

COMMONWEALTH OF KENTUCKY

BEFORE THE KENTUCKY STATE BOARD ON ELECTRIC GENERATION
AND TRANSMISSION SITING

In the Matter of:

ELECTRONIC APPLICATION OF BANJO CREEK)
SOLAR LLC FOR A CERTIFICATE OF)
CONSTRUCTION FOR AN APPROXIMATELY 120)
MEGAWATT ELECTRIC GENERATING FACILITY)
IN GRAVES COUNTY, KENTUCKY PURSUANT)
TO KRS 278.700 AND 807 KAR 5:110)

CASE NO.
2023-00263

NOTICE OF FILING

Notice is given to all parties that the following materials have been filed into the record of this proceeding:

- The digital video recording of the evidentiary hearing conducted on January 23, 2024 in this proceeding;
- Certification of the accuracy and correctness of the digital video recording;
- All exhibits introduced at the evidentiary hearing conducted on January 23, 2024 in this proceeding;
- A written log listing, inter alia, the date and time of where each witness' testimony begins and ends on the digital video recording of the evidentiary hearing conducted on January 23, 2024.

A copy of this Notice, the certification of the digital video record, and hearing log have been served upon all persons listed at the end of this Notice. Parties desiring to view the digital video recording of the hearing may do so at <https://youtu.be/qGBw3MAtrD8>.

Parties wishing an annotated digital video recording may submit a written request by electronic mail to pscfilings@ky.gov. A minimal fee will be assessed for a copy of this recording.

Done at Frankfort, Kentucky, this 29th day of February 2024.



Linda C. Bridwell
Executive Director
Public Service Commission of Kentucky

COMMONWEALTH OF KENTUCKY
BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

ELECTRONIC APPLICATION OF BANJO CREEK)
SOLAR LLC FOR A CERTIFICATE OF)
CONSTRUCTION FOR AN APPROXIMATELY)
120 MEGAWATT ELECTRIC GENERATING)
FACILITY IN GRAVES COUNTY, KENTUCKY)
PURSUANT TO KRS 278.700 AND)
807 KAR 5:110)

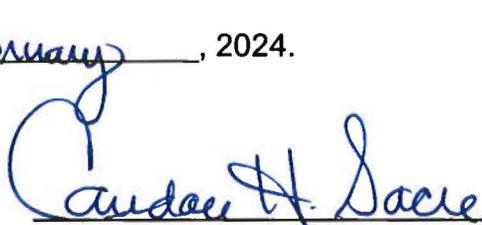
CASE NO.
2023-00263

CERTIFICATION

I, Candace H. Sacre, hereby certify that:

1. The attached flash drive contains a digital recording of the Formal Hearing conducted in the above-styled proceeding on January 23, 2024. The Formal Hearing Log, Exhibit, and Exhibit List are included with the recording on January 23, 2024;
2. I am responsible for the preparation of the digital recording;
3. The digital recording accurately and correctly depicts the Formal Hearing of January 23, 2024; and
4. The Formal Hearing Log attached to this Certificate accurately and correctly states the events that occurred at the Formal Hearing of January 23, 2024, and the time at which each occurred.

Signed this 23rd day of February, 2024.



Candace H. Sacre
Administrative Specialist III



Stephanie Schweighardt
Kentucky State at Large ID# KYNP 64180
Commission Expires: January 14, 2027



Session Report - Detail

2023-00263 23Jan2024

Banjo Creek Solar, LLC (Banjo Creek)

Date:	Type:	Location:	Department:
1/23/2024	Public Hearing\Public Comments	Hearing Room 1	Hearing Room 1 (HR 1)

Witness: Paul Coomes; Johnathan Flemings; Nick Kirkland; Harriet Seacat
 Judge: Angie Hatton; Mary Pat Regan
 Clerk: Candace Sacre

Event Time	Log Event
9:05:24 AM	Session Started
9:05:34 AM	Vice Chairman Hatton Note: Sacre, Candace
	On the record in Case No. 2023-00263.
9:06:00 AM	Vice Chairman Hatton Note: Sacre, Candace
	Preliminary remarks.
9:06:52 AM	Vice Chairman Hatton Note: Sacre, Candace
	Hearing and videoconference recommendations.
9:07:48 AM	Vice Chairman Hatton Note: Sacre, Candace
	Entry of appearance of counsel.
9:07:58 AM	Atty Osterloh Banjo Creek Note: Sacre, Candace
	Todd Osterloh, four witnesses today Johnathan Flemings, Harriet Richardson Seacat, Nck Kirkland, and Dr. Paul Coomes.
9:08:30 AM	Staff Atty Carr PSC Note: Sacre, Candace
	Nicole Carr.
9:08:32 AM	Staff Atty Tussey PSC Note: Sacre, Candace
	Moriah Tussey.
9:08:40 AM	Vice Chairman Hatton Note: Sacre, Candace
	Public notice.
9:08:50 AM	Vice Chairman Hatton Note: Sacre, Candace
	Outstanding motions.
9:10:10 AM	Vice Chairman Hatton Note: Sacre, Candace
	Public comments.
9:10:11 AM	PUBLIC COMMENTS Note: Sacre, Candace
	VARIOUS SPEAKERS.
9:32:49 AM	Vice Chairman Hatton Note: Sacre, Candace
	First witness.
9:32:51 AM	Atty Osterloh Banjo Creek Note: Sacre, Candace
	Johnathan Flemings.
9:33:22 AM	Vice Chairman Hatton Note: Sacre, Candace
	Witness is sworn.
9:33:33 AM	Atty Osterloh Banjo Creek - witness Flemings Note: Sacre, Candace
	Direct Examination. Name?
9:33:36 AM	Atty Osterloh Banjo Creek - witness Flemings Note: Sacre, Candace
	By whom employed?
9:33:39 AM	Atty Osterloh Banjo Creek - witness Flemings Note: Sacre, Candace
	Address?
9:33:48 AM	Atty Osterloh Banjo Creek - witness Flemings Note: Sacre, Candace
	Title?
9:33:52 AM	Atty Osterloh Banjo Creek - witness Flemings Note: Sacre, Candace
	What role with project?

9:34:06 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Assist in preparation of materials?

9:34:12 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Sponsor responses?

9:34:17 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Changes to those materials?

9:34:22 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Adopt as testimony?

9:34:26 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Notebook and notes in front of you?

9:34:52 AM Vice Chairman Hatton
Note: Sacre, Candace Procedural discussions. (Click on link for further comments.)

9:35:33 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Cross Examination. Preliminary site plan filed with application?

9:35:40 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Anything changed since plan submitted?

9:35:56 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Anticipate updates to site plan?

9:36:01 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace What anticipate could change?

9:36:44 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Start date for construction?

9:37:13 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Where is this project in TVA process?

9:37:37 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace How long construction take?

9:37:48 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Total project 1270 acres?

9:38:10 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace What responsibility Banjo Creek have ensure mitigation complied with or responsibility of Green Go?

9:38:36 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Who hire employees for construction?

9:38:50 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Will Green Go employ any or all employees hired under Banjo Creek?

9:39:23 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Know no planning/zoning Graves County, contact with executives?

9:40:45 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Letters sent out, what landowners sent to?

9:41:02 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Anticipate structures demolished during construction?

9:41:21 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Agreement with landowners?

9:41:31 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace How storm water and runoff addressed?

9:41:55 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Intention of Banjo Creek develop runoff water plan?

9:42:10 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace What placed between rows of panels?

9:42:22 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Not know how far height ground and panels yet?

9:42:28 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace What ground cover under panels?

9:42:48 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Access roads gravel?
9:43:07 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Explain how decided vegetative screening be?
9:43:37 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	What species trees/shrubs planning to use?
9:43:50 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	How tall trees be when planted?
9:44:01 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	All native to area?
9:44:20 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Request in post-hearing data request, describe native species to be planted?
9:44:21 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace Note: Sacre, Candace	STAFF ATTY CARR PSC - WITNESS FLEMINGS IDENTIFY NATIVE SPECIES OF TREES AND SHRUBS TO BE PLANTED
9:44:25 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Two acres of native pollinators?
9:44:45 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Requests to change vegetative screening?
9:45:18 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	When landscaping proposed to be done?
9:45:37 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Open houses, any residents approach regarding layout of project?
9:46:54 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Comments from neighboring property owners, will landscaping screen those properties?
9:47:28 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Expect updates to landscape plan?
9:47:40 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Mesh coating on fencing?
9:47:54 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Leases between tenant and Green Go?
9:48:07 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Where Banjo Creek fall in corporate structure Green Go?
9:48:38 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Setbacks, not requesting deviation from 2000 feet?
9:48:57 AM	Atty Osterloh Banjo Creek Note: Sacre, Candace	Setbacks. (Click on link for further comments.)
9:49:52 AM	Vice Chairman Hatton Note: Sacre, Candace	Post-hearing, supplement record and give notice. (Click on link for further comments.)
9:49:53 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace Note: Sacre, Candace	STAFF ATTY CARR PSC - WITNESS FLEMINGS CORRECTION TO SECTION 5, SETBACKS, REMOVE PARAGRAPH ERRONEOUSLY INCLUDED.
9:49:57 AM	Staff Atty Carr PSC Note: Sacre, Candace	No residential neighborhoods within 2000 feet. (Click on link for further comments.)
9:50:17 AM	Commissioner Regan Note: Sacre, Candace	First time noticing that? (Click on link for further comments.)
9:50:25 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Where requesting 300 feet, property line, more detail?

9:51:23 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace When 300 feet from residence, actual panel or project line?

9:51:40 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace What about setback inverters and substations?

9:52:09 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Residence setback, 300 feet property line to solar panel?

9:53:01 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Still doing typical buffer for that particular residence?

9:53:32 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Imposed 100 foot for nonparticipating property owners?

9:53:49 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Those are landowners who have not signed contracts with?

9:53:59 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Conversations with those landowners?

9:54:17 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Additional concessions, describe to Board?

9:55:08 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Able to tell distance proposing from closest nonparticipating residence to fencing panel inverter substation or battery storage system?

9:55:36 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Will be requesting those in post-hearing data request?

9:55:44 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Give as is right now?

9:55:45 AM POST-HEARING DATA REQUEST
Note: Sacre, Candace STAFF ATTY CARR PSC - WITNESS FLEMINGS
Note: Sacre, Candace PROVIDE DISTANCE FROM CLOSEST NONPARTICIPATING RESIDENCE TO FENCING, PANEL, INVERTER, SUBSTATION, OR BATTERY STORAGE SYSTEM

9:55:52 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Not concerns with karst?

9:56:02 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace What mitigation measures flood plain?

9:56:42 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Geotechnical report after TVA project completed?

9:56:58 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Banjo Creek have employees?

9:57:10 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Who is Jonathan Burke and title?

9:57:31 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace All employees employed by Green Go?

9:57:43 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Construction employees by Green Go?

9:57:55 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Employee ensure compliance?

9:58:04 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Mitigation measures?

9:58:35 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace What company employ individual ensure compliance during operations?

9:59:09 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Part 11 of application, not signed by Banjo Creek or Green go, no violations federal or state regulations, what companies have ownership interest in Banjo Creek?

9:59:48 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	What other company?
9:59:56 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Glenmont subsidiary of any company?
10:00:03 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Requesting post-hearing data request?
10:00:04 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace	STAFF ATTY CARR PSC - WITNESS FLEMINGS
	Note: Sacre, Candace	GLENMONT SUBSIDIARY OF ANY OTHER COMPANY
10:00:14 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Know when environmental compliance submitted, include Glenmont as having no environmental regulations?
10:00:39 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	As far as TVA interconnection, existing adjacent to TVA Paris-Mayfield?
10:00:51 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Is kilovolt 161?
10:01:00 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Substation within project boundary?
10:01:17 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Set right now or subject to change?
10:01:47 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	How long transmission interconnect be?
10:02:13 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	All TVA studies completed?
10:02:18 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	What studies need be completed?
10:02:50 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Other complaints/concerns by nonparticipating landowners besides setback, if have and are other concerns, detail those?
10:03:36 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Power purchase agreement executed?
10:03:43 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Leases contain decommissioning obligations as far as removal of all underground cabling or equipment?
10:03:56 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Request in a post-hearing data request?
10:03:57 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace	STAFF ATTY CARR PSC - WITNESS FLEMINGS
	Note: Sacre, Candace	PROVIDE DECOMMISSIONING OBLIGATIONS CONTAINED IN LEASES AS FAR AS REMOVAL OF UNDERGROUND CABLING AND EQUIPMENT
10:04:02 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Explain process ensure all soil quality maintained?
10:05:25 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Plan on entering into IRB or PILOT?
10:05:40 AM	Staff Atty Carr PSC - witness Flemings Note: Sacre, Candace	Road usage, impact construction have on roads?
10:06:24 AM	Vice Chairman Hatton Note: Sacre, Candace	Deputy Secretary Lyons?
10:06:45 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	Examination. TVA not committed to off-taking this power?
10:07:15 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	In end rely on end?

10:07:49 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	Response second quarter 2025, all information before us, buildings demolished in process, environmental concerns, so far down line before know what are, toxic leaching, panels sitting there undamaged, any anticipated leaching?
10:09:36 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	What about toxic leaching panel damaged by tornado or whatever?
10:10:27 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	Go to general maintenance, maintain that maintenance?
10:11:16 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	Flood plain, surprised build in flood plain, what damage expect if panel inundated by flood?
10:12:45 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	How many acres in flood plain?
10:13:36 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	No consultation with Fish and Wildlife, State Historical Properties, Kentucky Nature Preserves, no Phase 1 done, no NEPA completed, correct?
10:14:26 AM	Board Member Lyons - witness Flemings Note: Sacre, Candace	Confirm 180 acres of preclearing projected?
10:14:42 AM	Vice Chairman Hatton Note: Sacre, Candace	Mr. Montgomery?
10:15:00 AM	Board Member Montgomery - witness Flemings Note: Sacre, Candace	Examination. Emergency management plan?
10:15:46 AM	Board Member Montgomery - witness Flemings Note: Sacre, Candace	Familiar with report by Coomes?
10:16:02 AM	Board Member Montgomery - witness Flemings Note: Sacre, Candace	Company intends invest \$248 million, still accurate?
10:16:20 AM	Board Member Montgomery - witness Flemings Note: Sacre, Candace	Consistent with size and magnitude?
10:16:42 AM	Board Member Montgomery - witness Flemings Note: Sacre, Candace	Jobs and breakout, consistent seen on other projects?
10:17:06 AM	Board Member Montgomery - witness Flemings Note: Sacre, Candace	How company determine capital investment if not know what going to cost?
10:17:53 AM	Board Member Montgomery - witness Flemings Note: Sacre, Candace	Amount of spend be consistent with Coomes report?
10:18:12 AM	Vice Chairman Hatton Note: Sacre, Candace	Mr. Perry?
10:18:30 AM	Board Member Perry - witness Flemings Note: Sacre, Candace	Examination. New for Graves County, rebuild process now, meeting with Flemings, setbacks different from 300 feet, concerned, where are we with footage discussed that day brought back to everyone at meeting?
10:22:41 AM	Board Member Perry - witness Flemings Note: Sacre, Candace	Emergency management personnel prior to construction, should have been done last year, volunteer fire departments, what other sites with Green Go, research development have in place?
10:25:02 AM	Vice Chairman Hatton Note: Sacre, Candace	Can do that as a follow-up post-hearing data request.
10:25:03 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace Note: Sacre, Candace	BOARD MEMBER PERRY - WITNESS FLEMINGS OTHER PROJECTS GREEN GO HAS IN PLACE

10:25:24 AM Board Member Perry - witness Flemings
Note: Sacre, Candace Heat, what we don't know we don't know, remedy homes sunlight surrounding these homes, mitigation there?

10:26:54 AM Board Member Perry - witness Flemings
Note: Sacre, Candace Three farmers leases with this project, not extend lines more distance, what other landowners have you reached out to, why there and not for others?

10:30:54 AM Vice Chairman Hatton
Note: Sacre, Candace Board Member Waldrop?

10:31:13 AM Board Member Waldrop - witness Flemings
Note: Sacre, Candace Examination. Other paragraphs that need to be added or removed?

10:31:46 AM Board Member Waldrop - witness Flemings
Note: Sacre, Candace How land on specific number?

10:32:20 AM Board Member Waldrop - witness Flemings
Note: Sacre, Candace Reference to fire, been any episodes of panels catching on fire?

10:32:52 AM Board Member Waldrop - witness Flemings
Note: Sacre, Candace Any panels if catch on fire chemicals in air?

10:33:43 AM Board Member Waldrop - witness Flemings
Note: Sacre, Candace What would be maintenance schedule and how often?

10:34:02 AM Board Member Waldrop - witness Flemings
Note: Sacre, Candace Employees be local?

10:34:12 AM Board Member Waldrop - witness Flemings
Note: Sacre, Candace What is an IRB?

10:34:38 AM Vice Chairman Hatton
Note: Sacre, Candace Commissioner?

10:34:41 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Examination. How many meetings with commissioners and how many with residents?

10:35:18 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Discussion about setbacks happen in that meeting?

10:36:03 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Project five-year project, normally how long?

10:36:18 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Only thing holding back changing setbacks throw application out of TVA?

10:36:52 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Setbacks could be 1000 project have to be redone?

10:37:13 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Are setbacks from front door or property line?

10:38:02 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Reason within 300 feet because of interconnection?

10:38:20 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Interconnecting?

10:39:13 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace Explain that to them fully?

10:39:29 AM Commissioner Regan - witness Flemings
Note: Sacre, Candace The 323 jobs and \$23.1 million labor income, temporary?

10:40:20 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Examination. Ground water, able tell us how often testing done?

10:40:46 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Who could tell us that?

10:41:19 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Is report part of evidence in this case?

10:41:33 AM	Staff Atty Carr PSC Note: Sacre, Candace	Will be requesting that in post-hearing data request?
10:41:34 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace Note: Sacre, Candace	VICE CHAIRMAN HATTON - WITNESS FLEMINGS NC CLEAN ENERGY TECHNOLOGY CENTER HEALTH AND SAFETY IMPACT OF PHOTOVOLTAICS MAY 2017 STUDY
10:41:36 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Asked if samples kept anywhere?
10:42:04 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Asked or insinuated look for counties not local ordinances, consider that or not?
10:42:46 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Exact footage between homes and facility, final plans not made, no closer than?
10:43:03 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	What is no closer than number?
10:43:19 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Post-hearing data request
10:43:20 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace Note: Sacre, Candace	VICE CHAIRMAN HATTON - WITNESS FLEMINGS PROVIDE "NO-CLOSER-THAN" DISTANCES BETWEEN HOMES AND SOLAR FACILITIES
10:43:26 AM	Commissioner Regan - witness Flemings Note: Sacre, Candace	Examination. O&M contractor put out to bid?
10:43:49 AM	Commissioner Regan - witness Flemings Note: Sacre, Candace	Local companies?
10:43:52 AM	Commissioner Regan - witness Flemings Note: Sacre, Candace	Ask in post-hearing data request?
10:43:53 AM	POST-HEARING DATA REQUEST Note: Sacre, Candace Note: Sacre, Candace	COMMISSIONER REGAN - WITNESS FLEMINGS LOCAL OPERATION AND MAINTENANCE COMPANIES BE INCLUDED WHEN CONTRACT PUT OUT FOR BID
10:44:03 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Examination (cont'd). Relationship Banjo Creek and Green Go is Banjo Creek is a subsidiary of Green Go?
10:44:39 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Green Go has contract with Glenmont?
10:44:45 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	And Glenmont owns Banjo Creek?
10:44:47 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Banjo Creek not have employees?
10:44:52 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Who has employees, Glenmont or Green Go?
10:45:00 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Banjo Creek have other similar projects?
10:45:06 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Be first Banjo Creek constructed?
10:45:11 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Who have contracts with independent contractors?
10:45:23 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	When know answer to that?
10:45:49 AM	Vice Chairman Hatton - witness Flemings Note: Sacre, Candace	Similar projects be Glenmont projects or Green Go projects?

10:46:17 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Any still owned or operated by Green Go?

10:46:22 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Owned operated by Glenmont?

10:46:30 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Some in development?

10:47:00 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace If no power purchase agreements happen, project scrapped?

10:47:13 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace When know?

10:47:46 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Not be expected damage to ground water from leaching unless damage to panels?

10:48:35 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Graves County site of tornado, alert that happens because performance impacted?

10:49:05 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Not depend on physical inspection?

10:49:15 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Also physical inspection process?

10:49:20 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace How often?

10:49:27 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Assuming found something, how quickly replaced?

10:49:41 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Few weeks to be replaced?

10:49:45 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Procedure shield ground water from damage?

10:50:51 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Concerns about emergency management plan in case of fire, typical have a plan before construction?

10:51:15 AM Vice Chairman Hatton - witness Flemings
Note: Sacre, Candace Transparency as far as public seeing plan?

10:51:25 AM Vice Chairman Hatton
Note: Sacre, Candace Siting Board or Siting Board Counsel?

10:51:33 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Recross Examination. Know if Glenmont has environmental violations?

10:51:57 AM Staff Atty Carr PSC - witness Flemings
Note: Sacre, Candace Banjo Creek responsible making sure complied with or EPC?

10:52:14 AM Vice Chairman Hatton
Note: Sacre, Candace Mr. Osterloh?

10:52:18 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Redirect Examination. Banjo Creek responsible mitigation measures this case?

10:52:29 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Contract with EPC to make sure measures addressed?

10:52:42 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Still flows back to Banjo Creek?

10:52:49 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Setback edge of panel and a residence of 150 feet?

10:53:00 AM Atty Osterloh Banjo Creek - witness Flemings
Note: Sacre, Candace Proposing double that, have 300 feet between edge of panel and residence?

10:53:14 AM	Vice Chairman Hatton Note: Sacre, Candace	Recess until 11:05.
10:53:34 AM	Session Paused	
11:06:34 AM	Session Resumed	
11:06:46 AM	Vice Chairman Hatton Note: Sacre, Candace	Anything further from this witness?
11:06:58 AM	Vice Chairman Hatton Note: Sacre, Candace	Call next witness.
11:07:02 AM	Atty Osterloh Banjo Creek Note: Sacre, Candace	Harriet Richardson Seacat.
11:07:14 AM	Vice Chairman Hatton Note: Sacre, Candace	Witness is sworn.
11:07:35 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Direct Examination. Name?
11:07:44 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	By whom employed?
11:07:47 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Business address?
11:07:56 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Title there?
11:08:03 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Describe role in this project?
11:08:29 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Assist in preparation of materials?
11:08:33 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Sponsor responses?
11:08:37 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Adopt as testimony?
11:08:41 AM	Atty Osterloh Banjo Creek - witness Seacat Note: Sacre, Candace	Materials in front of you?
11:08:44 AM	Vice Chairman Hatton Note: Sacre, Candace	Counsel?
11:08:51 AM	Staff Atty Carr PSC - witness Seacat Note: Sacre, Candace	Cross Examination. What studies still have to be completed by TVA?
11:12:10 AM	Staff Atty Carr PSC - witness Seacat Note: Sacre, Candace	Where in TVA process are and when studies begin start?
11:12:51 AM	Staff Atty Carr PSC - witness Seacat Note: Sacre, Candace	For this project, give idea six months out, seven months out, when studies start?
11:13:23 AM	Vice Chairman Hatton Note: Sacre, Candace	Deputy Secretary Lyons?
11:13:31 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Examination. Since not have studies, opinion find endangered species?
11:14:42 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Safe assume clear tree encounter summertime bat habitat, agree with that?
11:15:54 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	180 acres of trees cleared, probably include bat roosting, what is process in terms of clearing trees?
11:18:06 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Not familiar with streams, are you?
11:18:26 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Suspected mollusk habitat in streams just by observation?

11:19:28 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Whatever information get make better informed decision, Kentucky biological assessment tool, believe applicant should run, just for the record put that out there.
11:21:12 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Be doing Phase 1?
11:21:43 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Red flag, what referring to?
11:22:10 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Familiar with environmental assessment?
11:22:22 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Did you complete?
11:22:29 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	What determination render?
11:23:36 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Include air emissions and waste management measures as well?
11:24:20 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Has HDR studied native species as buffer of choice, done consultation?
11:25:30 AM	Board Member Lyons - witness Seacat Note: Sacre, Candace	Historic properties, cemeteries, other historic property?
11:26:33 AM	Vice Chairman Hatton Note: Sacre, Candace	Mr. Montgomery?
11:26:41 AM	Board Member Montgomery Note: Sacre, Candace	No questions, state for record, not able participate for 15 more minutes. (Click on link for further comments.)
11:27:58 AM	Vice Chairman Hatton Note: Sacre, Candace	Ms. Waldrop?
11:28:11 AM	Board Member Waldrop - witness Seacat Note: Sacre, Candace	Examination. One of residents cited Columbia University study, familiar with study, similar plan for Banjo Creek?
11:31:04 AM	Vice Chairman Hatton Note: Sacre, Candace	Commissioner Regan?
11:31:06 AM	Commissioner Regan - witness Seacat Note: Sacre, Candace	Examination. Worked with Glenmont or Banjo Creek or Green Go?
11:31:43 AM	Commissioner Regan - witness Seacat Note: Sacre, Candace	Done work with other solar companies?
11:31:48 AM	Commissioner Regan - witness Seacat Note: Sacre, Candace	Anything about this location that causes concern?
11:33:33 AM	Vice Chairman Hatton - witness Seacat Note: Sacre, Candace	Examination. Mentioning desktop review, explain what that means?
11:34:48 AM	Vice Chairman Hatton - witness Seacat Note: Sacre, Candace	Means more not on site?
11:34:58 AM	Vice Chairman Hatton - witness Seacat Note: Sacre, Candace	Preliminary, off site?
11:35:07 AM	Vice Chairman Hatton - witness Seacat Note: Sacre, Candace	Not worked with these companies but other solar siting work?
11:35:20 AM	Vice Chairman Hatton - witness Seacat Note: Sacre, Candace	In all cases, every witness downplays environmental concerns, ever work on a project significant problems?
11:37:37 AM	Vice Chairman Hatton - witness Seacat Note: Sacre, Candace	Type of work do end once site approved or follow through the operation?

11:39:04 AM Vice Chairman Hatton - witness Seacat
Note: Sacre, Candace Even after solar facility in operation?

11:39:26 AM Vice Chairman Hatton - witness Seacat
Note: Sacre, Candace If sounds like bit effort made anticipate problem, local neighbors wildlife might have, in operation, anyone still looking?

11:39:59 AM Vice Chairman Hatton
Note: Sacre, Candace Any further questions?

11:40:08 AM Board Member Lyons - witness Seacat
Note: Sacre, Candace Examination. Any oil and gas activities on site?

11:40:12 AM Vice Chairman Hatton
Note: Sacre, Candace Mr. Osterloh?

11:40:26 AM Atty Osterloh Banjo Creek - witness Seacat
Note: Sacre, Candace Redirect Examination. Assisted with Russellville solar project in Kentucky approved by this Board?

11:40:34 AM Atty Osterloh Banjo Creek - witness Seacat
Note: Sacre, Candace Also TVA project?

11:40:37 AM Atty Osterloh Banjo Creek - witness Seacat
Note: Sacre, Candace Area of expertise?

11:40:42 AM Atty Osterloh Banjo Creek - witness Seacat
Note: Sacre, Candace Described process as comprehensive?

11:40:48 AM Atty Osterloh Banjo Creek - witness Seacat
Note: Sacre, Candace What makes TVA different than connection with MISO or PJM?

11:43:09 AM Atty Osterloh Banjo Creek - witness Seacat
Note: Sacre, Candace Fair to say comprehensive process prolongs process?

11:43:36 AM Vice Chairman Hatton
Note: Sacre, Candace Willing call witness out of order?

11:43:40 AM Atty Osterloh Banjo Creek
Note: Sacre, Candace Dr. Paul Coomes.

11:43:50 AM Vice Chairman Hatton
Note: Sacre, Candace Witness is sworn.

11:44:13 AM Atty Osterloh Banjo Creek - witness Coomes
Note: Sacre, Candace Direct Examination. Name?

11:44:17 AM Atty Osterloh Banjo Creek - witness Coomes
Note: Sacre, Candace Address?

11:44:25 AM Atty Osterloh Banjo Creek - witness Coomes
Note: Sacre, Candace Professor Emeritus of Economics, University of Louisville?

11:44:31 AM Atty Osterloh Banjo Creek - witness Coomes
Note: Sacre, Candace Prepare economic analysis report filed in this case?

11:44:37 AM Atty Osterloh Banjo Creek - witness Coomes
Note: Sacre, Candace Sponsor responses?

11:44:40 AM Atty Osterloh Banjo Creek - witness Coomes
Note: Sacre, Candace Accept report and responses as testimony?

11:44:48 AM Vice Chairman Hatton
Note: Sacre, Candace Mr. Montgomery?

11:44:55 AM Board Member Montgomery - witness Coomes
Note: Sacre, Candace Examination. Brief explanation about inputs, what is IMPLAN, and what are inputs?

11:48:06 AM Board Member Montgomery - witness Coomes
Note: Sacre, Candace Also provided Table 4 Kentucky wages and related occupations, and given not lot of data out there for solar installers this is very helpful, in property tax rate assessment 2022, changes in 2023 materially impact projections revenue for property?

11:50:17 AM Vice Chairman Hatton
Note: Sacre, Candace Judge Perry?

11:50:33 AM	Board Member Perry - witness Coomes Note: Sacre, Candace	Examination. On research put together, requested by Green Go?
11:50:49 AM	Board Member Perry - witness Coomes Note: Sacre, Candace	Work for U of L?
11:51:03 AM	Board Member Perry - witness Coomes Note: Sacre, Candace	Contracted for company to come up with research?
11:51:17 AM	Vice Chairman Hatton Note: Sacre, Candace	Questions?
11:51:27 AM	Commissioner Regan - witness Coomes Note: Sacre, Candace	Examination. Doing economic consulting, looked at other projects in Kentucky or outside Kentucky?
11:52:04 AM	Commissioner Regan - witness Coomes Note: Sacre, Candace	Track those projects from when do assessment to see if bears out numbers?
11:53:03 AM	Commissioner Regan - witness Coomes Note: Sacre, Candace	Not see as much economic growth in Graves County, not see trickle effect other businesses?
11:53:55 AM	Vice Chairman Hatton - witness Coomes Note: Sacre, Candace	Examination. Intend follow up and see if numbers true to expectations?
11:55:31 AM	Vice Chairman Hatton - witness Coomes Note: Sacre, Candace	Private consultant, know if anyone in Kentucky doing similar studies?
11:56:58 AM	Vice Chairman Hatton - witness Coomes Note: Sacre, Candace	Questions from Siting Board?
11:57:05 AM	Vice Chairman Hatton Note: Sacre, Candace	Redirect?
11:57:12 AM	Vice Chairman Hatton Note: Sacre, Candace	Next witness?
11:57:15 AM	Atty Osterloh Banjo Creek Note: Sacre, Candace	Nick Kirkland.
11:57:22 AM	Vice Chairman Hatton Note: Sacre, Candace	Witness is sworn.
11:57:37 AM	Atty Osterloh Banjo Creek - witness Kirkland Note: Sacre, Candace	Direct Examination. Name?
11:57:42 AM	Atty Osterloh Banjo Creek - witness Kirkland Note: Sacre, Candace	By whom employed?
11:57:45 AM	Atty Osterloh Banjo Creek - witness Kirkland Note: Sacre, Candace	Address?
11:57:50 AM	Atty Osterloh Banjo Creek - witness Kirkland Note: Sacre, Candace	Assist in preparation of property analysis report?
11:58:03 AM	Atty Osterloh Banjo Creek - witness Kirkland Note: Sacre, Candace	Changes?
11:58:09 AM	Atty Osterloh Banjo Creek - witness Kirkland Note: Sacre, Candace	Adopt as testimony?
11:58:14 AM	Vice Chairman Hatton Note: Sacre, Candace	Counsel for Siting Board?
11:58:17 AM	Staff Atty Carr PSC - witness Kirkland Note: Sacre, Candace	Cross Examination. What was your overall conclusion effect Banjo Creek to property values in Graves County?
11:58:38 AM	Vice Chairman Hatton Note: Sacre, Candace	Questions?
11:59:42 AM	Vice Chairman Hatton Note: Sacre, Candace	Any exhibits? (Click on link for further comments.)

11:59:43 AM	BANJO CREEK HEARING EXHIBIT 1 Note: Sacre, Candace Note: Sacre, Candace	VICE CHAIRMAN HATTON - WITNESS FLEMINGS NC CLEAN ENERGY TECHNOLOGY CENTER HEALTH AND SAFETY IMPACTS OF SOLAR PHOTOVOLTAICS MAY 2017 NC STATE UNIVERSITY
12:01:10 PM	Vice Chairman Hatton Note: Sacre, Candace	Post-hearing data requests.
12:02:19 PM	Vice Chairman Hatton Note: Sacre, Candace	Anything further? (Click on link for further comments.)
12:03:20 PM	Vice Chairman Hatton Note: Sacre, Candace	Adjourned.
12:03:38 PM	Session Ended	



Exhibit List Report

2023-00263 23Jan2024

**Banjo Creek Solar, LLC (Banjo
Creek)**

Name:**Description:**

BANJO CREEK HEARING
EXHIBIT 1

NC CLEAN ENERGY TECHNOLOGY CENTER HEALTH AND SAFETY IMPACTS OF SOLAR
PHOTOVOLTAICS MAY 2017 NC STATE UNIVERSITY



NC CLEAN ENERGY
TECHNOLOGY CENTER

**Health and Safety Impacts of Solar
Photovoltaics**
MAY 2017



NC STATE UNIVERSITY

**BANJO CREEK HEARING
EXHIBIT 1**

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.¹ This is in addition to the value of the electricity and suggests that the air quality benefits of solar are worth more than the electricity itself.

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

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

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

1. Hazardous Materials

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

(1.2) Project Installation/Construction

(1.2) System Components

1.2.1 Solar Panels: Construction and Durability

1.2.2 Photovoltaic technologies

(a) Crystalline Silicon

(b) Cadmium Telluride (CdTe)

(c) CIS/CIGS

1.2.3 Panel End of Life Management

1.2.4 Non-panel System Components

(1.3) Operations and Maintenance

1.1 Project Installation/Construction

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



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

1.2 System Components

1.2.1 Solar Panels: Construction and Durability

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

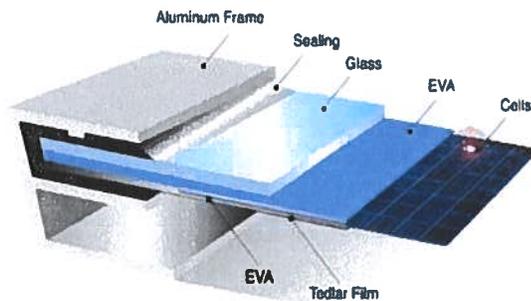


Figure 2: Components of crystalline silicon panels. The vast majority of silicon panels consist of a glass sheet on the topside with an aluminum frame providing structural support. Image Source: www.riteksolar.com.tw

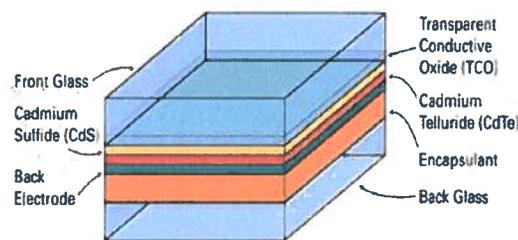


Figure 3: Layers of a common frameless thin-film panel (CdTe). Many thin film panels are frameless, including the most common thin-film panels, First Solar's CdTe. Frameless panels have protective glass on both the front and back of the panel. Layer thicknesses not to scale. Image Source: www.homepower.com

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



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

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

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

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

reasons, adequate insurance coverage is also generally a requirement of the bank or firm providing financing for the project.

1.2.2 Photovoltaic (PV) Technologies

a. Crystalline Silicon

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

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

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

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

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

The use of lead is common in our modern economy. However, only about 0.5% of the annual lead consumption in the U.S. is for electronic solder for all uses; PV solder makes up only a tiny portion of this 0.5%. Close to 90% of lead consumption in the US is in batteries, which do not encapsulate the pounds of lead contained in each typical automotive battery. This puts the lead in batteries at great risk of leaching into the environment. Estimates for the lead in a single PV panel with lead-based solder range from 1.6 to 24 grams of lead, with 13g (less than half of an ounce) per panel seen most often in the literature.¹¹ At 13 g/panel¹², each panel contains one-half of the lead in a typical 12-gauge shotgun shell. This amount equates to roughly 1/750th of the lead in a single car battery. In a panel, it is all durably encapsulated from air or water for the full life of the panel.¹⁴

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

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

b. Cadmium Telluride (CdTe) PV Panels

This subsection examines the components of a cadmium telluride (CdTe) PV panel. Research demonstrates that they pose negligible toxicity risk to public health and safety while significantly reducing the public's exposure to cadmium by reducing coal emissions. As of mid-2016, a few hundred MWs of

cadmium telluride (CdTe) panels, all manufactured by the U.S. company First Solar, have been installed in North Carolina.

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

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

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

Similar to silicon-based PV panels, CdTe panels are constructed of a tempered glass front, one instead of two clear plastic encapsulation layers, and a rear heat strengthened glass backing (together >98% by weight). The final product is built to withstand exposure to the elements without significant damage for over 25 years. While not representative of damage that may occur in the field or even at a landfill, laboratory evidence has illustrated that when panels are ground into a fine powder, very acidic water is able to leach portions of the cadmium and tellurium,³⁰ similar to the process used to recycle CdTe panels. Like many silicon-based panels, CdTe panels are reported (as far back as 1998³¹) to pass the EPA's Toxic Characteristic Leaching Procedure (TCLP) test, which tests the potential for crushed panels in a landfill to leach hazardous substances into groundwater.³² Passing this test means that they are classified as non-hazardous waste and can be deposited in landfills.^{33,34} For more information about PV panel end-of-life, see the Panel Disposal section.

There is also concern of environmental impact resulting from potential catastrophic events involving CdTe PV panels. An analysis of worst-case scenarios for environmental impact from CdTe PV panels, including earthquakes, fires, and floods, was conducted by the University of Tokyo in 2013. After reviewing the extensive international body of research on CdTe PV technology, their report concluded, "Even in the worst-case scenarios, it is unlikely that the Cd concentrations in air and sea water will exceed the environmental regulation values."³⁵ In a worst-case scenario of damaged panels abandoned on the ground, insignificant amounts of cadmium will leach from the panels. This is because this scenario is

much less conducive (larger module pieces, less acidity) to leaching than the conditions of the EPA's TCLP test used to simulate landfill conditions, which CdTe panels pass.³⁶

First Solar, a U.S. company, and the only significant supplier of CdTe panels, has a robust panel take-back and recycling program that has been operating commercially since 2005.³⁷ The company states that it is "committed to providing a commercially attractive recycling solution for photovoltaic (PV) power plant and module owners to help them meet their module (end of life) EOL obligation simply, cost-effectively and responsibly." First Solar global recycling services to their customers to collect and recycle panels once they reach the end of productive life whether due to age or damage. These recycling service agreements are structured to be financially attractive to both First Solar and the solar panel owner. For First Solar, the contract provides the company with an affordable source of raw materials needed for new panels and presumably a diminished risk of undesired release of Cd. The contract also benefits the solar panel owner by allowing them to avoid tipping fees at a waste disposal site. The legal contract helps provide peace of mind by ensuring compliance by both parties when considering the continuing trend of rising disposal costs and increasing regulatory requirements.

c. CIS/CIGS and other PV technologies

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

1.2.3 Panel End-of-Life Management

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

⁴⁹

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

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

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

A look at global PV recycling trends hints at the future possibilities of the practice in our country. Europe installed MW-scale volumes of PV years before the U.S. In 2007, a public-private partnership between the European Union and the solar industry set up a voluntary collection and recycling system called PV CYCLE. This arrangement was later made mandatory under the EU’s WEEE directive, a program for waste electrical and electronic equipment.⁵⁵ Its member companies (PV panel producers) fully finance the association. This makes it possible for end-users to return the member companies’ defective panels for recycling at any of the over 300 collection points around Europe without added costs. Additionally, PV CYCLE will pick up batches of 40 or more used panels at no cost to the user. This arrangement has been very successful, collecting and recycling over 13,000 tons by the end of 2015.⁵⁶

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

The success of the PV panel collection and recycling practices in Europe provides promise for the future of recycling in the U.S. In mid-2016, the US Solar Energy Industry Association (SEIA) announced that they are starting a national solar panel recycling program with the guidance and support of many

leading PV panel producers.⁵⁸ The program will aggregate the services offered by recycling vendors and PV manufacturers, which will make it easier for consumers to select a cost-effective and environmentally responsible end-of-life management solution for their PV products. According to SEIA, they are planning the program in an effort to make the entire industry landfill-free. In addition to the national recycling network program, the program will provide a portal for system owners and consumers with information on how to responsibly recycle their PV systems.

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

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

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

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

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

1.4 Operations and Maintenance – Panel Washing and Vegetation Control

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

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

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

2. Electromagnetic Fields (EMF)

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

produced in a solar farm. The following paragraphs provide some additional background and detail to support this conclusion.

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

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

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

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

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

other commonly encountered types of non-ionizing radiation like radio waves, infrared radiation, and visible light.

The wide use of electricity results in background levels of ELF EMFs in nearly all locations where people spend time – homes, workplaces, schools, cars, the supermarket, etc. A person's average exposure depends upon the sources they encounter, how close they are to them, and the amount of time they spend there.⁶⁸ As stated above, the average exposure to magnetic fields in the U.S. is estimated to be around one mG or 0.1 μ T, but can vary considerably depending on a person's exposure to EMF from electrical devices and wiring.⁶⁹ At times we are often exposed to much higher ELF magnetic fields, for example when standing three feet from a refrigerator the ELF magnetic field is 6 mG and when standing three feet from a microwave oven the field is about 50 mG.⁷⁰ The strength of these fields diminish quickly with distance from the source, but when surrounded by electricity in our homes and other buildings moving away from one source moves you closer to another. However, unless you are inside of the fence at a utility-scale solar facility or electrical substation it is impossible to get very close to the EMF sources. Because of this, EMF levels at the fence of electrical substations containing high voltages and currents are considered "generally negligible".^{71, 72}

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

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

3. Electric Shock and Arc Flash Hazards

There is a real danger of electric shock to anyone entering any of the electrical cabinets such as combiner boxes, disconnect switches, inverters, or transformers; or otherwise coming in contact with voltages over 50 Volts.⁷⁹ Another electrical hazard is an arc flash, which is an explosion of energy that can occur in a short circuit situation. This explosive release of energy causes a flash of heat and a shockwave, both of which can cause serious injury or death. Properly trained and equipped technicians and electricians know how to safely install, test, and repair PV systems, but there is always some risk of

injury when hazardous voltages and/or currents are present. Untrained individuals should not attempt to inspect, test, or repair any aspect of a PV system due to the potential for injury or death due to electric shock and arc flash. The National Electric Code (NEC) requires appropriate levels of warning signs on all electrical components based on the level of danger determined by the voltages and current potentials. The national electric code also requires the site to be secured from unauthorized visitors with either a six-foot chain link fence with three strands of barbed wire or an eight-foot fence, both with adequate hazard warning signs.

4. Fire Safety

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

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

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

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

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

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

Summary

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

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