

2018-2019

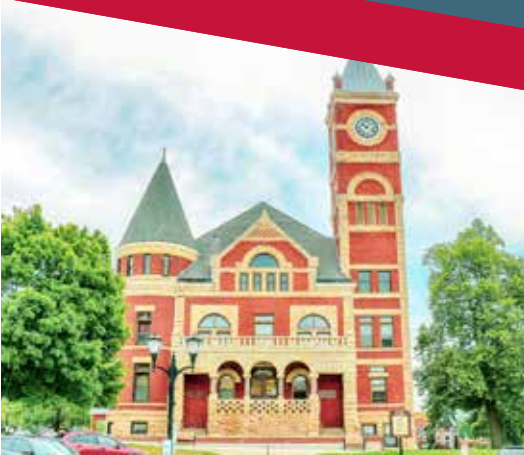
FINAL REPORT

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Solar panel recommendations for Juda School District

CIVIL ENGINEERING 421: ENVIRONMENTAL SUSTAINABILITY ENGINEERING



Executive Abstract

Presently, Juda School District, a small school in southern Wisconsin, receives a small amount of energy from renewable energy sources while having a large scale utility company, Alliant Energy, supply the rest. The schools current renewable energy source consists of a 36 panel solar system which offsets the schools energy usage by between 4.5% and 5.5% each year. In order to increase the school's commitment to sustainability, the school has created a program called the Green Initiative. One aspect of this program is to decrease the schools reliability on non-renewable sources of energy as well as to increase the overall efficiency of the school.

The goal of this project sought to research and analyze a solar energy system that would increase the schools energy independence while also being the most sustainable option in terms of environment, economics, and social. Each system was analysed by its inputs and outputs which included emissions, cost, manufacturing materials, end of life, and energy output. These categories of inputs and outputs were defined by the scope of the project, as other inputs and outputs would need significantly more analysis. The scope of this project also included a final recommendation of manufacturing company, and installation company that would meet the School's Green Initiative goals.

Previous literature pointed to the result that systems made of mono-crystal solar cells had higher efficiency rates in terms of energy absorption, and conversion than those made of poly-crystal solar cells. Previous literature also concluded that recycling solar panels at the panels end of life proved difficult due to hazardous materials and metals used to manufacture the panels.

Comparison of manufacturing companies showed that Sunpower fulfilled all three paradigms sustainability, and that Full Spectrum Solar was the best installer according to this project's criteria. Analysis of various configurations were examined using System Advisory Models, and it was determined that a 50kW system of 160 modules from SunPower's X22-270-C-AC series would be the most eco-effective option for the school to proceed with.

Examination of case studies of solar panel installations at other schools in Wisconsin shows that having renewable energy on campus provides the opportunity to integrate solar education into school curriculum and broaden student's understanding of energy and STEM fields. Solar panels then prove to be a socially sustainable energy option for Juda.

The project's final recommendation includes using Full Spectrum to install a 50kW system of 160 modules from SunPower's X22-270-C-AC series. This system achieves the school's goal of reaching 10% energy usage from renewable sources while also providing the most environmental, social, and economical benefits to the Juda School District.

Introduction

Juda School District is a school in Green County, Wisconsin. The school district consists of one school that comprises the elementary, middle school and high school grades. In total, the school serves 244 students. The school also holds a remote teaching program for not only its own students but also students of neighboring districts. Since 2012, the community has worked together with the high school's Physics and Engineering Curriculum to create the Green Initiative, which works to make the school, community, and ultimately the world a better place (Anderson 2018). The Green Initiative is a program headed by students to implement STEM

projects focused on the environment. The school recently completed a renovation that helps achieve the goals of the Green Initiative, by installing LED lights, solar panels, and new air conditioning units (Anderson 2018). The solar panels are located on the south side of the school, and are fixed, meaning that they don't move to follow the sun.

A primary component of this project was the work done by the Green Initiative, a program founded by Scott Anderson through Juda schools. Each year, Anderson's physics class decides on an idea that they would like to pursue, usually with a real-life element that is developed for the school. This year, the students strategized ways to increase the amount of renewable energy used by the school to 10% of the total energy consumed. The total usage in kWh for 2017 was 601,440. In order to meet the 10% offset, 60,144 kWh of energy needs to be produced by renewable energy sources. Solar power is already being used at the school, with a configuration of panels assembled on a corrugated metal roof. The initiative serves to engage students with their communities, and to help them develop deeper understandings of how STEM fields, particularly environmental sciences, can be used to create a better tomorrow.

Currently, the school district receives most of their gas and electricity from Alliant Energy Corporation. The Juda School District obtains between 4.5% and 5.5% of their electricity from the 36 solar panels installed on the school's roof. The school has partnered with Upper 90 Energy out of Madison, Wisconsin to increase their percentage of renewable energy use to 10% (Juda 2018). Together with Upper 90 Energy, the district has identified several Energy Conservation Measures that can be implemented independently at any time, as the school does not currently have the means for a large-scale initiative.

The school district is considering a referendum to obtain more revenue to fund and maintain the school's current operating costs. In 2016 the community approved a referendum to allow the district to spend \$150,000 more on operating costs during the school year (*Referendum 2018*). They considered another referendum on the November ballot, which passed and will “restore \$205,000 of operating revenue that the Revenue Limit prevents the District from receiving to maintain current programs and services, retain quality teachers, maintain appropriate class sizes, and maintain extracurricular activities at all levels” (*Referendum 2018*).

The school district has also applied for a grant through Public Service Commission of Wisconsin Office of Energy Innovation called the Energy Innovation Grant, which if awarded could help fund the installation of solar panels. The grant, which can be applied for yearly, “...supports the reduction of energy consumption and its cost to businesses and taxpayers, increased use of renewable energy and transportation technologies, comprehensive energy planning, and bolstered preparedness and resiliency in energy systems” (*Energy 2018*). Although funding has been applied for, keeping costs for the district low is integral to this analysis because it would allow them to implement more of the Energy Conservation Measures they designed with Upper 90 Energy in addition to the installation of panels.

Question

This project sought to determine which configuration of solar panels along with which solar company would best meet the needs of the district while reducing their carbon footprint and allowing the school to become more environmentally-friendly. The school district’s goal was to offset their energy dependency by 10% using renewable resources such as solar panels. They

also needed an option that is cost-effective for the district, because an affordable plan would free resources for other programs and opportunities that they could offer students. This study planned to assess the environmental, economic, and social costs and benefits of different solar panel configurations or systems, including the current system in place and a regression to buying all energy from the grid. This project looked into cost/benefits of 1 axis tracking vs stationary solar panels. In addition this study attempted to find a company that provided recycling for outdated solar panels. The environmental impact of solar panels does not simply include how they function as renewable energy sources, but also includes their production and end of life plan, and this was addressed during our analysis. The social implications of solar panel configurations, including whether money saved could be used for extracurricular activities, how students at the school will be involved in the Green Initiative program, and how the community could be affected by this change was also analyzed and examined. The project's scope, demonstrated by the map of flows in Figure 1, only included the life cycle of a solar panel from installation and use to the end of life, and did not look into the environmental, economic, and social consequences associated with material acquisition and manufacturing.

purpose of this study, however, thin-film technology will not be analyzed due to the cost and applications. Although the process of producing monocrystalline and polycrystalline are similar, they differ in the environmental impact during production and during the end of life.

Mono-crystalline photovoltaic cells are manufactured using molten high purity silicon while polycrystalline production uses lower grade silicon. Due to the purer structure of the silicon crystals, mono-crystalline cells require more energy during the production process than the polycrystalline process (Dubey 2013). Although each require energy during their production process, the environmental impact of the energy used is dependent on the source of such energy. Due to the pure silicon crystal being cylindrical, up to 20% of the crystal can be lost during the cutting process which forms wafers. Monocrystalline PV are more expensive than polycrystalline PV but have a higher efficiency. In the scope of this proposal, the energy sources of the production will not be analysed due to the nature of disaggregated production of industrial metabolites and raw materials. Rather the total energy expenditure used during the production process will be analysed instead.

The production process of photovoltaic cells can be broken down into the industrial metabolites and raw materials used. Each of these metabolites require energy to produce. The table below, *Table 1*, depicts the energy expenditures of each process of silicon production used in monocrystalline and polycrystalline photovoltaic cells (Dubey, 2013). When production energy expenditures are combined, the energy expenditure of manufacturing monocrystalline cells equates to 1000 kWh/ kg-Si and polycrystalline cells equates to 700 kWh/ kg-Si (Dubey, 2013).

Table 1: List of production processes and the corresponding energy expenditures of silicon (Dubey, 2013)

Electronic Grade Silicon			Upgraded Metallurgical Grade Silicon (Energy expenditure 15-20 kWh _{el} /kg-Si)		
Processes	Description	Energy expenditure (kWh _{el} /kg-Si)	Processes	Description	Energy expenditure (kWh _{el} /kg-Si)
Silane Production	The MGS is grounded and lapped with hydrogen chloride gas in a fluidised-bed reactor. This takes place at a temperature of 300 to 400 °C. Gaseous chlorsilanes arise. Chemical equation: $\text{Si} + 3\text{HCl} + 50 \text{ kWh/kg-Si} \rightarrow \text{SiHCl}_3 + \text{H}_2$	50	Monocrystalline Silicon	Monocrystalline silicon can be produced by further processing the EGS or UMGS in the Czochralski or float-zone pulling process.	15-20
Fractional Distillation	The chlorsilanes are separated and high purity trichlorsilane SiHCl_3 gases are the product.	100	Polycrystalline Silicon	The processes for producing polycrystalline silicon are ingot casting, edge defined film-fed growth method or the string-ribbon process.	50
Separation	The last step is adding hydrogen. This can either be done during the Chemical-Vapour-Deposition process at 1100 °C or in a fluidised bed reactor at 700 °C. $\text{SiHCl}_3 + \text{H}_2 + 50 \text{ kWh/kg-Si} \rightarrow \text{Si} + 3\text{HCl}$	200	Cutting ingots and Wafers	The silicon cells are cut or milled into ingots. Normal measures for ingots are 100×100 mm, 125×125 mm and 156×156 mm. Then wafers are milled from the ingots, which is coupled with material losses of 30 to 50 %, this is due to the use of silicon carbide for milling.	50

Production for either type of photovoltaic cell impacts the environment, whether it be affecting resources, human health, or increasing climate change. Mahmud found that “...PV panels are largely responsible for affecting human health and climate change, whereas batteries mostly affects resources” while “...hazardous fluids used to transfer heat in solar modules are mostly responsible for the high impacts of toxicity and acidification...” (2018). These concepts of waste produced during manufacturing and end-of-life planning will be considered during the comparative analysis of solar panel companies performed by this study.

List of Acronyms

kW	KiloWatts
h	hours
DC	Direct current
PV	Photovoltaic
kWh	KiloWatt hours
\$	United States Dollar
kg	kilograms
Si	Silicon
°C	Celsius
mm	Millimeters

Methods

In order to answer this question, the impacts of solar panels were analysed according to the three paradigms of sustainability so that a comprehensive and encompassing recommendation can be made to meet the needs of the district. To address the economic paradigm, a comparative analysis of different solar panel types, including stationary panels and 1-axis panels, as well as panel location and technology was conducted. A major concern of each of these systems included the power efficiency of each axis system, as advanced solar tracking systems can lead to decreased economy of such a system (Ghassoul 2017). Part of the analysis was conducted using the System Advisory Model, or SAM, a modeling software to compare efficiencies of the panels and economic costs. SAM was developed by the National Renewable Energy Laboratory (NREL) with funds from the U.S. Department of Energy (Gilman 2014).

Using the utility bills of the district to calculate the current operating cost to the grid, the impact of purchasing all of the district's energy from the Alliant Energy was analyzed. Another possible economic benefit of solar panels are tax incentives and grants, so the implications and incentives were researched on the basis of the district's qualifications.

The database of state incentives for renewable energy (DSIRE) is a comprehensive source of information on policies and incentives that support renewable energy and energy efficiency in the United States. DSIRE is funded by the U.S. Department of Energy and is operated by the N.C. Clean Energy Technology Center at N.C. State University (*Database*). The renewable rewards program, a state incentive, offers \$4,000 for customers installing solar PV. The USDA- High Energy Grant Program offers an ongoing incentive for the improvement of energy generation along with distribution and transmission facilities in rural communities. This grant ranges from \$50,000-\$3,000,000 (*High* 2018).

Concurrently, the environmental aspect of sustainability were addressed by examining two solar panel manufacturers, their process for creating new solar panels, and the environmental impacts of recycling and/or disposal. This study also compared two local solar panel consultants and installers. There are several companies in the southwestern Wisconsin region that distribute solar panels. This study looked at SunPower and Kyocera, both solar panel manufacturers, and compared their production methods, environmental responsibility, and plans for end-of-life. This project then compared Synergy Renewable, which installed the current configuration on the school, and Full Spectrum Solar as installers, and examined their pricing, as well their environmental accountability. The criteria for environmental comparison included responsibility

taken for their waste, how they mitigate their environmental impact, and any morals or values they associate with their mission and product. Research was conducted into the resources used in creating solar panels, and panels as monstrous hybrids that are difficult to dispose of, as well as technology for reusing or recycling panels. The lifespan of most solar panels is 30 years, but due to cadmium, lead, and selenium being present in photovoltaic cells, there is concern about disposables in municipal landfills being hazardous to communities (Fthenakis 2000). Part of this project focused on ways to recycle solar panels should the district decide to remove the current panels they have. In addition, this study looked at the impact to the grid of panels, and how Juda's current configuration factors in.

The third paradigm of sustainability focuses on the social aspect of choices. The community of Juda is very involved with the school, and the choices made regarding the movement forward of the Green Initiative will affect not only the students but the entire town. The social recommendation came from looking at case studies of other school districts that have implemented solar panel configurations, as well as the potential for education within the community about renewable energy sources and awareness about the student's involvement with the Green Initiative.

Company Comparison

One of the manufacturers examined was Kyocera, Inc., which is frequently used by Synergy Renewable and likely produced the panels currently installed at Juda. Kyocera is an international company, and has locations across the world, including several in the United States (*Global* 2018). The company did not list information on their production practices, end-of-life

plans, or supply chain sustainability on their website, but included information on the components of their panels (*Solar Modules* 2018). This lack of information made analysis difficult, but not impossible. Kyocera focuses on two types of polycrystalline solar modules, their 265 Wp and 270 Wp series, and boasts “maximum control with vertical integration across the entire value chain” (*Solar Modules* 2018). The efficiencies for these series is about 16.4%. There was no evidence of commitments to environmentally conscious behavior or that Kyocera took back their panels for recycling or reuse. Kyocera offers a 25 year performance guarantee but only a 10 year warranty (*Solar Modules* 2018). In order to achieve 10% independence from the grid, approximately 223 modules of Kyocera’s 270 series would need to be installed. A cost analysis provided by SAM suggests this system would cost around \$60,000.

Another manufacturer examined was SunPower, which is a global solar panel company that produces solar panel systems. Headquartered in Silicon Valley, SunPower specializes in high efficiency solar panels as well as sustainable manufacturing. SunPower manufactures three types of solar panels consisting of slightly different technologies, the X-Series, E-Series, and P-Series. Each series type have an expected lifespan of 40 years but have different average efficiencies which stand at 22.7%, 20%, 17% for each respective panel type (SunPower 2018). The company provides either a single axis or a stationary configuration for commercial installation through the companies Helix system line. SunPower’s website states a commitment to circular closed loop strategy for its product’s lifecycles (SunPower 2018). The company has received a silver Cradle to Cradle certification and a NSF sustainability Landfill free verification for their manufacturing processes of the E-series and X-series panels and the company’s

factories in Mexico and France (SunPower 2018). Part of the company's commitment to sustainability includes a recycling program for solar panels which was launched by Solar Energy Industries Association (SEIA). The company has also stated that the E-series and X-series panels are free of hazardous materials which increases ease of recycling. However, while they will offer maintenance to solar panels, they do not install the panels themselves. They have a list of certified installers on their website, which includes the first installation company analyzed by this study, Full Spectrum Solar (SunPower 2018).

Full Spectrum Solar is a solar installation company based in Madison, Wisconsin. Full Spectrum offers installation of a variety of solar systems. In addition, the company possesses electric car charging, and an office/shop space that has a zero energy cost due to primarily solar power along with a high-efficiency boiler system with radiant heat, motion activated on-demand hot water recirculation system, as well as other low-impact design decisions such as a rain garden, salvaged bamboo flooring, and super-insulated walls and ceiling (*About* 2018). The company offers consultations, where they review information from the buyer and gauge whether the site has good solar potential, prior to an on-site visit from which a full assessment is performed (*Request* 2018). Pricing, panel type, and end-of-life plans were not available on Full Spectrum's website. The company's site did mention that since the panels were constructed with silicon crystals from purified sand, and could therefore be recycled along with other glass and metals in the units, the panels are a sustainable energy system (*Solar* 2018). In addition, when a group member visited Full Spectrum Solar one of the employees stated that in the rare case that

someone does upgrade or “trade-in” their old panels, they often donate them to a local non-profit, charity, or school.

The second installer examined was Synergy Renewable, which installed the current configuration on the Juda school site. Located in Madison, WI, Synergy is part of a broader group of companies, including Thermal Design, Inc., which focuses on energy efficiency and renewable energy sources (*About* 2012). Synergy does both site assessments and installation for solar panels as well as wind turbines. The company claims that “Every dollar invested in reducing energy consumption can save approximately \$3-\$5 in renewable energy system costs” (Synergy 2012). While pricing for installation is not readily available on their website, they offer site assessments from staff certified by the Midwest Renewable Energy Association that recommend the best system for optimal performance in a specific location, including shade analysis, minimum tower height, and estimated energy production (*Site* 2012). According to the site assessment for Juda done prior to the installation of the current configuration, the school could afford anywhere from a 1kW to a 15kW system, and the system recommended in the Solar Electric Site Summary and Price Estimation Appendix is a 15 kW DC array with 1.9% shade and was estimated to generate 17,757 kW a year (Synergy 2012). Synergy Renewables website did not include a lot of information regarding what they offered for panel types or configurations, and lacked any sort of information on production, maintenance, or end-of-life plans. However, representative of the company discussed options such as donation to non-profits for reuse in developing countries if the panels still function, or recycling of materials such as silicon, metal, and glass if the panels were broken beyond repair (R. Harkin, personal communication,

November 6, 2018). He also mentioned a program facilitated by the Solar Energy Industries Association that focuses on take-back and recycling at the end-of-life, but it was unclear if Synergy Renewable takes part in this program (R. Harkin, personal communication, November 6, 2018). Juda schools do already have a relationship with the company, and have completed their site assessment prior to their installation of the current system.

Configuration Comparison: Efficiency and Effectiveness

The current configuration is a stationary system including 36 panels which was estimated to produce 5.5% of the schools current energy needs at the time of installation. Figure 2 below shows the monthly energy demand of the school, including what percentage of the demand is met by the current solar panel configuration. After analysis of the schools energy usage during 2017, the current solar panel system produces an estimated 0.85% of the schools energy needs which is equivalent to 5058 kWh/year. The energy usage of the school during 2017 is represented in *Figure 2* below.

Figure 2: Energy usage of Juda School District during 2017

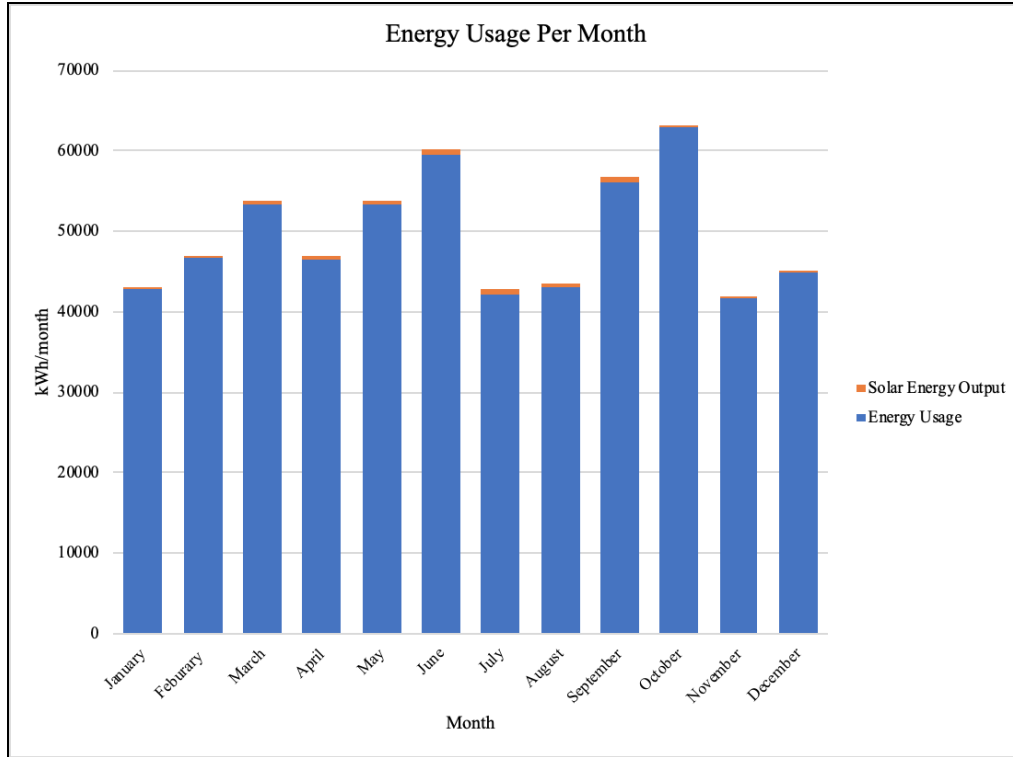
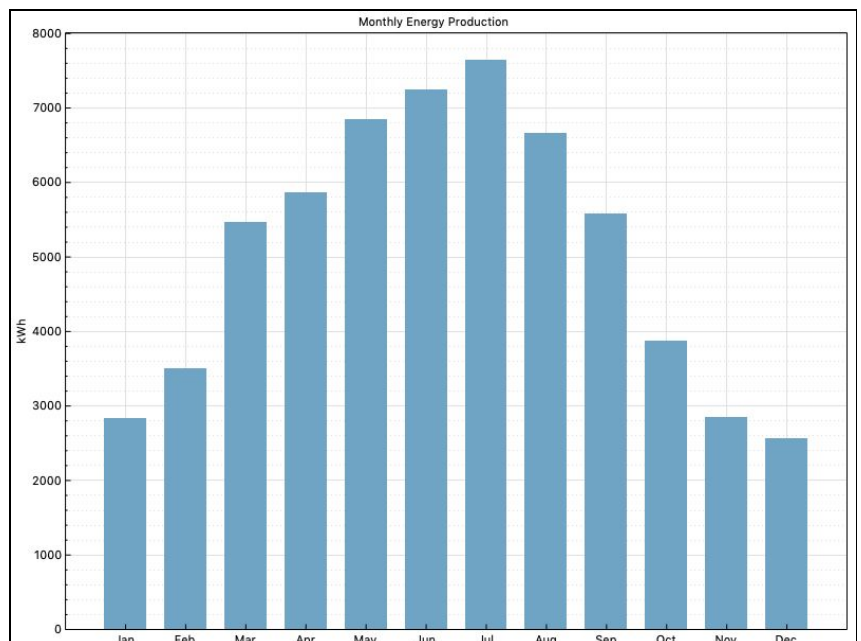


Figure 3: Analysis of system efficiency

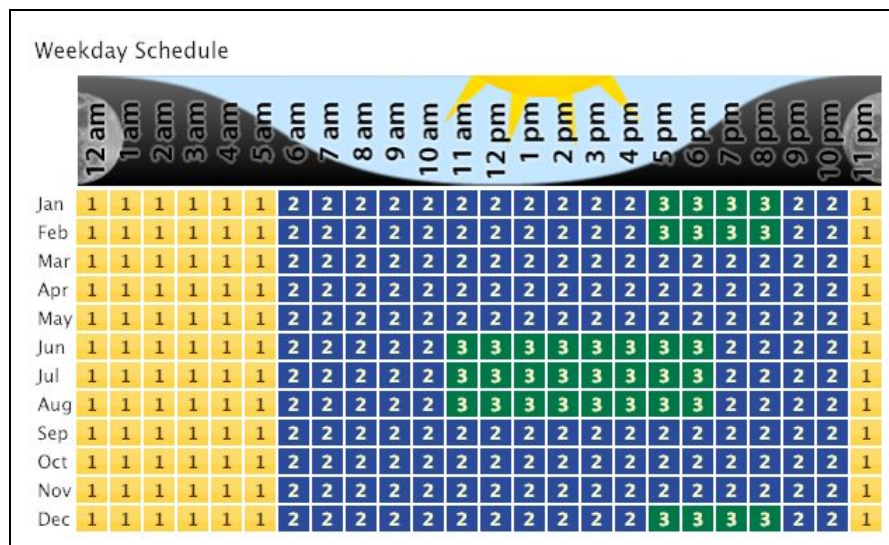
Metric	Value
Annual energy (year 1)	60,800 kWh
Capacity factor (year 1)	14.8%
Energy yield (year 1)	1,293 kWh/kW
Performance ratio (year 1)	0.82
Levelized COE (nominal)	14.71 ¢/kWh
Levelized COE (real)	11.75 ¢/kWh
Electricity bill without system (year 1)	\$62,961
Electricity bill with system (year 1)	\$58,387
Net savings with system (year 1)	\$4,574
Net present value	-\$31,222
Simple payback period	18.9 years
Discounted payback period	NaN
Net capital cost	\$63,062
Equity	\$63,062
Debt	\$0

Figure 4: Estimated Monthly Energy Production of system



Using the System Advisory Model (SAM), data files and energy rates were entered to approximate the weather, solar conditions, and energy costs observed at the Juda School location. The weather and solar data was obtained from the NREL National Solar Radiation Database (NSRDB). Madison Wisconsin was the location used by NSRDB because it was the closest weather file location provided. Electricity rates were obtained through SAM by the OpenEI Utility Rate Database (URDB). Rates are checked and updated annually by NREL under funding from the U.S. Department of Energy's Solar Energy Technologies Program (*Utility* 2018). The data provided by the URDB is useful for determining the value of energy by taking into account on and off peak energy rates. This is demonstrated in Figure 5. Billing rates for energy consumption from Alliant Energy utility company was obtained from the Juda School's electricity bills. WI CP1-Industrial TOD was the billing rate applied by the URDB into SAM (Alliant Energy , 2018). Monthly electric load data was then manually entered into SAM provided by Juda's 2017 electric bills. The load data has units of kWh per month.

Figure 5: Weekday schedule of energy loads and pricing from Alliant Energy (2017-2018)



In order to decrease the annual non-renewable energy consumption by 10%, at least 60,144 kWh of energy needs to be produced annually by renewable sources. This can be accomplished by installing a 50kWdc system of 160 models from SunPower's X22-370-C-AC series. The panels would have an estimated payback period of 18.9 years, and could save the school district approximately \$4,574 per year. Figure 4 shows the estimated production of the panels as modeled by SAM according to the area's typical weather patterns. All systems were entered to be at an angle of 10 degrees and default shading.

Community Effects

The Green Initiative was created to engage students in Juda schools, increase their understanding of STEM fields, and relate environmentally conscious concepts to real world problems. The solar panel project that this year's Green Initiative students are working on has been done at other schools, including one's in Wisconsin. Lakeland Union High School had the largest solar system on a public school in Wisconsin installed by SunPeak in 2016, and has 20% of their energy demands supplied by the panels (Verploegh 2016). The school is much larger than Juda, and has much higher energy demands, but the installation was successful and has helped the school become more sustainable. Teachers were also encouraged to integrate the solar panel project into subjects from math and science to engineering and the arts, and school principal Jim Bouche emphasized the importance of providing "...that energy-knowledge to our students as they come through LUHS" in addition to the environmental and economic benefits that the system gives the school (Verploegh 2016). Other schools that have utilized solar panels

as part of a comprehensive education for their students as well. Darlington Community Schools began the Solar Education Project in 2014, and has set goals to increase electricity savings and prevent spikes in energy costs, provide environmentally focused education for students and community, and decrease the over carbon footprint of the school (*Darlington* 2018). Not only have these schools been able transition some of their demands to renewable sources, but they have developed specific plans to educate their students on solar power and environmentally sustainable behavior, as well as energy and electricity. There are a myriad of programs to help teachers integrate solar into their curriculum, including resources from the National Energy Education Development Project, the Energy Education Program through the Department of Energy, and a library of materials from the US Energy Information Alliance (Stout 2018). Anderson's Physics and Engineering class already includes similar training with the Green Initiative, but could expand the program and public awareness of solar power benefits by growing their solar panel array. The community of Juda is incredibly involved with the school, and outreach education to the neighborhood and perhaps even the surrounding area is possible with the current system, but has the potential to be more comprehensive with more or different types of panels. Installation could also allow students the opportunity to see their project in action, and provide impetus to the school to grow the Green Initiative project to other classrooms and grade levels.

SunPower in particular also has developed a program for K-12 energy education. This curriculum, called SunPower Horizons® Solar Education Program, has projects and lesson plans for students, and can supplement education with guest speakers and solar panel demonstrations

(*SunPower Horizons*® 2018). These tools would be useful to the schools to engage students and the community with the new solar installations.

SunPower also has committed itself to being socially aware and formed framework to be socially just. They completed a social life cycle assessment and developed policy for five areas of social justice: labor practices, health and safety, energy and environment, management systems, and ethics (Kienitz). This framework is for themselves in addition to all of their suppliers, so that the chain remains socially sustainable. These areas included policy on fair wages and benefits, child labor avoidance, industrial hygiene, pollution prevention and resource reduction, management accountability and responsibility, and corrective action processes, among many others (Kienitz). This also makes SunPower the most aware and socially just company of those compared, again reassuring that this manufacturer is the most sustainable for Juda to purchase their panels from.

Regression to All Grid Supplied

If the district removed the panels they currently have and regress to buying all their energy needs from the grid, they would end up paying for the energy they currently generate from the solar panels as well as contributing to the fossil fuel industry as a consumer. The environmental impact of buying from the grid would be greater than the solar panels, especially because they would need to dispose of the panels they currently have first. Both fossil fuels and solar panels have environmental costs associated with resources extraction, but solar panels do not give off emissions while in use like fossil fuels do. The district would also stop receiving payback from selling excess electricity to the grid, which would undermine the payback period

for the current configuration, which is not yet up. Lastly, there would be social implications to removing the current solar panel system, in that the community would likely be resistant to removing something they and their students worked so hard to bring together. So much effort has gone into advocating for renewable energy and supporting the students in the Green Initiative that to dismantle their hard work would likely be viewed very poorly by the community.

Conclusion and Final Recommendation

Based on analysis of the three companies, this study recommends that Juda proceed with a 50kW system of 160 modules from SunPower's X22-370-C-AC series, and have Full Spectrum Solar perform the actual installation. Although Juda has worked with Synergy Renewable previously, SunPower was the most environmentally conscious company. Full Spectrum Solar has also shown commitment to becoming more green and focuses heavily on reducing energy cost and waste. These companies are the most environmentally sustainable, and would be the best choice to reduce the impact of further solar panel installation on Juda's roof. The configuration recommended will increase Juda's renewable energy usage to 10% of their total energy consumption, achieving the goal of the Green Initiative. SunPower's manufacturing process was the most circular, sustainable, and the company has also made efforts to ensure that their suppliers are socially responsible as well, while Full Spectrum Solar is the only certified installer in the region and includes environmental accountability as part of their mission, making these companies the most economically and environmentally sustainable of the ones compared.

Further installation of solar panels is also socially sustainable for Juda. Installing these panels fulfills the goals of this year's Green Initiative students, and allows the district the

opportunity to include more solar and renewable energy education in their curriculum. Scott Anderson has already done a tremendous job including environmental education and engineering principles in his classes, and further outreach is possible with installation of more panels. The community will also be positively impacted by this change, and provided with a chance to see and understand the benefits of solar power first hand. Taking all three paradigms of sustainability into consideration, this project recommends that Juda move forward with the Green Initiative project to install solar panels, and purchase 160 modules for a 50 kW system from SunPower's X22-270-C-AC series.

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About UniverCity Year



UniverCity Year is a three-phase partnership between UW-Madison and one community in Wisconsin. The concept is simple. The community partner identifies projects that would benefit from UW-Madison expertise. Faculty from across the university incorporate these projects into their courses, and UniverCity Year staff provide administrative support to ensure the collaboration's success. The results are powerful. Partners receive big ideas and feasible recommendations that spark momentum towards a more sustainable, livable, and resilient future. Join us as we create **better places together**.



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