

GREEN FRONT

Understanding
the Potential
for Community
Solar Power in

**HIGHLAND
PARK**

Acknowledgements

This report was written by Dow Sustainability Masters Fellows in partnership with Soulardarity. Thanks to Shimekia Smith, Soulardarity; Maria Thomas, Soulardarity; Jackson Koeppel, Soulardarity; Grace Brosnan; Soulardarity; Margaret Woolridge, Dow Sustainability Fellows Program; Nicole Berg, Graham Institute of Sustainability; Tony Reames; School for Environment and Sustainability; David Brosch, University Park Solar Co-op; Lisa Stolarski and Brian Donovan, the Cooperation Group; Rick Bunch, Southeast Michigan Regional Energy Office

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December 2017



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1. Executive Summary

Urban, poverty-stricken, and disinvested communities are struggling to reliably and affordably secure the energy services they need. At the same time, the moral and economic case for distributed renewable energy technologies promises transformative change for how electricity is created and consumed. Together, these trends enable a future where communities exercise agency over the way their energy is produced and consumed. Soulardarity, a grassroots community organization centered in Highland Park, Michigan, is working to make this vision of energy democracy a reality. The Dow Sustainability Fellowship team partnered with Soulardarity to assess the feasibility of installing a community-owned and operated solar project in Highland Park.

Community solar projects—where community members co-invest in an array of solar panels, and each receive benefits as the solar project generates electricity—are taking off around the country as the price for solar continues to decline.ⁱ They're proving to be a viable solution for expanding solar access to the estimated 50% of households who wouldn't otherwise be able to install solar due to renters status, inappropriate roof material, or other factors.ⁱⁱ But there are substantial barriers to community solar in Highland Park. State policies disallow group net metering and discourage third parties from being able to operate their own solar projects.

We propose that Soulardarity considers a *community power purchase agreement (community PPA)*. Rather than working directly with utility companies to manage a community solar program, a community group might buy solar panels, then partner with a host institution—like a church or a community center—and install the solar project onsite. Then the *host* institution pays the *owner*—in this case, the community group—for the energy from the solar panels. This way, the community institution gets cheaper and cleaner power, and the community group can raise money for future projects. While community PPAs are a relatively new concept, the model has already seen success at *Maryland's University Park Solar Co-Op*.

While a community PPA is logistically feasible, it must also be *economically* feasible in Highland Park. We created a Community Solar Calculator, which models the technical, economic, and financial details of a community solar project based on user inputs. Using the Community Solar Calculator, Soulardarity can model the costs of a project, the amount of roof space needed, and the economic returns for any potential solar project. Based on preliminary research in Highland Park,

we chose three community institutions as case studies for the calculator: Nandi's Knowledge Cafe, Parker Village, and Labelle Towers.

Our case studies found that while results vary substantially based on the chosen financing model, installed cost, markdown to project host, and discount rate, community solar projects have the potential to be economically viable at low-cost financing. While launching an innovative, long-term partnership such as a community PPA requires careful legal and accounting consideration, our research indicates that the basic economics are sound: a community PPA in Highland Park will save a Highland Park institution money on their utility bills while funding Soulardarity's mission.

2. Background

2.1 Highland Park Context

2.1.1 Highland Park

Highland Park is a community in Southeast Michigan, surrounded by the City of Detroit. Its population peaked around 52,000 in the 1930's with the early automotive industry, as both Ford and Chrysler were headquartered in the city. Since the 1930's Highland Park's population has declined. The population of Highland Park is now estimated at around 10,888 (2016 population estimate).ⁱⁱⁱ In the late 1900's Ford and Chrysler moved their headquarters instigating decades of economic decline in the community. According to The American Community Survey 2011-2015, 49.3% of the population lives below the poverty line, a number significantly above the national average of 14.7%.^{iv} As seen in Figure 1, median income in Highland Park is \$17,250 (the median property value is \$36,000 with 36% of residents owning a home).^v

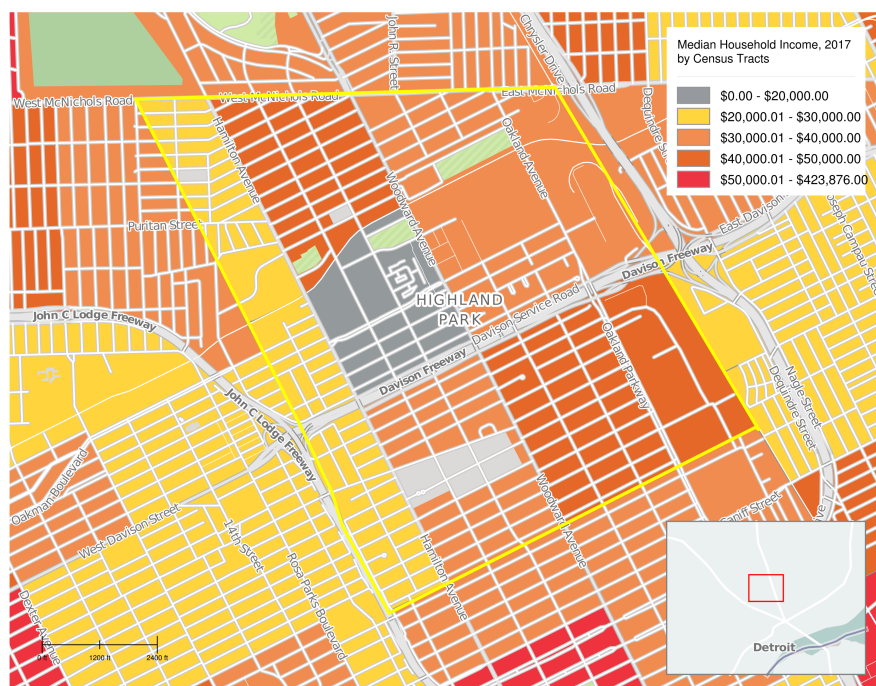


Figure 1: Median Income In Highland Park (city outlined in yellow)

According to The American Community Survey 2011-2015, 91.9% of the residents (10,203 +/- 274) identify as Black. 18.8% of the residents are between 5-18 years of age and 14.9% are between 45-54 years of age.^{vi}

2.1.2 About Our Client: Soulardarity

Soulardarity's mission is *to build a brighter future in Highland Park with education, organizing, and people-powered clean energy*. Soulardarity is a membership-based 501c3 non-profit working to install solar-powered streetlights, save money on energy bills, and work together with neighboring communities to build a just and equitable energy system for all.^{vii}

The organization was founded by Jackson Koeppel in 2011 in response to DTE Energy's repossession of over 1,000 streetlights from Highland Park. Soulardarity installed a pilot solar light in 2012, and has since worked with Highland Park on a proposal to erect 200 solar streetlights around the city. In the process, they've grown to over 120 members—a significant portion of Highland Park's 10,888 residents. Their vision and purpose has expanded to not simply replacing streetlights but also to reducing energy burdens on their community.

Understanding the Potential for Community Solar in Highland Park

2.2 Solar Resource Potential in Highland Park

Highland Park could pursue several types of renewable energy, but based on the interest of our client, Soulardarity, and scope of the project, we assumed that solar power would be employed. To confirm that Highland Park had sufficient solar resources, we conducted an initial solar energy assessment. We used several software programs to determine the total amount of solar energy possible through both rooftop panel installation and vacant lot conversion to ground solar panel systems. Google's Project Sunroof estimates that 68% of Highland Park's buildings are viable for rooftop solar panels, and that 83,000 MWh of AC electricity could be generated annually if every available rooftop had solar panels installed.^{viii} Figure 2 and 3 depict Project Sunroof's output for Highland Park specifically.

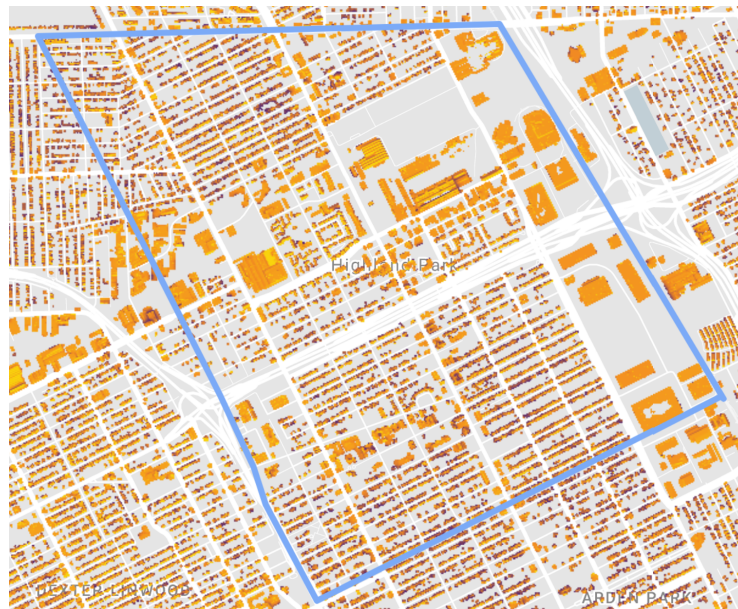


Figure 2: Google's Project Sunroof rooftop solar potential for Highland Park, MI

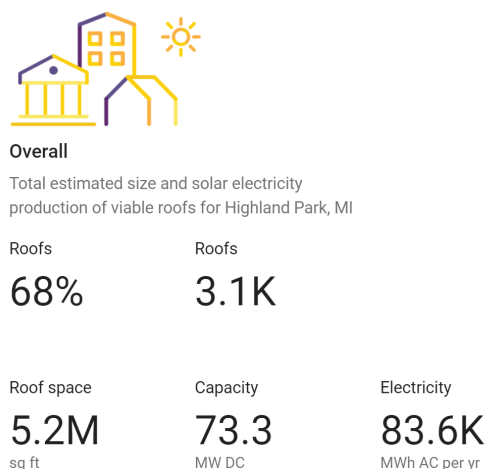


Figure 3: Google Project Sunroof Electricity estimations for Highland Park, MI

In addition to rooftop potential, we assumed that ground solar panel systems could be installed on vacant lots throughout Highland Park. The Motor City Mapping Highland Park Tool was used to find the total number of vacant lots available for solar power generation in Highland Park.^{xi} As seen in Figure 4, vacant lots account for approximately 30% of all lots in Highland Park. To deliver a rough estimate, we assumed that 30% of total land area within Highland Park consisted of vacant lots. Using this method, an assumption of 20% panel efficiency and an average solar irradiation of 4.41 kWh/m²/day, we determined that the total electricity available from vacant lot solar panel systems could reach approximately 707,400 MWh/yr.

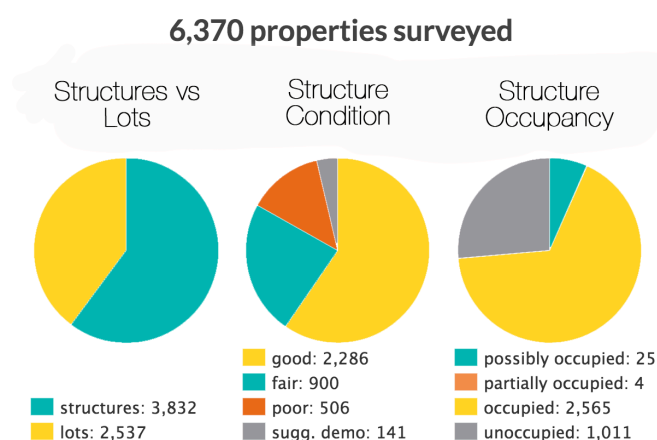


Figure 4: Output of Motor City Tool, with vacant lots in Highland Park highlighted.

Understanding the Potential for Community Solar in Highland Park

The total average annual energy demand in Highland Park for residential and commercial sectors is approximately 86,200 MWh, suggesting that if all viable rooftops in Highland Park had solar panels installed, then 96% of total residential and commercial energy demand could be met.^{xiii} Vacant lot solar panel systems could supply almost ten times the energy that Highland Park's residential and commercial sectors currently demand.

3. Problem Definition & Objectives

Low-income households tend to pay a higher portion of their income toward their utility bills. For the poorest households in Detroit, the percentage paid toward energy can reach over 15% of total income.^{xiv} High energy burdens such as these can crowd out other payments, displace investments, or force households to choose between heating their home and other needs. Similar research has shown a discrepancy in this energy burden between white households and households of color.

As Soulardarity's membership has grown, their mission has expanded to include alleviating community energy burden. Soulardarity members believe they are being mistreated by the utilities (DTE Energy) and are interested in becoming energy sovereign. They asked us to do two things, **1) get a better sense of the problem and potential need for solar energy to address financial burden and injustice in the community through a community survey, and 2) perform a feasibility study of bringing community solar to Highland Park.** To do this, a Community Solar Calculator was developed to estimate solar capacity and rate of return on investment for specific sites. This will be discussed in greater detail in Section 5.

On July 9, 2017 Soulardarity volunteers, led by Intern Grace Brosnan, walked the neighborhoods of Highland Park to conduct a survey about the resident's experiences with energy utilities (*Appendix A: Survey Questions* and *Appendix B: Survey Results* have been redacted from the public edition of this report). The purpose of the survey was to gain a better understanding of the need for community solar from both an economic and social justice perspective. Specifically, according to "Lights Out In The Cold" Environmental and Climate Justice Program NAACP, in Michigan^{xv}:

- Notice of disconnections must be provided by phone or mailing. Phone notice must be attempted two times at least one day before the scheduled disconnection. Mailed notice must be sent at least five days before the scheduled disconnection.

- November 1- March 31 there should be no disconnections for customers 65 years or older or for eligible low-income customers with entry into a payment plan where customer makes monthly payments equal to 7% of the annual bill.
- Customers with a medical certification can postpone disconnection for not more than 21 days. Certification may be renewed up to a total postponement of 63 days in a 12-month period. A utility is not required to grant postponements totaling more than 126 days per household.

The survey used convenience sampling and included 61 Highland Park residents. Given this was not a random sample, we cannot assume the responses truly represent the community but they do provide some insight into the utility burden. Specifically during the survey process, interviewers knocked on doors in the community and found they could not enter some apartment buildings, this resulted in a sample that skewed toward homeowners.

With that in mind, nearly 40% of respondents did express trouble paying energy (electric or gas) bills. Several respondents also self-reported illegal shut-offs as outlined above (Soulardarity leadership is following up on these instances). The survey suggests, although not statistically significant, that people of color experience more energy burden. Lastly, the survey found that people are still very concerned about the limited streetlights in Highland Park.

4. Community Solar and Energy Democracy in Highland Park

The results of Soulardarity's summer utility shutoff survey confirm what Highland Park residents and Soulardarity had already suspected: meeting energy needs is placing a heavy burden on the time, health, and budgets of Highland Park residents, and citizens have no say in how their community provides its energy. The removal of Highland Park's streetlights can be seen as a direct manifestation of the disconnect between the assets and concerns of the Highland Park community and the way that energy is produced, distributed and spent. Through solar streetlighting, Soulardarity is forwarding its core values—community ownership and energy democracy, or the ability for community members to have a say in meeting their energy needs. Streetlighting alone, though, does not solve Highland Park residents' energy burden. Soulardarity's ambition is to create and provide community-owned, community-controlled, pollution-free energy for Highland Park.

Solar-powered electricity projects allow Soulardarity to meet that ambition. Because solar energy does not require any fuel, solar projects are completely self-reliant, and Soulardarity's energy would truly be generated and used in Highland Park. With solar prices falling year after year, communities around the country and world are investing in solar energy.^{xvi} And while solar projects have historically been inaccessible to households without an appropriate roof or disposable income, community solar projects are breaking down those barriers. Community solar projects are centralized solar projects where many community members can invest in and benefit from the benefits of solar energy. Especially in a community where years of disinvestment have eroded available housing stock, community solar projects unlock energy independence and democracy for Highland Park.

This report aims to provide a guide for Soulardarity and Highland Park regarding what kinds of projects currently exist and what is feasible in Highland Park. We will do that by establishing criteria for a just and effective project, proposing a model for a Soulardarity community solar project, evaluating its feasibility on technical, policy, and economic grounds, and finally providing a roadmap of how to make that project a reality. With this report, Highland Park will be better equipped than ever to pursue energy democracy.

4.1 What does a Just & Effective Community Solar Project Look Like?

To better understand what kinds of solar projects will work for Highland Park, the following criteria were established.^{xvii} A just, effective community solar project for Highland Park will:

- **Contribute to energy democracy.** Building community capacity and independence is core to the mission of Soulardarity. Community solar models that are administered by local utilities or rely heavily on corporate investment and ownership do not fulfill the primary goal of establishing energy democracy.
- **Be technically & economically feasible.** Solar energy projects are inextricably linked to electricity markets, and building a community's capacity to provide their own energy means ensuring that there are financial returns on community investments.
- **Be appropriate for Highland Park's context.** Michigan state energy policy does not allow any kind of remote net metering—which means customers can only benefit from a solar project if it is co-located on their property. The implications of Michigan's net metering laws will be a major consideration.

We conducted a survey of community solar business models and resources to determine which might work best to fulfill the criteria for Soulardarity. For more information on community solar business models and case studies, see Section 8: Making Community Solar a Reality.

4.2 Proposed Business Model: Community Power Purchase Agreement (PPA)

Business models for community solar projects must define two terms: a) How the solar project generates value and b) How community members can invest. While many community solar projects are actively managed by utilities, Soulardarity's goal of increasing energy democracy means pursuing a community-owned, managed, and administered program. Essentially, owning and managing the solar project can be viewed like a business: Soulardarity invests money into equipment, then sells the energy output to customers in Highland Park. Fortunately, this approach has precedents, like the *University Park Solar Cooperative in University Park, Maryland*.^{xviii}

We recommend that Soulardarity members create a Special Purpose Entity, like a co-op, partnership, or LLC, to own and manage a solar project. And because remote net metering is not possible (and individually negotiating compensation for electricity from a utility is not likely to be successful for a single project), Soulardarity should partner with a Highland Park-based Project Host with the space and energy demand appropriate for a solar array. The Project Host would pay the Special Purpose Entity (a.k.a. Soulardarity) a flat rate for the electricity generated from the solar project, then either use it on-site or export it back to the utility through net metering. The negotiated agreement between the Special Purpose Entity and Project Host is often called a Power Purchase Agreement (often shortened to PPA), and this model will be referred to in this report as a Community PPA. A diagram tracing the flows of energy and economic value is shown below in Figure 5.

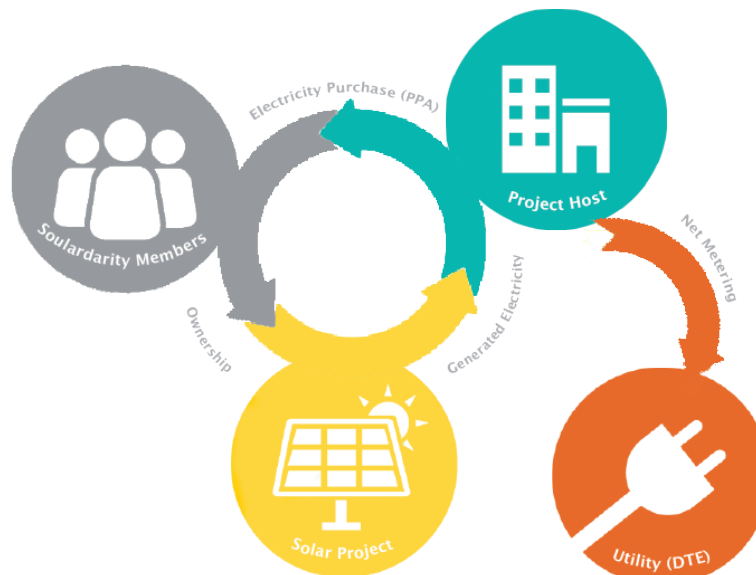


Figure 5: Community Public-Private Partnership Model

For further discussion of the Community PPA business model, refer to "[A Guidebook for Community Solar Programs in Michigan Communities](#)" from the Great Lakes Renewable Energy Association and "[A Guide to Community Solar: Utility, Private, and Non-profit Project Development](#)" from the National Renewable Energy Laboratory."

5. Methods: Community Solar Calculator

In order to assess the technical and economic feasibility of a community PPA solar project in Highland Park, we created a Community Solar Calculator. The design, including input and output descriptions, and assumptions of the Community Solar Calculator are outlined in Appendix C.

5.1 Inputs

User inputs include:

- Site Considerations
 - Option to define project size through available roof area or required project capacity
 - Roof area in square footage
 - Required project capacity in kW, AC
- Project host considerations
 - Host building use type (food service, education, religious, lodging, office)
 - Building square footage

- Host utility service type (residential or commercial)
 - Utility rate for electricity
- Technical Requirements
 - Panel type (economic, standard or premium)
 - Option to include a battery
- Project Finances
 - Discount rate (including inflation)
 - Additional grant funding
- Partnership considerations
 - Discount % on retail for host

5.2 Outputs

After applying the appropriate inputs, the output tab of the Community Solar Calculator reports:

- Annual energy produced (both DC and AC).
- The solar panel system size in kW DC
- Estimated load of the building
- Capital costs
- 25-year cash flow and project net present value
- Federal Investment Tax Credit (ITC) available

6. Results: Case Studies & Sensitivity Analysis

Our team used the Community Solar Calculator to assess three potential community solar sites in Highland Park: Parker Village (a community building), Labelle Towers (a senior living home), and Nandi Knowledge Cafe (a local gathering place and eatery). These sites were selected because of Soulardarity's personal interest in these locations, existing partnerships, and/or the high energy demand of these locations and their ability to take advantage of the various tax incentives when installing a commercial size PV array and partnering with a non-profit organization.

6.1 Parker Village

Parker Village is a community initiative spearheaded by one of the board members of Soulardarity. Parker Village is hoping to repurpose an abandoned space in Highland Park into a community center fully powered by renewables. The village will host businesses, offices and family homes.

Parker Village is already a Soulardarity partner, and development of the community center and office space is currently underway.

Parker Village Input Assumptions:

- One story high office space
- Building square footage the same as the roof square footage
- National average electricity demand (Michigan typically has higher electricity usages due to seasonal changes)
- Standard panels
- Battery included
- 4% discount rate

6.2 Labelle Towers

Labelle Towers is a 10-story apartment building located in Highland Park specifically designed for senior living. Due to its large square footage, it has a high energy demand. Labelle Towers is operated by a non-profit organization, so while the financial aspect will differ from the other two sites, we wanted to include a space that is used for lodging to determine how it affects the decisions of planning for community solar.

Labelle Towers Input Assumptions:

- Modeled energy demand for one story of the complex
- Building square footage the same as available roof square footage
- Demand is only for organizational electricity use (tenant is responsible for utilities)
- Standard panels
- Battery included
- 4% discount rate

6.3 Nandi's Knowledge Cafe

Nandi's Knowledge Cafe is a local eatery and early Soulardarity partner. The energy demand of Nandi's will not resemble the energy profile of either Parker Village or Labelle Towers. Nandi's, while being the smallest location of the three, has a significant energy demand because they serve

food. As a for-profit business Nandi's Knowledge Café will be able to benefit from the tax incentives offered by the government for solar development.

Nandi's Input Assumptions:

- Available roof space assumed to be entire building roof, of which Nandi's Knowledge Café represents only a portion
- Standard panels
- Battery included
- 4% discount rate

6.4 Calculator Outputs

The graph below shows the energy output of the array for each of the three case study locations. As seen in Figure 6, in each of the three cases, we maximize the use of the roof space, but it is unable to meet all the estimated demand of the locations.

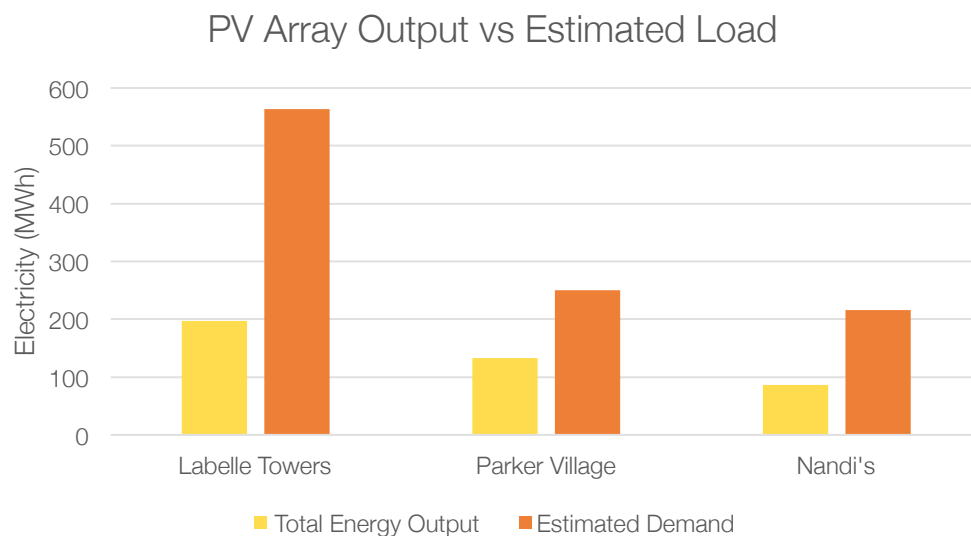


Figure 6: The three case study locations of Labelle Towers, Parker Village, and Nandi Knowledge Café, and the estimated PV output and energy demand.

Figure 7 shows the capital cost of each system assuming that the location went with the standard modules, a battery storage system, and utilized their entire roof space. Capital costs include the solar panels, battery, inverter, balance of systems (BOS), installation, permitting and licensing.

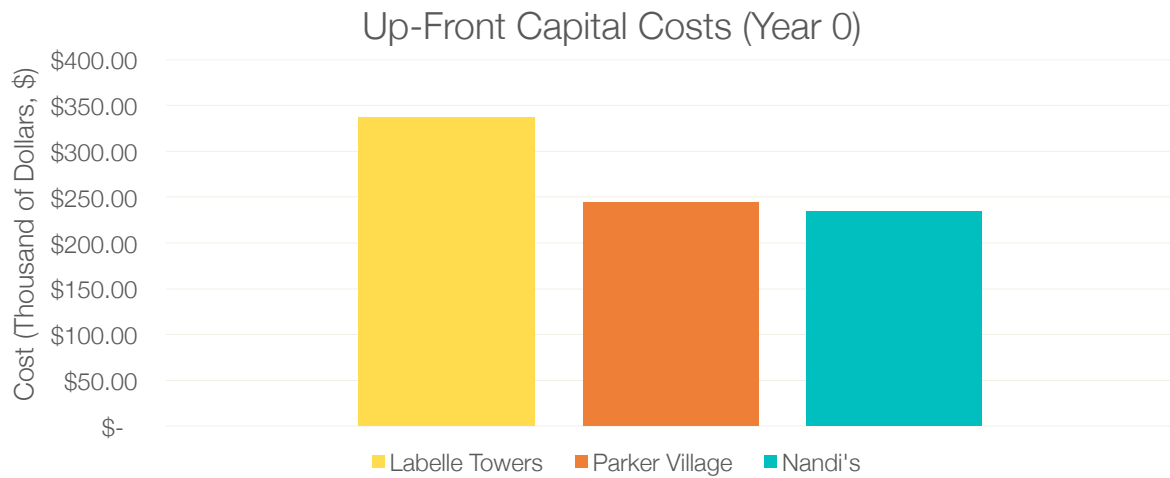


Figure 7: The total cost of each case study for Labelle Towers, 134 kW, Parker Village, 91 kW, and Knowledge Cafe, 59 kW system including battery, inverter, installation, and BOS.

6.5 Sensitivity Analysis

A sensitivity analysis was conducted on the amount of roof space utilized for PV array and the social discount rate. Figure 9 shows that as roof space coverage decreases, power generation decreases.

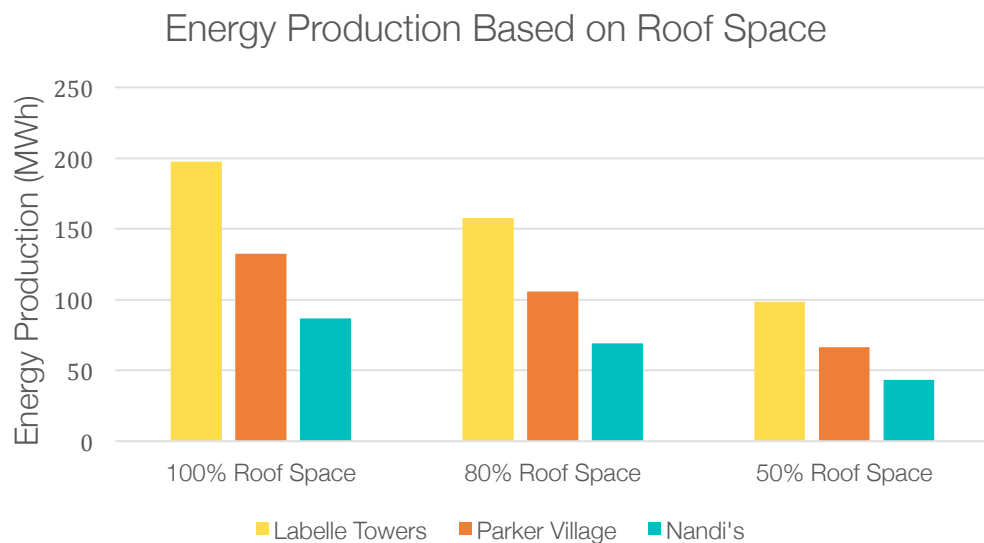


Figure 9: A sensitivity analysis on the effect of amount of roof space utilized for solar PV array on total energy production per year

Figure 10 shows that the 25 year net present value (NPV) of the solar project decreases as the social discount rate increases. If the calculator assumes a 7% discount rate (considered high by EPA standards), every location would have a negative NPV.

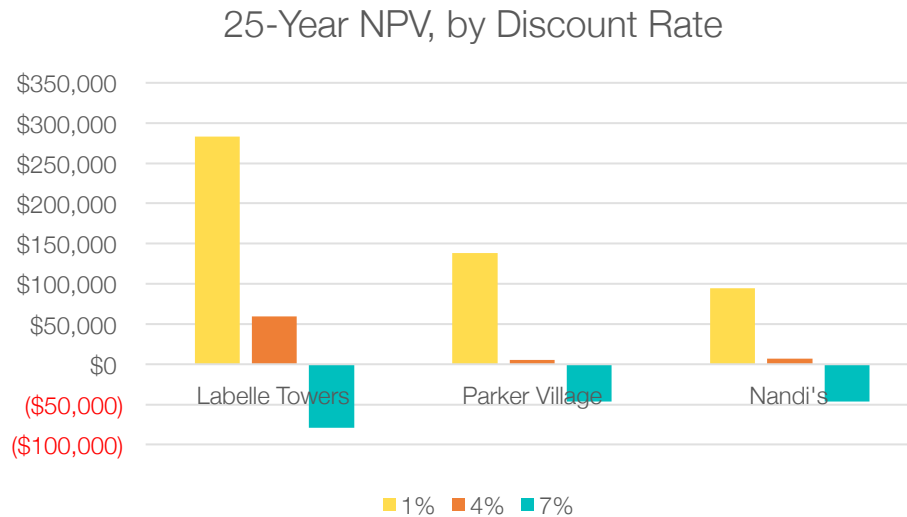


Figure 10: NPV Sensitivity analysis

7. Policy Considerations for Community Solar

Solar projects are complex propositions that interact with financial and tax policy, clean energy incentives, rules on issuing securities, local zoning ordinances, and utility operations. As such, understanding the nature of these policies and how they pose barriers and opportunities to solar projects is critical to assessing the feasibility of community solar in Highland Park. This section provides an overview of the relevant policies at the federal, state, and utility level that will interact with the details of a community solar project, and offers guidelines on how to best take advantage of opportunities and avoid barriers. This section is not meant to be a comprehensive treatment, and any community solar project should regularly consult a lawyer and accountant to ensure that the project is set up appropriately.

7.1 Federal Policy

7.1.1 Tax Incentives

Tax incentives are the largest incentive available to solar projects, adding up to over 30 percent of the project's installed cost.^{xix} The two major tax incentives are the Commercial Investment Tax Credit (ITC) and the Modified Accelerated Cost Recovery System (MACRS). The ITC allows investors

to take up to 30% of the installed cost of a system off of their tax liability, and MACRS allows 5-year depreciation of the project for tax reasons.^{xx}

These tax incentives are not refundable, which means that entities can only take advantage of them to reduce their tax burden. They're also restricted to taxes on 'passive' income that doesn't come from wages or salary.^{xxi} To take full advantage of these opportunities, Soulardarity should partner with a financial institution or other partner with a high passive tax burden. Partnerships with financial investors take multiple forms, but usually involve the financial partner taking full or majority ownership of a project for the initial years of operation, then 'selling back' the project to the administrators after tax incentives have been capitalized. This process adds substantial complexity to the finances of the project, but can substantially decrease its total cost (usually by over 30%). Soulardarity should decide whether partnering with a financial institution for capitalizing on tax liability is in line with the goals of the solar project.

7.1.2. Federal (and, if applicable, state) Securities Regulation.

Special purpose entities that sell interests or equity stakes in an asset (e.g. a solar project) technically qualify as securities, and as such there are policies that govern how and why securities can be sold.^{xxii} Exemptions to securities regulation are possible, and require a cap on the total amount of investors (usually 35) and their geographic location (the same state). It's recommended that Soulardarity's special purpose entity take advantage of this exemption to reduce the time, effort, and expertise required for project management.

7.2. State Policy

7.2.1. Renewable Portfolio Standard (RPS) and Renewable Energy Certificates (RECS)

Michigan's Renewable Portfolio Standard requires Michigan electricity to be made up of at least 15% renewable electricity by 2021.^{xxiii} To track which energy sources are renewable, the state of Michigan certifies and issues Renewable Energy Certificates (RECs) to the owners of renewable energy generators. Then, distribution utilities are responsible for producing or purchasing enough RECs to meet the 15% RPS threshold. The result is a REC market where project owners sell their certificates of renewable energy to utility companies.^{xxiv}

Soulardarity's community solar project would qualify for REC certification, and the project would generate one full REC per 1,000 kWh generated. Hypothetically, Soulardarity could sell their

renewable energy credits to utilities to meet their renewable portfolio standard; However, market prices for RECs are very low due to the low RPS standard and the proliferation of wind power in Michigan. Most solar project owners do not sell their RECs; the cost of entering the REC market is greater than the value generated by selling the certificates.^{xxv} Changes to the state RPS policy, like increasing from 15% or including a carve-out specifically for solar energy, might increase the project's REC value in the future.

7.2.2. Net Metering

Net metering is a utility practice that allows property owners using distributed energy to 'sell back' the electricity they produce when energy produced on-site exceeds their demand. Net metering practices are mandated by state law, but implementation across the state varies by utility. Net metering is generally only available when utility customers consume more energy than they produce each year.^{xxvi}

The state of Michigan and DTE allow for 'true net metering,' or paying customers for their energy at full retail value, for projects that are up to 20 kW in capacity. For projects with greater than 20 kW of capacity, 'modified net metering' applies. 'Modified net metering' reduces the value of energy when sold back to the grid by 40%. In terms of project economics, energy produced from a large solar project and used on-site still displaces a full retail-rate kilowatt-hour, but the decreased value applies when sold back to the grid.^{xxvii} As a result, accurately determining the revenue of the project becomes more uncertain. Even sites with a large amount of demand may not require high power during the afternoon, when solar projects generate the most energy.

At 150 kW of capacity or greater, projects must pay 'standby charges' when they're not generating electricity. Because generation timing is not controlled by the operator, standby charges make solar projects above the capacity cap prohibitively expensive.

7.2.3. Property Taxes

As a valuable asset, installed solar properties typically increase property taxes for the property they're installed on. Although many states have exemptions for on-site clean energy projects, Michigan's exemption for on-site clean energy projects lapsed in the 1970s. In some cases, city-level tax policies may also implement an exemption, but there is some uncertainty about how property tax would be calculated when the project host and project owner are different entities.^{xxviii} In any

case, property tax increases should be folded into financial calculations done for a prospective solar project.

8. Making Community Solar a Reality

The initial portion of the research project assessed the feasibility of a community solar project in Highland Park, and presented a sketch of what a community solar model might look like for Soulardarity and Highland Park. One conclusion from the analysis quickly became clear: Solar projects present logistical, legal, and financial complexity, and the accessible partnership model outlined here only increases that complexity. NREL's "Guide to Community Solar" book outlines a basic checklist of project development tasks for community solar projects, which is presented in Appendix D.

Soulardarity's context in Highland Park, mission, and the proposed business structure make this project unique. As Soulardarity staff move forward with a community solar installation, the following should be considered:

8.1 Setting project objectives

Community solar projects are a long-term investments and lasting partnerships between Soulardarity staff, Soulardarity members, Highland Park community members, project hosts, and financial partners. In the process of crafting this partnership, Soulardarity staff will be presented with a vast array of options and considerations for how exactly the project will be implemented. In some cases, options and considerations may ask Soulardarity to make trade-offs between outcomes (e.g. Should the project save more money for the host or generate more money for Soulardarity?). Although planning, forethought, and good project design should prevent surprising events or circumstances along the project's lifetime, Soulardarity staff may have to make difficult decisions along the life of the project.

Defining project objectives at the outset can provide clarity when choices present themselves, and they allow multiple staff members to coordinate on a single principle. If the goals are public, they might also present a consistent principle for project partners. Project development means juggling levels of risk and returns on investment alongside Soulardarity's own mission objectives like enhancing energy democracy, ensuring accessibility, and raising Soulardarity funding.

8.2 Forming a Special Purpose Entity:

Soulardarity has multiple options when it comes to the development of a special purpose entity for the community solar project, each with their own strengths and weaknesses. NREL's "A Guide to Community Solar" includes a concise explanation of the most common business arrangements as seen in Figure 11.^{xxix}

Entity Type	Liability for Owners	Taxation	Primary Advantages	Primary Disadvantages
General Partnerships	Personal liability	Pass-through	Ease of formation; pass-through taxation	Personal liability of partners
Limited Partnerships	Personal liability for general partners; limited liability for limited partners	Pass-through	Pass-through taxation; limited liability for limited partners	No liability shield for general partner
Limited Liability Companies	Limited Liability	Usually pass-through	Pass-through taxation; fewer formalities to maintain the LLC structure than corporations	Relatively new structure; may be harder to get financing
Cooperatives	Limited Liability	Separate tax entity	Cooperative principles	Inflexible Structure
"S" Corporations Limited Liability	Limited Liability	Pass-through	Liability shield; ease of investment; ease of transfer of shares in larger, non-close corporations	Limitations on number and identity of members
"C" Corporations	Limited Liability	Separate tax entity	Liability shield; ease of investment; ease of transfer of shares in larger non-close corporations	Complexity; double taxation
Non-Profit Entities	Limited Liability	Separate tax identity; tax exempt	Tax-exempt; tax deduction for donors	No return for donors; business purpose are limited; no voting rights for donors

Figure 11: NREL's "A Guide to Community Solar"

Appendix D.1 and Appendix D.2 include a charter and formation document for a limited-liability corporation, identical to that used by University Park Solar Co-operative.

8.3 Building relationships with potential partners.

Soulardarity needs several partners to make the community PPA a reality. Bringing together a diverse set of partners helps to forward Soulardarity's mission of uniting their community through energy provision, while expanding the total available pool of resources for the project. And because a large solar project requires substantial land, a large energy demand (to meet net metering rules), and a lot of up-front capital, Soulardarity should be intentional about seeking out partners who can further their mission and provide the necessary resources for the project. In particular, Soulardarity should identify **project hosts** and **financial partners**.^{xxx} Below are suggested criteria for evaluating potential project hosts:

- **Investment in Highland Park and Complementary Missions:** Part of Soulardarity's mission is to drive down the costs of energy for the community. Although a community PPA should generate returns for the project investors (including Soulardarity), it only directly reduces energy costs for the project host. For this project to further Soulardarity and decrease energy burdens in Highland Park, the project host should be an open, community-serving institution.
- **Space for a solar project:** Appropriate solar sites are easily accessible for maintenance, near existing electrical circuits, generally clean (not in risk of accumulating debris) and have uninterrupted access to sunlight. Even tall buildings around a potential solar site can have an impact on solar production. To reduce roof maintenance costs is done just before solar panels are installed and roofs should be inspected by an expert before any commitments are made.
- **Financial Stability:** Solar energy projects are, by nature, long time-horizon partnerships. Initial estimates for this project put a simple payback period at over 15 years, and typical estimates of solar lifetime for modern solar panels place them at 25 years or more. Soulardarity should be confident that their partner is likely to continue to own and operate the property over the long haul, or at the very minimum have procedures in place for a transfer of building ownership. In some cases, potential financial liabilities and risks that might cause the entity to move or sell the property should be evaluated. For this reason, common solar partners include churches and civic buildings. Although energy payments should represent a discount for the project host compared to their hypothetical utility prices, regular payment should still be an expectation, especially if the Special Purpose Entity takes on debt to finance the project.

8.4 Getting Legal & Accounting Support

For many projects, setting up the legal and financial structures that will serve the project are the most costly and time-consuming portions of a community solar project.^{xxxix} University Park Solar Cooperative, for instance, spent over two years developing their business plan before moving forward with the project. They relied on pro-bono work from the Maryland Intellectual Property Resource Center, alongside \$12,000 for other legal and accounting expenses. Soulardarity should examine its options closely when it comes to setting up a community solar business and financial structure. Documents provided in Appendix D to this report can form the basis for financial & legal structures for Soulardarity.

9. Discussion and Conclusions

Across our case studies in Highland Park, the community solar calculator found that community solar projects could flourish and meet their goals of providing access to solar, reducing energy burdens, raising money for Highland Park, and increasing the Highland Park community's autonomy when it comes to providing energy. We believe this is an incredible opportunity for the Highland Park community to achieve energy democracy, and we excitedly await the future of Highland Park's electricity grid.

The Community Solar Calculator relies on number of industry averages and assumptions to generate reasonably accurate technical and economic outputs. The detail provided here should allow users to further customize the calculator to meet their needs and the specifics of their developer and installation. Especially as solar equipment and 'soft' costs continue to drop, it's critical to remember that the model represents 2017 industry averages and details should be updated as pertinent information becomes available. Nevertheless, the calculator provides a solid foundation for estimating the technical and economic feasibility for a solar project.

For Highland Park and Soulardarity, the major barriers left to community solar are 1) Crafting a business and policy framework for Soulardarity and Highland Park and 2) Securing low-cost financing that will not put a high burden on Soulardarity.

While these barriers are surmountable by Soulardarity, they absolutely dampen access to affordable, renewable energy for those who need it most. Soulardarity's journey toward community solar demonstrates the viability of these projects to help people on the ground as well as the difficulty in making these projects a reality. In many states, legislation and policy have stepped in to increase access to community solar and allow residents greater autonomy in how they provide their own energy.^{xxxii} Our recommendation and hope is that the State of Michigan follow suit.

The way the world provides its electricity is changing. As the business and moral case for renewable energy shifts the fundamental nature of how we produce and consume energy, it's up to us to ensure that the benefits of clean and affordable energy accrue to everyone. Community solar in Highland Park will help achieve that mission, and Soulardarity's project might set an example for how communities facing high-energy burdens might join together, create something new, and become more free.

Appendices

Appendix A: Survey Design

Appendix B: Survey Results

Appendix D: Resources

Appendix D.1: Generic Maryland Operating Agreement

Appendix D.2: Generic Maryland Power Purchase Agreement

Appendix D.3: Community PPA Checklist

[For intellectual property and privacy reasons, these appendices have been redacted from the public report.]

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Appendix C: Community Solar Calculator Design and Assumptions

To create the calculator, we made assumptions regarding the infrastructure of the panel system itself, the solar resource in the area of Highland Park, the types of buildings being powered, and the project costs and credits. The following section will detail these assumptions as well as outline the way in which these aspects were incorporated into the calculator.

C.1 Solar Panel System

We considered three components of a photovoltaic solar panel system: the array (composed of individual modules), the inverter, and the battery. The module is a planar structure that consists of a number of photovoltaic cells that convert light into electrical energy. Each module can then be compiled into an array. The total photovoltaic system includes the inverter and battery. An inverter converts the electrical energy from direct current to alternating current, which is the type of current needed for the electricity grid. Batteries can be integrated into solar panel systems to store electrical energy that is produced that exceeds the demand of the electricity.

C.1.1 Module

Today there exist many manufacturers and models of solar panels or modules on the market, and the type of module that is appropriate for a project depends on project constraints such as budget and power requirements. In our calculator, users have the option to select one of three types of panels based on budget and efficiency constraints:ⁱ

- **Economy panels:** Least costly but have the lowest ranking in several categories including performance, quality, durability, and warranties.
- **Standard panels:** Dominate the market, and they have good power ratings, efficiencies, and performance characteristics.
- **Premium panels:** Most efficient and help to maximize energy production, and have the best durability, quality, and warranty, but they are also the most expensive.

Efficiency for each module classification was determined by averaging industry data reported by EnergySage for each module class. Refer to Table 1 below for the assumed efficiency of each module category.

Table 1: Assumed efficiency for each module type in solar power calculator.

Module Type	Efficiency
Economy	14.8%
Standard	16.0%
Premium	20.0%

Along with these efficiencies, we assumed panel dimensions measuring 77 inches in length and 39 inches in width, the industry average.ⁱⁱ

C.1.2 Inverter

Similarly to modules, there are many manufacturers and models of inverters. We used industry averages were used to define inverter characteristics: inverter loading ratio (ILR), efficiency, and replacement year. ILR refers to the ratio of DC electricity to AC electricity. Refer to Table 2 below for the values used in the calculator.

Table 2: Values for inverter characteristics using industry averages.

Characteristic	Value
Inverter Loading Ration (ILR)	1.15
Efficiency	0.92
Replacement Year	10

Solar array dimensions are used to size the inverter (which indicates the ILR specific to the site). The inverter is typically undersized from the reported DC output to achieve maximum output from the inverter. Since the system site is meant to be a variable in the Community Solar Calculator, an industry average was used for the ILR instead of relying on the site load curve.^{iii, iv, v} The efficiency and replacement year were also averaged from industry values for the same reason.^{xv, xvi} The replacement year is an important consideration, because it affects total system cost and payback period. The inverter will need to be replaced several times during the project lifetime, which adds additional cost.

While our model assumes we will only use one inverter at a time, systems often utilize several smaller inverters. The benefit of having fewer modules connected to each small inverter to create the entire array which is that it allows for systems that are more resilient to power outages. A

microinverter can also be wired individually to each module. These methods result in higher costs, therefore we assumed that only one inverter would be used for a project funded primarily by a non-profit and lower-income community.

C.1.3 Battery

The design of a battery system is highly dependent on the specific solar panel site. Generally, batteries are used in off-grid sites and can be used to offset electricity prices in areas with Time-of-Use (TOU) rates, neither of which are within the scope of this project (the local utility, DTE Energy, does not use TOU rates).^{vi} Despite this, the inclusion of a battery is still attractive as it can be used in times of power outage as well as to store excess energy. The assumptions related to the battery are included below in Table 3. Lead-acid batteries are advantageous over other battery technologies because they are typically the cheapest option and are easily replaceable with over-the-shelf products.^{vii,viii}

Table 3: Battery system characteristics using industry averages

Characteristic	Value
Type of Battery	Lead-acid
Lifetime ^{ix}	9 years
Roundtrip Efficiency ^x	82%

C.2 System Planning

After determining the necessary characteristics of each component of the system, they must be integrated to create an optimal and effective system for the businesses of Highland Park. Panels can be electrically wired depending on whether a desired voltage (series) or current (parallel) is more important. Other components of a photovoltaic system were not modeled individually as they will not influence energy generation but simply affect the total installation cost which is referenced in sections below. However, the design factors important to the entire solar panel system are included below in Table 4. Most of these assumptions were made based on information provided in the book *Renewable and Efficient Electric Power Systems*, except for the shading derate factor, which was obtained from NREL's solar calculator PVWatts.^{xi}

Table 4: Assumptions for PV systems characteristics based on optimization for Highland Park

Assumption Variable	Value
Collector Tilt	40°
Axis Tracking	No, fixed tilt
Ground Cover Ratio	0.42
Shading Derate Factor	0.975
Azimuth Angle	180°

C.3 Solar Availability

The first step to calculating the amount of power a solar panel system can generate is to determine the solar availability inherent to the system's location based on latitude. Solar availability of a region refers to the amount of solar energy radiating from the surface of the sun to that area and includes beam and diffuse radiation. Beam radiation is the dominant source of solar radiation, and passes in a direct line from the sun to the panel. Diffuse radiation refers to the light that has been scattered by molecules and aerosols in the atmosphere. For this model, we used NREL's solar energy and cost calculator, PVWatts to estimate solar availability.^{xii} Based on Highland Park's latitude of 42.42°N, PVWatts reports hourly solar irradiation in W/m². PVWatts defaults to the closest TMY2 (typical meteorological year) weather data, which for Highland Park, is data collected from Detroit, MI. The data was collected between 1961 to 1990. Solar irradiation is also influenced by the tilt of the array (assuming fixed tilt) as well as the azimuth angle of the array (cardinal direction that it is facing). As stated in the previous section, we assumed that the array was fixed at a 40° tilt and faced directly south (azimuth angle of 180°).

Based on these assumptions and averaged TMY2 data, we compiled the solar availability in W/m² for Highland Park on an hourly basis for each day of the year and calculated the average monthly irradiation. Table 5 displays the specific average irradiance used in the calculator to determine potential power output (multiply the average irradiation by total panel area and total hours of sunlight per month).

Table 5: Irradiance and monthly output data for latitude 42.42 deg N, obtained from PVWatts.*

Month	Average Irradiance (W/m ²)
January	117
February	145
March	172
April	203
May	232
June	234
July	227
August	238
September	209
October	164
November	106
December	87

C.4 Estimated Building Load

To determine the significance of the solar array output, it is important to compare output to a site's estimated load. In the instance that the user does not know the building load, the user can input building characteristics such as building type/activity and dimensions, and the model will report an estimated building load. This estimation is based on electricity consumption data from the EIA, which is reported by principal building activity^{xiv}. Table 6 below lists the rate of electricity used per square foot for a variety of building types. The model therefore reports what percentage of total monthly building load is satisfied through the solar panels. If the user does not input building dimensions, the average building size for that building type (as suggested by the EIA) is assumed.

Table 6: Building Type and rate of electricity per square foot

Building Type	Rate of Electricity Used (kWh/ft ²)
Religious	5.3
Office	15.9
Lodging	15.3
Food Service	45.1
Education	10.9

While there are more options studied from EIA, Highland Park and Soulandarity's potential partners are stemming mostly from these categories. To estimate the monthly building load, data was collected from EIA for monthly electricity consumption in the commercial sector.^{xv} Using this data, a trend for monthly usage was calculated and used to model electricity demand given by the user or estimated through assumptions from EIA.

C.5 Energy Output by Area

After determining the solar availability in W/m², the next step in calculating total power output of the system was to consider the system size, for which ground cover ratio is required. Ground cover ratio (GCR) is defined as the ratio of collector area to total ground area covered by the panel. GCR takes into account the fact that the tilt angle of the panel decreases the surface area capable of receiving sunlight. Figure 1 can be used to estimate the ground cover ratio for various solar panel configurations based on shading derate factor. Assuming a shading derate factor of 0.975 and a fixed 40 deg tilt collector configuration, we determined that the GCR for the proposed system in Highland Park would be 0.42. We then calculated the collector area (which is the physical area of the panel capable of collecting solar energy) using the equation below from the ground area (model input) and assumed GCR.

$$\text{Collector Area (ft}^2\text{)} = \text{GCR} \times \text{Ground Area (ft}^2\text{)}$$

To determine the hourly solar availability in kWh, we multiplied the insolation value in W/m² by the collector area. The hourly array output for the system was then determined by multiplying the solar availability by the efficiency of the panel. As highlighted earlier, the user has three panel types to choose from, with efficiencies ranging from 14.8% to 20%. The higher the efficiency, the greater the power output from the array. We summed the hourly array output over the total days of each

month to determine the monthly array output. In order to obtain the annual array output in DC, the temperature derate needed to be accounted for. The temperature derate factor accounts for the fact that solar panels have optimal operating temperatures, and an increase in the ambient temperature will cause the panel to generate less electricity.^{xvi} The Community Solar Calculator accounts for this effect by determining a temperature derate factor for each month, based on the average temperature of each month, provided by U.S. Climate Data.^{xvii} We used the following equations to calculate the temperature derate factor assuming a standard temperature of 25°C, an average normal operating condition temperature (NOCT) of 45.6°C, and an average temperature coefficient of -0.34%/°C.

$$\text{Cell Temp (}^{\circ}\text{C)} = \text{Avg. Monthly Temp (}^{\circ}\text{C)} + \frac{(\text{NOCT} - 20)^{\circ}\text{C}}{0.8} * S$$

$$\text{Temp. Derate} = 1 + \text{Avg. Temp Coeff. (\%/}^{\circ}\text{C)} \times [\text{Cell Temp (}^{\circ}\text{C)} - 25^{\circ}\text{C}]$$

To determine the adjusted monthly output we multiplied the monthly derate factor (which actually produced an increase in power generation for months September through May due to temperatures colder than the standard temperature (25°C)) by the respective monthly array output. These monthly adjusted output values could then be summed to determine the annual power output produced by the array in DC. Then using the ILR, the electricity produced in AC could be determined. The model will also report the required system size, reported in kW, which is useful for cost estimations.

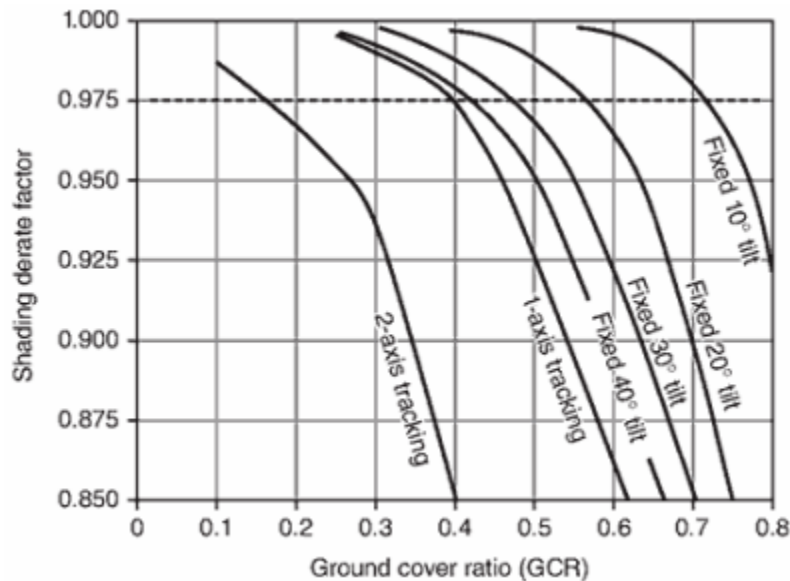


Figure 1: Shading derate factor versus GCR for a variety of solar panel configurations.-

C.6 Area Output by Energy Demand

To determine the amount of additional system area required to meet a desired energy demand (input by user), the model simply followed the reverse process described above to calculate the energy produced from array area. Assumptions related to tilt angle, ground cover ratio, and efficiency were held constant between Energy Output by Area and Area Output by Energy Demand calculations. We determined the annual amount of additional energy required by subtracting the produced amount of energy (from the available ground area) from the desired energy. We then proportioned out this annual amount by month after dividing out the temperature derate factor, and then by hour within each month. To calculate the hourly required solar availability in kWh we divided the hourly required array output by the panel efficiency, and then collector area could be calculated by dividing the hourly required solar availability (in kWh) by the solar insolation data provided by PVWatts. In the output tab, the calculator reports the required additional ground area required, which was determined by dividing out the assumed GCR of 0.42 from the collector area.

C.7 Environmental Factors and Project Lifetime

The Community Solar Calculator assumes that there will be no losses from shading or soiling of the panels, but it does account for partial shading of the project by overlapping panel shadows when the sun is very low in the sky. It also calculates efficiency impacts of ambient temperature. Given Michigan's colder climate, panels are expected to work more efficiently than standard test conditions.

The calculator uses National Renewable Energy Lab (NREL) industry standards to estimate panel degradation over time and panel lifetime. A recent NREL survey of studies found a median 0.5% degradation rate among panels, which is used within the calculator.^{xix} The NREL's Annual Technology Baseline specifies solar PV project economic lifetimes (the time over which the initial capital investment is paid off) at 20 years and its technical lifetime (the time over which the project is reliably functional) at 30 years.^{xx}

C.8 Financial Considerations

The community PPA model represents a partnership between project hosts and project owners, where both expect to receive a financial benefit from the generation of electricity. To be feasible,

the project must not only produce energy; it must also generate value for the project owner and project host.. A 'Cash Flow' tab within the calculator specifies annual costs and benefits for each entity over the lifetime of the project.

C.8.1 Time Value of Money and Net Present Value

Whenever capital is invested in a project, there are *opportunity costs*, or the other benefits that capital could've produced if it were used elsewhere. To determine whether a project would be a wise investment, investors often compare the estimated benefits of a proposed project against the benefits of a place-holder investment with average returns. For social projects, analysts might assume that a successful project would return 4% of the amount investment every year.^{xxi} They could use this 4% figure against any proposed investment to evaluate whether the investment is wise or not. These placeholder project return rates are called discount rates.^{xxii}

Comparing against an average yearly return is particularly helpful when costs and benefits are sustained at different time scales—for example, a project with a high up-front cost and long, drawn-out benefits. By comparing the benefits and costs of a project across its entire lifetime against the performance of a placeholder project with an average return rate, we can calculate a *net present value*, which clarifies with a quick glance whether a project would produce more or less value than a placeholder project.

The Community Solar Calculator compares the proposed community solar project against a 4% discount rate, which is between the 3% social discount rate and 7% market discount rate suggested by EPA.^{xxiii} The sections of the 'Cash Flow' tab labelled 'Discounted' use the 4% discount rate, compounded annually. The totals at the bottom of the ledger represent net present value for both the project host and owner. Because discount rates tend to discount values further in the future greater than values in the near future, discounted projects will take longer to break even and show less total benefits.

C.8.2 Host

The calculator estimates the total annual electricity production over the project's lifetime, and estimates a typical utility retail electricity rate by starting with DTE-reported retail rates and applying a 2.5% annual inflationary factor. Using the annual estimated production and the retail price, the calculator estimates total avoided payment to the utility. Then, using a user-specified markdown rate, the project host pays the project owner for the electricity based on total electricity

production. The difference between avoided payment to the utility and payment to the project owner represents the host's annual benefit from solar.

C.8.3 Owner

The project owner is assumed to be an entity formed by several investors, including Soulardarity's Special Purpose Intity and potentially its members. The project owner is responsible for paying the up-front and operations & maintenance (O&M) costs for the project, but they also receive payment from the project host over the lifetime of the project.

While solar production over time is easier to model, it is difficult to accurately predict the costs of equipment and installation because of the wide variance between regions and vendors and the influence of 'soft' costs like developer overhead and installation labor. To account for that uncertainty, the calculator offers multiple options for estimating solar costs. The first is bottom-up cost based on the NREL's 2017 first-quarter solar pricing benchmark.^{xxiv} This benchmark includes individual estimates for cost of the solar panel system (modules, inverter, battery), installation, and operation and maintenance (O&M). Module options for the NREL model include 'economy,' 'midrange,' and 'premium' standards, which have different respective costs and energy conversion efficiencies. The 'soft' costs refer to expenses that incurred during the installation and life of a solar panel system that aren't directly associated with equipment. According to the NREL, depending on the size of the system, extra costs have a range of \$1.29/kW (for 500-1000 kW systems) to \$1.58/kW (for systems less than 100 kW in size).^{xxv} Table 7 below summarizes the assumed costs for each of the components described above.

Table 7: Cost for solar panel system components

Variable	Cost
Module ^{xxvi}	0.32-0.44 (\$/W)
Inverter ^{xxvii}	0.1 (\$/W)
Battery (lifespan of 9 years) ^{xxviii}	147 (\$/kWh)
Operation and Maintenance ^{xxix}	15 (\$/kW)
Extra Costs (installation, EPC overhead, etc.) ^{xxx}	1.29-1.58 (\$/kW)

The second approach to estimating costs is a composite based on a number of sample quotes from the *EnergySage* solar marketplace for Highland Park's zipcode (48203). EnergySage offers a

simulation of what actual installed cost quotes from local solar developers might be, based on previous quotes by actual solar developers. An initial Highland Park query got quotes at around \$3.30 per installed Watt of capacity. Additional versions of the Community Solar Calculator could include additional options for pricing, including user-input pricing.

The total installed cost for each of these components is determined by multiplying the price per capacity (\$/Watt) by the specified system size. The owner is responsible for all upfront payment related to purchasing the panel components discussed above as well as installation, which all occur in “year zero,” indicating panel operation has not started. Total cost to the owner in “year zero” is therefore equal to the capital cost less the Federal Solar Investment Tax Credit (ITC), which here was assumed to be equal to 30% of the total upfront cost. In the first year of operation, O&M costs begin as well as payments from the host, and so total annual cash flow for the first year is payment from the host less the cost of O&M. This continues for every year after, except after every nine years of operation, it is assumed a new battery must be purchased, which reduces the net cash flow for those years. The 25 year cashflow is then discounted into today's dollars. The calculator shows in which year the owner will break even.

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