U of M Central Power Plant
Solar Roof: Educational Benefits and Recommendations

An Environ 391 Project

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Executive Summary

As the economic, social, and environmental costs of fossil fuel-based electricity continue to increase, it is important that the University of Michigan (U of M) integrate renewable energy sources into its infrastructure. In line with this global challenge as well as the University of Michigan’s goal of reducing carbon dioxide emissions, Richard Wickboldt, manager of the Central Power Plant (CPP), tasked the Solar Roof Team of Environment 391: Sustainability and the Campus to analyze the non-technical benefits of installing solar roofing on the plant. This study had two main objectives: to investigate possible benefits of installing the solar roof and to outline and begin an educational campaign to promote student awareness.

Due to the age and deterioration of the current plant roof, full replacement of the roof will be necessary within the coming years. Using this renovation as an opportunity, the CPP hopes to generate energy through the use of solar roofing materials. We investigated current installations at peer institutions to locate possible benefits of this installation. Oakland University, University of Iowa, and Arizona State University have used solar installations as an educational tool for both their campus and the public. We identified common successes and difficulties that can be taken into consideration when planning U of M’s installation. Although U of M has tested a similar installation on the roof of the Samuel T. Dana Building, there has been limited success in using this array for education because of the system’s inaccessibility and unreliable data. However, based upon our conversations with several University faculty members, there is a sizable and genuine interest in using the proposed CPP solar installation in existing coursework.

To begin to design an education plan, we issued a survey to over 100 students at six public locations to identify current awareness and interest in energy and the Power Plant. Fifty four percent of the students were aware of the power plant, 78% of students were in support of the proposed project and 72% remained in support even with a small increase in tuition. Sixty four percent of students expressed a desire to learn more about the project. This appetite for information about renewable energy highlights a desire by the U of M community at large to see and learn more about the future of energy.

In order to satisfy this desire for more solar technology education and opportunities, we recommend that, in addition to installing the solar array on the roof of the Central Power Plant, the University undertake the following tasks:

- Design the array to maximize public access by addressing safety concerns.
- Using the real time data generated by the array, collaborate with professors to establish informative and useful connections to the classroom and to the public to encourage education and awareness.
- Implement social outreach and educational programs to reach segments of the population that desire but would otherwise not encounter information about the array.

By utilizing the CPP solar roof as an educational asset, the University of Michigan can tap into a growing interest in renewable energy education among higher learning institutions.
Introduction

In the hope of promoting the implementation and continued use of renewable energy on campus, our team of students undertook the task of identifying the benefits of a solar roofing installation on the roof of U of M’s Central Power Plant. The current roof of the plant is in need of replacement within coming years offering a unique opportunity for the University. U of M can install a new array and roof simultaneously, rather than in separate projects, using a technology known as Building-Integrated Photovoltaics (BIPV). This will reduce the typically high upfront cost of solar installations. However, due to the technological limitations of BIPV, such an installation would not generate as much power as other mounted or pivoting arrays. With this in mind and the sponsorship of the CPP manager, Richard Wickboldt, we chose to identify the non-technical benefits of such an installation. As background research, we compiled several sets of data on current projects at other universities as well as identified opportunities for such a project available at Michigan. Based on this information and original research collected about student awareness, we designed and prepared the first stages of an education program to capitalize on the educational possibilities of this array for the U of M community as well as the public.

Objectives

This study had two primary goals:

- Identify the non-technical benefits of installing a solar roof on the Central Power Plant. This includes surveying similar projects at peer institutions as well as identifying opportunities available at U of M.
- Devise an educational campaign to use the project proposed for the U of M CPP for sustainable energy awareness. This includes preparing the first steps of the educational campaign for immediate implementation as well as outlining future steps.

Methodology

The first step taken was to contact peer institutions with similar solar energy programs to identify any trends in difficulties or successes they experienced. An e-mail communication describing our project was distributed by our sponsor to peer institutions in order to request information on similar solar programs. Mr. Wickboldt was able to send the communication to a large number of institutions including many in the Big Ten and Friends network. This information could then be used to make recommendations for the University of Michigan’s program. The next step was to contact professors through the U of M course guide to gauge interest in integrating the solar installation into a curriculum.
A student survey was then conducted to get a better understanding of student perceptions and opinions of the power plant and sustainable energy. Based on the feedback received, we were able to identify the most effective ways to implement an educational outreach campaign on campus. As a final follow-up to our findings, we designed a website and Facebook page for the proposed project, and formulated recommendations for the future.

**Peer Institution Research**

In order to ensure that U of M’s solar installation is a success, we researched and contacted peer institutions to gain information on the benefits and problems with similar initiatives. Many universities faced similar drawbacks to those found in U of M’s proposal. These include long payback periods, minimal community awareness and involvement, and absent educational opportunities. However, several universities were able to implement successful outreach programs with their solar installations and have effectively integrated solar power initiatives into the educational framework of the university. By synthesizing the successful initiatives of these institutions with the proposal at U of M, similarities amongst initiatives can be applied for the University’s benefit.

Following an initial inquiry, a short questionnaire was sent to participating institutions. The following questions were included in the survey:

1. Was there public support for your project initially? If not, how did you generate public interest in your project?
2. What are some current solar education and/or outreach programs that you are implementing?
3. What is the total investment and the payback period of the project?
4. Are you gathering real-time data and how are you using that?
5. What were the greatest difficulties you faced for your project?

These questions were chosen because they represent the most pressing problems in the proposed CPP installation. The responses to this questionnaire, outlined in the following sections, serve as useful comparisons to the University of Michigan’s project so as to ensure success. Appendix 1 contains a complete list of institutions who responded to our information request.
i. Soliciting Public Support

Many solar projects at peer institutions were initiated by public support and advocacy. In fact, the decision to construct a solar array on the roof at Arizona State University was influenced by a student-run research survey that included a condition assessment and feasibility of installation for a solar project. The completion of the solar project also helped Arizona State University obtain the first LEED(R) Platinum certification in the state of Arizona. Other universities, including Indiana University, held roundtables or facilitated discussions to obtain feedback and suggestions on how to better implement both the technical and educational aspects of the program. Some universities reported that their donors and stakeholders were in support of such a project. Indiana University hosted a group discussion with community stakeholders who expressed interest in a solar project, and the Dean of Engineering at Oakland University was a leading proponent of his institution’s project. The University of Iowa, which initially did not have support for its project, found that their installation became more popular with the campus community as educational opportunities were made available.

ii. Funding

Although the payback period of most solar projects remains long, 17 years for the Dana installation and 25 years for Purdue University’s installation, much of the upfront cost can be offset with the aid of awards and grants. While U of M does not currently have external funding for this proposed solar roof, research into other peer institutions shows that grants and awards are readily available for such a project. Grant amounts ranged from $25,000 at Indiana University to separate $100,000 grants from the State of Michigan for Oakland and Michigan State Universities. The City of Ann Arbor has also secured funding from private and community donations as well as the Energy Efficiency and Conservation Block Grant Program, a part of the American Recovery and Reinvestment Act. Many of these sources would be available for the proposed U of M installation.

iii. Difficulties

Mr. Bill O’Dell, the engineer in charge of the construction of the Dana Building array, experienced difficulties in contracting maintenance and servicing crews that were familiar with new photovoltaic technology. The BIPV technology proposed for the CPP is a relatively new technology as well and could present similar problems. However, the solar industry has shown rapid advancement in reliability and accessibility as it continues to receive more attention and greater investment. Despite possible difficulties with this technology, using BIPV for the University’s solar installation will place Michigan at the forefront of the technology as well as offering a reduction in cost over traditional solar installations.
Another major obstacle for many institutions was justifying their projects’ economics. Because the payback of such projects can be long, universities offset the initial cost or justify the investment. University of Iowa was able to move forward with their solar projects due to the steady decline in costs and improvement in technology of the solar cells. The City of Ann Arbor and Oakland University were only able to complete their projects by securing grant funding and significant subsidies and incentives. As the solar industry continues to grow, projects will continue to become more affordable and attractive.

iv. Real-Time Data

An essential aspect of many institutions’ solar programs was real-time data tracking of the solar installation. Universities provided this information to professors, researchers, and the public for analysis. Both Oakland University and the University of Iowa currently collect real time data and report it online. Arizona State University’s website includes a sophisticated “Campus Metabolism” web tool (http://cm.asu.edu/#) which tracks the energy output of each of its many solar installations across campus. Visitors are able to track how many kW each installation has generated on that day, as well as the overall averages for daily, weekly, monthly, and yearly power generation. Visitors are also able to see which installations generate the most power, and which times of day are most productive for solar energy generation. California Institute of Technology’s website includes a similar web tool. Other institutions use electronic displays in public locations directly connected to their solar installation to display the real-time data. California State University, Fresno (CSFU) has constructed four electronic kiosks near their parking-lot installation which allow visitors to observe current energy production. The University of Michigan’s Dana building has also installed a solar power monitor directly connected to its installation which is available for public viewing in the fourth floor lounge. Although the data monitoring system has encountered technical issues in the past, visitors are occasionally able to view real-time estimates of power generation from the solar panels. At the CPP, real-time data monitoring is built into the plant’s infrastructure. Thus, tracking and distributing the array’s production will not pose a problem.

v. Curriculum

Educational access by university professors is a critical component to integrating the solar installation into a broader educational framework. At Oakland University, there will be at least two classes, Solar and Other Renewable Energy Systems, and an upper level mechanical engineering course, that will incorporate the solar array as a case study. The University of Iowa’s College of Engineering is also incorporating its solar installations as teaching tools in its environmental and mechanical engineering classes. Based on this information, we contacted professors who are teaching similar courses at U of M to determine interest in utilizing the CPP solar roof for educational purposes.
vi. Successful Public Outreach

Several institutions have spurred campus and public support for their installations through the crafting of successful educational outreach campaigns. Almost every institution has constructed a website to advertise their installations, some even displaying real-time energy production. Public installations featuring real-time energy production such as CSFU’s informational kiosks are good examples of easy-access public education tools. Indiana University also offers public tours of its solar installation about four times a year, directly educating the public on the functions of its installation. Oakland University regularly offers an open house for viewing its installation, allowing the public to get an up close look at solar energy production. Another successful outreach method has been press coverage. To date, five separate articles have been published in local and city newspapers reporting on Oakland University’s installation. Many institutions have initiated press releases at the outset and completion of their solar project’s construction as well.

Survey

A survey of 120 students across North and Central Campus was performed in order to assess student attitudes and knowledge of the CPP. Each group member distributed 20 surveys to six public areas on campus. As an incentive to participate in the survey, a $25 gift card was offered in a random drawing. The survey sites were as follows:

The Michigan League (Central Campus)
Pierpont Commons (North Campus)
Shapiro Undergraduate Library (Central Campus)
The Michigan Union (Central Campus)
Angell Hall (Central Campus)
The Duderstadt Center (North Campus)

See Figure 1 for an example of the administered survey.

Results

We received 113 responses. Overall, the results highlighted the educational opportunities of the installation and revealed support for the project. In surveying basic attitudes about the environment among students, 96% of all students surveyed reported that protecting the environment was either very important or somewhat important (Figure 2). Overwhelming support for protecting the environment among students reveals a substantial interest in global and local environmental issues. The potential for U of M to be a leader in progressive environmental
policies and actions speaks to the student body. Although the proposed solar roof will produce limited energy, it will aid in bolstering educational programs that teach green technologies to the next generation of students.

When asked whether students would support a ~250kW solar array on the CPP roof, 79% of students were either somewhat or very supportive. The remaining 21% showed neutral support. When the question was repeated with the caveat of a $5 tuition increase, support for the project remained in the majority. With the caveat, 73% of students were either somewhat or very supportive, 24% were neutral, and 3% of students were somewhat opposed to the project (Figure 3). Thus, a large majority of students believe that protecting the environment is important and a similarly large majority is in firm support of the CPP installation.

With the educational opportunities of the installation in mind, we questioned students about their current knowledge and their desire to learn more. We found that 54% of students were unaware of the CPP’s existence on central campus. While this large facility is certainly noticeable to students traveling between the medical campus and central campus, many students are unaware of its function. Moreover, 64% of students expressed interest in learning more about this project. This reveals the sizable interest in learning more about renewable energy production and initiatives on campus in addition to student support for the project itself. The potential for education of students and faculty as well as the public is quite high.

Campus Education and Outreach

Survey results indicated that 30% of students would look for more about the project through a Facebook page while 52% would look for more information on a website (Figure 4). We determined that it would be advantageous for us to pursue both routes as part of our campus education and outreach. The website serves to inform visitors about the proposal, and can be found at www.umsolarroof.com. Included are additional resources related to the project such as information about the CPP, how solar energy production works, and in the future links to sustainability or energy-related courses at U of M. The Graham Institute will promote the website, and the website itself will be hosted by the CPP and maintained by its staff. The website is designed for UM students, staff, and faculty, but is accessible to the public. In the future, the real-time monitoring already in place at the CPP will be made available on the website.

The Facebook page will serve a similar purpose in regards to providing updates on the project, but will also include posts on solar energy news from around the world. It is geared towards students, but once again, anyone on Facebook will be able to “like” the page. The Facebook page can be found here: http://www.facebook.com/umsolarroof.

We contacted U of M professors to identify concrete educational opportunities created by the project. In general, professors who responded expressed great interest in students having access to real-time data from the solar panels to use for projects and case studies. Many of the professors contacted were affiliated with the College of Engineering or with the Taubman College of Architecture and Urban Planning. Professor Jamie Phillips has expressed interest in
using the solar panels in an Engineering 100 section that focuses on designing projects utilizing photovoltaics. Professor Phillips thought it would be beneficial for students to study the real-time data produced an array such as that proposed for the power plant. Both Professor Ku and Professor Margaret Wooldridge would be interested in using real-time data from the installation in their Electrical Engineering and Computer Science 429 and Mechanical Engineering 433 classes, respectively. Professor Mojtaba Nawab said the installation would provide an educational benefit within current courses in monitoring and creating predictive models for solar power application.

**Recommendations**

In order to satisfy the desire for more solar technology education at U of M, we recommend that, in addition to installing the solar array on the roof of the CPP, U of M undertake the following tasks:

**Design the array to maximize public access by addressing safety concerns.**

The accessibility of the array has been noted as a major drawback of the array currently installed on the Dana building. By ensuring safety for the public on the roof of the CPP, the array can accommodate hands-on study for coursework as well as tours for U of M affiliates and the public.

**Using the real time data generated by the array, collaborate with professors to establish informative and useful connections to the classroom and to the public to encourage education and awareness.**

By making the information produced by the array available to the public, U of M students and faculty as well as the community at large can access the data for causal interest as well as for education and research. Several professors have already expressed an interest in using the data for existing coursework. In addition, streaming data to a kiosk at the nearby Undergraduate Science Building or Mosher-Jordan Residence Hall would make data available where the roof is visible.

**Implement social outreach and educational programs to reach segments of the population that desire but would otherwise not encounter information about the array.**

Bring information about the proposed solar array as well as renewable energy to the university community using posters, tours, media coverage, and kiosks. This is crucial to increasing awareness and involvement. As well as pointing out the existence of the array, disseminated information could include its size (both physically and in terms of generating capacity), information about how it works, and a link to the website about the project. This public outreach will tie the installation to the community and encourage involvement in the energy discussion.
Conclusion

The results of this project yielded optimistic results with regards to the success of the solar roof. Correspondences with peer institutions and professors on campus provide evidence that such a project could garner U of M favorable opinions from the public as well as university faculty in related fields. Additionally, the survey results shed light on the students’ support for the project. Seventy-nine percent said they support the CPP solar roof project, and 73% said that they would be willing to contribute $5 (in the form of a tuition increase) to the funding of said project. The lack of student knowledge of the CPP points to the fact that an educational campaign should be implemented to better educate students of where their campus energy is coming from. By being one of the first universities to install a solar roof on a power plant and educating the student body about this project, U of M will demonstrate an initiative that makes its members leaders and best.
Appendices

Appendix 1

List of organizations that provided information

Arizona State University
California Institute of Technology
California State University, Fresno
City of Ann Arbor
Indiana University
Los Angeles Community Colleges
Michigan State University
Oakland University
Purdue University
University of Iowa
University of Michigan
Appendix 2

Environment 391: Sustainability and the Campus

Please fill out this brief survey. All responses are confidential. Write your uniqname at the end of the survey if you wish to be entered in a drawing for a $25 gift card. You email will only be used to contact you if you win.

How important is protecting the environment to you?
- Very important
- Somewhat important
- Not very important
- Not at all important

Do you know that the University owns a power plant on campus?
- Yes
- No

The University is currently considering installing a ~250kW solar array on the roof of the power plant. How supportive are you of this project?
- Very supportive
- Somewhat supportive
- Neutral
- Somewhat opposed
- Very opposed

If this project added $S to your tuition, how supportive would you be of the project?
- Very supportive
- Somewhat supportive
- Neutral
- Somewhat opposed
- Very opposed

Would you be interested to learn more about this project? (This question is purely to gauge interest. We will not email you based on your response to this question)
- Yes
- No

If yes, where would you be most likely to look for more information?
- Facebook
- A website
- Dial Posters
- Fliers
- Other: __________________________

Your uniqname for the drawing __________________________

Figure 1: Illustrates an example of a survey administered to students on campus.

How important is protecting the environment to you?

Figure 2: A visual representation of question 1 on the student survey.
Figure 3: A visual representation of questions 3 and 4 on the student survey.

Figure 4: A visual representation of responses for question 6 of the student survey.