Minutes

August 5, 2021

Commissioners present: Timothy Bechtol, Michael Pepple and William Bateson.

Also Present: Tammy Erwin, Cindy Land, Phil Johnson, James Sammet, Adam Witteman and Mary Ann LaRoche.

Commissioner Bechtol opened the meeting at 9:30 a.m. in the Commissioner's 1st floor conference room. The Pledge of Allegiance was recited. Minutes from the August 3rd, 2021 meeting were read with William Bateson making a motion to approve, Michael Pepple seconded. Motion passed 3-0. Minutes from the August 4th, 2021 meeting were read with William Bateson making a motion to approve, Michael Pepple seconded. Motion passed 3-0.

The Assistant Clerk presented the following resolutions for consideration:

Resolution #512-21 — Additional appropriation within the Auditor's certification — Commissioner's to appropriate to Juvenile Court Specialized Docket. William Bateson made a motion to approve, Michael Pepple seconded. Motion passed 3-0.

Resolution #513-21 — Transfer of Hancock County Solid Waste Management District Tier Disposal Fees to the Tiered Disposal Fee Fund. William Bateson made a motion to approve, Michael Pepple seconded. Motion passed 3-0.

Resolution #514-21 — Transfer of funds within the Appropriation — Buildings & Grounds-Maintenance. William Bateson made a motion to approve, Michael Pepple seconded. Motion passed 3-0.

Resolution #515-21 — Transfer of funds within the Appropriation — Veterans Services-Soldiers Relief. William Bateson made a motion to approve, Michael Pepple seconded. Motion passed 3-0.

Resolution #516-21 – Additional appropriation within the Auditor's certification – Commissioner's to appropriate to Housing Trust Fund. William Bateson made a motion to approve, Michael Pepple seconded. Motion passed 3-0.

William Bateson made a motion to approve the Warrant Journal, Michael Pepple seconded. Motion passed 3-0.

The Commissioners signed a position authorization form for JFS and two travel requests for the Sheriff. James Sammet, Maintenance Supervisor, has been getting quotes for window cleaning for 514 S. Main St. and the Courthouse. He presented those quotes to the Commissioners for their review and explained the process of the window cleaning as well as trimming greenery that has grown over some of the windows. The Commissioners agreed to go with Aloha as they had the lowest quote. Lucinda Land will prepare a resolution for next week.

Lucinda Land presented the following resolution for consideration:

Resolution #517 -21 —Authorization to enter into Change Order #1 to the contract with the Weber Company LLC., of Archbold, Ohio for the maintenance construction of the Dalzell Single County Ditch Maintenance Project. Lucinda stated that the change amount was \$10,577.00 for a total of \$47,552.45. William Bateson made a motion to approve, Michael Pepple seconded. Motion passed 3-0.

Phil Johnson presented the following resolution for consideration:

Resolution #518-21 – Authorization to approve execution of Memorandum of Understanding between Habitat for Humanity of Findlay/Hancock County, Inc., Great Lakes Community Action Partnership, and the Board of Hancock County Commissioners. William Bateson made a motion to approve, Timothy Bechtol seconded. Michael Pepple abstained. Motion passed 2-0.

Phil Johnson requested an executive session to discuss potential real estate acquisition and pending litigation.

Adam Witteman had nothing to report.

Meetings/Reports

William Bateson attended the special public meeting with Kasey Corbet regarding plan design for the Juvenile Probate Court building. He spent some time on the roof at the Findlay Village Mall. He stated that the majority of the roof looked good with some repairs needed. William attended the monthly Township Trustee meeting and he invited Senator McColley and Representative Jon Cross to attend to explain SB #52. He stated that Lucinda Land was there as well as the other two Commissioners. He also attended the Soil & Water meeting on Tuesday and Economic Development meeting this morning.

Michael Pepple attended the Soil & Water annual meeting on Tuesday night and the Township Trustee meeting at the Engineer's office.

Timothy Bechtol attended the Soil & Water meeting as well on Tuesday and attended the Township Trustee meeting on Wednesday. Trustee Gosche, from Marion Township gave a report about the mall roof and he was convinced that there is no portion of that roof that is over 30 years old right now, stating that it was all replaced back when they did renovations. William Bateson stated that the type of roof on there is a rubber roof called EPDM and they put a stamp on it stating how thick it is and the year. There was none over 2001 that he saw. Timothy stated that they are on Day 50 of the 75 day due diligence. Also, last Friday, Timothy sat in with Governor DeWine and Lt. Governor Husted to discuss NW Ohio issues. Solar Farms and Rural Broadband were the topic of discussion. Also, how to spend the new Federal dollars was discussed.

At 9:55 a.m. Timothy Bechtol made a motion to enter into executive session to discuss potential real estate acquisition, pending litigation and economic development. Michael Pepple seconded. A roll call vote resulted as follows: Timothy Bechtol, yes; Michael Pepple, yes; William Bateson, yes.

At 11:02 a.m., Timothy Bechtol made a motion to come out of executive session, having discussed potential real estate acquisition, pending litigation and economic development with no action taken. Michael Pepple seconded. Motion passed 3-0.

At 11:02 a.m. the Commissioners held a bid opening for the demolition of flood property at 119 Clinton Court. The bids were as follows:

All Excavating & Demo	\$6,797.50	
Advance Demolition	\$11,900.00	
Baumann Enterprises	\$33,000.00	
K-Cam Excavating	\$41,000.00	

The Commissioners will review the bids before making a decision.

At 11:15 a.m. the Commissioners met with Sheriff Heldman regarding portable radios. Others present included Tammy Erwin, Lucinda Land, Lt. Mark Price and Captain Ryan Kidwell. Sheriff Heldman discussed the need to update the portable radios. He stated that they have gotten 13 years out of the Motorola radios that were purchased back in 2008 by a 7 county grant that Hancock County was part of. They have lost some radios that cannot be repaired. They have received quotes from Radio Hospital and Motorola, which have been 50% less than retail price for 365 radios which includes the Sheriff's office and all county volunteer fire departments. Lt. Mark Price talked about the importance of radios and communication especially because of officer safety. He explained a situation where two radios failed and that was very scary. There are four other items that need to be upgraded as well and he submitted a breakdown of them to the Commissioners. The first being a new amplifier for lower and upper levels. The pager system went out this past weekend and fortunately Radio Hospital got it up and running right away. Updating the jail console-Level 2 is another item needed and Sheriff Dispatch Console Radios. In 2025, MARCS system will be changing the way they authenticate the way the Sheriff enters the system. They have a 2-system way now and it will be changing to a 3-system. The problem was that MARCS radio I.D's were getting pirated. They were getting stolen and they were being used and monitored. They would really like to purchase Kenwood radios through Radio Hospital. The radios are really improving and life expectancy is 10-20 years. The radios are readily available and they would like to buy an extra 18 radios to be used for floaters. Trade-ins are possible and they are still working on that. Lt. Price stated how Radio Hospital's maintenance is seamless and very easy to work with. They are also very quick to get things resolved and will handle the whole package. Motorola only sells the radios so they would need to find someone to provide maintenance service at an additional cost. Sheriff Heldman stated

that he talked with Charity regarding funding with ARP. They briefly discussed mobile devises on shoulder vs. on their belt. Lt. Price stated that they wear ear pieces which is an extension from the belt. William Bateson asked the Sheriff to bring in a couple of examples to the Commissioners and Lucinda Land stated that Charity needs to be involved in this regarding the funding and possible use of ARP funds. Timothy Bechtol updated Sheriff Heldman regarding the meeting held with Kasey Corbet yesterday. Capt. Kidwell discussed the P.O.N.I. training and stated that the last 2 hours will be the unveiling of the master plan and asked the Commissioners if they wanted community members there, business people there or just them? Something he wants the Commissioners to think about. Michael Pepple asked if they have a list of who has been invited or will be attending. Captain Kidwell stated that he does and will get a copy to each of the Commissioners.

At 1:30 p.m. the Commissioners met with Ed Lentz at the OSU Extension office. Others present included: Tammy Erwin, Doug Cade, Eric Romich, Jennifer Little and Tori Kirian. Eric Romich, an expert on solar panels, introduced himself. He works statewide with the Extension Office and is housed in Wyandot County. His title is Field Officer, Energy Education. Eric stated that he is here to help everyone understand what to expect in the process of Solar Farms and did a power point presentation (see attached) to cover many of the questions the Commissioners had. Timothy Bechtol thanked him and stated that it was nice to have an expert opinion. After the presentation, the Commissioners joined Ed Lentz outside to tour the new landscaping that was done by Master Gardeners.

Respectfully submitted,

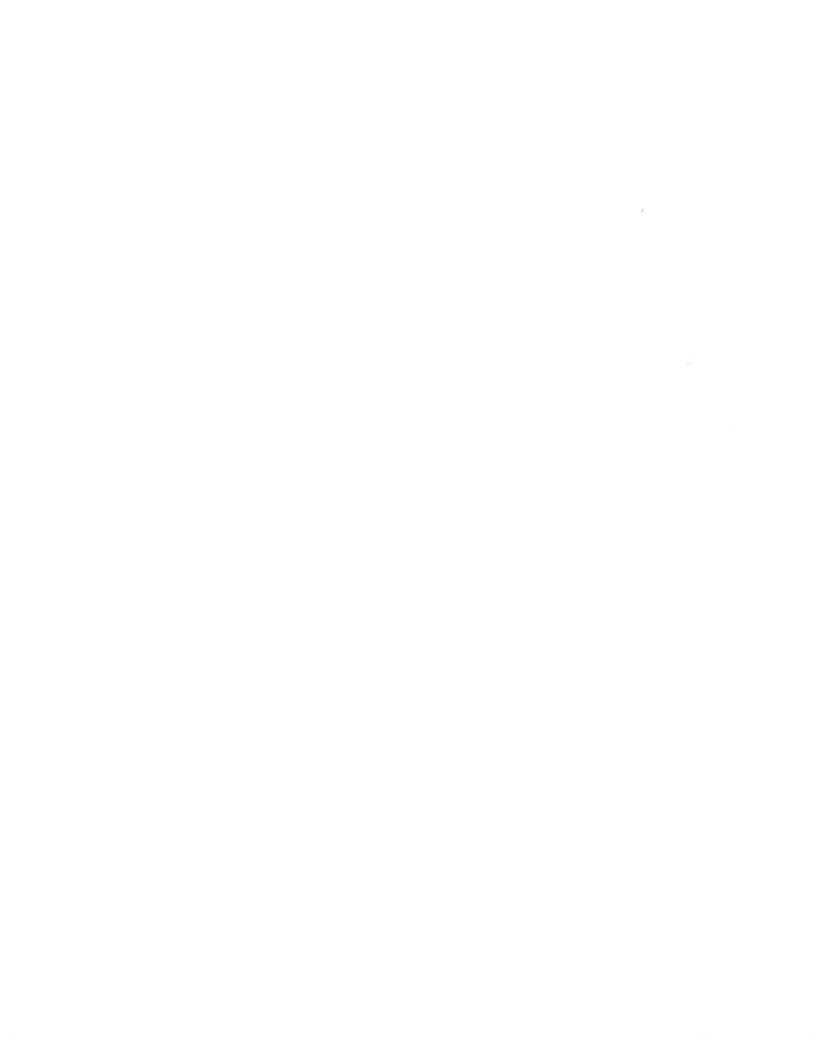
Tammy Erwin, Assistant Clerk

Reviewed and approved by:

Timothy K. Bechtol

Michael W. Pepple

William L. Bateson





Ross County Solar

Exhibit N

Decommissioning Plan

Case No. 20-1380-EL-BGN

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1. Introduction

Ross County Solar, LLC (Ross County Solar) is a proposed up to 120 MW solar photovoltaic electric generating facility in Ross County, Ohio (the Facility). The Facility will span approximately 1,400 acres and will connect to the electrical grid via the existing Buckskin substation. The operational life of the Facility is anticipated to be approximately 30 years. This Decommissioning Plan (Plan) describes the procedures, estimated costs, and financial assurances associated with decommissioning the Facility.

The goals for the Plan are to provide the procedures for restoring the site to agricultural use, or other economical land uses as desired by the relevant landowner, at the end of the Facility's operational life. The Plan describes procedures and estimated costs for removal of Facility components. The components of the Facility to be decommissioned are described in detail in Ross County Solar's Application for a Certificate of Environmental Compatibility and Public Need (Application) and the associated preliminary Facility layout.

2. Project Components

The Application and the preliminary Facility layout provide detailed information regarding the anticipated location and description of each of the Facility components. The Facility generally consists of the equipment and infrastructure outlined below:

- Steel Piers and Racking
- PV Panels
- Inverters
- Electrical Collection Lines
- Access Roads
- Fencing, Gating, and Safety Features
- Operations and Maintenance Building
- Weather Stations
- Project Substation

3. Permitting

Prior to the commencement of decommissioning, Ross County Solar will obtain the necessary local, state, and federal permits and permissions to complete decommissioning activities. Ross County Solar will assess the necessary permits and approvals in the future regulatory environment to ensure compliance. Currently, Ross County Solar would anticipate an evaluation of the following permits and permissions:

 Compliance with Section 404 of the Clean Water Act. Ross County Solar would anticipate temporary wetland impacts permitted by a nationwide permit issued by the United States Army Corps of Engineers.

- Development and implementation of a Stormwater Pollution Prevention Plan (SWPPP) in accordance with Ohio EPA General Construction Stormwater Permit No. OHC000005 or future permit iteration.
- Ross County building, road, or erosion control permits (as necessary).
- Ross County Soil and Water Conservation District permit for activity that involves the crossing, modifying, or discharge of stormwater into a county drain.
- Special state or local hauling permits (as necessary).

Decommissioning

Upon the end of the Facility's life, the decommissioning and site-restoration process would be initiated. At least 30 days prior to the commencement of decommissioning activities, Ross County Solar will notify Ohio Power Siting Board (OPSB) staff. The following general decommissioning activities will occur:

- Removal of panels
- Removal of weather stations, inverters, electrical equipment, racking, and scrap
- Removal of piles
- Removal of access roads
- Removal of electrical collection lines
- Removal of fencing
- Removal of substation

Some components may be left in place under certain circumstances. Electrical lines that will not impact future use of the Project Area (at least 48 inches in depth) may be left in place. Steel piles, where full removal is unattainable, may be cut and left in place at a depth of 48 inches greater below the ground surface. The Project substation may remain should another agreement necessitate its continued use. AEP-owned infrastructure at the substation is not subject to decommissioning. Additionally, landowners may desire that private access roads remain in place for their personal use. Should a landowner request a road or structure (such as the O&M building) remain in place, Ross County Solar will obtain a written request from said landowner.

5. Materials Salvage, Recycling, and Disposal

Many components of the Facility, such as racking, wiring, piles, and the panels themselves, retain value over time. Panels, while slightly less efficient, may be reused elsewhere, or components may be broken down and recycled. Recycling of solar panels and equipment is rapidly evolving and can be handled through a combination of sources such as certain manufacturers, PV Cycle (an international waste program founded by and for the PV industry), or waste management companies. More than 90 percent of the semiconductor material and glass can be reused in new modules and products. Other waste materials that hold no value will be recycled or disposed of via a licensed solid waste disposal facility.

6. Site Restoration

Following the completion of decommissioning activities, the site will primarily be converted back to pre-construction land uses. The land will be graded as necessary, though minimal grading is expected to be required, and decompacted to allow for productive agricultural use. For areas not to be returned to agricultural use, soils will be decompacted and reseeded to establish adequate vegetative cover. Topsoil conditions will be assessed to identify necessary topsoil additions or redistribution across the site to ensure productivity. Decommissioning of the Facility, including the removal of materials followed by site restoration, will be completed in approximately 12-18 months.

7. Cost Estimate

Ross County Solar contracted with Westwood Professional Services (an Ohio-licensed engineering firm) to obtain a cost estimate for the decommissioning activities summarized above, based on the preliminary Facility layout provided with Ross County Solar's Application. Based on current recycling costs and salvage values, the net cost of decommissioning the Facility is estimated to be approximately \$4,694,666. A decommissioning estimate is provided in Appendix A. These costs will not change significantly from the preliminary Facility layout to the final design.

8. Financial Assurance

Ross County Solar will post a performance bond with the OPSB as the obligee based on the net costs of decommissioning, calculated to be \$4,694,666, prior to the commencement of commercial operation of the Project. Following commencement of commercial operation, Ross County Solar will reevaluate decommissioning costs through an Ohio-licensed engineering firm or professional engineer every five years thereafter during the life of the Project. If this evaluation shows that the net decommissioning cost for the Project has increased, Ross County Solar will increase the amount of the performance bond accordingly.

Appendix A Decommissioning Estimate

Westwood

Based on ratios, previous decommissioning estimates

Project Name: Ross County Solar, OH Date: October 06,2020 WPS Project Number: 0028444 By: CVA/JTW

			405.40	MW-AC
Project Size	164.33 Quantity	MW-DC Unit	126.40 Unit Cost	Total Cost
22-hillippins (Pamakilippins	Quantity 1	Lump Sum	\$1,032,800.00	\$1,032,800
Mobilization/Demobilization Mobilization was estimated to be approximately 7% of total cost of other			***************************************	V-1
speaking with contractors.				
Permitting	_	v = 400	\$10,000.00	\$10,000
State Permits	1	Lump Sum	\$10,000.00	\$10,000
Subtotal Permitting Decommissioning will require a SWPPP and SPCC plan, cost is an estima	te of the permit r	renaration cost		410,000
Decommissioning wai require a Sweet and Secreptant, cost is an estand	ite of the bennit	reparador cost		
Civil infrastructure				
Removal Gravel Surfacing from Road	25,490	Cubic Yards (BV)	\$2.27	\$57,747
Haul Gravel Removed from Road	31,862	Cubic Yards (LV)	\$8.94	\$284,848
Disposal of Gravel Removal from Road	43,014	Tons	\$0.00	\$0
Grade Road Corridor (Re-spread Topsoil)	64,521	Linear Feet	\$1.23	\$79,502
Erosion and Sediment Control for Road Restoration	0	Linear Feet	\$1.81 \$11,277.20	\$0 \$400,890
Revegetation on Removed Road Area	35.55 80,950	Acres Linear Feet	\$6.00	\$485,700
Removal of Security Fence Subtotal Civil Infrastructure	80,530	Laigas Feet	40.00	\$1,308,688
Civil removal costs are based on RS Means cost for El Paso, TX and indu	estry standards on	ovided to Westwood		
CITILITIES COSC SIC DESCE ON TO INCOME COST OF EACH COST, IN SECOND	,			
Structural Infrastructure				
Removal Tracker Row Foundation Posts	60,294	Each	\$13.00	\$783,822
Haul Tracker Row Steel Post	4,070	Tons	\$11.20	\$45,582
Removal Drive Motor Posts	4,638	Each	\$15.00	\$69,570 \$4,987
Haul Drive Motor Posts	445	Ton	\$11.20 \$175.00	\$4,987 \$811,650
Removal of Tracker Row Racking	4,638 8,949	Each Ton	\$173.00	\$100,230
Haul Tracker Row Racking Subtotal Structural Infrastructure	0,343	1011	¥	\$1,815,841
Steel removal costs were calculated by using information from array ma	anufacturers for in	stallation rates and using t	he same	********
rates to calculate total days to remove equipment. Hauling calculations	are based on the	locations of metals recycle	rs.	
Electrical Collection/Transmission System				*
Removal of PV Panels	365,178	Each	\$13.00	\$4,747,314
Freight PV Panels for Resale - 95% of Panels - West Chester, NY	9,407	Tons	\$179.48	\$1,688,415 \$5,545
Freight PV Panels for Disposal - 5% of Panels - Wilmington, OH	495 495	Tons	\$11.20 \$75.00	\$37,134
Disposal of PV Panels	185	Tons Each	\$60.00	\$11,100
Removal of Combiner Boxes/String Inverters Removal of Pad Mounted Inverter and Transformer	37	Lump Sum	\$4,000.00	\$148,000
Disassembly and Removal of Main Power Transformer(s)	1	Each	\$4,500.00	\$4,500
Freight Transformer(s) Offsite	1	Each	\$3,400.00	\$3,400
Disposal of Transformer (Including Oil)	1	Each	\$0.00	\$0
Excavate Around Transformer Foundation(s)	1	Each	\$1,600.00	\$1,600
Remove Complete Transformer Foundation(s)	1	Each	\$5,800.00	\$5,800
Backfill Excavation Area from Transformer Foundation Removal	1	Each	\$738.00	\$738
Freight Concrete (Transformer, Switch Gear, etc. Foundations)	280	Tons	\$11.20 \$75.00	\$3,140 \$21,030
Disposal of Concrete from Transformer Foundation	280	Tons		
Remove, Haul, and Dispose of Timber Distribution Poles	1	Each	\$1,000.00 \$5.96	\$1,000 \$4,768
Remove and Haul Overhead Power Cables	800 1	Linear Feet Each	\$500.00	\$500
Removal of Scada Equipment Removal of DC Collector System Cables (copper)	88,335	Linear Feet	\$1.36	\$120,136
Removal of Underground (AC) Collector System Cables	48,776	Linear Feet	\$1.36	\$66,335
Hauf Cables for Recycling	311.0	Tons	\$11.20	\$3,483
Removal of Fiber Optic Cable	48,776	Linear Feet	\$2.01	\$98,040
Subtotal Electrical Collection/Transmission System				\$6,971,979
Electrical removal costs of PV Panels and Combiner Boxes were based in				
rates of a two man work crew. PCU Station, MV Equipment and Scada E	quipment remova	al cost are based on remova	al of	
equipment, concrete pads, and conduits using a truck mounted crane a			lation rates.	
Cable removal assumed are pulled out with a small buildozer using indu	istry standard pro	OUCTION Faltes.		
Site Restoration				
Stabilized Construction Entrance	1	Each	\$2,000.00	\$2,000
Perimeter Controls	26,500	Linear Feet	\$1.81	\$47,965
Permanent Seeding on area within Removed Array	927.0	Acres	\$4,307.60	\$3,993,145
Subtotal Site Restoration				\$4,043,110
Site restoration costs are based on past solar project experience.				
Project Management	30	weeks	\$3,800.00	\$114,000
Project Manager	55	weeks	\$3,525.00	\$193,875
Superintendent Field Engineer	110	weeks	\$2,325.00	\$255,750
Clerk	55	weeks	\$750.00	\$41,250
Subtotal Project Management				\$604,875
Project Management costs are based on past solar project experience.				
A half-time PM with a half-time superintendent, a field engineer, and a	clerk onsite			

Westwood

Standard industry weekly rates from RS Means. 55 week schedule used

Contingency \$1,474,449.34
10% of construction total (minus Mobilization/Demobilization/Permitting)

Subtotal Demolition/Removals \$17,261,742.77

Salvage				
Fencing	405	Tons	\$161.25	\$65,266
Steel Posts	4,515	Tons	\$161.25	\$728,059
Module Racking	8,949	Tons	\$161.25	\$1,443,049
PV Modules @ 80% We Recycle Estimate	346,919	Each	\$25.20	\$8,742,361
Inverters and Transformers	37	Each	\$32,773.35	\$1,212,614
Substation	1	Each	\$50,000.00	\$50,000
Scada Equipment	1	Each	\$0.00	\$0
DC Collection Lines	345,147	Pounds	\$0.73	\$251,957
AC Collection Lines	137,715	Pounds	\$0.53	\$72,300
AC Distribution Lines	2,800	Pounds	\$0.53	\$1,470

Salvage values are a combination of the following factors; current market metal salvage prices, current secondary market for solar panelmodule recycling, discussions with national companies that specialize in recycling and reselling electrical transformers and inverters, and the assumption that care is taken to prevent any damage or breakage of equipment.

Subtotal Salvage \$12,567,077

Total Demolition Minus Salvage \$4,694,666

Notes:

- 1. Prices used in analysis are estimated based on research of current average costs and salvage values.
- 2. Prices provided are estimates and may fluctuate over the life of the project.
- 3. Contractor means and methods may vary and price will be affected by these.

This foregoing document was electronically filed with the Public Utilities

Commission of Ohio Docketing Information System on

10/30/2020 4:03:41 PM

in

Case No(s). 20-1380-EL-BGN

Summary: Application Application Exhibit N electronically filed by Mr. Michael J. Settineri on behalf of Ross County Solar, LLC



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Forage as Vegetative Cover for Utility-Scale Solar in Ohio

Farm Energy Fact Sheet Series

CDFS-4106

Community Development

Date: 06/24/2021

Christine Gelley, Educator, Agriculture and Natural Resources, Ohio State University Extension, Noble County

James Morris, Educator, Agriculture and Natural Resources and Community Development, Ohio State University Extension, Brown County

Eric Romich, Associate Professor and Field Specialist, Energy Education and Community Development, Ohio State University Extension

The Midwest has seen an increase in photovoltaic (PV) solar energy production over the past several years. Nowhere is this more evident than in Ohio. Traditional ground cover options for utility-scale solar projects includes stone, gravel, bare earth, and various types of turfgrass vegetation. However, as the buildout of utility-scale solar projects increases, many are exploring the feasibility of dual land-use strategies that incorporate agricultural and conservation practices with solar production. Popular examples include pairing solar production with specialty vegetable crop production, livestock grazing, and pollinator habitats. However, as the size of utility-scale projects in Ohio has evolved from 100- to 200-acre projects into projects that are 2,000 acres or more, widespread integration of these practices faces real, common challenges:

- Growing specialty crops is labor intensive, requiring access for many people within the utility-scale solar site
- Raising livestock requires massive herds, frequent watering, and additional fencing to rotate the animals.
- Creating pollinator habitats requires expensive seed mixes and the control of noxious and invasive weeds.

This fact sheet provides developers and landowners information about alternative vegetative cover strategies—including forage crops—that prevent greenwashing opportunities while also offering legitimate benefits to the landowner and the solar developer over the project lifecycle. Topics include common vegetative cover strategies and how cool-season forage crops can provide the greatest environmental, social, and economic benefit. This fact sheet also summarizes the requirements of utility-scale solar vegetative cover, species selection, establishment, and site maintenance.

Solar Industry in Ohio

The Solar Market Insight Report 2020 Q2 estimates more than 80 gigawatts of utility-scale PV solar capacity additions are expected nationwide by 2025 (Wood Mackenzie 2020). Based on the average total direct land requirement for utility-scale PV solar project development of 7.9 acres per megawatt, it would take roughly 526,666 acres to develop 80 gigawatts (DC) of utility-scale PV solar across the United States. (Ong et al. 2013). The U.S. Office of Renewable Energy and Energy Efficiency defines utilityscale renewable energy projects as 10 megawatts or larger (USDOE 2020). However, this is not always an accurate definition, as there are now examples of projects larger than 10 MW that are installed behind the meter to serve individual business or industrial loads. This fact sheet defines a utility-scale solar project as a solar electric generation facility that is interconnected to the distribution or transmission grid, supplying an off-taker (usually a utility

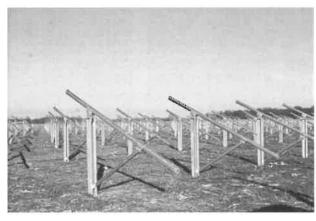


Figure 1: Utility-scale solar project under construction in northwest Ohio. *Photo: Eric Romich*

with a power purchase agreement) with the energy generation (Figure 1).

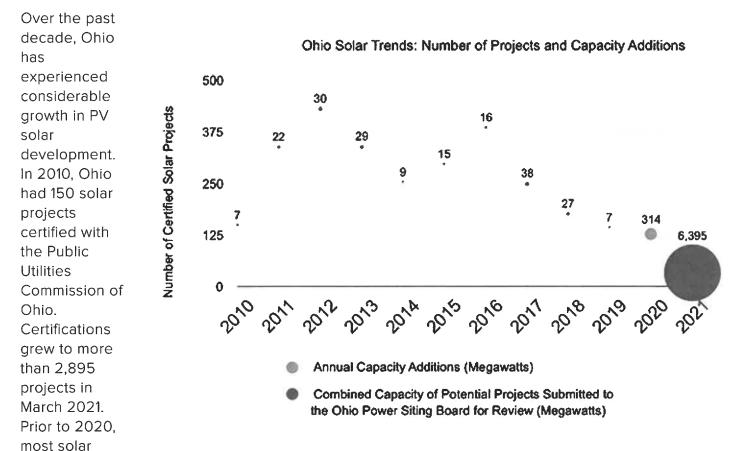


Figure 2: Ohio solar trends: number of projects and capacity additions.

small projects located on homes, farms, and businesses. In fact, between 2010 and 2020, certified solar

projects in Ohio were projects totaled 2,895 in Ohio, which yielded a combined installed capacity of 513 megawatts, or an average of 47 megawatts of capacity additions per year. While small scale behind-the-meter solar project development is expected to continue, significant growth is also projected for utility-scale solar projects. As of March 2021, there were 35 utility-scale PV solar projects submitted to the Ohio Power Siting Board, representing over 6,395 megawatts of potential electric generation capacity (Figure 2). Combined, these 35 utility-scale PV solar projects represent a footprint of over 60,000 acres of land to support the planned solar development in Ohio (Ohio Power Siting Board, 2021). Based on the amount of land leasing activity throughout the state, it is obvious that additional projects are currently under development and that more utility-scale solar projects will likely be submitted for review.

Community Concerns

Although solar energy is green and renewable, it is not without conflict. When it's compared to other energy sources, PV solar technology has a lower power density, which is defined as the amount of energy per unit volume. But power density can also be defined in other ways based on the technology application. According to Power Density Primer: Understanding the Spatial Dimension of the Unfolding Transition to Renewable Electricity Generation (Smil 2010), power density is the rate of transfer of energy per unit of horizontal surface area of land or water, expressed as a ratio of watt per square meter (W/m2). Due to the low power density of PV solar, utility-scale PV solar projects require large tracts of land, often involving thousands of acres. And while a utility-scale PV solar facility is often referred to as a temporary land-use conversion, they often include terms with an overall lifespan of 40 years or more. In addition, establishing a utility-scale PV solar facility may take an existing agricultural or forested land out of production and resuming such operations in the future will be a challenge (Coffey 2019). Due to the overall size and length of these projects, common concerns from landowners, neighbors, and community members are often related to impacts on the land, such as subsurface drainage, surface erosion, loss of wildlife habitats, and long-term soil health. The vegetative cover selected for a utility-scale PV solar development is a key component in solving these issues.

Characteristics of Utility-Scale Solar Vegetative Cover

Identifying a vegetation cover that minimizes the land use impacts can provide benefits to solar developers, project owners, landowners, and neighbors. For example, vegetative seed mix options can lower project installation and maintenance costs while providing wildlife and pollinator habitat, minimizing runoff, adding soil organic matter, and preventing the loss of soil carbon sequestration capacity. The challenge is identifying the seed mix that provides the desired benefits while meeting the performance needs of the solar developers. Solar developers are often contractually obligated to meet criteria outlined in a power purchase agreement with an entity that will buy the electrical generation from the project. As a result, developers are hesitant to adopt new vegetative cover practices that add liability and/or lower electricity production. For example, utility-scale solar developers are interested in seed mix options that are cost competitive, lower ongoing maintenance costs, and that control weed growth. It is essential that the seed mix cultivates low-height plants that will not exceed a height of 18 to 24 inches and that can thrive in low sunlight conditions underneath the PV solar modules. Utility-scale solar projects are industrial electric generation facilities with many tight spaces and obstructions. The vegetative cover must account for the limited ability to use large machinery to maintain the site.

Current Seeding Trends in the Midwest

Vegetative cover options typically used in the Midwest are turfgrass or pollinator plantings. These may include various types of plants including grasses (e.g., Kentucky bluegrass), legumes (e.g., clovers), and forbs (e.g., wildflowers) in various combinations. In Ohio, the most commonly utilized species are coolseason plants. Regardless of the vegetative cover chosen for the site, periodic maintenance to remove excessive growth is required. Turfgrass requires frequent mowing to maintain the appearance of a lawn. Pollinator mixes require mowing at the end of the growing season to self-seed and remove excess biomass. Depending on the goals of the developer, the design of the system, and the siting regulations, the cover that is best suited to the site could be a pure seeding of one plant species or a diverse mix of many.

Turfgrass plantings usually consist of pure grass species and provide excellent ground cover but do not fix nitrogen. A pure turfgrass stand does not provide food or habitat for pollinators such as bees and butterflies. Turfgrass varieties are not developed for animal consumption and should not be used as animal feed. In Ohio, it is best to use mixes that include cool-season grasses such as tall and fine fescues, perennial ryegrass, and Kentucky bluegrass (Sherratt, Street, and Gardner 2017). These mixes are low growing and tolerate frequent mowing. Mature tall fescue can reach heights between three to four feet, while mixes of fine fescue, perennial ryegrass, and Kentucky bluegrass reach two to three feet if left unmowed.

Pollinator mixes may provide adequate ground coverage and excellent benefits to pollinators but typically have more plant species per mix than other vegetative covers. These mixes also include a variety of annual and perennial species. Mixes typically include varieties of clover, coneflowers, milkweeds, various other wildflowers from the Aster family, and some grasses. To achieve maximum pollinator benefit and maintain season-long appeal, select a variety of species that flower at different times throughout the growing season (Ellsworth 2015). It is best practice to utilize mixes that include species native to the region. Maintenance height of these stands varies greatly depending on the selections. Warm-season grasses that thrive in Ohio's climate typically do not satisfy developers' height thresholds (Sulc, Barker, and Tilmon 2017) and therefore are not discussed in this fact sheet.



Figure 3: Unmowed cool-season pasture mix in early spring that includes tall fescue, orchardgrass, and reed canarygrass (April 10, 2019). *Photo: Christine Gelley*

The standard expectations for turfgrass systems are that they require frequent mowing and significant consumption

of energy and investment to maintain an appealing aesthetic while providing limited benefit for the surrounding ecosystem. For pollinator plantings to successfully maintain long-term ecosystem benefits, mowing should be avoided until after the peak growing season when flowering has subsided. However, weed populations may thrive under the same conditions. In naturalized prairies the most effective method for biomass removal and weed control is prescribed fire (NRCS 2020; ODNR 2021). When fire is not

feasible, spot spraying with herbicides is most effective. When neither are employable, hand pulling weeds is required as a last resort. Preventing the establishment of noxious and invasive weeds is critical for the site manager and surrounding landowners. Control of problematic weeds is a severe challenge in pollinator stands and is legally required to preserve environmental health (Hall 2018; Ohio Administrative Code 901:5-37-01; Ohio Revised Code § 731.51 to § 731.53).

Other options for vegetative cover also offer soil stabilization, carbon sequestration, pollinator value, and marketable products. Ohio and neighboring states are investigating cool-season pasture mixes as an option. Depending on the scale, panel height, alley spacing of the solar site, and local siting regulations, these plantings could either be intensively grazed by sheep or harvested for hay (American Solar Grazing Association 2019).

Cool-Season Pasture Mixes

Cool-season pasture mixes offer a mix of legume and grass varieties. Cool-season grasses and legumes can be utilized for their abundant ground cover, pollinator benefits, and livestock forage. Legumes also fix additional nitrogen for plant uptake. Cool-season pasture mixes grow in the spring when soil temperatures reach 45–50 degrees Fahrenheit, typically during April and May in Ohio. Coolseason grasses perform best when air temperatures are between 65–75°F and growth declines when summer temperatures rise over 80°F (Oregon State University 2021). In Ohio, this slump usually comes between June and August, but these grasses return with a second growth spike in the late-summer and early-fall when temperatures begin to decline again (Sulc, Barker, and Tilmon 2017). Normally, pasture mixes consist of perennials that enter dormancy during the winter months and continue growth in the spring. Therefore, a cool-season perennial mix can provide year-long ground coverage.



Figure 4: Unmowed pasture of tall fescue in late spring (May 31, 2019). *Photo:* Christine Gelley

Some cool-season grass species that typically perform well in Ohio include Kentucky bluegrass, tall fescue, meadow fescue, orchardgrass, perennial ryegrass, and meadow fescue. Some cool-season legumes include alfalfa, birdsfoot trefoil, and many species of clovers. Mixes with alfalfa, birdsfoot trefoil, perennial ryegrass, Kentucky bluegrass, and most clover varieties reach mature heights of around three feet, while mixes with orchardgrass and tall fescue can be up to five feet tall if left unharvested during late spring when plants produce seed heads (Sulc, Barker, and Tilmon 2017). As illustrated in Figure 3 through Figure 5, the selection of species variety and scheduled mowing



Figure 5: Recently mowed cool-season

throughout the growing season is important to maintain a desired grass height of 18 to 24 inches that keeps the vegetation below the front of the solar panels. Pasture mixes require two to four harvests per year to keep grass height below the solar panels, while also maintaining forage with nutritional value for livestock consumption.

pasture mix in early summer that includes tall fescue, orchardgrass, and reed canarygrass (June 4, 2019). *Photo: Christine Gelley*

Similarities and Differences Among Seed Mixes

Although the species names listed in forage mixes may be the same as listed for turfgrass seed or pollinator mixes, there are distinct differences among the varieties best suited for each purpose. Turf type seed is selected to be resistant to mowing and foot traffic. The most used turf type grass is KY 31 tall fescue, which contains a fungal endophyte that improves the stress tolerance of the plants, but also produces compounds that are toxic to grazing livestock in high concentrations. Therefore, turf type seed should not be used for forage fed to livestock. Pollinator seed is selected to provide nectar and pollen throughout the growing season. Forage type seed provides the best nutritional value for livestock and is easy to harvest. The cost of seed mixes varies greatly depending on the varieties included. Due to the increased labor and technology associated with creating and distributing mixed seed, the cost per pound increases when the diversity of the seed increases. Labor to maintain the site also increases due to variability between needs of each plant type. Each vegetative cover mix contributes benefits and challenges to providing soil cover in the solar field. The best cover option depends on the long-term maintenance plan and the priorities of the community where the site is located.

Cool-Season Pasture Species to Consider

When choosing the appropriate seed mix, site managers should consider the soil type, pH, prior crop history, and shading of the stand to select species that will thrive on location for the long term. The seed mix should provide uniform site coverage, be maintained below the height of the panels, and provide secondary benefits including improving soil health, carbon sequestration, and adding value to the community as a habitat for wildlife or as feed for livestock. All of the forages recommended in Tables 1 and 2 are perennial, cool-season forages with good to moderate shade tolerance.

	•	Table 1: Ohio	Perennial (Cool-Season Gras	sses	
Attributes	Max. Growth Height (ft.)	Tolerance to Acidic Soils	Seeding Rate (lb./ac.) & Depth (in.)	Environmental Stress	Frequent Defoliation Tolerance	Ease of Establishment
Kentucky bluegrass Poa pratensis						
Long-lived, short-growing,	3.5 ft.	Medium	16 lb./ac. ½–	Good	Good	Good

sod-forming grass			½ in.			
		S	Meadow f Schedonorus			
No alkaloid problem from endophytic fungi	3.5 ft.	Medium	16 lb./ac. 1⁄4-½ in.	Good	Good	Good
		Fes	Festulo tulolium Asc	lium h. X Graebn		
Hybrid cross of four potential grasses, with varieties available for different growing conditions	3.5 ft.	Medium	25 lb./ac. ¼-½ in.	Fair	Good	Excellent
	*/-		Perennial r	-		
Best suited for the northern half of Ohio	3.5 ft.	Medium	24 lb./ac. ¼-½ in.	Fair	Excellent	Excellent
	1		Orchard Dactylis glo	*		
Choose late- maturing varieties to help manage aggressive spring growth	4 ft.	Medium	10 lb./ac. ¼-½ in.	Good	Fair	Excellent
Smooth bromegrass Bromis inermis						
Later maturing than orchardgrass	4 ft.	Medium	16 lb./ac. ½ in.	Good	Fair	Good
Timothy Phleum pratense						
Late maturing						

Best suited for the northern

half of Ohio	4 ft.	Medium	1/4-1/2 in.	Poor	Fair	Good		
Novel enophyte tall fescue (NE+) Schedonorus arundinaceus								
Novel endophyte tall fescue, has an endophytic fungus present that does not cause animal health issues and is ideal for animal feed use	4 ft.	High	15 lb./ac. 1/3-½ in.	Excellent	Excellent	Good		
	Т	able 2: Ohio	Perennial C	Cool-Season Legu	ımes			
Perrenial Legume Forages for Consideration	Max Growth Height (ft.)	Tolerance to Acidic Soils	Seeding Rate (lb./ac.) & Depth (in.)	Environmental Stress Tolerance	Frequent Defoliation Tolerance	Ease of Establisment		
White clover Trifolium repens	1 ft.	Medium	5 lb./ac. 1⁄4-1⁄2 in.	Excellent	Excellent	Excellent		
Red clover Trifolium pratense	3 ft.	Medium	11 lb./ac. 1⁄4-1⁄2 in.	Good	Good	Excellent		
Alfalfa Medicago sativa	3 ft.	Low	15 lb./ac. ¼-½ in.	Good	Good	Good		
Birdsfoot trefoil Lotus corniculatus	3 ft.	High	9 lb./ac. ¼-½ in.	Excellent	Good	Poor		
The information in tables 1 and 2 is referenced from: Sulc, Barker, and Tilmon 2017; Lacefield et al.								

2000; and Van Sambeck et al. 2007.

Site Preparation, Seed Establishment, and Maintenance

Follow recommendations for forage establishment as provided in the *Ohio Agronomy Guide*, Chapter 7 (Sulc, Barker, and Tilmon 2017). Complete all soil tests and adjustments prior to seed selection and planting. Choose seed that is adapted to the growing site; has a high percentage of pure live seed, good germination rate, and low weed seed content; and comes with the proper inoculant for legume crops. After construction is complete, the planting site should be prepared so it is smooth, firm, and free of weeds. If this cannot be accomplished by the preferred seeding date, delay planting until good conditions are attainable both for the site and for the seed and in the appropriate seeding time frame. Conventional tillage, reduced tillage, and no-till planting methods can all be successful for establishing forages. Calibrate the planting equipment to seed at the appropriate rate and depth depending on the composition of the seed mix (Duiker et al. 2013).

Seeding too deep and weed competition in the first six weeks after planting are common causes of stand establishment failures. Allow at least two months of growth before first harvest of the crop. Delaying defoliation allows time for critical root development. Properly planted and maintained cool-season grass-legume forage mixes should produce two to three hay harvests per growing season. Soil tests should be taken every three years and fertilizer applications should be performed according to *Tri-State Fertilizer Recommendations* (Culman et al. 2020) based on the laboratory tests. Monitor the stand for weed encroachment, disease, and harmful insects. Consultation on forage pest threats can be assessed through Ohio State University Extension and the Ohio Forages website (https://forages.osu.edu). Depending on environmental and managerial pressures, forage stands may require overseeding or reseeding to maintain the desired mixture from year to year.

Anticipated Challenges

Limited information is available to guide the successful establishment and management of vegetative cover in solar fields. The Ohio State University College of Food, Agriculture, and Environmental Sciences is currently conducting research that addresses the following uncertainties:

- how to adjust seeding rates
- how spacing between solar panels impacts growth rates and forage quality
- how soil type variations impact plant growth and persistence

A fundamental challenge to realizing the economic benefit of a cool-season forage system within a solar field is related to panel spacing limitations and system layout designs. The solar field's design and panel spacing can prevent access and safe operation of the equipment required to rake, bale, and load out the harvested bales on trailers, or the safe and efficient operation of grazing livestock. Recognizing these challenges, simply establishing a cool-season forage ground cover and allowing the biomass to remain on site provides immediate environmental benefits and promotes long-term soil health. Additional research and ongoing communication between agricultural producers and solar developers must continue to aid in the development of technical advice on successful implementation of these practices in Ohio.

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Ohioline

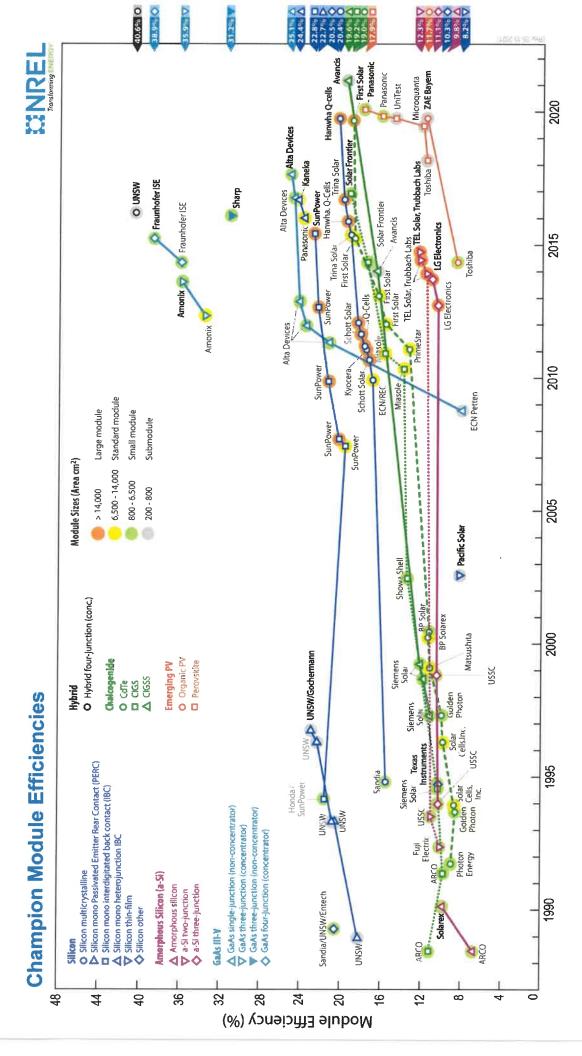
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Union Ridge Solar

Exhibit L

Decommissioning Plan

Case No. 20-1757-EL-BGN

DECOMMISSIONING PLAN

UNION RIDGE SOLAR HARRISON TOWNSHIP LICKING COUNTY, OH

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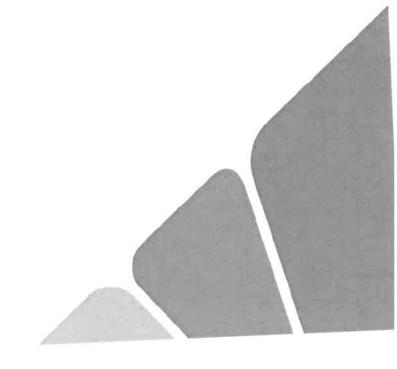




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Appendices

A. Union Ridge Solar – C.101 Overall Site Plan

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1.0 INTRODUCTION

Background

Union Ridge Solar, LLC (Project Company) is developing the Union Ridge Solar Project (Project) on approximately 513 acres of leased land. The Project will be located in Harrison Township, Licking County, Ohio. The Project will be located along the east and west sides of Watkins Road SW., approximately 0.7 miles north of the intersection of Watkins Road SW and Refugee Road SW. The site is accessible off Watkins Road SW and the geographical coordinates are 39°58'49.48"N, 82°38'43.99"W. The Solar Project is anticipated to remain operational for 35-40 years. Refer to Appendix A: C.101 Overall Site Plan for general location and Project layout.

The Project is planned to occupy approximately 513-acres of agricultural land for the solar field. The site is bound to the south and east by agricultural fields and residential property, to the west by agricultural fields, and to the north by woodland and agricultural fields. Site topography is moderately sloped and slopes from the north to the south with drainage towards the South Fork of the Licking River. The Federal Emergency Management Agency (FEMA) has designated the southern portion of the western site as Zone AE. No disturbance is anticipated in these areas.

This Decommissioning Plan (Plan) is developed in compliance with Ohio Power Siting Board and industry standards.

This Plan covers the following elements of the Solar Photovoltaic (PV) portion of the development:

- Removal off-site for disposal of all Project Components as defined, including any underground structures to at least 3 feet below-grade;
- Revegetation, restoration and road repair activities;
- Decommissioning escrow account.

If the Project ceases to perform its intended function for more than twelve (12) months, the Project will be completely removed within twelve (12) months, and the site restored in accordance with this Decommissioning Plan and Ohio Power Siting Board rules and regulations.

2.0 PROJECT COMPONENTS

The Project Components that are subject to decommissioning include the Solar PV equipment summarized below. The decommissioning activities associated with these components are discussed in Section 3.0 of this Plan.

PV Equipment

The Project will use Solar Photovoltaic (PV) modules mounted on single axis trackers installed on steel pile foundations.

Internal Power Collection System

The PV-generated DC power will be collected from each of the multiple rows of PV modules through one or more combiner boxes and conveyed to inverters. The inverters will convert the DC power to AC power. A project substation will be constructed to covert the electricity voltage, as necessary. The project will be interconnected into the existing Kirk Substation through a High Voltage Overhead Power Line.

Inverters, transformers, and PV combining switchgear will be mounted on concrete or pile foundations.

Earthwork

It is anticipated the site will require minimal grading for the Project. Site grading and drainage will be conducted in accordance with Final Engineering plans approved by Harrison Township, Licking County and the Ohio Power Siting Board.

Roads

Access to the Project will be via Watkins Road SW. The site access roads will be constructed in accordance with Licking County requirements. The on-site access roads will be compacted dirt or gravel in accordance with the Final Geotechnical Report.

Fencing

The Project site will be fenced with an approximately seven-foot-high fence for security purposes. Entry gates will be provided at the site access points on Watkins Road SW.

3.0 PROJECT DECOMMISSIONING AND RECYLCING

Decommissioning includes removal of above-ground and below-ground structures relating to the Solar PV portion of the Project. Only minor grading is anticipated during construction; and therefore, will require limited to no grading following decommissioning. Temporary erosion and sedimentation control Best Management Practices will be implemented during the decommissioning phase of the Project.

Decommissioning Preparation

The first step in the decommissioning process will be to assess existing site conditions and prepare the site for demolition. Onsite storage area(s) will be established, for collection and temporary storage of demolition debris, pending final transportation and disposal and/or recycling according to the procedures listed below.

Permits and Approvals

It is anticipated that an NPDES Permit from the Ohio Environmental Protection Agency Division of Surface Water (DSW) will be required. The site is not anticipated to impact waters of the United States or Threatened or Endangered species; thus, no federal approvals are expected. Appropriate applications for permits will be submitted and approved prior to decommissioning activities, including any permits required through the Soil and Water Conservation District, Harrison Township, and/or Licking County.

PV Equipment Removal and Recycling

During decommissioning, Project components owned by the Project Company that are no longer needed will be removed from the site and recycled or disposed of at an appropriately licensed disposal facility. Above ground portions of the PV module supports will be removed. Below ground portions of the PV module supports will be removed entirely where practical. Those supports that are more firmly anchored may be cut off to a safe depth of at least three (3) feet below grade or to the depth of bedrock, and the remaining support may be left in place. This depth will avoid impact of underground equipment on future farming or other construction activities. The demolition debris and removed equipment may be cut or dismantled into pieces that can be safely lifted or carried with the onsite equipment being used. The debris and equipment will be processed for transportation and delivery to an appropriately licensed disposal facility or recycling center. Modules will be disposed of or recycled in accordance with local, state, and federal regulations.

Internal Power Collection System

The combiner boxes, cables, inverters, and transformers will be dismantled. The concrete foundations will be broken up, removed and recycled. If ground-screw or steel foundations are used, they will be removed and recycled. The underground cable and conduit will be removed where less than three (3) feet below grade. Overhead conductors will be removed from the poles, and the poles and pole foundations will be removed. Aluminum from the conductors will be recycled or removed from the site to an appropriately licensed disposal facility. All components of the project substation including, but not limited to, foundations, buildings, machinery, equipment, cabling, and connections to transmission lines will be removed.

Roads

Unless requested in writing by the landowner, gravel from on-site access roads will be removed and recycled. Once the gravel is removed, the soil below the gravel along compacted dirt access roads will be scarified a depth of 18-inches and blended, as noted in the Site Restoration section below.

Fencing

Unless requested in writing by the landowner, project site perimeter fence will be removed at the end of the decommissioning project. Since the Project site is not currently fenced, this includes removal of all posts, footings, fencing material, gates, etc. to return the site to pre-Project condition.

Landscaping

Unless requested in writing by the landowner to be removed, all vegetative landscaping and screening installed as part of the Project will be left in place. Landscape areas in which landscaping is removed will be restored as noted in the Site Restoration section below.

Site Restoration

Once removal of all Project equipment and landscaping is complete, all areas of the Project site that were traversed by vehicles and construction and/or decommission equipment that exhibit compaction and rutting, will be restored by the Project Company. All prior agricultural land will be ripped at least 18 inches deep or to the extent practicable and all pasture will be ripped at least 12 inches deep or to the extent practicable. The existence of drain tile lines or underground utilities may necessitate less ripping depth. Once this is complete, seed will be distributed for the establishment of vegetative land cover.

4.0 FUTURE LAND USE

The Project site is currently agricultural land. All solar panels will be removed from the property and the land will be restored so that it can be returned to agricultural use at the end of the Project life cycle. This Decommissioning Plan is consistent with Ohio Power Siting Board (OPSB) requirements to return the land to its pre-Project conditions, suitable for agricultural use.

5.0 PROJECT DECOMMISSION COSTS AND FINANCIAL ASSURANCE

This Decommissioning Plan will be updated prior to Construction and will consider salvage value of the Solar PV components of the Project. All solar components will be repurposed, salvaged, recycled, or hauled offsite for disposal. Solar components that are anticipated to have resale or salvage value that may be used to offset the cost of decommissioning include solar modules, racking system, steel piles, inverters, and transformers. Materials that have no value at the time of decommissioning will be recycled when possible or hauled offsite to a licensed solid waste disposal facility. A Project decommissioning cost estimate was created based on the Union Ridge Solar – Overall Site Plan included in Appendix A. See Table 1 below for a current decommissioning cost estimate, excluding salvage value This estimate will be updated prior to construction to include salvage value. See Table 1 below for a current decommissioning cost estimate. Industry standard prices in 2021 for removal costs were determined using RS Means cost data. Removal costs includes materials, contractor installation/demolition, mobilization and demobilization, overhead and profit, and performance bonding.

In the event that the Total Decommission Cost (decommission costs minus salvage value) is a net positive number, the Project Company will post decommissioning funds in the form of a surety bond, letter of credit, guaranty, including affiliate guaranty or other financial assurance consistent with the Final Decommissioning Cost Estimate. This Decommissioning Plan and financial assurance will be reviewed and updated in year 10 of operations and every 5 years thereafter to assess the value of the financial assurance versus the Total Decommission Cost.

TABLE 1 UNION RIDGE SOLAR DECOMMISSIONING COST ESTIMATE

NO.	ITEMS	QUANTITY	UNIT S	PRICE	COST
_	Mobilization	1	LS	\$117,080	\$117,080
1		1	LS	\$20,000	\$20,000
2	SWPPP, Erosion Control Measures	478	AC.	\$208	\$99,424
3	Seeding			***	\$47,322
4	Ripping 18" soil/ scarifying and rough grading existing soil	478	AC.	\$99	\$170,160
5	Fence Removal (includes gate removal)	34,032	LF	\$5	-
6	Underground Collector Removal (AC and DC) and Backfill	30,735	LF	\$2	\$61,470
7	Remove Electrical Equipment (includes inverter removal, transformer removal, and foundation removal)	34	EA	\$204	\$6,936
8	Remove Photovottaic Modules	281,060	EA	\$2	\$562,120
9	Remove Steel Piles (12' W6x9 piles @ 14.6' OC assumed)	44,000³	EA	\$13	\$572,000
10	Remove Support Assemblies (Racking)	3,8893	EA	\$204	\$792,000
11	Substation Removal	1	LS	\$85,000	\$85,000
	Gen-Tie Line Removal	1	LS	\$13,000	\$13,000
12	Disconnection and demolition of substation equipment	1	LS	\$17,813	\$17,813
13	Transportation (this assumes 300-mile round trip) ²	1	LS	\$78,570	\$78,570
14	Transportation (this assumes 550-mile reality app	SUB-TOTAL O	F DECOMM	IISSION COSTS	\$2,642,895
		44,000³	EA	(\$7)	(\$320,760)
14	Salvage Steel Piles	1	LS	(\$1,120,000)	(\$1,120,000)
15	Salvage Tracker Steel			OF SALVAGE VALU	ES (\$1,440,760
	(DECOMMISSION COSTS – SALVAGE VALUE)				\$1,202,13

¹This Engineer's Opinion of Probable Construction Cost is based upon the Overall Site Plan prepared Westwood Professional Services, Inc. dated 11/18/2020. The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information $known\ to\ Engineer\ at\ this\ time\ and\ represent\ only\ the\ Engineer's\ judgment\ as\ a\ design\ professional\ familiar\ with\ the\ construction\ industry.$ The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs. These quantities and costs are subject to change pending Final Engineering and should be updated as necessary.

² This assumes that approximately 423 trips of a 40,000 lb. capacity demolition roll-off truck will travel 300 miles round trip to a recycling and disposal facility.

³ Steel pile and support assembly quantities were provided by Leeward Renewable Energy.

⁴ This Salvage Value Estimate is based on the following salvage and material values:

Steel pile salvage value of 12' W6x9 at \$7.29 per pile, using scrap metal steel price of \$135 per ton;

Steel tracker salvage value is assumed to be 10% of original cost based on information provided by Leeward Renewable Energy;

APPENDIX A

Union Ridge Solar – C.101 Overall Site Plan



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Case No(s). 20-1757-EL-BGN

Summary: Application Exhibit L - Decommissioning Plan electronically filed by Teresa Orahood on behalf of Dylan F. Borchers

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Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Development

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NC STATE UNIVERSITY

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Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Development

Introduction

For centuries North Carolina farmers have made a major contribution to the state's economy by working the land and providing billions of pounds of agricultural and forestry products to meet demands for food and fiber. This resource serves as a foundational economic building block for the state. North Carolina's farming and forestry community provides North Carolinians and people across the world with food and fiber. That said, the demands of our growing, modern society require renewable forms of energy to begin to replace finite non-renewable energy resources that have traditionally provided the means for transportation, electricity, and much more.

Given that land and climatic conditions suitable for agriculture are finite, solar development may compete with agricultural land use. One use converts sunlight and fertilizer into food and fiber, while the other converts sunlight into electricity. The purpose of this paper is to explore the extent to which solar photovoltaic facilities and agricultural production compete for land use, as well as the extent to which agricultural production is affected by solar development. The paper is divided into two sections:

- (1) Understanding the Context of Solar Development and Agriculture in North Carolina.
 - (1.1) Developing Renewable Energy,
 - (1.2) Landowner Land Use Choice,
 - (1.3) Solar Facility Construction,
 - (1.4) Duration of Solar Use,
- (2) Weighing the Impact of PV Development on Agriculture

- (2.1) Solar PV Land Use
- (2.2) Impact on Agricultural Productivity

1. Understanding the Context of Solar Development and Agriculture in NC

This section provides some background on solar development in North Carolina. By illustrating the existing demand for renewable energy (1.1), touching on the state's political climate towards private land use (1.2), and highlighting two important considerations of PV development (1.3 and 1.4), the context surrounding the two competing land uses of solar development and agriculture can be better understood. As agriculture is and has been a dominant, established land use in this state for generations, discussion in this section will primarily focus on the increasing demands of land to be used for solar development.

1.1 Developing Renewable Energy

Currently, almost all of North Carolina's electricity is generated from fuels, such as coal, natural gas, and uranium, which are produced outside the state. Some coal plants in North Carolina are reaching the end of their useful lives and being retired. Alternative sources of energy, such as solar and wind, have become much more

economically attractive in the last several years, making it possible to economically replace some nuclear, coal, and gas electricity generation with these sources.³

More than three hundred privately financed utility-scale solar facilities operate in North Carolina under current electricity prices, regulations, and policies, with more planned for the future. As with any new technology, price drops and performance improvements may be expected over time as production volumes increase and experience is gained. Since 2009, the total cost to develop and build a utility-scale solar facility in North Carolina has dropped from over \$5 per watt to about \$1 per watt. This rapid cost reduction in utility-scale solar facilities has greatly improved the financial viability of solar projects; many solar projects are now being planned even without the North Carolina renewable energy tax credit that expired at the end of 2015.4,5

In addition to the increasingly attractive economics, some of the shift towards solar energy has been driven by policy choices. Solar and other types of renewable energy have many benefits that have motivated support from policymakers. For instance, they do not use imported fuel, reducing our exposure to fuel price volatility. Solar energy also does not produce the air pollution and greenhouse gases emitted by fossil fuel-powered electricity generation, and it avoids some other environmental risks associated with fossil and nuclear fuels such as coal ash and radioactive waste disposal. Reduction of air pollution has been part of state and national policy for decades, and the U.S. has seen steadily improving air quality as a result⁶ Solar and other clean energy sources assist in this ongoing reduction in air pollution.

Solar energy offers many benefits to North Carolina. However, while solar development provides a source of clean in-state energy, it requires land to do so. This means that solar energy projects will sometimes compete with other potential land uses.

1.2 Landowner Land Use Choice

North Carolina policy generally leaves land use decisions in the hands of landowners. That said, the state, local, and federal governments can encourage or discourage specific landowner choices through the incentives or disincentives that they provide for particular uses, as well as through various forms of regulation, such as zoning rules and environmental restrictions. The balance of state-provided incentives for agricultural or solar energy production can, in some cases, be the determining factor in the decision to invest in solar or agriculture development. Also, the current grid infrastructure limits the sites feasible for solar development; it is only feasible to connect solar to certain locations in the grid and only to a limited density.

North Carolina has granted local governments the power to regulate land use in their jurisdictions, although state and federal rules apply in many circumstances. This means that local governments can manage land development with the needs of the community in mind, while also safeguarding natural resources. These land-use regulations can put limits on the allowed uses for some land and thus limit landowners' options, in some cases affecting the viability of solar development. Some agricultural land has been exempted from certain regulations due to "grandfathering," and changing the land use to solar may remove these exemptions, which can affect the ability to return the land to agricultural use in the future.

Land use regulations that may be relevant to solar development, depending on the location, can include (but are not limited to):8

- Local zoning and land use rules (fencing, buffer zones between buildings and roads, border shrubs/trees, etc.)
- · Floodplain development rules

- Erosion and sedimentation rules
- Permitting regarding military and air traffic impact
- Water quality rules (i.e. Neuse nutrient strategy rules, Coastal Area Management Act rules)
- USDA wetlands impact rules

To determine whether these and other rules are relevant for a potential solar development, land-owners and solar developers should consult their local government planning departments, the Soil and Water Conservation Division of the N.C. Department of Agriculture and Consumer Services, the USDA Natural Resources Conservation Service office, and the USDA Farm Services Agency.

1.3 Solar Facility Construction

Solar panels are supported by steel or aluminum racks. The racks are attached to galvanized steel posts driven 6-8 feet into the ground without concrete, although very occasionally, site conditions require the use of cement grout in the pile hole. The only concrete is generally at the inverter/transformer pads which are typically about 10' by 20' each. There is usually no more than one such pad per MW of AC capacity. At some sites these pads are precast concrete or steel skids that sit above grade on helical steel piers. Much of the wiring at the site is above-ground attached to the racking under the rows of panels. The rest of the wiring is 2 to 3 feet underground either as direct-bury cables or in 2"-6" PVC conduit. Most sites involve minimal grading of the land.

Every site provides access for vehicles, which requires roads, or "access aisles," to be constructed. These roads are sometimes improved with gravel, but they do not require application of concrete or asphalt. Many sites only use gravel close to the entry to the public Right of Way, as required by NCDOT regulation, with the rest

of the access aisles as simply compacted native soil. Some developers use reusable wooden logging mats to provide temporary stabilization during construction to avoid the need for the addition of gravel. A best practice when building a gravel access aisle is to strip the organic topsoil, place a geotextile fabric under the aggregate and redistribute the topsoil on site to assist in soil stabilization. This will provide stability for the aggregate, allow for more efficient removal of the gravel at the end of the project's life cycle by providing separation between aggregate and subgrade, while preserving the valuable topsoil on site for future agricultural use. Well-drafted leases will specify allowable construction techniques and locations of roads and other infrastructure. The NC Department of Environmental Quality (DEQ) requires soil erosion and sedimentation control plans and permits and inspects implemented measures on the site until vegetative groundcover is established.

1.4 Duration of Solar Use

Currently in North Carolina most utility-scale solar projects have a 15-year Power Purchase Agreement (PPA) with the local electric utility. Some developers prefer to purchase the land, while others prefer to lease, depending on the project's business model and financing arrangements. Typical land leases have a term of 15 to 30 years, often with several optional 5-year extensions. 10 While specific lease rates are generally undisclosed, in our understanding lease rates often range between \$500 and \$1,000 per acre per year. Most solar PV panel manufacturers include a 25-year power warranty on their panels, which cover the panels to produce at least 80% of their original power output at the expiration of the warranty period.

Modern solar facilities may be considered a temporary, albeit long-term, use of the land, in the sense that the systems can be readily removed from the site at the end of their productive life. At this point, the site can be returned to agricultural use, albeit with a potential for some short-term reduction in productivity due to loss of topsoil, compaction, change in pH, and change in available nutrients. Leasing farmland for solar PV use, particularly land that is not actively being farmed today, is a viable way to preserve land for potential future agricultural use. PV use is particularly valuable in this regard when compared to commercial or residential development, which require changes to the land that are very difficult to reverse. For landowners struggling to retain ownership of their land due to financial strains, solar leasing may provide a vital, stable income solution. It may also serve as a more appealing alternative to selling their land to buyers intending to use the land for other, more permanent non-agricultural uses.

While it is very difficult to predict the state of electricity, agriculture, and real estate markets 25 or more years into the future, existing circumstances can provide some insight into the likelihood of today's solar facilities continuing as solar facilities at the end of the initial PV modules' useful lifetime. The he economics of existing solar facilities are such that many of the projects built today are likely to update some of their equipment after 20 or more years and continue to operate as a solar electricity facility for many more years. The ability to facilitate interconnection to the electric grid provides great value to a landowner. A parcel of land featuring this capability in today's market will likely also appeal to solar developers in the future due to the infrastructure cost savings.

2. Weighing the Impact of PV Development on Agriculture

The purpose of this section is to explore how the competing land uses of solar development and ag-

riculture interact and can coexist with each other. Subsection 2.1 provides analysis of data and metrics that quantify the current and potential amount of solar development on agricultural land in North Carolina. Subsection 2.2 explores the impacts that solar development could have on future agricultural production on the developed site and neighboring properties. Taken together, Section 2 of this factsheet provides several factors to consider when weighing the impact of PV development on agriculture.

2.1 Solar PV Land-Use

The NC Sustainable Energy Association (NCSEA) with the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) used GIS software to quantify the amount of solar land use. As of December 2016, solar installations occupied 0.2 percent (9,074 acres) of North Carolina's 4.75 million acres of cropland.11 NCDA&CS has provided an updated estimate; they estimate that 14,864 acres of cropland, or 0.31 percent of the total, were occupied by solar development at the end of the first quarter of 2017.12 NCSEA and NC-DA&CS were able to locate and quantify solar use for 318 of 341 currently-installed utility-scale facilities in North Carolina. A map of the solar installations in the state prepared by NCSEA is available at: http://energyncmaps.org/gis/solar/index.html.13 The researchers extrapolated the per-MW findings of the 318 sites found in aerial photos to generate an estimate for the remaining 23 projects not yet visible in the latest aerial photography. Across all projects, 79% of solar project area was formerly farmland, defined as land identified from aerial photography to have been used for crops, hay, or pasture before solar development. On average, the solar projects occupied 5.78 acres per MW_{AC}.

N.C. has been losing farmland to various forms of development for many years. Over the last decade, North Carolina has lost about one million acres of cropland to development and housing.

Since 1940, total cropland in N.C. has fallen from 8.42 million acres to 4.75 million acres (as of 2012). The North Carolina Department of Agriculture has identified farmland preservation as one of its top priorities since 2005.

As of the end of 2016, solar PV installations added 2,300 MWAC of solar generating capacity to North Carolina's electricity grid, making NC second in the nation for installed solar PV capacity. These installations generate enough electricity to power approximately 256,000 average N.C. homes, equaling 6.2% of all households in the state. ACSEA and NCDA&CS published the summary of their land-use analysis in February of 2017 and NCSEA released a report on this research in April of this year.

If the current siting and production trends were to continue until ground-mounted solar produced, on average, an amount of electricity equal to 100% of N.C.'s current electricity use, solar facilities would cover about 8% of current N.C. cropland. 16 This is an unrealistic extreme to illustrate the limited possible magnitude of land usage for solar even at very high solar generation levels, yet even this scenario would occupy only about half of the N.C. cropland acreage lost to development in the last 10 years. Even if solar were to provide all of our electricity, ground-mounted utility-scale solar will almost certainly not be the only source of electricity. As PV prices continue to decline it is likely that North Carolina will see more and more rooftop and parking lot canopies, reducing the need for green field development. A recent Department of Energy study found that rooftop systems have the technical capability to meet 23.5% of North Carolina's electricity demand.17

A more likely scenario, even assuming that fossil fuel and nuclear based electricity is entirely phased out, is that other sources of renewable electricity and technologies will meet a large portion of our electricity needs. A Stanford University study of the optimal mix of renewable energy sources for

each state to achieve 100% renewable energy found that North Carolina would get only 26.5% of its electricity from utility-scale solar plants. ¹⁸ At this still highly expanded level of solar development, based off of the 8.3% land use for 100% solar figure calculated earlier, the amount of NC cropland used for solar would be around 2.2%.

More realistically, in the next decade or two, solar electricity may grow to provide around 5 - 20% of North Carolina's electricity, which would allow solar to meet, or nearly meet, the full requirements of the North Carolina Renewable Energy and Energy Efficiency Portfolio Standard. At the 12.5% REPS requirement, this is about 13 GW_{AC} of PV, which will require about 75,000 acres of land at the average historic density found in the NCCETC/NCDA study. This is not an insignificant amount of land, but if split between agricultural and non-agricultural land at the same ratio as the first 2.3 GW installed in NC this represents about 1.1% of cropland in the state. NCSEA projects that by 2030, utility-scale solar will provide 5.03% of North Carolina's electricity and use 0.57% of available cropland.19

Solar energy's land use requirements are comparable to those of existing energy sources. According to an MIT study, supplying 100% of U.S. electricity demand in 2050 with solar would require us of about 0.4% of the country's land area; this is only half the amount of land currently used to grow corn for ethanol fuel production, and about the same amount of land as has been disturbed by surface coal mining.²⁰

For landowners interested in solar development, it is important to understand the agricultural value of the land before entering into a solar lease agreement. Careful due diligence in the siting phase can help mitigate the use of the most valuable farmland. Landowners can contact their county tax office for property value information. The following online resources can assist landowners and developers in assessing the agricultural value of land

before selecting the final footprint for solar development:

- www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/dma/ The USDA Natural Resources Conservation Service provides several tools in this link to identify soil types on property.
- www.ncmhtd.com/rye/ The North Carolina Realistic Yields Database provides landowners with a useful mapping and soil analysis tool that produces realistic productivity yields for expected crops given the landowner's property location and soil type.

2.2 Impact on Agricultural Productivity

This subsection provides an overview of impacts that solar development may have on agricultural land. The discussion of these impacts is divided into the following subtopics: construction grading and soil preservation, compaction, erosion, weed control, toxicity, and pollinators, followed by a brief discussion of decommissioning. The subtopic discussions illustrate that solar development, with proper planning and implementation, results in a small but manageable impact on the future agricultural productivity of the land on which it is sited. Further, these discussions also illustrate that solar development is unlikely to significantly affect the agricultural productivity of neighboring properties now or in the future.

Construction Grading and Soil Preservation

The amount of grading necessary to prepare a parcel for a utility-scale solar facility is dependent on the slope of land and the type of solar mounting used. In much of N.C., fixed-tilt mounting of PV requires little to no grading for installation of the PV system. Single-axis tracking systems that

slowly rotate each row of panels to track the sun's path across the sky generally require flatter land (typically less than 8% grading) and thus more often require grading of the site, particularly for projects in the Piedmont region or farther west. ²¹ Typical construction practices require that topsoil be stripped and stockpiled prior to cut/fill operations. The stockpiled topsoil will be redistributed across graded areas, to assist in growing adequate ground cover as quickly as possible to provide ground stabilization. The stripping, stockpiling and redistribution of topsoil in this manner will have some impact on the amount of organics and nutrients that remain in the soil immediately after placement. However, proper ground stabilization practices include soil testing to determine the appropriate levels of lime, fertilizer and seed to be applied to establish ground cover. Proper installation practices require these additives to be tilled into the soil, which effectively reduces the compaction of the upper soil stratum, typically to a depth of 8"-12". Typical solar projects will not remove any topsoil from the project site, partly due to financial implications, but more importantly due to its value in establishing ground cover as quickly as possible22 (removing soil also requires a mining permit).23 Most landowners steer solar projects to their least productive soils on a given piece of property to the extent practical.24

Soil Quality

Modern agriculture relies on regular additions of lime and fertilizer to maintain soil pH and fertility. Solar facilities maintain vegetative ground covers that can help build soil quality over time, which may require lime and fertilizer to be applied. When the vegetation is cut, the organic matter is left in place to decompose which adds valuable organic matter to the soil. A facility operation and maintenance schedule should include a plan for maintenance of sufficient plant groundcover to protect soil from erosion. Maintaining healthy plant cover will require monitoring of soil fertility and may call for the addition of fertilizer or lime to ensure sufficient

nutrients are available for plant growth and that soil pH is adequate. Vegetation mixes may help balance soil nutrient needs, but will need to be managed. Species composition will change over time.25 NREL and others are researching and using vegetation mixes that include many native grasses with deep root systems; many include some nitrogen fixing plants as well. According to a study published in July 2016 that measured soil and air microclimate, vegetation and greenhouse gas emissions for twelve months under photovoltaic (PV) arrays, in gaps between PV arrays and in control areas at a UK solar sited on species-rich grassland, UK scientists found no change in soil properties among the three locations. After a solar project is removed, a routine soil test (available from the North Carolina Department of Agriculture) should be obtained to determine fertility requirements, including lime, for optimum crop production.

Compaction

Soil compaction can negatively impact soil productivity and will occur to some degree on every solar site. Soil compaction can also limit water infiltration into the soil environment, and lead to greater surface water runoff during rain events.27 In addition to the roads built in and around solar project sites, the construction of the facility itself as well as regular use of lawn mowers compacts the soil, decreasing the ability of plant roots to grow. However, use of land as a solar site will avoid agriculture-related activities that can induce compaction, such as tillage. There are no data available on the degree of compaction common at solar facilities, but it is possible that some sites could experience heavy compaction in frequently used areas. In cases of heavy compaction, hard pans in the soil will form that can take decades to naturally free up; however, tractor implements such as chisels and vibrators designed to break up hard pan can often remove enough compaction to restore productivity. To prevent damage to soil due to compaction, landowners can negotiate for practices that will result in the least amount of compaction and for roads to be constructed on less productive land. Additionally, maintaining healthy ground-cover, especially varieties with deep root systems, can serve to keep the soil arable for potential future agricultural use. The appropriate use of alternative vegetative maintenance strategies, such as grazing with sheep, can reduce the use of mowing equipment onsite and therefore the compaction that may result from using this equipment.²⁸ Furthermore, livestock grazing works to cycle nutrients in the pasture ecosystem onsite and improve the soil.

Erosion

According to its current Stormwater Design Manual, the N.C. Department of Environmental Quality allows solar panels associated with ground-mounted solar farms to be considered pervious if configured such that they promote sheet flow of stormwater from the panels and allow natural infiltration of stormwater into the ground beneath the panels.29 For solar development, an erosion control and sedimentation permit is required, which involves on-site inspections and approval by the North Carolina Department of Environmental Quality. The permit requires establishment of permanent vegetative ground cover sufficient to restrain erosion; according to DEQ staff, the site must be "completely stabilized," although this does not require a specific percentage of ground cover.30 In-depth information on erosion control and sedimentation laws. rules, principles, and practices is available at the NC DEQ's website, at http://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/erosion-sediment-control-planning-design-manual. Once permanent vegetation is established it will be necessary to maintain soil pH and fertility as mentioned above in order to ensure sufficient, healthy, and continuous ground cover for erosion control.

Weed and Vegetation Control

Maintenance of vegetation on site can be accom-

-plished using several options, including but not limited to the following: mowing, weed eaters, herbicides, and sheep. Reductions in fertilizer use on the site will slow growth of vegetation and weeds. Mowing allows the landowner to have the option of laying cut grass or vegetation on grounds of site to decompose and improve long-term soil fertility. In some cases, landowners have used grazing animals, normally sheep, to frequent the solar site grounds and control the vegetation and weeds, which also returns organic matter to the soil on site.

Like most lawns and parks, many utility-scale solar facilities in N.C. use a combination of mowing and herbicides to maintain the vegetation. When using herbicides, applicators are advised to be mindful of label instructions and local conditions. Herbicide persistence is affected by the organic matter content and moisture level of the soil. The importance of complying with legal responsibilities in using the treatments cannot be stressed enough, especially for land located near surface water, land where the surface is near the water table, or where application might carry over to other neighboring lands.

Herbicide use at solar facilities is typically similar to that in agriculture, and the types of herbicides used are similar between the two uses. As such. the impact of herbicides used at solar facilities on neighboring land and the environment is likely to be no more than that of conventional agriculture. Herbicide use differs widely among different crops and farming techniques, so the change in herbicide appliance between agricultural and solar use will vary in individual cases, but in the aggregate, there is no reason to believe that solar facilities will result in more herbicide impacts on neighboring lands than do current agricultural uses.31 Herbicide use can be discontinued 1-2 years before decommissioning of a site, minimizing any residual impact on crop production at former solar sites.³²

A number of sites use sheep at low densities to

maintain vegetation during the growing season, although the sheep do not fully replace the need for mowing and/or herbicide use. The sheep are leased from sheep farmers, and the demand for sheep at solar facilities has been beneficial for North Carolina's sheep industry.³³ The grazing of sheep at solar facilities incorporates local farmers into the management of the sites, engaging the local community with solar development. The growth of solar farms represents a huge opportunity for the North Carolina sheep industry, with thousands of acres that are fenced well for sheep, and allow North Carolina farmers to diversify into new agricultural products for which there is increasing demand.³⁴

Toxicity

There is no significant cause for concern about leaking and leaching of toxic materials from solar site infrastructure.³⁵ Naturally occurring rain is adequate to generally keep the panels clean enough for good electricity production. If panels do need to be washed, the washing process requires nothing more than soap and water. Additionally, the materials used to build each panel provide negligible risk of toxic exposure to the soil, environment, or people in the community. Details about toxicity for aluminum and zinc are described below, and more information on the potential for human toxicity can be found in the NCSU Health and Safety Impacts of Solar Photovoltaics white paper.

Aluminum

Aluminum is very common in soils around the world, including those common in North Carolina. In fact, the earth's crust is about 7% aluminum, and most soils are over 1% aluminum!³⁶ The aluminum is generally unavailable to plants as long as the soil pH is above about 5.5. In acidic soils many forms of aluminum become more bio-available to plants; this can be toxic to many plant species.³⁷ This effect is one of the major reason many plants

do not tolerate very acidic soils. The use of aluminum building materials releases negligible amounts of aluminum during their useful life because the material is so corrosion resistant.38 The aluminum frames of PV modules are anodized which adds a very thin hard coating of aluminum oxide to the exterior of the aluminum that greatly improves aluminum's already-high resistance to corrosion. Therefore, any minute amount of aluminum that could be released by corrosion from aluminum construction materials during the life of a solar project will not materially add to the thousands or millions of pounds of aluminum naturally present in the soil of a typical N.C. solar facility. The common practice of liming soils to maintain appropriate soil pH for crop systems alleviates most, if not all, concerns about aluminum impacting crop growth in the future.

Zinc

Zinc from galvanized components, including support posts for solar panels, can move into the soil.39 Zinc from building material stockpiles has been previously noted as a localized problem for peanut production in some North Carolina fields. 40 While it is difficult to predict in advance the degree to which this will occur, it is relatively simple to collect soil samples and monitor this situation in existing installations. Analysis of zinc is included in routine soil testing procedures used by the NC Department of Agriculture & Consumer Services Agronomic Services Division Laboratory. Awareness of zinc concentrations in the soil, and any spatial patterns noted with depth and distance from structures, should allow producers to determine if the field is adequate for desired crops as is. If zinc limitations exist, awareness of concentrations and spatial distribution patterns may indicate the potential for deep tillage, liming, or crop selection alternatives required for successful agricultural use. Of the agronomic crops grown in NC, peanuts are the most sensitive crop to

zinc toxicity. Based on information from the N.C. Department of Agriculture and Consumer Services, there is risk of toxicity to peanuts when the zinc availability index (Zn-Al) is 250 or higher, particularly in low-pH situations. Risk increases with increasing soil test levels, especially if pH management through a liming program is not followed. For most other crops, zinc toxicity does not become problematic until the Zn-Al index reaches 2,000-3,000.41

Pollinators

Solar projects with appropriate vegetation can provide habitat for pollinators, as well as other wildlife.42 Rather than planting common turf grasses, some solar facilities are starting to use seed mixes of native grasses and pollinator-friendly flowering plants as ground cover in solar facilities. 43,44 This provides habitat for pollinators, which can be beneficial to neighboring farms. Minnesota passed the country's first statewide standards for "pollinator friendly solar" in 2016. According to Fresh Energy, a clean energy nonprofit in St. Paul, more than 2.300 acres of these plants took root near solar panels last year, according to Fresh Energy.45 Solar facilities can also cooperate with commercial beekeepers to facilitate honey production, although this may conflict with providing habitat for wild pollinators. 46,47 Pollinators provide benefits for agricultural production at nearby farms where insect-pollinated crops are grown.48

Temperature Effects

Solar PV facilities can cause changes in the air and surface temperature of the space in which they are located. The effect of solar PV facilities on surface and air temperatures is different. Solar panels shade the ground on which they are located, reducing the surface (ground) temperature from what it would be without solar banels present. 49 However, solar panels absorb solar radiation more effectively than do typical

agricultural land surfaces due to their darket color, leading to an increase in air temperature directly above the solar panels as the absorbed radiation is released as heat. The decrease of increase for surface and air temperatures, respectively, is around 2-4 degrees Celsius (3.6-7,2 degrees Fahrenheit), depending on the type of land cover in the area.^{50,51}

Temperature effects on land outside the solar facility are much smaller. One study found that an air temperature increase of 1.9 degrees Celsius directly over a solar farm dissipated to 0,5 degrees Celsius at 100 meters in horizontal distance from the solar farm, and less than a 0.3 degree increase at 300 meters.52 Another study found that a temperature difference of 3-4 deprees Celsius directly above a solar farm was dissipated to the point that it could not be measured at a distance of 100 feet from the solar farm's edge.53 Meteorological factors can affect the range and size of any temperature effect on land nearby a solar facility, but even under very conducive circumstances the possible temperature increase for nearby land would be on the order of tenths of degrees. Studies have varied on the time at which temperature differences are most pronounced; one study noted as taking place in a desert landscape found that temperature differences were larger at night,54 while another study found larger temperature differences during midday;55 differences in weather and landscape between the study locations may be responsible for the different results.

Decommissioning

If land used for a solar facility is to be returned to agricultural use in the future, it will be necessary to remove the solar equipment from the land. This process is known as decommissioning. Decommissioning is basically the construction process in reverse; it involves removal of the solar panels, breakup of support pads, removal of access roads, replacement of any displaced

soil, and revegetation.

Solar development often takes place on leased land, although it also occurs on land owned by solar companies. When leased land is involved, it must be determined whether the landowner or the solar developer bears responsibility for decommissioning. Responsibilities for decommissioning are lease-specific in North Carolina. It is important for landowners to consider decommissioning when setting lease terms, although landowners may choose in some cases to accept decommissioning responsibility themselves. Although state rules on solar decommissioning do not currently exist in North Carolina, local jurisdictions can choose to adopt regulations pertaining to decommissioning.

The materials recovered in the decommissioning process have significant economic value, which can help pay for the costs of decommissioning. Some engineering analyses have indicated that the salvage value of recovered materials is more than enough to pay for the removal of all the materials and to return the site to its pre-construction state. 56,57,58,59

NCSU has produced several resources that provide more information on decommissioning. They include:

- Health and Safety Impacts of Solar Photovoltaics⁶⁰
- Template Ordinance for Solar Energy Development in North Carolina⁶¹
- Working Paper: State Regulation of Solar Decommissioning⁶²
- Landowner Solar Leasing: Contract Terms
 Explained⁶³

Summary

The purpose of this paper is to explore the extent to which competition exists between solar development and agriculture and the extent to which the agricultural productivity of land is affected by solar development. Discussion on this topic was divided into two sections: (1) Understanding the Context of Solar Development and Agriculture in North Carolina and (2) Weighing the Impact of PV Development on Agriculture. In these sections, information and tools were provided to aid in understanding the impact of solar development on agricultural land. Equipped with the information and tools provided by this paper, landowners may be able to better evaluate the viability of solar development on their land.

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Analysis of the Potential for a Heat Island Effect in Large Solar Farms

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Abstract — Large-scale solar power plants are being built at a rapid rate, and are setting up to use hundreds of thousands of acres of land surface. The thermal energy flows to the environment related to the operation of such facilities have not. so far, been addressed comprehensively. We are developing rigorous computational fluid dynamics (CFD) simulation capabilities for modeling the air velocity, turbulence, and energy flow fields induced by large solar PV farms to answer questions pertaining to potential impacts of solar farms on local microclimate. Using the CFD codes Ansys CFX and Fluent, we conducted detailed 3-D simulations of a 1 MW section of a solar farm in North America and compared the results with recorded wind and temperature field data from the whole solar farm. Both the field data and the simulations show that the annual average of air temperatures in the center of PV field can reach up to 1.9°C above the ambient temperature, and that this thermal energy completely dissipates to the environment at heights of 5 to 18 m. The data also show a prompt dissipation of thermal energy with distance from the solar farm, with the air temperatures approaching (within 0.3°C) the ambient at about 300 m away of the perimeter of the solar farm. Analysis of 18 months of detailed data showed that in most days, the solar array was completely cooled at night, and, thus, it is unlikely that a heat island effect could occur. Work is in progress to approximate the flow fields in the solar farm with 2-D simulations and detail the temperature and wind profiles of the whole utility scale PV plant and the surrounding region. The results from these simulations can be extrapolated to assess potential local impacts from a number of solar farms reflecting various scenarios of large PV penetration into regional and global grids.

Index Terms - PV, climate change, heat island, fluid dynamics

I. INTRODUCTION

Solar farms in the capacity range of 50MW to 500 MW are being proliferating in North America and other parts of the world and those occupy land in the range from 275 to 4000 acres. The environmental impacts from the installation and operation phases of large solar farms deserve comprehensive research and understanding. Turney and Fthenakis [1] investigated 32 categories of impacts from the life-stages of solar farms and were able to categorize such impacts as either beneficial or neutral, with the exception of the "local climate" effects for which they concluded that research and observation are needed. PV panels convert most of the incident solar radiation into heat and can alter the air-flow and temperature profiles near the panels. Such changes, may subsequently affect the thermal environment of near-by populations of humans and other species. Nemet [2] investigated the effect on

global climate due to albedo change from widespread installation of solar panels and found this to be small compared to benefits from the reduction in greenhouse gas emissions. However, Nemet did not consider local microclimates and his analytical results have not been verified with any field data. Donovan [3] assumed that the albedo of ground-mounted PV panels is similar to that of underlying grassland and, using simple calculations, postulated that the heat island effect from installing PV on grassy land would be negligible. Yutaka [4] investigated the potential for large scale of roof-top PV installations in Tokyo to alter the heat island effect of the city and found this to be negligible if PV systems are installed on black roofs.

In our study we aim in comprehensively addressing the issue by modeling the air and energy flows around a solar farm and comparing those with measured wind and temperature data.

II. FIELD DATA DESCRIPTION AND ANALYSIS

Detailed measurements of temperature, wind speed, wind direction, solar irradiance, relative humidity, and rain fall were recorded at a large solar farm in North America. Fig. 1 shows an aerial photograph of the solar farm and the locations where the field measurements are taken.

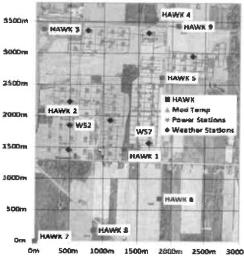
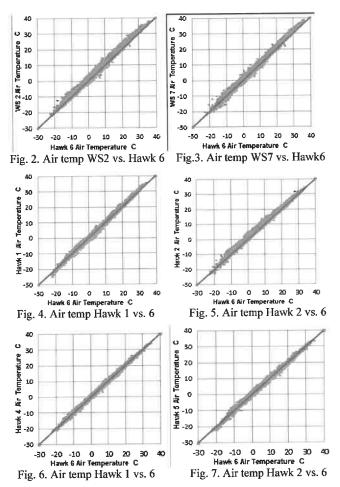


Fig. 1. A picture of the solar farm indicating the locations of the monitoring stations

The field data are obtained from 17 monitoring stations within and around the solar farm, including 8 weather stations (WS) and 9 Hawk stations (HK), all at 2.5 m heights off the ground. There also 80 module temperature (MT) sensors at the back-side of the modules close to each of the corresponding power stations. The WS and MT provide data at 1-min intervals, while the Hawk provides data every 30 minutes. The WS and MT data cover a period of one year from October 2010 to September 2011, while the Hawk data cover a period of 18 months from March 2010 through August 2011.

Hawk stations 3, 6, 7, 8 and 9 are outside the solar farm and were used as reference points indicating ambient conditions. The measurements from Hawk 3, 6, 8 and 9 agree very well confirming that their distances from the perimeter of the solar farm are sufficient for them to be unaffected by the thermal mass of the PV system; Hawk 7 shows higher temperatures likely due to a calibration inaccuracy. In our comparative data analysis we use Hawk 6 as a reference point and, since the prevailing winds are from the south, we selected the section around WS7 as the field for our CFD simulations. Figures 2 to 7 show the difference between the temperatures in Hawk 6 and those in the weather stations WS2 and WS7 within the field, and Hawks 1, 2, 4 and 5 around the solar field.



These figures and Table 1 show that with the exception of Hawk 4, the closer the proximity to solar farm the higher the temperature difference from the ambient (indicated by Hawk 6). The relative high temperatures recorded at Hawk 4, and also the relative low temperatures at Hawks 1 and 5 are explained by the prevailing wind direction, which for the time period used in our analysis (8/14/2010-3/14/2011) was Southerly (158°-202°). Hawk 4 is downwind of the solar farm, whereas Hawks 1 and 5 are upwind; the downwind station "feels" more the effect of the heat generated at the solar farm than the ones upwind.

Fig. 8 shows the decline in air temperature as a function of distance to solar farm perimeter. Distances for WS2 and WS7 are negative since they are located inside the solar farm site. WS2 is further into the solar farm and this is reflected in its higher temperature difference than WS7.

TABLE I
DIFFERENCE OF AIR TEMPERATURE (@2.5 M HEIGHTS) BETWEEN THE
LISTED WEATHER AND HAWK STATIONS AND THE AMBIENT

Met Station	WS2	WS7	HK1	HK2	нк3	HK4	HK5	HK9
Temp Difference from H6 (°C)	1.878	1.468	0.488	1.292	0.292	0.609	0.664	0.289
Distance to solar farm perimeter (m)	-440	-100	100	10	450	210	20	300

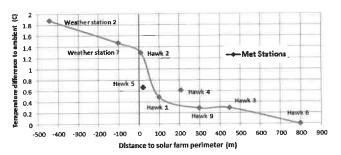


Fig. 8. Air temperature difference as a function of distance from the perimeter of the solar farm. Negative distances indicate locations within the solar farm.

We also examined in detail the temperature differences between the modules and the surrounding air. These vary throughout the year but the module temperatures are consistently higher than those of the surrounding air during the day, whereas at night the modules cool to temperatures below ambient; an example is shown in Fig. 9. Thus, this PV solar farm did not induce a day-after-day increase in ambient temperature, and therefore, adverse micro-climate changes from a potential PV plant are not a concern.

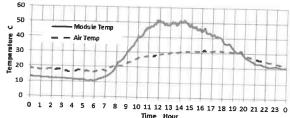


Fig. 9. Comparison of module temperature and air temperature 2.5 m off the ground on a sunny day (July 1, 2011)

III. CFD MODEL DEVELOPMENT

In preliminary simulations we tested the Ansys CFX and FLUENT computational fluid dynamics codes (CFD) and decided to use FLUENT in detailed simulations. FLUENT offers several turbulence schemes including multiple variations of the k-ε models, as well as k-ω models, and Reynolds stress turbulence models. We used the standard, renormalized-group (RNG), and realizable k-ɛ turbulence closure scheme as it is the most commonly used model in street canyon flow and thermal stratification studies [5]. FLUENT incorporates the P-1 radiation model which affords detailed radiation transfer between the solar arrays, the ground and the ambient air; it also incorporates standard free convection and wind-forced convection models. Our choice of solver was the pressure-based algorithm SIMPLE which uses a relationship between velocity and pressure corrections to enforce mass conservation and obtain the pressure field. We conducted both three-dimensional (3-D) and 2-D simulations.

A 3-D model was built of four fields each covering an area of 93-meters by 73-meters (Fig. 10). Each field contains 23 linear arrays of 73-meter length and 1.8-meter width. Each array has 180 modules of 10.5% rated efficiency, placed facing south at a 25-degree angle from horizontal, with their bottom raised 0.5 m from the ground and their top reaching a height of $1.3\ m$. Each array was modeled as a single $73\ m$ $\times 1.8$ m $\times 1$ cm rectangular. The arrays are spaced 4 meters apart and the roads between the fields are 8 m. Fig. 10 shows the simulated temperatures on the arrays at 14:00 pm on 7/1/2011, when the irradiance was 966 W/m². As shown, the highest average temperatures occur on the last array (array 46). Temperature on the front edge (array 1) is lower than in the center (array 23). Also, temperature on array 24 is lower than array 23, which is apparently caused by the cooling induced by the road space between two fields, and the magnitude of the temperature difference between arrays 24 and 46 is lower than that between arrays 1 and 23, as higher temperature differences from the ambient, result in more efficient cooling.

TABLE II

Modules Temperature

WIODULES TEMPERATURE							
Arrays	1 23		24	46			
Temperature ℃	46.1	56.4	53.1	57.8			

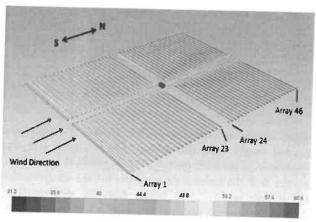
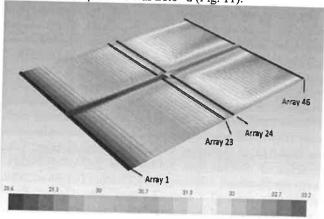


Fig. 10. Module temperatures from 3-D simulations of air flows and thermal exchange during a sunny day

Our simulations also showed that the air temperatures above the arrays at a height of 2.5 m ranged from 28.6 °C to 31.1°C; the ambient temperature was 28.6 °C (Fig. 11).



(a)

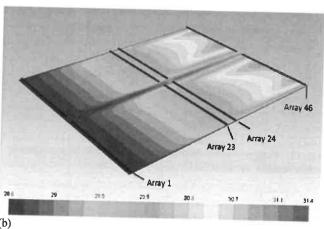


Fig. 11 Air temperatures from 3-D simulations during a sunny day. a) Air temperatures at a height of 1.5 m; b) air temperatures at a height of 2.5 m.

TABLE III
AIR TEMPERATURE

AIR TEM ERRITOR						
Ambient (°C)	Low (°C)	High (℃)	Average (°C)			
28.6	28.6	31.1	30.1			
28.6	28.6	33.2	30.8			
	Ambient (°C) 28.6	Ambient (°C) Low (°C) 28.6 28.6	Ambient (°C) Low (°C) High (°C) 28.6 28.6 31.1			

These simulations show a profound cooling effect with increasing height from the ground. It is shown that the temperatures on the back surface of solar panels is up to 30° C warmer than the ambient temperature, but the air above the arrays is only up to 2.5°C higher than the ambient (i.e., 31.1°C). Also the road between the fields allows for cooling, which is more evident at the temperatures 1.5 m off the ground (Fig. 11a). The simulations show that heat build-up at the power station in the middle of the fields has a negligible effect on the temperature flow fields; it was estimated that a power station adds only about 0.4% to the heat generated by the corresponding modules.

The 3-D model showed that the temperature and air velocity fields within each field of the solar farm were symmetrical along the cross-wind axis; therefore a 2-D model of the downwind and the vertical dimensions was deemed to be sufficiently accurate. A 2-D model reduced the computational requirements and allowed for running simulations for several subsequent days using actual 30-min solar irradiance and wind input data. We tested the numerical results for three layers of different mesh sizes and determined that the following mesh sizes retain sufficient detail for an accurate representation of the field data: a) Top layer: 2m by 1m, b) Middle layer: 1.5m by 0.6m, c) Bottom layer: 1m by 0.4m. According to these mesh specifications, a simulation of 92 arrays (length of 388m, height 9m), required a total of 13600 cells. Figures 12-15 show comparisons of the modeled and measured module and air temperatures.

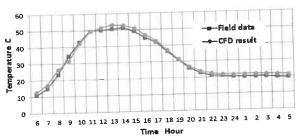


Fig. 12. Comparisons of field and modeled module temperatures; a sunny summer day (7/1/2011); 2-D simulations.

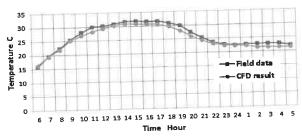


Fig. 13. Comparisons of field and modeled air temperatures at a height of 2.5 m; a sunny summer day (7/1/2011); 2-D simulations.

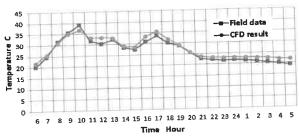


Fig. 14. Comparisons of field and modeled module temperatures; a cloudy summer day (7/11/2011); 2-D simulations.

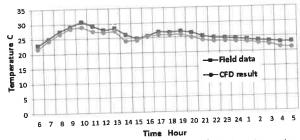
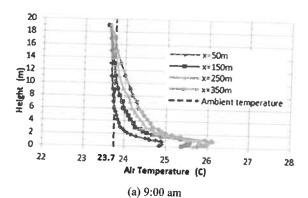


Fig. 15. Comparisons of field and modeled air temperatures at a height of 2.5 m; a cloudy summer day (7/11/2011); 2-D simulations.

Figures 16a and 16b show the air temperature as a function of height at different downwind distances in the morning and afternoon during a sunny summer day. At 9 am (irradiance 500 W/m2, wind speed 1.6 m/s, inlet ambient temperature 23.7°C), the heat from the solar array is dissipated at heights of 5-15m, whereas at 2 pm (irradiance 966 W/m², wind speed 2.8m/s, inlet ambient temperature 28.6°C, the temperature of the panels has reached the daily peak, and the thermal energy takes up to 18 m to dissipate.



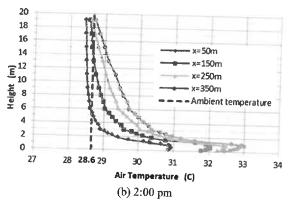


Fig. 16 Air temperatures within the solar farm, as a function of height at different downwind distances. From 2-D simulations during a sunny summer day (7/1/2011) at 9 am and 2 pm.

IV. CONCLUSION

The field data and our simulations show that the annual average of air temperatures at 2.5 m of the ground in the center of simulated solar farm section is 1.9°C higher than the

ambient and that it declines to the ambient temperature at 5 to 18 m heights. The field data also show a clear decline of air temperatures as a function of distance from the perimeter of the solar farm, with the temperatures approaching the ambient temperature (within 0.3°C), at about 300 m away. Analysis of 18 months of detailed data showed that in most days, the solar array was completely cooled at night, and, thus, it is unlikely that a heat island effect could occur.

Our simulations also show that the access roads between solar fields allow for substantial cooling, and therefore, increase of the size of the solar farm may not affect the temperature of the surroundings. Simulations of large (e.g., 1 million m²) solar fields are needed to test this hypothesis.

ACKNOWLEDGEMENT

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Health and Safety Impacts of Solar Photovoltaics MAY 2017







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 (SO₂), 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. 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.

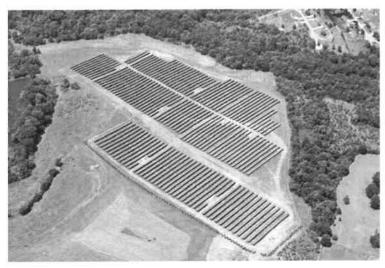


Figure 1: Utility-scale solar facility (5 MW_{AC}) located in Catawba County. Source: Strata Solar

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.

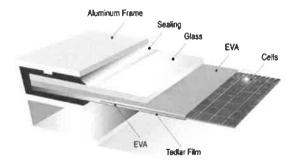


Figure 2: Components of crystalline silicon panels.
The vast majority of silicon panels consist of a glass sheet on the topside with an aluminum frame providing structural support. Image Source:

www.riteksolar.com.tw

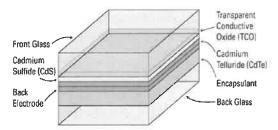


Figure 3: Layers of a common frameless thin-film panel (CdTe). Many thin film panels are frameless, including the most common thin-film panels, First Solar's CdTe. Frameless panels have protective glass on both the front and back of the panel. Layer thicknesses not to scale. Image Source: www.homepower.com

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. 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.

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 (SiO₂) 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. 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... At 13 g/panel. 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... 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... 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, similar to the process used to recycle CdTe panels. Like many silicon-based panels, CdTe panels are reported (as far back ask 1998. 1) 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. 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." 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. 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. Al, 44, 45 Multiple sources report that most modern PV panels (both crystalline silicon and cadmium telluride) pass the TCLP test. 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. Al, 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. 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. 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.

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. 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.. The successful to the user of 2015..

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 moving 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 μ T (microteslas) (equal to 3.0 to 4.0 mG (milligauss)). μ T 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 μ T, with about 1% of the population with an average exposure in excess of 0.4 μ T (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 μ T (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. 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. 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. 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"... Pagnetic fields in the U.S. is estimated to be around one mG or 0.1 µT, but can vary considered be around one mG or 0.1 µT, but can vary considered be around one mG or 0.1 µT, but can vary considered be around one mG or 0.1 µT, but can vary considered when they spend on a person's exposure to them, and the amount of time they spend they spend one source moves you closer to another.

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.. 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.. Representations of the solar project to maintain project to maintain

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. 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. While it is possible for electrical faults in PV systems on homes or commercial buildings to start a fire, this is extremely rare. 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

- <u>Firefighter Safety and Response for Solar Power Systems</u>, National Fire Protection Research Foundation
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- <u>Guidelines for Fire Safety Elements of Solar Photovoltaic Systems</u>, Orange County Fire Chiefs Association
- <u>Solar Photovoltaic Installation Guidelines</u>, 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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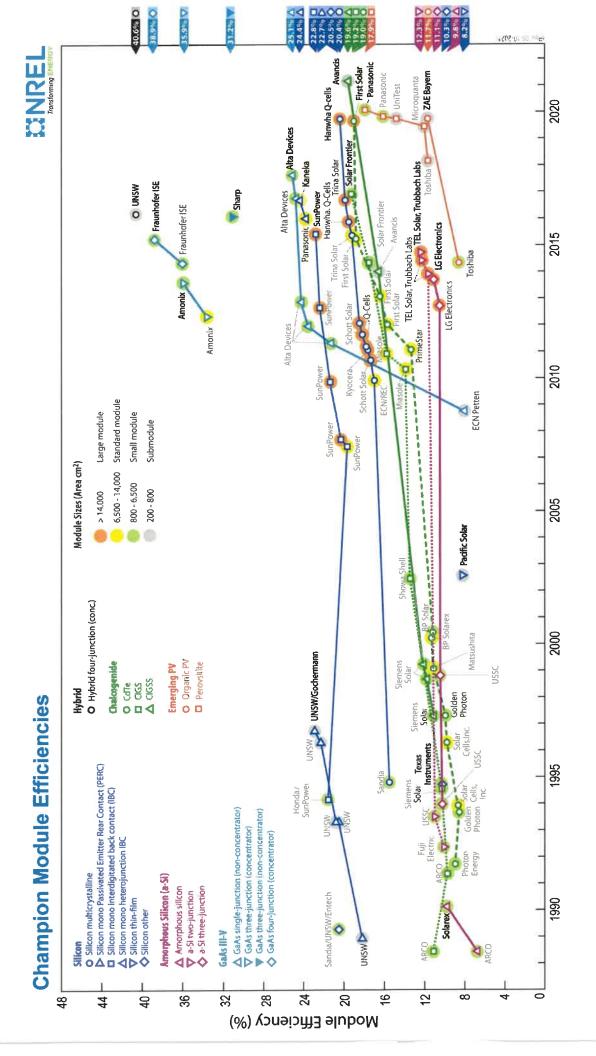
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Published by the N.C. Clean Energy Technology Center at N.C. State University







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Union Ridge Solar

Exhibit L

Decommissioning Plan

Case No. 20-1757-EL-BGN

DECOMMISSIONING PLAN

UNION RIDGE SOLAR HARRISON TOWNSHIP LICKING COUNTY, OH

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Prepared on: February 26, 2021





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Appendices

A. Union Ridge Solar - C.101 Overall Site Plan



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Kimley » Horn

1.0 INTRODUCTION

Background

Union Ridge Solar, LLC (Project Company) is developing the Union Ridge Solar Project (Project) on approximately 513 acres of leased land. The Project will be located in Harrison Township, Licking County, Ohio. The Project will be located along the east and west sides of Watkins Road SW., approximately 0.7 miles north of the intersection of Watkins Road SW and Refugee Road SW. The site is accessible off Watkins Road SW and the geographical coordinates are 39°58'49.48"N, 82°38'43.99"W. The Solar Project is anticipated to remain operational for 35-40 years. Refer to Appendix A: C.101 Overall Site Plan for general location and Project layout.

The Project is planned to occupy approximately 513-acres of agricultural land for the solar field. The site is bound to the south and east by agricultural fields and residential property, to the west by agricultural fields, and to the north by woodland and agricultural fields. Site topography is moderately sloped and slopes from the north to the south with drainage towards the South Fork of the Licking River. The Federal Emergency Management Agency (FEMA) has designated the southern portion of the western site as Zone AE. No disturbance is anticipated in these areas.

This Decommissioning Plan (Plan) is developed in compliance with Ohio Power Siting Board and industry standards.

This Plan covers the following elements of the Solar Photovoltaic (PV) portion of the development:

- Removal off-site for disposal of all Project Components as defined, including any underground structures to at least 3 feet below-grade;
- Revegetation, restoration and road repair activities;
- Decommissioning escrow account.

If the Project ceases to perform its intended function for more than twelve (12) months, the Project will be completely removed within twelve (12) months, and the site restored in accordance with this Decommissioning Plan and Ohio Power Siting Board rules and regulations.

Kimley »Horn

2.0 PROJECT COMPONENTS

The Project Components that are subject to decommissioning include the Solar PV equipment summarized below. The decommissioning activities associated with these components are discussed in Section 3.0 of this Plan.

PV Equipment

The Project will use Solar Photovoltaic (PV) modules mounted on single axis trackers installed on steel pile foundations.

Internal Power Collection System

The PV-generated DC power will be collected from each of the multiple rows of PV modules through one or more combiner boxes and conveyed to inverters. The inverters will convert the DC power to AC power. A project substation will be constructed to covert the electricity voltage, as necessary. The project will be interconnected into the existing Kirk Substation through a High Voltage Overhead Power Line.

Inverters, transformers, and PV combining switchgear will be mounted on concrete or pile foundations.

Earthwork

It is anticipated the site will require minimal grading for the Project. Site grading and drainage will be conducted in accordance with Final Engineering plans approved by Harrison Township, Licking County and the Ohio Power Siting Board.

Roads

Access to the Project will be via Watkins Road SW. The site access roads will be constructed in accordance with Licking County requirements. The on-site access roads will be compacted dirt or gravel in accordance with the Final Geotechnical Report.

Fencing

The Project site will be fenced with an approximately seven-foot-high fence for security purposes. Entry gates will be provided at the site access points on Watkins Road SW.

Kimley »Horn

3.0 PROJECT DECOMMISSIONING AND RECYLCING

Decommissioning includes removal of above-ground and below-ground structures relating to the Solar PV portion of the Project. Only minor grading is anticipated during construction; and therefore, will require limited to no grading following decommissioning. Temporary erosion and sedimentation control Best Management Practices will be implemented during the decommissioning phase of the Project.

Decommissioning Preparation

The first step in the decommissioning process will be to assess existing site conditions and prepare the site for demolition. Onsite storage area(s) will be established, for collection and temporary storage of demolition debris, pending final transportation and disposal and/or recycling according to the procedures listed below.

Permits and Approvals

It is anticipated that an NPDES Permit from the Ohio Environmental Protection Agency Division of Surface Water (DSW) will be required. The site is not anticipated to impact waters of the United States or Threatened or Endangered species; thus, no federal approvals are expected. Appropriate applications for permits will be submitted and approved prior to decommissioning activities, including any permits required through the Soil and Water Conservation District, Harrison Township, and/or Licking County.

PV Equipment Removal and Recycling

During decommissioning, Project components owned by the Project Company that are no longer needed will be removed from the site and recycled or disposed of at an appropriately licensed disposal facility. Above ground portions of the PV module supports will be removed. Below ground portions of the PV module supports will be removed entirely where practical. Those supports that are more firmly anchored may be cut off to a safe depth of at least three (3) feet below grade or to the depth of bedrock, and the remaining support may be left in place. This depth will avoid impact of underground equipment on future farming or other construction activities. The demolition debris and removed equipment may be cut or dismantled into pieces that can be safely lifted or carried with the onsite equipment being used. The debris and equipment will be processed for transportation and delivery to an appropriately licensed disposal facility or recycling center. Modules will be disposed of or recycled in accordance with local, state, and federal regulations.

Internal Power Collection System

The combiner boxes, cables, inverters, and transformers will be dismantled. The concrete foundations will be broken up, removed and recycled. If ground-screw or steel foundations are used, they will be removed and recycled. The underground cable and conduit will be removed where less than three (3) feet below grade. Overhead conductors will be removed from the poles, and the poles and pole foundations will be removed. Aluminum from the conductors will be recycled or removed from the site to an appropriately licensed disposal facility. All components of the project substation including, but not limited to, foundations, buildings, machinery, equipment, cabling, and connections to transmission lines will be removed.

Kimley » Horn

Roads

Unless requested in writing by the landowner, gravel from on-site access roads will be removed and recycled. Once the gravel is removed, the soil below the gravel along compacted dirt access roads will be scarified a depth of 18-inches and blended, as noted in the Site Restoration section below.

Fencing

Unless requested in writing by the landowner, project site perimeter fence will be removed at the end of the decommissioning project. Since the Project site is not currently fenced, this includes removal of all posts, footings, fencing material, gates, etc. to return the site to pre-Project condition.

Landscaping

Unless requested in writing by the landowner to be removed, all vegetative landscaping and screening installed as part of the Project will be left in place. Landscape areas in which landscaping is removed will be restored as noted in the Site Restoration section below.

Site Restoration

Once removal of all Project equipment and landscaping is complete, all areas of the Project site that were traversed by vehicles and construction and/or decommission equipment that exhibit compaction and rutting, will be restored by the Project Company. All prior agricultural land will be ripped at least 18 inches deep or to the extent practicable and all pasture will be ripped at least 12 inches deep or to the extent practicable. The existence of drain tile lines or underground utilities may necessitate less ripping depth. Once this is complete, seed will be distributed for the establishment of vegetative land cover.

4.0 FUTURE LAND USE

The Project site is currently agricultural land. All solar panels will be removed from the property and the land will be restored so that it can be returned to agricultural use at the end of the Project life cycle. This Decommissioning Plan is consistent with Ohio Power Siting Board (OPSB) requirements to return the land to its pre-Project conditions, suitable for agricultural use.

Kimley »Horn

5.0 PROJECT DECOMMISSION COSTS AND FINANCIAL ASSURANCE

This Decommissioning Plan will be updated prior to Construction and will consider salvage value of the Solar PV components of the Project. All solar components will be repurposed, salvaged, recycled, or hauled offsite for disposal. Solar components that are anticipated to have resale or salvage value that may be used to offset the cost of decommissioning include solar modules, racking system, steel piles, inverters, and transformers. Materials that have no value at the time of decommissioning will be recycled when possible or hauled offsite to a licensed solid waste disposal facility. A Project decommissioning cost estimate was created based on the Union Ridge Solar – Overall Site Plan included in Appendix A. See Table 1 below for a current decommissioning cost estimate, excluding salvage value This estimate will be updated prior to construction to include salvage value. See Table 1 below for a current decommissioning cost estimate. Industry standard prices in 2021 for removal costs were determined using RS Means cost data. Removal costs includes materials, contractor installation/demolition, mobilization and demobilization, overhead and profit, and performance bonding.

In the event that the Total Decommission Cost (decommission costs minus salvage value) is a net positive number, the Project Company will post decommissioning funds in the form of a surety bond, letter of credit, guaranty, including affiliate guaranty or other financial assurance consistent with the Final Decommissioning Cost Estimate. This Decommissioning Plan and financial assurance will be reviewed and updated in year 10 of operations and every 5 years thereafter to assess the value of the financial assurance versus the Total Decommission Cost.



TABLE 1 UNION RIDGE SOLAR DECOMMISSIONING COST ESTIMATE:

NO.	ITEMS	QUANTITY	UNIT S	PRICE	COST
1	Mobilization	1	LS	\$117,080	\$117,080
2	SWPPP, Erosion Control Measures	1	LS	\$20,000	\$20,000
3	Seeding	478	AC.	\$208	\$99,424
4	Ripping 18" soil/ scarifying and rough grading existing soil	478	AC.	\$99	\$47,322
5	Fence Removal (includes gate removal)	34,032	LF	\$5	\$170,160
6	Underground Collector Removal (AC and DC) and Backfill	30,735	LF	\$2	\$61,470
7	Remove Electrical Equipment (includes inverter removal, transformer removal, and foundation removal)	34	EA	\$204	\$6,936
8	Remove Photovoltaic Modules	281,060	EA	\$2	\$562,120
9	Remove Steel Piles (12' W6x9 piles @ 14.6' OC assumed)	44,000³	EA	\$13	\$572,000
10	Remove Support Assemblies (Racking)	3,889³	EA	\$204	\$792,000
11	Substation Removal	1	LS	\$85,000	\$85,000
12	Gen-Tie Line Removal	1	LS	\$13,000	\$13,000
13	Disconnection and demolition of substation equipment	1	LS	\$17,813	\$17,813
14	Transportation (this assumes 300-mile round trip) ²	1	LS	\$78,570	\$78,570
	s	UB-TOTAL OF	DECOMM	ISSION COSTS	\$2,642,89
14	Salvage Steel Piles	44,000³	EA	(\$7)	(\$320,760)
15	Salvage Tracker Steel	1	LS	(\$1,120,000)	(\$1,120,000
		SUI	B-TOTAL C	F SALVAGE VALUES	(\$1,440,760
TAL /P	DECOMMISSION COSTS - SALVAGE VALUE)				\$1,202,13

¹ This Engineer's Opinion of Probable Construction Cost is based upon the Overall Site Plan prepared Westwood Professional Services, Inc. dated 11/18/2020. The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs. These quantities and costs are subject to change pending Final Engineering and should be updated as necessary.

Steel pile salvage value of 12' W6x9 at \$7.29 per pile, using scrap metal steel price of \$135 per ton;

Steel tracker salvage value is assumed to be 10% of original cost based on information provided by Leeward Renewable Energy;

²This assumes that approximately 423 trips of a 40,000 lb. capacity demolition roll-off truck will travel 300 miles round trip to a recycling and disposal facility.

³ Steel pile and support assembly quantities were provided by Leeward Renewable Energy.

⁴ This Salvage Value Estimate is based on the following salvage and material values:

APPENDIX A

Union Ridge Solar – C.101 Overall Site Plan



This foregoing document was electronically filed with the Public Utilities

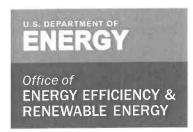
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Case No(s). 20-1757-EL-BGN

Summary: Application Exhibit L - Decommissioning Plan electronically filed by Teresa Orahood on behalf of Dylan F. Borchers



Guide to the Federal Investment Tax Credit for Commercial Solar Photovoltaics

Disclaimer: This guide provides an overview of the federal investment tax credit for those interested in commercial solar photovoltaics, or PV. It does not constitute professional tax advice or other professional financial guidance. And it should not be used as the only source of information when making purchasing decisions, investment decisions, or tax decisions, or when executing other binding agreements.

Overview

The solar investment tax credit (ITC) is a tax credit that can be claimed on federal corporate income taxes for 30% of the cost of a solar photovoltaic (PV) system that is placed in service during the tax year.¹ (Other types of renewable

The U.S. Department of Energy Solar Energy Technologies

Office supports early-stage research and development to improve the affordability, reliability, and performance of solar technologies on the grid. The office invests in innovative research efforts that securely integrate more solar energy into the grid, enhance the use and storage of solar energy, and lower solar electricity costs.



energy are also eligible for the ITC but are beyond the scope of this guidance.)

- In December 2020, Congress passed an extension of the ITC, which provides a 26% for systems commencing construction in 2020-2022, 22% for systems commencing construction in 2023, and 10% for systems commencing construction in 2024 or thereafter. Any PV system placed in service after 2025, regardless of when it commenced construction, can receive a maximum tax credit of 10%.²
- Typically, a solar PV system that is eligible for the ITC can also use an accelerated depreciation corporate deduction.

Eligible Projects

To be eligible for the business ITC (section 48 of the tax code), the solar PV system must be:

- Used by a business subject to U.S. federal income taxes (i.e., it cannot be used by a tax-exempt entity like a charity)
- Located in the United States or U.S. territories (though can only be used against federal income tax obligations)³
- Systems must use new and limited previously used equipment⁴
- Not used to generate energy for heating a swimming pool.

The eligible ITC percentage scales down over time as follows:

• 30% tax credit for projects commencing construction between January 1, 2006, and December 31, 2019, but placed in service before 2026 (before 2024 for projects commencing construction in 2019 and which use the IRS continuity safe harbor. See below for further detail on "continuity safe harbor").

- 26% tax credit for projects commencing construction between January 1, 2020, and December 31, 2022, but placed in service before 2026 (before 2025 for projects commencing construction in 2020 and which use the IRS continuity safe harbor. See below for further detail on "continuity safe harbor").
- 22% tax credit for projects commencing construction between January 1, 2023, and December 31, 2023, but placed in service before 2026.
- 10% tax credit for projects commencing construction after December 31, 2023, or placed in service after December 31, 2025.⁵

A solar project is considered to have commenced construction if:

- At least 5% of final qualifying project costs are incurred. Expenses have to be "integral" to generating electricity, and equipment and services have to be delivered (or delivered within 3.5 months after payment).
- Or, "physical work of significant nature" is commenced on the project site or on project equipment at the factory. Physical work has to be "integral" to the project. Preliminary activities on site (e.g., clearing the site or building a fence or an access road) do not count as "integral."

Both tests require that the project make continuous progress towards completion once construction has begun, which the IRS considers satisfied automatically if the project is placed in service no later than four calendar years (or ten years, for projects that meet the definition of being constructed on federal land⁶) after the calendar year in which construction began (these four and ten year time periods are known as "continuity safe harbor"). Projects can still potentially satisfy the continuity safe harbor beyond four years, depending on their individual facts and circumstances, however, because this is not guaranteed, owners may bear additional risk.⁷

Eligible Expenses

The ITC is calculated by multiplying the applicable tax credit percentage (10%–30%) by the "tax basis," which is the amount invested in eligible property. Eligible property includes the following:

- Solar PV panels, inverters, racking, balance-of-system equipment, and sales and use taxes on the equipment
- · Installation costs and indirect costs
- Step-up transformers, circuit breakers, and surge arrestors
- Energy storage devices (if charged by a renewable energy system more than 75% of the time)⁸

Other Incentives and the ITC

For current information on incentives, including incentive-specific contact information, see the Database of State Incentives for Renewables and Efficiency (DSIRE) at www.dsireusa.org.

Electric Utility and State Government Rebates

Under most circumstances, solar PV system rebates provided by a utility or state government are considered taxable income and do not affect the tax basis when calculating the ITC. For example, if the tax basis is \$1,000,000 for a PV system installed at a retail business that commenced construction before December 31, 2019 and was placed in service before December 31, 2023, and the state government gives a one-time rebate of \$100,000, the ITC would be calculated as follows:

 $0.3 * $1,000,000 = $300,000^9$

One exception is if the rebate is provided by a utility to a customer for purchasing or installing any "energy conservation measure," including solar PV, at a residence. 10 When this is the case, the utility rebate is subtracted from the tax basis, reducing the amount of the ITC claimed; however, the rebate is not considered taxable income. For example, if the tax basis is \$1,000,000 for a PV system installed at an apartment complex and the utility gave a one-time rebate of \$100,000, and the project commenced construction before December 31, 2019 and was placed in service before December 31, 2023, the ITC would be calculated as follows:

0.3 * (\$1,000,000 - \$100,000) = \$270,000

Other Incentives

The following are some examples of incentives and policies associated with a solar PV system that typically do not reduce the tax basis related to the ITC (but some may be considered taxable income):

- Revenue from the sale of renewable energy credits or other environmental attributes associated with the electricity generated by the solar PV system¹¹
- Payments for a state performancebased incentive
- · State and local income tax credits
- State and local property tax exemptions on the equipment
- · Taxable state or nonprofit grants
- · Loan guarantees
- Tax-exempt and subsidized energy financing (in 2009 or after)
- Depreciation deductions (see below).

Accelerated Depreciation and the Depreciation Bonus

Accelerated Depreciation

A taxpayer who claims the commercial ITC for a solar PV system placed in service can typically also take advantage of accelerated depreciation (Modified Accelerated Cost-Recovery System, or MACRS) to reduce the overall cost of a PV installation. To calculate the income on which federal corporate taxes are owed, a business takes the difference between its revenues and expenses, plus

or minus any adjustments to income. Because depreciation is considered an expense, having a larger amount to depreciate during the tax year results in a smaller overall tax liability. Note that while the ITC is a tax *credit*—a dollar-for-dollar reduction in taxes owed—depreciation is a *deduction*, meaning it only reduces a business's taxes by the depreciation amount multiplied by the business's tax rate (see below for an example).

When the commercial ITC¹² is claimed, accelerated depreciation rules allow the full tax basis minus half the ITC to be depreciated over a five-year MACRS depreciation schedule using a half-year convention¹³ (where any unused depreciation can be carried forward indefinitely)¹⁴. Under the rules of this depreciation schedule, taxpayers are allowed to deduct a larger portion of this amount in earlier years, giving them the benefit of a greater immediate reduction in federal tax liability.

Bonus Depreciation

A business with a solar PV system placed in service between January 1, 2008, and September 8, 2010, or between January 1, 2012, and December 31, 2017, can elect to claim a 50% depreciation bonus. Systems placed in service between September 9, 2010 and December 31, 2011 or between January 1, 2018 and December 31, 2022, can elect to claim a 100% bonus depreciation. Starting in 2023, the percentage of capital equipment that can be expensed immediately drops 20% per year (e.g., 80% in 2023 and 60% in 2024) until the provision drops to 0% in 2027.15

Example of a Calculation

A generic example can help illustrate how each incentive could be calculated and applied at a business. Consider a business that commenced construction of a \$1,000,000 solar PV system in 2023, placed it in service in 2025, and uses the calendar year as its tax year. What is the net effect of claiming the ITC, bonus depreciation, and accelerated depreciation on its 2025 tax liability?

ITC Calculation

As indicated above for a solar PV property that commenced construction in 2023 and was eligible for a 22% ITC,

when the tax basis is \$1,000,000, the 22% ITC reduces tax liability by \$220,000.

Bonus Depreciation Calculation

Because the business is claiming the ITC, its depreciable basis for the system after applying the ITC is 89% (100% - 22%/2) of the tax basis:

0.89 * \$1,000,000 = \$890,000

To calculate the bonus depreciation for a solar PV property placed in service in 2025, the business multiplies the depreciable basis by 40%:

0.4 * \$890,000 = \$356,000

Accelerated Depreciation Calculation

In the example, the business uses accelerated depreciation to determine what amount of depreciation it will deduct in each year from 2025 to 2030. Assuming this five-year recovery period, a half-year convention, and a 200% declining balance method, IRS Publication 946 Table A-1 lists the depreciation rate as 20% for Year 1. The business calculates its accelerated depreciation deduction by taking the difference between the original depreciable basis and the amount claimed for the bonus depreciation and multiplying by the depreciation rate: 0.20 * (\$890,000 - \$356,000) = \$106,800

Total Impact on Tax Liability

Assuming the business has a federal tax rate of 21%, the net impact of depreciation deductions is calculated as:

0.21 * (\$356,000 + \$106,800) = \$97,188

Therefore, the total reduced tax liability for 2023 from depreciation deductions and the ITC is:

\$220,000 + \$97,188 = \$317,188

The business will continue to claim accelerated depreciation deductions for tax years 2026, 2027, 2028, 2029, and 2030—but the specific depreciation rate will vary by year. ¹⁶

Unused Tax Credits

Carryback and Carryforward Rules

Unused tax credits related to the commercial ITC may be carried back

1 year and forward 20 years. After 20 years, one- half of any unused credit can be deducted, with the remaining amount expiring.

Tax Equity Financing

When a business developing a solar project does not have a large tax liability, tax equity financing may be an option to take full advantage of federal tax benefits. The business can partner with a tax equity investor who has a relatively large tax appetite and can make use of the tax benefits. There are the following three commonly used models, although the specific arrangements can be quite complicated:

- Sale-Leasebacks: The developer sells the solar PV system to a tax equity investor who leases the system back to the developer.
- Partnership Flips: The developer and investor form a partnership, and the economic returns "flip" from the investor to the developer after the investor makes use of the tax benefits and achieves target yields.
- Inverted Leases: The developer leases the system to the investor, structuring the agreement in a way that allows the investor to use the tax benefits.

Other Issues

Tax-Exempt Entities

Generally, if the solar PV system is used by a tax-exempt entity such as a school, municipal utility, government agency, or charity, the ITC may not be claimed.

In some states, a tax-exempt entity can indirectly benefit from federal tax benefits related to solar by entering into a third-party ownership (TPO) arrangement. Specifically, a tax-exempt entity can agree to purchase the electricity produced by a solar PV system owned and installed by a solar company (who claims the associated federal tax benefits) for an agreed-upon number of years at a set price. This type of TPO arrangement is called a power purchase agreement (PPA). As of June 29, 2019, at least 28 states and Washington, D.C. authorize this type of TPO, 7 states prohibit them, and their legal status is

unclear in the rest.¹⁷ Additionally, the ITC cannot be claimed if a tax-exempt entity simply leases the solar equipment, which is another common type of TPO arrangement used in the residential and commercial sectors; thus, in states that do not allows PPAs, tax-exempt entities cannot use the TPO arrangement to capture tax benefits.

Financing

Eligible solar PV equipment purchased through debt financing qualifies for the ITC. However, individuals (including partnerships or limited liability companies), S corporations, and closelyheld C corporations financing a solar PV project by borrowing on a "nonrecourse basis" face additional rules that may delay claiming of the ITC. Borrowing on a nonrecourse basis means the borrower is not personally liable to repay the loan, and the lender primarily relies on the solar PV project as collateral. In general, the portion of the solar PV project paid through nonrecourse financing is not immediately included when calculating the ITC (although several exceptions exist); instead, in future tax years, the taxpayer can claim the ITC on the portion of the loan principal (but not the interest) as it is repaid.

A Note on Recapture Rules

Though the ITC can be claimed in full for the year in which the solar PV system is placed in service, the business claiming the ITC must retain ownership of the system until the sixth year of the system's operation, or the business will be required to repay a portion of the tax credit. Because the ITC "vests" at a rate of 20% per year over five years, any "unvested" portion is recaptured (i.e., repaid to the Department of the Treasury) if something happens during the five years that would have made the project ineligible for the ITC in the first place. For example, if the business claims the ITC and then sells the system a year later, after it has only vested 20%, it will have to repay 80% of the amount it claimed from the ITC to the Department of the Treasury.

Structures and Building Integrated PV

Structures holding the solar PV system may be eligible for the ITC if the solar PV system is designed with the primary goal of electricity generation and other uses of the structure are merely incidental. Though structural components typically do not qualify for the ITC, the IRS noted an exception for components so specifically engineered that it is in essence part of the machinery or equipment with which it functions."

Claiming the ITC

To claim the ITC, a taxpayer must complete and attach IRS Form 3468 to their tax return. Instructions for completing the form are available at http://www.irs.gov/pub/irs-pdf/i3468.pdf ("Instructions for Form 3468," IRS).

More Information

Ask Questions

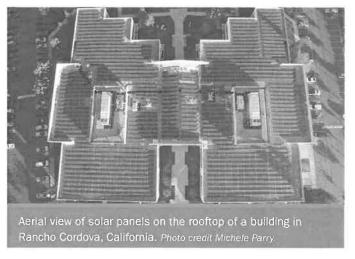
Internal Revenue Service (IRS), 1111 Constitution Avenue, N.W., Washington, D.C. 20224, (800) 829-1040.

Find Resources

- The federal statute regarding the ITC: 26 U.S.C. § 48 at www. govinfo.gov.
- Updated information on the status of the ITC: DSIRE at www. dsireusa.org.

Endnotes

- ¹ 126 U.S.C. § 48, https://www.govinfo.gov/content/pkg/USCODE-2011-title26/pdf/USCODE-2011-title26-subtitleA-chap1-subchapA-partIV-subpartE-sec48.pdf.
- 2 Solar PV systems that commenced construction on or before December 31, 2019 were eligible for a 30% tax credit.
- ³ The IRS has ruled the ITC can be claimed by U.S. corporations, citizens, or partnerships that own solar in U.S. territories; however, companies and individuals are not eligible to receive the tax benefits if they do not pay federal income tax, which means most Puerto Ricans and Puerto Ricans and Puerto Ricans en ineligible. Therefore, solar assets in U.S. territories would most likely need to be owned by outside U.S. investors to take advantage of the ITC (Farrell, Mac, Lindsay Cherry, Jeffrey Lepley, Astha Ummat, and Giovanni Pagan. 2018. Reimagining Grid Solutions: A Better Way Forward for Puerto Rico. Prepared for the Global Collaboratory Panel. https://sipa columbia.edu/sites/default/files/embedded-media/Reimagining%20Grid%20Solutions_Final%20SIPA%20REPORT_0.pdf).
- ⁴ No more than 20% of the eligible value of the PV system can be classified as used equipment.
- ⁵ Tax Cuts and Jobs Act of 2017; Consolidated Appropriations Act, 2021.
- ⁶ "Beginning of Construction for Sections 45 and 48; Extension of Continuity Safe Harbor for Offshore Projects and Federal Land Projects." IRS. Notice 2021-05.
- 7 "Beginning of Construction for the Investment Tax Credit under Section 48." IRS. Notice 2018-59. https://www.irs.gov/pub/irs-drop/n-18-59.pdf. The IRS provided a one-year extension to the Continuity Safe Harbor for projects that began in 2016 or 2017, and a new safe harbor for satisfying the 3.5 month rule for property or services purchased after September 15, 2019 and received by the taxpayer no later than October 15, 2020. "Beginning of Construction for Sections 45 and 48; Extension of Continuity Safe Harbor to Address Delays Related to COVID-19." IRS. Notice 2020-41. https://www.irs.gov/pub/irs-drop/n-20-41.pdf
- 8 Additional considerations apply when the energy storage device is also used to store energy generated from a source other than the solar PV system. For more information, see: IRS. 2013, February 22. IRS private letter ruling 121432-12. http://www.irs.gov/pub/irs-wd/1308005.pdf.
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FS-7A40-70384. https://www.nrcl.gov/docs/fy18osti/70384.pdf.

- 9 If the project commenced construction between January 1, 2020, and December 31, 2022, and it was placed in service before 2026, the ITC is calculated as 0.26 * \$1,000,000 = \$260,000.
- ¹⁰ 26 U.S.C. § 136, https://www.govinfo.gov/app/details/USCODE-2011-title26/USCODE-2011-title26-subtitleA-chap1-subchapB-partIII-sec136.
- 11 IRS. 2010, September 3. IRS private letter ruling 201035003. https://www.irs.gov/pub/irs-wd/1035003.pdf.
- ¹² For projects claiming a 30% ITC, project owners can depreciate 85% of the tax basis, or 100% 30%/2 = 85% (26 U.S.C. § 168, https://www.govinfo.gov/app/details/USCODE-2017-title26/USCODE-2017-title26-subtitleA-chap1-subchapB-partVI-sec168).
- 13 A half-year convention is a tax principle that treats equipment as if it were installed in the middle of the tax year (regardless of when it was actually installed), allowing half a year's depreciation for the first tax year. The half-year convention effectively spreads the five-year MACRS depreciation over six years, with the first year being calculated as half of the 200% declining-balance basis.
- ¹⁴ Before 2018, any unused depreciation could be carried back 2 years and forward 20 years, but that changed with the passage of the Tax Cuts and Jobs Act of 2017 ("Who Needs Sec. 179 Expensing When 100% Bonus Depreciation is Available?" Thomson Reuters Tax and Accounting. October 5, 2018. https://tax.thomsonreuters.com/news/who-needs-sec-179-expensing-when-100-bonus-depreciation-is-available/).
- 15 The bonus depreciation, after 2018, is available for purchased new and used equipment. (Martin, Keith. 2017, December. "How the US Tax Changes Affect Transactions." Norton Rose Fulbright Project Finance Newswire. https://www.nortonrosefulbright.com/en-us/knowledge/publications/68becf68/how-the-us-tax-changes-affect-transactions).
- ¹⁶ IRS. 2015. How to Depreciate Property. Publication 946, Cat. No. 13081F. http://www.irs.gov/pub/irs-pdf/p946.pdf.
- ¹⁷ DSIRE (Database of State Incentives for Renewables and Efficiency). 2019. Third-Party Solar PV Power Purchase Agreements. Updated June 2019. https://www.dsireusa.org/resources/dctailed-summary-maps/ ("Detailed Summary Maps").
- ¹⁸ Meehan, Chris. "Solar Carports, Incentives and the Investment Tax Credit: It's Complicated, Kinda." Solar-Estimate. Last updated August 1, 2019: https://www.solar-estimate.org/news/solar-carports-incentives-investment-tax-credit-113017.
- ¹⁹ IRS. 2010, October 29. IRS private letter ruling 201043023. https://www.irs.gov/pub/irs-wd/1043023.pdf.



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OPEN The Photovoltaic Heat Island **Effect: Larger solar power plants** increase local temperatures

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While photovoltaic (PV) renewable energy production has surged, concerns remain about whether or not PV power plants induce a "heat island" (PVHI) effect, much like the increase in ambient temperatures relative to wildlands generates an Urban Heat Island effect in cities. Transitions to PV plants alter the way that incoming energy is reflected back to the atmosphere or absorbed, stored, and reradiated because PV plants change the albedo, vegetation, and structure of the terrain. Prior work on the PVHI has been mostly theoretical or based upon simulated models. Furthermore, past empirical work has been limited in scope to a single biome. Because there are still large uncertainties surrounding the potential for a PHVI effect, we examined the PVHI empirically with experiments that spanned three biomes. We found temperatures over a PV plant were regularly 3-4°C warmer than wildlands at night, which is in direct contrast to other studies based on models that suggested that PV systems should decrease ambient temperatures. Deducing the underlying cause and scale of the PVHI effect and identifying mitigation strategies are key in supporting decision-making regarding PV development, particularly in semiarid landscapes, which are among the most likely for large-scale PV installations.

Electricity production from large-scale photovoltaic (PV) installations has increased exponentially in recent decades1-3. This proliferation in renewable energy portfolios and PV powerplants demonstrate an increase in the acceptance and cost-effectiveness of this technology^{4,5}. Corresponding with this upsurge in installation has been an increase in the assessment of the impacts of utility-scale PV^{4,6-8}, including those on the efficacy of PV to offset energy needs9,10. A growing concern that remains understudied is whether or not PV installations cause a "heat island" (PVHI) effect that warms surrounding areas, thereby potentially influencing wildlife habitat, ecosystem function in wildlands, and human health and even home values in residential areas11. As with the Urban Heat Island (UHI) effect, large PV power plants induce a landscape change that reduces albedo so that the modified landscape is darker and, therefore, less reflective. Lowering the terrestrial albedo from ~20% in natural deserts12 to ~5% over PV panels13 alters the energy balance of absorption, storage, and release of short- and longwave radiation^{14,15}. However, several differences between the UHI and potential PVHI effects confound a simple comparison and produce competing hypotheses about whether or not large-scale PV installations will create a heat island effect. These include: (i) PV installations shade a portion of the ground and therefore could reduce heat absorption in surface soils¹⁶, (ii) PV panels are thin and have little heat capacity per unit area but PV modules emit thermal radiation both up and down, and this is particularly significant during the day when PV modules are often 20 °C warmer than ambient temperatures, (iii) vegetation is usually removed from PV power plants, reducing the amount of cooling due to transpiration 14, (iv) electric power removes energy from PV power plants, and (v) PV panels reflect and absorb upwelling longwave radiation, and thus can prevent the soil from cooling as much as it might under a dark sky at night.

Public concerns over a PVHI effect have, in some cases, led to resistance to large-scale solar development. By some estimates, nearly half of recently proposed energy projects have been delayed or abandoned due to local opposition¹¹. Yet, there is a remarkable lack of data as to whether or not the PVHI effect is real or simply an issue

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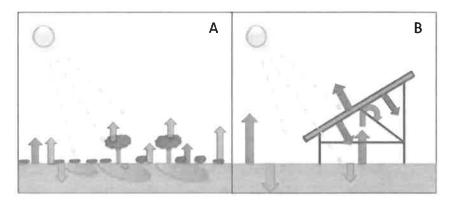


Figure 1. Illustration of midday energy exchange. Assuming equal rates of incoming energy from the sun, a transition from (A) a vegetated ecosystem to (B) a photovoltaic (PV) power plant installation will significantly alter the energy flux dynamics of the area. Within natural ecosystems, vegetation reduces heat capture and storage in soils (orange arrows), and infiltrated water and vegetation release heat-dissipating latent energy fluxes in the transition of water-to-water vapor to the atmosphere through evapotranspiration (blue arrows). These latent heat fluxes are dramatically reduced in typical PV installations, leading to greater sensible heat fluxes (red arrows). Energy re-radiation from PV panels (brown arrow) and energy transferred to electricity (purple arrow) are also shown.

associated with perceptions of environmental change caused by the installations that lead to "not in my back-yard" (NIMBY) thinking. Some models have suggested that PV systems can actually cause a cooling effect on the local environment, depending on the efficiency and placement of the PV panels^{17,18}. But these studies are limited in their applicability when evaluating large-scale PV installations because they consider changes in albedo and energy exchange within an urban environment (rather than a natural ecosystem) or in European locations that are not representative of semiarid energy dynamics where large-scale PV installations are concentrated^{10,19}. Most previous research, then, is based on untested theory and numerical modeling. Therefore, the potential for a PHVI effect must be examined with empirical data obtained through rigorous experimental terms.

The significance of a PVHI effect depends on energy balance. Incoming solar energy typically is either reflected back to the atmosphere or absorbed, stored, and later re-radiated in the form of latent or sensible heat (Fig. 1)^{20,21}. Within natural ecosystems, vegetation reduces heat gain and storage in soils by creating surface shading, though the degree of shading varies among plant types²². Energy absorbed by vegetation and surface soils can be released as latent heat in the transition of liquid water to water vapor to the atmosphere through evapotranspiration - the combined water loss from soils (evaporation) and vegetation (transpiration). This heat-dissipating latent energy exchange is dramatically reduced in a typical PV installation (Fig. 1 transition from A-to-B), potentially leading to greater heat absorption by soils in PV installations. This increased absorption, in turn, could increase soil temperatures and lead to greater sensible heat efflux from the soil in the form of radiation and convection. Additionally, PV panel surfaces absorb more solar insolation due to a decreased albedo^{13,23,24}. PV panels will re-radiate most of this energy as longwave sensible heat and convert a lesser amount (~20%) of this energy into usable electricity. PV panels also allow some light energy to pass, which, again, in unvegetated soils will lead to greater heat absorption. This increased absorption could lead to greater sensible heat efflux from the soil that may be trapped under the PV panels. A PVHI effect would be the result of a detectable increase in sensible heat flux (atmospheric warming) resulting from an alteration in the balance of incoming and outgoing energy fluxes due to landscape transformation. Developing a full thermal model is challenging 17,18,25, and there are large uncertainties surrounding multiple terms including variations in albedo, cloud cover, seasonality in advection, and panel efficiency, which itself is dynamic and impacted by the local environment. These uncertainties are compounded by the lack of empirical data.

We addressed the paucity of direct quantification of a PVHI effect by simultaneously monitoring three sites that represent a natural desert ecosystem, the traditional built environment (parking lot surrounded by commercial buildings), and a PV power plant. We define a PVHI effect as the difference in ambient air temperature between the PV power plant and the desert landscape. Similarly, UHI is defined as the difference in temperature between the built environment and the desert. We reduced confounding effects of variability in local incoming energy, temperature, and precipitation by utilizing sites contained within a 1 km area.

At each site, we monitored air temperature continuously for over one year using aspirated temperature probes 2.5 m above the soil surface. Average annual temperature was 22.7 + 0.5 °C in the PV installation, while the nearby desert ecosystem was only 20.3 + 0.5 °C, indicating a PVHI effect. Temperature differences between areas varied significantly depending on time of day and month of the year (Fig. 2), but the PV installation was always greater than or equal in temperature to other sites. As is the case with the UHI effect in dryland regions, the PVHI effect delayed the cooling of ambient temperatures in the evening, yielding the most significant difference in overnight temperatures across all seasons. Annual average midnight temperatures were 19.3 + 0.6 °C in the PV installation, while the nearby desert ecosystem was only 15.8 + 0.6 °C. This PVHI effect was more significant in terms of actual degrees of warming (+3.5 °C) in warm months (Spring and Summer; Fig. 3, right).

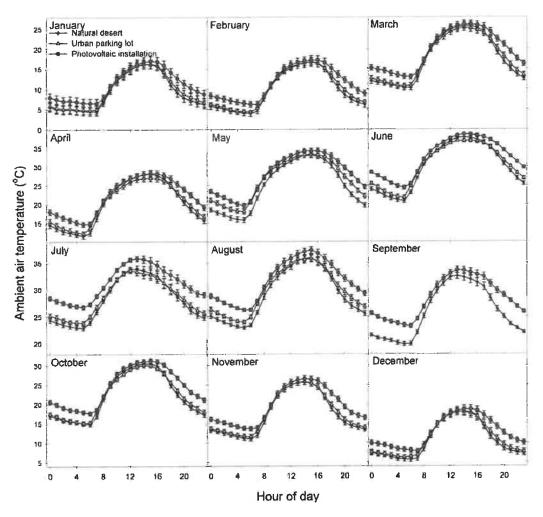


Figure 2. Average monthly ambient temperatures throughout a 24-hour period provide evidence of a photovoltaic heat island (PVHI) effect.

In both PVHI and UHI scenarios, the greater amount of exposed ground surfaces compared to natural systems absorbs a larger proportion of high-energy, shortwave solar radiation during the day. Combined with minimal rates of heat-dissipating transpiration from vegetation, a proportionally higher amount of stored energy is reradiated as longwave radiation during the night in the form of sensible heat (Fig. 1)¹⁵. Because PV installations introduce shading with a material that, itself, should not store much incoming radiation, one might hypothesize that the effect of a PVHI effect would be lesser than that of a UHI. Here, we found that the difference in evening ambient air temperature was consistently greater between the PV installation and the desert site than between the parking lot (UHI) and the desert site (Fig. 3). The PVHI effect caused ambient temperature to regularly approach or be in excess of 4 °C warmer than the natural desert in the evenings, essentially doubling the temperature increase due to UHI measured here. This more significant warming under the PVHI than the UHI may be due to heat trapping of re-radiated sensible heat flux under PV arrays at night. Daytime differences from the natural ecosystem were similar between the PV installation and urban parking lot areas, with the exception of the Spring and Summer months, when the PVHI effect was significantly greater than UHI in the day. During these warm seasons, average midnight temperatures were 25.5 + 0.5 °C in the PV installation and 23.2 + 0.5 °C in the parking lot, while the nearby desert ecosystem was only 21.4 + 0.5 °C.

The results presented here demonstrate that the PVHI effect is real and can significantly increase temperatures over PV power plant installations relative to nearby wildlands. More detailed measurements of the underlying causes of the PVHI effect, potential mitigation strategies, and the relative influence of PVHI in the context of the intrinsic carbon offsets from the use of this renewable energy are needed. Thus, we raise several new questions and highlight critical unknowns requiring future research.

What is the physical basis of land transformations that might cause a PVHI?

We hypothesize that the PVHI effect results from the effective transition in how energy moves in and out of a PV installation versus a natural ecosystem. However, measuring the individual components of an energy flux model remains a necessary task. These measurements are difficult and expensive but, nevertheless, are indispensable in identifying the relative influence of multiple potential drivers of the PVHI effect found here. Environmental

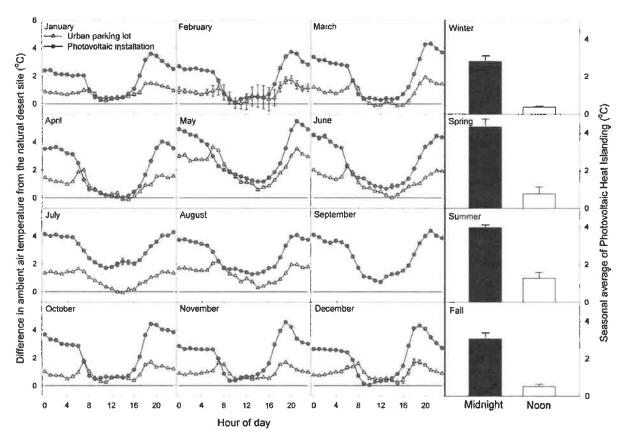


Figure 3. (Left) Average monthly levels of Photovoltaic Heat Islanding (ambient temperature difference between PV installation and desert) and Urban Heat Islanding (ambient temperature difference between the urban parking lot and the desert). (Right) Average night and day temperatures for four seasonal periods, illustrating a significant PVHI effect across all seasons, with the greatest influence on ambient temperatures at night.

conditions that determine patterns of ecosystem carbon, energy, and water dynamics are driven by the means through which incoming energy is reflected or absorbed. Because we lack fundamental knowledge of the changes in surface energy fluxes and microclimates of ecosystems undergoing this land use change, we have little ability to predict the implications in terms of carbon or water cycling^{4,8}.

What are the physical implications of a PVHI, and how do they vary by region?

The size of an UHI is determined by properties of the city, including total population 26-28, spatial extent, and the geographic location of that city 29-31. We should, similarly, consider the spatial scale and geographic position of a PV installation when considering the presence and importance of the PVHI effect. Remote sensing could be coupled with ground-based measurements to determine the lateral and vertical extent of the PVHI effect. We could then determine if the size of the PVHI effect scales with some measure of the power plant (for example, panel density or spatial footprint) and whether or not a PVHI effect reaches surrounding areas like wildlands and neighborhoods. Given that different regions around the globe each have distinct background levels of vegetative ground cover and thermodynamic patterns of latent and sensible heat exchange, it is possible that a transition from a natural wildland to a typical PV power plant will have different outcomes than demonstrated here. The paucity in data on the physical effects of this important and growing land use and land cover change warrants more studies from representative ecosystems.

What are the human implications of a PVHI, and how might we mitigate these effects?

With the growing popularity of renewable energy production, the boundaries between residential areas and larger-scale PV installations are decreasing. In fact, closer proximity with residential areas is leading to increased calls for zoning and city planning codes for larger PV installations^{32,33}, and PVHI-based concerns over potential reductions in real estate value or health issues tied to Human Thermal Comfort (HTC)³⁴. Mitigation of a PVHI effect through targeted revegetation could have synergistic effects in easing ecosystem degradation associated with development of a utility scale PV site and increasing the collective ecosystem services associated with an area⁴. But what are the best mitigation measures? What tradeoffs exist in terms of various means of revegetating degraded PV installations? Can other albedo modifications be used to moderate the severity of the PVHI?



Figure 4. Experimental sites. Monitoring a (1) natural semiarid desert ecosystem, (2) solar (PV) photovoltaic installation, and (3) an "urban" parking lot – the typical source of urban heat islanding – within a 1 km² area enabled relative control for the incoming solar energy, allowing us to quantify variation in the localized temperature of these three environments over a year-long time period. The Google Earth image shows the University of Arizona's Science and Technology Park's Solar Zone.

To fully contextualize these findings in terms of global warming, one needs to consider the relative significance of the (globally averaged) decrease in albedo due to PV power plants and their associated warming from the PVHI against the carbon dioxide emission reductions associated with PV power plants. The data presented here represents the first experimental and empirical examination of the presence of a heat island effect associated with PV power plants. An integrated approach to the physical and social dimensions of the PVHI is key in supporting decision-making regarding PV development.

Methods

Site Description. We simultaneously monitored a suite of sites that represent the traditional built urban environment (a parking lot) and the transformation from a natural system (undeveloped desert) to a 1 MW PV power plant (Fig. 4; Map data: Google). To minimize confounding effects of variability in local incoming energy, temperature, and precipitation, we identified sites within a 1 km area. All sites were within the boundaries of the University of Arizona Science and Technology Park Solar Zone (32.092150°N, 110.808764°W; elevation: 888 m ASL). Within a 200 m diameter of the semiarid desert site's environmental monitoring station, the area is composed of a sparse mix of semiarid grasses (Sporobolus wrightii, Eragrostis lehmanniana, and Muhlenbergia porteri), cacti (Opuntia spp. and Ferocactus spp.), and occasional woody shrubs including creosote bush (Larrea tridentata), whitethorn acacia (Acacia constricta), and velvet mesquite (Prosopis velutina). The remaining area is bare soil. These species commonly co-occur on low elevation desert bajadas, creosote bush flats, and semiarid grasslands. The photovoltaic installation was put in place in early 2011, three full years prior when we initiated monitoring at the site. We maintained the measurement installations for one full year to capture seasonal variation due to sun angle and extremes associated with hot and cold periods. Panels rest on a single-axis tracker system that pivot east-to-west throughout the day. A parking lot with associated building served as our "urban" site and is of comparable spatial scale as our PV site.

Monitoring Equipment & Variables Monitored. Ambient air temperature (°C) was measured with a shaded, aspirated temperature probe 2.5 m above the soil surface (Vaisala HMP60, Vaisala, Helsinki, Finland in the desert and Microdaq U23, Onset, Bourne, MA in the parking lot). Temperature probes were cross-validated for precision (closeness of temperature readings across all probes) at the onset of the experiment. Measurements of temperature were recorded at 30-minute intervals throughout a 24-hour day. Data were recorded on a data-logger (CR1000, Campbell Scientific, Logan, Utah or Microstation, Onset, Bourne, MA). Data from this

instrument array is shown for a yearlong period from April 2014 through March 2015. Data from the parking lot was lost for September 2014 because of power supply issues with the datalogger.

Statistical analysis. Monthly averages of hourly (on-the-hour) data were used to compare across the natural semiarid desert, urban, and PV sites. A Photovoltaic Heat Island (PVHI) effect was calculated as differences in these hourly averages between the PV site and the natural desert site, and estimates of Urban Heat Island (UHI) effect was calculated as differences in hourly averages between the urban parking lot site and the natural desert site. We used midnight and noon values to examine maximum and minimum, respectively, differences in temperatures among the three measurement sites and to test for significance of heat islanding at these times. Comparisons among the sites were made using Tukey's honestly significant difference (HSD) test³⁵. Standard errors to calculate HSD were made using pooled midnight and noon values across seasonal periods of winter (January-March), spring (April-June), summer (July-September), and fall (October-December). Seasonal analyses allowed us to identify variation throughout a yearlong period and relate patterns of PVHI or UHI effects with seasons of high or low average temperature to examine correlations between background environmental parameters and localized heat islanding.

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Author Contributions

G.A.B.-G., R.L.M. and N.A.A. established research sites and installed monitoring equipment. G.A.B.-G. directed research and R.L.M. conducted most site maintenance. G.A.B.-G., N.A.A., A.D.C. and M.A.P.-Z. led efforts to secure funding for the research. All authors discussed the results and contributed to the manuscript.

Additional Information

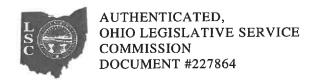
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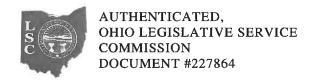
Ohio Revised Code

Section 5727.75 Exemption on tangible personal property and real property of certain qualified energy projects.

Effective: October 17, 2019

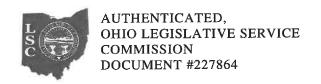
Legislation: House Bill 166, House Bill 6 - 133rd General Assembly

- (A) For purposes of this section:
- (1) "Qualified energy project" means an energy project certified by the director of development services pursuant to this section.
- (2) "Energy project" means a project to provide electric power through the construction, installation, and use of an energy facility.
- (3) "Alternative energy zone" means a county declared as such by the board of county commissioners under division (E)(1)(b) or (c) of this section.
- (4) "Full-time equivalent employee" means the total number of employee-hours for which compensation was paid to individuals employed at a qualified energy project for services performed at the project during the calendar year divided by two thousand eighty hours.
- (5) "Solar energy project" means an energy project composed of an energy facility using solar panels to generate electricity.
- (6) "Internet identifier of record" has the same meaning as in section 9.312 of the Revised Code.
- (B)(1) Tangible personal property of a qualified energy project using renewable energy resources is exempt from taxation for tax years 2011 through 2023 if all of the following conditions are satisfied:
- (a) On or before December 31, 2022, the owner or a lessee pursuant to a sale and leaseback transaction of the project submits an application to the power siting board for a certificate under section 4906.20 of the Revised Code, or if that section does not apply, submits an application for any approval, consent, permit, or certificate or satisfies any condition required by a public agency or

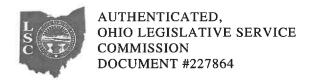


political subdivision of this state for the construction or initial operation of an energy project.

- (b) Construction or installation of the energy facility begins on or after January 1, 2009, and before January 1, 2023. For the purposes of this division, construction begins on the earlier of the date of application for a certificate or other approval or permit described in division (B)(1)(a) of this section, or the date the contract for the construction or installation of the energy facility is entered into.
- (c) For a qualified energy project with a nameplate capacity of twenty megawatts or greater, a board of county commissioners of a county in which property of the project is located has adopted a resolution under division (E)(1)(b) or (c) of this section to approve the application submitted under division (E) of this section to exempt the property located in that county from taxation. A board's adoption of a resolution rejecting an application or its failure to adopt a resolution approving the application does not affect the tax-exempt status of the qualified energy project's property that is located in another county.
- (2) If tangible personal property of a qualified energy project using renewable energy resources was exempt from taxation under this section beginning in any of tax years 2011 through 2023, and the certification under division (E)(2) of this section has not been revoked, the tangible personal property of the qualified energy project is exempt from taxation for tax year 2024 and all ensuing tax years if the property was placed into service before January 1, 2024, as certified in the construction progress report required under division (F)(2) of this section. Tangible personal property that has not been placed into service before that date is taxable property subject to taxation. An energy project for which certification has been revoked is ineligible for further exemption under this section. Revocation does not affect the tax-exempt status of the project's tangible personal property for the tax year in which revocation occurs or any prior tax year.
- (C) Tangible personal property of a qualified energy project using clean coal technology, advanced nuclear technology, or cogeneration technology is exempt from taxation for the first tax year that the property would be listed for taxation and all subsequent years if all of the following circumstances are met:
- (1) The property was placed into service before January 1, 2021. Tangible personal property that has not been placed into service before that date is taxable property subject to taxation.



- (2) For such a qualified energy project with a nameplate capacity of twenty megawatts or greater, a board of county commissioners of a county in which property of the qualified energy project is located has adopted a resolution under division (E)(1)(b) or (c) of this section to approve the application submitted under division (E) of this section to exempt the property located in that county from taxation. A board's adoption of a resolution rejecting the application or its failure to adopt a resolution approving the application does not affect the tax-exempt status of the qualified energy project's property that is located in another county.
- (3) The certification for the qualified energy project issued under division (E)(2) of this section has not been revoked. An energy project for which certification has been revoked is ineligible for exemption under this section. Revocation does not affect the tax-exempt status of the project's tangible personal property for the tax year in which revocation occurs or any prior tax year.
- (D) Except as otherwise provided in this section, real property of a qualified energy project is exempt from taxation for any tax year for which the tangible personal property of the qualified energy project is exempted under this section.
- (E)(1)(a) A person may apply to the director of development services for certification of an energy project as a qualified energy project on or before the following dates:
- (i) December 31, 2022, for an energy project using renewable energy resources;
- (ii) December 31, 2017, for an energy project using clean coal technology, advanced nuclear technology, or cogeneration technology.
- (b) The director shall forward a copy of each application for certification of an energy project with a nameplate capacity of twenty megawatts or greater to the board of county commissioners of each county in which the project is located and to each taxing unit with territory located in each of the affected counties. Any board that receives from the director a copy of an application submitted under this division shall adopt a resolution approving or rejecting the application unless it has adopted a resolution under division (E)(1)(c) of this section. A resolution adopted under division (E)(1)(b) or (c) of this section may require an annual service payment to be made in addition to the service



payment required under division (G) of this section. The sum of the service payment required in the resolution and the service payment required under division (G) of this section shall not exceed nine thousand dollars per megawatt of nameplate capacity located in the county. The resolution shall specify the time and manner in which the payments required by the resolution shall be paid to the county treasurer. The county treasurer shall deposit the payment to the credit of the county's general fund to be used for any purpose for which money credited to that fund may be used.

The board shall send copies of the resolution to the owner of the facility and the director by certified mail or, if the board has record of an internet identifier of record associated with the owner or director, by ordinary mail and by that internet identifier of record. The board shall send such notice within thirty days after receipt of the application, or a longer period of time if authorized by the director.

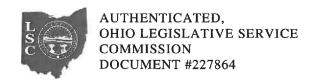
(c) A board of county commissioners may adopt a resolution declaring the county to be an alternative energy zone and declaring all applications submitted to the director of development services under this division after the adoption of the resolution, and prior to its repeal, to be approved by the board.

All tangible personal property and real property of an energy project with a nameplate capacity of twenty megawatts or greater is taxable if it is located in a county in which the board of county commissioners adopted a resolution rejecting the application submitted under this division or failed to adopt a resolution approving the application under division (E)(1)(b) or (c) of this section.

- (2) The director shall certify an energy project if all of the following circumstances exist:
- (a) The application was timely submitted.
- (b) For an energy project with a nameplate capacity of twenty megawatts or greater, a board of county commissioners of at least one county in which the project is located has adopted a resolution approving the application under division (E)(1)(b) or (c) of this section.
- (c) No portion of the project's facility was used to supply electricity before December 31, 2009.

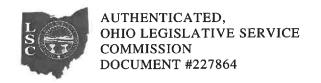


- (3) The director shall deny a certification application if the director determines the person has failed to comply with any requirement under this section. The director may revoke a certification if the director determines the person, or subsequent owner or lessee pursuant to a sale and leaseback transaction of the qualified energy project, has failed to comply with any requirement under this section. Upon certification or revocation, the director shall notify the person, owner, or lessee, the tax commissioner, and the county auditor of a county in which the project is located of the certification or revocation. Notice shall be provided in a manner convenient to the director.
- (F) The owner or a lessee pursuant to a sale and leaseback transaction of a qualified energy project shall do each of the following:
- (1) Comply with all applicable regulations;
- (2) File with the director of development services a certified construction progress report before the first day of March of each year during the energy facility's construction or installation indicating the percentage of the project completed, and the project's nameplate capacity, as of the preceding thirty-first day of December. Unless otherwise instructed by the director of development services, the owner or lessee of an energy project shall file a report with the director on or before the first day of March each year after completion of the energy facility's construction or installation indicating the project's nameplate capacity as of the preceding thirty-first day of December. Not later than sixty days after June 17, 2010, the owner or lessee of an energy project, the construction of which was completed before June 17, 2010, shall file a certificate indicating the project's nameplate capacity.
- (3) File with the director of development services, in a manner prescribed by the director, a report of the total number of full-time equivalent employees, and the total number of full-time equivalent employees domiciled in Ohio, who are employed in the construction or installation of the energy facility;
- (4) For energy projects with a nameplate capacity of twenty megawatts or greater, repair all roads, bridges, and culverts affected by construction as reasonably required to restore them to their preconstruction condition, as determined by the county engineer in consultation with the local jurisdiction responsible for the roads, bridges, and culverts. In the event that the county engineer deems any road, bridge, or culvert to be inadequate to support the construction or decommissioning



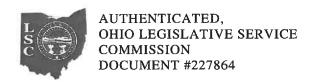
of the energy facility, the road, bridge, or culvert shall be rebuilt or reinforced to the specifications established by the county engineer prior to the construction or decommissioning of the facility. The owner or lessee of the facility shall post a bond in an amount established by the county engineer and to be held by the board of county commissioners to ensure funding for repairs of roads, bridges, and culverts affected during the construction. The bond shall be released by the board not later than one year after the date the repairs are completed. The energy facility owner or lessee pursuant to a sale and leaseback transaction shall post a bond, as may be required by the Ohio power siting board in the certificate authorizing commencement of construction issued pursuant to section 4906.10 of the Revised Code, to ensure funding for repairs to roads, bridges, and culverts resulting from decommissioning of the facility. The energy facility owner or lessee and the county engineer may enter into an agreement regarding specific transportation plans, reinforcements, modifications, use and repair of roads, financial security to be provided, and any other relevant issue.

- (5) Provide or facilitate training for fire and emergency responders for response to emergency situations related to the energy project and, for energy projects with a nameplate capacity of twenty megawatts or greater, at the person's expense, equip the fire and emergency responders with proper equipment as reasonably required to enable them to respond to such emergency situations;
- (6) Maintain a ratio of Ohio-domiciled full-time equivalent employees employed in the construction or installation of the energy project to total full-time equivalent employees employed in the construction or installation of the energy project of not less than eighty per cent in the case of a solar energy project, and not less than fifty per cent in the case of any other energy project. In the case of an energy project for which certification from the power siting board is required under section 4906.20 of the Revised Code, the number of full-time equivalent employees employed in the construction or installation of the energy project equals the number actually employed or the number projected to be employed in the certificate application, if such projection is required under regulations adopted pursuant to section 4906.03 of the Revised Code, whichever is greater. For all other energy projects, the number of full-time equivalent employees employed in the construction or installation of the energy project equals the number actually employed or the number projected to be employed by the director of development services, whichever is greater. To estimate the number of employees to be employed in the construction or installation of an energy project, the director shall use a generally accepted job-estimating model in use for renewable energy projects, including but not limited to the job and economic development impact model. The director may adjust an estimate

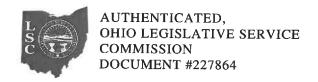


produced by a model to account for variables not accounted for by the model.

- (7) For energy projects with a nameplate capacity in excess of twenty megawatts, establish a relationship with a member of the university system of Ohio as defined in section 3345.011 of the Revised Code or with a person offering an apprenticeship program registered with the employment and training administration within the United States department of labor or with the apprenticeship council created by section 4139.02 of the Revised Code, to educate and train individuals for careers in the wind or solar energy industry. The relationship may include endowments, cooperative programs, internships, apprenticeships, research and development projects, and curriculum development.
- (8) Offer to sell power or renewable energy credits from the energy project to electric distribution utilities or electric service companies subject to renewable energy resource requirements under section 4928.64 of the Revised Code that have issued requests for proposal for such power or renewable energy credits. If no electric distribution utility or electric service company issues a request for proposal on or before December 31, 2010, or accepts an offer for power or renewable energy credits within forty-five days after the offer is submitted, power or renewable energy credits from the energy project may be sold to other persons. Division (F)(8) of this section does not apply if:
- (a) The owner or lessee is a rural electric company or a municipal power agency as defined in section 3734.058 of the Revised Code.
- (b) The owner or lessee is a person that, before completion of the energy project, contracted for the sale of power or renewable energy credits with a rural electric company or a municipal power agency.
- (c) The owner or lessee contracts for the sale of power or renewable energy credits from the energy project before June 17, 2010.
- (9) Make annual service payments as required by division (G) of this section and as may be required in a resolution adopted by a board of county commissioners under division (E) of this section.



- (G) The owner or a lessee pursuant to a sale and leaseback transaction of a qualified energy project shall make annual service payments in lieu of taxes to the county treasurer on or before the final dates for payments of taxes on public utility personal property on the real and public utility personal property tax list for each tax year for which property of the energy project is exempt from taxation under this section. The county treasurer shall allocate the payment on the basis of the project's physical location. Upon receipt of a payment, or if timely payment has not been received, the county treasurer shall certify such receipt or non-receipt to the director of development services and tax commissioner in a form determined by the director and commissioner, respectively. Each payment shall be in the following amount:
- (1) In the case of a solar energy project, seven thousand dollars per megawatt of nameplate capacity located in the county as of the thirty-first-day of December of the preceding tax year;
- (2) In the case of any other energy project using renewable energy resources, the following:
- (a) If the project maintains during the construction or installation of the energy facility a ratio of Ohio-domiciled full-time equivalent employees to total full-time equivalent employees of not less than seventy-five per cent, six thousand dollars per megawatt of nameplate capacity located in the county as of the thirty-first day of December of the preceding tax year;
- (b) If the project maintains during the construction or installation of the energy facility a ratio of Ohio-domiciled full-time equivalent employees to total full-time equivalent employees of less than seventy-five per cent but not less than sixty per cent, seven thousand dollars per megawatt of nameplate capacity located in the county as of the thirty-first day of December of the preceding tax year;
- (c) If the project maintains during the construction or installation of the energy facility a ratio of Ohio-domiciled full-time equivalent employees to total full-time equivalent employees of less than sixty per cent but not less than fifty per cent, eight thousand dollars per megawatt of nameplate capacity located in the county as of the thirty-first day of December of the preceding tax year.
- (3) In the case of an energy project using clean coal technology, advanced nuclear technology, or cogeneration technology, the following:



- (a) If the project maintains during the construction or installation of the energy facility a ratio of Ohio-domiciled full-time equivalent employees to total full-time equivalent employees of not less than seventy-five per cent, six thousand dollars per megawatt of nameplate capacity located in the county as of the thirty-first day of December of the preceding tax year;
- (b) If the project maintains during the construction or installation of the energy facility a ratio of Ohio-domiciled full-time equivalent employees to total full-time equivalent employees of less than seventy-five per cent but not less than sixty per cent, seven thousand dollars per megawatt of nameplate capacity located in the county as of the thirty-first day of December of the preceding tax year;
- (c) If the project maintains during the construction or installation of the energy facility a ratio of Ohio-domiciled full-time equivalent employees to total full-time equivalent employees of less than sixty per cent but not less than fifty per cent, eight thousand dollars per megawatt of nameplate capacity located in the county as of the thirty-first day of December of the preceding tax year.
- (H) The director of development services in consultation with the tax commissioner shall adopt rules pursuant to Chapter 119. of the Revised Code to implement and enforce this section.

The Legislative Service Commission presents the text of this section as a composite of the section as amended by multiple acts of the General Assembly. This presentation recognizes the principle stated in R.C. 1.52(B) that amendments are to be harmonized if reasonably capable of simultaneous operation.

Ohio legislature passes solar and wind project siting and approval bill

By:Peggy Kirk Hall, Associate Professor, Agricultural & Resource Law Thursday, July 01st, 2021

Update: Governor DeWine signed this bill on July 12, 2021 and it becomes effective on October 9, 2021.

It's been a long and winding road to the Governor's desk for Senate Bill 52, the controversial bill on siting and approval of large-scale wind and solar facilities in Ohio. The bill generated opposition and concern from the outset, requiring a major overhaul early on. A substitute bill passed the Senate on June 2 after six hearings and hundreds of witnesses testifying for and against the bill. It took the House five hearings to pass a further revised version of the bill earlier this week, and the Senate agreed to those revisions the same day. Now the bill awaits Governor DeWine's action. If the Governor signs the bill, it would become effective in 90 days.

S.B. 52 generates conflicting opinions on property rights and renewable energy. It would grant counties and townships a voice in the siting and approval of large-scale wind and solar projects, allowing a community to go so far as to reject facility applications and prohibit facilities in identified restricted areas of the county. Supporters of the bill say that new local authority would allow local residents to protect their individual property rights as well as the fate of the community. On the other side, opponents claim that the bill interferes with the property rights of those who want to lease their land for solar and wind development and unfairly subjects renewable energy to stricter controls than other energy projects.

The bill itself is lengthy and a bit tedious but we've organized it into the following summary. An important first step is to understand the types of projects subject to the law, so we begin with the definitions section of the bill.

Definitions – Ohio Revised Code 303.57

The bill defines several key terms used to identify the types of wind and solar projects and applications that would be subject to the new law:

- "Economically significant wind farm" means wind turbines and associated facilities with a single interconnection to the electrical grid and designed for, or capable of, operation at an aggregate capacity of five or more megawatts but less than fifty megawatts, excluding any such wind farm in operation on June 24, 2008 and one or more wind turbines and associated facilities that are primarily dedicated to providing electricity to a single customer at a single location and that are designed for, or capable of, operation at an aggregate capacity of less than twenty megawatts, as measured at the customer's point of interconnection to the electrical grid.
- "Large wind farm" means an electric generating plant that consists of wind turbines and associated facilities with a single interconnection to the electrical grid that is a "major utility facility."
- "Large solar facility" means an electric generating plant that consists of solar panels and associated facilities with a single interconnection to the electrical grid that is a major utility facility.
- "Utility facility" means all of the above.
- "Major utility facility" means (a) electric generating plant and associated facilities designed for, or capable of, operation at a capacity of fifty megawatts or more, (and also includes certain electric transmission lines and gas pipelines).

 "Material amendment" means an amendment to an existing utility facility certificate that changes its generation type, increases its nameplate capacity or changes the boundaries outside existing boundaries or that increase the number or height of wind turbines.

Designation of utility facility restricted areas in a county – ORC 303.58 and ORC 303.59

The bill would allow the county commissioners to designate "restricted areas" within the unincorporated parts of the county where economically significant wind farms, large wind farms, and large solar facilities may <u>not</u> be constructed.

- The commissioners may take this action at a regular or special meeting.
- The commissioners must give public notice of the meeting and proposed restricted areas at least 30 days prior, including to all townships, school districts and municipalities within the proposed restricted areas.
- The restricted area designations shall not apply to utility facilities that were not prohibited by the commissioners in the county review under ORC 303.61, described below.
- The restricted area designations become effective 30 days after the commissioners adopt the resolution unless a petition for referendum, described below, is presented to the commissioners within 30 days of adoption.
- Once effective, a restricted area designation prohibits anyone from filing an application for a certificate or a material amendment to an existing certificate to construct, operate or maintain a utility facility in the restricted area.

Referendum on designation of utility facility restricted areas - ORC

303.59

If a county approves a restricted area, the bill sets up a referendum procedure to allow voters to have a say in the designation. Residents may file a petition for referendum and request the county commissioners to submit the designation of a utility facility restricted area to a vote of the electors in the county.

- At least 8% of the total vote cast for governor in the most recent election must sign the petition.
- The petition must be presented to the commissioners within 30 days of the resolution adopted to designate the restricted areas.
- Within two weeks of receiving the petition and no less than 90 days prior to the election, the county commissioners must certify the petition to the county board of elections, who must verify the validity of the petition.
- The utility facility restricted area designation must be submitted to electors for approval or rejection at a special election on the day of the next primary or general election that occurs at least 120 days after the petition is filed.
- If a majority of the vote is in favor of the restricted area designation, the designation shall be effective immediately.

County review of proposed wind and solar utility facilities -- ORC 303.61

Local residents and officials have expressed concerns that they're the last to know of a proposed large-scale wind or solar development proposed for their community. Under the bill, utility facilities must hold a public meeting in each county where the facility will be located within 90 to 300 days prior to applying for or making a material amendment to an application for a

certificate from the Ohio Power Siting Board.

- The facility applicant must give a 14 day advance written notice of the public meeting to the county commissioners and to trustees of townships in which facility would be located.
- At the meeting, the facility applicant must present in written form the type of utility facility, its maximum nameplate capacity, and a map of its geographic boundaries.
- Up to 90 days after the public meeting, the county commissioners may adopt a resolution that prohibits the construction of the facility or limits its boundaries to a smaller part of the proposed location. If the county commissioners do not prohibit or limit the facility, the applicant may proceed with the application.

Ohio Power Siting Board Composition - ORC 4906.021 to ORC 4906.025

The bill also responds to concerns that community members do not have a voice in the facility approval process overseen by Ohio's Power Siting Board (OPSB). For every utility facility application or material amendment to an application, the bill would require the OPSB to include two voting "ad hoc" members on the board to represent residents in the area where the facility is proposed.

- The ad hoc members shall be the chair of the township trustees and the
 president of the county commissioners in the township and county of
 the proposed location, or their elected official or resident designees, or
 a trustee and commissioner chosen by a vote of the trustees and
 commissioners if the application affects multiple townships and
 counties.
- An ad hoc member or the member's immediate family members cannot

- have an interest in a lease or easement or any other beneficial interest with the applicant utility facility and cannot be an intervenor or have an immediate family member who is an intervenor in the OPSB proceeding.
- The ad hoc members must be designated no more than 30 days after the county or township is notified by the OPSB that the application has been submitted and meets statutory requirements.
- An ad hoc member may not vote on a resolution by its county commissioners or township trustees to intervene in the application proceeding.
- An ad hoc member is exempt from restrictions on ex parte communications with parties in the case but must disclose the date and participants of ex parte conversations and shall not disclose or use confidential information acquired in the course of official duties.

OPSB Authority - ORC 4901.101; ORC 4906.30

There are parameters in the bill for projects that the OPSB may not approve. The OPSB may not grant a certificate for the construction, operation, and maintenance of or material amendment to an existing certificate for a utility facility in these situations:

- If the utility facility is prohibited by a restricted area designation.
- If the county commissioners have prohibited the utility facility by resolution.
 - Where the utility facility would be in multiple counties, the OPSB must modify a certificate to exclude the area of a county whose commissioners prohibited the facility.
- For any areas outside the boundaries of the utility facility that were changed by action of the county commissioners.
- If the facility has a nameplate capacity exceeding the capacity provided to the county commissioners, has a geographic area not completely

within the boundaries provided to the county commissioners, or is a different type of generation than that provided to the county commissioners.

Decommissioning Plans for Utility Facilities - ORC 4906.21 to ORC 4906.212

The question of what happens to a facility when its production life ends has been another issue of voiced concern. The bill establishes decommissioning procedures for facilities. At least 60 days prior to commencement of construction of a utility facility, an applicant must submit a decommissioning plan for review and approval by the OPSB.

- A state registered professional engineer must prepare the plan, and the OPSB may reject the selected engineer.
- The plan must include:
 - A list of parties responsible for decommissioning of the utility facility.
 - A schedule of decommissioning activities, which cannot extend more than 12 months beyond the date the utility facility ceases operation.
 - Estimates of the full cost of decommissioning, including proper disposal of facility components and restoration of the land on which the facility is located to its pre-construction state, but not including salvage value of facility materials.
 - The estimate of the full cost of decommissioning a utility facility must be recalculated every five years by an engineer retained by the applicant.

Performance Bonds - ORC 4906.22 to ORC 4906.222

How to and who pays for facility decommissioning is also addressed in the

bill. Before beginning construction of a utility facility, the applicant must post a performance bond to ensure that funds are available for the decommissioning of the facility.

- The utility facility must name the OPSB as the bond oblige.
- The bond shall equal the estimate of decommissioning costs included in the facility's decommissioning plan.
- The bond shall be updated every five years according to the most recent costs of decommissioning the facility and shall increase if estimated costs increase but shall not decrease if estimated costs decrease.

OPSB Provision of Approved Application -- ORC 4906.31

Under the bill, local governments would formally know if a project receives OPSB approval. The OPSB must provide a complete copy of an approved application for or material amendment to a certificate to each board of trustees and county commissioners in the townships and counties of the facility location.

- The copy must be provided within 3 days of the OPSB's acceptance of the application and filing fee payment by the applicant.
- The copy may be in electronic or paper form.

Effect on Utility Facility Applications in Process – Sections 3, 4 and 5 of the Act

Many wind and solar facility projects are currently in process, so the bill addresses what happens to those projects should the law go into effect.

 The new law would apply to all applications for a certificate or a material amendment to an existing certificate for an economically significant wind farm or large wind farm that is not accepted by the OPSB within 30 days after the effective date of the legislation.

- An application for an economically significant wind farm or large wind farm that is not approved within 30 days after the effective date would be subject to review by the county commissioners, who would have 90 days after the effective date to review the application and act according to the provisions of the new law.
- If an application for a certificate or material amendment to a certificate for a utility facility has not been accepted by the OPSB as of the new law's effective date, the OPSB must include "ad hoc" members in further OPSB proceedings on the application.
- The new law would not apply to an application for a certificate or
 material amendment to a certificate for a large solar facility that, as of
 the effective date of the new law, is in the new services queue of the
 PJM interconnection and regional transmission organization at the time
 the application is accepted by OPSB and the applicant has received a
 completed system impact study from PJM and paid its filing fee.
 - If the facility has multiple positions in the PJM new services queue, all queue position in effect on the law's effective date are exempt from the new law.
 - If the facility submits a new queue position for an increase in its capacity interconnection rights, the change shall not subject the facility to the new law as long as the facility's nameplate capacity does not increase.

We'll keep an eye on the Governor to learn where S.B. 52's road will end. Read the full text of S.B. 52 and further information about it on the Ohio General Assembly's website.

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