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Research article

Feasibility of applying Illinois Solar for All (ILSFA) to the Bloomington Normal Water Reclamation District

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Abstract: This research study assesses the feasibility of solar energy at the Bloomington Normal Water Reclamation District (BNWRD) in Bloomington, IL through examining the framework of the Illinois Solar for All (ISFA) program. ISFA is a state funded energy finance program dedicated to promoting and proliferating solar energy throughout Illinois for low-to-moderate income residents, non-profits, public facilities, and environmental justice communities. The BNWRD is a wastewater treatment plant that resides in an environmental justice community located in west Bloomington. After acquiring energy consumption data and site information from this local government facility, we incorporated the collected data set into solar photovoltaic (PV) system performance modeling tools to estimate the total electricity generated by a potential on-site solar PV system. Potential financing of the solar array according to the various financial structures established by the ISFA is also simulated with these solar energy performance models. The outcomes demonstrate potential energy savings the ISFA program can provide for the BNWRD. This research project suggests an optimum solar array system and financing plan to be used by the BNWRD through the ILSFA program, which can be a replicable model for other areas in the state. Potential vendors and facilities in Illinois intending to utilize the ILSFA program can reference this research to seek a better understanding of the functionality of the program.

Keywords: photovoltaics; distributed energy generation; renewable energy; sustainability; Illinois Solar for All; wastewater; energy incentives; environmental justice

1. Introduction

Illinois Solar for All (ISFA) is a state funded energy incentive program dedicated to promoting and proliferating solar energy throughout Illinois for low-to-moderate income residents, nonprofits, public facilities and environmental justice communities [1]. The Bloomington Normal Water Reclamation District (BNWRD) is a wastewater treatment plant that resides in an environmental justice community located in west Bloomington in Illinois. This research study assesses the feasibility of installing a solar photovoltaic (PV) system at the BNWRD by examining the ISFA program framework. The primary goal of this research is to discover the optimal solar PV system for the BNWRD in terms of energy output, net metering (NM) credits, renewable energy credits (REC) and cost under the ISFA program. This research project suggests an optimum solar array system and financing plan for the BNWRD through the ILSFA program, which can be a replicable model for other areas in the state. Potential vendors and facilities in Illinois intending to utilize the ILSFA program can reference this research to seek a better understanding of the functionality of the program.

Although some prior works have introduced state funded energy incentive programs, none of these studies has provided more in-depth analyses to better understand the approach that should be used to determine the optimum level for seamlessly integrated PV system to existing infrastructures. Renewable energy projects economic evaluation methods and financing options have been extensively analyzed. Jo et al. [2] highlighted the payment methods currently used for distributed community solar projects throughout the US and suggested appropriate options for purchasesrs using a real-world case study in Illinois along with the evaluation of the jobs and total economic impact of a PV system implementation. Dranka et al. [3] proposed the framework which provided the opportunities for decision-makers to flexibly respond to changes in the business and economic market. Thang et al. [4] proposed a nulti-scenario optimization model to optimize the investment of renewable sources considering uncertainties based on the minimum life cycle cost. Although these prior works provided greater insights regarding renewable projects economic evaluation and financing options, none of them specifically evaluated the feasibility of solar PV system incentives available for nonprofit organizations and low-income community. Through this proposed study, we are evaluating a number of different case scenarios to determine the effectiveness of the state funded energy incentive program to promote sustainable energy infrastructures.

1.1. Low-income community solar incentives in the US

Although the installation cost of solar photovoltaic (PV) has gone down significantly during the past decade, the initial cost of installing solar is still a barrier for many households. Special solar financing options can make it easier for middle-income families to install solar PV systems, but for low-income homeowners it is still out of reach to install solar PV systems [5]. Many states have adopted solar incentive programs to assist low-income families who would like to install residential solar systems. Most of these state solar programs are designed to serve families with incomes at a federally defined threshold of income level, which means at or below 80% of area median income (AMI) [5]. Below are some of the state programs which support solar installations for low income homeowners.

California's Single Family Affordable Solar Homes (SASH) program subsidizes the installation of solar PV systems for low-income single-family homes by providing $3000 per installed kW, up to a maximum of 5 kW. To be eligible, applicants must own and live in the property and have a household income that is 80% or below the AMI. The applicant's home needs to be located in low-income communities or must be defined as affordable housing. California also has a certain portion of the program funding assigned for the communities most in need, known as Disadvantaged Communities Single Family Solar Homes (DAC-SASH) program. To qualify, homeowners must live in one of the top 25 percent most disadvantaged communities as identified by the CalEnvironScreen [6].

The Colorado Energy Office (CEO) subsidizes the installation of solar modules for low-income single-family homes via the federal Weatherization Assistance Program (WAP) [7]. To be eligible, applicants must own and live in their own home and have a household income that is 200% or less of the federal poverty level. The installation of solar must also be shown to create a net benefit above cost as assessed by the CEO.

Hawaii's Green Energy Market Securitization On-Bill Repayment Program (GEM) offers fixed rate loans for solar installation and energy efficiency projects which are then paid back in monthly installments as part of the household's electricity bill. Both homeowners and renters are eligible and the loan obligation is attached to the household electric meter, not the residents, making it easily transferable. The minimum loan size for residential solar projects is $5000 and they must result in a 10% utility bill savings, including the added loan repayment fee [8].

Massachusetts has the Solar Renewable Target Program (SMART) and Solar Loan Support Program. The SMART program incentivizes the installation of solar systems by paying owners an incentive rate for each kWh of electricity produced, with a small bonus incentive paid for low-income property owners. The Solar Loan Support program provides three types of incentives to support low and moderate-income households in getting affordable loans to install solar panels. The incentives include reducing loan principal by up to 30%, reducing loan interest rates by up to 1.5% and providing a loan loss guarantee to lenders for residents with bad credit [9].

New York's Affordable Solar program [10] and Washington D.C.'s Solar for All program [11] are similar programs which incentivize installers to target lower-income households when selling and leasing solar systems, creating cost savings which can be passed on to the consumer.

The Illinois IFSA program is similar to the other states' solar assistance program in that it is designed to support low-income communities. In addition, the ISFA assists with environmental justice communities and promotes solar training opportunities. The next section provides more details about the ISFA framework.

1.2. Illinois Solar for All program overview

ISFA was created with the passage of the Future Energy Jobs Act by the Illinois State legislature in December 2016 and has been in operation for three program years, 2018–2019, 2019–2020 and 2020–2021. The funds for ISFA come from the Illinois Power Agency (IPA) Renewable Energy Resources Fund which is considered a special fund in the Illinois Treasury [1], and can also come from contracts with utilities. Based on the number of submitted projects, funding selection can be competitive. Solar installers wishing to be a part of the ISFA program must go through an approval process through the Adjustable Block Program, which is Illinois' main solar PV incentive program, to become approved vendors. ISFA also mandates job training opportunities be provided by approved vendors.

A major benefit of the ISFA program to the recipients is that they have zero upfront costs and any ongoing costs or fees will not exceed 50% of the value of energy produced by the solar system through avoided usage or NM credit [12]. Any installed solar system must yield a minimum of a 50% energy cost savings for the participants. Participants pay for their solar systems through outright purchase, system lease, or entering into a Power Purchase Agreement (PPA). Another key feature of ISFA is its incentives for the environmentally disadvantaged. ISFA sets aside 25% of its operating budget for projects based in environmental justice communities (EJC). This incentivizes approved vendors to build projects in EJCs because there is a higher likelihood an EJC project gets funded. EJCs are designated by the EPA and are based on the EPA's screening tool which identifies areas in the United States that demonstrate higher risk of exposure to pollution based on environmental and socioeconomic factors [13].

The process for participating in the ISFA program begins with an approved vendor submitting a Part I application online to the ISFA program administrator for a potential solar system. This is completed during the planning phase of a solar system and includes technical information such as size, estimated Renewable Energy Credits (REC) production, equipment and installation company information [14]. After a cure period where applicants can correct, revise or add information to their submission, projects are reviewed by the ISFA program administrator and a REC contract, with an ISFA recommendation, is sent to the Illinois Commerce Commission (ICC) for approval. If approved by the ICC, REC contracting between the IPA and the approved vendor, or between a utility and an approved vendor, will be executed.

Next, the approved vendor constructs the proposed solar system and begins the Part II application process. Part II is essentially a verification of information submitted in Part 1. This ensures no changes in violation of ISFA guidelines have occurred. At the end of the quarter during which the solar system was energized, a one-time payment for 15 years of RECs is sent to the approved vendor. RECs are then transferred to the IPA or utility from the approved vendor every month for 15 years. Specifically, 'For systems larger than 5 kW, the first REC must be delivered within 90 days of the date the system is energized and registered in PJM-GATS or M-RETS. For systems smaller than 5 kW, 180 days for the first REC delivery will be allowed. The 15-year delivery term will begin in the month following the first REC delivery and will last 180 months' [14].

Prices for RECs through ISFA are higher than the Adjustable Block Program. According to the ISFA Approved Vendor Manual: 'RECs purchased at a higher value through ILSFA are intended to provide cost recovery for the additional anticipated expenses of implementing ILSFA projects and allows a greater share of incentives to be passed on directly to qualifying participants.'

REC calculation is as follows (Eq 1):

$$System\ Inverter\ Size\ (MWac) * approved\ capacity\ factor * \frac{365\ days}{year} * \frac{24\ hours}{day} * 15\ years * \frac{1\ REC}{1\ MWh} * \frac{\$}{REC} \quad (1)$$

1.3. Bloomington Normal Water Reclamation District (BNWRD)

BNWRD's participation in the ISFA program would be done in the Non-Profit and Public Facilities subprogram. Eligibility requirements for this subprogram include being a non-profit or public entity, being located in an EJC or a low-income community, and have a Critical Service Provider designation. The BNWRD meets these requirements and can be an eligible participant in the Non-Profit and Public Facilities subprogram.

Table 1 represents the REC schedule for Non-Profits and Public Facilities. The Group A rate schedule is for projects in the service areas of Ameren Illinois, MidAmerican, Mt. Carmel, Rural Electric Cooperatives and Municipal Utilities located in the MISO territory. The Group B rate schedule is for projects in the service areas of ComEd and Rural Electric Cooperatives and Municipal Utilities located in the PJM territory. BNWRD's electric utility is Ameren Illinois, which puts them in Group A.

Table 1. REC pricing schedule for the ISFA non-profits and public facilities subprogram ($/REC) [14].

System size	Group A	Group B
≤10 kW	$155.87	$156.57
>10–25 kW	$142.55	$143.26
>25–100 kW	$118.57	$119.28
>100–200 kW	$102.83	$103.55
>200–500 kW	$95.61	$96.34
>500–2000 kW	$91.31	$92.04

BNWRD was chosen as the subject of this study over other non-profits and public facilities in its EJC because it has a sizeable amount of land available for a potential solar system. The BNWRD facilities also use a lot of electricity, and a solar array built on its property could generate a large amount of electricity. Therefore, it was determined to be a suitable case study project.

There was a similar case study which assessed the current status of solar PV adoption across different California water treatment plants (WTPs) and considered three specific factors affecting its integration in the sector—flow rate, anaerobic digester and location [15]. The overall analysis of PV adoption for WTPs of various sizes was informative to understand how beneficial a potential solar array can be for the BNWRD. The size categories for the study were based on the flow rate of wastewater processed. The three categories were <5 million gallons per day (MGD), 5–50 MGD and 50 > MGD. The BNWRD processes 24.5 MGD [16] and therefore fits into the 5–50 MGD category. It was found that for the WTPs in the 5–50 MGD category, solar PV contributed between 8% and 30% of the electricity needs [15]. This case study also found that 1 MW was the most common size of solar array present in the WTPs. This tells us that we can expect our potential solar array to supply 8–30% of the electrical needs of the BNWRD and potentially be around 1 MW in capacity.

Regardless of size, WTPs use a lot of electricity all day long and all year long [17]. For solar energy to provide for a majority of that electricity, a massive solar array over many acres of property would need to be constructed. Smaller WTPs in rural areas have large land availability and smaller electrical loads so solar was able to provide for most, if not all, of their electricity needs [15]. WTPs in the 5–50 MGD category were located in more populous areas without a lot of land availability and required more electricity than smaller plants [15]. The BNWRD is surrounded by a highway, farmland and wetlands.

2. Methodology

Electricity consumption and electricity expenditure data were collected from the BNWRD after contacting the plant operators. Helioscope software was then used to model differently sized solar array 'cases' on the BNWRD property. Helioscope is a widely used cloud based online solar development tool used by solar PV developers and installers. After reading the ILSFA Project Selection Protocol guideline, we determined that a 1 MWac system may not have a good chance of being selected for funding considering the similar project sizes formerly funded. We created multiple cases with smaller sized systems to evaluate the financial and technical feasibility of potential solar PV systems. Case sizes included 1 MWac, 812 kWac, 500 kWac, 250 kWac and 100 kWac.

Further modeling based on the technical details from Helioscope was completed by using System Advisory Model (SAM). SAM is an energy system modeling software developed by the National Renewable Energy Laboratory. SAM modeling provided monthly and annual energy output, capacity factor and energy yield for each case. REC payment amount per watt ($/Wdc) was calculated to compare to potential per watt installation costs. We then modeled different financial scenarios like PPAs, outright purchase, and system leases for each case. These financial scenarios had to abide by the unique guidelines set forth by ISFA, so they are slightly different than usual financial structures.

For the PPAs, the net metering (NM) credit amount was calculated based on the BNWRD's Ameren bill and Illinois' electricity excise tax [18]. Since ISFA participants pay up to 50% of the value of the energy generated, the BNWRD would be expected to pay an approved vendor half of the value of the NM credits. This amount is then divided by the energy output of the system for each month of the first year and then averaged to find the first year PPA rate ($/kWh). Subsequently, the PPA rate and energy output is modeled over 15 years. Leases and outright purchases consider the lifetime NM credits of the system. For outright purchase, that amount would be paid in full and for a lease that amount would be paid off in monthly payments over 15 years. Scenarios were evaluated based on the percent savings yielded. If the percent savings was not at the minimum 50%, then more analysis was completed to determine what additional incentives were needed to reach the 50% threshold. This study excluded the implications of federal tax credits and the costs of grid interconnection.

After contacting the BNWRD about their electricity data, we were given consumption and billing data from October 2018 to December 2019. The electricity is provided by an energy broker, Champion Energy and the local utility, Ameren Illinois, delivers the electricity. BNWRD pays Champion about $0.046/kWh. Table 2 represents the energy data received from the BNWRD. An annual amount (12/7/2018–12/7/2019) for each column can be found at the bottom row. The first two rows of data are separated by a blank row to indicate they were not included in the annual amounts or total rate amounts since they would not represent the latest data for the annual amount calculation.

Table 2. BNWRD monthly and annual electricity consumption and payment.

Start date	End date	Energy (kWh)	Delivery charge (Ameren)	Provider charge (Champion)	Total cost	Estimated total rate ($/kWh)
10/6/2018	11/6/2018	790763	$21395.50	$36873.28	$58268.78	-
11/6/2018	12/7/2018	661084	$9380.78	$26808.99	$36189.77	-
12/7/2018	1/10/2019	743789	$11590.51	$34682.00	$46272.51	0.062
1/10/2019	2/8/2019	727232	$10786.10	$33910.87	$44696.97	0.061
2/8/2019	3/9/2019	714458	$11396.24	$33315.21	$44711.45	0.063
3/9/2019	4/9/2019	786268	$11912.59	$36663.73	$48576.32	0.062

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Start date	End date	Energy (kWh)	Delivery charge (Ameren)	Provider charge (Champion)	Total cost	Estimated total rate ($/kWh)
4/9/2019	5/9/2019	976844	$15234.08	$45550.25	$60784.33	0.062
5/9/2019	6/8/2019	1017956	$15735.21	$47643.00	$63378.21	0.062
6/8/2019	7/10/2019	900756	$14913.90	$42587.72	$57501.62	0.064
7/10/2019	8/8/2019	680193	$11767.97	$32159.55	$43927.52	0.065
8/8/2019	9/7/2019	808120	$13964.93	$38207.92	$52172.85	0.065
9/7/2019	10/8/2019	959214	$15077.99	$45351.66	$60429.65	0.063
10/8/2019	11/6/2019	930232	$15606.61	$43981.00	$59587.61	0.064
11/6/2019	12/7/2019	663659	$10265.69	$31377.82	$41643.51	0.063
12/7/2018	12/7/2019	9908721	$158251.82	$465430.73	$623682.55	0.063

3. Results and discussions

Solar PV system arrays were created using Helioscope to generate the most energy within the given property constraints. They all use REC Solar REC-250PE solar panels per the recommendation made by a local solar PV developer. The panels are arranged in a portrait orientation with eight feet of spacing between rows. Arrays also used Sunny Tripower 24000TL-US inverters which are the preset model of inverter used on Helioscope. The racking is fixed-tilt set at the latitude of the BNWRD which is about 40.5°.

The generated information presented in Table 3 was then input into SAM to find the monthly and annual energy production. The ISFA assumes a degradation rate of 0.5% per year and 14% system losses in its REC calculations. Table 4 represents the SAM modeling outcomes for each case scenario.

Table 3. Solar PV system array cases and their component data (kWdc, kWac, DC/AC ratio, number of modules and approximate area of system).

Case size (Wac)	Size (kWac)	Size (kWdc)	DC/AC ratio	# of modules	# of inverters	Approx. area (ft^2)
1 MWac	1010.50	1250.00	1.24	5000	42	301540.70
812 kWac (25% Incentive)	818.00	1000.00	1.22	4000	34	229219.20
500 kWac	505.30	630.00	1.25	2520	21	147191.50
250 kWac	240.60	300.00	1.25	1200	10	69734.20
100 kWac	96.20	110.00	1.14	440	4	29620.70

Table 4. Monthly and annual energy production for each array case.

Month	1 MWac case	812 kWac case	500 kWac case	250 kWac case	100 kWac case
Jan	114750.00	92085.50	57710.30	27481.10	10275.30
Feb	124612.00	99824.20	62734.40	29873.50	11033.30
Mar	161031.00	129106.00	81033.30	38587.30	14307.50
Apr	150027.00	120057.00	75592.80	35996.60	13216.50

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Month	1 MWac case	812 kWac case	500 kWac case	250 kWac case	100 kWac case
May	158127.00	126509.00	79689.30	37947.30	13916.10
Jun	158865.00	127093.00	80067.30	38127.30	13980.30
Jul	162524.00	130020.00	81911.70	39005.60	14302.30
Aug	163550.00	130841.00	82428.40	39251.60	14392.90
Sep	164229.00	131436.00	82743.30	39401.60	14466.50
Oct	146524.00	117318.00	73797.10	35141.50	12919.60
Nov	119271.00	95458.40	60091.60	28615.10	10511.30
Dec	95468.10	76374.60	48115.80	22912.30	8400.98
Total	1718978.10	1376122.70	865915.30	412340.80	151722.58
Energy offset estimate	17.348%	13.888%	8.739%	4.161%	1.531%

3.1. 1 MWac case

3.1.1. 1 MWac RECs

After SAM modeling, the 1 MWac capacity factor was calculated to be 15.7%. This metric is used while calculating the total amount of money an approved vendor would receive for 15 years' worth of RECs. However, the ISFA uses PVWatts when calculating REC quantities and the preset capacity factor for a fixed-tilt system is set at 16.42%. Approved vendors can use alternative capacity factors with proper documentation, but a higher capacity factor will yield a higher REC payment. Calculations for both scenarios are shown in Table 5.

Table 5. Two REC payment scenarios that differ in capacity factor which leads to a difference in 15-year REC payment totals and $/Wdc.

Inverter size (MWac)	Capacity factor	Days/ year	Hour/ day	Years	REC/ MWh	$/REC	15 Year total	Wdc	$/Wdc
1010.50	0.157	365	24	15	1	$91.13	$1899733.61	1250000	1.52
1010.50	0.1642	365	24	15	1	$91.13	$1986855.15	1250000	1.59

Also shown is the amount of payment received per watt DC of the 1 MWac system. This number can be compared to the per watt installation costs to determine the approved vendor's potential total profit and how much savings can be passed on to the participant i.e., having a $/Wdc installation cost that is lower than the $/Wdc REC payment would possibly yield more savings that could be passed on to the participant.

After finding each month's energy output, we were able to calculate the amount of NM credits the BNWRD would receive from Ameren. The credits are the sum of the volumetric rate charges, taxes, and charges per kWh that appear on the BNWRD's Ameren bill. Any other charges such as power or reactive power charges were not included in the NM credit calculation. The aggregate volumetric rate, excluding taxes, for the BNWRD is $0.0046/kWh. Tax on electricity is charged based on usage blocks so there is not a set rate.

Ameren would use the electricity generated by the system for delivery in their service area and thus would need to compensate the BNWRD for the electricity generated. NM credits would not be provided by Champion since they only provide the electricity to their customers. The energy generated has no value for Champion.

Since participants only pay a maximum of 50% of the value of the energy generated, BNWRD would be expected to pay half of the value of their NM credit. Per the ISFA Approved Vendor Manual: 'Under Illinois law, utilities are required to supply a certain amount of their energy from renewable sources through the purchase and retirement of RECs. If the RECs from a customer's PV system are transferred to a utility or the IPA through the ILSFA program, then that customer should not claim to be using clean or renewable electricity. Thus, approved vendors and their subcontractors may not suggest that customers participating in the ILSFA program will receive or use renewable electricity [14].' Therefore, there is no avoided energy usage. BNWRD would still be requiring electricity from Champion Energy and the electricity generated would be used throughout Ameren's delivery network, not directly in the BNWRD.

3.1.2. 1 MWac power purchase agreement case

We first crafted a power purchase agreement (PPA) model based on the maximum amount that BNWRD would need to pay under ISFA. We found that a first-year rate of $0.003860405048/kWh would yield the proper payment for 50% of the value of the NM credits the system would yield from Ameren. The rate was determined by dividing the 50% value of NM credits by the monthly energy output estimate by SAM.

In Table 6, the PPA rate in the 'Total' row is an average of the above theoretical monthly PPA rates. This parameter also applies to Tables 9, 12, 15 and 18.

Table 6. Calculation of the annual PPA rate for the BNWRD in order to pay for 50% of the value of the energy generated.

Month	SAM energy output (kWh)	Ameren NM credit ($)	50% of NM value that BNWRD pays ($)	PPA rate ($/kWh)	Savings per month ($)
Jan	114750.00	888.81	444.41	0.0039	444.41
Feb	124612.00	963.98	481.99	0.0039	481.99
Mar	161031.00	1241.55	620.77	0.0039	620.77
Apr	150027.00	1157.68	578.84	0.0039	578.84
May	158127.00	1219.42	609.71	0.0039	609.71
Jun	158865.00	1225.04	612.52	0.0039	612.52
Jul	162524.00	1252.93	626.46	0.0039	626.46
Aug	163550.00	1260.75	630.37	0.0039	630.37
Sep	164229.00	1265.92	632.96	0.0039	632.96
Oct	146524.00	1130.98	565.49	0.0039	565.49
Nov	119271.00	923.27	461.63	0.0039	461.63
Dec	95468.10	741.58	370.79	0.0039	370.79
Total	1718978.10	13271.90	6635.95	0.0039	6635.95

In Table 7, an energy degradation rate of 0.5%, a Champion Energy escalation rate of 0.5%, and a PPA rate escalation rate of 1.7% were all assumed for the solar system. These were assumptions set forth by the ISFA Approved Vendor Manual. The 'Percent Savings' row was based on the net present values (NPV). The values for Champion's electricity rate and PPA rate in the 'Total' row are averages of the rates in the above columns. The 'Net Energy Cost' in NPV row was calculated by subtracting the NM credit amount from the sum of the PPA cost and Champion cost. These parameters are also used in Tables 10, 13, 16 and 19.

Table 7. The PPA schedule for the 1 MWac case.

Year	Energy (kWh)	Energy rate ($/kWh)	Champion cost ($)	PPA ($/kWh)	PPA cost ($)	NM credit ($)	Net energy cost ($)
1	1718978.10	0.047	80155.95	0.0039	6635.95	13271.90	$73520.00
2	1710383.21	0.047	80153.94	0.0039	6715.02	13430.04	$73438.93
3	1701831.29	0.047	80151.94	0.0040	6795.03	13590.06	$73356.91
4	1693322.14	0.047	80149.94	0.0041	6875.99	13751.98	$73273.95
5	1684855.53	0.048	80147.93	0.0041	6957.92	13915.84	$73190.01
6	1676431.25	0.048	80145.93	0.0042	7040.82	14081.64	$73105.11
7	1668049.09	0.048	80143.93	0.0043	7124.71	14249.43	$73019.21
8	1659708.85	0.048	80141.92	0.0043	7209.60	14419.21	$72932.32
9	1651410.30	0.049	80139.92	0.0044	7295.51	14591.01	$72844.41
10	1643153.25	0.049	80137.92	0.0045	7382.43	14764.87	$72755.48
11	1634937.48	0.049	80135.91	0.0046	7470.39	14940.79	$72665.52
12	1626762.80	0.049	80133.91	0.0046	7559.40	15118.81	$72574.50
13	1618628.98	0.050	80131.91	0.0047	7649.47	15298.95	$72482.43
14	1610535.84	0.050	80129.90	0.0048	7740.62	15481.24	$72389.28
15	1602483.16	0.050	80127.90	0.0049	7832.85	15665.70	$72295.05
Total	24901471.27	0.048	1202128.85	0.0044	108285.73	216571.46	$1093843.11
NPV at 5% discount for cash flows		-	$831864.53	-	74132.22	148264.43	757732.31
Percent savings							8.91%

When applied over 15 years, the PPA option does not yield a high enough energy cost savings to be eligible for ISFA. All projects in ISFA must yield at least a 50% energy cost savings. Because there is no avoided energy, the BNWRD still pays $0.046/kWh to Champion Energy. This limits the ability of the BNWRD to save money. Essentially, the BNWRD would be paying a cost through PPA to receive a NM credit worth double the PPA cost. There is an electricity cost savings but not enough for the ISFA.

Unless an extra $267667.83 in incentives that reduced BNWRD electricity costs were included, a savings of 50% would not be reached. This is equivalent to $0.0107/kWh and when subtracted from the base PPA rate, would create a negative PPA rate throughout the contract term.

3.1.3. 1 MWac lease

We then created a potential lease structure. The BNWRD would make 180 monthly payments to the Approved Vendor equal to 50% of the value of the energy generated. We have already calculated the lifetime value of the energy generated to be $108285.73 based on the numbers from Table 7. That amount paid over 180 months equals $601.59/month. The average monthly energy production for the lifetime of the system is 138341.507 kWh. This means the BNWRD would be paying $0.0043/kWh to an approved vendor during this lease, which is equivalent to the average lifetime PPA rate from Table 7. However, this does not include the rate of electricity BNWRD still has to pay to Champion. That rate is equivalent to $0.04829/kWh and when added to the lease electricity rate found prior equals $0.0526/kWh. The total cost for 24901471.27kWh would be $1310975.68.

Currently, BNWRD pays an estimated rate of about $0.063/kWh for electricity from Champion and its delivery through Ameren. This means that the 1 MWac system would yield a lower $/kWh rate for the BNWRD than its current total electricity cost rate while also ensuring the BNWRD pays for 50% of the value of the energy generated.

3.1.4. 1 MWac purchase outright

A comparable situation occurs if the BNWRD decides to purchase the system outright. The potential 1 MWac solar array would yield 24901471.27 kWh over its lifetime and produce $216571.46 worth of NM credits. BNWRD would only be expected to pay 50% of the value of that energy per ISFA guidelines, therefore, BNWRD would pay $108285.73 to the approved vendor for the system. This yields a $/kWh rate of $0.0043/kWh.

When the cost of Champion Energy's electricity is factored in, this rate will increase. The average lifetime rate at which BNWRD buys electricity from Champion is $0.0483/kWh. If this rate is combined with the above rate, the total rate for electricity is $0.05265/kWh. This is equivalent to the rate paid in the lease option and is still lower than the current total electricity rate BNWRD pays.

3.2. 25% of budget (818 kWac) case

3.2.1. 818 kWac RECs

Since 25% of the budget for the Non-Profits and Public Facilities subprogram is set aside for projects in EJCs, we wanted to calculate an array that would yield a REC amount for the entirety of that EJC incentive. The total budget for the Non-Profits and Public Facilities subprogram in the 2019–2020 program year was $6.4 million, therefore, the incentive amount set aside for EJCs was $1.6 million. Using the REC calculation and the preset established capacity factor of 16.42%, we were able to calculate the array size to be around 818 kWac. This yields a REC amount higher than $1.6 million, but the actual array, if built, would be closer to the stated case size. When the technical details of the array were input into SAM, the resulting capacity factor was calculated to be 15.7%. Since approved vendors can opt to use the preset 16.42% capacity factor, REC amounts for both capacity factors were calculated as represented in Table 8.

Table 8. Two REC payment scenarios that differ on capacity factor which leads to a difference in 15-year REC payment totals and $/Wdc.

Inverter size (MWac)	Capacity factor	Days/ Year	Hour/ day	Years	REC/ MWh	$/REC	15 year total	Wdc	$/Wdc
0.818	0.157	365	24	15	1	$91.13	$1537834.83	1000000	1.54
0.818	0.1642	365	24	15	1	$91.13	$1608359.73	1000000	1.61

3.2.2. 818 kWac PPA

Our simulated PPA was created in a similar fashion to the 1 MWac case. We found that a first-year rate of $0.003872059862/kWh would yield the proper payment for 50% of the value of the NM credits the system would yield from Ameren. Again, the rate was determined by dividing the 50% value of NM credits by the monthly energy output estimate by SAM. Table 9 represents the calculation of the annual PPA rate for the BNWRD in order to pay for 50% of the value of the energy generated.

Table 9. Calculation of the annual PPA rate for the BNWRD in order to pay for 50% of the value of the energy generated.

Month	SAM energy output (kWh)	Ameren NM credit ($)	50% of NM value that BNWRD pays ($)	PPA rate ($/kWh)	Savings per month ($)
Jan	92085.50	715.59	357.80	0.0039	357.80
Feb	99824.20	775.04	387.52	0.0039	387.52
Mar	129106.00	998.23	499.11	0.0039	499.11
Apr	120057.00	929.26	464.63	0.0039	464.63
May	126509.00	978.43	489.22	0.0039	489.22
Jun	127093.00	982.88	491.44	0.0039	491.44
Jul	130020.00	1005.19	502.60	0.0039	502.60
Aug	130841.00	1011.45	505.73	0.0039	505.73
Sep	131436.00	1015.99	507.99	0.0039	507.99
Oct	117318.00	908.38	454.19	0.0039	454.19
Nov	95458.40	741.50	370.75	0.0039	370.75
Dec	76374.60	594.91	297.45	0.0039	297.45
Total	1376122.70	10656.86	5328.43	0.0039	5328.43

When simulated over 15 years, our PPA only yields an 8.94% energy cost savings which does not meet the threshold for ISFA as quantified in Table 10. To meet the 50% energy cost savings threshold, an extra $273447.82 in incentives would need to be included for the BNWRD. If this incentive is divided by the lifetime energy output and subtracted from the PPA rate, the rate becomes negative.

Table 10. The PPA schedule for the 812 kWac case.

Year	Energy (kWh)	Energy rate ($/kWh)	Champion cost ($)	PPA ($/kWh)	PPA cost ($)	NM credit ($)	Net energy cost ($)
1	1376122.70	0.047	64168.60	0.0039	5328.43	10656.86	58840.17
2	1369242.09	0.047	64167.00	0.0039	5391.92	10783.84	58775.08
3	1362395.88	0.047	64165.39	0.0040	5456.16	10912.32	58709.23
4	1355583.90	0.047	64163.79	0.0041	5521.17	11042.35	58642.62
5	1348805.98	0.048	64162.18	0.0041	5586.96	11173.91	58575.23
6	1342061.95	0.048	64160.58	0.0042	5653.53	11307.05	58507.05
7	1335351.64	0.048	64158.98	0.0043	5720.89	11441.78	58438.09
8	1328674.88	0.048	64157.37	0.0044	5789.05	11578.10	58368.32
9	1322031.50	0.049	64155.77	0.0044	5858.03	11716.06	58297.74
10	1315421.35	0.049	64154.17	0.0045	5927.83	11855.65	58226.34
11	1308844.24	0.049	64152.56	0.0046	5998.46	11996.91	58154.10
12	1302300.02	0.049	64150.96	0.0047	6069.93	12139.86	58081.03
13	1295788.52	0.050	64149.35	0.0047	6142.25	12284.50	58007.10
14	1289309.58	0.050	64147.75	0.0048	6215.44	12430.87	57932.31
15	1282863.03	0.050	64146.15	0.0049	6289.49	12578.99	57856.65
Total	19934797.24	0.048	962360.60	0.0044	87086.69	173899.06	875411.07
NPV at 5% discount for cash flows		-	665946.62	-	59525.49	119050.98	606421.13
Percent savings							8.94%

3.2.3. 818 kWac lease

The lease structure for the 818 kWac case is like the lease structure of the 1 MWac case. BNWRD would need to make 180 monthly payments over 15 years to an approved vendor. The amount paid by the BNWRD would be equivalent to 50% of the value of the energy generated, in this case $87086.69. This creates a monthly payment of $483.81. The rate will increase once the lifetime cost of $962360.60 to Champion energy is factored in. The lifetime total energy cost would be $1049447.29 and yields a monthly payment of $5830.26 and lifetime $/kWh rate of $0.0526/kWh. This rate is lower than the current rate BNWRD pays to Champion and Ameren for electricity, which is based on the data provided by the BNWRD.

3.2.4. 818 kWac purchase outright

If the BNWRD wanted to purchase the system outright, the cost would still be $87086.69, yielding a $/kWh rate of $0.0044/kWh based on the 19934797.24 kWh of lifetime energy production. When the amount owed to Champion for that same energy output is factored in, the total cost of energy for 19934797.24 kWh becomes $1049447.29 yielding a lifetime $/kWh rate of $0.05264399093/kWh, which is the same as the lease example above.

3.3. 500 kWac case

3.3.1. 500 kWac RECs

The REC calculation for the 500 kWac case is the same as the previous cases. Tables 11 and 12 represent the 15 year REC payment total for this case and the calculation of the annual PPA rate for the facility in order to pay foor 50% of the energy generated respectively.

Table 11. 15 year REC payment total for 500 kWac case.

Inverter size (MWac)	Capacity factor	Days/ year	Hour/ day	Years	REC/ MWh	$/REC	15 year total	Wdc	$/Wdc
0.5053	0.157	365	24	15	1	$91.13	$949960.80	630000	1.51
0.5053	0.1642	365	24	15	1	$91.13	$993525.88	630000	1.58

3.3.2. 500 kWac PPA

Table 12. Calculation of the annual PPA rate for the BNWRD in order to pay for 50% of the value of the energy generated.

Month	SAM energy output (kWh)	Ameren NM credit ($)	50% of NM value that BNWRD pays ($)	PPA rate ($/kWh)	Savings per month ($)
Jan	57710.30	451.53	225.77	0.0039	225.77
Feb	62734.40	490.13	245.06	0.0039	245.06
Mar	81033.30	630.69	315.35	0.0039	315.35
Apr	75592.80	588.90	294.45	0.0039	294.45
May	79689.30	620.37	310.18	0.0039	310.18
Jun	80067.30	623.27	311.64	0.0039	311.64
Jul	81911.70	637.44	318.72	0.0039	318.72
Aug	82428.40	641.41	320.71	0.0039	320.71
Sep	82743.30	643.83	321.91	0.0039	321.91
Oct	73797.10	575.11	287.55	0.0039	287.55
Nov	60091.60	469.83	234.91	0.0039	234.91
Dec	48115.80	377.53	188.76	0.0039	188.76
Total	865915.30	6298.51	3149.25	0.0036	3149.25

During the first year of operation for the 500 kWac system, a PPA rate of $0.0036/kWh will yield the proper energy cost savings. Table 13 represents the PPA schedule for the 500kWac case.

Table 13. The PPA schedule for the 500 kWac case.

Year	Energy (kWh)	Energy rate ($/kWh)	Champion cost ($)	PPA ($/kWh)	PPA cost ($)	NM credit ($)	Net energy cost ($)
1	865915.30	0.0466	40377.63	0.0036	3149.25	6298.51	37228.38
2	861585.72	0.0469	40376.62	0.0037	3186.78	6373.55	37189.84
3	857277.79	0.0471	40375.61	0.0038	3224.75	6449.49	37150.86
4	852991.41	0.0473	40374.60	0.0038	3263.17	6526.34	37111.43
5	848726.45	0.0476	40373.59	0.0039	3302.05	6604.10	37071.54
6	844482.82	0.0478	40372.58	0.0040	3341.39	6682.79	37031.19
7	840260.40	0.0480	40371.57	0.0040	3381.21	6762.41	36990.37
8	836059.10	0.0483	40370.56	0.0041	3421.49	6842.99	36949.07
9	831878.81	0.0485	40369.56	0.0042	3462.26	6924.52	36907.29
10	827719.41	0.0488	40368.55	0.0042	3503.51	7007.03	36865.03
11	823580.81	0.0490	40367.54	0.0043	3545.26	7090.52	36822.28
12	819462.91	0.0493	40366.53	0.0044	3587.50	7175.00	36779.03
13	815365.60	0.0495	40365.52	0.0045	3630.25	7260.49	36735.27
14	811288.77	0.0498	40364.51	0.0045	3673.50	7347.00	36691.01
15	807232.32	0.0500	40363.50	0.0046	3717.27	7434.54	36646.23
Total	12543827.62	0.0482	605558.48	0.0041	51470.71	102779.29	554168.83
NPV at 5% discount for cash flows		-	419042.12	-	35181.26	70362.52	383860.86
Percent savings							8.40%

Over a 15-year period, the system does not yield the energy cost savings required by ISFA. An extra $174339.80 is needed in additional incentives to meet the 50% energy cost savings.

3.3.3. 500 kWac lease and outright purchase

The lease structure and outright purchase structure are very similar and will be discussed together in this section.

The amount of money BNWRD owes to an approved vendor for the 500 kWac system is equal to 50% of the value of the energy of that system. For the 500 kWac case, the cost is $51470.71. This can be paid in full if the system is purchased outright or paid over 180 months for a 15-year lease. The monthly payments would be $285.95. In either option, the $/kWh would be $0.0041/kWh.

The lifetime total energy cost would be $657029.19 when the cost to Champion Energy is factored in. This would create a total energy monthly payment of $3650.16 if the lease option was used and the lifetime $/kWh rate would be $0.0523/kWh.

3.4. 250 kWac Case

Because this system is 250 kWac, it is in a different REC price tier than the three previous cases. The $/REC for the 250 kWac case is $95.61/REC. Tables 14–16 represent the 15 year REC payment total, the calculation of the annual PPA rate, and the PPA schedule for 250 kWac case respectively.

Table 14. 15 year REC payment total for 250 kWac case.

Inverter size (MWac)	Capacity factor	Days/ year	Hour/ day	Years	REC/ MWh	$/REC	15 year total	Wdc	$/Wdc
0.2406	0.157	365	24	15	1	$95.61	$474563.09	300000	1.58
0.2406	0.1642	365	24	15	1	$95.61	$496326.49	300000	1.65

Table 15. Calculation of the annual PPA rate for the BNWRD in order to pay for 50% of the value of the energy generated.

Month	SAM energy output (kWh)	Ameren NM credit ($)	50% of NM value that BNWRD pays ($)	PPA rate ($/kWh)	Savings per month ($)
Jan	27481.10	215.72	107.86	0.0039	107.86
Feb	29873.50	234.48	117.24	0.0039	117.24
Mar	38587.30	302.81	151.41	0.0039	151.41
Apr	35996.60	282.49	141.25	0.0039	141.25
May	37947.30	297.79	148.90	0.0039	148.90
Jun	38127.30	299.20	149.60	0.0039	149.60
Jul	39005.60	306.09	153.05	0.0039	153.05
Aug	39251.60	308.02	154.01	0.0039	154.01
Sep	39401.60	309.20	154.60	0.0039	154.60
Oct	35141.50	275.79	137.89	0.0039	137.89
Nov	28615.10	224.61	112.31	0.0039	112.31
Dec	22912.30	179.89	89.95	0.0039	89.95
Total	412340.80	3236.09	1618.05	0.0039	1618.05

The first year PPA rate for 250kWac is $0.0039/kWh to meet the energy cost savings requirement.

Table 16. The PPA schedule for the 250 kWac case.

Year	Energy (kWh)	Energy rate ($/kWh)	Champion cost ($)	PPA ($/kWh)	PPA cost ($)	NM credit ($)	Net energy cost ($)
1	412340.80	0.0466	19227.45	0.0039	1618.05	3236.09	17609.41
2	410279.10	0.0469	19226.97	0.0040	1637.33	3274.65	17589.65
3	408227.70	0.0471	19226.49	0.0041	1656.83	3313.67	17569.66

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Year	Energy (kWh)	Energy rate ($/kWh)	Champion cost ($)	PPA ($/kWh)	PPA cost ($)	NM credit ($)	Net energy cost ($)
4	406186.56	0.0473	19226.01	0.0041	1676.58	3353.15	17549.43
5	404155.63	0.0476	19225.53	0.0042	1696.55	3393.10	17528.98
6	402134.85	0.0478	19225.05	0.0043	1716.77	3433.53	17508.28
7	400124.18	0.0480	19224.57	0.0043	1737.22	3474.44	17487.35
8	398123.56	0.0483	19224.09	0.0044	1757.92	3515.84	17466.17
9	396132.94	0.0485	19223.61	0.0045	1778.87	3557.73	17444.74
10	394152.27	0.0488	19223.13	0.0046	1800.06	3600.12	17423.06
11	392181.51	0.0490	19222.65	0.0046	1821.51	3643.02	17401.14
12	390220.60	0.0493	19222.16	0.0047	1843.21	3686.42	17378.95
13	388269.50	0.0495	19221.68	0.0048	1865.17	3730.35	17356.51
14	386328.15	0.0498	19221.20	0.0049	1887.40	3774.80	17333.81
15	384396.51	0.0500	19220.72	0.0050	1909.89	3819.77	17310.84
Total	5973253.87	0.0482	288361.31	0.0044	26445.00	52806.70	261957.96
NPV at 5% discount for cash flows		-	199543.95	-	18075.68	36151.37	181468.27
Percent savings							9.06%

The percent savings is not enough to qualify for the ISFA in the PPA scenario. An extra $81696.29 in incentives is needed to achieve the mandatory 50% energy savings cost.

The amount of money BNWRD owes to an approved vendor for the 250 kWac system is equal to 50% of the value of the energy of that system. For the 250 kWac case, the cost is $26445.00. This can be paid in full if the system is purchased outright or paid over 180 months for a 15-year lease. The monthly payments would be $146.92. In either option, the $/kWh would be $0.0044/kWh.

The lifetime total energy cost would be $314806.30 when the cost to Champion Energy is factored in. This would create a total energy monthly payment of $1748.92 if the lease option was used and the lifetime $/kWh rate would be $0.0527/kWh.

3.5. 100 kWac Case

Because this system is 100 kWac, it is in a different REC price tier than the four previous cases. The $/REC for the 100 kWac case is $102.83/REC. Tables 17–19 represent the 15 year REC payment total, the calculation of the annual PPA rate, and the PPA schedule for 100 kWac case respectively.

Table 17. 15 year REC payment total for 100 kWac case.

Inverter size (MWac)	Capacity factor	Days/ year	Hour/ day	Years	REC/ MWh	$/REC	15 year total	Wdc	$/Wdc
0.0962	0.157	365	24	15	1	$102.83	$235312.45	110,000	2.14
0.0962	0.1642	365	24	15	1	$102.83	$246103.85	110,000	2.24

Table 18. Calculation of the annual PPA rate for the BNWRD in order to pay for 50% of the value of the energy generated.

Month	SAM energy output (kWh)	Ameren NM credit ($)	50% of NM value that BNWRD pays ($)	PPA rate ($/kWh)	Savings per month ($)
Jan	10275.30	80.80	40.40	0.0039	40.40
Feb	11033.30	86.74	43.37	0.0039	43.37
Mar	14307.50	112.42	56.21	0.0039	56.21
Apr	13216.50	103.86	51.93	0.0039	51.93
May	13916.10	109.35	54.67	0.0039	54.67
Jun	13980.30	109.85	54.92	0.0039	54.92
Jul	14302.30	112.37	56.19	0.0039	56.19
Aug	14392.90	113.08	56.54	0.0039	56.54
Sep	14466.50	113.66	56.83	0.0039	56.83
Oct	12919.60	101.53	50.77	0.0039	50.77
Nov	10511.30	82.65	41.32	0.0039	41.32
Dec	8400.98	66.10	33.05	0.0039	33.05
Total	151722.58	1192.40	596.20	0.0039	596.20

The first year PPA rate for the 100 kWac case is $0.0039/kWh.

Table 19. The PPA schedule for the 100 kWac case.

Year	Energy (kWh)	Energy rate ($/kWh)	Champion cost ($)	PPA ($/kWh)	PPA cost ($)	NM credit ($)	Net energy cost ($)
1	151722.58	0.0466	7074.82	0.0039	596.20	1192.40	6478.62
2	150963.97	0.0469	7074.65	0.0040	603.31	1206.61	6471.34
3	150209.15	0.0471	7074.47	0.0041	610.49	1220.99	6463.98
4	149458.10	0.0473	7074.29	0.0041	617.77	1235.54	6456.53
5	148710.81	0.0476	7074.12	0.0042	625.13	1250.26	6448.99
6	147967.26	0.0478	7073.94	0.0043	632.58	1265.15	6441.36
7	147227.42	0.0480	7073.76	0.0043	640.11	1280.23	6433.65
8	146491.28	0.0483	7073.59	0.0044	647.74	1295.48	6425.85
9	145758.83	0.0485	7073.41	0.0045	655.46	1310.92	6417.95
10	145030.03	0.0488	7073.23	0.0046	663.27	1326.54	6409.96
11	144304.88	0.0490	7073.06	0.0047	671.17	1342.34	6401.88
12	143583.36	0.0493	7072.88	0.0047	679.17	1358.34	6393.71
13	142865.44	0.0495	7072.70	0.0048	687.26	1374.52	6385.44
14	142151.11	0.0498	7072.52	0.0049	695.45	1390.90	6377.08

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Year	Energy (kWh)	Energy rate ($/kWh)	Champion cost ($)	PPA ($/kWh)	PPA cost ($)	NM credit ($)	Net energy cost ($)
15	141440.36	0.0500	7072.35	0.0050	703.74	1407.47	6368.61
Total	2197884.58	0.0482	106103.79	0.0044	9744.19	19457.68	96374.95
NPV at 5% discount for cash flows		-	73423.06	-	6660.35	13320.69	66762.71
Percent savings							9.07%

The energy cost savings is not high enough to meet the requirements of ISFA. An extra $30051.18 in incentives is needed to yield the 50% energy cost savings over the contract term.

The amount of money BNWRD owes to an approved vendor for the 100 kWac system is equal to 50% of the value of the energy of that system. For the 100 kWac case, the cost is $9744.19. This can be paid in full if the system is purchased outright or paid over 180 months for a 15-year lease. The monthly payments would be $54.13. In either option, the $/kWh would be $0.0044/kWh.

The lifetime total energy cost would be $115847.98 when the cost to Champion Energy is factored in. This would create a total energy monthly payment of $643.60 if the lease option was used and the lifetime $/kWh rate would be $0.0527/kWh. Table 20 summarizes the results of financial analyses completed for this case study.

Table 20. Results of financial analysis for each case.

	Lease	Purchase	Purchase ($/kWh)	PPA
1 MWac	$601.59/month	$108285.73	0.0043	Does not meet minimum percent savings criteria
812 kWac	$483.81/month	$87086.69	0.0044	
500 kWac	$285.95/month	$51470.71	0.0041	
250 kWac	$146.92/month	$26445.00	0.0044	
100 kWac	$54.13/month	$9744.19	0.0044	

4. Conclusions

The ISFA program is attempting to grow the PV market to underserved communities in Illinois. This is accomplished by the program paying higher rates for RECs than the standard Adjustable Block Program. The BNWRD uses a lot of energy and could potentially save money on that energy by installing a solar array on its property through the favorable conditions of the ISFA.

While the PPA remains a popular financial structure for most solar installations, our analysis has concluded that a lease or outright purchase would yield the most electricity cost savings for the BNWRD. For each of the cases, the PPA structure failed to yield an energy cost savings that reached 50%. Therefore, no PPA would be eligible for funding under the ISFA program. However, a lease and outright purchase structure could be created that yielded the required energy savings for each case. This study can conclude that a solar array built through the ISFA for the BNWRD is feasible. This study did not have the scope to determine whether an approved vendor would want to build an array.

The larger arrays have a higher energy offset percentage but are not as likely to be chosen for funding due to their larger REC payments. Smaller arrays have a higher chance of being selected for funding but will not yield as much energy as the larger arrays. This tradeoff will have to be examined for any large energy user who wishes to participate in the ISFA program. More funding and clearer project selection criteria could eliminate this tradeoff and allow for more participation in the ISFA.

The BNWRD's entire electricity demand will not be supplied by the potential array, but it would be a good start and a potential model for other WTPs in Illinois to replicate. If the generous REC payments are still active, non-profits and public facilities should contact an approved vendor to begin a preliminary assessment.

Conflict of interests

All authors declare no conflicts of interest in this paper.

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