D. For the equations included above I simplified these If- Then statements into their most key components that easily allow the reader to understand not only the complexity of this model but also how interconnected the process of CSF financing can be through the reliance of inputs on other inputs.

Some equations above (1.9, 1.10, 1.11, 1.14, 2.3, 2.5, 2.6) had variables that were made up of over thirty smaller equations and a similar number of inputs. In these instances, the variables have been indexed to Appendix C in order to provide a more condensed, digestible explanation of the complexity of the sub-equations and calculations thereof. The variables included in this index came from complex equations that could not be easily translated from the CSBCT in Excel into simple text equations due to the complexity of their modeled formulas. Appendix C serves as a guide to summarize the complexity of these inputs and allow the reader to find the variables relevant to their foundational equations.

Though the Community Solar Business Case Tool offered modeling options for the two most common methods for CSF participation: panel ownership and panel leasing, I did modify the model to better reflect the specific scenario that ACTT was interested in, panel purchasing true ownership. I also modeled a lease-to-own scenario that has great potential to meet ACTT's true ownership goal while also being accommodating of LMI needs. The modifications made to the model to achieve outputs in terms of these scenarios are best reflected in their own, unique model outputs that were not applicable to the other scenarios, a more complete description of these can be found in Section 3.1.

3.3– Literature Review on Best Practices for LMI Engagement

To do my literature review on the best practices for LMI engagement in CSFs

I began by finding articles, papers, and published documents that talk about using CSFs as a means to increase LMI access to renewable energy. Articles specifically on this topic were somewhat limited so my search range expanded to include LMI specific involvement for any kind of solar and programs that use community solar to expand access to anyone, not specifically LMI consumers.

The goal of this literature review is to develop a summary of best practices for LMI engagement that can be used to recommend actions that organizations like ACTT can take when developing CSFs for LMI citizens. This is necessary because LMI individuals are severely underserved in the field of renewable energy due to a number of influencing factors like a lack of financial flexibility. Oftentimes, as we see more states requiring carve-outs where 5-20% of all new CSFs must be subscribed to LMI consumers it is difficult for those projects to find the necessary amount of subscribers, resulting in the offering of free subscriptions with those costs being absorbed by other subscribers on the system.

4. RESULTS

The Community Solar Business Case Tool offers two business models, panel ownership (purchasing) and panel leasing. After some modifications to the model I was able to run four different scenarios, panel purchasing true ownership, panel purchasing with developer, panel leasing with no end ownership, and lease-to-own. For modeling purposes, the default value for the panel purchase or panel lease price was set at the “breakeven price” for the electricity of the panel either per month or over the lifetime of the panel. The minimum and maximum panel purchase or lease price was staggered by 20% of the default value, except in the case of the lease-to-own scenario where the minimum and maximum values were assigned to reflect the average payback period of a residential solar array in the state of Maine with the low end being about 10 years and the high end being about 12 years[53]. Additionally, there are two versions of output snapshots, used to generate the data in the following section, included in Appendix E, one version shows the outputs that were generated with the inclusion of Renewable Energy Certificates (RECs) and the other without. All results shown in the following section do not include RECs as a financing opportunity as the addition of RECs only increased the System Owner NPV by about $1,000 and can be considered counterproductive to ACTT’s goal of promoting the use of renewable energy by selling certificates that allow people to claim CSF energy that they don’t use as their own renewable resource to offset the potentially dirty energy they still rely on.

The only modifications that I was required to make to the CSBCT for management scenarios were for the panel purchasing true ownership and lease-to-own scenarios. All other model modifications were made by way of changing inputs and can be found in **Appendix B**. For panel purchasing true ownership the only modifications necessary to retrofit the model for this scenario was to change the inputs to 0% for the Anchor Subscriber subscription and the Annual Subscriber Retirement/Acquisition rate to simulate a total "subscriber" ownership scenario. Then we multiplied the subscriber Participant Bill Credits by the number of cumulative subscribers and used that value as the Subscriber Payments under System Owner Financials. That value was then used to generate the System Owner NPV which was divided by the number of owners, 146, to find a new Individual System Owner NPV of $3,329 for 16 panels.

The modifications for the lease-to-own scenario were also fairly involved. To model this scenario we found what would be the total cost of a 16 panel system by collecting all of the $/watt costs (including those for operations and maintenance and administrative costs) and multiplied that by the wattage of a 16-panel system. From that point, we just had to modify the participant expenditures to end after the total cost of the system was paid off through the monthly panel lease. We did this by creating an If, Then scenario, similar to that of the model's payback period calculation, that caused the monthly lease payments to become $0 after the cumulative monthly lease payments were equal to the total system cost per subscriber.

4.1 – Overview of Outputs

The Community Solar Business Case Tool provides a wide range of outputs that offers a quick look into the financials of a CSF. The tool is programmed to provide an "Output Snapshot" with the most relevant data for modeling a CSF, panel purchasing/leasing price, system owner and subscriber NPV, and system owner MIRR and ROI. For the lease-to-own scenario I modified this output snapshot to include the total system cost, per subscriber, and the total years to system ownership, I also added the payback period for system owners and subscribers to the output snapshot for the other three scenarios for comparison, a full output snapshot of the default value results can be seen in Table 5 and all of the individual minimum, maximum, and default output snapshots can be found in Appendix E.

Regarding the panel purchasing true ownership scenario, some values are listed as "N/A" because this scenario does not have a true "subscriber" role. Every participant in the panel purchasing true ownership scenario is acting as a "system owner" so subscriber values are irrelevant. Though, as seen in Table 5 and the following graphs the system owner values for the panel purchasing true ownership scenario are displayed with the subscriber values to help comparisons between the benefits of an individual's participation in each of these scenarios. Additionally, the subscriber payback period for the lease-to-own scenario is listed as N/A because the time that it takes the subscriber to pay for their share of the CSF is found under "years to system ownership" and during this time they are benefitting from the panels but have not yet fully paid them so this time period is not a true payback period, it's more of a payoff period.

Table 5: "Output Snapshots" from the Community Solar Business Case Tool for the default values of each financing scenario.

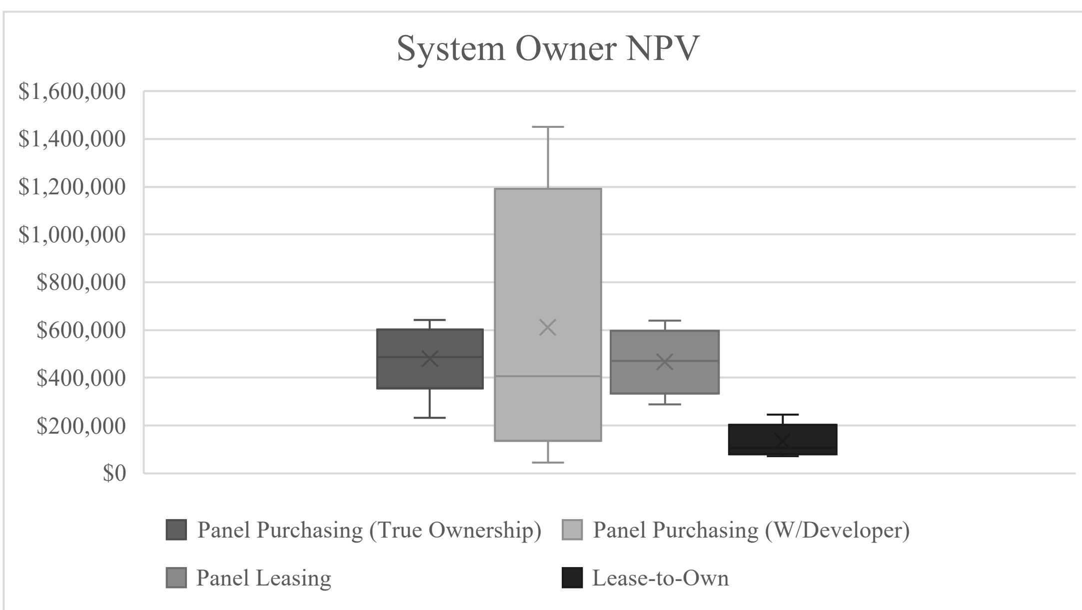
Output Snapshot				
	Panel Purchasing (True Ownership)	Panel Purchasing (W/Developer)	Panel Leasing	Lease-to-own
Panel Purchase Price:	N/A	$710	N/A	N/A
Monthly Panel Lease Price:	N/A	N/A	$5.34	$5.34
Subscriber NPV:	$3,329	$744	$1,016	$3,496
System Owner NPV:	$485,527*	$407,395	$470,293	$71,631
System Owner MIRR:	11%	8%	11%	9%
Subscriber ROI:	N/A	120%	17%	153%
System Owner ROI:	79%	1%	72%	17%
Total System Cost (Per Subscriber):	N/A	N/A	N/A	$11,802.10
Years to System Ownership (Subscriber):	N/A	N/A	N/A	11
System Owner Payback Period (Years):	9.9	0.3	7.7	7.7
Subscriber Payback Period (Years):	9.9	12.2	0	N/A

*Represents the NPV of the CSF as a whole, while NPV for individual system owners is shown under Subscriber NPV for the panel purchasing true ownership scenario

4.2 – Benefit-Cost Analysis

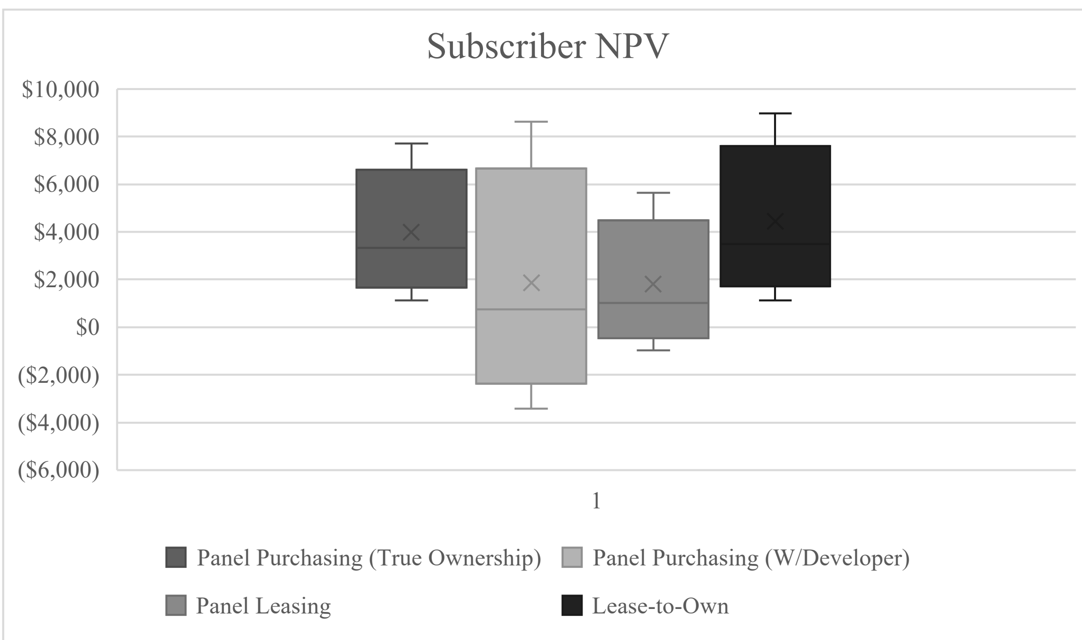
The Community Solar Business Case Tool provides two Net Present Value (NPV) outputs: Subscriber NPV and System Owner NPV. An NPV assesses the time value of money; a higher NPV means a better payout for the time spent on the project. The goal of modeling for ACTT was to minimize the costs that the subscriber would have to incur to become a part of a CSF and therefore, a lower System Owner NPV was preferred. The System Owner NPV (seen in **Figure 1**) is lowest overall in the lease-to-own scenario but has the lowest potential value in the panel purchasing with developer scenario. However, panel purchasing with developer also has the highest potential NPV for the system owner, meaning that this may be the most preferable scenario for the system owner and developer. The case of the panel purchasing true ownership NPV is the same here as in Table 5 where the NPV for the full system is shown in Figure 1 and the individual NPV will be seen in Figure 2.

Figure 1: System Owner net present value (NPV) for the panel purchasing with developer, panel leasing, and lease-to-own scenarios.



Regarding Subscriber NPV, the lease-to-own scenario has the highest potential NPV meaning that this scenario has the greatest financial net benefit for subscribers, this is supported by its low System Owner NPV as well. The panel purchasing true ownership scenario appears on the Subscriber NPV graph (**Figure 2**) as the NPV for the individual CSF participants is very low and is easier to understand when compared to subscriber values despite participant's status as a "system owner". This also allows for better comparison of how individual subscribers could potentially benefit from a panel purchasing true ownership scenario because its easily comparable to the alternative participant financing scenarios.

Figure 2: Subscriber NPV for the panel purchasing – true ownership, panel purchasing with developer, panel leasing, and lease to own scenarios.



The scenario with the greatest NPV potential is the lease-to-own scenario and the least NPV potential is the panel purchasing with developer scenario, which has the greatest potential NPV range overall, allowing for subscriber NPV to fall into the negative range which makes this scenario riskier for LMI customers comparatively to the other scenarios. Additionally, panel purchasing with developer also has the highest potential System Owner NPV which reinforces the riskiness of this scenario for the subscriber because the system owner can choose to increase their personal benefit and NPV and lower the benefit to the subscriber. This makes panel purchasing with developer risky, especially for LMI individuals who tend to lack financial flexibility and rely on a higher level of benefit to make projects worthwhile.

Another method that can be used to assess the cost and profitability of a CSF is the modified internal rate of return (MIRR). MIRR assumes that positive cash flows are reinvested at the cost of capital. It is optimal for the MIRR value to be higher than the return on investment (ROI), the ratio of net profit to the cost of an investment. By way of comparing the MIRR and ROI values for all four scenarios with each data set the only optimal scenarios for the system owner are the max, default, and min for the panel purchasing with developer and the min for the lease-to-own scenarios.

Figure 3: System Owner modified rate of return (MIRR) for each scenario organized by maximum, default, and minimum input values.

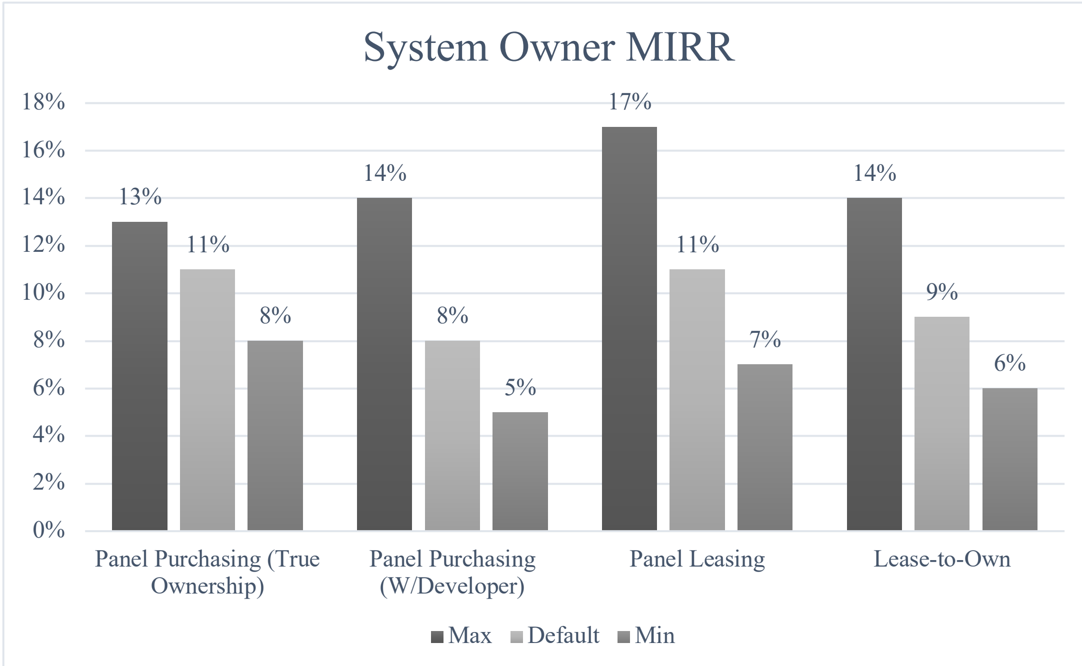
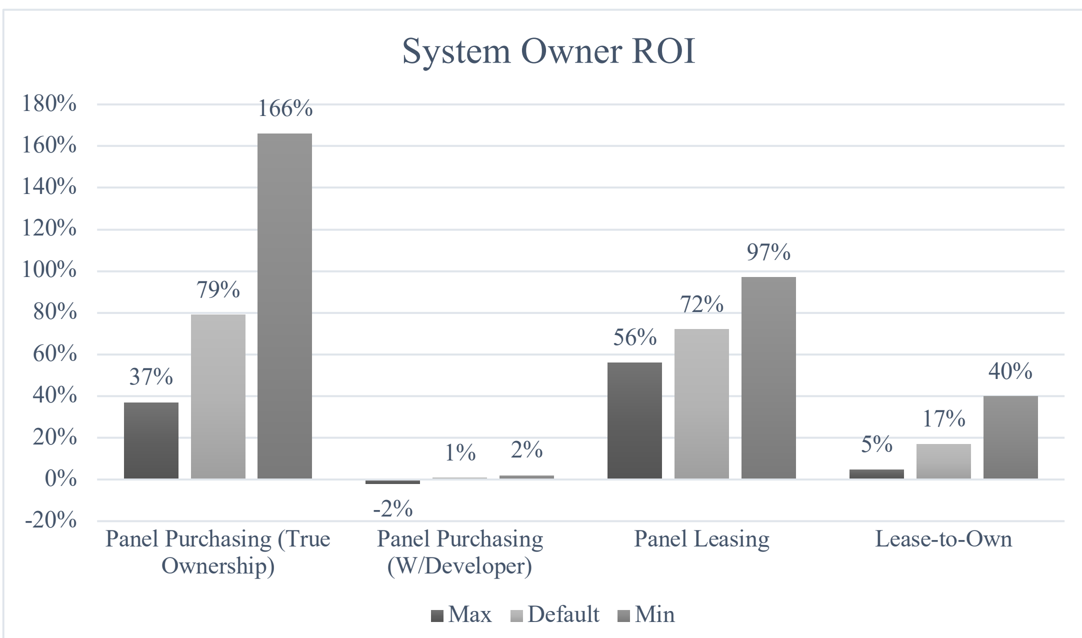
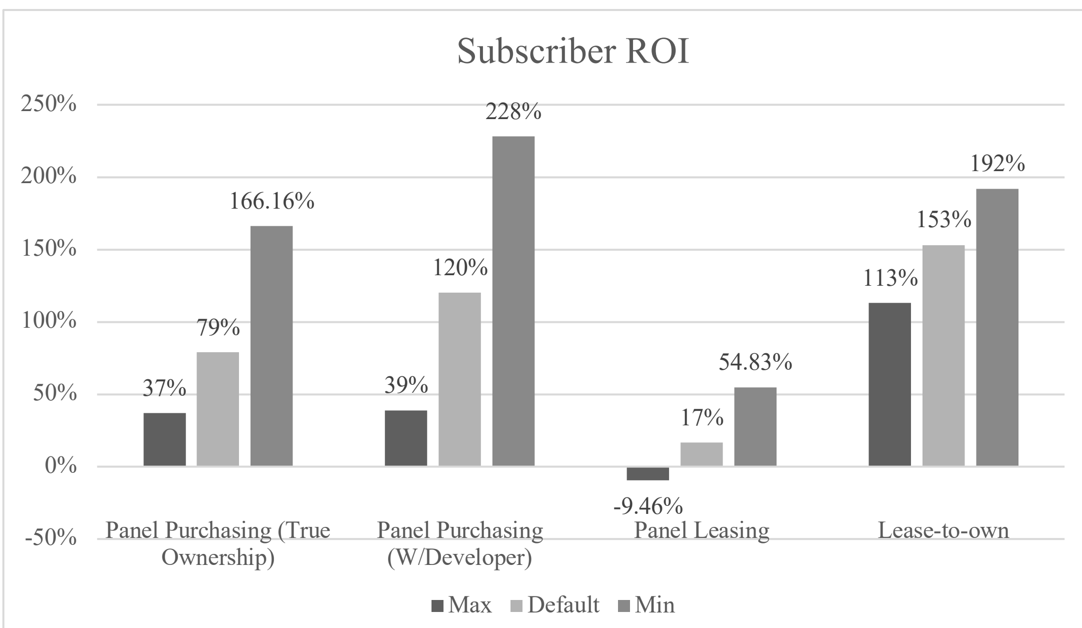


Figure 4: System Owner return on investment (ROI) for each scenario organized by maximum, default, and minimum input values.



Though the model did not include Subscriber ROI in the original Output Snapshot, this value was calculated. As seen in the Subscriber NPV graph (**Figure 2)**, the values provided for the panel purchasing true ownership scenario are based off the system owner values as system ownership is on a much smaller, subscriber-sized scale for that scenario. Based off the values for subscriber ROI the most optimal scenario would be lease-to-own as it would provide the most profit for the costs that the subscriber had to pay. This is because this scenario has the highest default value, meaning that under normal, not the extremes that create the minimum and maximum inputs, circumstances lease-to-own provides the highest return on investment for the subscriber. Also, notably, the panel purchasing with developer scenario has the highest potential Subscriber ROI, with a consistently low System Owner ROI across all three input levels, which reinforces the aforementioned concern that this scenario can be risky and variable dependent upon the management and structure of the CSF.

Figure 5: This graph shows the Subscriber ROI for each scenario using the minimum, maximum, and default values.

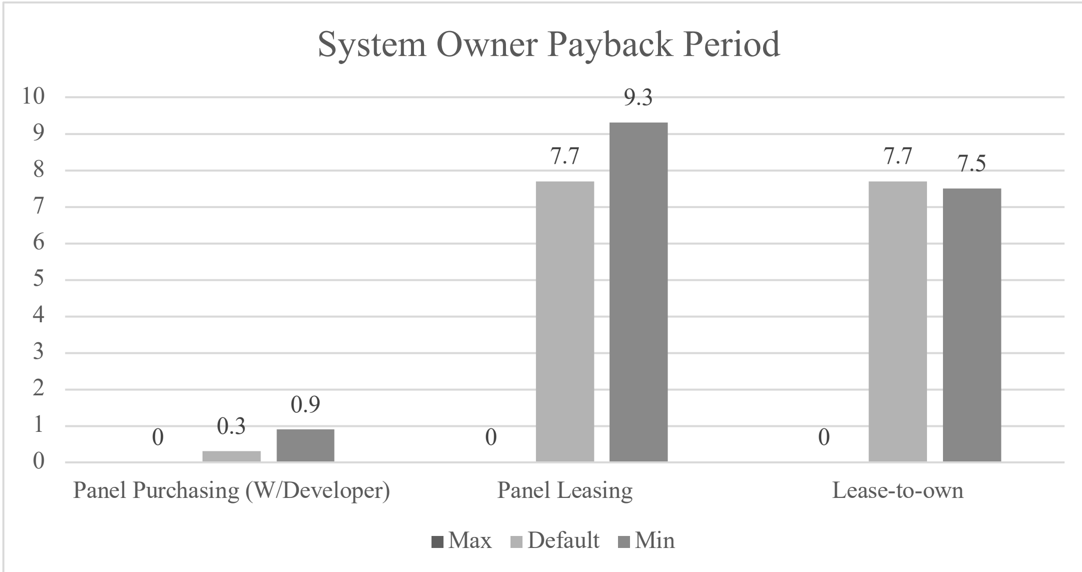


Lastly, the model also calculated both a System Owner and a Subscriber Payback Period. The calculation for these values seems to be inconsistent and consists of a set of

If, Then statements made up of inequalities but the payback periods appear reasonable with the exception of the 0 values which typically occurred only with the maximum input value. The payback periods are ordered similarly to the above models for consistency in that the panel purchasing true ownership values are again, included with the subscriber outputs. In the case of the lease-to-own scenario the Subscriber Payback Period is the length of time that it would take a subscriber to pay for the full cost of their panels at the monthly lease rate.

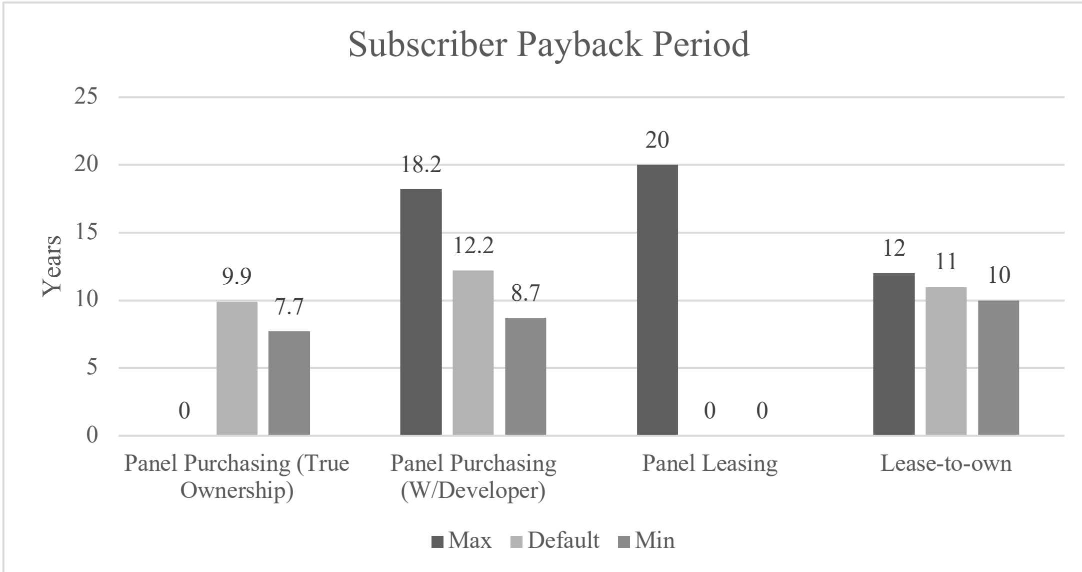
Most notably in the System Owner Payback Period graph is panel purchasing with developer which has payback periods of less than one year in both the minimum and default value models due to the fact that, as a panel purchasing model, the system owner should be paid back in entirety almost immediately if subscribers are simply outright buying the panels as the CSBCT assumes. Both leasing scenarios offer similar payback periods for the system owner, especially when considering in the case of panel leasing that lease payments would continue monthly after the end of the payback period through year 25.

Figure 6: System Owner Payback Period



The scenario with the shortest Subscriber Payback Period is panel purchasing true ownership with a payback period of 9.9 years, using the default input values, which is just 0.7 years longer than Maine's lower typical residential solar payback period of 9.2-12.4 years on average[53]. Panel purchasing with developer again shows the widest range of potential outcomes with payback periods ranging from 8.7 years, short for the State of Maine, and 18.2 years which is about 6 more years than longer solar PV payback periods in Maine. Notably, the payback period in the lease-to-own scenario is flexible as it is relative to the monthly panel lease price which is set by the owner of the CSF, the same goes for the values seen for the panel leasing scenario as those are all relative to the monthly lease price that the system owner choses.

Figure 7: Subscriber Payback Period



4.3 – Literature Review on Best Practices for LMI Engagement

There are many resources available that identify and explain all the barriers that exist when it comes to LMI individuals participating in solar energy. However, there are not many that identify the best practices for overcoming these barriers and increasing LMI engagement and participation. The barriers to LMI participation in solar and community solar are discussed in Section 2.4 while this section will largely focus on strategies that have succeeded in increasing participation from the LMI community.

In the 2018 *Community Solar Update* by SEPA[23] 44% of 25 community solar programs surveyed said that they had some level of LMI participation due to utilizing one of three methods: subsidizing LMI participation, leveraging external funding to lessen the overall costs for LMI participants, or “creatively structuring the customer offer”(17) by donating excess production value to a local LMI bill assistance program[23]. In addition, SEPA claims that, due to the price conscious nature of LMI consumers, creating a subscription price that is equal to or less than the prevailing cost of electricity is necessary to continue to expand LMI participation in CSFs.

Shared Renewable Energy for LMI Consumers: Policy Guidelines and Model Provisions from the Interstate Renewable Energy Council (IREC) provides a list of recommended "Model Provisions for shared Renewable Energy Programs"(35)[35]. These model provisions largely include tactics for CSF owners to help ensure the financial security of LMI participants by: 1) using non-LMI participants as a backup guarantee in the case of an LMI customer defaulting on their bill; 2) offering direct incentives like rebates or cost waivers or loan loss reserve programs to participating LMI customers; and 3) using low-cost public financing options like municipal or government bonds to increase the financial flexibility of LMI participants.[35] This document also encourages the utilization of LMI partner organizations to do the marketing, outreach, and education to the LMI community for CSFs[35]. LMI partner organizations are those who have experience administering programs for the benefit of LMI customers, such as LMI housing or LMI specific energy programs. These organizations already have a strong and trusted relationship with local LMI communities and can help connect LMI customers to CSF owners and ensure that LMI participants have access to any relevant financing incentives or opportunities that they may qualify for as a participant in a CSF[35].The partnership with organizations that already exist to aid LMI individuals also ensures that the target audience, LMI customers, will have access to multi-lingual content and a variety of outreach options including web-based, phone-based, and mail-based outreach from trustworthy sources to minimize the mistrust that some LMI individuals have regarding government programs and financial ventures[35].

This idea is reinforced in the paper *Solar State of Mind: Expanding Community Distributed Generation In New York State* by a capstone group from Columbia University[34]. This paper reviews the best practices for solar stakeholders to overcome barriers that LMI individuals have to adopting solar power[54]. One of the first best practices states that "outreach and educational barriers have traditionally restricted low-income customers from benefitting from solar"(p. 39). Another critical factor is trust. The authors suggest that trust issues can be resolved by transferring program information through trusted LMI community resources like non-profits, school, churches, or hospitals[34]. Other recommendations to increase LMI participation from this paper also follow suit with previously listed ideas with the primary concepts being: lower-cost debt and loan loss reserve for low-income solar projects as well as the creation of an online subscriber waitlist with opt-in enrollment for low-income customers to help eliminate the risks of subscriber default and reduce the number of steps that it takes for low-income customers to receive solar benefits because ease and convenience are also important factors for LMI consumers[34].

Another method that has helped to increase the participation of LMI individuals in community solar is the state-wide implementation of "carve-outs" where new CSFs must have a minimum of anywhere from 5-20% of its subscribers be from the LMI community[7,55]. Laws that require these carve-outs exist in Colorado (the Colorado Community Solar Gardens Act[7]), New York, and, as of 2019 Maine, where 10% of subscribers are required to be LMI for all new CSFs[7,15,55]. However, there have been issues with meeting these requirements in some areas, due to a lack of LMI individuals willing to subscribe due to a lack of education about CSFs or monetary concerns, which has resulted in CSF owners simply giving LMI individuals subscriptions for free and the other subscribers absorbing those costs[7].

Other government programs that can help increase LMI participation are the NCSP and SIYCC. Both of these programs exist to help create solar projects, like CSFs, that primarily serve underserved populations like the LMI community[16,26]. The Solar in Your Community Challenge accomplishes this by awarding $5 million to incentivize the development of new approaches that make electricity more affordable and expand solar adoption across America by increasing the participation of groups with unique barriers to solar adoption, like LMI individuals, but is not limited to CSFs like NCSP is[26]. The National Community Solar Partnership is a coalition of community solar stakeholders that aim to increase access to affordable community solar to all U.S. households by 2025, largely by focusing on lower-income and underserved individuals across the country[16]. There is also a program similar to NCSP and SIYCC in Victoria, Australia, the Renewable Communities Program (RCP) that provides grant funding to support community-led renewable energy projects, including solar arrays and solar farms[46]. All of these federally and state managed methods to increase solar participation from LMI individuals are valuable methods to increase the overall participation of these underserved groups.

In summary, the best practices to increase LMI participation in CSFs seem to be programs that can limit the direct costs incurred by LMI individuals by using options like direct incentives or utilizing lower-risk loans or loan loss reserve programs to increase the financial flexibility that LMI individuals often lack[23,34,35]. Another useful technique is to pass knowledge and education about these programs through trusted community resources that already have a strong relationship with the LMI community such as local non-profits, schools, and hospitals[7,34]. Finally, the utilization of state and federal programs that aim to increase solar adoption by underserved populations can also help to support the participation of LMI individuals by providing more opportunities for them to adopt solar under incentivized circumstances such as in the case of solar carve-outs[7,16,26,55].

4.4 – Discussion

Based off the graphical results in Section 4.2 from my four modeling scenarios, panel purchasing true ownership, panel purchasing with developer, panel leasing, and lease-to-own, the scenario that has the most potential to accommodate LMI needs and fulfill ACTT's preference of LMI customers having full ownership of their panels is the lease-to-own scenario. Lease-to-own has the benefit of low, monthly lease payments, as opposed to a high upfront cost like in panel purchasing true ownership. Also, as the CSF is owned by a third-party instead of a non-profit, there is the potential for the use of State and federal financing incentives or private funding to potentially lower panel purchase price to better accommodate and work with the financial needs of LMI customers, these incentives are reflected in all four scenarios. Subscriber costs can be lowered further through private or federal funding if LMI engagement recommendations are followed and the system owner is able to form a relationship with community organizations that specialize in soliciting project funding for the LMI community. Additionally, it offers a high Subscriber ROI and a manageable payback period that is well within the range of the average residential solar PV payback period in the State of Maine of 9.2-12.4 years[53]. Another benefit of both the panel leasing and lease-to-own scenarios is that the monthly panel lease price can be set as low or high as the system owner wants to meet a certain subscriber or system owner payback period. This flexibility can be utilized to better accommodate LMI needs by offering a low monthly lease price.

Alternatively, the panel purchasing with developer scenario has significant potential to be used as a model for a CSF that caters to the LMI community under the right structure and management. As seen in the figures in Section 4.2, panel purchasing with developer has the most variable range of potential outcomes out of all four scenarios. If managed correctly, panel purchasing with developer can offer participants a high ROI and a short Payback period but this is unlikely to be a practical scenario for LMI individuals as it wouldn't offer long-term and/or flexible financing options due to the mandatory high upfront cost of buying the panels from the developer. Though, this scenario may be more adept to the use of loans as a financing mechanism as participants, if eligible, could pay for the large upfront purchase cost using a loan that would allow them to pay it off over a longer period. However, as noted in Section 2.4, LMI individuals often are unable to qualify for loans or are only eligible for loans that have interest rates that are too high for them to afford.

Regarding ACTT's interest in the financing mechanisms: On-Bill Financing, LIHEAP/WAP, Bulk Purchasing, Loans, and Capital Refinancing, on-bill financing is best utilized by lease-to-own and panel leasing. Lease-to-own, panel purchasing with developer, and panel purchasing true ownership also have the potential to utilize LIHEAP/WAP funding if it were to become available for solar PV financing in Maine to lessen the overall cost of a set of panels by allowing the subscriber to use that money to pay off a portion of the overall panel cost. Neither lease-to-own or panel leasing would be able to utilize loans as they are incompatible with the monthly leasing structure and would add unnecessary interest rates and extra costs to these scenarios. Panel purchasing true ownership and panel purchasing with developer would not be eligible to use on-bill financing to cover the cost of solar panels as both scenarios require one large, upfront payment to acquire the panels. However, they could both potentially use LIHEAP/WAP and loans to cover these large upfront costs. All four scenarios already utilize bulk purchasing in a way, as a standard CSF has lower $/Watt costs than a residential solar array because the panels and materials are purchased in bulk, often closer to wholesale or commercial pricing, due to the size of array. It is also important to note that these costs may fall more for CSFs in Maine as LD 1711 allows arrays to be bigger which can often encourage bulk purchasing that drives costs down.

The primary LMI needs that must be met by these financing mechanisms and management scenarios are financial flexibility and homeownership, both of which can be easily met by utilizing the management scenarios and financing mechanisms above. However, there are additional methods that encourage LMI participation beyond meeting their needs. It is important to understand and respect the human factor of developing a project meant to help and underserved community. In this respect, it is important to ensure that LMI investments in these projects are always safe and sensible to be respectful of their income, one of the goals of a solar PV investment is to reduce household energy costs and even a small monthly saving on a home energy bill can be significant in an LMI household. The safety of an investment can also be encouraged through the construction of a good, trusting relationship between the LMI community and the CSF developer, this may also help to protect the CSF in the case of a subscriber defaulting on their monthly lease price by having a number of interested participants on a waiting list to take their spot because of the CSF presence in the LMI community and the potential savings that it offers. Another important factor of LMI engagement is to encourage LMI participation while not inhibiting other's want or ability to participate. There are reasonable concerns about LMI solar carve-outs inhibiting the construction of a CSF due to the mandatory LMI participation in new arrays, this is occasionally solved by other CSF participants or the developer simply buying and gifting the panels to LMI individuals for the sake of meeting a quota and raises the concern of encouraging the further development of class biases that may make LMI individuals feel unwelcome in CSFs and related projects. One way that this issue can be approached is through the diversification of management scenarios where different subscribers can choose to pay upfront or long-terms costs depending upon their preference and financial status so that not all subscribers are forced to abide by a monthly leasing schedule or high upfront cost if it does not meet their needs or preferences. Additionally, successful CSFs in LMI communities have utilized local public resources and LMI allies (such as social workers and people or organizations that work with LMI communities) to encourage trust in LMI participants. This may be best understood through the use of an interdisciplinary approach during CSF development that encourages the CSF owner to work with LMI representatives or LMI serving organizations to better understand the local LMI community and the best ways to serve them. These resources can also be a part of what develops a waiting list of LMI participants for a CSF.

5.CONCLUSION

Ultimately, (RQ1) the CSF financing mechanisms that ACTT is interested in that have the most potential for improving solar affordability for LMI individuals on MDI are 1) on-bill financing, when used in conjunction with a lease-to-own scenario; 2) loans, when used with a panel purchasing with developer scenario; 3) LIHEAP/WAP, if or once state legislation is expanded to allow LIHEAP to fund LMI solar projects. (RQ 3) Of the four financing scenarios examined in this paper, the one with the most potential to accommodate LMI needs is lease-to-own because it allows for flexible financing, dependent upon the system owner, as well as on-bill financing and the potential to utilize state or federal funding such as LIHEAP. If a lease-to-own scenario is used in conjunction with the engagement approach of facilitating and developing a relationship between the developer of the CSF and trusted LMI community resources LMI engagement may increase due to the presence of that relationship. This relationship can help to facilitate trust between the developer and the LMI community making it easier for LMI individuals to engage with future projects. (RQ 2) The primary limitations of using state or federal financing programs to fund a CSF that includes LMI individuals on MDI is the limited availability of programs like PACE loans, (only available in Tremont, not Manset or Bar Harbor) LIHEAP/WAP, and the recent discontinuation of federal loan programs that could have potentially been used to finance a predominantly LMI CSF.

Additionally, panel leasing, despite its inability to meet ACTT's goal of true panel ownership, is still a valid method to include LMI individuals in community solar. Panel leasing is flexible and does not require a long-term commitment to be made by the subscriber to receive the benefits of CSF involvement. Additionally, LMI individuals have a tendency to default on their electric bills so a long-term lease option with no commitment allows the system owner to easily replace defaulting-subscribers if necessary.

Limitations of this study include the limited capabilities of the Community Solar Business Case Tool, as it is limited in its ability to model different scenarios and needed to be modified to fit the full scope of this study. Additionally, when modifications were made, the model it so complex that a single change often cause several equations to be altered in order to obtain a full set of results. For this reason, I was not able to thoroughly explore odd model outputs, such as the 0 values in the Payback Period results. This was partially because once an issue was found it became nearly untraceable after working backwards through several precedent equations. Also notable was the COVID-19 pandemic which caused the primary source for my technical variables to fall through and also significantly impacted the amount of time that I was able to use to complete the study due to the personal impacts of this event and I ultimately had to reduce the scope of the project accordingly.

In addition to the way that time limitations impacted the scope of my project, they also inhibited my ability to pursue new modeling opportunities as my understanding of the model developed. For example, to develop the panel lease price for the panel leasing I set the default value to the breakeven price for electricity and reduced that by 20% for the minimum value and increased it by 20% for the maximum. In the lease-to-own scenario I set the minimum, default, and maximum lease prices to values that would generate a "years to system ownership" value of 10, 11, or 12 years respectively. However, I recently found out that these methods of deciding panel lease price resulted, in some cases, of the subscriber paying more in year one than what they would save by participating in the lease agreement. These monthly lease prices should instead be set as a result of the subscriber internal rate of return (IRR) at an appropriate percentage (i.e. 10%) or a positive subscriber first year net savings so that the benefit for the subscriber to participate in a CSF is maximized.

Finally, I believe that this study can be improved upon by the addition of either a sensitivity analysis or a Monte Carlo simulation to provide a more realistic variation of the input values that I used as my maximum and minimum. Another goal for future research to help ACTT and the LMI communities on MDI specifically would be to reach out and survey LMI interests in and concerns about CSFs and then work accordingly to form a relationship from this information that encourages their participation in future projects. In addition to surveys, in-person interviews or focus groups could also be used to obtain LMI opinion data relevant to CSFs and these in-person approaches may help to facilitate a relationship by reaffirming the importance of LMI opinions and the human factors relevant to CSF development.

If ACTT were to pursue any policy actions to help them facilitate the implementation of a CSF that is geared towards serving the LMI community, I would recommend working to expand Maine state legislation to include solar PV and CSFs in LIHEAP funding. Another method would be to encourage the state to develop a grant that would help CSFs to offset the costs paid by their LMI subscribers to encourage more LMI participation in such projects. Regarding a CSF management technique, I would recommend ACTT to pursue a lease-to-own model because it has the greatest potential to accommodate LMI needs through flexible financing and offers high ROI and NPV potential that makes this financing scenario a safe and efficient investment for LMI customers comparatively to the other three financing scenarios. Additionally, I think that pursuing a diversified management approach where different CSF subscribers are able to pay for their panels through different methods, such as a lease-to-own scenario for LMI individuals and a panel purchasing true ownership scenario for local businesses or more financially secure subscribers. This would also help to alleviate the initial upfront cost that the system owner would face upon the construction of the CSF. Above all, I recommend that ACTT facilitate communication between their organization and the local LMI community, possibly through community outreach similar to past events that they've held, to develop a relationship that better enables ACTT to work with the LMI individuals on MDI to meet their goal of becoming energy independent by 2030. This relationship would have the potential to plan future projects that could further reduce the energy burden of the MDI LMI community by way of their involvement in renewable energy projects, like CSFs, that are suited to accommodating their needs.

5.1 – Follow Up with A Climate to Thrive

I had the opportunity to share the results of this thesis with ACTT at one of their monthly Energy Committee Meetings. In my discussion with them it became clear that to continue tailoring this research to their needs and interests that this study would have to take on a greater approach to the intricacies and possibilities of financing a CSF. The majority of the questions that I was asked concerned how home loans or homeownership can play a role in CSF panel ownership as well as how a CSF with individual panel ownership as opposed to power purchasing agreements (PPAs, financial agreements where a developer arranges for the design, permitting, financing and installation of a solar array on a customer's property at little to no cost[56]) would work in the case of a micro-grid. Specifically, these homeownership questions revolved around what happens to the panels that an individual owns if they move away from the area that their array is located in. In part, this question was easy to answer as some homeowners choose to tie their CSF panel ownership to the home in which they are currently living and this ownership transfers to the next homeowners. However, there is no information that I could find that mentions how this could affect LMI individuals, especially considering the potential of sudden changes in residency (i.e. homelessness or being forced to move due to financial troubles or a change in landlord who may not want to be responsible for a portion of a CSF). Ultimately, these questions became more of an issue of how CSFs can work for LMI individuals in the long-run, a question likely best answered through further research and the development of a relationship with local LMI resources that's more familiar with the matter of LMI housing and how a CSF could play into low-income housing programs. Further research to aid ACTT in the development of a CSF designed to help LMI individuals would have to provide answers to these homeownership questions as well as develop a better understanding of how a CSF could work in the unique energy model that ACTT is pursuing, which is now largely revolving around micro-grids and PPAs instead of true panel ownership formats for larger solar arrays as modeled in this thesis.

BIBLIOGRAPHY

1. Cook JJ, Bird LA. *Unlocking Solar for Low- and Moderate-Income Residents: A Matrix of Financing Options by Resident, Provider, and Housing Type*.; 2018:NREL/TP--6A20-70477, 1416133. doi:10.2172/1416133

2. Ever Wondered "What is Low- and Moderate-Income or LMI"? Here's Your Answer. findCRA Learning Center. Published June 25, 2018. Accessed February 6, 2020. https://www.learncra.com/our-new-infographic-explains-what-is-low-or-moderate-income-or-lmi/

3. A Climate to Thrive. Accessed October 7, 2019. https://www.aclimatetothrive.org/

4. Bureau USC. American FactFinder. Accessed January 14, 2020. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

5. Database of State Incentives for Renewables & Efficiency®. DSIRE. Accessed November 11, 2019. https://www.dsireusa.org/

6. Community Solar Toolkit | Natural Resources Council of Maine. Accessed October 21, 2019. https://www.nrcm.org/projects/sustainability/sustainable-maine-community-toolkits/community-solar-toolkit/

7. Bentham Paulos, PaulosAnalysis. Bringing the Benefits of Solar Energy to Low-Income Consumers A Guide for States & Municipalities. Published online May 2017.

8. What is a Green Bank? – Green Bank Network. Accessed February 3, 2020. https://greenbanknetwork.org/what-is-a-green-bank-2/

9. Low- and Moderate-Income Solar Policy Basics | State, Local, and Tribal Governments | NREL. Accessed November 11, 2019. https://www.nrel.gov/state-local-tribal/lmi-solar.html

10. Jennifer S. Szaro. Community Solar from the Participants' Perspective. Presented at the: NCSP Atlanta; May 24, 2016.

11. On-Bill Recovery/On-Bill Financing | Low-Income Solar Policy Guide. Accessed October 21, 2019. https://www.lowincomesolar.org/toolbox/on-bill-recovery/

12. Gary Friedman. Questions for Honors Thesis. Published online November 4, 2019.

13. Fortunat Mueller. Phone call with Fortunat Mueller. Published online January 24, 2020.

14. A Climate to Thrive. The Story of ACTT. Google Docs. Accessed January 14, 2020. https://drive.google.com/file/d/1bEVAHxPnToHBHdUPsAR6bzpEiyLcANP1/view?usp=embed_facebook

15. 129th Maine Legislature. LD 1711. Published online May 9, 2019. http://www.mainelegislature.org/legis/bills/getPDF.asp?paper=SP0565&item=1&snum=129

16. National Community Solar Partnership. Energy.gov. Accessed February 3, 2020. https://www.energy.gov/eere/solar/national-community-solar-partnership

17. Farrell J. Community Solar Power - Obstacles and Opportunities. *New Rules Project*.:42.

18. Watkins F. Here Are The Top 19 Community Solar States in 2018 - Solstice™ Community Solar. Solstice™ Community Solar. Published July 17, 2018. Accessed February 3, 2020. https://solstice.us/solstice-blog/top-community-solar-states-2019/

19. Becker S. Solar Energy Statistics: 44 Numbers That Define U.S. Solar - Solstice™ Community Solar. Solstice™ Community Solar. Published April 14, 2019. Accessed February 3, 2020. https://solstice.us/solstice-blog/solar-energy-statistics/

20. Heeter JS, Bird LA, O'Shaughnessy EJ, Koebrich S. *Design and Implementation of Community Solar Programs for Low- and Moderate-Income Customers*.; 2018:NREL/TP--6A20-71652, 1488510. doi:10.2172/1488510

21. Virtual Net Metering: What Is It? How Does It Work? | EnergySage. Solar News. Published May 4, 2019. Accessed February 5, 2020. https://news.energysage.com/virtual-net-metering-what-is-it-how-does-it-work/

22. Fortunat Mueller. Re: Introduction and Questions. Published online December 3, 2019.

23. Dan Chwastyk, Manager SEPA, Jared Leader, Associate SEPA, Jeff Cramer, Executive Director CCSA, Mason Rolph, Intern CCSA. Community Solar Program Design Models. Published online 2018.

24. Community Solar. SEIA. Accessed November 11, 2019. /initiatives/community-solar

25. Switching to Solar Power in Maine: Incentives, Environment, & Economy. Natural Resources Council of Maine. Published January 15, 2014. Accessed February 5, 2020. https://www.nrcm.org/programs/climate/clean-energy/solar-power-in-maine/

26. Solar in Your Community Challenge. Energy.gov. Accessed February 5, 2020. https://www.energy.gov/eere/solar/solar-your-community-challenge

27. Low-Income Solar Policy Guide. Low-Income Solar Policy Guide. Accessed November 21, 2019. https://www.lowincomesolar.org/

28. LIHEAP and WAP- Two Sides of the Same Coin – NASCSP. Accessed February 6, 2020. https://nascsp.org/liheap-and-wap-two-sides-of-the-same-coin/

29. LIHEAP Service Eligibility Guidelines. Office of Community Services | ACF. Accessed November 21, 2019. https://www.acf.hhs.gov/ocs/resource/liheap-eligibility-criteria

30. Federal Energy Assistance Programs. Low-Income Solar Policy Guide. Accessed November 21, 2019. https://www.lowincomesolar.org/toolbox/federal-energy-assistance-programs/

31. Energy.gov. Energy.gov. Accessed November 21, 2019. https://www.energy.gov/energygov

32. WAP and CHIP Programs. Accessed February 6, 2020. https://www.mainehousing.org/partners/partner-type/community-agencies/maine-weatherization-programs

33. Chan C, Ernst K, Newcomb J. NEW MODELS THAT DELIVER ENERGY SOLUTIONS TO LOW-INCOME CUSTOMERS. :23.

34. Ariane Benrey, Ellie Kahn, Mark Kim David Maravilla, Jully Meriño Carela, Parth Vaidya. Solar State of Mind: Expanding Community Distributed Generation in New York State. Published online May 2017.

35. Interstate Renewable Energy Council. Shared Renewable Energy for LMI Consumers: Policy Guidelines and Model Provisions. Published online March 2016.

36. Community Solar Business Case Tool. Elevate Energy. Accessed February 24, 2020. https://www.elevateenergy.org/programs/solar-energy/community-solar/communitysolarbusinesscasetool/

37. Lips B, Proudlove A, Sarkisian D, et al. Community Solar for the Southeast Implementation Guide. :18.

38. Stephanie Coffey. Financial and Social Implication of Community Solar in New England. Published online August 2016.

39. Eian S. Ray. Fesibility Study for Economic Viability of a Makah Community Solar Farm. Published online 2013.

40. Wittkowski K, Morton S, Silber L, Nassar J. Community Solar Initiatives. :20.

41. New Analysis Shows National Potential for Solar Power in Low-Income Communities. Energy.gov. Accessed March 10, 2020.

https://www.energy.gov/eere/articles/new-analysis-shows-national-potential-solar-power-low-income-communities

42. Shakouri M, Hyun Woo Lee, Yong-Woo Kim. A probabilistic portfolio-based model for financial valuation of community solar. Published online February 14, 2017.

43. Ray D. Lazard's Levelized Cost of Energy Analysis—Version 12.0. Published online 2018:20.

44. Vannoy MA, Littell DP, McLean CJT, et al. Maine Public Utilities Commission. :180.

45. Solar Cost-Benefit Studies. SEIA. Accessed March 9, 2020. /initiatives/solar-cost-benefit-studies

46. Department of Environment L, Energy. Community energy. Energy. Published November 7, 2019. Accessed December 2, 2019. https://www.energy.vic.gov.au/renewable-energy/community-energy

47. PVWatts Calculator. Accessed May 17, 2020. https://pvwatts.nrel.gov/index.php

48. EIA - Electricity Data. Accessed February 20, 2020. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

49. GreenSky | Get There Faster. GreenSky. Accessed May 17, 2020. http://gsavalpweb03.prde1.greensky.net/

50. Solar Loans & Financing for Homes in ME, NH, MA. ReVision Energy. Accessed May 17, 2020. https://www.revisionenergy.com/solar-power-for-your-home/solar-loans/

51. Stephenson A. Home Energy Loans. Efficiency Maine. Accessed May 17, 2020. https://www.efficiencymaine.com/at-home/energy-loans/

52. Home Page | Join Mosaic. Accessed May 17, 2020. https://www.joinmosaic.com/?utm_source=ReVision+Energy+List&utm_campaign=e3828c5dca-Dec-2017-All&utm_medium=email&utm_term=0_893c35417a-e3828c5dca-381294721

53. Maine Solar Panels | 2020 Pricing & Savings | EnergySage. Accessed May 14, 2020. https://www.energysage.com/solar-panels/me/

54. Community Solar for Low- to Moderate-Income Households | Columbia SIPA. Accessed February 26, 2020. https://sipa.columbia.edu/academics/capstone-projects/community-solar-low-moderate-income-households

55. Passer B. Bringing Community Solar to a Broader Community. :20.

56. Solar Power Purchase Agreements. SEIA. Accessed June 6, 2020. https://www.seia.org/research-resources/solar-power-purchase-agreements

57. Friedman G. Model Inputs for Benefit-Cost Analysis - Please Respond by March 2nd. Published online March 1, 2020.

58. Solar Panel Cost 2020 | Current avg. solar system price by Maine. Accessed March 27, 2020. https://www.solarreviews.com/solar-panels/solar-panel-cost/cost-of-solar-panels-in-maine

59. ISO New England - Energy, Load, and Demand Reports. Accessed April 17, 2020. https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/yearly-wholesale-load-cost-report

60. Host or Join a Community Solar Farm in ME, NH, MA. ReVision Energy. Accessed April 26, 2020. https://www.revisionenergy.com/solar-power-for-your-home/community-solar-farms/

61. Solar Investment Tax Credit (ITC). SEIA. Accessed February 18, 2020. /initiatives/solar-investment-tax-credit-itc

62. Status and Trends in the U.S. Voluntary Green Power Market. Energy.gov. Accessed May 17, 2020. https://www.energy.gov/eere/analysis/downloads/status-and-trends-us-voluntary-green-power-market

63. Residential Electricity Rates - United States. Accessed March 25, 2020. https://sunmetrix.com/residential-electricity-rates-united-states/

64. Coughlin J, Jennifer Grove, Linda Irvine, et al. A Guide To Community Shared Solar: Utility, Private, and Nonprofit Project Development. Published online May 2012.

65. US EPA O. Unbundled Renewable Energy Certificates (RECs). US EPA. Published July 24, 2018. Accessed April 4, 2020. https://www.epa.gov/greenpower/unbundled-renewable-energy-certificates-recs

APPENDICES

APPENDIX A – TABLE OF FINANCING MECHANISMS
(p. 66 – 71)

Name of Financing Mechanism	Description	Ideal for LMI?	Used in Maine?	Other states where used	Citations relevant to this row
Bond Program	A program where entities or organizations looking to implement clean or renewable energy can request bonds from their state government to help fund the project	Yes	No	IL, ID, UT, NM, HI	5
Bulk Purchasing*	allows multiple people to purchase systems together at a lower cost (not typically directed to LMI)	No	Yes	Many (MA is leader)	1 p.3, 6
Capital Refinancing*	"a building owner negotiates a new mortgage rate and term to generate additional capital for building improvements including PV", not used widespread for PV	N/A	Yes	Many	1 p. 3
Crowdfunding	financing approach where capital is from public donors instead of from accredited investors, viability varies case-by-case	No	No	NY, CA, FL, MA, ID, WV	1 p. 3
Direct Cash Incentives	Payments/reimbursements (grants/rebates) for the deployment of PV. Rebates in some states will cover the full system cost for LMI residents	Yes	No (yes before LePage)	CA, CO, D.C., IL, MA, NY, WA	1 p. 4, 7 p. 25-27
Grant Program	A program where organizations can apply for a grant to help them fund a renewable energy project. There are several grant programs available from the Federal government but only for special groups.	Yes	No	WA, OR, CA, AK, CO, MN, WI, MI, IL, IN, NY, PA, MD, RI, MA, NH	5

Name of Financing Mechanism	Description	Ideal for LMI?	Used in Maine?	Other states where used	Citations relevant to this row
Green Banks	A specialized financial entity that works with the private sector to fund sustainable infrastructure projects with environmental benefits. Typically helps to finance commercially viable and proved clean energy technologies which may face barriers attracting capital.	Possibly	Yes	CT, NY, CA, RI, MD, HI	8
Green Panel purchasing	Legislation that mandates that a certain percentage of power for all government buildings must come from a renewable energy source. In Maine all government buildings must use 100% renewably produced energy with preference being given to community-based renewable energy generators.	Possibly	Yes	AZ, CO, TX, WI, IL, MI, PA, MD, SC, MA, CT	5.
LIHEAP/WAP*	Low income home energy assistance program/weatherization assistance program; DOE programs that allow states to use the program money to install cost-effective PV	Yes	Yes (but not for solar - used for weatherization)	Avalible in all states	1 p. 4
Loan Loss Reserve	Makes it easier for low-credit score residents to get loans for solar because the loaner is offered protection for the provision of the loan; most likely used in conjuction with one of other loan options listed here	Yes	Probably not (technically maybe possible with PACE?)	NY	9
Loans*	granted by public or private financial instutions, often under-subsidized terms, used to deploy PV; potentially may be combined with Loan Loss Reserve for people with low credit scores	Possibly	Maybe (ReVision?)	MA	1 p. 4, [20]

Name of Financing Mechanism	Description	Ideal for LMI?	Used in Maine?	Other states where used	Citations relevant to this row
Net Metering	Compensation structure that allows for customers to be credited for the excess generation of their PV system, net metering programs do not typically address up-front cost barriers, additional incentives would need to be offered to aid LMI residents	No	Yes	AK, AR, AS, AZ, CA, CO, CT, D.C., DE, FL, GA, GU, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MP, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, PR, PW, RI, SC, TX, UT, VA, VI, VT, WA, WI, WY	1 p. 4, 5
On Bill Financing*	funding structure where a third party pays the upfront costs of a PV system and the residents pay for the investment through monthly electric bills	Yes	No	NY, NC, CO	1 p. 5, 10 p. 11, 11
PACE	Property Assesed Clean Energy; allows customers to pay for PV installation through property tax bills, payments take priority over mortgages to reassure private lenders that associated loans will be repaid; potentially may be combined with Loan Loss Reserve for people with low credit scores	Possibly	Yes	CA, FL, MI	1 p. 5, 5

Name of Financing Mechanism	Description	Ideal for LMI?	Used in Maine?	Other states where used	Citations relevant to this row
Pay-as-you save (PAYS)*	The Utility invests in the energy upgrade instead of the homeowner. The utility is paid back through the customer's tariff, there is no loan or lein involved and the repayment obligation stays with the property, not the homeowner.	Yes	No (utilities can't own generation)	CO? (they have a lot of coops); the utility dive article mentions a coop in NC	7 p.44
Production Incentives	generation-based incentives for the output of PV systems, can be fixed or varied on market prices	No	No	AK, AL. CA, CO, FL, GA, KY, MN, MS, NC, NM, NV, NY, OH, OR, RI, SC, TN, TX, VA, VI, VT, WA	1 p. 5, 5
Property Tax Incentive	State law that allows a taxable property to be tax exempt for a certain period of times (MA is 20 years) if the property uses an on site renewable energy source as a primary or auxiliary power system on the property.	No	No	OR, CA, AK, HI, ID, NV, AZ, MT, ND, SD, NE, KS, CO, NM, TX, MN, IA, WI, IL, MI, IN, OH, TN, LA, MO, FL, NC, VA, MD, DE, NY, VT, NH, MA, CT, RI	5
Public Benefits Fund	Money set aside from customer utility bills or through contributions from utilities. The fund supports grants for renewable energy demonstration projects to Maine-based nonprofits, consumer owned electric	Possibly	Yes	OR, CA, MT, MN, WI, IL, OH, PA, VA, NJ, DE, NY, CT, RI, VT	5

Name of Financing Mechanism	Description	Ideal for LMI?	Used in Maine?	Other states where used	Citations relevant to this row
	transmission and distribution utilities, community-based nonprofit organizations and more.				
Sales Tax Incentive	State law that exempts equipment relating directly to any solar, wind powered, or heat pump system which is being used as a primary or auxiliary power system for heating or supplying energy to an individual's residence from state sales tax.	No	No	WA, CA, NV, UT, AZ, NM, CO, ND, SD, NE, MN, IA, WI, IN, KY, TN, MI, FL, NY, VT, MA, CT, RI, NJ, MD	5
Solar Renewable Energy Credit Program	A solar incentive that allows homeowners to sell certificates for energy to their utility. The homeowner earns one solar renewable energy credit (SREC) for every 1000kWhs produced by their solar panel system.	No	No (although ME participates in RECs market)	IL, OH, PA, MD, DE, CT, MA	5
Third Party Leasing/ESA	Third Party leasing/energy service agreements (ESA) allow LMI customers or multifamily housing providers to contract with a third-party contractor to fund/construct/operate a PV system. Benefits of the PV system are then distributed amongst the customer and contractor. Third party leasing is only legal in some states, LMI residents are often not targeted due to low credit scores.	No	Yes (very limited, ReVision)	CA, OR, NV, UT, AZ, CO, NM, TX, OK, AR, IA, IL, MI, GA, VA, OH, PA, D.C., MA, MD, NY, VT, NH, CT, NJ, RI, PR	1 p. 5, 5

Name of Financing Mechanism	Description	Ideal for LMI?	Used in Maine?	Other states where used	Citations relevant to this row
Third Party Ownership (Solar Hosting)	a third-party pays a homeowner to install/operate rooftop PV, third party remains owner of the array and its generation	No (unless savings passed to renters through some established mechanism)	Yes (very limited, ReVision)	CA, OR, NV, UT, AZ, CO, NM, TX, OK, AR, IA, IL, MI, GA, VA, OH, PA, D.C., MA, MD, NY, VT, NH, CT, NJ, RI, PR	1 p. 5, 5
Value of Solar Tariff	Customers are billed for all electricity usage under their existing applicable tariff and are credited for the solar electricity they produce under the approved value of solar tariff (VOST).	No	No	MN, TX	5

APPENDIX B – CSBCT INPUTS
(p. 72-80)

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
Cf_{Dev}	Cash Flow, Developer			Calculated	$	
Cf_{Sub}	Cash Flow, Subscriber			Calculated	$	
ACF_t	Annual Cash Flow by Term			Calculated	$	
$B_{25YNetDev}$	25 Year Net Benefits, Developer			Calculated	$	
$B_{25YNetSub}$	25 Year Net Benefits, Subscriber			Calculated	$	
C_{25YDev}	25 Year Costs, Developer			Calculated	$	
$C_{25YNetSub}$	25 Y Costs, Subscriber			Calculated	$	
$C_{Billing}$	Billing Templates and Setup		0	0	$	[57]
$C_{capBillingSoftware}$	Upfront Billing Software Costs	0	0	0	$	[57]
C_{Chat}	Live Chat Setup	0	0	0	$	[36]
C_{CISInt}	CIS Integration	0	0	0	$	[57]
C_{Email}	Email Setup	0	0	0	$	[57]
$C_{E\text{-}Pay}$	E-pay Solution Integration	0	0	0	$	[57]
$C_{EquipLabor}$	Cost of Equipment and Labor			Calculated	$	
$C_{FinancingDev}$	Total Financing Costs, Developer			Calculated	$	
$C_{FinancingDev\ Lifetime}$	Total Financing Costs, Developer Over Project Lifetime			Calculated	$	
$C_{FinancingSub}$	Total Financing Costs, Subscriber			Calculated	$	
$C_{FinancingSub\ Lifetime}$	Total Financing Costs, Subscriber, Over Project Lifetime			Calculated	$	
$C_{GrossSysCapital\ Lifetime}$	Total System Gross Capital Costs Over Project Lifetime			Calculated	$	
$C_{GrossSysCapital}$	Total System Gross Capital Costs			Calculated	$	
C_{IVR}	IVR Setup	0	0	0	$	[57]

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
$C_{laborhourlyacquisition}$	Labor Rate for Acquisition Activities	31.5	38.5	35	$	[57]
C_{Land}	Cost of Land, Upfront and/or Lease			Calculated	$	
$C_{marketing}$	Marketing Materials	900	1100	1000	$	[57]
C_{media}	Media Buy	225	275	250	$	[57]
C_{mess}	Messaging	0	0	0	$	[57]
C_{OM}	Operations and Maintenece Costs			Calculated	$	
$C_{OMAnnual}$	Annual System Operations and Maintenance	12	16	14	$/kW/ year	[43]
$C_{OMBillingSoftware}$	Ongoing Billing Software Licensing Costs	0	0	0	$/year	[57]
$C_{OngoingTotalt(i)}$	Total Ongoing Costs, Indexed			Calculated	$	
$C_{OngoingTransBilling}$	Ongoing Transactional and Billing Costs			Calculated	$	
$C_{Operating}$	Total Operating Costs			Calculated	$	
$C_{OperatingLifetime}$	Total Operating Costs Over Project Lifetime			Calculated	$	
$C_{PanelLease}$/ $C_{PanelPurchasing}$	Panel Purchasing or Lease Price	567.72 (purchasing) 4.272(leasing) (PPmin - 464.8) 5.16(lease to own)	851.58 (purchasing) 6.408 (leasing) (PPmax - 697.2) 5.59(lease to own)	709.65 (purchasing) 5.34 (lease)	$	Built From Model
C_{phone}	Phone Number	0	0	0	$	[36]
$C_{PVModules}$	Cost of inverters.	$1.81	$2.22	$2.02	$/W	[58]

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
	Racking costs.					
	Balance of system costs.					
	Engineering and design costs.					
	Permitting and interconnection costs.					
	Cost of installation and labor.					
	Equipment rental and freight costs.					
	Development overhead costs.					
$C_{removal}$	Removal Cost	0	0	0	$	[36]
C_{site}	Purchase Cost of Site			0	$	[57]
$C_{SiteLease}$	Annual Lease Payments for Site			0	$/Year	[36]
$C_{siteprep}$	Site/Land Preparation Costs	0.25	0.1	0.143	$/W	[57]
C_{SOPs}	SOPs	0	0	0	$	[57]
$C_{SOPsAdmin}$	SOPs	0	0	0	$	[57]
$C_{SysRemoval}$	System Removal Costs			Calculated	$	
$C_{Templates}$	Templates and SOPs	0	0	0	$	[57]
$C_{trainingexec}$	Training Execution	0	0	0	$	[36]
$C_{TrainingExecOutreach}$	Training Execution	0	0	0	$	[57]
$C_{trainingprep}$	Training Prep	0	0	0	$	[36]
$C_{TrainingPrepOutreach}$	Training Prep	0	0	0	$	[57]
$C_{UpfrontAdmin(i)}$	Upfront Administrative and Billing Costs, Indexed			Calculated	$	
$C_{website}$	Website	0	0	0	$	[57]
CF	Capacity Factor			0.145		[47]
$inc_{CapacityPayment}$	State/Local Capacity Incentive			Calculated	$	
$inc_{GenerationPayment}$	State/Local Generation Incentives			Calculated	$	
$ITC_{CashEquivalent}$	Cash Equivalent Value of the ITC			Calculated	$	

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
$Loan_{Dev}$	Loan Amount, Developer			Calculated	$	
$Loan_{Sub}$	Loan Amount, Subscriber			Calculated	$	
$MACRS_{CashEquivalent(i)}$	Cash Equivalent Value of MACRS, Indexed			Calculated	$	
$MIRR_{Dev}$	Modified Internal Rate of Return, Developer			Calculated	%	
$MIRR_{Sub}$	Modified Internal Rate of Return, Subscriber			Calculated	%	
$N_{Cumulative}$	Cumulative Subscribers			Calculated		
$N_{Dropped}$	Dropped Subscribers			Calculated		
N_{New}	New Subscribers			Calculated		
N_{Panels}	Panels Per Subscriber			16		[57]
N/A	Subscriber Acquisition Difficulty	Easy	Difficult	Moderate		[57]
N/A	City			Mount Desert Island		[12]
N/A	Business Model			Panel Purchasing/Panel Leasing		[12]
N/A	Installation Type			Ground Mount		[57]
N/A	Ownership Entity			Non-Tax-Exempt Entity		[57]
p_{Anchor}	Percent of System Subscribed by Anchor Subscriber			20 (0 for PPTO)	%	[57]
$P_{elecsold}$	Unsusbscribed Electricity	0.02	0.06	0.04	$	[59]
$P_{elecsubTOT}$	Applicable Subscriber Credit Rate – January			0.1638	$/kWh and	[48]

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
					kWh/kW	
	Applicable Subscriber Credit Rate – February			0.1169	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – March			0.1199	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – April			0.1792	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – May			0.1814	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – June			0.1818	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – July			0.179	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – August			0.179	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – September			0.1811	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – October			0.1833	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – November			0.1782	$/kWh and kWh/kW	
	Applicable Subscriber Credit Rate – December			0.177	$/kWh and kWh/kW	

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
$p_{LoanDev}$	Percent of Costs Financed – Developer	0	100	50	%	[57]
$p_{LoanSub}$	Percent of Costs Financed – Subscriber	0	100	50	%	[36,57]
$p_{Salvage}$	Salvage Value			0	%	[36]
PBP(i)	Payback Period			Calculated	Years	
PMT(i)	PMT Equation, Indexed			Calculated		
$PRO_{SysBenefits}$	Total System Production Benefits			Calculated	$	
PV	Present Value of Annual Cash Flow			Calculated	$	
PW_{panel}	Panel Size			300	W	[36,60]
$PW_{SystemDC}$	System size - DC (grosskW)	400	1000	700	kW	[12]
PYT_{Annual}	Annual Payments			Calculated	$	
PYT_{incDev}	Total Incentive Payments, Developer			Calculated	$	
PYT_{incSub}	Total Incentive Payments, Subscriber			Calculated	$	
$PYT_{Monthly}$	Subscriber Monthly Payments			Calculated	$	
PYT_{SREC}	SREC Benefits			Calculated	$	
PYT_{Sub}	Total Subscriber Payments			Calculated	$	
$PYT_{SubPanelLeasing}$	Subscriber Payments: Panel Leasing, Ongoing			Calculated	$	
$PYT_{SubPanelPurchasing}$	Subscriber Payments: Panel Purchasing, Upfront			Calculated	$	
$PYT_{UnsubEnergy}$	Unsubscribed Energy Payments			Calculated	$	
$R_{Annualt}$	Annual Generation Rate by Year			Calculated	kWh	
R_{csub}	State/Local Capacity Subsidy			0	$/Watt	[5]
$r_{degradation}$	Annual Derate	0.05	1	0.5	%	[36]
r_{Dev}	Interest Rate – Developer			6	%	[57]
$r_{DiscDev}$	Developer Net Present Value Discount Rate	5	15	8	%	[36]

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
$r_{DiscSub}$	Subscriber Net Present Value Discount Rate)	5	15	10	%	[36]
$r_{effinverter}$	Inverter Efficiency			96	%	[47]
R_{inc}	State/Local Generation Incentives			0	$/kWh	[5]
$R_{inclump}$	State/Local Lump Sum Initiatives			0	$	[5]
r_{itc}	Federal Investment Tax Credit			26	%	[61]
$r_{Laboresc}$	Labor Rate Escalator	0	0	0	%	[57]
r_{loss}	System Losses			14.08	%	[47]
R_{Out}	Generation Output			Calculated	kWh	
R_{outTOT}	Generation Output – January	74.471	74.471	74.47	kWh/kW	[47]
	Generation Output – February	91.168	91.168	91.168	kWh/kW	
	Generation Output – March	125.231	125.231	125.231	kWh/kW	
	Generation Output – April	125.697	125.697	125.697	kWh/kW	
	Generation Output – May	137.427	137.427	137.427	kWh/kW	
	Generation Output – June	129.1	129.1	129.1	kWh/kW	
	Generation Output – July	135.172	135.172	135.171	kWh/kW	
	Generation Output – August	134.468	134.468	134.467	kWh/kW	
	Generation Output – September	113.781	113.781	113.781	kWh/kW	
	Generation Output – October	84.184	84.184	84.184	kWh/kW	
	Generation Output – November	59.896	59.896	59.896	kWh/kW	
	Generation Output – December	58.049	58.049	58.049	kWh/kW	
R_{SREC}	Solar Renewable Energy Certificates (SREC) Value			0.7	$/SREC(MWh)	[62]
r_{Sub}	Interest Rate – Subscriber	4.99	10	6.99	%	[51]
R_t	Generation Rate by term			Calculated	kWh	

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
$r_{turnover}$	Annual Subscriber Retirement/Acquisition Rate	1	2	1.5	%	[36,57]
rC_{Panel}	Panel Price/Lease Escalator			0	%	[36]
ROI_{Dev}	Return on Investment, Developer			Calculated	%	
ROI_{Sub}	Return on Investment, Subscriber			Calculated	%	
$rP_{elecEsc}$	Annual Energy and Demand Cost Increase			1.64	%	[63]
$Sub_{AnnualCumulativeRate}$	Annual Cumulative Subscription Rate			Calculated		
$Sub_{Expenditures(i)}$	Total Participant Expenditures, Indexed			Calculated	$	
$Sub_{ExpendituresLifetime}$	Total Participant Expenditures Over Project Lifetime			Calculated	$	
$Sys_{TotalPanels}$	Total Panels in System			2333		Calculated in Model
SysOwner NPV	System Owner NPV			Calculated	$	
T	System Lifetime			25	Years	[36]
T	Year, Term			0-25	Year	[36]
$t_{Billing}$	Billing Templates and Setup	18	22	20	$	[36]
t_{Chat}	Live Chat Setup	14.4	17.6	16	$	[36]
t_{CISInt}	CIS Integration	21.6	26.4	24	$	[36]
t_{Dev}	Financing Term – Developer			10	Years	[57]
t_{Email}	Email Setup	3.6	4.4	4	$	[36]
t_{E-pay}	E-pay Solution Integration	16.2	19.8	18	$	[36]
t_{IVR}	IVR Setup	5.4	6.6	6	$	[36]
t_{MACRS}	Tax Rate for Modified Accelerated Cost Recovery Systems (MACRs) Depreciation			13?	%	[64]

Symbols	Name	Min Value	Max Value	Default Value	Units	Citation
$t_{marketing}$	Marketing Materials	18	22	20	$	[36]
T_{maxsub}	Years to full subscription			1		[57]
t_{media}	Media Buy	18	22	20	$	[36]
t_{mess}	Messaging	18	22	20	$	[36]
t_{Phone}	Phone Number	1.8	2.2	2	$	[36]
$t_{SOPsAdmin}$	SOPs	7.2	8.8	8	$	[36]
$t_{SOPsOutreach}$	SOPs	10.8	13.2	12	$	[36]
t_{SREC}	Solar Renewable Energy Certificates (SREC) Lifetime			1	Years	[65]
$t_{SRECpayout}$	Solar Renewable Energy Certificates (SREC) Payout Schedule			1	Years	[65]
t_{Sub}	Financing Term – Subscriber	5	15	10	Years	[51]
$t_{Templates}$	Templates and SOPs	14.4	17.6	16	$	[36]
$t_{TrainingExec}$	Training Execution	18	22	20	$	[36]
$t_{TrainingExecOutreach}$	Training Execution	18	22	20	$	[36]
$t_{TrainingPrep}$	Training Prep	10.8	13.2	12	$	[36]
$t_{TrainingPrepOutreach}$	Training Prep	14.4	17.6	16	$	[36]
$t_{website}$	Website	25.2	30.2	28	$	[36]
$V_{Salvage}$	Salvage Value			Calculated	$	

APPENDIX C – VARIABLES INDEX

$\mathbf{C_{OngoingTotalt(i)}}$ - Summary of Admin & Transaction Costs > Subscriber Management Costs, composite value of Admin & Transaction Costs > Outreach, Sales, Sign-up Transaction, Customer Service, and Billing Administration over the course of the project lifetime (25 years) divided by System Size ($PW_{SystemDC}$)*1000. Initial values collected from Key Assumptions and Inputs > Administrative and Transactional Cost Assumptions

$\mathbf{C_{UpfrontAdmin(i)}}$ – Summary of Community Solar Business Case > Community Solar System Financials – System Owner > Upfront Administrative and Billing Costs which is a product of Admin & Transaction Costs > Total Upfront Administrative Costs (Marketing & Communications, Customer Acquisition Setup, Outreach Setup, Admin Setup, and Year 1 Subscriber Management Costs), developed from Admin & Transaction Costs > Upfront Costs > Labor Hours and OOP (Out-of-pocket) Costs, less the Year 1 Subscriber Management Costs plus Key Assumptions & Inputs > Administrative & Transactional Cost Assumptions > Upfront Billing Software Costs ($C_{capbillingSoftware}$)

$\mathbf{MACRS_{CashEquivalent(i)}}$ – Product of a complex If, Then statement that varies depending on the age of the system due to MACRs five-year depreciation (Year 1 – 20%, Year 2 – 32%, Year 3 – 19.2%, Year 4 – 11.52%, Year 5 – 11.52%, Year 6 – 5.76%)

PBP(i) – The payback period calculation in this model seemed to be faulty, in part by neglecting to utilize a proper formula and instead uses a complex If, Then statement to generate this output.

PMT(i) – Used in the Community Solar Business Case >Community Solar System Financials – System Owner > Project Financing > Annual Payments as an Excel calculation of the payments for a loan or annuity with constant payments and a constant interest rate as part of an IF, Then statement, the inputs for this PMT equation were Key Assumptions & Inputs > Financing Assumptions > Developer Interest Rate (r_{Dev}), Developer Financing Term (Years) (t_{Dev}), Developer Percent of Costs Financed ($p_{LoanDev}$) and Community Solar Business Case > Community Solar System Financials – System Owner > System Capital > Cost of Land (upfront and/or lease) (C_{Land}) and Equipment and Labor ($C_{EquipLabor}$). A PMT equation was also used in Community Solar Business Case > Subscriber Community Solar System Financials > Project Financing > Monthly Payments using Key Assumptions & Inputs > Solar Project Financing Options > Subscriber Interest Rate (r_{Sub}), Financing Term (years) (t_{Sub}), and Community Solar Business Case > Subscriber Community Solar System Financials > Project Financing > Loan Amount ($Loan_{Sub}$).

$Sub_{Expenditures(i)}$ – Total Community Solar Business Case > Subscriber Community Solar System Financials > Participant Expenditures. Complex, two part If, Then statement that cannot be easily condensed into an equation.

APPENDIX D – COMMUNITY SOLAR BUSINESS CASE TOOL

- CSBCT Excel File
- Elevate Energy Website - https://www.elevateenergy.org/programs/solar-energy/community-solar/communitysolarbusinesscasetool/

APPENDIX E – OUTPUT SNAPSHOTS

Lease-to-Own (WO/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.16
Subscriber NPV:	$8,989
System Owner NPV:	$105,711
Subscriber MIRR:	N/A
System Owner MIRR:	6%
Subscriber ROI:	192%
System Owner ROI:	40%
System Owner Payback Period:	7.5 y
Total System Cost (Per Subscriber):	$10,878.07
Years to System Ownership (Subscriber):	10 y

Max

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.59
Subscriber NPV:	$1,129
System Owner NPV:	$246,288
Subscriber MIRR:	28.07%
System Owner MIRR:	14%
Subscriber ROI:	113%
System Owner ROI:	5%
System Owner Payback Period:	0 y
Total System Cost (Per Subscriber):	$13,091.66
Years to System Ownership (Subscriber):	12 y

Default

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.34
Subscriber NPV:	$3,496
System Owner NPV:	$71,631
Subscriber MIRR:	N/A
System Owner MIRR:	9%
Subscriber ROI:	153%
System Owner ROI:	17%
System Owner Payback Period:	7.7 y
Total System Cost (Per Subscriber):	$11,802.10
Years to System Ownership (Subscriber):	11 y

Panel Purchasing (True Ownership) (WO/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	N/A
Subscriber NPV:	N/A
System Owner NPV per Owner:	$7,705
Subscriber MIRR:	N/A
System Owner MIRR:	8%
Subscriber ROI:	N/A
System Owner ROI:	166%
System Owner Payback Period:	7.7 y
Subscriber Payback Period:	0 y

Max

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	N/A
Subscriber NPV:	N/A
System Owner NPV per Owner:	$1,114
Subscriber MIRR:	N/A
System Owner MIRR:	13%
Subscriber ROI:	N/A
System Owner ROI:	37%
System Owner Payback Period:	0 y
Subscriber Payback Period:	0 y

Default

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	N/A
Subscriber NPV:	N/A
System Owner NPV per Owner:	$3,329
Subscriber MIRR:	N/A
System Owner MIRR:	11%
Subscriber ROI:	N/A
System Owner ROI:	79%
System Owner Payback Period:	9.9 y
Subscriber Payback Period:	0 y

Panel Purchasing (w/ Developer) (WO/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	$568
Monthly Panel Lease Price:	N/A
Subscriber NPV:	$8,641
System Owner NPV:	$46,058
Subscriber MIRR:	10.30%
System Owner MIRR:	5%
Subscriber ROI:	228%
System Owner ROI:	2%
System Owner Payback Period:	0.9 y
Subscriber Payback Period:	8.7 y

Max

Output Snapshot*	
Panel Purchase Price:	$852
Monthly Panel Lease Price:	N/A
Subscriber NPV:	($3,410)
System Owner NPV:	$1,450,168
Subscriber MIRR:	9.27%
System Owner MIRR:	14%
Subscriber ROI:	39%
System Owner ROI:	-2%
System Owner Payback Period:	0 y
Subscriber Payback Period:	18.2 y

Default

Output Snapshot*	
Panel Purchase Price:	$710
Monthly Panel Lease Price:	N/A
Subscriber NPV:	$744
System Owner NPV:	$407,395
Subscriber MIRR:	10.30%
System Owner MIRR:	8%
Subscriber ROI:	120%
System Owner ROI:	1%
System Owner Payback Period:	0.3 y
Subscriber Payback Period:	12.2 y

Panel Leasing (WO/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$4.27
Subscriber NPV:	$5,646
System Owner NPV:	$288,493
Subscriber MIRR:	N/A
System Owner MIRR:	7%
Subscriber ROI:	54.83%
System Owner ROI:	97%
System Owner Payback Period:	9.3 y
Subscriber Payback Period:	0 y

Max

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$6.41
Subscriber NPV:	($972)
System Owner NPV:	$638,711
Subscriber MIRR:	-100%
System Owner MIRR:	17%
Subscriber ROI:	-9.46%
System Owner ROI:	56%
System Owner Payback Period:	0 y
Subscriber Payback Period:	20 y

Default

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.34
Subscriber NPV:	$1,016
System Owner NPV:	$470,293
Subscriber MIRR:	N/A
System Owner MIRR:	11%
Subscriber ROI:	16.66%
System Owner ROI:	72%
System Owner Payback Period:	7.7 y
Subscriber Payback Period:	0 y

Lease-to-Own (W/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.16
Subscriber NPV:	$8,989
System Owner NPV:	$106,049
Subscriber MIRR:	N/A
System Owner MIRR:	6%
Subscriber ROI:	192%
System Owner ROI:	40%
System Owner Payback Period:	7.5 y
Total System Cost (Per Subscriber):	$10,878.07
Years to System Ownership (Subscriber):	10 y

Max

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.59
Subscriber NPV:	$1,129
System Owner NPV:	$247,060
Subscriber MIRR:	28.07%
System Owner MIRR:	14%
Subscriber ROI:	113%
System Owner ROI:	5%
System Owner Payback Period:	0 y
Total System Cost (Per Subscriber):	$13,091.66
Years to System Ownership (Subscriber):	12 y

Default

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.34
Subscriber NPV:	$3,496
System Owner NPV:	$72,207
Subscriber MIRR:	N/A
System Owner MIRR:	9%
Subscriber ROI:	153%
System Owner ROI:	17%
System Owner Payback Period:	7.7 y
Total System Cost (Per Subscriber):	$11,802.10
Years to System Ownership (Subscriber):	11 y

Panel Purchasing (True Ownership) (W/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	N/A
Subscriber NPV:	N/A
System Owner NPV per Owner:	$7,709
Subscriber MIRR:	N/A
System Owner MIRR:	8%
Subscriber ROI:	N/A
System Owner ROI:	166%
System Owner Payback Period:	7.7 y
Subscriber Payback Period:	0 y

Max

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	N/A
Subscriber NPV:	N/A
System Owner NPV per Owner:	$1,118
Subscriber MIRR:	N/A
System Owner MIRR:	13%
Subscriber ROI:	N/A
System Owner ROI:	37%
System Owner Payback Period:	0 y
Subscriber Payback Period:	0 y

Default

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	N/A
Subscriber NPV:	N/A
System Owner NPV per Owner:	$3,333
Subscriber MIRR:	N/A
System Owner MIRR:	11%
Subscriber ROI:	N/A
System Owner ROI:	79%
System Owner Payback Period:	9.9 y
Subscriber Payback Period:	0 y

Panel Purchasing (w/ Developer) (W/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	$568
Monthly Panel Lease Price:	N/A
Subscriber NPV:	$8,641
System Owner NPV:	$46,396
Subscriber MIRR:	10.30%
System Owner MIRR:	5%
Subscriber ROI:	228%
System Owner ROI:	2%
System Owner Payback Period:	0.9 y
Subscriber Payback Period:	8.7 y

Max

Output Snapshot*	
Panel Purchase Price:	$852
Monthly Panel Lease Price:	N/A
Subscriber NPV:	($3,410)
System Owner NPV:	$1,450,940
Subscriber MIRR:	9.27%
System Owner MIRR:	14%
Subscriber ROI:	39%
System Owner ROI:	-2%
System Owner Payback Period:	0 y
Subscriber Payback Period:	18.2 y

Default

Output Snapshot*	
Panel Purchase Price:	$710
Monthly Panel Lease Price:	N/A
Subscriber NPV:	$744
System Owner NPV:	$407,970
Subscriber MIRR:	10.30%
System Owner MIRR:	8%
Subscriber ROI:	120%
System Owner ROI:	1%
System Owner Payback Period:	0.3 y
Subscriber Payback Period:	12.2 y

Panel Leasing (W/RECs):

Min

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$4.27
Subscriber NPV:	$5,646
System Owner NPV:	$288,83 1
Subscriber MIRR:	N/A
System Owner MIRR:	7%
Subscriber ROI:	54.83%
System Owner ROI:	97%
System Owner Payback Period:	9.3 y
Subscriber Payback Period:	0 y

Max

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$6.41
Subscriber NPV:	($972)
System Owner NPV:	$639,483
Subscriber MIRR:	-100%
System Owner MIRR:	17%
Subscriber ROI:	-9.46%
System Owner ROI:	56%
System Owner Payback Period:	0 y
Subscriber Payback Period:	20 y

Default

Output Snapshot*	
Panel Purchase Price:	N/A
Monthly Panel Lease Price:	$5.34
Subscriber NPV:	$1,016
System Owner NPV:	$470,868
Subscriber MIRR:	N/A
System Owner MIRR:	11%
Subscriber ROI:	16.66%
System Owner ROI:	72%
System Owner Payback Period:	7.7 y
Subscriber Payback Period:	0 y

AUTHOR'S BIOGRAPHY

Abigayle I. Hargreaves was born and raised in Concord, California, a suburb of the San Francisco Bay Area and graduated from Clayton Valley Charter High School in 2016. She majored in Ecology and Environmental Science with a double minor in Sustainable Food Systems and Renewable Energy: Economics and Policy. Through college at the University of Maine she was an active member of the Pride of Maine Black Bear Marching Band and the Screamin' Black Bears Pep Band as well as being a member of Tau Beta Sigma, the National Honorary Band Sorority.

After graduation, Abigayle is planning on transferring to Idaho State University to complete a second Bachelor's degree in Nuclear Engineering in pursuit of her goal to find a clean, reliable energy source that can be used to resolve the world's energy burden.