ODRC Solar Field Installation Potential and Reducing Recidivism

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Table of Contents

Executive Summary

This report provides the Ohio Department of Rehabilitation and Correction (ODRC) with research regarding the potential implementation of a photovoltaic solar field and a solar installation education program for the incarcerated population. The ODRC has a goal of becoming carbon neutral by the year 2040, and strives to reduce recidivism rates. This report was designed to help them to achieve these goals.

The ODRC initially expressed their goal for a seven-year return on investment (ROI) for the solar field; however, once the team conducted an NPV analysis for direct ownership of the solar fields, it was determined that a seven-year ROI was unrealistic. As a result, the team pivoted the project focus to researching alternative financing options. After breaking down the options and consulting with an expert who worked on the financing of a similar solar project, the team determined that a power purchase agreement was the best option. We also investigated locations by reviewing GIS maps, researching the soil content at the prospective locations, and exploring solar construction requirements. Based on this, we recommend that the photovoltaic field be located at Allen-Oakwood Correctional Institution. I-beam construction was determined to be the most cost-effective method of construction given the soil content at this location.

Through interviews and accessing Solar4America's educational program resources, the team created a solar education curriculum that can be implemented effectively. The curriculum allows the incarcerated population to learn the basics of the solar industry thereby qualifying them for jobs upon release. The team ultimately produced recommendations for where and how to implement the solar field, an alternative funding plan utilizing a power purchasing agreement, and the education curriculum for offenders. We believe that these deliverables will allow the

ODRC to be more informed when they seek to execute their plans to implement a solar field and start a solar education program for the incarcerated population.

Introduction

Overall Research Goals and Set of Objectives

Our project aims to provide the Ohio Department of Rehabilitation and Correction (ODRC) with the necessary research to assist in making decisions regarding the potential implementation of a solar energy field and a solar installation education program for the incarcerated population. Our first goal was to determine the feasibility of installing and maintaining a photovoltaic solar panel field at one of the previously surveyed ODRC locations, with a positive 7-year return on investment. Our second goal was to provide the ODRC with information on creating an education plan for solar installation certification to provide the incarcerated population with better job prospects upon release.

In order to achieve these goals, we had the following research objectives:

1. Utilize baseline analysis to review GIS locations, past energy usage & fiscal data to identify the maximum installation capacity with a goal of maintaining a 7-year ROI.
2. Research direct and third-party funding options including power purchasing agreements (PPAs) and lease agreements to determine the best option for ODRC
3. Observe similar solar panel fields in place to see how they are financed
4. Create core educational standards for the installation and maintenance of solar panel plots

Purpose and Motivation for Research

Our project strives to help the ODRC achieve their mission of reducing recidivism among

the incarcerated population while moving closer to their sustainability goal of becoming carbon neutral by 2040. Our vision is that the ODRC could develop a new solar field that will reduce their reliance on non-renewable energy sources, helping to save money while reducing their carbon footprint. Furthermore, a solar education program could provide the incarcerated population with core learning requirements that should improve their job prospects upon release, therefore reducing their chances of becoming incarcerated again. Reducing recidivism is both socially and economically beneficial to society and it reduces the ODRC's operating costs.

Summary of Findings and Recommendations

We recommend that the proposed solar field be located at Allen-Oakwood instead of Grafton on account of its superior geographic features. The recommended type of ground installation for the solar panels is I-beams on account of the clay-filled soil, large installation size, and peak hours of sunlight. The recommended size range of the solar field is 24 to 32 acres for a 100% mitigation rate in electricity generation from the grid. Over 25 years (the estimated lifetime of the solar panels), the internal rate of return (IRR) or ROI is 3.49% and the investment would first yield a positive IRR or ROI in year 18. However, the IRR/ROI would be negative for the seven-year time frame used by ODRC. This 18 year timeline could be reduced further by the expected additional reduction in recidivism from the implementation of the solar education program, though almost certainly not enough to warrant the up-front investment in solar by ODRC.

Using third-party financing could provide the ODRC with a way to finance the solar field without having to deal with the large initial investment that comes with direct ownership. Solar lease agreements and PPAs are both financing options that would have no up-front cost for the ODRC and could provide stable and predictable electricity prices. The team looked at other

comparable solar fields in Ohio to determine how these fields were financed and found that the PPA is the most common financing method used. Recent PPA contracts in the Ohio villages of Minster and Grafton are examples of very similar projects that show that a PPA deal could yield significant NPV cost savings vs. current electricity purchases. The PPA could be used by the ODRC to make the implementation of the solar field more feasible while also potentially saving the ODRC money.

The Offender Training Curriculum was modeled after Solar For America's curriculum. The team determined that an electrician's license should not be required if ODRC partners with a company to provide an apprenticeship program. The curriculum was created after discussions with Dwight Pressler regarding the success of his own solar education program at Ross Correctional Facility. From this conversation, the team concluded that future programs should be partnered with Ohio-based companies and that there has been a reduction in recidivism since the implementation of the program at Ross. We can expect similar results with the expansion of these education programs throughout other correctional facilities.

Research Methods, Data Collection, and Findings

1) Solar – Location Selection

The team researched key differences between the two proposed locations to determine which was the more economically efficient choice for ODRC. The differences related to geography, sunlight exposure, and energy usage. Once a location was chosen the correct size for a solar field was determined, based on a 100% reduction in net electricity usage from the grid. Following the size determination, an NPV analysis was conducted including the degradation of

solar panels, approximated capital and maintenance costs, as well as possible further reductions in the determined ROI.

The data collection began with observing the GIS data for both proposed locations, observing soil content and efficient ground installations per soil type. Then using the energy data from JadeTrack the amount of MW provided by the solar field was found. Following the determination of the magnitude of the field, a Net Present Value Analysis was conducted to determine the payback period for 100% of electricity mitigation from the grid using only photovoltaic panels. (The analysis assumed that this is net-zero usage of electricity from the grid which includes excess power from the array being sold back to the grid during the day, while ODRC would still be buying electricity at night from the grid.)

Next, we analyzed the data to determine the best location for the solar array between previously surveyed locations, Grafton and Allen-Oakwood. Based on this review, we determined that there were no large differences between distributions of the source from electricity consumption, population, or cost-per-inmate between the two facilities. Therefore, we determined the final location solely based on soil feasibility for sustainable ground installations from GIS analysis.

Table 1. Average consumption and cost values over 2019-2021 for Grafton and Allen-Oakwood Correctional Facilities. Data sourced from ODRC JadeTrack Reports.

Average 2019-2021 Values				
Site	**Source**	**Cost**	**Co2E (Metric tons)**	**Consumption (kwh)**
Grafton	Total	$ 2,764,636.25	22525.79	
pop: 1626	Electric	$ 685,546.90	5778.33	7,545,195.00
cost/inmate: $1314.98	Other:	$ 2,079,089.36	16747.46	8,089,298.33
Site	**Source**	**Cost**	**Co2E (Metric tons)**	**Consumption (kwh)**
Allen-Oakwood	Total	$ 2,284,719.33	12829.97	
pop: 1445	Electric	$ 525,635.00	5342.33	6,853,644.33
cost/inmate: $1218.37	Other:	$ 1,759,084.33	7487.64	6,864,449.67

After analyzing GIS data and referencing soil surveys by the Ohio Natural Resources Conservation Service (USDA-NRCS, 2018), we determined that the soil type for Allen-Oakwood is composed mainly of medium silt to fine clay and Grafton is mainly composed of limestone. There are available PV solar panel ground installations for every type of soil. The team identified the most appropriate types of solar panel ground installations per soil type of clay and rocky contained as I-beams and Ground Screws, respectively. We then researched the different types of ground installations based on economic efficiency for the magnitude of the solar field. I-beams were determined to be the most cost-efficient in large solar fields, due to only two points of contact on each panel to the foundation (2020, Ludt). Peak sunlight hours by county were researched and findings concluded that Allen, OH receives an annual average of 4.1 peak sunlight hours, and Grafton, OH receives an annual average of 3.98 hours (2022, Beale). Based on these findings, we concluded that the most cost and energy-efficient solar field would be located at Allen-Oakwood Correctional Facility

2) Solar Assumptions and IRR Analysis – Allen Oakwood Site

After selecting the Allen Oakwood Site, we estimated the size of the field using the annual electricity kWh usage at the facility as noted before. The maximum annual capacity of the recommended solar field is equivalent to the annual consumption of electricity, approximately 6,835,970 kWh which results in roughly a 4.58 MW solar field. The necessary generation was used to approximate the acreage of the solar panels, determined to be 10.51 acres (Dataset 4, Cost and Energy Capacity), with an additional 10-15 acres for spacing between the panels, and 3-8 for the power station. This places the size range of the solar field at 24-32 acres in total. The size of the solar field determined the installation costs for the NPV analysis. Our best estimate

for total installation costs was $13.25 million, absent actual bids from providers. This estimate is an approximation based on 10.51 acres being required for the solar installation.

Next, we conducted detailed NPV analyses and IRR analyses of the Allen Oakwood site. The analyses included the following key economic and cost assumptions:

- **Electricity Prices -- $0.09/kWh rate of electricity** which is ODRC's 2020 commercial rate of $0.077/kwh rate inflated by about 4% per year inflation until 2024 when the system would be fully operational.
- **Electricity Price Inflation of 3% per year-** This may be conservatively low if high inflation persists
- **Discount Rate- 5% for NPV analysis.**
- **Capital Costs of Installation of $13.25 Million as noted above**.
- **~0.5% yearly degradation of solar panel efficiency**,
- **Solar Panel Lifetime 25 years -** Solar panels are usually guaranteed for a 25-year period.

We first analyzed the project on the basis of a 7-year IRR as per ODRC guidance. We determined that the project would **not** be economic in 7 years (**would have a negative IRR**). We next analyzed at what point the solar installation would break even (would first have a positive IRR) and this would not occur until year 18 of the project. Lastly, we conducted an IRR analysis over the full 25- year life of the project and determined that it would have a 3.49 % IRR over this period. (See Table 2 below)

Table 2. Internal Rate of Return for Solar Field over 25 yearlifetime. Data sourced from JadeTrack table (Table 1) and Dataset 4, listed in the Appendix.

Electrical Parameters		Financial Parameters	
Year 1 Electricity Savings (kWh)	6,853,644	Electricity Rate ($/kWh)	$ 0.09
Annual Output Degradation (linear)	0.50%	Installation Cost	$ 13,250,000
		Internal Rate of Return (IRR)	3.49%
		Electricity Price Inflation Rate	3.00%

Calculations				
Year	Energy Generation	Energy Price	Energy Savings	Present Value
1	6,853,644	$ 0.09	$ 616,828	$ 596,004
2	6,819,376	$ 0.09	$ 632,156	$ 590,193
3	6,785,108	$ 0.10	$ 647,849	$ 584,425
4	6,750,839	$ 0.10	$ 663,914	$ 578,698
5	6,716,571	$ 0.10	$ 680,360	$ 573,012
6	6,682,303	$ 0.10	$ 697,196	$ 567,368
7	6,648,035	$ 0.11	$ 714,429	$ 561,764
8	6,613,766	$ 0.11	$ 732,069	$ 556,201
9	6,579,498	$ 0.11	$ 750,124	$ 550,678
10	6,545,230	$ 0.12	$ 768,604	$ 545,195
11	6,510,962	$ 0.12	$ 787,517	$ 539,752
12	6,476,694	$ 0.12	$ 806,873	$ 534,349
13	6,442,425	$ 0.13	$ 826,682	$ 528,985
14	6,408,157	$ 0.13	$ 846,954	$ 523,660
15	6,373,889	$ 0.14	$ 867,697	$ 518,373
16	6,339,621	$ 0.14	$ 888,923	$ 513,126
17	6,305,352	$ 0.14	$ 910,642	$ 507,916
18	6,271,084	$ 0.15	$ 932,863	$ 502,745
19	6,236,816	$ 0.15	$ 955,599	$ 497,611
20	6,202,548	$ 0.16	$ 978,858	$ 492,515
21	6,168,280	$ 0.16	$ 1,002,654	$ 487,456
22	6,134,011	$ 0.17	$ 1,026,996	$ 482,434
23	6,099,743	$ 0.17	$ 1,051,896	$ 477,449
24	6,065,475	$ 0.18	$ 1,077,367	$ 472,501
25	6,031,207	$ 0.18	$ 1,103,418	$ 467,589
		Results:	Net Present Value	$ 0.00

This resultant IRR means the recommended solar system will generate a 3.49% return on investment over the 25-year life of the system, assuming any energy generated beyond the operating needs of Allen-Oakwood can be sold back to the grid for the current commercial rate of electricity.

We also evaluated the potential financial impact of a solar education program coupled with a new solar installation at Allen-Oakwood. Using a secondary study on the impact of recidivism rates with and without an education program (See Table 3), we developed estimated net present value cost savings based on the annual cost per prisoner of $75,000 (as provided by ODRC). These are shown in Table 4. While even a very lucrative educational program will not change the decision to own and build the solar field with up-front capital, the savings to ODRC should be included in the assessment of solar PPAs in future evaluations.

Table 3. Recidivism rates by state after implementation of education programs. Data sourced from *Three-State Recidivism Study* by the Institute of Education Sciences.

	N	Participants	Non-participants
Maryland			
Re-arrest	840	54%	57%
Re-conviction	840	32%	37%
Re-incarceration	840	31%	37%
Minnesota			
Re-arrest	1025	42%	54%
Re-conviction	1025	24%	34%
Re-incarceration	1025	14%	21%
Ohio			
Re-arrest	1234	50%	58%
Re-conviction	1234	26%	33%
Re-incarceration	1234	24%	31%

Table 4. Reduction in Future Costs. Data sourced from Table 3. Represented in Dataset 4 within the appendix.

Reduction in NPV Costs	
Participants	(Cost Saved for Reduction in Recidivism)
50	$ 262,500.00
100	$ 525,000.00
200	$ 1,050,000.00
300	$ 1,575,000.00
400	$ 2,100,000.00
500	$ 2,625,000.00
600	$ 3,150,000.00
700	$ 3,675,000.00
800	$ 4,200,000.00
900	$ 4,725,000.00
1000	$ 5,250,000.00

3) Assessing Third-Party Financing Options

After analyzing data for the net present value of the cost of direct ownership and finding that the return on investment significantly exceeded 7 years, the team decided to explore other financing options. The team researched the benefits that third-party ownership might provide. We used a variety of internet sources, including the Interstate Renewable Energy Council's (IREC) power purchase agreement toolkit for local governments. IREC's toolkit includes a model template for a PPA, which helped us look at the specifics of what a contract could look like.

Both PPAs and lease agreements are similar methods of alternative financing that the ODRC could utilize. For both methods, a developer will design, obtain permits for, finance, install, and maintain a solar field on the customer's land. The difference between the two lies in the financing structure. For a power purchase agreement, the customer signs a contract - typically for a 20-to-30-year timeframe - with the developer requiring that all of the energy generated by the solar power system over a given time frame is to be purchased by the customer at a specified rate (Solar Energy Industries Association, n.d.). Conversely, a lease agreement dictates that the customer pays the financing party a monthly rate for the right to access the solar system and its benefits (Thoubboron, 2021).

The primary benefit that third-party ownership provides is that it eliminates the high up-front cost of direct ownership (Sendy, 2021). This is very advantageous for the ODRC since their preferred ROI within 7 years will not be feasible under direct ownership. There are no up-front investments with third-party ownership, and the ODRC would merely pay a monthly bill. The primary drawback that comes with third-party ownership is that the ODRC would save less over time by financing through a third-party, compared to owning the panels directly (Sendy,

2021). Another thing to consider is that both agreements typically involve an annual price escalator each year, often within the 1-5% range (Sendy, 2021).

PPAs provide numerous other benefits besides the lack of an up-front cost. Some of these benefits include:

- Predictable electricity prices for an extended period
- Hedges against the risk of rising energy prices and energy price shocks
- No responsibility by ODRC for operation or maintenance
- The only cost is paying for the electricity that is generated
- The contract-specified price is likely to be cheaper than paying for electricity from the grid
- The risk of the panels performing below expectation is mitigated. This would fall on the company that owns the panels, not the ODRC
- The developer can utilize the tax credits, which indirectly lower the rates ODRC pays

Source: Interstate Renewable Energy Council (2015)

Lease agreements have similar benefits to those of a power purchase agreement. Predictable energy prices, insulation from rising energy prices, and no responsibility for operation and maintenance are also benefits that come from a lease agreement. Another benefit is that the stable and predictable monthly lease payment stays constant as solar production rises, which makes budgeting easier (Thoubboron, 2021). Analogous to a power purchase agreement, a lease agreement would likely save the ODRC money over time, since the lease payment is often cheaper than the typical monthly electric bills that a customer would pay if energy from the grid was used (Lane, 2021).

While the two different types of third-party financing are similar, the power purchase agreement may be a better option for the ODRC. The performance of the system is tied directly to the payments (Thoubboron, 2021). Thus, the ODRC would receive an amount of electricity that is proportional to what it pays for, and it would not be paying an artificially high bill in the winter when the system isn't producing as much electricity. This could potentially allow you to save more over the course of the contract, compared to a lease agreement (Sendy, 2021). It also means that the ODRC would not have to worry about paying for electricity if the panels were to fail, which would fall on the developer (IREC, 2015). Additionally, the power purchase agreement is a more common financing method and is rapidly being adopted, particularly in the commercial sector (Engie, 2021). As will be detailed below, the villages of Grafton and Minster both successfully utilized PPAs in their recent solar projects.

4) Financing Experience of Comparable Solar Fields

The team researched solar fields recently built in Ohio of comparable size to look into how they were financed. The team focused on solar fields from the Village of Grafton and the Village of Minster. The criteria for a similar solar field is that (1) it is in Ohio, (3) is roughly 3-5 MW in size, and that (3) the field is hosted by a government entity. This ensures that the comparable fields receive similar amounts of sunlight as Allen-Oakwood, are of similar size to what we are proposing, and that the entity similar to ODRC cannot take advantage of tax credits. To find comparable solar fields, the team looked through news articles to find other entities in Ohio with existing solar farms. The team then did research using a combination of news articles, developer websites, and an interview with Dave Dwyer. Dave works for Design Energy, the company that completed the Minster project, and he designed the PPA for the project.

The City of Grafton built a 36-acre, 4 MW solar field - located right across the street from the ODRC's Grafton location - that went live in November of 2019 (Spectrum News, 2020). The system was funded with third-party ownership, utilizing a power purchasing agreement. The system was designed, developed, and built by a company called Eitri Foundry. Grafton has a 30 year PPA with Safari Energy, the company that owns the solar field (Safari Energy, 2019). Village Administrator Joe Price says that the goal is for Grafton to have the cheapest electricity of any municipality in Ohio (Spectrum News, 2020). The system is estimated to offset 200,000 metric tons of greenhouse gasses over its lifetime (Safari Energy, 2019).

The Village of Minster built a roughly 4 MW solar field in 2016 using a PPA as the financing method. The team was able to get the specifics of this agreement thanks to an interview with Dave Dwyer, who created the PPA. According to Dave, the Minster contract runs for 25 years and started at a rate of 7 cents per kilowatt-hour, with a 3% annual price escalator. Given this 3% increase, Minster is paying roughly 8.4 cents per kilowatt-hour for their solar-generated electricity in 2022. According to Dave, there are a multitude of factors that go into creating the price for a PPA, so this is not necessarily indicative of what the ODRC would pay. However, our proposed solar field is very similar to the Minster field in terms of size and location, so we believe the Minster price could be used as a rough estimate for what ODRC could be looking at. According to Jadetrack data, the Allen-Oakwood location has spent $513,537 on electricity over the past 12 months and utilized 6,804,301 kWh. This calculates out to about 7.5 cents per kWh.

Given Minster's 2016 PPA price of 7 cents per kWh and the current Allen-Oakwood electricity payment average of 7.5 cents per kWh, it is difficult to definitively say whether a PPA would save the ODRC money compared to the status quo. The average price of solar PPAs has

gone down significantly over the past ten years but has stabilized in the last couple of years (Boisture, 2021). It is very likely that PPA rates are cheaper now than they were in 2016 when Minster completed their project, and that Minster could have likely gotten a cheaper rate if they created the project in 2022. This leads the team to believe that the ODRC could potentially negotiate a PPA price under 7 cents per kWh, which would save them money relative to ODRC's current electricity rates. However, it is important to note that this is merely an estimate based on the Minster PPA price and the national PPA price trends. The only way to definitively know this is if the ODRC consults a developer and goes through an extensive project development process. Dave recommended that the ODRC should hire a developer because they could provide this information to the ODRC, allowing them to be more informed when negotiating a PPA price.

5) Solar Education

The team was tasked with creating an outline of a solar education program to reduce recidivism as part of the ODRC's mission. This program is designed to give the incarcerated population a chance at installing and maintaining solar panels. This will allow for these people to serve in jobs that are fairly new to the state and in the rapidly growing renewable energy field.

Much of the research was obtaining copies of the former solar programs inside of ODRC. Ross Correctional Institution had a solar program that we used to model our program. Ross's past program was designed by Solar4America, under contract with Ross Correctional Institution, and implemented into the institution. Obtaining and reviewing a copy of this program was the key to the development of our curriculum.

First, the team researched the differences between solar thermal, the type of solar utilized by Ross, and solar photovoltaic. It was determined that only the differences between the educational requirements would be within the installation of the system.

In addition to the installation, we felt it pertinent to supplement the Ross curriculum by requiring Roots of Success as a prerequisite. Roots of Success is a comprehensive program that provides the baseline knowledge required for over 100+ environmental jobs and career pathways. With this prerequisite requirement, students enrolling in our solar program should have the baseline knowledge and motivation to succeed in our course.

Along with the curriculum itself, the team attempted to see how it would perform. To do so we interviewed Dwight Presler, Clide Smith, and Bill Cooper, all of whom had a hand in overseeing the Solar4America implementation at Ross Correctional Facility. From this conversation, the team received encouragement to move forward with the project. While we did not receive a direct answer as to how this program has affected recidivism, we were informed that several of the offenders have received job offers from Solar4America, post-completion. It seems that if the company was Ohio-based, then more offenders would have accepted jobs on release. There is hesitation in leaving the support network for a career, thus ODRC should look to partner with local companies in the future.

The conversation also offered guidance as to the setup of the program. We were informed that an electrician's certificate is not a requirement for installation but should be obtained by the instructor of the course. Moreover, the program should be set up like an apprenticeship in conjunction with a local company. This would involve half the time in the classroom, and the other half spent on hands-on instruction by a trained professional.

Recommendations

Solar Field Implementation

The team recommends that the ODRC chooses Allen-Oakwood Correctional Facility as the location for the photovoltaic solar field. The capacity for energy generation at Allen-Oakwood is higher than Grafton due to more peak sunlight hours. Also, it is more economically efficient for the type of ground installation suited for the soil. The appropriate size of the total solar field would range between 24-32 acres, composed of 10.51 for the panels themselves, 10-15 acres for spacing between the panels, and 3-8 acres for the power station. This size of the solar field would generate 6.9 million kWh of energy within the first year, and decrease every year following due to the natural degradation of solar panels.

Best Financing Option

The team recommends that the ODRC pursue a power purchase agreement to finance their solar field. The NPV analysis shows that direct ownership of the solar fields is not a feasible option, given the ODRC's return on investment constraints. Third-party ownership is a better option for the ODRC because it provides a way for them to install a solar field without having to pay an up-front cost. There would be no concerns about the project paying itself off within a given time frame. The PPA is an increasingly common solar financing method, and it is currently being successfully utilized throughout other government entities in Ohio, in the Villages of Minster and Grafton. The PPA would be particularly beneficial for the ODRC because it would result in predictable electricity rates for an extended period while also mitigating the risk of rising energy prices and energy price shocks.

After consulting with Dave Dwyer about the Minster solar PPA and by looking at the trend of falling solar PPA prices, the team believes that the ODRC could likely negotiate a PPA price that is cheaper than the 7.5 cents per kWh they are currently paying for electricity at the Allen-Oakwood correctional facility. Further, as noted earlier, electricity rates are expected to increase significantly owing to inflation. However, it is important to note that this is an estimate; the only way that the ODRC can for sure know they will save money is by consulting with a developer and creating detailed plans for the solar field. Additionally, while we believe a PPA is the best option for the ODRC, a lease agreement would also provide many of the same benefits.

Solar Education Program

The team's recommendation for the solar education program is to adapt the solar education program outlined from the Solar4America curriculum. This curriculum is easy to implement across different institutions. It would be ideal that there is a company working with ODRC to implement the solar curriculum and allow access to solar panels to work on for classroom instruction. With a hands-on approach, the students would be able to use this information on a resume to prove they have experience with solar panels and this kind of work. This work will prepare them upon release to get jobs in the growing solar industry.

Solar Market Outlook

Looking forward, the solar market is showing promising potential for investment that can lead to a more cost-effective bottom line. As of right now, solar energy only makes up a small portion of America's energy output, just over 3%. As policy shifts towards renewable energy and energy independence, it can be expected that the solar market is going to continue to grow at

rapid rates. The EIA has projected that the renewable energy generation share will increase from 20% in 2021 to 22% in 2022 and following that an increase to 42% by the year 2050. Ohio specifically is a good spot for siting solar energy due to the landscape and climate that allows for lots of open space for solar fields. Based on the current work that the state of Ohio has in their pipeline, solar energy is expected to pass coal between 2027 and 2028. Due to the increased demand for solar energy in recent years, prices may be slightly inflated from what can be expected in the future. Supply should increase due to the personal preferences of people and businesses as well as government policy. Ultimately, the high upfront costs of solar energy will likely be offset by the dropping prices and overall efficiency of solar energy.

Limitations of Our Research

The team was limited in trying to recommend a feasible solar field that would align with ODRC's goal of a 7-year ROI. Without substantial mitigation of energy from the grid, the high installation costs would make project implementation inefficient. Therefore, research was conducted based on a 100% mitigation rate, so the maximum ROI could be provided to the ODRC, and if the mitigation rate was altered it would only further decrease the ROI timeline. There were also limitations during the analysis such as the NPV/IRR analysis. This is because it is difficult to provide an accurate installation quote without reaching out to actual commercial-scale solar installers who need to come and survey the property. Other limitations include the future inflation rate of energy prices which can substantially change the results if there are years with outlier inflation rates such as this past year, 2021-2022.

The team was also limited in our ability to estimate the cost of a power purchase agreement for the ODRC. Obtaining a legitimate quote for the project was unrealistic and we

were unable to find a current average PPA price for Ohio. This means we were unable to definitively say that a PPA would save money over the status quo. However, the sources we utilized stated that PPAs typically offer a cheaper electricity rate than purchasing from the grid. This is supported by our consultation with Dave Dwyer. An additional limitation we faced was not being able to find the PPA rate for the Grafton solar field, which could have been used as a comparison to the Minster field. Attempts to contact people involved with the key people who worked on the project proved unsuccessful.

The biggest limitation in implementing and writing a solar curriculum is that the team is not trained in education and does not have prior experience with writing an education program. Much of the data around solar programs are marked for internal use as there are very few programs right now. It was hard to find programs to base this one on. The best way to implement and write a solar program was by using the curriculum previously implemented inside ODRC. This limited the scope of solar programs since it was the only one obtainable. With only one obtainable program, there were very few changes that could be made to better the program. Interviews with previous instructors were difficult to arrange due to the COVID-19 pandemic halting the solar education program. As such, some instructors were hard to reach or no longer in the same field.

Conclusions

The team concluded that for an efficient photovoltaic solar field installation the preferred location is Allen-Oakwood Correctional Facility, with a capacity of 4.58 MW, a size range of 23-34 acres, and an initial installation cost of approximately $13,250,000. The IRR/ROI analysis concluded that the ROI wouldn’t turn positive until year 18. When we evaluated the project with

a 25-year payback lifetime, it achieved an IRR of 3.49%. The payback period could be reduced somewhat based on expected reductions in recidivism (and resultant cost savings to ODRC) after the implementation of the solar education program.

The team found that direct ownership of the solar field is not a realistic option for the ODRC given its 7 year ROI requirement. However, utilizing a power purchase agreement could be an economically favorable financing option. The PPA would allow the ODRC to build a solar field without worrying about a large initial investment and could give them cheap and predictable electricity prices for the next couple of decades. The PPA has already been shown to be successful at institutions with comparable solar fields, and the team believes that the ODRC could also find this success. The solar field would help the ODRC achieve its goal of becoming carbon neutral by 2040, while likely saving money on future electricity costs at the Allen-Oakwood institution.

The implementation of solar panels at Allen-Oakwood will be beneficial to the ODRC, as it joins the trend of economic renewable development particularly in solar. Ohio's solar capacity is on track to pass coal by 2028 and Ohio is projected to have the 3rd highest MW in new solar installations behind California and Texas over the next 2 years. Moreover, not only does solar electricity improve grid security but it is a clean source of electricity without emissions.

In addition, a solar education program could be very beneficial. Despite making up close to 5% of the global population, the U.S. has more than 20% of the world’s prison population (American Civil Liberties Union, 2022). Reducing recidivism will not only lower the prison population, but can contribute to stabilizing the lives of formerly incarcerated people and their families, lowering the costs associated with incarceration, and reducing crime rates (American Civil Liberties Union, 2022).

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Appendices

Dataset #1: Solar4America Interview

Source: Dwight Presler, Clide Smith, and Bill Cooper from Solar4America

This data set includes meeting notes and a set of interview questions that guided the Solar4America Interview with Dwight Presler, Clide Smith, and Bill Cooper. We discussed the success of the solar thermal implementation and education program at Ross Correctional Facility

Dataset #2**:** Solar Education Curriculum

This dataset includes the finalized Solar Education Curriculum recommended for ODRC to implement.

Dataset #3: Interview with Dave Dwyer

Source: Dave Dwyer from Design Energy. Dave designed the PPA for the Minster solar field.

Phone: 614-507-3073

This dataset includes the interview questions and meeting notes for the interview with Dave Dwyer, which was conducted over the phone on April 12, 2022. The interview discussed the specifics of the power purchase agreement used for the solar field in Minster, OH.

Dataset #4**:** Cost and Energy Capacity

This excel table includes sheets: Site Tables, Solar Generation, and Reduction in ROI. These sheets provide the annual energy consumption per site evaluated, as well as approximate acreage based upon kWh generation, and potential reduction in ROI following the implementation of the Solar Education Program.

Dataset #5**:** Direct Ownership NPV Analysis

This excel worksheet includes three total tables, one each for electrical and financial parameters, and one table for the calculations with results for the NPV and IRR analysis.