From: Melissa Aucompaugh
To: Lynch, Ariel D (APA)
Cc: tmitchell@EDPLLP.com; Steve Long; leigh@solsourcepower.com
Subject: Re: Vineyard Solar project (P2024-0046)
Date: Monday, March 18, 2024 1:08:07 PM
Attachments: 180412_Adjacent Property Values Solar Impact Study by CohnReznic.pdf
11_2017-5 NC STATE Study Health-and-Safety-Impacts-of-Solar.pdf

Ariel,

In response to the comment letter and phone call you received for the Vineyard Solar Project, I have attached the following documents(studies) that address the concerns that they have with property values and water contamination:

- Cypress Creek Renewables -Property Value Impact Study dated 3/20/18
- NC Clean Energy -Health and Safety impacts of Solar Photovoltaics dated May 2017

Please feel free to give me a call at 518-376-1134 if you have any questions or need additional information.

Sincerely,
Mellissa

Melissa Aucompaugh

Project Manager

Environmental Design Partnership

On Mon, Mar 18, 2024 at 8:52 AM Lynch, Ariel D (APA) <Ariel.Lynch@apa.ny.gov> wrote:

> Hi Melissa,
>
> Sorry about that. Can you open the attached?
>
> I'll try calling later this morning.

Ariel

Ariel Lynch

Environmental Program Specialist 2

she/her/hers

NYS Adirondack Park Agency

PO Box 99

1133 NYS Route 86

Ray Brook, NY 12977

OFFICE: (518) 891-4050

MOBILE: (518) 319-0231

ariel.lynch@apa.ny.gov

www.apa.ny.gov

From: Melissa Aucompaugh <maucompaugh@edpllp.com>
Sent: Monday, March 18, 2024 8:35 AM
To: Lynch, Ariel D (APA) <Ariel.Lynch@apa.ny.gov>

Subject: Re: Vineyard Solar project (P2024-0046)

ATTENTION: This email came from an external source. Do not open attachments or click on links from unknown senders or unexpected emails.

Good morning Ariel,

I received your voicemail on Friday. You can give me a call at your convenience at 518-376-1134.

Also , we cannot open this attachment. Is it possible to scan it in another format?

I look forward to speaking with you.

Sincerely,

Melissa

Melissa Aucompaugh

Project Manager

Environmental Design Partnership

On Fri, Mar 15, 2024 at 12:02 PM Lynch, Ariel D (APA) <Ariel.Lynch@apa.ny.gov> wrote:

> Hi Travis and Melissa,
>
> I am passing along one comment letter that we received for the Vineyard Solar project, for your information. See attached.
>
> We also received a phone message from a different neighbor with concerns about

heavy metals leaching form solar panels into the creek, then into groundwater, and contaminating the town water supply. Do you have any information that might address this concern?

Thanks,

Ariel

Ariel Lynch

Environmental Program Specialist 2

she/her/hers

NYS Adirondack Park Agency

PO Box 99

1133 NYS Route 86

Ray Brook, NY 12977

OFFICE: (518) 891-4050

MOBILE: (518) 319-0231

ariel.lynch@apa.ny.gov

www.apa.ny.gov

CohnReznick
Accounting • Tax • Advisory

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CYPRESS CREEK RENEWABLES

PROPERTY VALUE IMPACT STUDY

ADJACENT PROPERTY VALUES SOLAR IMPACT STUDY: A STUDY OF NINE EXISTING SOLAR FARMS

Located in Champaign, LaSalle, and Winnebago Counties, Illinois; and, Lake, Porter, Madison, Marion, And Elkhart Counties, Indiana

PREPARED FOR:
Mr. Jason Carr
Director of Community Relations
Cypress Creek Renewables
2660 NE Hwy 20, Suite 610 #30
Bend, OR 97701

SUBMITTED BY:
CohnReznick, LLP
Valuation Advisory Services
200 S Wacker Drive, Suite 2600
Chicago, IL 60606

Patricia L. McGarr, MAI, CRE, FRICS
patricia.mcgarr@cohnreznick.com
Direct: (312) 508-5802

March 20, 2018

EXECUTIVE SUMMARY

The purpose of this real estate impact study is to determine whether the existing solar farm uses under study have had any measurable impact on the value of adjacent properties.

According to the Solar Energy Industries Association (SEIA) 2016 report, Illinois had 81.52 Megawatts (MW) of solar panels installed, compared to Indiana which has had 265.64 MW of solar panels installed. As we are studying the impact of this use on adjacent property values, we have included several of these established solar farms in Indiana, focusing on similar rural and suburban areas, that we believe are comparable to those locations proposed in Illinois.

Our study includes research and analyses of nine existing solar panel farms and the property value trends of the adjacent land uses, including agricultural, single family and residential properties; review of published studies, and discussions with market participants, summarized as follows:

- Solar Farm 1 (*Grand Ridge Solar Farm*) is located near the City of Streator in LaSalle County, Illinois, in a primarily rural area, on two contiguous parcels totaling 160 acres. Surrounding uses consist of agricultural land, some with homesteads, and single family homes to the northwest. We found one adjoining property which qualified for a paired sales analysis.
- Solar Farm 2 *(Portage Solar Farm)* is located near the City of Portage, in Porter County, Indiana. This solar farm is situated in a residential area on a 56-acre parcel of land. The surrounding uses consist of agricultural land to the north and east, and residential uses such as single family homes to the west and northwest, and multifamily apartments to the south. We found two adjoining properties that qualified for a paired sales analysis.
- Solar Farm 3 (*IMPA Frankton Solar Farm*) is located in the Town of Frankton, in Madison County, Indiana. This solar farm is situated in a fairly rural area and is located on a 13-acre parcel. The surrounding uses consist of single family homes to the east, agricultural land to the south, west, and north, and some baseball fields as well. We found two adjoining properties which qualified for a paired sales analysis.
- Solar Farm 4 (*Dominion Indy Solar Farm III*) is located in a suburban, yet rural area outside of Indianapolis, in Marion County, Indiana, on a parcel totaling 134 acres. The surrounding uses consist of agricultural land to the east, west and south, and a single family subdivision to the north. We found six adjoining properties which qualified for a paired sales analysis.
- Solar Farm 5 (*Valparaiso Solar Farm*) is located near the City of Valparaiso, in Porter County, Indiana. This solar farm is situated in a fairly rural area on two contiguous parcels totaling 27.9 acres. The surrounding uses consist of vacant land to the north, and single family homes to the east, south and west. We considered two adjoining properties which qualified for a paired sales analysis.
- Solar Farm 6 (*Middlebury Solar Farm*) is located near the Town of Middlebury, in Elkhart County, Indiana. This solar farm is situated in a fairly rural area on a 33.86-acre parcel. The surrounding uses consist of residential uses to the east, north and west, industrial uses to the south, and a medical office use to the southwest. We considered one adjoining property which qualified for a paired sales analysis.
- Solar Farm 7 (*Rockford Solar Farm*) is located in the City of Rockford in Winnebago County, Illinois, just a little over one mile south of the Chicago-Rockford International Airport and is comprised of three parcels for a total acreage of 182.29 acres. This solar farm was announced for construction in March 2011, and completed in October 2012. The surrounding uses include agricultural and industrial land. Many of the surrounding parcels are owned by the Chicago-Rockford International Airport Authority. We found two adjoining properties which qualified for a paired sales analysis.

- Solar Farm 8 (*Lincoln Solar Farm*) is located near Merrillville, in Lake County, Indiana. This solar farm is situated in a fairly rural area located on one parcel made up of 20 acres. Surrounding uses included agricultural land directly west and north, single family uses to the east, and church use to the south. There were no adjoining properties with sales that fit the criteria to perform a paired sales analysis for Solar Farm 8.
- Solar Farm 9 (*University of Illinois Solar Farm*) is located in the City of Champaign, Champaign County, Illinois, just south of the University Illinois Urbana-Champaign Campus. This solar farm is located on 20.79 acres of land. The solar farm was announced for construction on November 12, 2012, and completed on November 2015. This solar farm is owned and operated by the University of Illinois and is considered one of the largest university solar farms in the country. Surrounding uses include a nature preserve to the east and south, commercial offices to the west, and university-occupied land to the north. There were no adjoining properties with sales that fit the criteria to perform a paired sales analysis for Solar Farm 9.
- We performed a paired sales analysis for each adjoining property that fit the criteria for analysis that were adjacent to the solar farms we studied. The sales adjacent to solar farms, or Test Areas, were compared to agricultural land sales and single family home sales not adjacent to solar farms within the same county as subject solar farms, or Control Areas. **We analyzed 16 adjoining property sales in Test Areas and 72 comparable sales in Control Areas,** collectively, for the Rockford Solar Farm, the Grand Ridge Solar Farm, the Portage Solar Farm, the IMPA Frankton Solar Farm, the Dominion Indy III Solar Farm, the Valparaiso LLC Solar Farm, and the Middlebury Solar Farm over the past five years. The remaining two solar farms did not have data available for analysis.

The basic premise of this comparative analysis is that if there is any impact on the property values, by virtue of their proximity to a solar farm, it would be reflected by such factors as the range of sale prices, differences in unit sale prices, conditions of sale, and overall marketability. When comparing these factors for properties near the solar farm to properties locationally removed from the solar farm, we would expect to see some emerging and consistent pattern of substantial difference in these comparative elements – if, in fact, there was an effect.

We have also reviewed published methodology for measuring impact on property values as well as published studies that specifically analyzed the impact of solar farms on nearby property values. We have also interviewed market participants, including Township Assessors, to give us additional insight as to how the market evaluates farm land and single family homes with views of the solar farm. These studies found little to no measurable and consistent difference in value between the Test Area Sales and the Control Area Sales attributed to the proximity to solar farms and are generally considered a compatible use. Considering all of this information, we can conclude that since the Adjoining Property Sales (Test Area Sales) for the existing solar farms analyzed were not adversely affected by their proximity to solar farms, that properties surrounding other solar farms operating in compliance with all regulatory standards will similarly not be adversely affected, in either the short or long term periods.

March 20, 2018

Mr. Jason Carr
Director of Community Relations
Cypress Creek Renewables
2660 NE Hwy 20, Suite 610 #30
Bend, OR 97701

SUBJECT: Property Value Impact Study
Nine Solar Farms
Located in Champaign, LaSalle, and Winnebago Counties, Illinois; and,
Lake, Porter, Madison, Marion, and Elkhart Counties, Indiana

Dear Mr. Carr:

CohnReznick is pleased to submit the accompanying adjacent property values impact study of the above referenced subject properties. Per the client's request, we have researched three solar farms in Illinois: Grand Ridge in LaSalle County, Illinois (Solar Farm 1), Chicago Rockford International Airport in Winnebago County (Solar Farm 7), and the University of Illinois Solar Farm in Champaign County (Solar Farm 9). We have also researched six solar farms in Indiana: Portage Solar Farm in Porter County, Indiana (Solar Farm 2), IMPA Frankton Solar Farm in Madison County, Indiana (Solar Farm 3), Indy Solar III Farm in Marion County, Indiana (Solar Farm 4), Valparaiso Solar LLC Farm in Porter County, Indiana (Solar Farm 5), Middlebury Solar Farm in Elkhart County, Indiana (Solar Farm 6), and Lincoln Solar Farm in Lake County (Solar Farm 8).

In forming this report, we have researched and visited the existing solar farms in Illinois and Indiana, researched articles and other published studies, and interviewed real estate professionals and Township Assessors, active in the market where solar farms are located, to gain an understanding of market perceptions.

The purpose of the assignment is to determine whether the proximity of the subject facilities (solar farms) resulted in any significant measurable and consistent impact on adjacent property values, given the existing uses and zoning of nearby property at the time of development. The intended use of our opinions and conclusions is to assist the client in addressing local concerns regarding a solar farm's potential impact on surrounding property values, in addition to addressing the required criteria for obtaining approvals for proposed solar energy uses, such as minimizing the impact on adjacent property values. We have not been asked to value any specific property, and we have not done so. The client for the assignment is Cypress Creek Renewables, LLC. The report may be used only for the aforementioned purpose and may not be distributed without the written consent of CohnReznick LLP ("CohnReznick").

The assignment is intended to conform to the Uniform Standards of Professional Appraisal Practice (USPAP), the Code of Professional Ethics and Standards of Professional Appraisal Practice of the Appraisal Institute as well as applicable state appraisal regulations.

Based on the analysis in the accompanying report, and subject to the definitions, assumptions, and limiting conditions expressed in the report, our opinion is as follows below.

CONCLUSIONS

We analyzed 16 adjoining property sales and 72 comparable sales, collectively, for the Rockford Solar Farm, the Grand Ridge Solar Farm, the Portage Solar Farm, the IMPA Frankton Solar Farm, the Indy III Solar Farm, the Valparaiso LLC Solar Farm, and the Middlebury Solar Farm over the past five years. The remaining solar farms did not have data available for analysis. We note that proximity to the solar farms has not deterred sales of nearby agricultural land and residential single family homes.

No empirical evidence evolved that indicated a more favorable real estate impact on the Control Area Sales as compared to the adjoining, Test Area Sales with regard to such market elements as:

1. Range of sale prices
2. Differences in unit sale prices
3. Conditions of sale
4. Overall marketability

We have also reviewed published methodology for measuring impact on property values as well as published studies that specifically analyzed the impact of solar farms on nearby property values. We have also interviewed market participants, including Township Assessors, to give us additional insight as to how the market evaluates farm land and single family homes with views of the solar farm. These studies found little to no measurable and consistent difference in value between the Test Area Sales and the Control Area Sales attributed to the proximity to solar farms and are generally considered a compatible use. Considering all of this information, we can conclude that since the Adjoining Property Sales (Test Area Sales) for the existing solar farms analyzed were not adversely affected by their proximity to solar farms, that properties surrounding other solar farms operating in compliance with all regulatory standards will similarly not be adversely affected, in either the short or long term periods.

If you have any questions or comments, please contact the undersigned. Thank you for the opportunity to be of service.

Very truly yours,

CohnReznick, LLP

Patricia L. McGarr, MAI, CRE, FRICS
National Director - Valuation Advisory Services
Certified General Real Estate Appraiser
Illinois License No. #553.000621
Expires 9/30/2019
Indiana License No. #CG49600131
Expires 6/30/2018

Martin D. Broerman, MAI
Senior Manager
Certified General Real Estate Appraiser
Illinois License No. #553.002252
Expires 9/30/2019
Indiana License No. #CG41400050
Expires 6/30/2018

Andrew R. Lines, MAI
Principal
Certified General Real Estate Appraiser
Illinois License No. #553.001841
Expires 9/30/2019
Indiana License No. #CG41500037
Expires 6/30/2018

Sonia K. Singh
Manager

TABLE OF CONTENTS

SCOPE OF WORK

CLIENT

Cypress Creek Renewables, LLC

INTENDED USERS

Cypress Creek Renewables; other intended users may include the client's legal and accounting site development professionals.

INTENDED USE

The intended use of our opinions and conclusions is to assist the client in addressing local concerns regarding a solar farm's potential impact on surrounding property values, in addition to addressing the required criteria for obtaining approvals for proposed solar energy uses, such as minimizing the impact on adjacent property values. The report may be used only for the aforementioned purpose and may not be distributed without the written consent of CohnReznick LLP ("CohnReznick").

PURPOSE

The purpose of this report is to address local concerns regarding a solar farm use having a perceived impact on surrounding property values, and provide a consulting report that can be submitted to municipal planning departments for the purposes of addressing the required criteria for obtaining approvals for proposed solar energy sites.

EFFECTIVE DATE

March 1, 2018

DATE OF REPORT

March 20, 2018

PRIOR SERVICES

USPAP requires appraisers to disclose to the client any services they have provided in connection with the subject property in the prior three years, including valuation, consulting, property management, brokerage, or any other services.

This report is a compilation of the Solar Farms which we have studied over the past year, and is not evaluating a specific subject site. In this instance, there is no "subject property" to disclose.

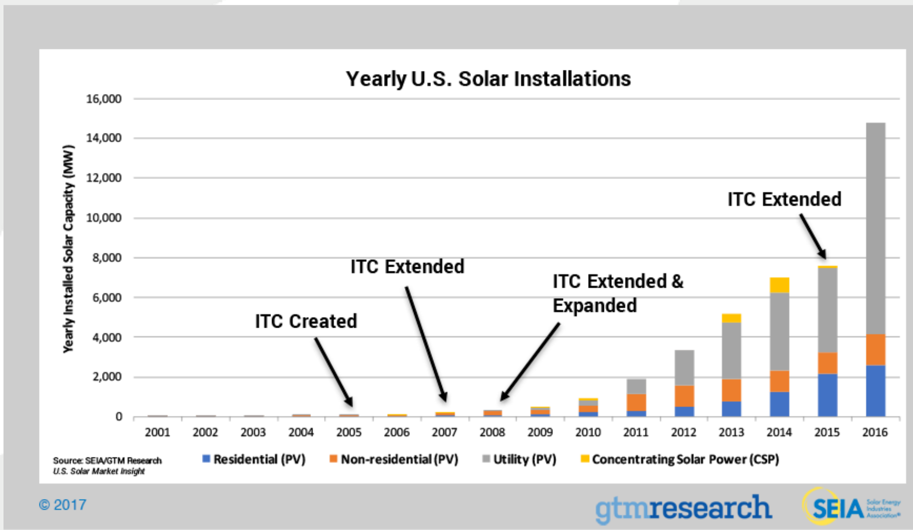
INSPECTION

Patricia L. McGarr and Martin D. Broerman have performed an inspection of the exterior of the properties that are the subject of this impact study on various dates in October 2017. The inspections were conducted via public rights of way.

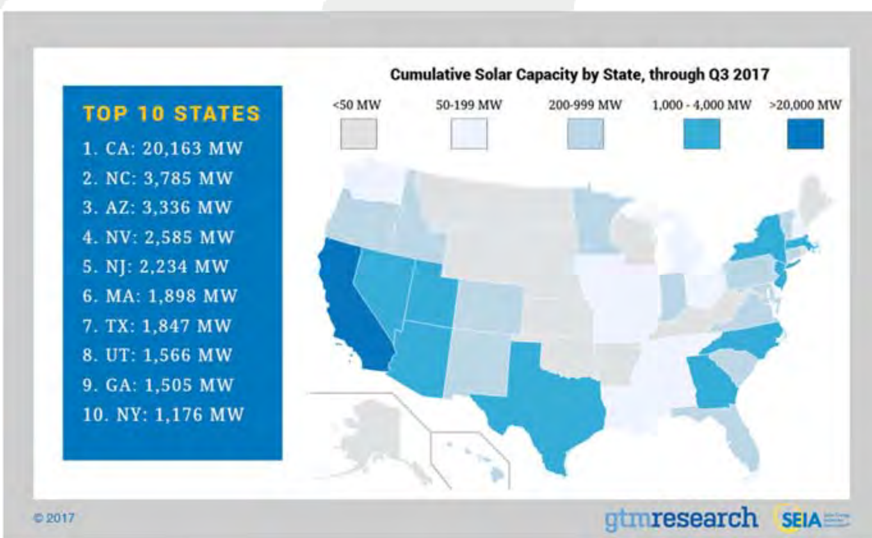
Patricia L. McGarr, Andrew R. Lines, Martin D. Broerman and Sonia K. Singh have viewed the exterior of all comparable data referenced in this report in person, via photographs, or aerial imagery.

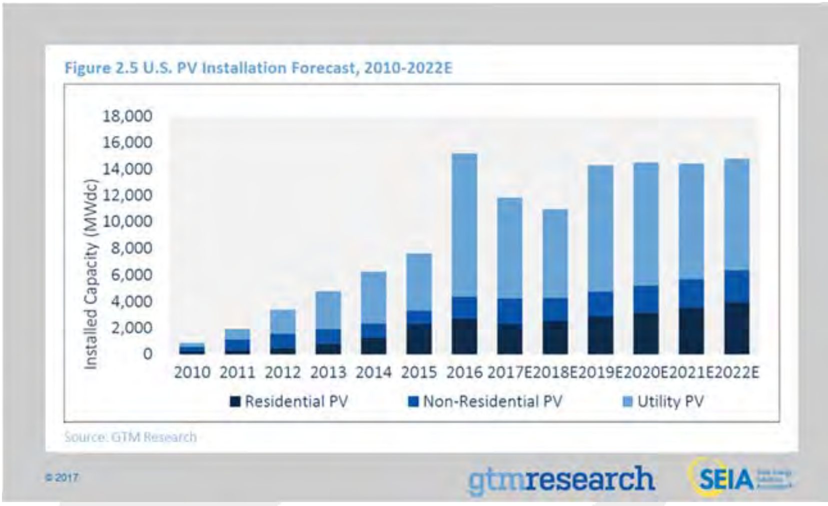
OVERVIEW OF SOLAR DEVELOPMENT

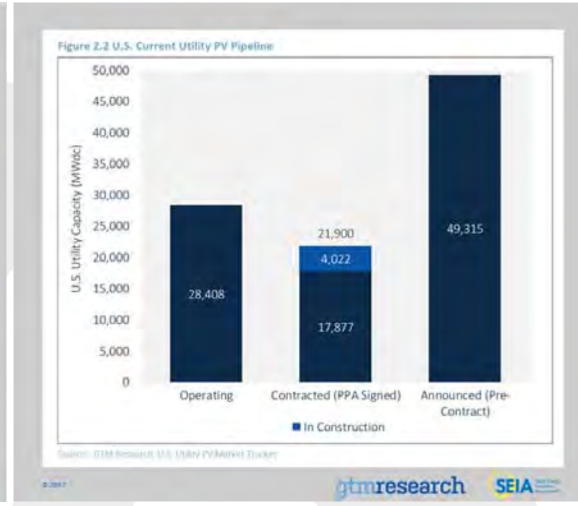
Photovoltaic (PV) cell installations, commonly known as solar cells, increased almost exponentially over the past ten years in the United States as technology and the economic incentives (Solar Investment Tax Credits or ITC) made the installation of solar farms economically reasonable. Majority of these solar farm installations come from larger-scale solar farm developments for utility purposes. The charts below portray the increases of the solar installations in the US as a whole on an annual basis, courtesy of Solar Energy Industries Association (SEIA) and GTM Research.



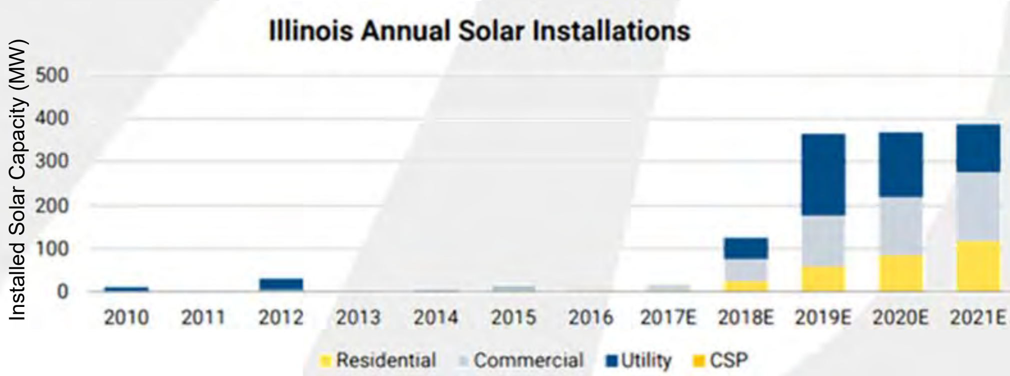
Additionally, nearly 250,000 Americans work in the solar industry. The cost to install solar panels has dropped nationally by 70% since 2010, which has led to the increase in installations. The map below portrays solar capacity by state.



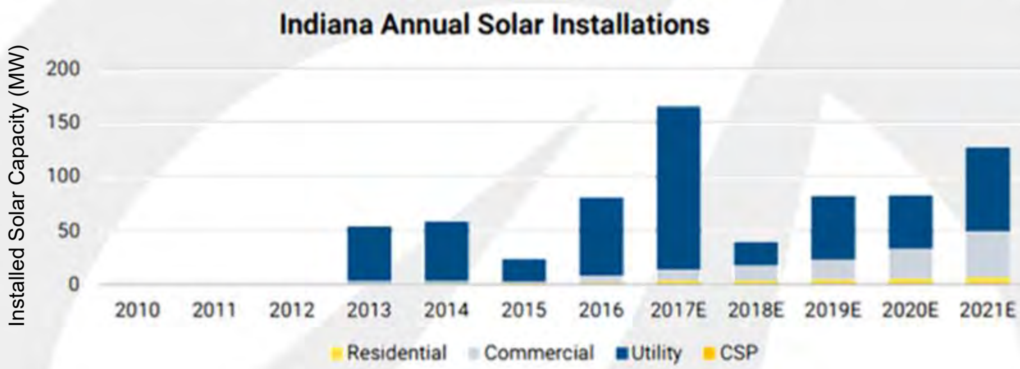




Illinois has recently picked up investment in solar installations. According to the SEIA, to date there was $227.54 million invested in solar, however, only $13.49 million has been invested in 2016. Additionally, to date only 81.52 MW of solar panels are installed, and only 1.7 MW were installed in 2016. Illinois was ranked 33rd in the nation by the SEIA in 2017. Although, this state is relatively behind in solar production, they ranked 17th in solar jobs in 2016.



The state of Indiana has clearly seen a significant uptick in solar investments. According to the Solar Energy Industries Association (SEIA), $384.70 million has been invested in solar, with $104.44 million being invested in 2016 alone. The increase in solar investments is due to the falling costs of installations. According to the SEIA, solar prices have declined by 55% over the past five years in the state. Currently, solar energy powers 31,000 Indiana homes with 265.64 MW of solar installed. Indiana ranks in the middle of the pack comparatively to other states, at 22nd.



MARKET ANALYSIS OF THE IMPACT ON VALUE FROM SOLAR FARMS

METHODOLOGY

According to Randall Bell, PhD, MAI, author of *Real Estate Damages,* published by the Appraisal Institute in 2016, the paired sales analysis is an effective method of determining if there is a detrimental impact on surrounding properties.

> *"This type of analysis may compare the subject property or similarly impacted properties called* ***Test Areas*** *(at Points B, C, D, E, or F) with unimpaired properties called* ***Control Areas*** *(Point A). A comparison may also be made between the unimpaired value of the subject property before and after the discovery of a detrimental condition. If a legitimate detrimental condition exists, there will likely be a measurable and consistent difference between the two sets of market data; if not, there will likely be no significant difference between the two sets of data. This process involves the study of a group of sales with a detrimental condition, which are then compared to a group of otherwise similar sales without the detrimental condition."*[1]

As an approved method, this technique can be utilized to extract the effect of a single characteristic on value. By definition, paired data analysis is "a quantitative technique used to identify and measure adjustments to the sale prices or rents of comparable properties; to apply this technique, sales or rental data on nearly identical properties is analyzed to isolate a single characteristic's effect on value or rent."[2] The text further describes that this method is theoretically sound when an abundance of market data is available for analysis. It may be impractical for those property types that do not frequently sell, such as commercial properties. *The Appraisal of Real Estate* states that the lack of data can reduce the strength of the analysis, and that "an adjustment derived from a single pair of sales is not necessarily indicative" of the value of the single difference.

We also utilized a Trend Analysis to adjust our comparable Control Sales to a constant valuation date, the date of the Test Area sale. According to the *Dictionary of Real Estate Appraisal, 6th edition,* a Trend Analysis is defined as:

> *"A quantitative technique used to identify and measure trends in the sale prices of comparable properties; useful when sales data on highly comparable properties is lacking but a broad database on properties with less similar characteristics is available. Market sensitivity is investigated by testing various factors that influence sale prices."*

We utilized a Trend Analysis to adjust the Control Sales for market conditions, as this is a variable that affects all properties similarly and can be adjusted for. Given the reduced amount of sale data and sales with highly similar characteristics to the Test Area sales, we concluded that adjusting only for market conditions is reasonable as this is explainable by a linear regression analysis, a form of Trend Analysis. This involved plotting our Control Sales unit sale prices against their sale dates and plotting a "Line of Best Fit" to explain market

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[1] *Bell, Randall, PhD, MAI. Real Estate Damages. Third ed. Chicago, IL: Appraisal Institute, 2016.*
[2] *The Appraisal of Real Estate 14th Edition. Chicago, IL: Appraisal Institute, 2013.*

condition trends. We extracted a monthly appreciation rate for each set of Control Sales and applied that to each respective grouping to normalize the sales to a common valuation date.

PUBLISHED STUDIES

We have also considered various studies that consider the impact of solar farms on surrounding property values. The studies range from survey-based formal research to less formal analyses.

The studies show that over the past decade, the solar industry has experienced unprecedented growth. Among the factors contributing to its growth were government incentives, significant capacity additions from existing and new entrants and continual innovation. The incentives made the solar photovoltaic (PV) industry economically attractive for many consumers and as a result set the conditions for the boom. A significant amount of farmland trades have been to solar developers, transaction prices for these deals were reported to be between 30 to 50 percent above normal agricultural land prices in 2016. Clean Energy Trends, a publication developed by Clean Edge, reported in 2013 that investments in new capacity of solar farms increased from approximately $3 billion USD in 2000 to approximately $91 billion USD in 2013, just short of the record of $92 billion USD in 2011. Solar PV installations increased from 31 Gigawatts (GW) in 2012 to a record of approximately 37 GW in 2013. As a result, annual solar PV installations exceed annual wind installations for the first time. Before 2011, annual wind installations were double annual solar PV installations.

Solar farms offer a wide array of economic and environmental benefits to surrounding properties. Unlike other energy sources, solar energy does not produce emissions that may cause negative health effects or environmental damage. Solar farms produce a lower electromagnetic field exposure than most household appliances, such as TV and refrigerators, and studies have confirmed there are no health issues related to solar farms.[3] The Solar Foundation measured that the solar industry employed 22 percent more workers in the period from 2013 to 2015. Solar farm construction in rural areas has also dramatically increased the tax value of the land on which they are built, which has provided a financial boost to some counties. According to Duke University's Center on Globalization, Governance, and Competitiveness ("DUCGCC"), study of solar projects in North Carolina indicated despite the 80% tax abatement, the taxable value of a parcel with a solar farm is significantly larger than the taxable value of that same land under agricultural zoning.

Beyond creating jobs, solar farms are also benefiting the overall long-term agricultural health of the community. As explained by ReThink Energy, a conservation foundation, a typical solar farm has more than two-thirds of the field left open and uncovered by solar panels. This unused land, and also all the land beneath the solar panels, will be left to repair naturally. In the long run this is a better use of land since the soil is allowed to recuperate instead of being ploughed and fertilized year in and year out.

A solar farm can greatly increase the value of land, offering some financial security for the property owner over 20 to 25 years. Once solar panel racking systems are removed, the land can revert to its original use.[4]

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[3] *"Electromagnetic Field and Public Health." Media Centre (2013): 1-4. World Health Organization.*
[4] *NC State Extension. (May 2016). Landowner Solar Leasing: Contract Terms Explained. Retrieved from: https://content.ces.ncsu.edu/landowner-solar-leasing-contract-terms-explained*

Studies have also noted that the installation of utility-scale solar on a property has no negative impact on its value. According to a report titled “Mapleton Solar Impact Study” from Kirkland Appraisals, LLC, conducted in Murfreesboro, North Carolina in September 2017, the study found that the proposed solar farm had no impact to adjacent vacant residential, agricultural land, or residential homes. The adjoining land for the paired data sales analysis in the report was primarily low density residential and agricultural uses, although there was one case where the solar farm adjoined to two dense subdivisions of homes.

ADJACENT PROPERTY VALUES IMPACT STUDY

We identified nine solar farms to study with comparable sales where generally the only difference was the attribute under study: proximity to a solar farm.

Ownership and sales history for each adjoining property to an existing solar farm through the effective date of this report is maintained within our workfile. Adjoining properties with no sales data or that sold prior to the development of the solar farm were excluded from further analysis. Adjoining properties that sold during construction were not considered for a paired sales analysis because the impact of being proximate to the solar farm could not be differentiated from the impact of the construction. Adjoining properties that sold in a non-arm's length transaction (such as a transaction between related parties, bank-owned transaction, or between adjacent owners) were excluded from analysis as these are not considered to be reflective of market price levels. The adjoining properties that remained after exclusions were considered for a paired sale analysis.

The difference in price is considered to be the impact of the proximity to the solar farm. Two types of paired sales analyses were considered based on the availability of data:

- Comparing sales of adjoining properties prior to the announcement of the solar farm to sales of adjoining properties after the completion of the solar farm.
- Comparing sales of adjoining properties after the completion of the solar farm to sales of comparable properties that are proximate to solar farms, but not adjoining to them.

We have considered only one type of paired sales analysis, which was comparing sales of properties proximate to the solar farm (Control Area) to the sales of adjoining properties after the completion of the solar farm project (Test Area). We were unable to compare any sales of adjoining properties that occurred prior to the announcement of the solar farm with the sales of the adjoining properties after the completion of the solar farm project as there were no adjoining properties that sold prior to the announcement of the solar farm, within a reasonable period of time.

We have found Control Area sales data through the Northern Illinois Multiple Listing Service (MLS), Zillow, Gateway Sales Disclosure Form website, and the Illinois Land Sales Bulletin, and verified these sales through county records, conversations with brokers, and the County Assessor's Office. It is important to note that these Control Area Sales are not adjoining to any solar farm, nor do they have a view of one from the property. Therefore, the announcement nor the completion of the solar farm use could not have impacted the sales price of these properties.

To make direct comparisons, the sale price of the Control Area sales will need to be adjusted for market conditions to a common date. In this analysis, the common date is the date of the Adjoining Property Sale after the completion of the solar farm. After adjustment, any measurable difference between the sale prices would be indicative of a possible price impact of the solar farm, if any.

Presented on the following pages is a summary of the analyses completed for each of the existing solar farms studied. Detail of these analyses is retained within our workfile.

SOLAR FARM 1: GRAND RIDGE SOLAR FARM, STREATOR, IL

Location: Grand Ridge Solar Farm in LaSalle County, IL

Coordinates: Latitude 41.143421, Longitude -88.758340

PIN: 34-22-100-000, 34-22-101-000

Total Project Size: 160 AC

Date Project Announced: December 31, 2010

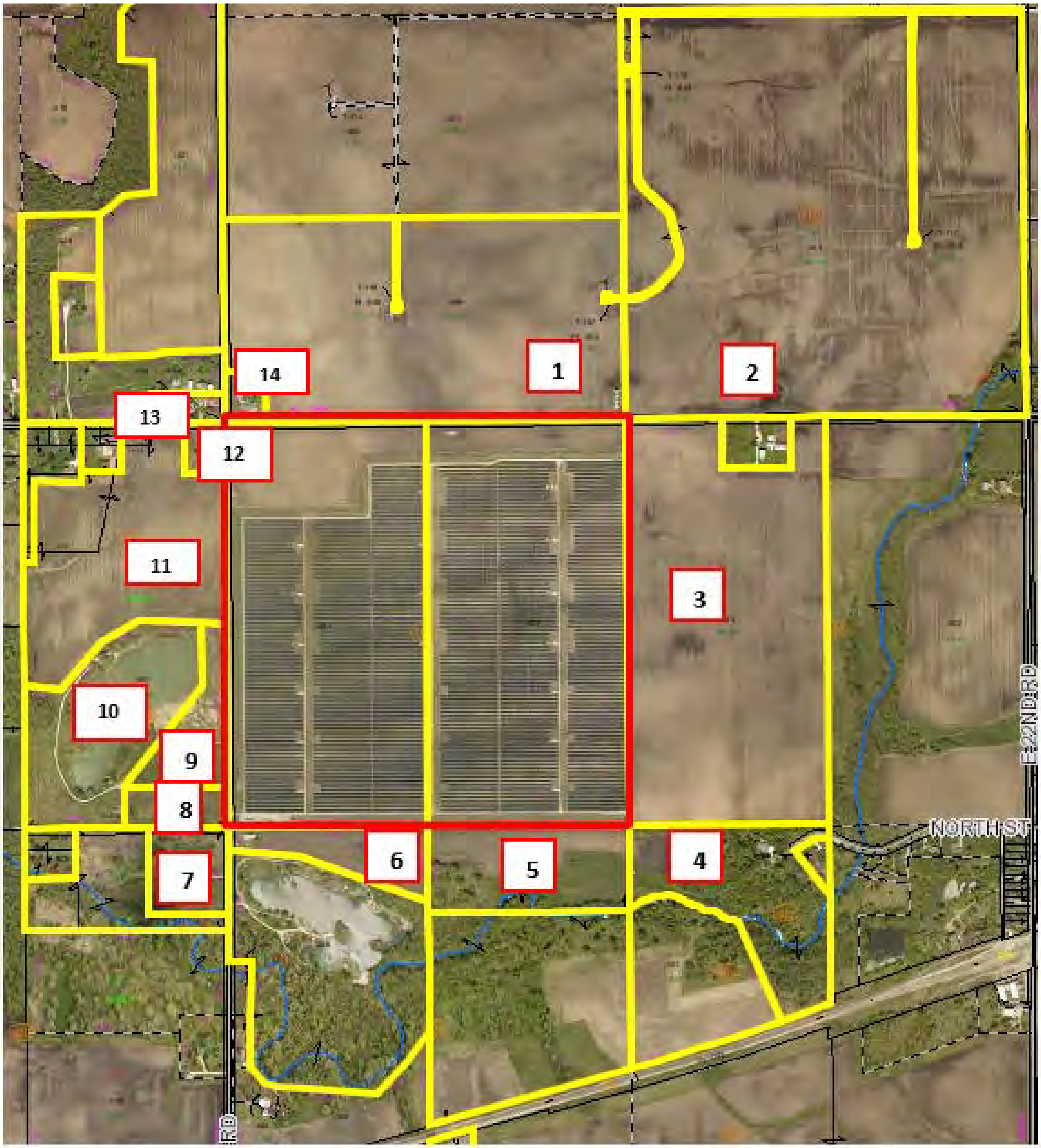
Date Project Completed: July 2012

Project Size: 11.90 AC

Output: 23 MW DC (20 MW AC)

This solar farm is located at the southeast corner at the intersection of 21st and 15th roads. The solar farm was developed by Invenergy and is considered to be one of the largest renewable energy centers in the world. It includes a 210 MW wind farm, 20 MW AC project solar and 1.5 MW advanced-energy storage project all in one location. The solar facility consists of twenty individual 1 MW solar inverters and over 155,000 photovoltaic modules supplied by General Electric. The solar farm has vacant agricultural land to the north and east, and natural vegetation to the east and south. The solar plant is located adjacent to Invenergy's wind farm.

Real Estate Tax Info: Prior to development of the solar farm, during the period between 2009 and 2011, this 160 acre farm paid real estate taxes of about $1,500 per 80 acre parcel ($3,000 per year in total). In the 5 years since the solar farm has been operating, the real estate taxes have increased to about $1,600 per acre ($255,000 per year in total). The map on the following page displays the parcels within the solar farm is located (outlined in red). Properties adjoining this parcel are numbered for subsequent analysis.



Solar Farm 1 Adjoining Properties

Adjoining Property 12 (Test Area) was considered for a paired sales analysis, and we analyzed this property as a single-family home use. We analyzed five Control Area single family home sales on similar lot sizes that sold within a reasonable time frame from Adjoining Property 12's sale date, and adjusted the Control Area sales for market conditions using regression analysis to identify the appropriate monthly market conditions adjustment. The result of our analysis for Solar Farm 1 is presented below.

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$74.35
Adjoining Property 12 (Test Area)	Yes: Solar Farm was completed by the sale date	$79.90
Difference		7.46%

Noting the relatively small price differential ***slightly over 5%***, it does not appear that Solar Farm 1 impacted the sales price of Adjoining Property 12 in either direction (positive or negative).

SOLAR FARM 2: PORTAGE SOLAR FARM, PORTAGE TOWNSHIP, IN

Location: Portage Solar Farm in Porter County, IN

Coordinates: Latitude 41.333263, Longitude -87.093015

PIN: 64-06-19-176-001.000-015

Total Project Size: 56 AC

Recorded Owner: PLH Inc

Date Project Announced: February 2012

Date Project Completed: September 2012

Project Size: 1.5 MW

Output: 1.5 MW DC (1.96 MW AC)

This solar farm is located on the south side of Robbins Road, located just outside the City of Portage. The solar farm was developed by Ecos Energy, who is a subsidiary of Allco Renewable Energy Limited. This solar farm is ground mounted has the capacity for 1.5 Megawatts (MW) of power, which is enough to power 300 homes. This solar farm consists of 7,128 solar modules which are of a fixed tilt installation, and contains three inverters. The solar farm is fenced from adjacent properties by a fence that surrounds all of the solar panels. Natural vegetation borders the western and northern sides of the solar farm.

Real Estate Tax Info: The 56 acres of farm land was paying $1,400 per year in taxes. After the solar farm was developed, only 13 acres (23% of the site) was reassessed and the remaining 43 acres continued to be farmed. The total real estate tax bill increased to $16,350 per year after the solar farm was built, including both uses on the site. This indicates that the real estate taxes for the solar farm increased from $25 per acre to $1,175 per acre after the solar farm was developed. The map on the following page displays the parcels within the solar farm is located (outlined in red). Properties adjoining this parcel are numbered for subsequent analysis.

Solar Farm 2 Adjoining Properties

Solar Farm 2 Adjoining Properties

Adjoining Properties 1 and 7 (Test Areas) were each considered for a paired sales analysis. Adjoining Property 1 was analyzed as homestead/small farm land tract since at the time of purchase the site was used as agricultural land. The buyer bought it as vacant land and subsequently built a home on site. Adjoining Property 7 was analyzed as a single-family home use.

For Adjoining Property 1, we analyzed nine Control Area homestead/small farm land tract sales that sold within a reasonable time frame from Adjoining Property 1's sale date. For Adjoining Property 7, we analyzed seven Control Area single family home sales that sold within a reasonable time frame from Adjoining Property 7's sale date. All Control area sales were adjusted for market conditions using regression analysis to identify the appropriate monthly market conditions adjustment.

The result of our analyses for Solar Farm 2 is presented below.

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per Acre
Adjusted Control Area Sales	No: Not adjoining solar farm	$7,674
Adjoining Property 1 (Test Area)	Yes: Solar Farm was completed by the sale date	$8,000
Difference		4.25%

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$84.27
Adjoining Property 7 (Test Area)	Yes: Solar Farm was completed by the sale date	$84.35
Difference		0.10%

Noting the relatively small price differential, with both adjacent sales (Adjoining Property 1 or 7) having higher unit sale prices than the Control Area sales, it does not appear that Solar Farm 2 had any negative impact on adjacent property values.

SOLAR FARM 3: IMPA FRANKTON SOLAR FARM, FRANKTON, IN

Location: IMPA Frankton Solar Farm in Madison County, IN

Coordinates: Latitude 40.125701; Longitude -85.4626.88

PIN: 48-08-06-500-012.001-020

Total Project Size: 13 AC

Recorded Owner: IMPA

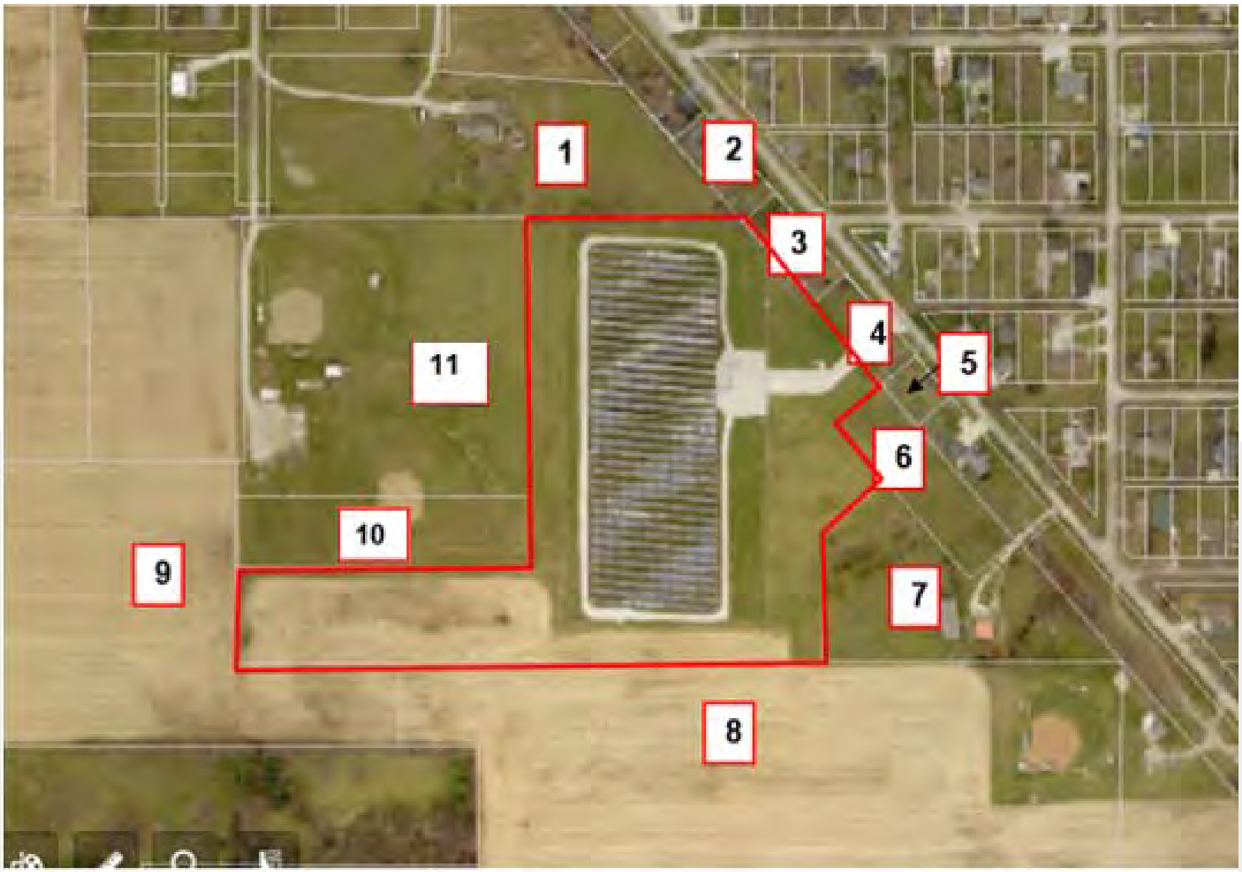
Date Project Announced: November 2013

Date Project Completed: June 2014

Project Size: 1 MW

Output: 1,426 Mwh Annually

This solar farm is located on the west side of South Lafayette Street, located in the Town of Frankton. IMPA Frankton Solar Farm was built in 2014 in joint effort by Inovateus Solar and Indian Municipal Power Agency (IMPA). This solar farm has the capacity for 1 MW and its expected annual output is 1,426 MWh (megawatt hours). The solar farm is separated off from their adjacent properties by a 6' fence that surrounds the entirety of the solar panels. From our inspection of the site we note that the driveway to access the panels slopes downward and allows some views of the site. The map on the following page displays the parcels within the solar farm is located (outlined in red). Properties adjoining this parcel are numbered for subsequent analysis.



Solar Farm 3 Adjoining Properties

Adjoining Properties 2 and 7 (Test Areas) were each considered for a paired sales analysis. Adjoining Property 2 was manufactured single family home use. Adjoining Property 7 was analyzed as a single-family home use.

For Adjoining Property 2, we analyzed six Control Area sales that sold within a reasonable time frame from Adjoining Property 2's sale date. For Adjoining Property 7, we analyzed five Control Area sales that sold within a reasonable time frame from Adjoining Property 7's sale date. All Control area sales were adjusted for market conditions using regression analysis to identify the appropriate monthly market conditions adjustment.

The result of our analyses for Solar Farm 3 is presented below.

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$28.42
Adjoining Property 2 (Test Area)	Yes: Solar Farm was completed by the sale date	$28.58
Difference		0.56%

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$51.47
Adjoining Property 7 (Test Area)	Yes: Solar Farm was completed by the sale date	$52.40
Difference		1.81%

Noting the relatively small price differential, in which both Adjoining Property Sales 2 and 7 sold at a slightly higher unit sale price that the Control Area Sales, it does not appear that Solar Farm 3 had any negative impact on adjoining property sales.

SOLAR FARM 4: DOMINION INDY SOLAR III, INDIANAPOLIS, IN

Location: Dominion Indy Solar III, in Marion County, IN

Coordinates: Latitude 39.3914.16, Longitude -86.153485

PIN: 49-13-13-113-001.000-200

Total Project Size: 134 AC

Recorded Owner: PLH Inc

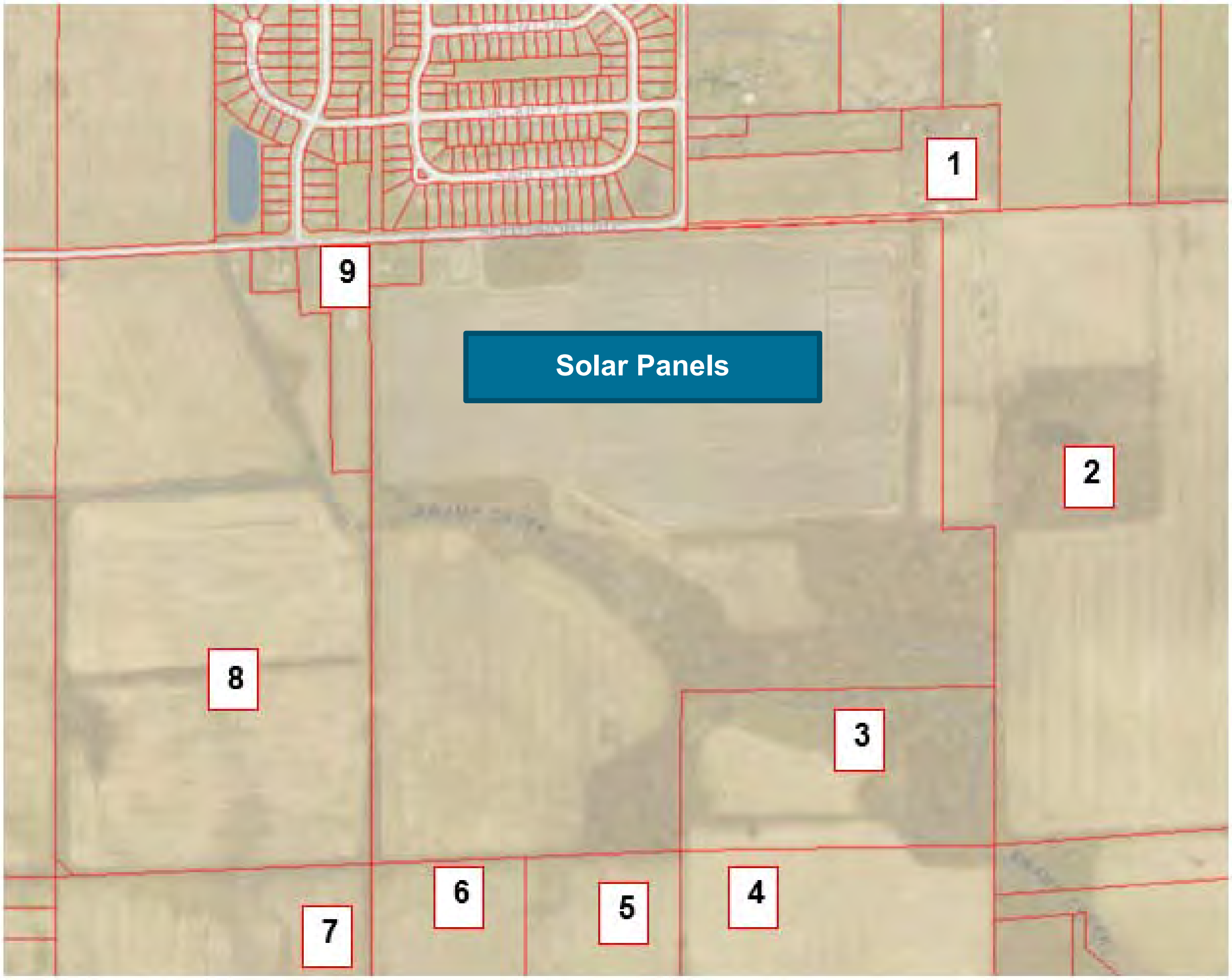
Date Project Announced: August 2012

Date Project Completed: December 2013

Project Size: 11.9 MW

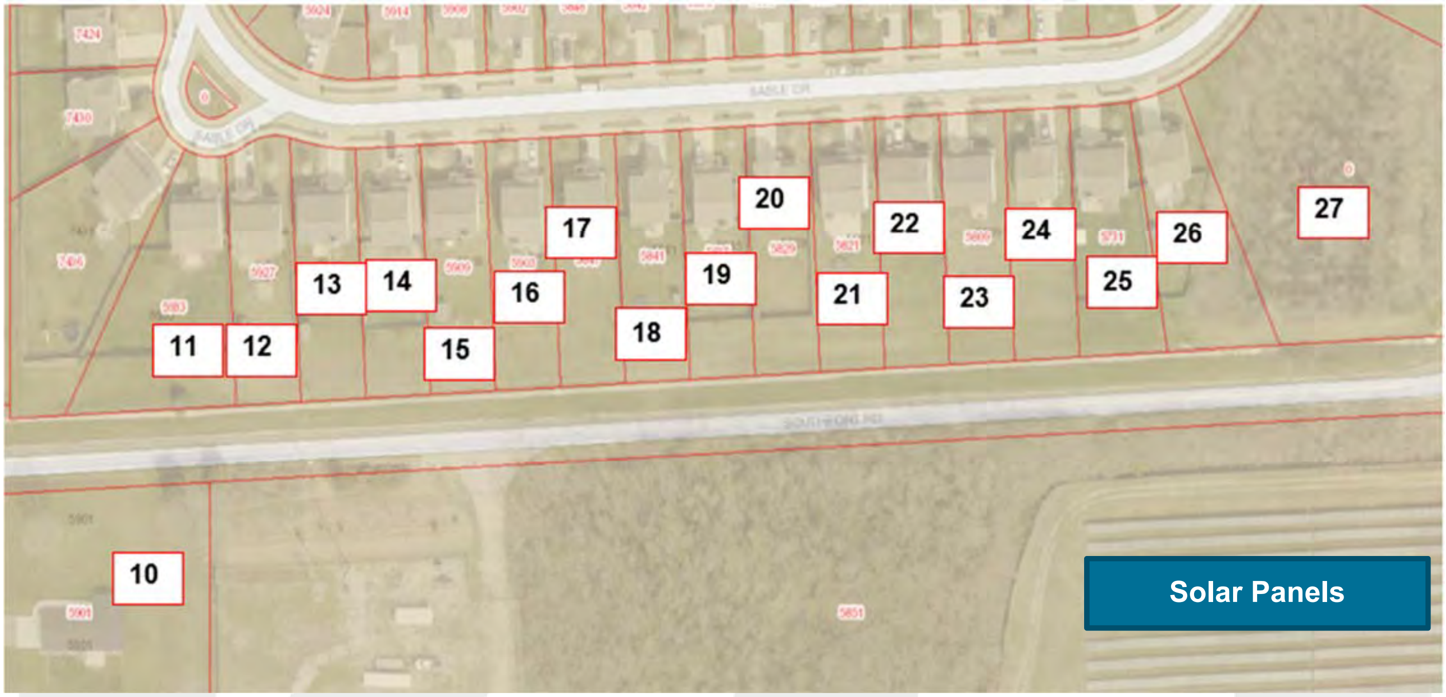
Output: 11.9 MW DC (8.6 MW AC)

This solar farm is located on the southern side of West Southport Road, located approximately eight and a half miles from the heart of Indianapolis. The solar farm was developed by Dominion Renewable Energy. This solar farm is ground mounted has the capacity for 11.9 Megawatts (MW) of power. The panels are mounted in a fixed tilt fashion and there are 12 inverters in this solar farm. The solar farm is lined by a chain link fence that surrounds all of the solar panels. Additionally, there are some natural bushes and trees on all sides of the property; this vegetation has been in place since before development of the solar farm. The maps on the following pages display the parcels within the solar farm is located (outlined in red). Properties adjoining this parcel are numbered for subsequent analysis.



Solar Farm 4 Adjoining Properties

Adjoining homes in the Crossfield Subdivision



Solar Farm 4 Adjoining Properties

Several Adjoining Properties (Test Areas) were considered for a paired sales analysis and were analyzed as single-family home uses. Due to the similarities of the adjoining properties that were included in our paired sales analysis, we will conduct the paired sales analysis in two groupings, based on sale dates. The adjoining properties that were considered for a paired sale analysis are indicated in the table below.

#	Address	Sale Price	Site Size (AC)	Beds	Baths	Year Built	Square Feet	Sale date	Groups	PSF
11	5933 SABLE DR	$ 140,000	0.31	3	1.5	2006	2412	12/9/2015	1	$ 58.04
13	5921 SABLE DR	$ 160,000	0.24	4	1.5	2006	2412	9/6/2017	2	$ 66.33
14	5915 SABLE DR	$ 147,000	0.23	3	2.5	2009	2028	5/10/2017	2	$ 72.49
20	5829 SABLE DR	$ 131,750	0.23	4	2.5	2011	2190	12/9/2015	1	$ 60.16
22	5813 SABLE DR	$ 127,000	0.23	4	1.5	2005	2080	3/4/2015	1	$ 61.06
24	5737 SABLE DR	$ 120,000	0.23	3	2.5	2010	2136	2/3/2014	1	$ 56.18

For Group 1, we analyzed eight Control Area sales that sold within a reasonable time frame from the average sale date of the Group 1 sales. For Group 2, we analyzed seven Control Area sales that sold within a reasonable time frame from the average sale date of the Group 2 sales. All Control area sales were adjusted for market conditions using regression analysis to identify the appropriate monthly market conditions adjustment.

The result of our analyses for Solar Farm 4 is presented below.

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$57.84
Group 1 (Test Area)	Yes: Solar Farm was completed by the sale date	$59.81
Difference		3.40%

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$68.67
Group 2 (Test Area)	Yes: Solar Farm was completed by the sale date	$69.14
Difference		0.69%

Noting the relatively small price differential, in which the Test Area Sales were slightly higher than the average for the Control Areas, it does not appear that Solar Farm 4 had any negative impact on adjoining property values.

SOLAR FARM 5: VALPARAISO SOLAR LLC, VAPARAISO, IN

Location: Valparaiso Solar LLC, in Porter County, IN

Coordinates: Latitude 41.301180, Longitude –87.094055

PIN: 64-09-07-152-001.000-019, 64-09-07-152-002.000-019

Total Project Size: 27.9 AC

Recorded Owner: PLH Inc

Date Project Announced: March 2012

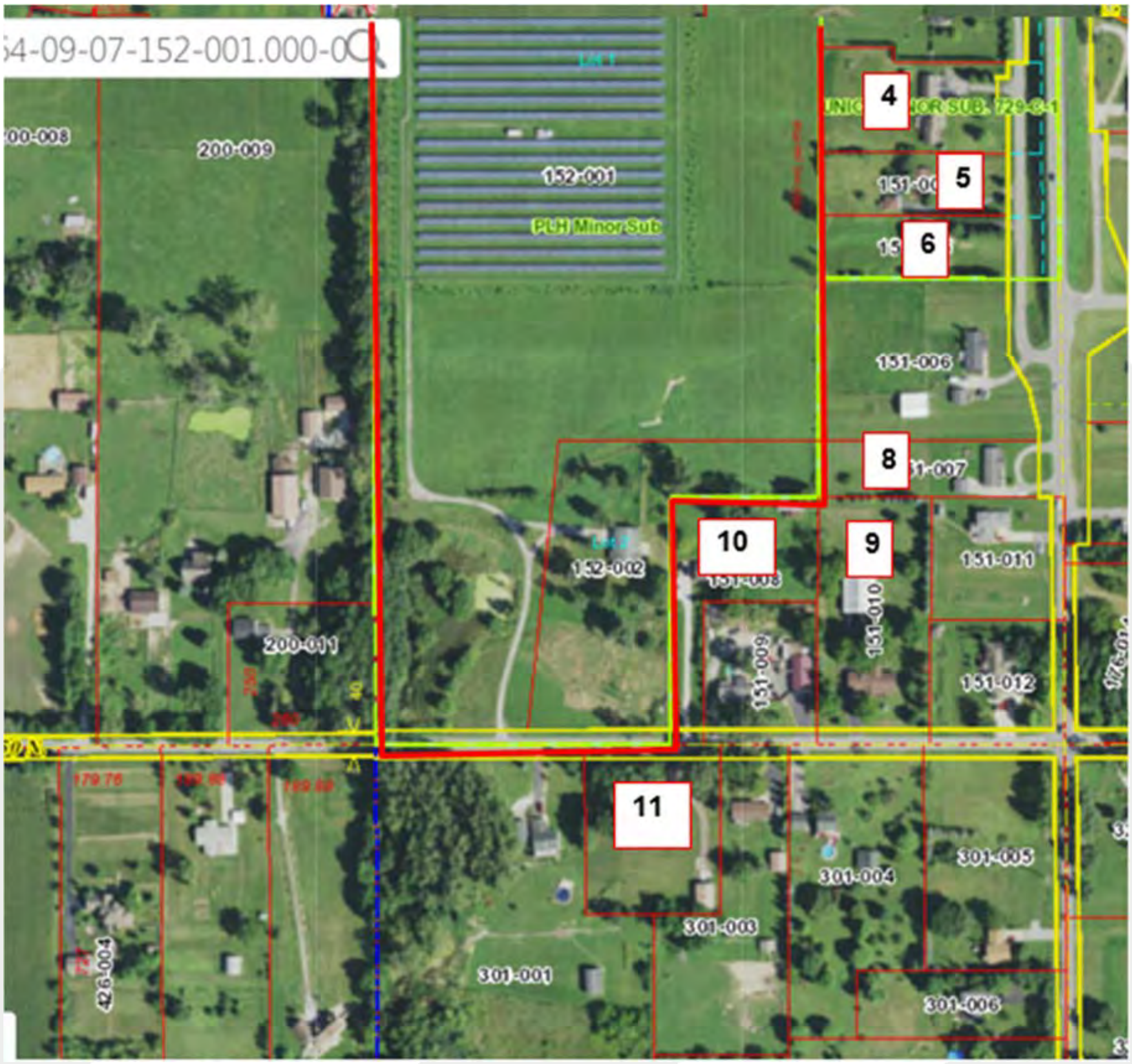
Date Project Completed: December 20, 2012

Project Size: 1.3 MW

Output: 1.3 MW DC (1 MW AC)

This solar farm is located on the southern side of Indiana Route 130 (Railroad Ave), located approximately 35 miles southwest of the Chicago Loop. The solar farm was developed by Sustainable Power Group LLC and has ground mounted capacity for 1.3 Megawatts (MW) of power. The panels are mounted in a fixed tilt fashion and there are 2 inverters in this solar farm. The solar farm is lined by a chain link fence that surrounds all of the solar panels. Additionally, there are some natural bushes and trees to the north and west of the solar panels; this vegetation has been in place since before development of the solar farm. Other small trees were planted spaced out around the perimeter of the solar farm after development. From our inspection, the solar panels cannot be seen from Indiana State Route 130 from the north, nor on N 475 W Road to the east as this is a raised roadway. The adjacent properties to the east of the solar panels have full view of the panels from their backyards. The maps on the following pages display the parcels within the solar farm is located (outlined in red). Properties adjoining this parcel are numbered for subsequent analysis.

Solar Farm 5 Adjoining Properties



Solar Farm 5 Adjoining Properties

Adjoining Properties 10 and 14 (Test Areas) were each considered for a paired sales analysis. Both were analyzed as single-family home uses.

For Adjoining Property 10, we analyzed five Control Area sales that sold within a reasonable time frame from Adjoining Property 10's sale date. For Adjoining Property 14, we analyzed five Control Area sales that sold within a reasonable time frame from Adjoining Property 14's sale date. All Control area sales were adjusted for market conditions using regression analysis to identify the appropriate monthly market conditions adjustment.

The result of our analyses for Solar Farm 5 is presented below.

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$79.95
Adjoining Property 10 (Test Area)	Yes: Solar Farm was completed by the sale date	$82.42
Difference		3.09%

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$64.07
Adjoining Property 14 (Test Area)	Yes: Solar Farm was completed by the sale date	$62.11
Difference		-3.06%

Noting the relatively small price differential, with one matched pair reflecting a unit sale price of 3% higher for the adjacent sale and the other matched pair reflecting a 3% lower unit sale price, it does not appear that Solar Farm 5 negatively impacted the sales price of Adjoining Property 10 or 14 in any consistent way.

SOLAR FARM 6: MIDDLEBURY SOLAR FARM, MIDDLEBURY, IN

Location: Middlebury Solar Farm, in Elkhart County, IN

Coordinates: Latitude 41.415202, Longitude –85.411819

PIN: 20-04-35-379-014.000-032

Total Project Size: 33.86 AC

Recorded Owner: PLH Inc/Allco

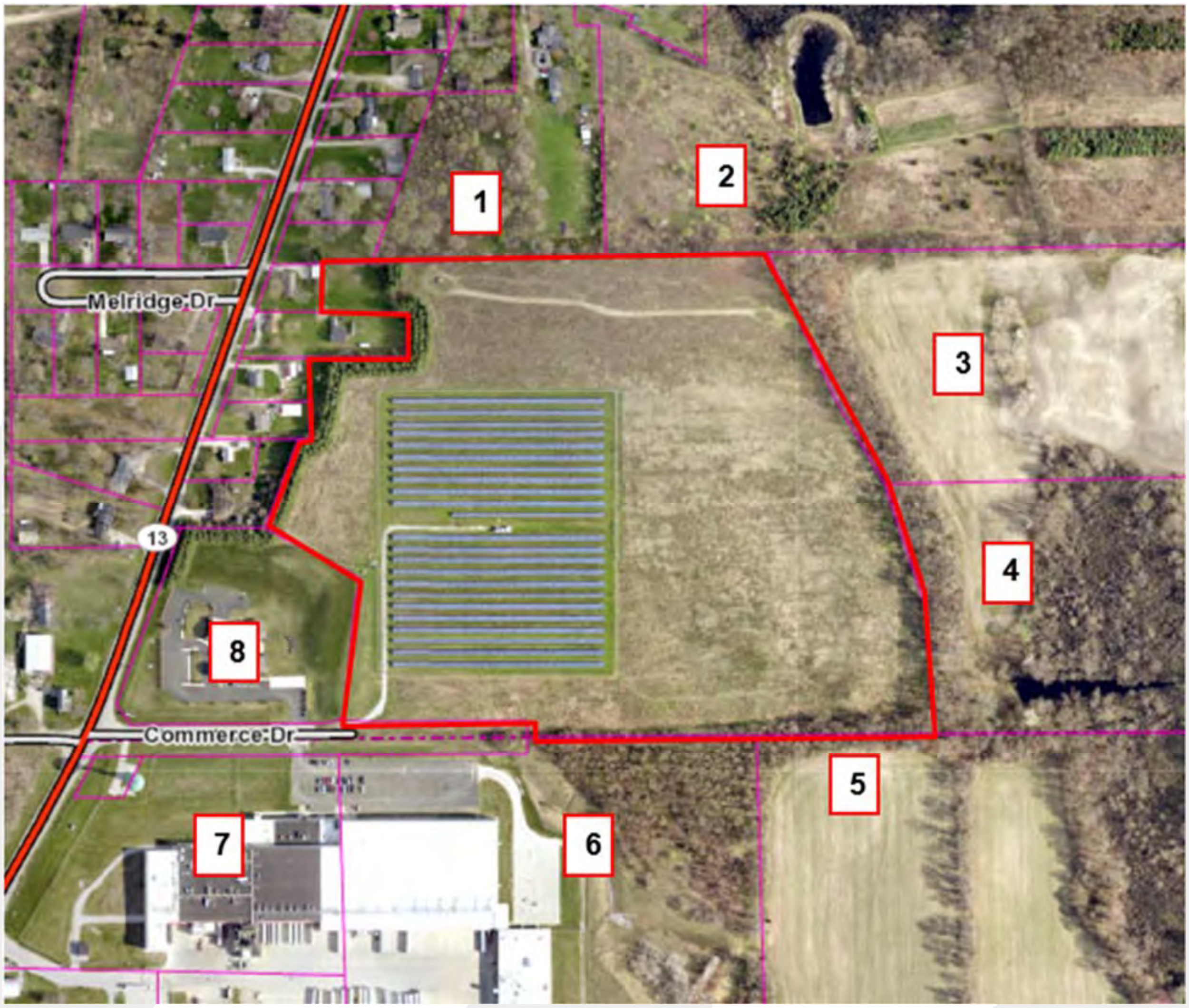
Date Project Announced: December 2011

Date Project Completed: December 2012

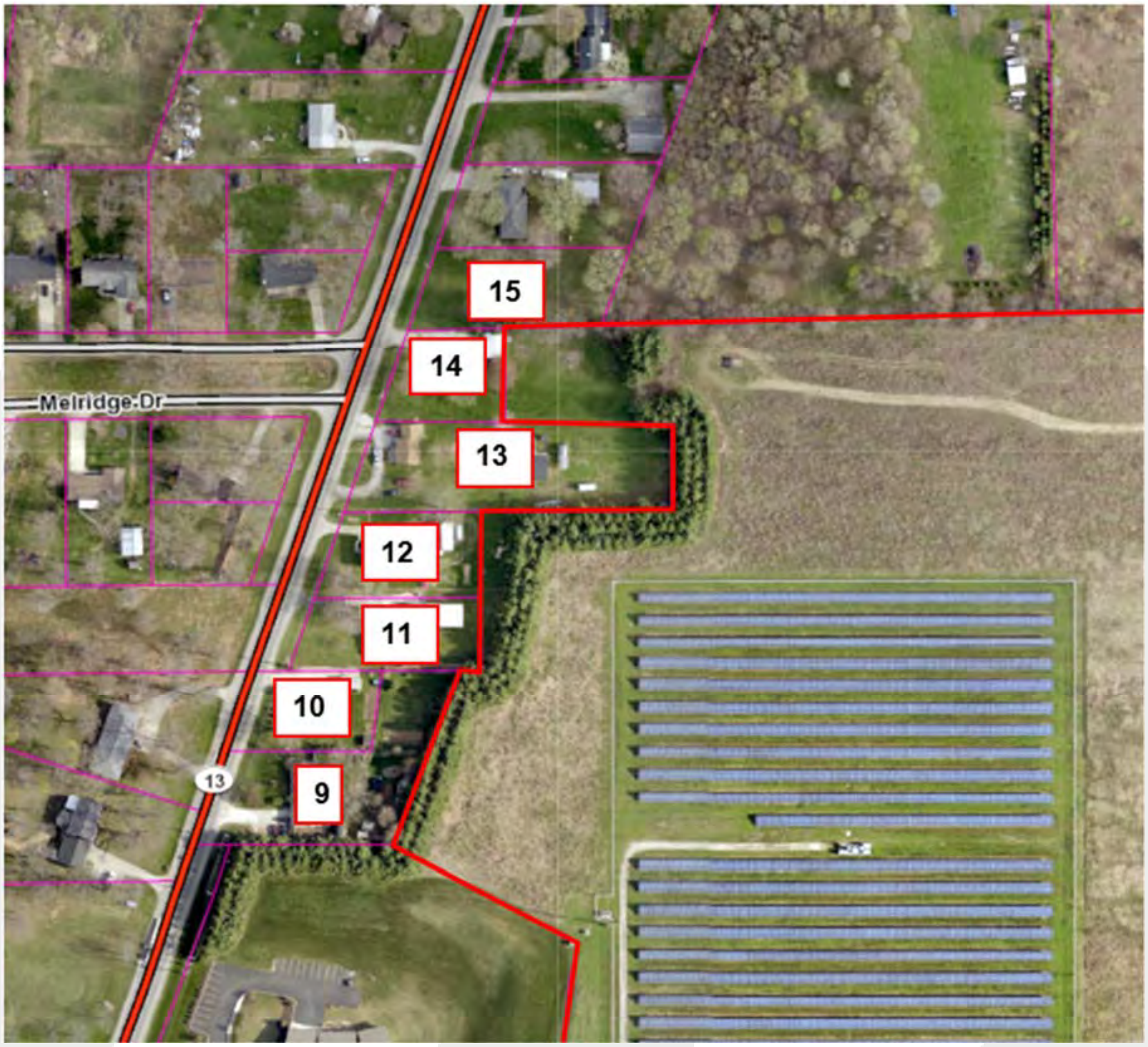
Project Size: 1.5 MW

Output: 1.96 MW DC (1.5 MW AC)

This solar farm is located on the eastern side of Indiana State Route 12, located approximately one and a half miles northeast of downtown Middlebury. The solar farm was developed by Ecos Energy LLC, a subsidiary of Allco Renewable Energy Limited. This solar farm is ground mounted and has the capacity for 1.96 Megawatts (MW) of power. The panels are mounted in a fixed tilt fashion and there are 3 inverters in this solar farm. The solar farm is lined by a chain link fence that surrounds all of the solar panels. Additionally, there are some natural bushes and trees on all sides of the solar panels; this vegetation has been in place since before development of the solar farm. From our inspection, the panels are only visible by the Meijer distribution facility to the south, the medical clinic access road to the southwest, and a slight view is present from the medical clinic's parking lot looking northeast. The medical clinic was developed prior to the solar farm and developed a landscaped berm behind the improvements. This berm was in place prior to development of the solar farm. The maps on the following pages display the parcels within the solar farm is located (outlined in red). Properties adjoining this parcel are numbered for subsequent analysis.



Solar Farm 6 Adjoining Properties



Solar Farm 6 Adjoining Properties

Adjoining Property 10 (Test Area) was considered for a paired sales analysis, and we analyzed this property as a single-family home use. We analyzed eight Control Area single family home sales on similar lot sizes that sold within a reasonable time frame from Adjoining Property 10's sale date, and adjusted the Control Area sales for market conditions using regression analysis to identify the appropriate monthly market conditions adjustment. The result of our analysis for Solar Farm 6 is presented below.

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per SF
Adjusted Control Area Sales	No: Not adjoining solar farm	$104.26
Adjoining Property 10 (Test Area)	Yes: Solar Farm was completed by the sale date	$132.79
Difference		27.36%

The unit sale price for Adjoining Property 10 was significantly higher than the median unadjusted and adjusted unit sale prices for the Control Area Sales. This is primarily due to the smaller size of Adjoining Property 10 and larger site area in comparison to the median statistics of the Control Area Sales.

SOLAR FARM 7: ROCKFORD SOLAR FARM, ROCKFORD, IL

Location: Chicago-Rockford International Airport in Winnebago County, IL

Coordinates: Latitude 42.175278, Longitude -89.08833

PINs: 15-26-151-005, 15-26-176-003, 15-26-300-009

Total Land Size: 182.29 AC

Recorded Owner: Greater Rockford Airport Authority

Total Project Size: 70 AC (Total three phases)

Current Project size: 15 AC (Approximate)

Date Project Announced: March 30, 2011

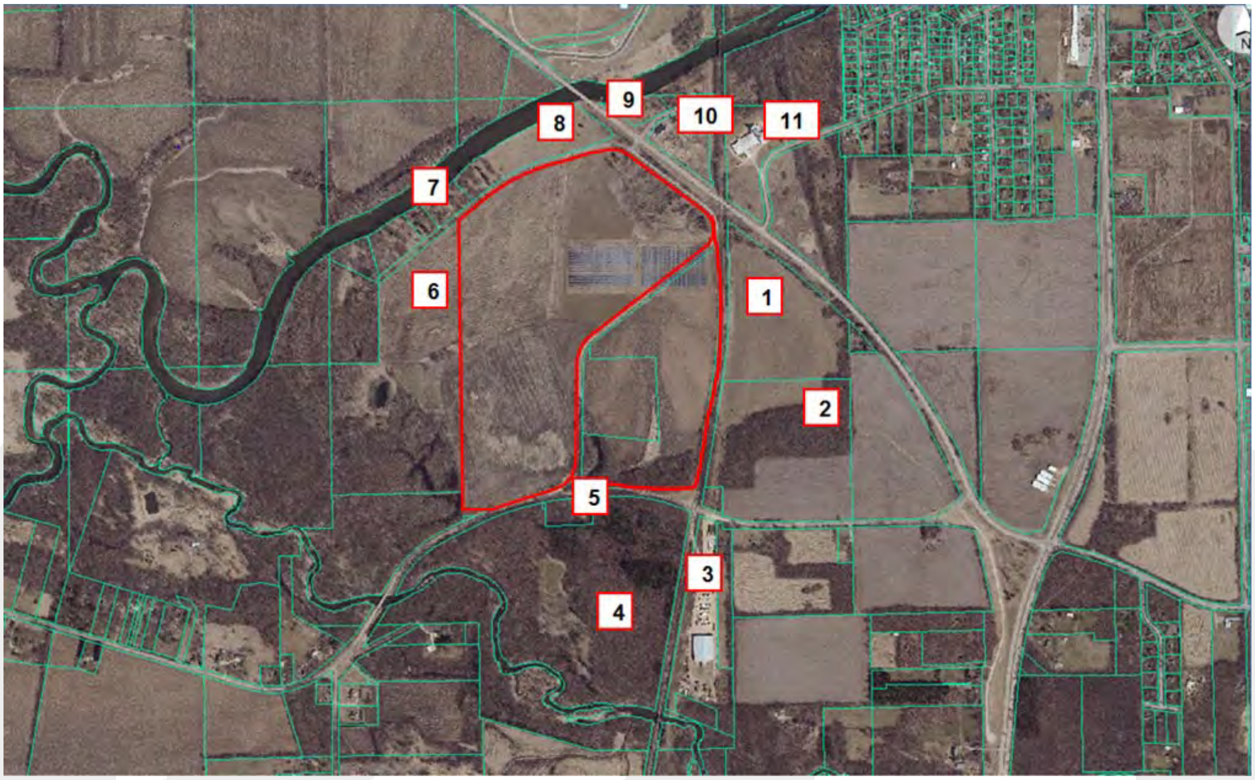
Date Project Completed: October 2012

Current Output: 3.06 MW (Phase I)

Future Output: 62 MW (Total three phases)

This solar farm is located in the City of Rockford, near the banks of Rock River which is about 80 miles northwest of Chicago. The project was initiated as a joint venture effort between Wanxiang American Corporation (Wanxiang) and New Generation Power (NGP) under the name Rockford Solar Partners, LLC. The initial goal of the project was to create hundreds of sustainable, green-collar jobs and provide a lasting economic boost to the state of Illinois, and is the largest airport-based solar photovoltaic (PV) electricity generating facility in the US. In the past, the city of Rockford was predominately a blue-collar capital filled with machine shops and factories. However, due to modernization, many of these workplaces have closed. The city now looks to the renewable energy industry to help stimulate the local economy. The project was also part of a larger, state-wide initiative to increase solar power production and reduce dependence on fossil fuels.

The total cost of Rockford Solar Partner's proposed three-phase, project was approximately $127 million and was financed six months prior to the date it was announced. In March 2010, the solar project received a $4 million USD grant from the Illinois Department of Commerce and Economic Opportunity (DCEO). The first phase of development was completed in October 2012. A railroad track runs along the solar farm to the east, and a series of natural bushes and trees line the panels to the north. There is no proximate natural vegetation to the western and southern areas near the panels; however, there is approximately 1,080 feet between most western solar panel and the western property line. Additionally, there is approximately 2,045 feet between the most southern solar panel and the southern property line. The map on the following page displays the parcels within the solar farm is located (outlined in red). Properties adjoining this parcel are numbered for subsequent analysis.



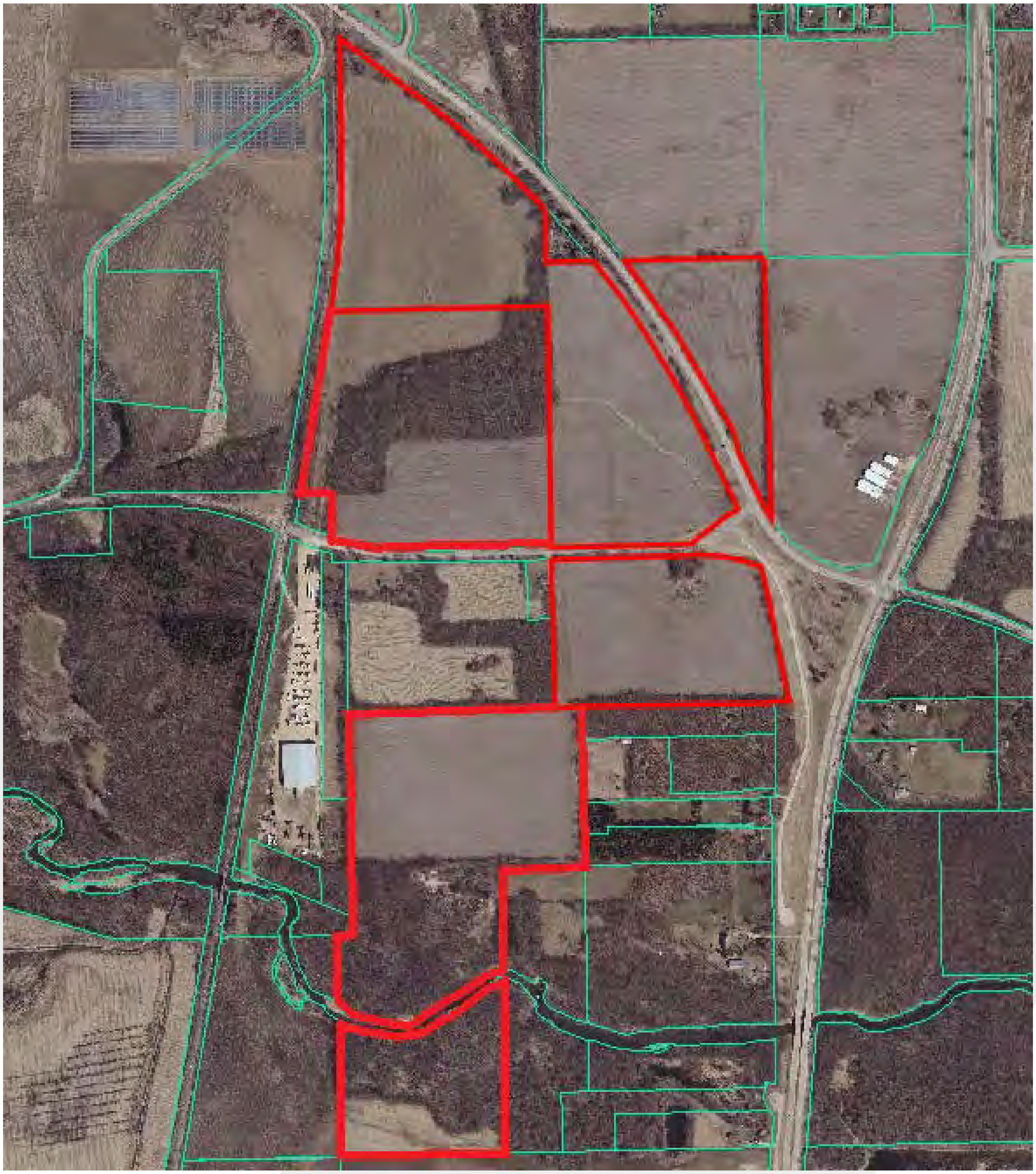
Solar Farm 7 Adjoining Properties

Adjoining Properties 1 and 2 (Test Area) were considered for a paired sales analysis, and we analyzed this property as agricultural land. Adjoining Properties 1 and 2 were sold in 2017, which is a reasonable time after completion of the solar farm. These two parcels sold with a third, contiguous parcel that measures 66.83 acres, for a total size of 214.7 acres, reflecting a unit sale price of $3,942 per acre. Therefore, Adjoining Properties 1 and 2 (Test Area) were considered for a paired sales analysis. Since these properties were sold together, along with a third contiguous parcel, we have considered it as one sale (Test Area Sale). An aerial image of all three of the parcels that sold is presented on the following page, with the parcels outlined in red. Parcel 1 is located within flood zone AE, which has a 1% annual chance of flood hazard, and Parcel 3 is located within flood zone AE and within a regulatory floodway. Parcel 3 also contains freshwaterforested/shrub wetlands on site. The floodplain, floodway and wetlands maps are all presented on the following pages. Additionally, the entire site has a relatively low Productivity Index (PI) of 103. Farm land unit prices are primarily influenced by productivity.

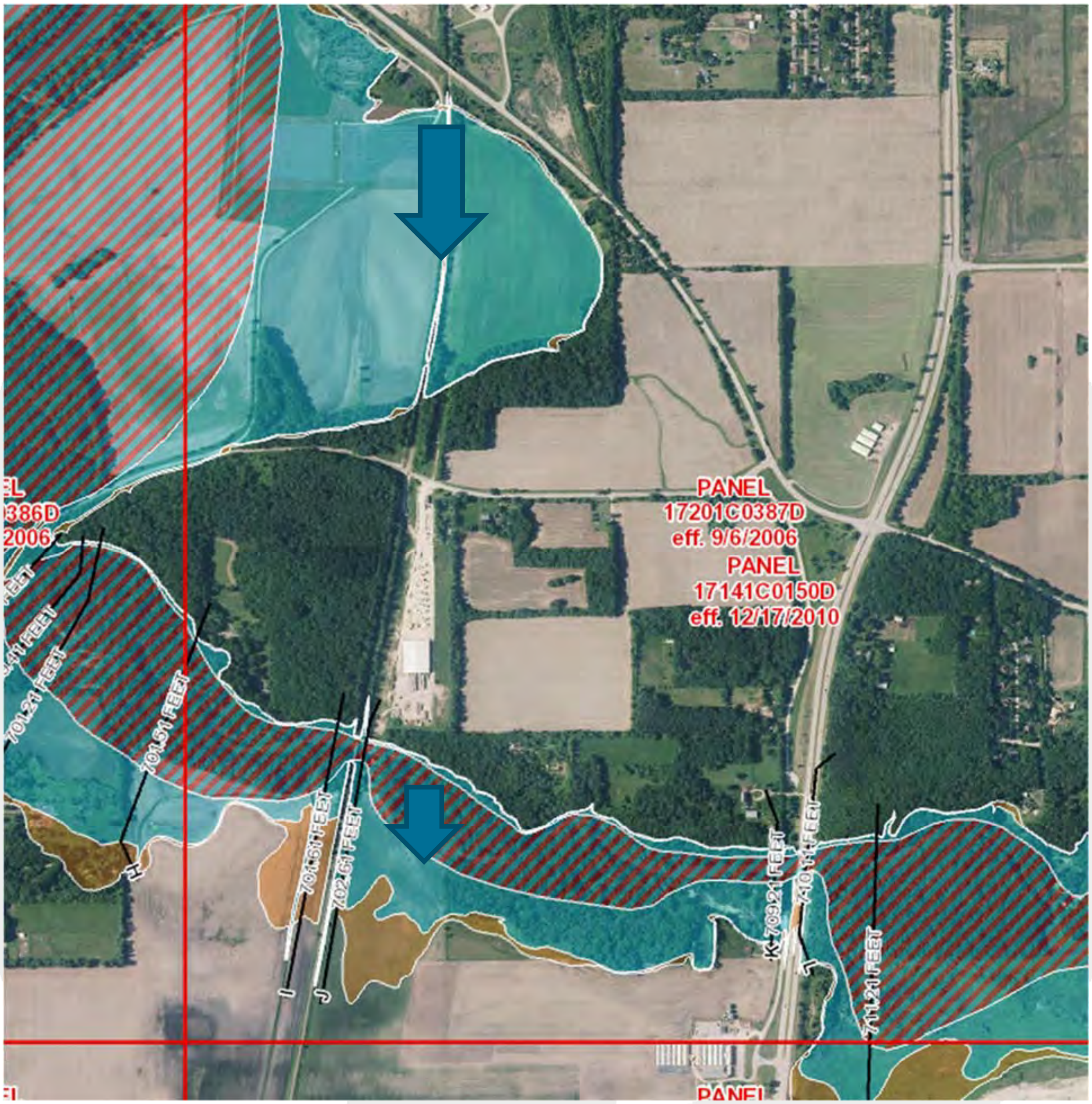
For soils in Illinois, optimum soil PI ranges from 47 to 147. Soil productivity ratings under optimum management for Illinois farmland on this scale are as follows.

Soil Rating	PI Range	Soil Class
Excellent	133-147	Class A
Good	117-132	Class B
Average	100-116	Class C
Fair	Less than 100	

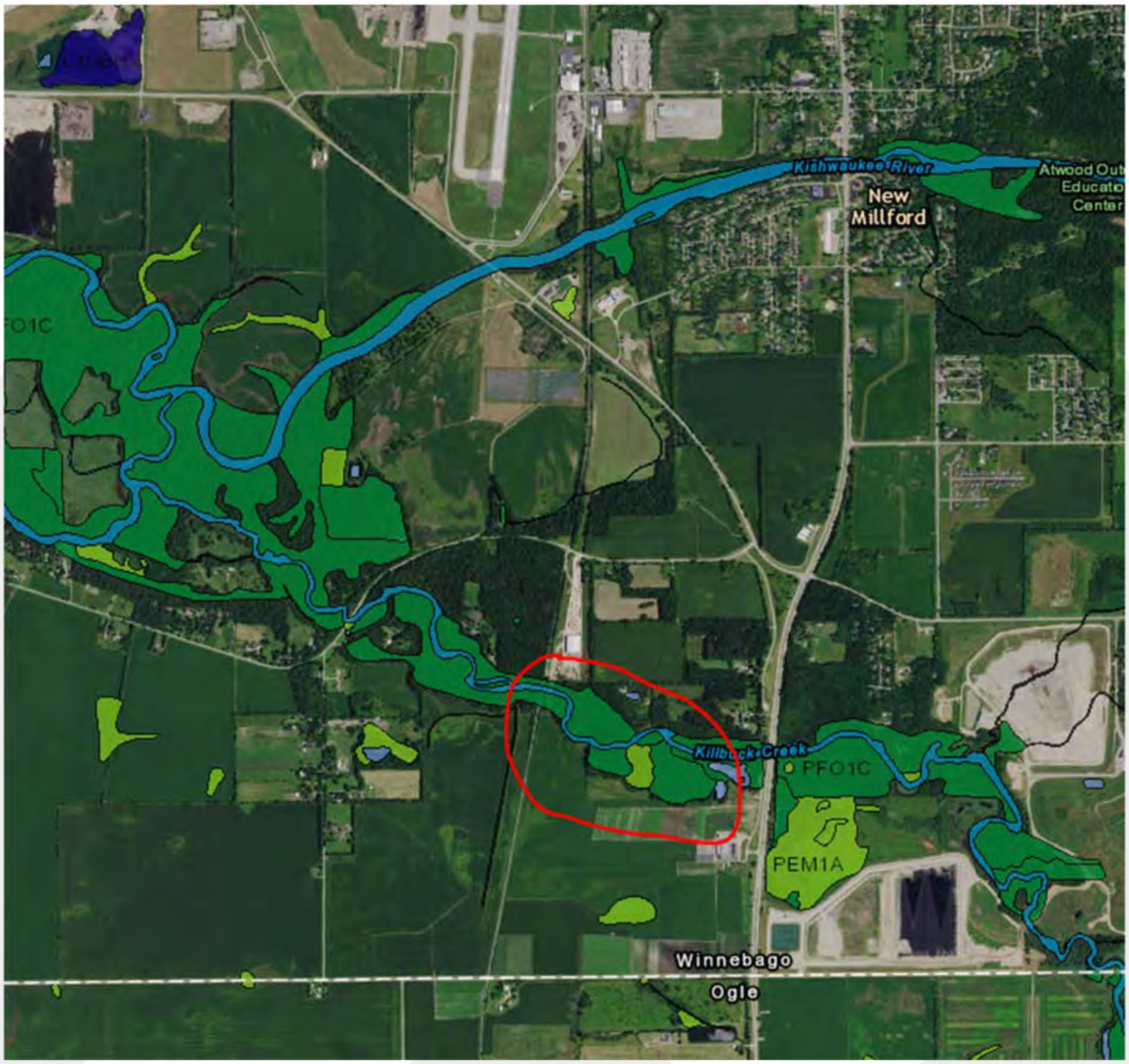
We have presented the adjoining property's surety map on the following pages as well.



Adjoining Properties 1 and 2 (and Contiguous Parcel) Parcel Map

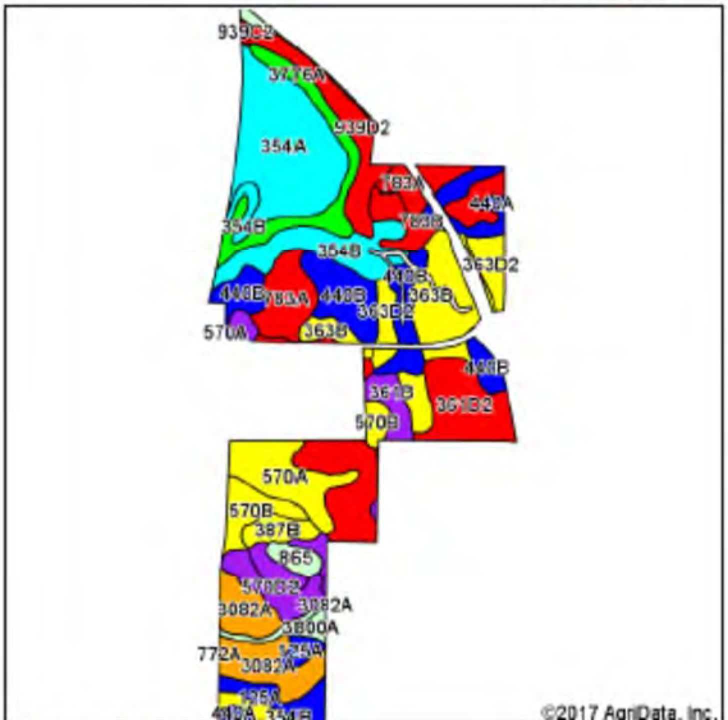


Adjoining Properties 1 and 2 (and Contiguous Parcel) Floodplain Map

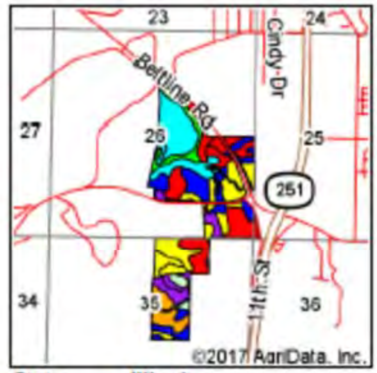


Adjoining Properties 1 and 2 (and Contiguous Parcel) Wetlands Map

Soils Map



Soils data provided by USDA and NRCS.



State: **Illinois**
County: **Winnebago**
Location: **26-43N-1E**
Township: **Rockford**
Acres: **221.61**
Date: **8/12/2017**

Area Symbol: IL201, Soil Area Version: 12

Code	Soil Description	Acres	Percent of field	Il. State Productivity Index Legend	Subsoil rooting a	Corn Bu/A	Soybeans Bu/A	Wheat Bu/A	Oats Bu/A b	Sorghum c Bu/A	Alfalfa d hay, T/A	Grass-legume e hay, T/A	Crop productivity index for optimum management
354A	Hononegah loamy coarse sand, 0 to 2 percent slopes	26.25	11.8%		FAV	114	37	47	56	0	0.00	3.51	84
**361D2	Kidder loam, 6 to 12 percent slopes, eroded	24.37	11.0%		FAV	**127	**43	**52	**60	0	**3.26	0.00	**95
**440B	Jasper silt loam, 2 to 5 percent slopes	20.62	9.3%		FAV	**173	**56	**70	**93	0	**5.71	0.00	**129
783A	Flagler sandy loam, 0 to 2 percent slopes	15.47	7.0%		FAV	129	44	51	60	0	2.88	0.00	96
3082A	Millington silt loam, 0 to 2 percent slopes, frequently flooded	14.42	6.5%		FAV	171	54	65	79	0	0.00	5.14	125
**363B	Griswold loam, 2 to 4 percent slopes	14.14	6.4%		FAV	**154	**51	**63	**76	0	**4.72	0.00	**116
570A	Martinsville silt loam, 0 to 2 percent slopes	14.05	6.3%		FAV	155	49	63	75	0	4.52	0.00	114
**354B	Hononegah loamy coarse sand, 2 to 6 percent slopes	13.59	6.1%		FAV	**113	**37	**47	**55	0	0.00	**3.47	**83
3776A	Comfrey loam, 0 to 2 percent slopes, frequently flooded	10.63	4.8%		FAV	185	61	69	89	0	0.00	5.52	138
**939D2	Rodman-Warsaw complex, 6 to 12 percent slopes, eroded	10.31	4.7%		UNF	**113	**40	**45	**54	0	0.00	**3.82	**88
**570B	Martinsville silt loam, 2 to 4 percent slopes	7.37	3.3%		FAV	**153	**49	**62	**74	0	**4.47	0.00	**113

**363D2	Griswold loam, 6 to 12 percent slopes, eroded	6.67	3.0%		FAV	**145	**48	**60	**72	0	**4.44	0.00	**109
125A	Selma loam, 0 to 2 percent slopes	6.23	2.8%		FAV	176	57	70	90	0	0.00	6.38	129
**570D2	Martinsville silt loam, 6 to 12 percent slopes, eroded	6.00	2.7%		FAV	**144	**46	**59	**70	0	**4.20	0.00	**106
440A	Jasper silt loam, 0 to 2 percent slopes	5.58	2.5%		FAV	175	57	71	94	0	5.77	0.00	130
**783B	Flagler sandy loam, 2 to 6 percent slopes	4.38	2.0%		FAV	**128	**44	**50	**59	0	**2.85	0.00	**95
**361B	Kidder loam, 2 to 4 percent slopes	4.16	1.9%		FAV	**136	**46	**55	**63	0	**3.47	0.00	**101
**327D2	Fox silt loam, 6 to 12 percent slopes, eroded	3.74	1.7%		FAV	**139	**45	**55	**68	0	**3.26	0.00	**101
**387B	Ockley silt loam, 2 to 5 percent slopes	3.54	1.6%		FAV	**154	**49	**60	**78	0	**5.34	0.00	**114
865	Pits, gravel	2.52	1.1%		CROP YIELD DATA NOT AVAILABLE						.00	.00	
**290D2	Warsaw loam, 6 to 12 percent slopes, eroded	1.80	0.8%		FAV	**150	**48	**60	**76	0	**4.78	0.00	**111
W	Water	1.44	0.6%										
**332B	Billett sandy loam, 2 to 5 percent slopes	1.43	0.6%		FAV	**134	**44	**53	**63	0	**2.98	0.00	**98
3800A	Psamments, 0 to 2 percent slopes, frequently flooded	1.41	0.6%		CROP YIELD DATA NOT AVAILABLE						.00	.00	
802B	Orthents, loamy, undulating	1.11	0.5%		CROP YIELD DATA NOT AVAILABLE						.00	.00	
**939C2	Rodman-Warsaw complex, 4 to 6 percent slopes, eroded	0.38	0.2%		UNF	**116	**41	**47	**56	0	0.00	**3.94	**91
					Weighted Average	**138.3**	**45.7**	**55.9**	**68.2**	***-**	**2.62**	**1.67**	**103.4**

Table: Optimum Crop Productivity Ratings for Illinois Soil by K.R. Olson and J.M. Lang, Office of Research, ACES, University of Illinois at Champaign-Urbana. Version: 1/2/2012 Amended Table S2 B811
Crop yields and productivity indices for optimum management (B811) are maintained at the following NRES web site:
https://www.ideals.illinois.edu/handle/2142/1027/
** Indexes adjusted for slope and erosion according to Bulletin 811 Table S3
a UNF = unfavorable; FAV = favorable
b Soils in the southern region were not rated for oats and are shown with a zero "0".
c Soils in the northern region or in both regions were not rated for grain sorghum and are shown with a zero "0".
d Soils in the poorly drained group were not rated for alfalfa and are shown with a zero "0".
e Soils in the well drained group were not rated for grass-legume and are shown with a zero "0".

*c: Using Capabilities Class Dominant Condition Aggregation Method

Soils data provided by USDA and NRCS. Soils data provided by University of Illinois at Champaign-Urbana.

It is important to note that Adjoining Property 2 and the third contiguous parcel have heavily wooded areas on their parcels. The following table outlines the characteristics of Adjoining Property 1-2 and the third contiguous parcel.

Adjoining Properties 1-2 with Third Parcel									
Status	PIN	Address	Sale Price	Site Size (AC)	PI Index	Improvements	Wooded Area %	Sale Price/AC	Sale Date
Sold	15-26-400-003, 15-26-400-001; 15-35-200-001	N/A	$846,555	214.7	103.4	None	25%	$3,943	Apr-17

We analyzed seven Control Area agricultural sales on similar lot sizes that sold within a reasonable time frame from Adjoining Properties 1 and 2's sale date, and adjusted the Control Area sales for market conditions using regression analysis to identify the appropriate monthly market conditions adjustment. We have excluded sales of strictly residential land and included sales of unimproved land that would be mainly used for agricultural purposes and had lower PIs like the Adjoining Properties. The result of our analysis for Solar Farm 7 is presented below.

CohnReznick Paired Sale Analysis		
	Potentially Impacted by Solar Farm	Adjusted Median Price Per Acre
Adjusted Control Area Sales	No: Not adjoining solar farm	$4,075
Adjoining Properties 1-2 (Test Area)	Yes: Solar Farm was completed by the sale date	$3,943
Difference		-3.23%

The unit sale price of Adjoining Properties 1 and 2 (Test Area) was slightly lower than the median adjusted unit sale price of Control Area Sales. Noting the relatively small price differential reflecting a 3% lower unit sale price, it does not appear that Solar Farm 7 negatively impacted the sales price of Adjoining Properties 1 and 2.

SOLAR FARM 8: LINCOLN SOLAR FARM, LAKE COUNTY, IN

Location: Lincoln Solar Farm in Lake County, IN

Coordinates: Latitude 41.274994, Longitude -87.153610

PIN: 45-13-30-200-010.000-030

Total Project Size: 20 AC

Recorded Owner: PLH Inc

Date Project Announced: January 2012

Date Project Completed: September 2012

Project Size: 1.5 MW

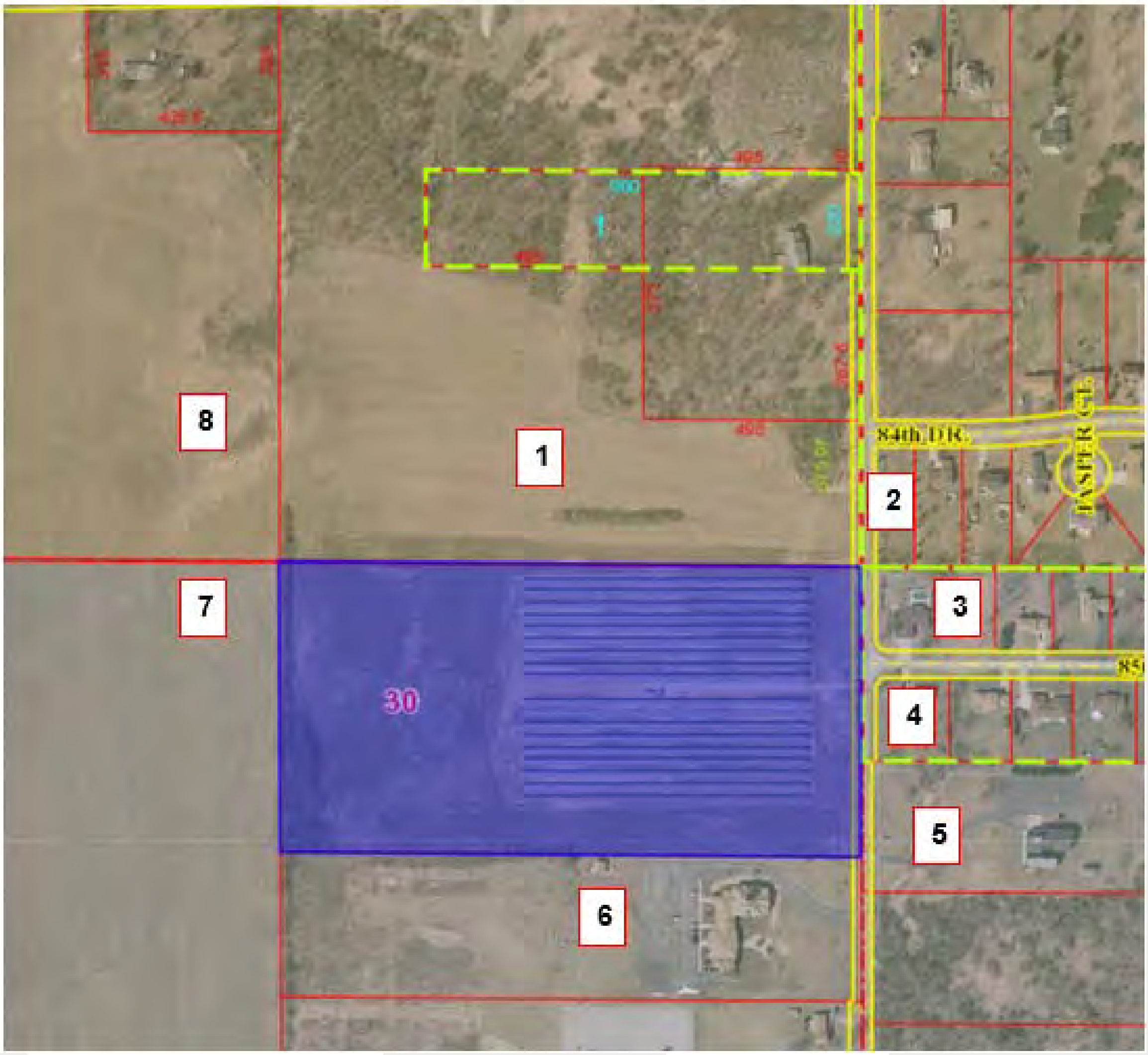
Output: 1.5 MW DC (1.98 MW AC)

This solar farm is located on the western side of Grand Boulevard, located approximately three miles east of the Town of Merrillville. The solar farm was developed by Ecos Energy, who is a subsidiary of Allco Renewable Energy Limited. This solar farm is ground mounted has the capacity for 1.5 Megawatts (MW) of power, which is enough to power 300 homes. This solar farm consists of 7,128 solar modules which are of a fixed tilt installation, and contains three inverters. The subject solar farm is separated from adjacent properties by a 6 foot chain link fence topped with barbed wire that surrounds all of the solar panels. There is no adjacent natural or landscaped vegetation. The panels are visible to all adjacent property owners. From our inspection, it does appear the neighbor to the south (Protection of the Virgin Mary Orthodox Church) had planted medium sized pines (6'). In their current growth, they do not block total view of the solar panels. See images on the following page.

Imagery Dated October 2017

Imagery Dated April 2017

The map below displays the parcels within the solar farm is located (shaded in blue). Properties adjoining this parcel are numbered for subsequent analysis.



Solar Farm 8 Adjoining Properties

For Solar Farm 8, there were no adjoining properties with sales that fit the criteria to perform a paired sales analysis.

SOLAR FARM 9: UNIVERSITY OF ILLINOIS SOLAR FARM, CHAMPAIGN, IL

Location: University of Illinois at Urbana-Champaign in Champaign County, IL

Coordinates: Latitude 40.08223, Longitude -88.244399

PIN: 03-20-25-226-006

Total Project Size: 20.79 AC

Recorded Owner: Phoenix Solar South Farms

Date Project Announced: November 12, 2012

Date Project Completed: November 2015

Output: 5.87 MW

The solar farm is located south of Windsor Road and east of US Route 45, near the University of Illinois, and is considered to be one of the largest university solar arrays in the country. The university signed a 10-year power purchase agreement with Phoenix South Solar Farms, LLC in November 2012 to purchase all electricity produced by the solar farm and deliver it directly to the campus grid. In addition, the university will own/receive all current and future Renewable Energy Certificates (RECs) and emission credits associated with energy from the solar farm. In addition, Phoenix South Solar Farms was hired to design, build, and operate the solar farm. The solar farm produces an estimated 7.86 million kilowatt-hours (kWh) annually or approximately two percent of the annual electrical demand for the university campus. Additional research estimates the solar farm will generate up to 91 percent of its original output even in year 20 of the project and collect energy for up to 40 years. The total cost of the project was approximately $15.5 million over 20 years, of which the Student Sustainability Committee provided $1.05 million USD and the Campus Utility Budget provided $4.25 million USD. There is natural vegetation of small trees and bushes to the east, north, and west. The map on the following page displays the parcels within the solar farm is located (outlined in pink). Properties adjoining this parcel are numbered for subsequent analysis.

Solar Farm 9 Adjoining Properties

Solar Farm 9 Adjoining Properties

For Solar Farm 9, there were no adjoining properties with sales that fit the criteria to perform a paired sales analysis.

SUMMARY OF ADJOINING USES

The table below summarizes each subject solar farm's adjoining uses.

Solar Farm	Parcel ID	Owner	Acreage % of Surrounding Agricultural Uses	Acreage % of Surrounding Residential Uses	Acreage % of Surrounding Industrial Uses	Acreage % of Surrounding Office Uses	Acreage % of Surrounding Other Uses	Average Distance from Panels to Improvements
Grand Ridge	34-22-100-000; 32-22-101-000	Missel, Eugene / Dorothy Ttee	97.60%	1.40%	0.00%	0.00%	1.00%	553
Portage	64-06-19-176-001.000-015	PLH LLC	65.50%	34.50%	0.00%	0.00%	0.00%	991
IMPA Frankton	48-08-06-500-012.001-020	IMPA	76.30%	5.70%	0.00%	0.00%	18.00%	236
Indy Solar III	49-13-13-113-001.000-200	Indy Solar Development LLC	97.70%	2.30%	0.00%	0.00%	0.00%	474
Valparaiso Solar LLC	64-09-07-152-001.000-019, 64-09-07-152-002.000-019	PLH Inc	81.60%	18.40%	0.00%	0.00%	0.00%	659
Middlebury Solar Farm	20-04-35-379-014.000-032	Plh Llc C/o Allco	0.00%	81.50%	15.60%	2.90%	0.00%	379
Rockford	15-26-151-003, -300-009, -176-003	Greater Rockford Airport Authority	50.30%	0.00%	49.70%	0.00%	0.00%	1,876
Lincoln Solar	45-13-30-200-010.000-030	PLH LLC	76.40%	2.60%	0.00%	0.00%	21.00%	567
University of Illinois	03-20-25-266-006	Phoenix Solar South Farms	60.60%	0.00%	0.00%	3.90%	35.50%	552

Overall, the vast majority of the surrounding acreage for each comparable solar farm, with the exception of the Middlebury Solar Farm, is made up of agricultural land, some of which have homesteads. There are also smaller single family home sites that adjoin to the solar farms we have studied. We have found that these comparable solar farms are sound comparables in terms of adjoining uses, location, and size.

Five of the seven studies with paired sale analyses reflected sales of property adjoining an existing solar farm in which the unit sale prices were effectively the same or higher (+0.10% to +27.36%) than the comparable Control Area sales that were not near any solar farms.

Considering this analysis, we conclude that there was no demonstrated impact on adjacent property values that was associated with proximity to solar farms.

MARKET COMMENTARY

We have additionally contacted market participants such as appraisers, brokers, and developers. Our conversations with these market participants are noted below.

We contacted the selling broker of the Adjoining Property 12 of the **Grand Ridge Solar Farm**, Tina Sergenti with Coldwell Banker, and were told that the proximity of the solar farm had no impact on the marketing time or selling price of the property.

We contacted the Lake County Indiana Assessor, Jerome Prince, to discuss the recent developments of solar farms in Indiana and how it would impact property values of adjacent properties. He directed us to his colleague, Robert Metz, who is familiar with the **Lincoln Solar Farm** in Merrillville. He stated that "there doesn't seem to be a major impact in my initial investigation." He also stated that "*sales in the homes to the east of that site have sold and haven't seen any value diminished*."

We spoke with James Allen, who is a county assessor in Elkhart County, Indiana. He stated that he conducted a study on residential properties with one acre and greater to see if there was any impact with the **Middlebury Solar Farm** *and found no impact on land or property values.*

We spoke with Ken Surface, a Senior Vice President of Nexus Group. Nexus Group is a large valuation group in Indiana and has been hired by 20 counties in Indiana regarding property assessments. Mr. Surface is familiar with the solar farm sites in Harrison County (**Lanesville Solar Farm**) and Monroe County (**Ellettsville Solar Farm**) and stated he has noticed *no impact on property values from these sites*.

We have spoken to Mendy Lassaline, the County Assessor for Perry County, Indiana. She stated that she has seen *no impact on land or residences from the solar farm* in her county (**IMPA Tell City Solar Park**).

We interviewed Patti St. Clair, the Chief Deputy to the St. Josephs County Assessor in Indiana. She stated that she has seen *no impact from the solar farm on land or properties* in her county (**Olive PV Solar Farm**). Additionally, she stated that *no appeals have come in to her office stating that this solar farm has had any negative effect.*

According to Betty Smith-Hanson, the Wayne County Assessor in Indiana, there has been *no impact on land or property values from the solar farm* in her county (**IMPA Richmond Solar Park**).

Finally, we interviewed Missy Tetrick, a Commercial Valuation Analyst for the Marion County Indiana Assessor. She mentioned the **Indy Solar I, II, and III sites** and stated that she saw *no impact on land or property prices from these solar farms*.

SOLAR FARM FACTORS ON HARMONY OF USE

The data from the solar farms included in this Property Value Impact Study, clearly indicates that solar farms are generally a compatible use with agricultural and residential uses.

The following section analyzes specific physical characteristics of solar farms and is based on research and our solar farm site visits.

Appearance: Most solar panels have a similar appearance to a greenhouse or single story residence and are usually not more than 10 feet high. As previously mentioned, developers generally surround a solar farm with a fence and often leave existing perimeter foliage, which minimizes the visibility of the farm. The physical characteristics of solar farms are compatible with adjoining agricultural and residential uses.

Noise: Solar panels in general are effectively silent and noise levels are minimal, similar to ambient noise. The only two sources of noise include the tracking motors and inverters housed in a sound-proofed container, which produce a quiet hum. However, neither source are typically heard outside the facility fence. Additionally, solar farms don't emit sound at nighttime.

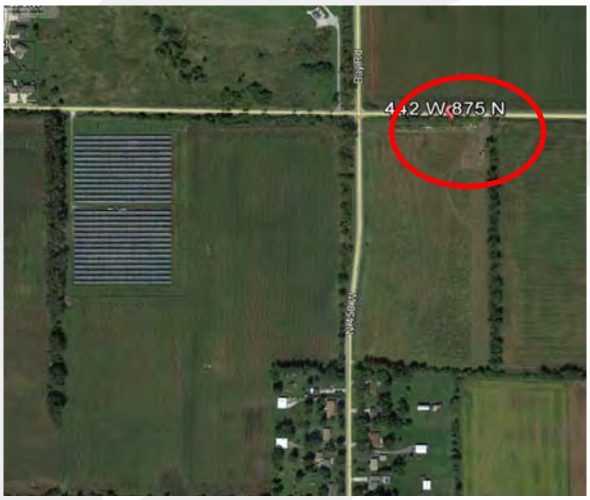
Odor: Solar panels do not produce any byproduct or odor.

Traffic: The solar farm does not require regular maintenance from on-site employees and as a result does not attract traffic during daily operation aside from the initial construction and installation of the farm.

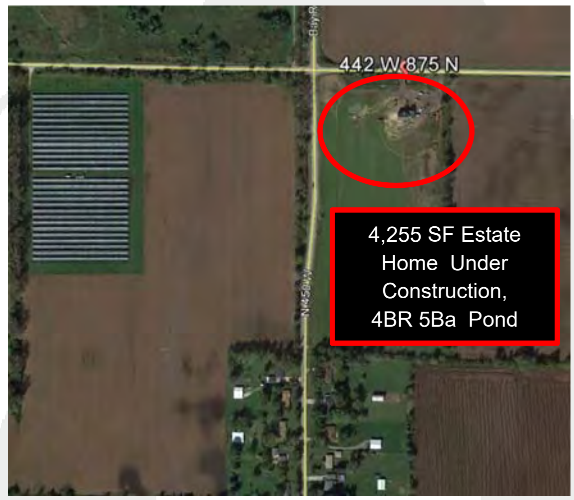
Hazardous Material: Modern solar panel arrays are constructed to U.S. government standards, and contain only aluminum, glass, silicon and EVA (a high-grade plastic); all of these materials are recyclable.

COMPATIBILITY WITH EXISTING USES

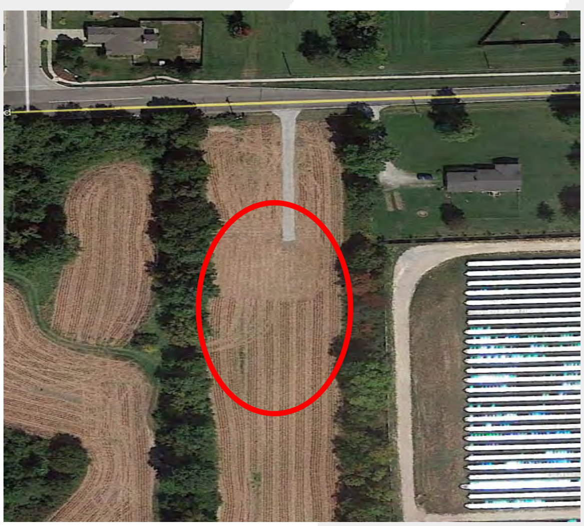
We have examined multiple instances where adjoining property owners have developed homes next to an operational solar farm, which shows that the presence of solar farms has not deterred new development. In Solar Farm 4, the adjacent land to the west was purchased and subsequently developed with a large estate home – after the solar panels had been in operation for years. Supporting aerial imagery is presented below.



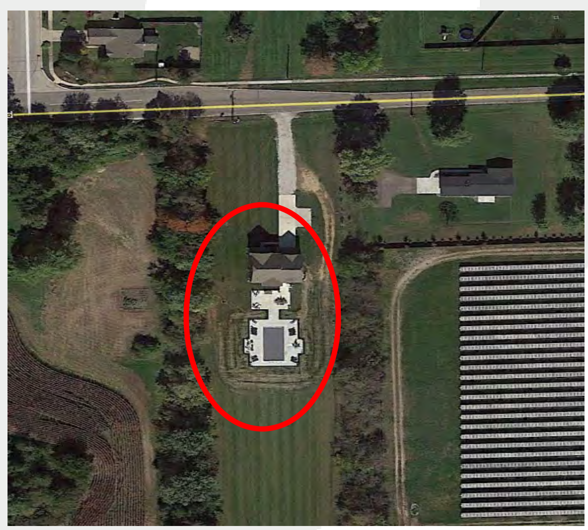
Portage Solar Farm (Solar Farm 2)
October 2015



Portage Solar Farm (Solar Farm 2)
October 2016



Dominion INDY III Solar Farm (Solar Farm 4)
September 2014



Dominion INDY III Solar Farm (Solar Farm 4)
October 2016

SUMMARY AND FINAL CONCLUSIONS

We have reviewed published methodology for measuring impact on property values as well as published studies that analyzed the impact of solar farms on property values. We have also interviewed market participants to give us additional insight as to how the market evaluates farm land and single family homes with views of the solar farm. These studies found little to no measurable and consistent difference between the Test Area Sales and the Control Area Sales attributed to the solar farms, and are generally considered a compatible use. We then can conclude that since the Adjoining Property Sales (Test Area Sales) were not adversely affected by their proximity to the solar farm, that properties surrounding other proposed solar farms operating in compliance with all regulatory standards will similarly not be adversely affected, in either the short or long term periods.

The purpose of this property value impact study is to determine whether the presence of a solar farm has caused a measurable and consistent difference in values between the Test Area Sales and the Control Area Sales. A summary of our findings for the paired sales analyses is presented below.

CohnReznick Impact Study Analysis Conclusions						
	Solar Farm	Adj. Property Number	Adjoining Property Sale (Test Area) Price Per Unit	Control Area Sales Median Price Per Unit	% Difference	Impact Found
1	Grand Ridge Solar	12	$79.90	$74.35	+7.5%	No Impact
2	Portage Solar	1	$8,000	$7,674	+4.3%	No Impact
	Portage Solar	7	$84.35	$84.27	+0.1%	No Impact
3	IMPA Frankton	2	$25.58	$28.42	+0.6%	No Impact
	IMPA Frankton	7	$52.40	$51.47	+1.8%	No Impact
4	Indy Solar III	Group 1	$59.81	$57.84	+3.4%	No Impact
	Indy Solar III	Group 2	$69.14	$68.67	+0.7%	No Impact
5	Valparaiso Solar LLC	10	$82.42	$79.95	+3.1%	No Impact
	Valparaiso Solar LLC	14	$62.11	$64.07	-3.1%	No Impact
6	Middlebury Solar	10	$132.79	$104.23	+27.4%	No Impact
7	Rockford Solar	1 & 2	$3,943	$4,075	-3.2%	No Impact
Average Variance in Sale Prices for Test to Control Areas					**+3.9%**	

Based upon our examination, research, and analyses of the existing solar farm uses, the surrounding areas, and an extensive market database, we have concluded that ***no consistent negative impact has occurred to adjacent property that could be attributed to proximity to the adjacent solar farm***, with regard to unit sale prices or other influential market indicators. This conclusion has been confirmed by numerous County Assessors who have also investigated this use's potential impact.

If you have any questions or comments, please contact the undersigned. Thank you for the opportunity to be of service.

Respectfully submitted,

CohnReznick, LLP

Patricia L. McGarr, MAI, CRE, FRICS
National Director - Valuation Advisory Services
Certified General Real Estate Appraiser
Illinois License No. #553.000621
Expires 9/30/2019
Indiana License No. #CG49600131
Expires 6/30/2018

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Expires 6/30/2018

Andrew R. Lines, MAI
Principal
Certified General Real Estate Appraiser
Illinois License No. #553.001841
Expires 9/30/2019
Indiana License No. #CG41500037
Expires 6/30/2018

Sonia K. Singh
Manager

CERTIFICATION

We certify that, to the best of our knowledge and belief:

1. The statements of fact and data reported are true and correct.
2. The reported analyses, opinions, and conclusions in this consulting report are limited only by the reported assumptions and limiting conditions, and are our personal, impartial, and unbiased professional analyses, opinions, and conclusions.
3. We have no present or prospective interest in the property that is the subject of this report and no personal interest with respect to the parties involved.
4. We have performed no services, as an appraiser or in any other capacity, regarding the property that is the subject of this report within the three-year period immediately preceding acceptance of this assignment.
5. We have no bias with respect to the property that is the subject of this report or the parties involved with this assignment.
6. Our engagement in this assignment was not contingent upon developing or reporting predetermined results.
7. Our compensation for completing this assignment is not contingent upon the development or reporting of a predetermined value or direction in value that favors the cause of the client, the amount of the value opinion, the attainment of a stipulated result, or the occurrence of a subsequent event directly related to the intended use of this report.
8. Our analyses, opinions, and conclusions were developed, and this report has been prepared, in conformity with the requirements of the Code of Professional Ethics and Standards of Professional Appraisal Practice of the Appraisal Institute, which includes the Uniform Standards of Professional Appraisal Practice (USPAP).
9. The use of this report is subject to the requirements of the Appraisal Institute relating to review by its duly authorized representatives.
10. Patricia L. McGarr, MAI, CRE, FRICS has made a personal inspection of the properties that is the subject of this work. Andrew R. Lines, MAI, Martin D. Broerman, MAI, and Sonia K. Singh have not made a personal inspection of the properties.
11. We have not relied on unsupported conclusions relating to characteristics such as race, color, religion, national origin, gender, marital status, familial status, age, and receipt of public assistance income, handicap, or an unsupported conclusion that homogeneity of such characteristics is necessary to maximize value.
12. Michael F. Antypas provided significant appraisal consulting assistance to the persons signing this certification.
13. We have experience in reviewing properties similar to the subject and are in compliance with the Competency Rule of USPAP.
14. As of the date of this report, Patricia L. McGarr, MAI, CRE, FRICS, Andrew R. Lines, MAI, and Martin D. Broerman, MAI have completed the continuing education program of the Appraisal Institute.
15. As of the date of this report, Sonia K. Singh has completed the Standards and Ethics Education Requirements for Candidates of the Appraisal Institute.

If you have any questions or comments, please contact the undersigned. Thank you for the opportunity to be of service.

Respectfully submitted,

CohnReznick, LLP

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Expires 6/30/2018

Sonia K. Singh
Manager

ASSUMPTIONS AND LIMITING CONDITIONS

This report is based on the following assumptions, except as otherwise noted in the report.

1. The title is marketable and free and clear of all liens, encumbrances, encroachments, easements and restrictions. The property is under responsible ownership and competent management and is available for its highest and best use.
2. There are no existing judgments or pending or threatened litigation that could affect the value of the property.
3. There are no hidden or undisclosed conditions of the land or of the improvements that would render the property more or less valuable. Furthermore, there is no asbestos in the property.
4. The revenue stamps placed on any deed referenced herein to indicate the sale price are in correct relation to the actual dollar amount of the transaction.
5. The property is in compliance with all applicable building, environmental, zoning, and other federal, state and local laws, regulations and codes.
6. The information furnished by others is believed to be reliable, but no warranty is given for its accuracy.

This report is subject to the following limiting conditions, except as otherwise noted in the report.

1. An appraisal is inherently subjective and represents our opinion as to the value of the property appraised.
2. The conclusions stated in our appraisal apply only as of the effective date of the appraisal, and no representation is made as to the effect of subsequent events.
3. No changes in any federal, state or local laws, regulations or codes (including, without limitation, the Internal Revenue Code) are anticipated.
4. No environmental impact studies were either requested or made in conjunction with this appraisal, and we reserve the right to revise or rescind any of the value opinions based upon any subsequent environmental impact studies. If any environmental impact statement is required by law, the appraisal assumes that such statement will be favorable and will be approved by the appropriate regulatory bodies.
5. Unless otherwise agreed to in writing, we are not required to give testimony, respond to any subpoena or attend any court, governmental or other hearing with reference to the property without compensation relative to such additional employment.
6. We have made no survey of the property and assume no responsibility in connection with such matters. Any sketch or survey of the property included in this report is for illustrative purposes only and should not be considered to be scaled accurately for size. The appraisal covers the property as described in this report, and the areas and dimensions set forth are assumed to be correct.
7. No opinion is expressed as to the value of subsurface oil, gas or mineral rights, if any, and we have assumed that the property is not subject to surface entry for the exploration or removal of such materials, unless otherwise noted in our appraisal.
8. We accept no responsibility for considerations requiring expertise in other fields. Such considerations include, but are not limited to, legal descriptions and other legal matters such as legal title, geologic considerations such as soils and seismic stability, and civil, mechanical, electrical, structural and other engineering and environmental matters.

9. The distribution of the total valuation in the report between land and improvements applies only under the reported highest and best use of the property. The allocations of value for land and improvements must not be used in conjunction with any other appraisal and are invalid if so used. The appraisal report shall be considered only in its entirety. No part of the appraisal report shall be utilized separately or out of context.
10. Neither all nor any part of the contents of this report (especially any conclusions as to value, the identity of the appraisers, or any reference to the Appraisal Institute) shall be disseminated through advertising media, public relations media, news media or any other means of communication (including without limitation prospectuses, private offering memoranda and other offering material provided to prospective investors) without the prior written consent of the person signing the report.
11. Information, estimates and opinions contained in the report, obtained from third-party sources are assumed to be reliable and have not been independently verified.
12. Any income and expense estimates contained in the appraisal report are used only for the purpose of estimating value and do not constitute predictions of future operating results.
13. If the property is subject to one or more leases, any estimate of residual value contained in the appraisal may be particularly affected by significant changes in the condition of the economy, of the real estate industry, or of the appraised property at the time these leases expire or otherwise terminate.
14. No consideration has been given to personal property located on the premises or to the cost of moving or relocating such personal property; only the real property has been considered.
15. The current purchasing power of the dollar is the basis for the value stated in our appraisal; we have assumed that no extreme fluctuations in economic cycles will occur.
16. The value found herein is subject to these and to any other assumptions or conditions set forth in the body of this report but which may have been omitted from this list of Assumptions and Limiting Conditions.
17. The analyses contained in the report necessarily incorporate numerous estimates and assumptions regarding property performance, general and local business and economic conditions, the absence of material changes in the competitive environment and other matters. Some estimates or assumptions, however, inevitably will not materialize, and unanticipated events and circumstances may occur; therefore, actual results achieved during the period covered by our analysis will vary from our estimates, and the variations may be material.
18. The *Americans with Disabilities Act (ADA)* became effective January 26, 1992. We have not made a specific survey or analysis of any property to determine whether the physical aspects of the improvements meet the *ADA* accessibility guidelines. In as much as compliance matches each owner's financial ability with the cost to cure the non-conforming physical characteristics of a property, we cannot comment on compliance to *ADA*. Given that compliance can change with each owner's financial ability to cure non-accessibility, the value of the subject does not consider possible non-compliance. A specific study of both the owner's financial ability and the cost to cure any deficiencies would be needed for the Department of Justice to determine compliance.
19. The appraisal report is prepared for the exclusive benefit of the Client, its subsidiaries and/or affiliates. It may not be used or relied upon by any other party. All parties who use or rely upon any information in the report without our written consent do so at their own risk.
20. No studies have been provided to us indicating the presence or absence of hazardous materials on the subject property or in the improvements, and our valuation is predicated upon the assumption that the

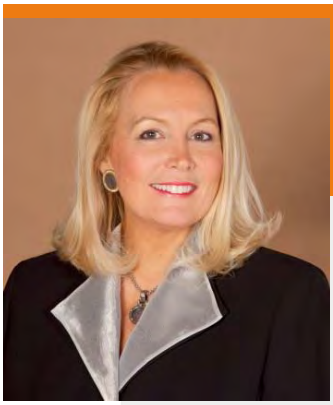
subject property is free and clear of any environment hazards including, without limitation, hazardous wastes, toxic substances and mold. No representations or warranties are made regarding the environmental condition of the subject property and the person signing the report shall not be responsible for any such environmental conditions that do exist or for any engineering or testing that might be required to discover whether such conditions exist. Because we are not experts in the field of environmental conditions, the appraisal report cannot be considered as an environmental assessment of the subject property.

21. The person signing the report may have reviewed available flood maps and may have noted in the appraisal report whether the subject property is located in an identified Special Flood Hazard Area. We are not qualified to detect such areas and therefore do not guarantee such determinations. The presence of flood plain areas and/or wetlands may affect the value of the property, and the value conclusion is predicated on the assumption that wetlands are non-existent or minimal.
22. CohnReznick is not a building or environmental inspector. CohnReznick does not guarantee that the subject property is free of defects or environmental problems. Mold may be present in the subject property and a professional inspection is recommended.
23. The appraisal report and value conclusion for an appraisal assumes the satisfactory completion of construction, repairs or alterations in a workmanlike manner.
24. CohnReznick an independently owned and operated company, has prepared the appraisal for the specific purpose stated elsewhere in the report. The intended use of the appraisal is stated in the General Information section of the report. The use of the appraisal report by anyone other than the Client is prohibited except as otherwise provided. Accordingly, the appraisal report is addressed to and shall be solely for the Client's use and benefit unless we provide our prior written consent. We expressly reserve the unrestricted right to withhold our consent to your disclosure of the appraisal report (or any part thereof including, without limitation, conclusions of value and our identity), to any third parties. Stated again for clarification, unless our prior written consent is obtained, no third party may rely on the appraisal report (even if their reliance was foreseeable).
25. The conclusions of this report are estimates based on known current trends and reasonably foreseeable future occurrences. These estimates are based partly on property information, data obtained in public records, interviews, existing trends, buyer-seller decision criteria in the current market, and research conducted by third parties, and such data are not always completely reliable. CohnReznick and the undersigned are not responsible for these and other future occurrences that could not have reasonably been foreseen on the effective date of this assignment. Furthermore, it is inevitable that some assumptions will not materialize and that unanticipated events may occur that will likely affect actual performance. While we are of the opinion that our findings are reasonable based on current market conditions, we do not represent that these estimates will actually be achieved, as they are subject to considerable risk and uncertainty. Moreover, we assume competent and effective management and marketing for the duration of the projected holding period of this property.
26. All prospective value estimates presented in this report are estimates and forecasts which are prospective in nature and are subject to considerable risk and uncertainty. In addition to the contingencies noted in the preceding paragraph, several events may occur that could substantially alter the outcome of our estimates such as, but not limited to changes in the economy, interest rates, and capitalization rates, behavior of consumers, investors and lenders, fire and other physical destruction, changes in title or

conveyances of easements and deed restrictions, etc. It is assumed that conditions reasonably foreseeable at the present time are consistent or similar with the future.

27. While this appraisal has been proofed for typographical errors, mathematical inaccuracies, and other discrepancies, others may be discovered in subsequent reviews performed by the client or their designated agent. We reserve the right to correct any typographical errors, mathematical inaccuracies, or other discrepancies that may affect the estimate of value contained in the report. These corrections will be corrected promptly upon the written request of the client.

ADDENDUM A:
APPRAISER QUALIFICATIONS



Patricia L. McGarr, MAI, CRE, FRICS, CRA

Principal,
National Director, Valuation Advisory Services

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Patricia L. McGarr, MAI, CRE, FRICS, CRA, is a principal and National Director of CohnReznick Advisory Group's Valuation Advisory Services practice who is based in Chicago. Pat's experience includes market value appraisals of varied property types for acquisition, condemnation, mortgage, estate, ad valorem tax, litigation, zoning, and other purposes. Pat has been involved in the real estate business since 1980. From June 1980 to January 1984, she was involved with the sales and brokerage of residential and commercial properties. Her responsibilities during this time included the formation, management, and training of sales staff in addition to her sales, marketing, and analytical functions. Of special note was her development of a commercial division for a major Chicago-area brokerage firm.

Since January 1984, Pat has been exclusively involved in the valuation of real estate. Her experience includes the valuation of a wide variety of property types including residential, commercial, industrial, and special purpose properties including such diverse subjects as quarries, marinas, riverboat gaming sites, shopping centers, manufacturing plants, and office buildings. She is also experienced in the valuation of leasehold and leased fee interests. Pat has performed appraisal assignments throughout Illinois and the Chicago Metropolitan area as well as Wisconsin, Indiana, Michigan, New York, New Jersey, California, Nevada, Florida, Utah, Texas, and Ohio. Pat has gained substantial experience in the study and analysis of the establishment and expansion of sanitary landfills in various metropolitan areas including the preparation of real estate impact studies to address criteria required by Senate Bill 172. She has also developed an accepted format for allocating value of a landfill operation between real property, landfill improvements, and franchise (permits) value.

Over the past several years, Pat has developed a valuation group that specializes in serving utility companies establish new utility corridors for electric power transmission and pipelines. This includes determining acquisition budgets, easement acquisitions, and litigation support. Pat has considerable experience in performing valuation impact studies on potential detrimental conditions and has studied properties adjoining landfills, waste transfer stations, stone quarries, cellular towers, schools, electrical power transmission lines, "Big Box" retail facilities, levies, properties with restrictive covenants, landmark districts, environmental contamination, airports, material defects in construction, stigma, and loss of view amenity for residential high rises.

Pat has qualified as an expert valuation witness in numerous local, state and federal courts.

Pat's has participated in specialized real estate appraisal education and has completed more than 50 courses and seminars offered by the Appraisal Institute totaling more than 600 classroom hours, including real estate transaction courses as a prerequisite to obtaining a State of Illinois Real Estate Salesman License.

Pat has earned the professional designations of Counselors of Real Estate (CRE), Member of the Appraisal Institute (MAI), Fellow of Royal Institution of Chartered Surveyors (FRICS) and Certified Review Appraiser (CRA).

She is also a certified general real estate appraiser with active licenses in California, District of Columbia, Florida, Illinois, Indiana, Las Vegas, Maryland, New Jersey, New York, Texas and Wisconsin.

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Valuations have been completed nationwide for a variety of assignments including mortgage financing, litigation, tax appeal, estate gifts, asset management, workouts, and restructuring, as well as valuation for financial reporting including purchase price allocations (ASC 805), impairment studies, and appraisals for investment company guidelines and REIS standards. Andrew has qualified as an expert witness, providing testimony for eminent domain cases in the states of IL and MD. Andrew has also performed appraisal review assignments for accounting purposes (audit support), asset management, litigation and as an evaluator for a large Midwest regional bank.

Andrew has earned the professional designation of Member of the Appraisal Institute (MAI). He has also qualified for certified general commercial real estate appraiser licenses in Arizona, California, Maryland, Florida, Wisconsin, Georgia, Illinois, Indiana, New Jersey and New York. Temporary licenses have been granted in Connecticut, Colorado, Ohio, Pennsylvania, Idaho, Kansas, Minnesota and South Carolina.

Education

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Professional Affiliations

- Chicago Chapter of the Appraisal Institute - Alternate Regional Representative (2016 - Present)
- International Real Estate Management (IREM)
- National Council of Real Estate Investment Fiduciaries (NCREIF)

Community Involvement

- Fellows Alumni Network - World Business Chicago, Founding member
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Martin's retail assignments have ranged from freestanding retail stores to shopping centers of all varieties. His industrial assignments include distribution warehouses, cold storage warehouses, R&D facilities, truck terminals, manufacturing facilities and data centers. Martin's office assignments include hi-rise downtown offices, low- to mid-rise suburban offices, and medical office buildings. His residential assignments include single family homes, apartment projects of all sizes, residential subdivisions, and condominium developments/conversions. Martin's specialized real estate assignments include portfolio analysis, utility corridors, right-of-way projects, pipelines, mixed-use properties, ground leaseholds, healthcare facilities, parking garages, vacant land, and various easement valuations. His extensive experience in commercial real estate is focused on properties located in the Chicago metropolitan area, but includes significant assets located nationwide.

Martin has served an array of clients, including municipalities, lenders, law firms, investment firms, utility companies, private corporations, educational institutions, developers, and various governmental agencies including the Illinois Department of Transportation (IDOT) and General Services Administration (GSA).

Martin is a certified general real estate appraiser with active licenses in Illinois, Indiana and Ohio.

Education

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She is adept at valuing a variety of real estate property types across the United States, including the following: right-of-way acquisitions for utility corridors; single- and multi-tenant industrial buildings; historic redevelopment projects; freestanding and retail shopping centers; trophy, class A office buildings; continuing care retirement communities; marinas; car dealerships; athletic clubs; boutique and luxury flag hotels with for-sale residential villas; and medical office buildings with a surgical center. Real estate appraisals have been prepared for pending litigation matters, estate planning, estate & gift tax purposes, and asset management.

In addition to real estate appraisal services, she has completed over 1,500 hours related to generating purchase price allocations for the acquisition of tangible and intangible assets for financial reporting purposes under the guidance of ASC 805. Other experienced real estate consulting services include useful life analysis, appraisal review, statistical analysis, and financial forecasts for development projects. Several impact studies were prepared by her and her peers measuring the impact, if any, of economic and environmental influences on property values.

Other services she provided significant assistance with include useful life analysis of real estate and valuation of minority interests for gift and estate tax purposes. In addition, she has developed several financial forecasts for real estate development to illustrate profit measures as well as return on capital for potential investors.

Sonia is working towards obtaining a Certified General Real Estate Appraiser license for the state of Virginia. She has also completed the following actuarial exams: Probability, Financial Mathematics, and Models for Financial Economics.

Education

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He graduated from the Villanova School of Business in May of 2016. Some of his other experience working in Real Estate originated through interning with commercial brokers. Throughout his senior year in college, Michael interned with Newmark Grubb Knight Frank as a Capital Markets intern. There he helped create and revise many marketing packages for the firm's senior managing directors. He also assisted in developing underwriting models and projections for offering memorandums. He also worked with a boutique restaurant broker in Washington D.C, Papadopoulos Properties where he compiled market research for his client's use and surveyed prospective restaurants to gauge their interest in expanding to the Washington D.C. market.

Education

- Villanova University: Bachelor of Business Administration, Finance and Real Estate, Minor in Business Analytics

Certifications

- Argus Enterprise Certified

Professional Affiliations

- Appraisal Institute, Practicing Affiliate

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Health and Safety Impacts of Solar Photovoltaics

MAY 2017

NC STATE UNIVERSITY

Health and Safety Impacts of Solar Photovoltaics

The increasing presence of utility-scale solar photovoltaic (PV) systems (sometimes referred to as solar farms) is a rather new development in North Carolina's landscape. Due to the new and unknown nature of this technology, it is natural for communities near such developments to be concerned about health and safety impacts. Unfortunately, the quick emergence of utility-scale solar has cultivated fertile grounds for myths and half-truths about the health impacts of this technology, which can lead to unnecessary fear and conflict.

Photovoltaic (PV) technologies and solar inverters are not known to pose any significant health dangers to their neighbors. The most important dangers posed are increased highway traffic during the relative short construction period and dangers posed to trespassers of contact with high voltage equipment. This latter risk is mitigated by signage and the security measures that industry uses to deter trespassing. As will be discussed in more detail below, risks of site contamination are much less than for most other industrial uses because PV technologies employ few toxic chemicals and those used are used in very small quantities. Due to the reduction in the pollution from fossil-fuel-fired electric generators, the overall impact of solar development on human health is overwhelmingly positive. This pollution reduction results from a partial replacement of fossil-fuel fired generation by emission-free PV-generated electricity, which reduces harmful sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulate matter ($PM_{2.5}$). Analysis from the National Renewable Energy Laboratory and the Lawrence Berkeley National Laboratory, both affiliates of the U.S. Department of Energy, estimates the health-related air quality benefits to the southeast region from solar PV generators to be worth 8.0 ¢ per kilowatt-hour of solar generation.[1] This is in addition to the value of the electricity and suggests that the air quality benefits of solar are worth more than the electricity itself.

Even though we have only recently seen large-scale installation of PV technologies, the technology and its potential impacts have been studied since the 1950s. A combination of this solar-specific research and general scientific research has led to the scientific community having a good understanding of the science behind potential health and safety impacts of solar energy. This paper utilizes the latest scientific literature and knowledge of solar practices in N.C. to address the health and safety risks associated with solar PV technology. These risks are extremely small, far less than those associated with common activities such as driving a car, and vastly outweighed by health benefits of the generation of clean electricity.

This paper addresses the potential health and safety impacts of solar PV development in North Carolina, organized into the following four categories:

(1) Hazardous Materials
(2) Electromagnetic Fields (EMF)
(3) Electric Shock and Arc Flash
(4) Fire Safety

1. Hazardous Materials

One of the more common concerns towards solar is that the panels (referred to as "modules" in the solar industry) consist of toxic materials that endanger public health. However, as shown in this section, solar energy systems may contain small amounts of toxic materials, but these materials do not endanger public health. To understand potential toxic hazards coming from a solar project, one must understand system installation, materials used, the panel end-of-life protocols, and system operation. This section will examine these aspects of a solar farm and the potential for toxicity impacts in the following subsections:

(1.2) Project Installation/Construction
(1.2) System Components
    1.2.1 Solar Panels: Construction and Durability
    1.2.2 Photovoltaic technologies
        (a) Crystalline Silicon
        (b) Cadmium Telluride (CdTe)
        (c) CIS/CIGS
    1.2.3 Panel End of Life Management
    1.2.4 Non-panel System Components
(1.3) Operations and Maintenance

1.1 Project Installation/Construction

The system installation, or construction, process does not require toxic chemicals or processes. The site is mechanically cleared of large vegetation, fences are constructed, and the land is surveyed to layout exact installation locations. Trenches for underground wiring are dug and support posts are driven into the ground. The solar panels are bolted to steel and aluminum support structures and wired together. Inverter pads are installed, and an inverter and transformer are installed on each pad. Once everything is connected, the system is tested, and only then turned on.

Figure 1: Utility-scale solar facility (5 MW_{AC}) located in Catawba County. Source: Strata Solar

1.2 System Components

1.2.1 Solar Panels: Construction and Durability

Solar PV panels typically consist of glass, polymer, aluminum, copper, and semiconductor materials that can be recovered and recycled at the end of their useful life. [2] Today there are two PV technologies used in PV panels at utility-scale solar facilities, silicon, and thin film. As of 2016, all thin film used in North Carolina solar facilities are cadmium telluride (CdTe) panels from the US manufacturer First Solar, but there are other thin film PV panels available on the market, such as Solar Frontier's CIGS panels. Crystalline silicon technology consists of silicon wafers which are made into cells and assembled into panels, thin film technologies consist of thin layers of semiconductor material deposited onto glass, polymer or metal substrates. While there are differences in the components and manufacturing processes of these two types of solar technologies, many aspects of their PV panel construction are very similar. Specifics about each type of PV chemistry as it relates to toxicity are covered in subsections a, b, and c in section 1.2.2; on crystalline silicon, cadmium telluride, and CIS/CIGS respectively. The rest of this section applies equally to both silicon and thin film panels.

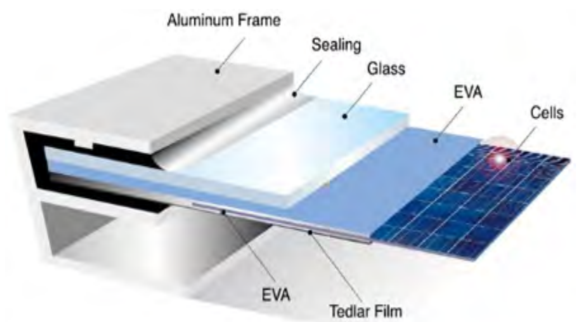

Figure 2: Components of crystalline silicon panels. The vast majority of silicon panels consist of a glass sheet on the topside with an aluminum frame providing structural support. Image Source: www.riteksolar.com.tw

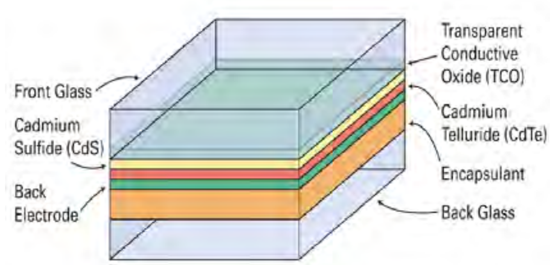

Figure 3: Layers of a common frameless thin-film panel (CdTe). Many thin film panels are frameless, including the most common thin-film panels, First Solar's CdTe. Frameless panels have protective glass on both the front and back of the panel. Layer thicknesses not to scale. Image Source: www.homepower.com

To provide decades of corrosion-free operation, PV cells in PV panels are encapsulated from air and moisture between two layers of plastic. The encapsulation layers are protected on the top with a layer of tempered glass and on the backside with a polymer sheet. Frameless modules include a protective layer of glass on the rear of the panel, which may also be tempered. The plastic ethylene-vinyl acetate (EVA) commonly provides the cell encapsulation. For decades, this same material has been used between layers of tempered glass to give car windshields and hurricane windows their great strength. In the same way that a car windshield cracks but stays intact, the EVA layers in PV panels keep broken panels intact (see Figure 4). Thus, a damaged module does not generally create small pieces of debris; instead, it largely remains together as one piece.

Figure 4: The mangled PV panels in this picture illustrate the nature of broken solar panels; the glass cracks but the panel is still in one piece. Image Source: http://img.alibaba.com/photo/115259576/broken_solar_panel.jpg

PV panels constructed with the same basic components as modern panels have been installed across the globe for well over thirty years.[3] The long-term durability and performance demonstrated over these decades, as well as the results of accelerated lifetime testing, helped lead to an industry-standard 25-year power production warranty for PV panels. These power warranties warrant a PV panel to produce at least 80% of their original nameplate production after 25 years of use. A recent SolarCity and DNV GL study reported that today's quality PV panels should be expected to reliably and efficiently produce power for thirty-five years.[4]

Local building codes require all structures, including ground mounted solar arrays, to be engineered to withstand anticipated wind speeds, as defined by the local wind speed requirements. Many racking products are available in versions engineered for wind speeds of up to 150 miles per hour, which is significantly higher than the wind speed requirement anywhere in North Carolina. The strength of PV mounting structures were demonstrated during Hurricane Sandy in 2012 and again during Hurricane Matthew in 2016. During Hurricane Sandy, the many large-scale solar facilities in New Jersey and New York at that time suffered only minor damage.[5] In the fall of 2016, the US and Caribbean experienced destructive winds and torrential rains from Hurricane Matthew, yet one leading solar tracker manufacturer reported that their numerous systems in the impacted area received zero damage from wind or flooding.[6]

In the event of a catastrophic event capable of damaging solar equipment, such as a tornado, the system will almost certainly have property insurance that will cover the cost to cleanup and repair the project. It is in the best interest of the system owner to protect their investment against such risks. It is also in their interest to get the project repaired and producing full power as soon as possible. Therefore, the investment in adequate insurance is a wise business practice for the system owner. For the same reasons, adequate insurance coverage is also generally a requirement of the bank or firm providing financing for the project.

1.2.2 Photovoltaic (PV) Technologies

a. **Crystalline Silicon**

This subsection explores the toxicity of silicon-based PV panels and concludes that they do not pose a material risk of toxicity to public health and safety. Modern crystalline silicon PV panels, which account for over 90% of solar PV panels installed today, are, more or less, a commodity product. The overwhelming majority of panels installed in North Carolina are crystalline silicon panels that are informally classified as Tier I panels. Tier I panels are from well-respected manufacturers that have a good chance of being able to honor warranty claims. Tier I panels are understood to be of high quality, with predictable performance, durability, and content. Well over 80% (by weight) of the content of a PV panel is the tempered glass front and the aluminum frame, both of which are common building materials. Most of the remaining portion are common plastics, including polyethylene terephthalate in the backsheet, EVA encapsulation of the PV cells, polyphenyl ether in the junction box, and polyethylene insulation on the wire leads. The active, working components of the system are the silicon photovoltaic cells, the small electrical leads connecting them together, and to the wires coming out of the back of the panel. The electricity generating and conducting components makeup less than 5% of the weight of most panels. The PV cell itself is nearly 100% silicon, and silicon is the second most common element in the Earth's crust. The silicon for PV cells is obtained by high-temperature processing of quartz sand (SiO_2) that removes its oxygen molecules. The refined silicon is converted to a PV cell by adding extremely small amounts of boron and phosphorus, both of which are common and of very low toxicity.

The other minor components of the PV cell are also generally benign; however, some contain lead, which is a human toxicant that is particularly harmful to young children. The minor components include an extremely thin antireflective coating (silicon nitride or titanium dioxide), a thin layer of aluminum on the rear, and thin strips of silver alloy that are screen-printed on the front and rear of cell.[7] In order for the front and rear electrodes to make effective electrical contact with the proper layer of the PV cell, other materials (called glass frit) are mixed with the silver alloy and then heated to etch the metals into the cell. This glass frit historically contains a small amount of lead (Pb) in the form of lead oxide. The 60 or 72 PV cells in a PV panel are connected by soldering thin solder-covered copper tabs from the back of one cell to the front of the next cell. Traditionally a tin-based solder containing some lead (Pb) is used, but some manufacturers have switched to lead-free solder. The glass frit and/or the solder may contain trace amounts of other metals, potentially including some with human toxicity such as cadmium. However, testing to simulate the potential for leaching from broken panels, which is discussed in more detail below, did not find a potential toxicity threat from these trace elements. Therefore, the tiny amount of lead in the grass frit and the solder is the only part of silicon PV panels with a potential to create a negative health impact. However, as described below, the very limited amount of lead involved and its strong physical and chemical attachment to other components of the PV panel means that even in worst-case scenarios the health hazard it poses is insignificant.

As with many electronic industries, the solder in silicon PV panels has historically been a lead-based solder, often 36% lead, due to the superior properties of such solder. However, recent advances in lead-free solders have spurred a trend among PV panel manufacturers to reduce or remove the lead in their panels. According to the 2015 Solar Scorecard from the Silicon Valley Toxics Coalition, a group that tracks environmental responsibility of photovoltaic panel manufacturers, fourteen companies (increased from twelve companies in 2014) manufacture PV panels certified to meet the European Restriction of

Hazardous Substances (RoHS) standard. This means that the amount of cadmium and lead in the panels they manufacture fall below the RoHS thresholds, which are set by the European Union and serve as the world's de facto standard for hazardous substances in manufactured goods.[8] The Restriction of Hazardous Substances (RoHS) standard requires that the maximum concentration found in any homogenous material in a produce is less than 0.01% cadmium and less than 0.10% lead, therefore, any solder can be no more than 0.10% lead.[9]

While some manufacturers are producing PV panels that meet the RoHS standard, there is no requirement that they do so because the RoHS Directive explicitly states that the directive does not apply to photovoltaic panels.[10] The justification for this is provided in item 17 of the current RoHS Directive: "The development of renewable forms of energy is one of the Union's key objectives, and the contribution made by renewable energy sources to environmental and climate objectives is crucial. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources (4) recalls that there should be coherence between those objectives and other Union environmental legislation. Consequently, this Directive should not prevent the development of renewable energy technologies that have no negative impact on health and the environment and that are sustainable and economically viable."

The use of lead is common in our modern economy. However, only about 0.5% of the annual lead consumption in the U.S. is for electronic solder for all uses; PV solder makes up only a tiny portion of this 0.5%. Close to 90% of lead consumption in the US is in batteries, which do not encapsulate the pounds of lead contained in each typical automotive battery. This puts the lead in batteries at great risk of leaching into the environment. Estimates for the lead in a single PV panel with lead-based solder range from 1.6 to 24 grams of lead, with 13g (less than half of an ounce) per panel seen most often in the literature.[11] At 13 g/panel[12], each panel contains one-half of the lead in a typical 12-gauge shotgun shell. This amount equates to roughly 1/750th of the lead in a single car battery. In a panel, it is all durably encapsulated from air or water for the full life of the panel.[14]

As indicated by their 20 to 30-year power warranty, PV modules are designed for a long service life, generally over 25 years. For a panel to comply with its 25-year power warranty, its internal components, including lead, must be sealed from any moisture. Otherwise, they would corrode and the panel's output would fall below power warranty levels. Thus, the lead in operating PV modules is not at risk of release to the environment during their service lifetime. In extreme experiments, researchers have shown that lead can leach from crushed or pulverized panels.[15, 16] However, more real-world tests designed to represent typical trash compaction that are used to classify waste as hazardous or non-hazardous show no danger from leaching.[17, 18] For more information about PV panel end-of-life, see the Panel Disposal section.

As illustrated throughout this section, silicon-based PV panels do not pose a material threat to public health and safety. The only aspect of the panels with potential toxicity concerns is the very small amount of lead in some panels. However, any lead in a panel is well sealed from environmental exposure for the operating lifetime of the solar panel and thus not at risk of release into the environment.

b. Cadmium Telluride (CdTe) PV Panels

This subsection examines the components of a cadmium telluride (CdTe) PV panel. Research demonstrates that they pose negligible toxicity risk to public health and safety while significantly reducing the public's exposure to cadmium by reducing coal emissions. As of mid-2016, a few hundred MWs of cadmium telluride (CdTe) panels, all manufactured by the U.S. company First Solar, have been installed in North Carolina.

Questions about the potential health and environmental impacts from the use of this PV technology are related to the concern that these panels contain cadmium, a toxic heavy metal. However, scientific studies have shown that cadmium telluride differs from cadmium due to its high chemical and thermal stability.[19] Research has shown that the tiny amount of cadmium in these panels does not pose a health or safety risk.[20] Further, there are very compelling reasons to welcome its adoption due to reductions in unhealthy pollution associated with burning coal. Every GWh of electricity generated by burning coal produces about 4 grams of cadmium air emissions.[21] Even though North Carolina produces a significant fraction of our electricity from coal, electricity from solar offsets much more natural gas than coal due to natural gas plants being able to adjust their rate of production more easily and quickly. If solar electricity offsets 90% natural gas and 10% coal, each 5-megawatt (5 MW_{AC}, which is generally 7 MW_{DC}) CdTe solar facility in North Carolina keeps about 157 grams, or about a third of a pound, of cadmium *out of* our environment.[22, 23]

Cadmium is toxic, but all the approximately 7 grams of cadmium in one CdTe panel is in the form of a chemical compound cadmium telluride, [24] which has 1/100th the toxicity of free cadmium.[25] Cadmium telluride is a very stable compound that is non-volatile and non-soluble in water. Even in the case of a fire, research shows that less than 0.1% of the cadmium is released when a CdTe panel is exposed to fire. The fire melts the glass and encapsulates over 99.9% of the cadmium in the molten glass.[27]

It is important to understand the source of the cadmium used to manufacture CdTe PV panels. The cadmium is a byproduct of zinc and lead refining. The element is collected from emissions and waste streams during the production of these metals and combined with tellurium to create the CdTe used in PV panels. If the cadmium were not collected for use in the PV panels or other products, it would otherwise either be stockpiled for future use, cemented and buried, or disposed of.[28] Nearly all the cadmium in old or broken panels can be recycled which can eventually serve as the primary source of cadmium for new PV panels.[29]

Similar to silicon-based PV panels, CdTe panels are constructed of a tempered glass front, one instead of two clear plastic encapsulation layers, and a rear heat strengthened glass backing (together >98% by weight). The final product is built to withstand exposure to the elements without significant damage for over 25 years. While not representative of damage that may occur in the field or even at a landfill, laboratory evidence has illustrated that when panels are ground into a fine powder, very acidic water is able to leach portions of the cadmium and tellurium,[30] similar to the process used to recycle CdTe panels. Like many silicon-based panels, CdTe panels are reported (as far back ask 1998[31]) to pass the EPA's Toxic Characteristic Leaching Procedure (TCLP) test, which tests the potential for crushed panels in a landfill to leach hazardous substances into groundwater.[32] Passing this test means that they are classified as non-hazardous waste and can be deposited in landfills.[33, 34] For more information about PV panel end-of-life, see the Panel Disposal section.

There is also concern of environmental impact resulting from potential catastrophic events involving CdTe PV panels. An analysis of worst-case scenarios for environmental impact from CdTe PV panels, including earthquakes, fires, and floods, was conducted by the University of Tokyo in 2013. After reviewing the extensive international body of research on CdTe PV technology, their report concluded, "Even in the worst-case scenarios, it is unlikely that the Cd concentrations in air and sea water will exceed the environmental regulation values."[35] In a worst-case scenario of damaged panels abandoned on the ground, insignificant amounts of cadmium will leach from the panels. This is because this scenario is much less conducive (larger module pieces, less acidity) to leaching than the conditions of the EPA's TCLP test used to simulate landfill conditions, which CdTe panels pass.[36]

First Solar, a U.S. company, and the only significant supplier of CdTe panels, has a robust panel take-back and recycling program that has been operating commercially since 2005.[37] The company states that it is "committed to providing a commercially attractive recycling solution for photovoltaic (PV) power plant and module owners to help them meet their module (end of life) EOL obligation simply, cost-effectively and responsibly." First Solar global recycling services to their customers to collect and recycle panels once they reach the end of productive life whether due to age or damage. These recycling service agreements are structured to be financially attractive to both First Solar and the solar panel owner. For First Solar, the contract provides the company with an affordable source of raw materials needed for new panels and presumably a diminished risk of undesired release of Cd. The contract also benefits the solar panel owner by allowing them to avoid tipping fees at a waste disposal site. The legal contract helps provide peace of mind by ensuring compliance by both parties when considering the continuing trend of rising disposal costs and increasing regulatory requirements.

c. **CIS/CIGS and other PV technologies**

Copper indium gallium selenide PV technology, often referred to as CIGS, is the second most common type of thin-film PV panel but a distant second behind CdTe. CIGS cells are composed of a thin layer of copper, indium, gallium, and selenium on a glass or plastic backing. None of these elements are very toxic, although selenium is a regulated metal under the Federal Resource Conservation and Recovery Act (RCRA).[38] The cells often also have an extremely thin layer of cadmium sulfide that contains a tiny amount of cadmium, which is toxic. The promise of high efficiency CIGS panels drove heavy investment in this technology in the past. However, researchers have struggled to transfer high efficiency success in the lab to low-cost full-scale panels in the field.[39] Recently, a CIGS manufacturer based in Japan, Solar Frontier, has achieved some market success with a rigid, glass-faced CIGS module that competes with silicon panels. Solar Frontier produces the majority of CIS panels on the market today.[40] Notably, these panels are RoHS compliant,[41] thus meeting the rigorous toxicity standard adopted by the European Union even thought this directive exempts PV panels. The authors are unaware of any completed or proposed utility-scale system in North Carolina using CIS/CIGS panels.

1.2.3 Panel End-of-Life Management

Concerns about the volume, disposal, toxicity, and recycling of PV panels are addressed in this subsection. To put the volume of PV waste into perspective, consider that by 2050, when PV systems installed in 2020 will reach the end of their lives, it is estimated that the global annual PV panel waste tonnage will be 10% of the 2014 global e-waste tonnage.[42] In the U.S., end-of-life disposal of solar products is governed by the Federal Resource Conservation and Recovery Act (RCRA), as well as state policies in some situations. RCRA separates waste into hazardous (not accepted at ordinary landfill) and solid waste (generally accepted at ordinary landfill) based on a series of rules. According to RCRA, the way to determine if a PV panel is classified as hazardous waste is the Toxic Characteristic Leaching Procedure (TCLP) test. This EPA test is designed to simulate landfill disposal and determine the risk of hazardous substances leaching out of the landfill.[43,44,45] Multiple sources report that most modern PV panels (both crystalline silicon and cadmium telluride) pass the TCLP test.[46,47] Some studies found that some older (1990s) crystalline silicon panels, and perhaps some newer crystalline silicon panels (specifics are not given about vintage of panels tested), do not pass the lead (Pb) leachate limits in the TCLP test.[48,49]

The test begins with the crushing of a panel into centimeter-sized pieces. The pieces are then mixed in an acid bath. After tumbling for eighteen hours, the fluid is tested for forty hazardous substances that all must be below specific threshold levels to pass the test. Research comparing TCLP conditions to conditions of damaged panels in the field found that simulated landfill conditions provide overly conservative estimates of leaching for field-damaged panels.[50] Additionally, research in Japan has found no detectable Cd leaching from cracked CdTe panels when exposed to simulated acid rain.[51]

Although modern panels can generally be landfilled, they can also be recycled. Even though recent waste volume has not been adequate to support significant PV-specific recycling infrastructure, the existing recycling industry in North Carolina reports that it recycles much of the current small volume of broken PV panels. In an informal survey conducted by the NC Clean Energy Technology Center survey in early 2016, seven of the eight large active North Carolina utility-scale solar developers surveyed reported that they send damaged panels back to the manufacturer and/or to a local recycler. Only one developer reported sending damaged panels to the landfill.

The developers reported at that time that they are usually paid a small amount per panel by local recycling firms. In early 2017, a PV developer reported that a local recycler was charging a small fee per panel to recycle damaged PV panels. The local recycling firm known to authors to accept PV panels described their current PV panel recycling practice as of early 2016 as removing the aluminum frame for local recycling and removing the wire leads for local copper recycling. The remainder of the panel is sent to a facility for processing the non-metallic portions of crushed vehicles, referred to as "fluff" in the recycling industry.[52] This processing within existing general recycling plants allows for significant material recovery of major components, including glass which is 80% of the module weight, but at lower yields than PV-specific recycling plants. Notably almost half of the material value in a PV panel is in the few grams of silver contained in almost every PV panel produced today. In the long-term, dedicated PV panel recycling plants can increase treatment capacities and maximize revenues resulting in better output quality and the ability to recover a greater fraction of the useful materials.[53] PV-specific panel recycling technologies have been researched and implemented to some extent for the past decade, and have been shown to be able to recover over 95% of PV material (semiconductor) and over 90% of the glass in a PV panel.[54]

A look at global PV recycling trends hints at the future possibilities of the practice in our country. Europe installed MW-scale volumes of PV years before the U.S. In 2007, a public-private partnership between the European Union and the solar industry set up a voluntary collection and recycling system called PV CYCLE. This arrangement was later made mandatory under the EU's WEEE directive, a program for waste electrical and electronic equipment.[55] Its member companies (PV panel producers) fully finance the association. This makes it possible for end-users to return the member companies' defective panels for recycling at any of the over 300 collection points around Europe without added costs. Additionally, PV CYCLE will pick up batches of 40 or more used panels at no cost to the user. This arrangement has been very successful, collecting and recycling over 13,000 tons by the end of 2015.[56]

In 2012, the WEEE Directive added the end-of-life collection and recycling of PV panels to its scope.[57] This directive is based on the principle of extended-producer-responsibility. It has a global impact because producers that want to sell into the EU market are legally responsible for end-of-life management. Starting in 2018, this directive targets that 85% of PV products "put in the market" in Europe are recovered and 80% is prepared for reuse and recycling.

The success of the PV panel collection and recycling practices in Europe provides promise for the future of recycling in the U.S. In mid-2016, the US Solar Energy Industry Association (SEIA) announced that they are starting a national solar panel recycling program with the guidance and support of many leading PV panel producers.[58] The program will aggregate the services offered by recycling vendors and PV manufacturers, which will make it easier for consumers to select a cost-effective and environmentally responsible end-of-life management solution for their PV products. According to SEIA, they are planning the program in an effort to make the entire industry landfill-free. In addition to the national recycling network program, the program will provide a portal for system owners and consumers with information on how to responsibly recycle their PV systems.

While a cautious approach toward the potential for negative environmental and/or health impacts from retired PV panels is fully warranted, this section has shown that the positive health impacts of reduced emissions from fossil fuel combustion from PV systems more than outweighs any potential risk. Testing shows that silicon and CdTe panels are both safe to dispose of in landfills, and are also safe in worst case conditions of abandonment or damage in a disaster. Additionally, analysis by local engineers has found that the current salvage value of the equipment in a utility scale PV facility generally exceeds general contractor estimates for the cost to remove the entire PV system.[59, 60, 61]

1.2.4 Non-Panel System Components (racking, wiring, inverter, transformer)

While previous toxicity subsections discussed PV panels, this subsection describes the non-panel components of utility-scale PV systems and investigates any potential public health and safety concerns. The most significant non-panel component of a ground-mounted PV system is the mounting structure of the rows of panels, commonly referred to as “racking”. The vertical post portion of the racking is galvanized steel and the remaining above-ground racking components are either galvanized steel or aluminum, which are both extremely common and benign building materials. The inverters that make the solar generated electricity ready to send to the grid have weather-proof steel enclosures that protect the working components from the elements. The only fluids that they might contain are associated with their cooling systems, which are not unlike the cooling system in a computer. Many inverters today are RoHS compliant.

The electrical transformers (to boost the inverter output voltage to the voltage of the utility connection point) do contain a liquid cooling oil. However, the fluid used for that function is either a non-toxic mineral oil or a biodegradable non-toxic vegetable oil, such as BIOTEMP from ABB. These vegetable transformer oils have the additional advantage of being much less flammable than traditional mineral oils. Significant health hazards are associated with old transformers containing cooling oil with toxic PCBs. Transfers with PCB-containing oil were common before PCBs were outlawed in the U.S. in 1979. PCBs still exist in older transformers in the field across the country.

Other than a few utility research sites, there are no batteries on- or off-site associated with utility-scale solar energy facilities in North Carolina, avoiding any potential health or safety concerns related to battery technologies. However, as battery technologies continue to improve and prices continue to decline we are likely to start seeing some batteries at solar facilities. Lithium ion batteries currently dominate the world utility-scale battery market, which are not very toxic. No non-panel system components were found to pose any health or environmental dangers.

1.4 Operations and Maintenance – Panel Washing and Vegetation Control

Throughout the eastern U.S., the climate provides frequent and heavy enough rain to keep panels adequately clean. This dependable weather pattern eliminates the need to wash the panels on a regular basis. Some system owners may choose to wash panels as often as once a year to increase production, but most in N.C. do not regularly wash any PV panels. Dirt build up over time may justify panel washing a few times over the panels' lifetime; however, nothing more than soap and water are required for this activity.

The maintenance of ground-mounted PV facilities requires that vegetation be kept low, both for aesthetics and to avoid shading of the PV panels. Several approaches are used to maintain vegetation at NC solar facilities, including planting of limited-height species, mowing, weed-eating, herbicides, and grazing livestock (sheep). The following descriptions of vegetation maintenance practices are based on interviews with several solar developers as well as with three maintenance firms that together are contracted to maintain well over 100 of the solar facilities in N.C. The majority of solar facilities in North Carolina maintain vegetation primarily by mowing. Each row of panels has a single row of supports, allowing sickle mowers to mow under the panels. The sites usually require mowing about once a month during the growing season. Some sites employ sheep to graze the site, which greatly reduces the human effort required to maintain the vegetation and produces high quality lamb meat.[62]

In addition to mowing and weed eating, solar facilities often use some herbicides. Solar facilities generally do not spray herbicides over the entire acreage; rather they apply them only in strategic locations such as at the base of the perimeter fence, around exterior vegetative buffer, on interior dirt roads, and near the panel support posts. Also unlike many row crop operations, solar facilities generally use only general use herbicides, which are available over the counter, as opposed to restricted use herbicides commonly used in commercial agriculture that require a special restricted use license. The herbicides used at solar facilities are primarily 2-4-D and glyphosate (Round-up®), which are two of the most common herbicides used in lawns, parks, and agriculture across the country. One maintenance firm that was interviewed sprays the grass with a class of herbicide known as a growth regulator in order to slow the growth of grass so that mowing is only required twice a year. Growth regulators are commonly used on highway roadsides and golf courses for the same purpose. A commercial pesticide applicator license is required for anyone other than the landowner to apply herbicides, which helps ensure that all applicators are adequately educated about proper herbicide use and application. The license must be renewed annually and requires passing of a certification exam appropriate to the area in which the applicator wishes to work. Based on the limited data available, it appears that solar facilities in N.C. generally use significantly less herbicides per acre than most commercial agriculture or lawn maintenance services.

2. Electromagnetic Fields (EMF)

PV systems do not emit any material during their operation; however, they do generate electromagnetic fields (EMF), sometimes referred to as radiation. EMF produced by electricity is non-ionizing radiation, meaning the radiation has enough energy to move atoms in a molecule around (experienced as heat), but not enough energy to remove electrons from an atom or molecule (ionize) or to damage DNA. As shown below, modern humans are all exposed to EMF throughout our daily lives without negative health impact. Someone outside of the fenced perimeter of a solar facility is not exposed to significant EMF from the solar facility. Therefore, there is no negative health impact from the EMF produced in a solar farm. The following paragraphs provide some additional background and detail to support this conclusion.

Since the 1970s, some have expressed concern over potential health consequences of EMF from electricity, but no studies have ever shown this EMF to cause health problems.[63] These concerns are based on some epidemiological studies that found a slight increase in childhood leukemia associated with average exposure to residential power-frequency magnetic fields above 0.3 to 0.4 µT (microteslas) (equal to 3.0 to 4.0 mG (milligauss)). µT and mG are both units used to measure magnetic field strength. For comparison, the average exposure for people in the U.S. is one mG or 0.1 µT, with about 1% of the population with an average exposure in excess of 0.4 µT (or 4 mG).[64] These epidemiological studies, which found an association but not a causal relationship, led the World Health Organization's International Agency for Research on Cancer (IARC) to classify ELF magnetic fields as "possibly carcinogenic to humans". Coffee also has this classification. This classification means there is limited evidence but not enough evidence to designate as either a "probable carcinogen" or "human carcinogen". Overall, there is very little concern that ELF EMF damages public health. The only concern that does exist is for long-term exposure above 0.4 µT (4 mG) that may have some connection to increased cases of childhood leukemia. In 1997, the National Academies of Science were directed by Congress to examine this concern and concluded:

> "Based on a comprehensive evaluation of published studies relating to the effects of power-frequency electric and magnetic fields on cells, tissues, and organisms (including humans), the conclusion of the committee is that the current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects."[65]

There are two aspects to electromagnetic fields, an electric field and a magnetic field. The electric field is generated by voltage and the magnetic field is generated by electric current, i.e., moving electrons. A task group of scientific experts convened by the World Health Organization (WHO) in 2005 concluded that there were no substantive health issues related to *electric* fields (0 to 100,000 Hz) at levels generally encountered by members of the public.[66] The relatively low voltages in a solar facility and the fact that electric fields are easily shielded (i.e., blocked) by common materials, such as plastic, metal, or soil means that there is no concern of negative health impacts from the electric fields generated by a solar facility. Thus, the remainder of this section addresses magnetic fields. Magnetic fields are not shielded by most common materials and thus can easily pass through them. Both types of fields are strongest close to the source of electric generation and weaken quickly with distance from the source.

The direct current (DC) electricity produced by PV panels produce stationary (0 Hz) electric and magnetic fields. Because of minimal concern about potential risks of stationary fields, little scientific research has examined stationary fields' impact on human health.[67] In even the largest PV facilities, the DC voltages and currents are not very high. One can illustrate the weakness of the EMF generated by a PV panel by placing a compass on an operating solar panel and observing that the needle still points north.

While the electricity throughout the majority of a solar site is DC electricity, the inverters convert this DC electricity to alternating current (AC) electricity matching the 60 Hz frequency of the grid. Therefore, the inverters and the wires delivering this power to the grid are producing non-stationary EMF, known as extremely low frequency (ELF) EMF, normally oscillating with a frequency of 60 Hz. This frequency is at the low-energy end of the electromagnetic spectrum. Therefore, it has less energy than other commonly encountered types of non-ionizing radiation like radio waves, infrared radiation, and visible light.

The wide use of electricity results in background levels of ELF EMFs in nearly all locations where people spend time – homes, workplaces, schools, cars, the supermarket, etc. A person's average exposure depends upon the sources they encounter, how close they are to them, and the amount of time they spend there.[68] As stated above, the average exposure to magnetic fields in the U.S. is estimated to be around one mG or 0.1 µT, but can vary considerably depending on a person's exposure to EMF from electrical devices and wiring.[69] At times we are often exposed to much higher ELF magnetic fields, for example when standing three feet from a refrigerator the ELF magnetic field is 6 mG and when standing three feet from a microwave oven the field is about 50 mG.[70] The strength of these fields diminish quickly with distance from the source, but when surrounded by electricity in our homes and other buildings moving away from one source moves you closer to another. However, unless you are inside of the fence at a utility-scale solar facility or electrical substation it is impossible to get very close to the EMF sources. Because of this, EMF levels at the fence of electrical substations containing high voltages and currents are considered "generally negligible".[71, 72]

The strength of ELF-EMF present at the perimeter of a solar facility or near a PV system in a commercial or residential building is significantly lower than the typical American's average EMF exposure.[73, 74] Researchers in Massachusetts measured magnetic fields at PV projects and found the magnetic fields dropped to very low levels of 0.5 mG or less, and in many cases to less than background levels (0.2 mG), at distances of no more than nine feet from the residential inverters and 150 feet from the utility-scale inverters.[75] Even when measured within a few feet of the utility-scale inverter, the ELF magnetic fields were well below the International Commission on Non-Ionizing Radiation Protection's recommended magnetic field level exposure limit for the general public of 2,000 mG.[76] It is typical that utility scale designs locate large inverters central to the PV panels that feed them because this minimizes the length of wire required and shields neighbors from the sound of the inverter's cooling fans. Thus, it is rare for a large PV inverter to be within 150 feet of the project's security fence.

Anyone relying on a medical device such as pacemaker or other implanted device to maintain proper heart rhythm may have concern about the potential for a solar project to interfere with the operation of his or her device. However, there is no reason for concern because the EMF outside of the solar facility's fence is less than 1/1000 of the level at which manufacturers test for ELF EMF interference, which is 1,000 mG.[77] Manufacturers of potentially affected implanted devices often provide advice on electromagnetic interference that includes avoiding letting the implanted device get too close to certain sources of fields such as some household appliances, some walkie-talkies, and similar transmitting devices. Some manufacturers' literature does not mention high-voltage power lines, some say that exposure in public areas should not give interference, and some advise not spending extended periods of time close to power lines.[78]

3. Electric Shock and Arc Flash Hazards

There is a real danger of electric shock to anyone entering any of the electrical cabinets such as combiner boxes, disconnect switches, inverters, or transformers; or otherwise coming in contact with voltages over 50 Volts.[79] Another electrical hazard is an arc flash, which is an explosion of energy that can occur in a short circuit situation. This explosive release of energy causes a flash of heat and a shockwave, both of which can cause serious injury or death. Properly trained and equipped technicians and electricians know how to safely install, test, and repair PV systems, but there is always some risk of injury when hazardous voltages and/or currents are present. Untrained individuals should not attempt to inspect, test, or repair any aspect of a PV system due to the potential for injury or death due to electric shock and arc flash, The National Electric Code (NEC) requires appropriate levels of warning signs on all electrical components based on the level of danger determined by the voltages and current potentials. The national electric code also requires the site to be secured from unauthorized visitors with either a six-foot chain link fence with three strands of barbed wire or an eight-foot fence, both with adequate hazard warning signs.

4. Fire Safety

The possibility of fires resulting from or intensified by PV systems may trigger concern among the general public as well as among firefighters. However, concern over solar fire hazards should be limited because only a small portion of materials in the panels are flammable, and those components cannot self-support a significant fire. Flammable components of PV panels include the thin layers of polymer encapsulates surrounding the PV cells, polymer backsheets (framed panels only), plastic junction boxes on rear of panel, and insulation on wiring. The rest of the panel is composed of non-flammable components, notably including one or two layers of protective glass that make up over three quarters of the panel's weight.

Heat from a small flame is not adequate to ignite a PV panel, but heat from a more intense fire or energy from an electrical fault can ignite a PV panel.[80] One real-world example of this occurred during July 2015 in an arid area of California. Three acres of grass under a thin film PV facility burned without igniting the panels mounted on fixed-tilt racks just above the grass.[81] While it is possible for electrical faults in PV systems on homes or commercial buildings to start a fire, this is extremely rare.[82] Improving understanding of the PV-specific risks, safer system designs, and updated fire-related codes and standards will continue to reduce the risk of fire caused by PV systems.

PV systems on buildings can affect firefighters in two primary ways, 1) impact their methods of fighting the fire, and 2) pose safety hazard to the firefighters. One of the most important techniques that firefighters use to suppress fire is ventilation of a building's roof. This technique allows superheated toxic gases to quickly exit the building. By doing so, the firefighters gain easier and safer access to the building, Ventilation of the roof also makes the challenge of putting out the fire easier. However, the placement of rooftop PV panels may interfere with ventilating the roof by limiting access to desired venting locations.

New solar-specific building code requirements are working to minimize these concerns. Also, the latest National Electric Code has added requirements that make it easier for first responders to safely and effectively turn off a PV system. Concern for firefighting a building with PV can be reduced with proper fire fighter training, system design, and installation. Numerous organizations have studied fire fighter safety related to PV. Many organizations have published valuable guides and training programs. Some notable examples are listed below.

- The International Association of Fire Fighters (IAFF) and International Renewable Energy Council (IREC) partnered to create an online training course that is far beyond the PowerPoint click-and-view model. The self-paced online course, "Solar PV Safety for Fire Fighters," features rich video content and simulated environments so fire fighters can practice the knowledge they've learned. www.iaff.org/pvsafetytraining
- Photovoltaic Systems and the Fire Code: Office of NC Fire Marshal
- Fire Service Training, Underwriter's Laboratory

- Firefighter Safety and Response for Solar Power Systems, National Fire Protection Research Foundation
- Bridging the Gap: Fire Safety & Green Buildings, National Association of State Fire Marshalls
- Guidelines for Fire Safety Elements of Solar Photovoltaic Systems, Orange County Fire Chiefs Association
- Solar Photovoltaic Installation Guidelines, California Department of Forestry & Fire Protection, Office of the State Fire Marshall
- PV Safety & Firefighting, Matthew Paiss, Homepower Magazine
- PV Safety and Code Development: Matthew Paiss, Cooperative Research Network

Summary

The purpose of this paper is to address and alleviate concerns of public health and safety for utility-scale solar PV projects. Concerns of public health and safety were divided and discussed in the four following sections: (1) Toxicity, (2) Electromagnetic Fields, (3) Electric Shock and Arc Flash, and (4) Fire. In each of these sections, the negative health and safety impacts of utility-scale PV development were shown to be negligible, while the public health and safety benefits of installing these facilities are significant and far outweigh any negative impacts.

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