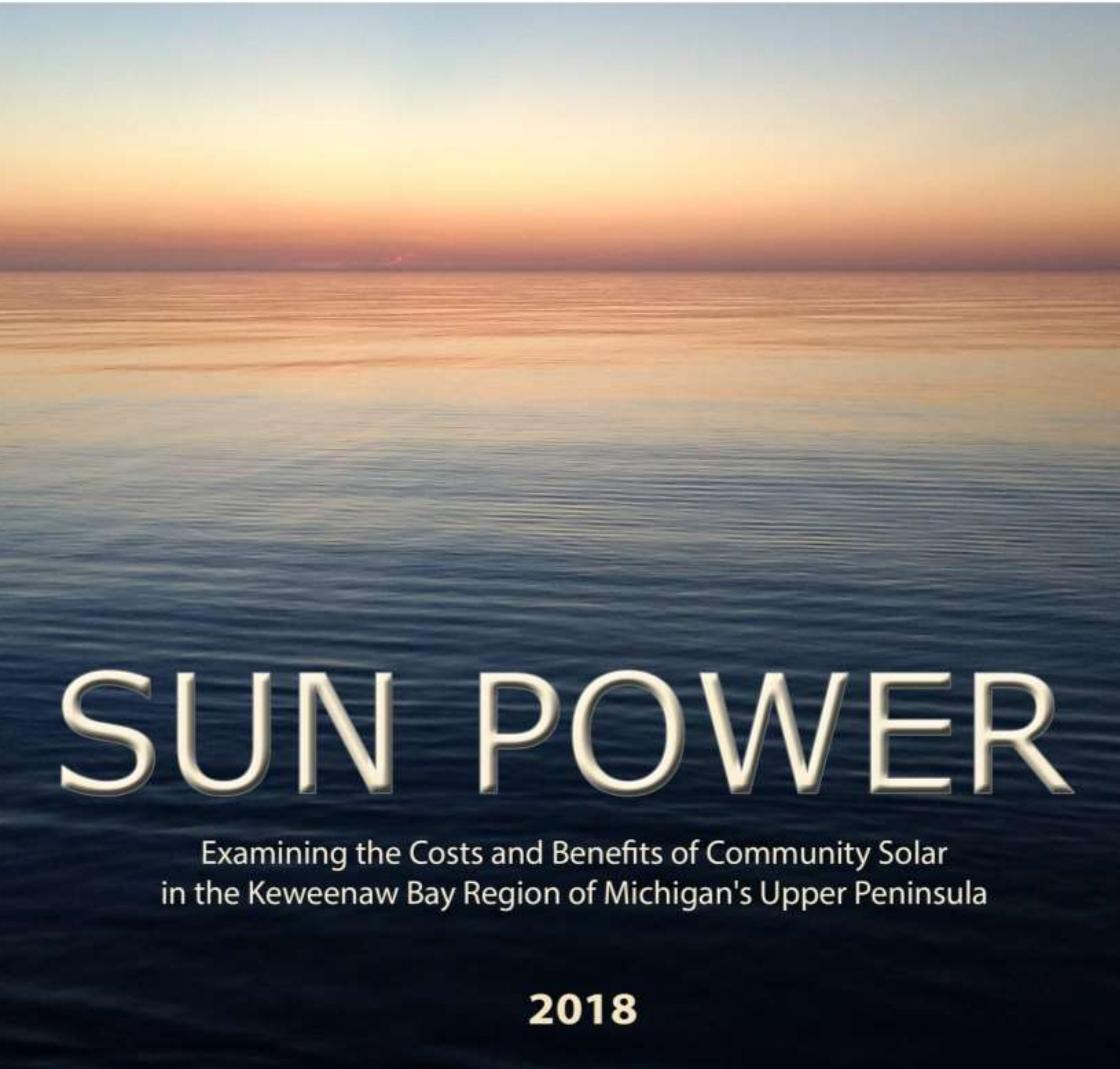
DOW SUSTAINABILITY FELLOWS
UNIVERSITY OF MICHIGAN

sustainability.umich.edu/dow

Kevin Dunn Krutarth Jhaveri Lauryn Lin Julie Michalski Benjamin Rego



SUN POWER

Examining the Costs and Benefits of Community Solar in the Keweenaw Bay Region of Michigan's Upper Peninsula

2018

DOW SUSTAINABILITY FELLOWS
UNIVERSITY OF MICHIGAN
sustainability.umich.edu/dow

Sun Power

Examining the Costs and Benefits of Community Solar in the Keweenaw Bay Region of Michigan's Upper Peninsula

2018

Team Members:
Kevin Dunn, Energy Systems Engineering
Krutarth Jhaveri, Chemical Engineering & Environment and Sustainability
Lauryn Lin, Public Health
Julie Michalski, Law
Benjamin Rego, Environment and Sustainability & Public Policy

Faculty Advisor:
Margaret Wooldridge, Professor
Departments of Mechanical and Aerospace Engineering
University of Michigan

Executive Summary

Background

Michigan's Upper Peninsula (UP) faces unique energy challenges. The terrain is rural, rugged, and quite removed from major electricity generation. In addition, the UP's low population combined with the high cost of transmission results in electricity rates among the highest across the United States, with an average of 0.23-0.25 $/kwh.[i] The UP's majority population is composed of low to moderate income earners (LMI), making energy costs a particularly high financial burden. This has led UP communities, wanting to reduce cost, to consider bringing generation closer to home through rooftop solar, wind farms, and community solar programs.

Client

Our client, The Western Upper Peninsula Planning and Development Region (WUPPDR), provides general planning support to six western counties of the UP. WUPPDR expressed a need for assistance with a community solar project in the town of Baraga, and, in particular, with conducting a cost-benefit analysis (CBA) as per a requirement of the local power company's, WPPI Energy's (WPPI), Demonstration of Energy & Efficiency Developments (DEED) grant funding[ii] for the project.

Objectives

Our project contained three objectives: 1) complete the CBA and develop user-friendly dashboards for WPPI to assess community solar projects; 2) provide the community residents in WUPPDR's Baraga area with an online dashboard to estimate their own costs and returns were they to buy-in to a community solar project; and 3) tailor the models to the Baraga project, but create the dashboards in a flexible and general way such that the tools could be applied to other projects across WUPPDR and WPPI's regions.

Methods

In the spring of 2018, group members traveled to the UP to meet with various stakeholders and better understand the problem of energy costs in this region. Research was conducted in legal, public health, environmental, and energy costs associated with this community solar project. We worked with stakeholders to receive data on energy usage and rates, including energy efficiency information.

Data was compiled into an Excel spreadsheet to form the CBA, which in turn was used to create interactive dashboards in R Shiny. These dashboards will allow WPPI to gauge the appropriateness of a community solar program in Baraga, and also help consumers understand the impact of participation on their households. With these dashboards, WPPI and consumers can clearly visualize the impacts of a community solar program and energy efficiency updates on their costs. Additionally, the tools are customizable and can be adjusted to the parameters of different projects, allowing communities considering community solar to use the tool in their own analysis.

Our group originally planned to travel to Baraga to instruct community members and stakeholders on how to use the tools. Unfortunately, our client and other stakeholders postponed the community meeting indefinitely, and we were not able to assist community members in person. In lieu of this, we hosted several online training and feedback sessions in October and November with WUPPDR and WPPI.

Outcomes

Feedback was taken from WUPPDR, WPPI, and the village managers, and adjustments were made to the tool.

Next steps

The dashboards are ready to be set up online, and the working Excel file and R scripts will be sent to WUPPDR, WPPI, and the director of Michigan Tech's Keweenaw Research Center, Jay Meldrum, for future modification as needed. We are actively working with the stakeholders on the handoff of the dashboards.

For future projects, it would be very helpful to have a better understanding of successful community engagement techniques in rural, LMI areas like Baraga, which would allow for greater project reach and participation among consumers. Given the difficulties involved in community engagement in this setting, it would be worthwhile to look further into means of informing people about their energy consumption and generation options, outside of community meetings. An example might be adding a link to the solar tool on utility bills to bring awareness of the tool to consumers. More research on this area would be helpful to future projects in the area which require community engagement, but was outside of the scope and timeline of our project.

Table of Contents

Introduction & Background

Baraga Context

Baraga is a village in the Western Upper Peninsula of Michigan, along the shores of Keweenaw Bay on Lake Superior. The population of the village is 2053.[1] The village is located on the L'Anse Indian Reservation, and approximately 62.6% of the village population are tribal members of the Keweenaw Bay Indian Community (KBIC). [2,3] 33.2% of the population lives below the poverty line, a number more than double the national average of 15.1%.[4,5] Just across the bay (a 5-mile drive overland) is the Village of L'Anse. Baraga County, which includes both the villages of Baraga and L'Anse, receives an average of 216 inches of snowfall annually.[6]

Figure 1

Electricity rates in the Upper Peninsula (UP) have consistently been higher than the national average and some of the highest across the United States with an average of $0.23 - $0.25/kwh.[7] This is primarily attributed to high transmission and distribution costs for power companies across a wide geographic area with a low population density.[8] Although costs in the Village of Baraga itself are below the UP average, at $0.125/kwh,[9] the majority of people in Baraga are low to moderate income (LMI) earners, making their energy costs a particularly high financial burden.

Baraga's long winters, LMI population, and low population density combine to create high energy costs in relation to income. Community solar has been proposed in the Keweenaw Bay area of the UP as a low-carbon energy option that may help residents mitigate the high prices, as well as to help the neighboring communities of Baraga and L'Anse towards self-sufficiency with their energy needs.

Client and Stakeholders

Western Upper Peninsula Planning & Development Region (*Client*)

The Western Upper Peninsula Planning and Development Region (WUPPDR) was formed in 1968 to provide general planning support to the western six counties of Michigan's UP (Baraga, Houghton, Keweenaw, Ontonagon, Iron, and Gogebic) with the goal of fostering stable and diversified economies.[10] It also serves as the regional clearinghouse for federal and state-funded programs, enhancing intergovernmental coordination and encouraging opportunities for public comment on projects.

WUPPDR has been involved in an ongoing community solar project in L'Anse. While the L'Anse project will be breaking ground in the fall of 2018 or spring of 2019, the Baraga project is in early stages, evaluating community reactions and feasibility. Brad Barnett, Regional Planner and our main contact at WUPPDR, suggested that our group could be of use in the Baraga project. Mr. Barnett included our group in monthly meetings with project stakeholders where, in collaboration with those stakeholders, we determined that conducting a CBA would leverage our group's diverse skill sets while helping meet project needs. Although multiple stakeholders are involved in both the L'Anse and Baraga solar projects, WUPPDR—as a planning group with coordination among stakeholders across the area—was the best choice for our client.

Why so many stakeholders?

"Human rights are also at the heart of energy justice: energy is essential to human life. Political systems have only rarely defined energy as a basic right [.] Energy justice also poses questions of procedural justice. Many changes are currently taking place with little input from community and consumer voices, potentially laying the foundations of yet more injustices in [the] future."

Miller, Iles, & Jones, 2013

WPPI Energy

WPPI Energy (WPPI) is a non-profit, wholesale power company serving 51 locally owned, not-for-profit electric utilities providing power for 200,000 homes and businesses in Wisconsin, Michigan's UP, and Iowa.[11] Through WPPI Energy, these public power utilities share resources and own generation facilities, socializing the cost of electricity across the region and allowing for bulk pricing on outside power purchases. Both L'Anse and Baraga have municipal utilities which purchase their power from WPPI Energy. Although WUPPDR was our client, we worked closely with Brett Niemi, Energy Services Representative at WPPI, to develop the CBA for WPPI's use in evaluating community solar projects.

Additional Stakeholders

Additional stakeholders include the L'Anse and Baraga village managers, KBIC tribal leaders and members, researchers from Michigan Technological University, and sustainability consulting firms. An overview of interactions with such groups is included in the Appendix. WUPPDR, WPPI, and these additional stakeholders formed an unofficial coalition, dubbed the "DEED team" (named for the DEED grant funding they received for area community solar projects).

Objectives

Our role in providing the CBA to the community solar project involved three objectives: 1) complete the CBA for the Baraga Project and develop user-friendly dashboards for WPPI to assess community solar projects; 2) provide the community residents with an online dashboard to estimate their own costs and returns, were they to buy-in to a community solar project; and 3) tailor the models to the Baraga project, but create the dashboards in such a way that both tools could be applied to future projects across WUPPDR and WPPI's regions. It was extremely important to our group that the project be client-driven—for the community to tell us what they wanted and needed, rather than externally imposed.

Methods

Project Scope & Client Selection

Our team formed around a common interest in sustainable energy. We were interested in a variety of subtopics as potential components of the project, including but not limited to, renewable energy, energy access, energy poverty, and energy efficiency. We then connected with several potential clients and projects of interest through professional networks and email outreach. After establishing contact with Brad Barnett, our team identified WUPPDR as the client organization and Baraga as the community of interest due to the following factors: a flexible and feasible project within the remaining 11-month fellowship period; mutual project benefit for our Fellows team, the client organization and its stakeholders; strong interest and support from WUPPDR contacts and project stakeholders; geographic proximity (within a 1-day drive from Ann Arbor) and topical relevance for the Fellows team. We also felt that the energy needs of UP residents were often overlooked, and ripe for assistance.

Stakeholder Meetings: Spring 2018

Upon selecting WUPPDR as our client, three team members travelled to the UP to meet in person with WUPPDR and relevant stakeholders to solidify the scope of the team's work. Prior to visiting Baraga and Houghton, MI, our team initiated contact with several project stakeholders to meet in person during our visit on May 7-8, 2018. The primary objectives for the visit included understanding the current state of the project by meeting with the DEED team, and identifying our group's scope of work for our Fellows project. See the Appendix for a detailed overview of meetings.

Cost-Benefit Analysis Literature Review

Over the summer, each team member conducted research on the costs, benefits, and overall impact of community solar related to his or her discipline of study. Research findings were used in the Excel and R versions of the CBA and are summarized in this report.

Financial Component

Our research conducted on the financial components of solar cost-benefit analyses showed that methods used to analyze these costs and benefits differ greatly across studies, mostly due to different financial assumptions associated with calculating lifetime costs and benefits.[12] Calculating the lifetime costs and benefits was important as it provided a point of comparison to other generation assets, but it also introduced challenges associated with forecasting exogenous factors like fuel prices and grid composition. That said, once the assumptions were determined, the accounting of financial costs and benefits was straightforward.

Legal Component

Legal research was conducted in local, state, and federal areas of law. Tax credits, including the expenditures tax credit and the Federal Business Energy Investment Tax Credit (ITC) were investigated as potential cost-savings components for the project. Incentives researched included the Modified Accelerated Cost-Recovery System (MACRS), the USDA's Rural Energy for America Program (REAP), Michigan's Renaissance Zones, Clean Renewable Energy Bonds (CREBs) and PACE financing. Pending legislation and Renewable Energy Credits (RECs) were also reviewed, and potential siting and securities issues identified. Disclaimer language for the citizen dashboard was also researched and drafted with the assistance of an attorney.

Environmental Component

Research on the environmental impacts of energy systems suggested that the life cycle framework was one way to quantify the impacts of a specific system over its lifetime, from its construction, through its use, till its end-of-life.[13] This framework has been found valuable in accurately representing the environmental impacts and tradeoffs associated with different energy systems.[14] The environmental effects of renewable energy systems, such as this community solar project, is that power generated from dirtier fossil fuels can be avoided, and hence reduce the overall environmental impact of electricity generation. While obtaining data for the systems in the project was challenging, information from relevant stakeholders and previously published works enabled us to make the necessary assumptions and use the appropriate values. [15,16]

Public Health Components

Through a broad literature review, research was conducted on the social and public health benefits of solar energy and community solar programs. Both academic research literature and reports from a variety of national, state, and local government agencies were reviewed. While a quantitative assessment of the public health costs and benefits of community solar programming was beyond the scope of our project, and because there is little research on the direct health impacts of community solar, we were unable to use specific values in our models. However, a qualitative review of the current research and literature assessing the public health implications of diminished fossil fuel-based energy generation, solar generation, and broader impact of community solar programming is discussed in the Results section below.

Cost-Benefit Analysis Excel & Dashboard

After our research phase, our team developed a framework for the CBA through an Excel workbook and programmed the dashboards through R Shiny programming software.

Dashboards

Although the dashboard tools are intended to be easily understood and accessible to users, ongoing feedback in development and training was critical for the tools' value to be fully realized. The team originally planned to visit Baraga again in the late summer or early fall to present CBA results and the developed dashboards. Presenting our results to key stakeholders and community members would solicit additional feedback for the tool and provide an opportunity for the team to train users on future use and maintenance of the tool. However, in June, a 1000-year catastrophic flood event occurred in the area, destroying WUPPDR's office along with major roads, causing widespread infrastructure damage in the area.[17] This event pushed back the timeline of the next community meeting, which was tentatively rescheduled for mid-October.

However, due to a variety of factors related to the DEED team's progress, we decided to forgo an additional visit due to logistical and time constraints. The DEED team did not host another community meeting, and reformulated other community engagement strategies for the project. Due to low participation at its original community engagement meeting held early spring, the DEED team decided that it would be more effective to connect with community members at other community gatherings, such as church activities and council meetings. Going out into the community to present findings and gather feedback, instead of relying on community members to attend additional meetings, would gather more input on the community solar project.

In light of this adaptation, and considering the short turnaround between completion of the dashboards and the end of the fellowship, our team gathered feedback from WUPPDR and WPPI through two online meetings. Each dashboard was shared online via a Google Hangout screen share, and feedback was received for changes to each dashboard. The village managers were unable to attend, but dashboard information was communicated via WPPI stakeholders.

More in-depth training for the tool beyond the screen share Google Hangout meetings will also be a priority for key stakeholders, including our contacts at WPPI Energy, WUPPDR, and the Village Managers of Baraga and L'Anse, who are integral to the tool's implementation. To this end, our team is developing brief informational handouts that provide visual overviews to dashboard use.

Results

Cost-Benefits Literature Review

Financial Component

Given how the financial results of the cost-benefit analysis are impacted greatly by the underlying assumptions, we deferred to WPPI to set those assumptions as well as determine how they wanted the costs and benefits to be displayed. Based on their needs, we elected to capture the costs and benefits to subscribers and the power company separately.

For information regarding the financing of the solar array, WPPI provided our team with information on four proposals that they were considering, which included the installation cost ($/watt) and rated power (watts) of each of the proposals. They also gave us information regarding the down payment and interest rates they had secured for the project, as well as the rates for assumed average insolation, system degradation, utility escalation, and discounting future cash flows. Although they currently have no impact on the financials of the project, we also added into the dashboard the option to include operation and maintenance, marketing, and equipment replacement expenses. In terms of cash in-flows, we included three subscription plans that can be set at different percentages of subscribership.

Legal Component

Because the parties to the project are non-profits, many of tax credits and incentives commonly used for similar projects did not apply.

Some portion of the ITC and/or MARCS could be applied if the communities used a developer willing to pass-through some of the tax and depreciation savings, but this is unlikely due to the small scale of the project (which is unlikely to attract a developer) and desire for a local developer (limiting the pool). CREBS, as tax credit bonds, are also unlikely to apply.[18] The expenditures tax credit has been used by consumers in the past for their purchase of a share in a community solar project,[19] but the IRS has not ruled definitively on its universal application in this manner and we considered it too volatile to include as an offset of the consumer's investment.

The REAP program is designed for agricultural producers and rural small businesses.[20] The small businesses in Baraga are a key to the success of the project, and may be able to apply for grants or loans to cover the cost of purchasing a larger number of shares. Michigan Renaissance Zones provide a virtually tax-free area for localities that are likely to create jobs and increase economic growth, but are inapplicable here as few, if any, jobs will be created by the project. Additionally, PACE financing, which allows businesses to receive upfront capital for renewable improvements and repay using special assessment on their property taxes[21] is not available because Baraga county is not participating in the program.

Once the project is complete, WPPI will be able to sell any extra RECs generated to raise additional funds,[22] but RECs will not affect the cost to build or buy into the project.

Siting raises some interesting legal issues, depending on the ultimate location of the array. The entirety of the Village of Baraga is on the L'Anse Indian Reservation, and land purchases or leases within the village may be subject to Bureau of Indian Affairs approval, depending on whether the parcel is held in trust or in fee. Currently, the proposed sites for the array are those already owned by the Villages of Baraga or L'Anse, negating this issue.

Also, although not affecting the initial build or buy-in cost (and thus not included as part of our calculations), parties will need to carefully structure their community solar purchase agreements to not inadvertently created securities, which must be regulated by the SEC, creating an unnecessary burden on the project.[23]

Finally, a legal disclaimer was researched and drafted (with the oversight of an attorney) for use with the citizen dashboard, to prevent inadvertent legal or financial reliance on the dashboard.

Environmental Component

The electricity grid is comprised of various power generating sources such as coal, natural gas, nuclear, hydro, and solar. To consolidate the varying environmental impacts of different power generating systems, a weighted average was used to calculate an overall average grid factor. This was calculated using values obtained from the relevant stakeholders and previously published works. Through discussions with stakeholders and a survey of literature, two major environmental metrics were selected: (1) greenhouse gas (GHG) emissions and (2) particulate matter (PM) 2.5. GHG emissions include carbon dioxide, methane, nitrous oxide, and fluorinated gases. PM 2.5 refers to small particles in the air with a diameter of less than 2.5 micrometers. The net environmental impact of installing the solar project was calculated by taking the difference between the avoided life cycle impact from traditional electric generation and the life cycle impact from the solar project.

To account for the temporal variation in the grid, a renewable adoption rate parameter was added to the model. This value represents the rate at which renewable sources are added to the grid, and we assume they equally displaced existing fossil fuel sources. This adoption rate was factored in to calculate the overall environmental impact of the community solar project over its lifetime. The power company dashboard models focus on representing quantitative results of the environmental impacts from the solar project, and permit for more nuanced analysis by allowing user input for baseline conditions (e.g. if the solar project was not commissioned and used). The citizen dashboard focuses on highlighting final results with relatable context for the users in order to allow for the easy understanding of the solar project's impacts.

One metric not represented in the dashboards is land use. While it can be an important metric for renewable sources, there is ambiguity around values for all the involved energy sources. However, it is important to recognize that the community solar project will require suitable space (either on rooftops or ground level), and, to our understanding, the stakeholders involved are ensuring siting is determined in a fair and appropriate manner.

Public Health Component

The field of public health aims to mitigate risk factors and causes of illness and disease by addressing the social determinants of health. The social determinants of health include 'upstream' social determinants, including but not limited to economic resources, housing and energy resources that influence people's behaviors and ultimately, their health outcomes.[24] Thus, addressing a community's energy insecurity and/or access to sustainable and clean energy through community solar programs takes a social determinants of health approach to addressing and preventing poor health outcomes.

Due to the relatively new nature of community solar programming, little research has assessed its impact on the health outcomes of a community or individuals. However, while this remains an unknown area in the health and renewable energy literature, the impact of solar energy and the displacement of carbon or fossil fuel-based energy on human health is a growing area of research. The results presented here are to serve as a broad backdrop for understanding the health implications of further pursuing solar energy both in Baraga and within the UP as communities attempt to shift to a more sustainable energy future.

To understand the public health benefits of community solar and displacement of fossil fuel-based energy generation, several emissions related to fossil fuel-based generation were considered. Emissions such as $PM_{2.5}$, sulfur dioxide (SO_2), and nitrogen oxides (NO_x) are known to have detrimental health impacts. Particulate matter, such as $PM_{2.5}$, is a key indicator of air pollution and is known to cause the most significant health impact due to its ability to travel into the lungs and potentially enter the bloodstream. $PM_{2.5}$ exposure through air pollution means greater risk to both the heart and the lungs and can lead to premature death in people with heart or lung disease, non-fatal heart attacks, aggravated asthma, decreased lung function, and increased chronic respiratory symptoms (coughing, irritation of airways, or difficulty breathing), among others. Long-term, these health impacts can also lead to restricted activity, increased risk of cancer or diabetes. Thus, the individual financial impact of increased healthcare spending and the systematic burdens placed on the public health and healthcare systems through more emergency room visits and hospital admissions collectively lead to decreased quality of life and economic activity.[25]

Further, SO_2 is another environmental air pollutant that can significantly impact health outcomes. Because the largest contributor of SO_2 to the atmosphere is through the burning of fossil fuels by power plants or other industrial facilities, encouraging greater production of other renewable energies can support the reduction of SO_2 present in the atmosphere and associated poor health outcomes, including difficulty breathing (especially among children, elderly, and those who suffer from asthma). Further, SO_2 emissions and high air concentration of SO_2 can contribute to the generation of other sulfur oxides (SO_x) in the environment; SO_x can react with other atmospheric compounds that generate particles and particulate matter pollution. As mentioned previously, PM can travel deep into the lungs and cause significant short and long-term respiratory health issues.[26]

Therefore, there are several public health co-benefits that occur when renewable energy sources, such as solar, replace coal-based energy generation. Pursuing more sustainable and renewable energy resources, including community solar programming, can support more positive long-term health outcomes. Significant public health benefits may occur on a regional scale should the displacement of GHG emissions occur through decreases in fossil fuel or coal-based energy generation as solar generation increases. However, the quantification and assessment of public health benefits from renewable energy and solar generation is challenging to calculate due to several variable factors, including, but not limited to: (1) the contribution of GHG, SO_2, and NO_x emissions to electrical generating units (EGUs); (2) the EGUs that renewable energy such as solar may displace, depending upon performance, location, and time characteristics; (3) properties of other EGUs on a particular grid and their interactions with a grid's characteristics (such as transmission capability); and, (4) the public health impacts of $PM_{2.5}$ created from SO_2 and NO_x emissions as they interact with atmospheric conditions and the distribution of populations downwind.[27]

Thus, considering the impact of the previously mentioned factors, the public health benefits of community solar are largely dependent upon the amount of solar energy generated and deployed, as well as the location of deployment. Further, benefits are also hinged upon the assumption that an increase in community solar generation will impact the amount of fossil fuel-based energy generation in other areas within the United States beyond Baraga. Therefore, while these factors were considered, we were unable to incorporate them in our models. However, increased community engagement and education around community solar programming, energy access, and energy justice issues can further contribute to other public health goals within Baraga and other LMI communities.

Dashboards

After an intensive review of stakeholder information and applicable literature, our team developed three distinct dashboards from an excel model we developed, a screenshot of which is in Figure 2.

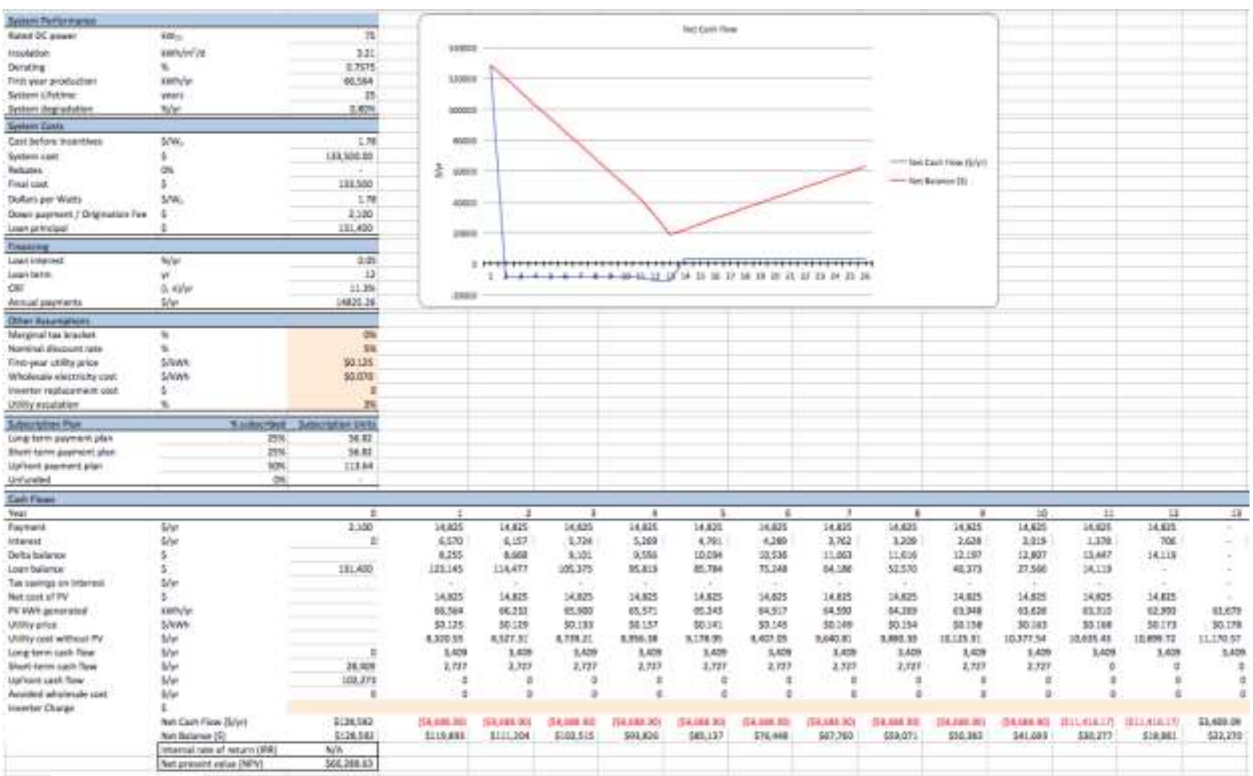


Figure 2

*Excel sheet model continued through year 25

Two dashboards were created for WPPI's use in assessing community solar projects, and one for community members to compare buy-in plans and energy cost savings were they to participate in the program.

The first dashboard developed was the Power Company Dashboard titled *Cost Benefit Analysis of Solar Array*, screenshots of which are displayed in Figures 3 and 4. The purpose of this dashboard was to capture the net present value of a community solar system as different financing and environmental factors are adjusted by the user.

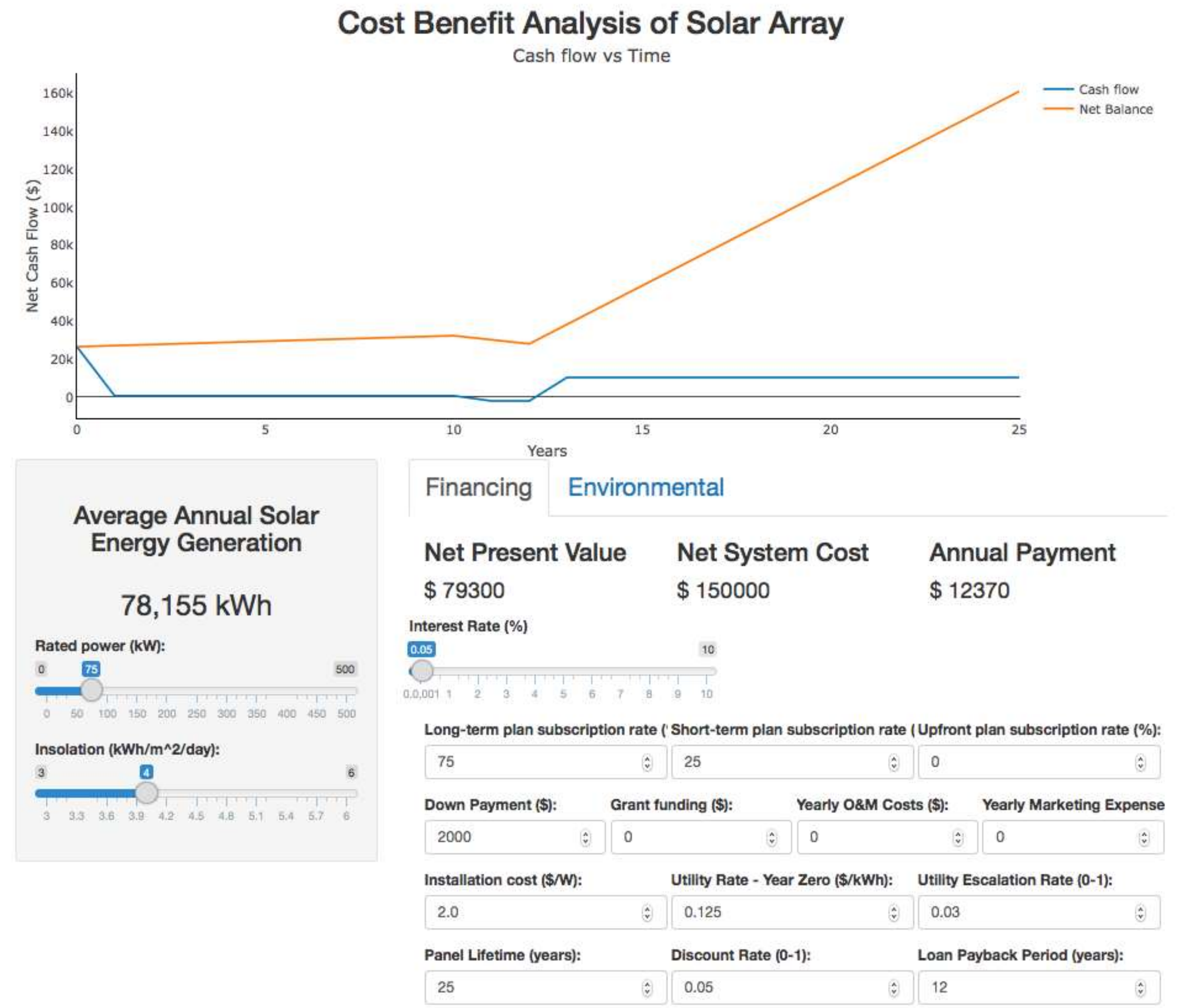


Figure 3

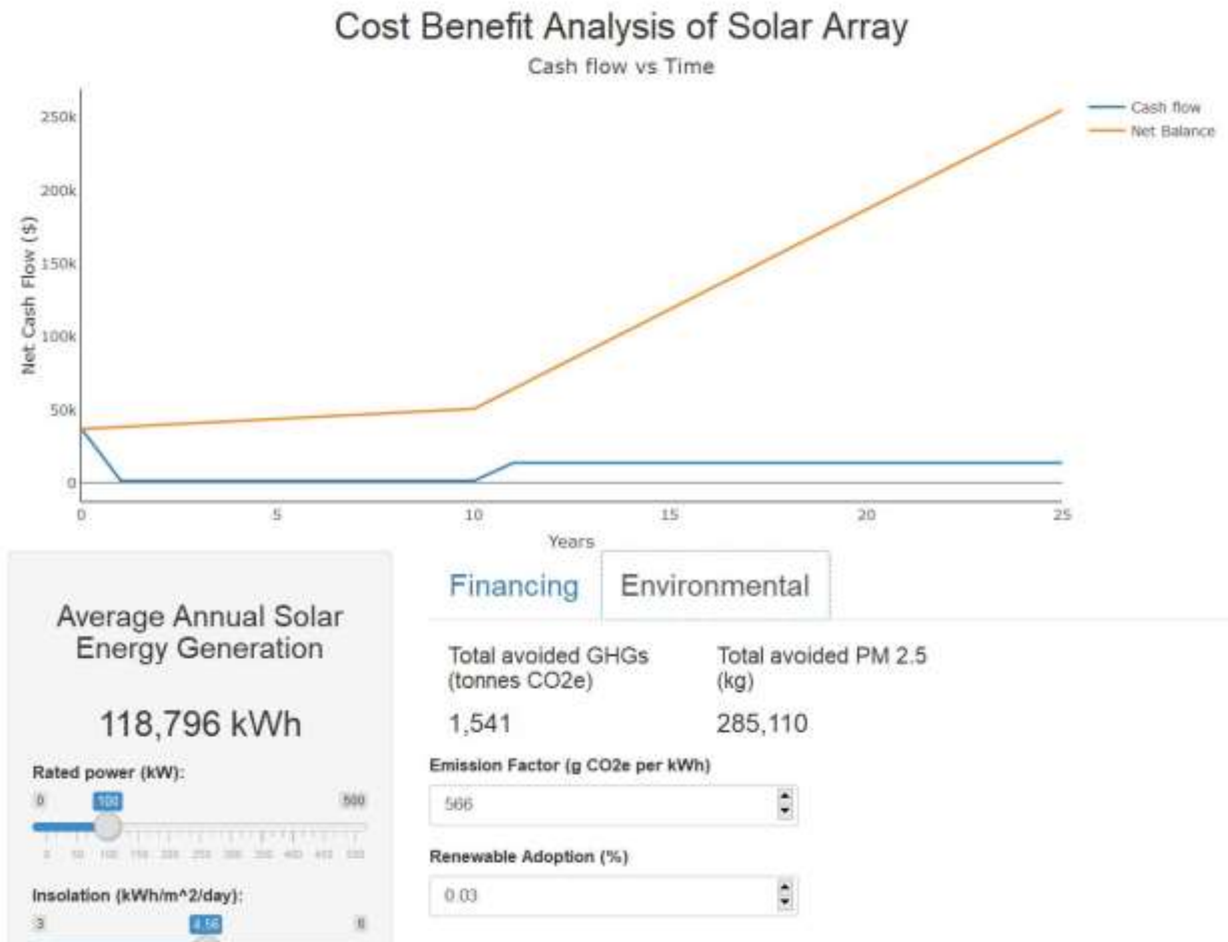

Cost Benefit Analysis of Solar Array
Cash flow vs Time
Net Cash Flow ($)
250k
200k
150k
100k
50k
0
0
5
10
15
20
25
Years
Cash flow
Net Balance
Average Annual Solar Energy Generation
118,796 kWh
Rated power (kW):
Insolation (kWh/m^2/day):
Financing
Environmental
Total avoided GHGs (tonnes CO2e)
1,541
Total avoided PM 2.5 (kg)
285,110
Emission Factor (g CO2e per kWh)
566
Renewable Adoption (%)
0.03

Figure 4

The second dashboard, *Aggregate Community Impact of Solar Array*, shown in Figure 5, was also developed for the power company, and shows the net present value of the aggregate community impact of the solar array. This dashboard is intended to give a broad overview of the community benefit provided by the array taking into account the costs to the power company of creating the array and the benefit to consumers in terms of cost savings.

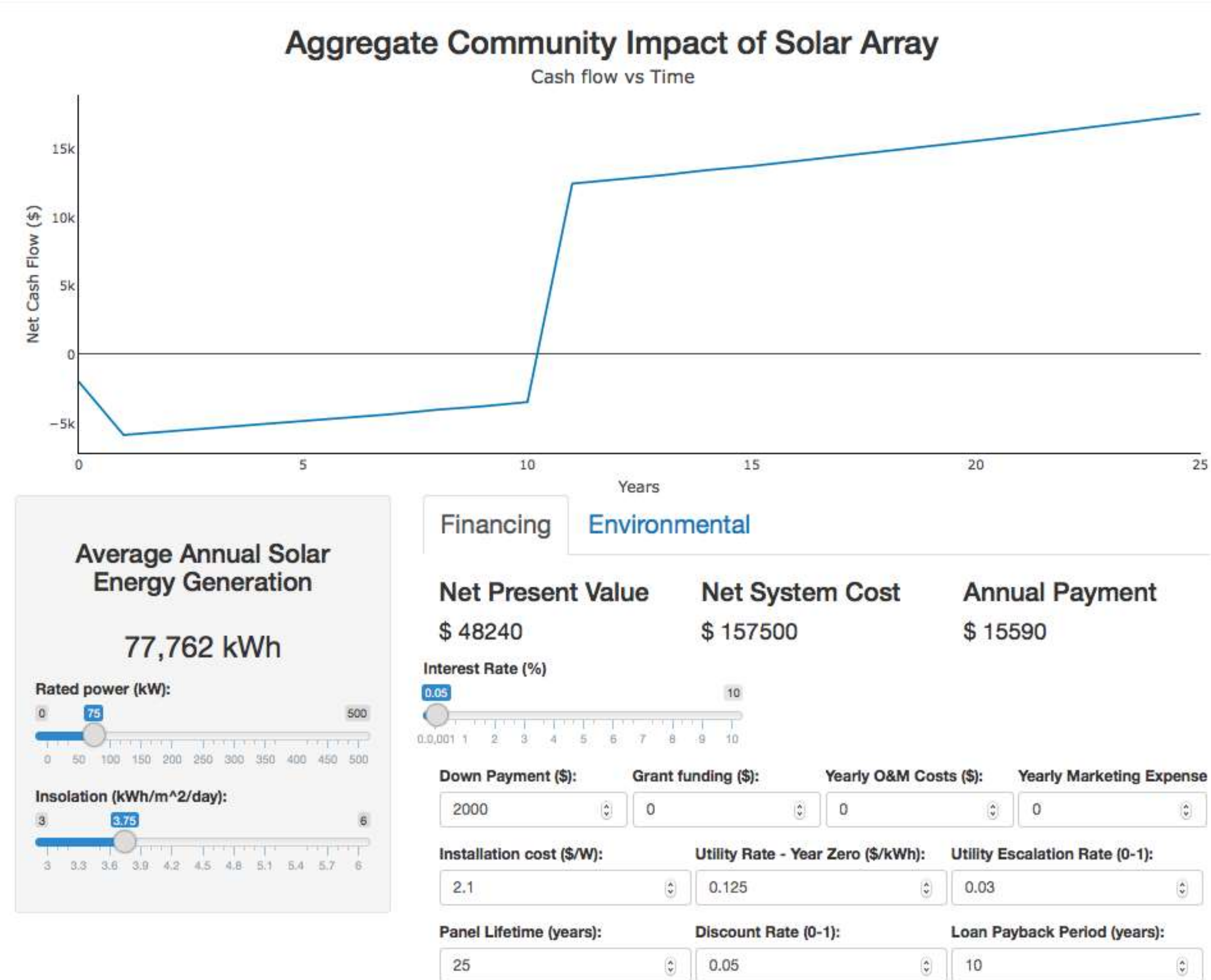


Figure 5

The third dashboard was developed for community members to better understand their buy-in options and the effect on their energy savings those options could have. A screenshot of this dashboard is located in Figure 6.

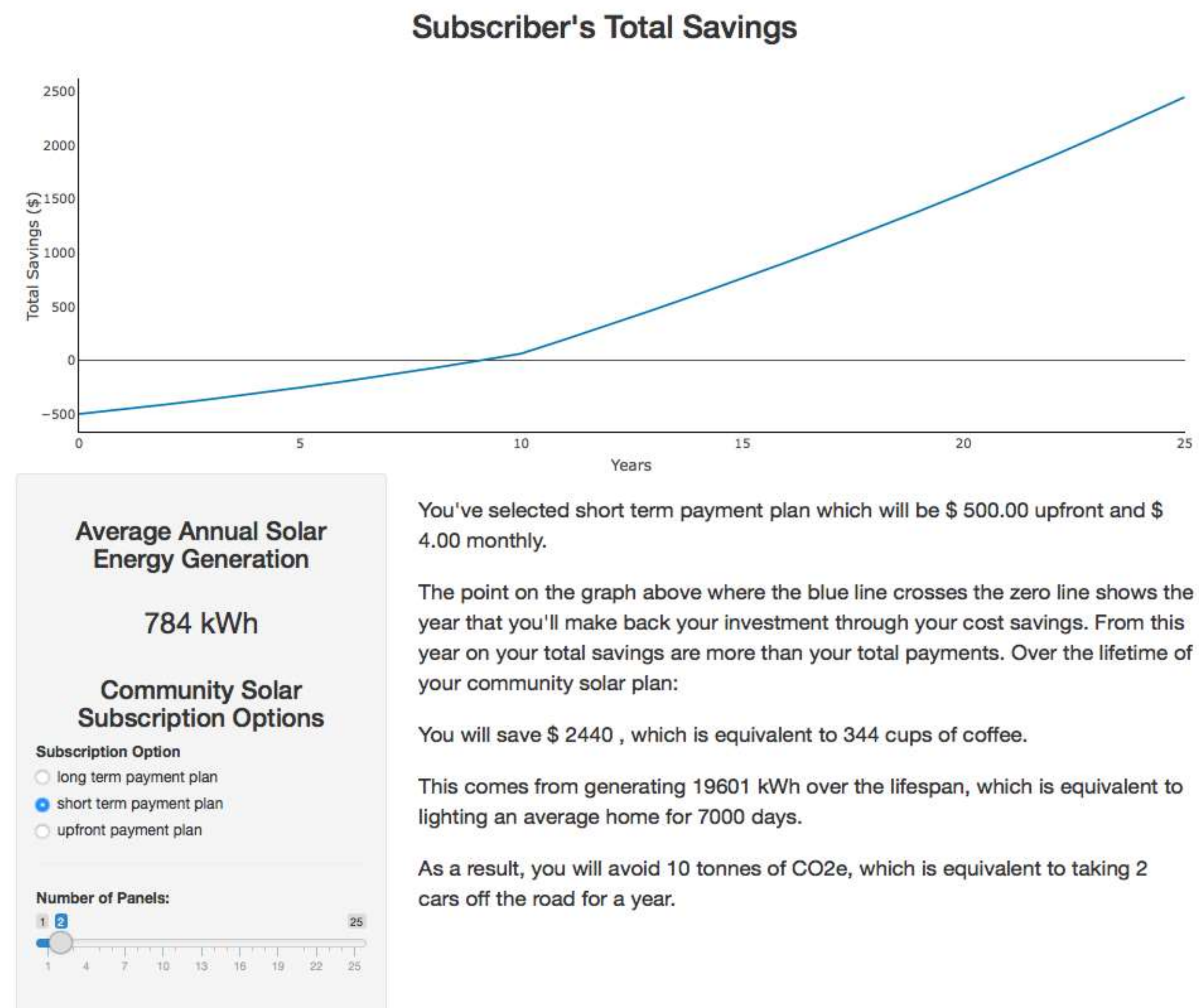


Figure 6

Our team has been in active communication with WPPI and WUPPDR about how to most effectively deploy the dashboards. The R scripts for all three tools will be passed on to both WUPPDR and WPPI, and WPPI plans to deploy the tool on their local server. While this report was generated, several other servers were considered, including hosting through MiServer (through the University of Michigan), through WPPI, or through Michigan Technological University with the help of Jay Meldrum, a DEED team member.

Training on the use and deployment of the tools is important to ensure continuing results, as the tools were intended to be broadly scoped and modular, such that the results of this project can be easily and readily adapted for use in other communities considering community solar projects.

DEED team stakeholders have noted some difficulty engaging the Baraga community with its hopes for community solar, and attendance at traditional community meetings has been low. However, a survey conducted by researchers at Michigan Technological University indicated positive interest by Baraga citizens in the community solar project, and the DEED project team is evaluating methods to increase community participation. While an exploration of non-traditional outreach methods may be helpful in increasing attendance and thus increasing usage of the citizen dashboard throughout the community, the time constraints of the project did not allow our group to pursue this area of research.

Discussion

Anticipated Impact

The deliverables of this project will provide WUPPDR, WPPI and the Baraga community with the tools and requisite knowledge needed to make informed decisions on the individual and community-level value of community solar projects in the region.

The tools are designed to be user-friendly and applicable to communities beyond Baraga. WPPI will have full access to both the Excel spreadsheet and the online dashboard, and will be able to manipulate data as needed to apply the model to other municipalities within its cooperative. The online community dashboard will allow individuals to fully appreciate the costs and benefits of buying into a community solar program in their community.

Conclusion

Limitations

Several limitations bounded our work. As previously mentioned, the UP experienced severe flash flooding in June. Infrastructure, homes, and offices were critically damaged. In particular, WUPPDR's office was flooded and the organization was forced to relocate. As a result, the DEED team's original timeline for several project components was delayed and our team needed to readjust plans for stakeholder and community engagement.

Further, because of the flooding and low turnout of the first community solar engagement meeting, the DEED team's engagement strategy evolved throughout the late summer and fall. While we planned to present our CBA results and dashboards at the second community meeting scheduled for August, the DEED team decided to further postpone the formal community meeting until late fall. Finally, when the formal community meeting was canceled, we decided to pursue other forms of remote stakeholder training. The long travel time and distance to the UP, along with the timeline of community engagement coinciding with the team's academic semester schedule, prevented us from visiting the UP a second time. Thus, we decided that hosting online feedback sessions via Google Hangout with WUPPDR, WPPI, and other stakeholders were most feasible given our travel and time constraints. As a result, we also are relying upon our stakeholders and their ties to community members to disseminate the dashboard for citizen use.

Lessons Learned

Several lessons and themes emerged throughout the duration of the fellowship. First, identifying and clarifying needs among stakeholders was of the utmost importance. This was an ongoing process as additional stakeholders were identified, unexpected barriers arose, and miscommunication related to the dashboards occurred. Second, considerable flexibility was needed as the team worked remotely in tandem with the DEED team. Many decisions, such as dates the team would travel to the UP, our participation in the second community meeting, and dissemination of the dashboards and training, were tentatively planned for but required adjustment due to extenuating circumstances beyond the team's control. Finally, staying in consistent communication with WUPPDR, WPPI, and other key project stakeholders was influential in the development of the project and ultimately facilitated the creation of the third dashboard.

Future Direction

While our group focused on the creation of the CBA dashboards, several potential avenues of community engagement remain to be explored. Dissemination of the tool to community members will be an ongoing effort facilitated by WUPPDR while the DEED team continues to develop solar programming among the Baraga and L'Anse communities. These ongoing efforts could be an avenue of continued work for future Dow Sustainability Fellows teams.

Furthermore, WUPPDR's work in advancing energy efficiency is another viable avenue for future Dow Sustainability Fellow teams, and Mr. Barnett indicated that WUPPDR would like to work with future teams on various local projects. Specifically, there may be space for a Dow Fellows team to further engage communities with education and outreach efforts among WUPPDR's six county service areas. Prospective activities and outputs could include developing tools or materials for UP communities to more effectively learn about and participate in energy efficiency programs, or more readily access and adapt energy efficiency technologies. Such work would involve assessing the associated economic, health, and policy landscapes that may foster opportunities or barriers for communities to adapt energy efficiency behaviors. Considering the variety of renewable energy and energy efficiency initiatives that WUPPDR and UP communities are considering, several points of engagement are possible and could continue our team's progress.

Acknowledgements

The Dow Fellowship Team would like to acknowledge and thank the following organizations and individuals for their support, guidance, and feedback on the project: The Dow Chemical Foundation, Western Upper Peninsula Planning and Development Region, WPPI Energy, Village of Baraga, Village of L'Anse, Michigan Technological University, the Keweenaw Bay Indian Community, the DEED Grant Research Project Team, Margaret Wooldridge, and Kevin Hunter of Steptoe & Johnson LLP.

Appendix - Stakeholder Interaction

Organization	Contact Name(s)	Description of Interaction
Western Upper Peninsula Planning & Development Region (WUPPDR) *Client*	Brad Barnett Regional Planner	The team met with and continues to facilitate ongoing conversation with Mr. Barnett to discuss our scope of work, understand the progress of the larger DEED grant research project, and receive feedback on the CBA dashboards.
DEED Grant Research Project Group	Brad Barnett, WUPPDR Brett Niemi, WPPI Energy	Group members attended the bi-monthly research team meetings in person and remotely to learn how the CBA and dashboards fit into the larger DEED research project. The DEED team will continue to guide the dissemination of the dashboards for Baraga and other UP communities.
Keweenaw Bay Indian Community (KBIC)	Sarah Smith Assistant CEO	Group members facilitated a phone meeting to understand the KBIC's current & past energy grant projects and community perceptions related to community solar.
Lotus Engineering & Sustainability	Julia Ferguson Sustainability Consultant	Group members facilitated a phone call meeting to inform Ms. Ferguson about the CBA and understand her energy efficiency project within the larger DEED grant.
Michigan Technological University (MTU)	Jay Meldrum Director Keweenaw Research Center	Discussed Fellows work which could be adapted for community solar projects in other parts of the UP outside of WPPI's region with Mr. Meldrum after a DEED team meeting while visiting the UP.
Michigan Technological University (MTU)	Chelsea Schelly, PhD Associate Professor of Sociology	Group members spoke with Dr. Schelly remotely to understand MTU's involvement with the DEED grant project and current community engagement efforts with the Baraga and L'Anse communities.

Village of Baraga Baraga, MI	LeAnn LeClaire Village Manager	Group members met in person with Ms. LeClaire to understand the demographics of Baraga and how community solar programming may impact low-income residents.
WPPI Energy	Brett Niemi Senior Energy Services Representative	Group members met with Mr. Niemi in person and remotely for solar system technical assistance and to learn the relationship between WPPI Energy and the Village of Baraga.

References

[i] Keith Matheny, *Power bills are whoppers for some in Michigan's U.P.*, Detroit Free Press, Sept. 08, 2016. Retrieved from https://www.freep.com/story/news/local/michigan/2016/09/07/power-outrage-electric-bills-upper-peninsula/89593302/.

[ii] American Public Power Association, *Deed R&D Funding*. Retrieved Nov. 1, 2018 from https://www.publicpower.org/deed-rd-funding.

[1] United States Census Bureau, *American Fact Finder 2010 Census*. Retrieved Nov. 28, 2018 from https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml?src=bkmk

[2] United States Census Bureau, *American Fact Finder 2010 Census*. Retrieved Nov. 28, 2018 from https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml?src=bkmk

[3] State of Michigan, Population of Indian Reservations, Trust Lands and Tribal Statistical Areas in Michigan, 2000. Retrieved Nov. 28, 2018 from https://www.michigan.gov/documents/indiancountry_31994_7.pdf

[4] United States Census Bureau, *American Fact Finder 2012-2016 American Community Survey*. Retrieved Nov. 1, 2018 from https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_5YR_DP03&prodType=table.

[5] United States Census Bureau, *American Community Survey Population and Housing Narrative Profile*
2012-2016 American Community Survey 5-Year Estimates. Retrieved Nov. 1, 2018 from https://thedataweb.rm.census.gov/TheDataWeb_HotReport2/profile/2016/5yr/np01.hrml?SUMLEV=160&place=05320&state=26

[6] Village of Baraga, *Village of Baraga Master Plan Draft 2018*. Retrieved Nov. 1, 2018 from http://www.villageofbaraga.com/PDF/2017-12-07-Master-Plan-draft.pdf

[7] Keith Matheny, *Power bills are whoppers for some in Michigan's U.P.*, Detroit Free Press, Sept. 08, 2016. Retrieved from https://www.freep.com/story/news/local/michigan/2016/09/07/power-outrage-electric-bills-upper-peninsula/89593302/.

[8] 2015-2019 Western Upper Peninsula Regional Prosperity Plan. (n.d.). Retrieved May 19, 2018, from http://www.wuppdr.org/wp-content/uploads/2014/01/WUPRPP_RPP_FinalAdopted_MD1.pdf

[9] Village of Baraga. Utility Rates. Retrieved from http://www.villageofbaraga.com/utilities.htm

[10] Western Upper Peninsula Planning & Development Region, www.wuppdr.org.

[11] WPPI Energy, https://wppienergy.org/.

[12] Denholm, Paul, et al. (2014) Methods for analyzing the benefits and costs of distributed photovoltaic generation to the US electric utility system. National Renewable Energy Laboratory.

[13] Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., ... & Pennington, D. W. (2004). Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications. *Environment international*, *30*(5), 701-720.

[14] Turconi, R., Boldrin, A., & Astrup, T. (2013). Life cycle assessment (LCA) of electricity generation technologies: Overview, comparability and limitations. *Renewable and sustainable energy reviews*, *28*, 555-565.

[15] Sathaye, J., Lucon, O., Rahman, A., Christensen, J., Denton, F., Fujino, J., ... & Shmakin, A. (2011). Renewable energy in the context of sustainable development.

[16] Hertwich, E. G., Gibon, T., Bouman, E. A., Arvesen, A., Suh, S., Heath, G. A., ... & Shi, L. (2015). Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies. *Proceedings of the National Academy of Sciences*, *112*(20), 6277-6282.

[17] Caroline Blackmon, *What we know about flooding in Upper Peninsula*, Detroit Free Press, June 19, 2018. Retrieved from https://www.freep.com/story/news/local/michigan/2018/06/19/upper-peninsula-flooding-houghton-michigan/713059002/

[18] DSIRE USA, *Clean Energy Renewable Bonds*. Retrieved Nov. 1, 2018 from http://programs.dsireusa.org/system/program/detail/2510

[19] DSIRE USA, *Residential Renewable Energy Tax Credit*. Retrieved Nov. 1, 2018 from http://programs.dsireusa.org/system/program/detail/1235

[20] DSIRE USA, *USDA - Rural Energy for America Program (REAP) Grants*. Retrieved Nov. 1, 2018 from http://programs.dsireusa.org/system/program/detail/917

[21] Lean and Green Michigan, *How PACE Financing Works*. Retrieved Nov. 1, 2018 from https://leanandgreenmi.com/how_pace_works

[22] DSIRE USA, *Renewable Energy Standard*. Retrieved Nov. 1, 2018 from http://programs.dsireusa.org/system/program/detail/3094

[23] Feldman, et al, National Renewable Energy Laboratory, *Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation*. Retrieved Nov. 28, 2018 from https://www.nrel.gov/docs/fy15osti/63892.pdf

[24] Braveman, P. A., Cubbin, C., Egerter, S., Williams, D. R., & Pamuk, E. (2010). Socioeconomic disparities in health in the United States: what the patterns tell us. *American journal of public health*, *100*(S1), S186-S196.

[25] United States Environmental Protection Agency. Particulate Matter (PM) Pollution. Retrieved from https://www.epa.gov/pm-pollution; Kim, K. H., Kabir, E., & Kabir, S. (2015). A review on the human health impact of airborne particulate matter. *Environment international*, *74*, 136-143.

[26] United States Environmental Protection Agency. Sulfur Dioxide Basics. Retrieved from https://www.epa.gov/so2-pollution/sulfur-dioxide-basics

[27] Buonocore, J. J., Luckow, P., Norris, G., Spengler, J. D., Biewald, B., Fisher, J., & Levy, J. I. (2016). Health and climate benefits of different energy-efficiency and renewable energy choices. *Nature Climate Change*, *6*(1), 100.