HEALTH AND SAFETY ASSESSMENT REPORT

Copper Box Solar

200 MW_{AC} Photovoltaic Facility

Montgomery County, IN

ABSTRACT

This is an assessment of the potential health and safety impacts of the proposed 200 MW_{AC} Copper Box Solar photovoltaic facility in Montgomery County, IN that considers the project design, equipment specifications, facility operations, and the end of the life of the facility. The assessment evaluates potential positive and negative impacts on public health and safety. The conclusion of the assessment is that the Copper Box Solar project will not create negative health and safety impacts. The clean electricity the project will produce will reduce the burning of fossil fuels, which will reduce pollution from those sources and provide millions of dollars' worth of local public health benefits as a result.

Tommy Cleveland

Solar Health and Safety Expert

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December 19, 2025 (Revision 1)

Health & Safety Assessment Report

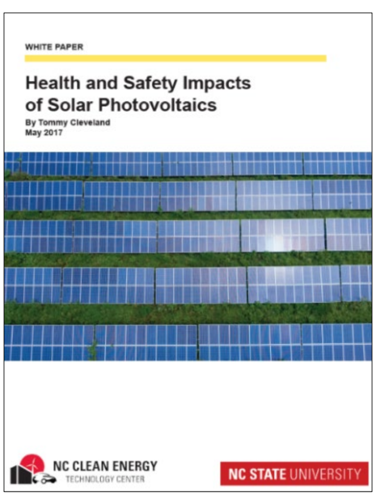
Copper Box Solar
Montgomery County, IN

Project Overview:

- **Project Name:** Copper Box Solar
- **Developer**: ENGIE North America
- **Capacity**: 200 MW_{AC} (~270 MW_{DC})
- **Area Inside the Fence**: 900 acres
- **Solar Panels**: crystalline silicon: Trina 620W bifacial, or similar
- **Structure**: single-axis trackers (~north-south rows, slowly rotate east to west each day)
- **Inverters**: central station type (~4 MW each): SunGrow SG3600UD, or equivalent
- **Battery Energy Storage:** none
- **Point of Interconnection**: Duke Energy 138 kV transmission line running northeast-southwest over 1 mile west of the project area; interconnection point 1.3 miles west of project fence
- **Interconnection Equipment**: 138 kV/34.5 kV project substation located near northwest corner of project area, Duke Energy switchyard 1.3 miles west of substation and just south of point of interconnection

Report Author

The author of this report is **Tommy Cleveland** (the "Author"), an expert in solar energy and its community impacts, based in Raleigh, North Carolina. Mr. Cleveland graduated from North Carolina State University ("NC State") with undergraduate and master's degrees in mechanical engineering, where he focused on energy. His solar career started with his master's thesis, which led to working over 12 years at the North Carolina Clean Energy Technology Center at NC State University. While at the university, Tommy worked on nearly every aspect of solar energy; from teaching, to testing equipment, to research & development, to leading a statewide stakeholder group in the development of a template solar ordinance. During his time at NC State, North Carolina became the state to install more photovoltaic ("PV") capacity than any state other than California, mostly in the form of 2-5 MW_{AC} utility-scale solar facilities covering around 40 acres each. Utility-scale solar was unfamiliar to the hundreds of communities around the state where the systems were proposed, and many of those communities had questions about the technology and its potential to harm public health or the environment in their community. Many of those questions found their way to Mr. Cleveland and he expanded his already broad knowledge of PV to research and find answers to the questions being asked. Over time he became an expert on the potential health and safety impacts of PV and was the lead author of the 2017 NC State white paper on the topic (pictured to the left). Since mid-2017 Mr. Cleveland has worked as a solar engineer at an energy engineering firm conducting interconnection commissioning of utility-scale solar and battery facilities for utilities in North and South Carolina. In this role Mr. Cleveland was the engineer responsible for (interconnection) commissioning over 60 PV sites and 4 battery sites. Mr. Cleveland has been licensed as a professional engineer in NC since 2007, and is also licensed in SC, VA, FL, and OH.



Executive Summary

This report assesses the potential health and safety impacts of the proposed Copper Box Solar approximately 200 MW_{AC} PV project. The Copper Box facility, located in Montgomery County, Indiana, will install crystalline silicon solar panels on single-axis tracking racks that slowly rotate to follow the sun. Over 50 large inverters will convert the DC solar electricity generated by the solar panels into grid-synced AC electricity. Step-up transformers will boost the voltage for connection to an onsite substation that connects to a Duke Energy transmission line that passes northwest of the solar facility. All inverters and transformers are at least 750 feet from homes in the preliminary site plan.

Photovoltaic (PV) panels are not new. They have been used and studied for over 40 years and are well understood by the scientific community. Utility-scale solar facilities are newer, but they too have been installed and studied for over a decade, and scientists also have a clear understanding of their function and impacts.

PV systems produce emission-free electricity. This directly replaces electricity produced by fossil fuel power plants that produce harmful air emissions in the form of gaseous pollutants and particulate matter. The health benefits of clean electricity produced by utility-scale solar are hard to put a dollar figure on, but the EPA's best attempt at doing just that puts the value in the "Midwest" between 2.7 and 6.0 cents per kWh. Even at the bottom end of this range, **Copper Box Solar will provide over $12 million of public health benefit per year, and over $346 million of public health benefit over 30 years.**

The limited risks to health and safety of the Copper Box Solar project are not unique to solar but exist for any source or use of grid electricity. These are electric shock, arc flash, and fire. Due to world-class safety regulations in the U.S. and an experienced solar industry, these risks are extremely low, and the secure and isolated nature of ground-mounted PV facilities, including Copper Box, results in negligible risk to the public.

Common concerns about toxicity, and electric and magnetic fields (EMF) from solar facilities are understandable, but the operating characteristics and materials present in the equipment means that neither toxicity nor EMF pose a risk to public health or safety. The potential for toxicity impacts from PV technology has been studied by academic and regulatory entities for decades, resulting in an understanding that while solar panels may contain small amounts of toxic materials, they pose no risk to public health. EMF is generated by all electricity, including solar PV systems, but does not extend far beyond the physical wires and equipment, so any EMF generated by the project will not impact anyone outside of the facility.

Other common concerns, such as heat island effect, glare, noise, and disposal, are also investigated as potential impacts of Copper Box Solar. Research and experience show that, like other utility-scale PV projects, the Copper Box Solar project will not change the temperature of the surrounding area. The two closest airports are two small airports 10 and 16 miles away and neither have an air traffic control tower, which means there is no risk of causing a solar glare hazard for aviation. Sun-tracking panels removes most glare likely visible to motorists. The large setback of equipment results in no sound impact.

When the solar panels reach the end of their useful life they will be removed from the site and disposed of in conformance with federal, state, and local requirements, which could mean recycling or disposal in a landfill. Today the main constituents of the solar panels, and the other equipment such as racking and transformers, can be recycled within the existing recycling infrastructure. Technology to recycle nearly all the constituents in solar panels exists today and is expected to be much cheaper and widely available when the solar panels at this project reach the end of their useful life. The project has a decommissioning plan and will post a decommissioning surety to cover the cost of decommissioning in a worst-case scenario.

Based on my knowledge of science and engineering, personal experience with PV technology, review of academic research, analysis of the proposed project, and review of materials provided by the project developers about the proposed Copper Box project in Montgomery County, Indiana, my conclusions are summarized as follows:

- The Copper Box Solar project will result in a significant reduction of regional air pollution.
- The Copper Box Solar project will not materially endanger public health or safety.
- The Copper Box Solar project will not increase the temperature of the area surrounding the site.
- The Copper Box Solar project will not create a glare hazard for aviation.
- The Copper Box Solar project will not create bothersome noise for any neighbors.

Introduction

Purpose:

This report assesses the potential health and safety impacts of the proposed Copper Box Solar ("Copper Box") project. It also seeks to educate readers on the health and safety impacts of PV systems using accurate scientific sources of information.

Overview of Potential Impacts:

The proposed solar PV system is likely to remain in operation for at least 30 years, and this report considers its potential impacts in Montgomery County from the start of construction onward, including decommissioning of the project and restoration of the land. This assessment considers all aspects of the project but focuses on those unique to solar projects. The Copper Box project site is in a rural area outside of Crawfordsville, IN. The project site is currently mostly in agricultural use, with residential properties scattered around the project area. The preliminary site plan maintains at least a 500-foot setback of the project fence from residential property lines, resulting in significant separation between nearby homes and the closest solar equipment.

Potential Positive Health and Safety Impacts:

Every utility-scale PV project creates a significant reduction in pollution because it produces emission-free electricity that replaces electricity that otherwise would have been largely produced by burning coal and natural gas. Burning these fossil fuels for electricity production is a significant source of air, water, and soil pollution, so reducing their use is a clear public health benefit.

The US Environmental Protection Agency (EPA) conducted a study across 14 US regions to estimate how much pollution PV systems avoid and how much public health value the resulting cleaner air provides to each region. These experts calculated that based on the sunshine available, the way electricity is produced, and the public health impacts of fossil fuel-fired electricity, every kilowatt-hour (kWh) of electricity produced by utility-scale solar in the "Midwest" region provides 2.7 to 6.0 cents of public health benefit.[1] At this rate of benefit, **the Copper Box project will produce $12 to $26 million of public health benefits every year**, which could add up to $346 to $780 million over the life of the project. The public health benefits of generating pollution-free electricity with PV are very significant.

The positive benefits of PV are widely understood and well documented, so this report will not address them further. Furthermore, the positive public health impacts of the Copper Box project dramatically overwhelm any negative health and safety risks.

Potential Negative Health and Safety Impacts:

While PV facilities, like any electricity generating facility, provide some potential for negative health and safety impacts, the Copper Box project does not present any negative health and safety risks specific to its location or technology choice. The only aspects of PV systems that presents risk of physical harm are the potential for electrical shock, arc flash, or fire, which are hazards present with any electrical system and not unique to solar. These risks only apply to people inside the site fence working closely with the equipment, and therefore do not impact the public outside of the project fence. There are several other aspects of PV systems that often raise public health and safety concerns, but no other aspect of PV systems poses more than an insignficant risk of negative public health or safety impacts. This report will address all the potential health and/or safety risks of the Copper Box project, including common concerns that have no potential for public health impact. Specifically, this report addresses the following possible negative impacts/concerns:

- Electrical Shock and Arc Flash
- Fire and Emergency Response
- Toxicity
- Electromagnetic Fields (EMF)
- Heat Island Effect
- Glare and Noise

[1] US Environmental Protection Agency, Public Health Benefits-per-kWh of Energy Efficiency and Renewable Energy in the United States: A Technical Report. 2nd Ed, May 2021, www.epa.gov/statelocalenergy/public-health-benefits-kwh-energy-efficiency-and-renewable-energy-united-states

Utility-Scale PV Equipment, Construction, and Operations[2]

To understand the potential impacts of a utility-scale PV system it is helpful to understand the components of a typical PV facility, as well as how a facility is constructed and maintained. The components and practices in this overview are typical of the industry and representative of the proposed Copper Box project. The initial site work occurs first, but the order of the other construction steps is flexible and may occur concurrently.

Initial Site Work (construction entrance/driveway, erosion and sedimentation control installation, clearing and grubbing, potentially some grading, perimeter fence, and internal road installation)



Underground Work (trenching for wires from PV combiner boxes to inverters, inverter pad installation, trenching for medium voltage cables to interconnection equipment)



PV Panel Structure/Racking (driving of steel piles, installation of racking “tables”, installation of PV panels)

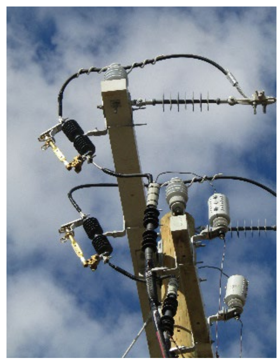


[2] Photo sources: author, ncre-usa.com, NC DEQ, blueoakenergy.com, solarbuildermag.com, hbc-inc.com, solarprofessional.com, ccrenew.com, and landiscontracting.com

Electrical Work (connection of PV module wiring, combiner boxes, inverters, transformers, interconnection facilities)

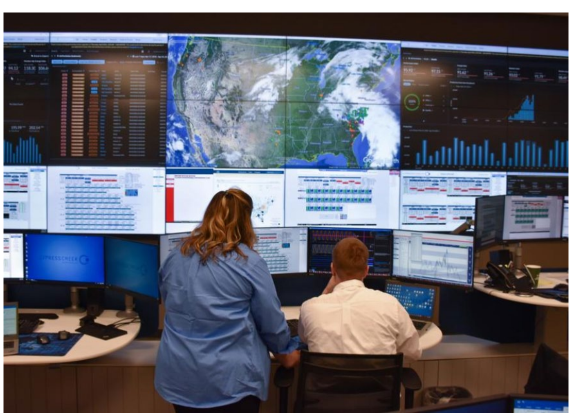







Establishment of Ground Cover (required to close out sedimentation and erosion control permitting)


Operations and Maintenance (24/7 remote monitoring, vegetation maintenance, preventative maintenance)


Electrical Shock and Arc Flash

Figure 1. Perimeter Fence with Warning Signs

Any electricity over 50 volts presents an electrical shock hazard, including the electricity in PV facilities. However, like electrical systems in buildings, the solar facility must adhere to the National Electrical Code (NEC) and the equipment must be certified to the appropriate UL safety standards. Unlike buildings, members of the public are restricted from entering a utility-scale solar facility (via a perimeter fence). To help ensure that only qualified people have access to the equipment, the NEC requires a perimeter security fence with electrical warning signs. The lack of public access coupled with the high U.S. electrical safety standards results in effectively no risk of electric shock for the public.

In circuits with significant available fault current there is another electrical hazard, called arc flash, which is an explosion of energy that can occur due to a short circuit. This explosive release of energy causes a flash of light and heat, and creates a shockwave that can knock someone off their feet. The risk of arc flash in a solar facility is no different than the risk at commercial or industrial buildings, except that solar facilities are much less accessible. Equipment with an arc flash risk require arc flash warning labels, and only trained personnel wearing the proper personal protective equipment are allowed to work on it. Due to the secure perimeter and the high U.S. electrical safety standards, there is effectively no arc flash risk to the public.

Fire and Emergency Response

Every electrical system has some risk of starting a fire, including electrical systems in residential, commercial, and industrial buildings. It is this hazard that motivated the creation of the NEC over 100 years ago. Due to the high standard required by the NEC, modern electrical systems rarely start fires. Like electrical systems in buildings, PV systems must also adhere to the NEC, which includes sections specifically addressing photovoltaic equipment and large-scale photovoltaic systems. In the rare case that a PV system has a fault that starts a fire, there is very little combustible material present for it to ignite. The only flammable portions of PV panels are the few thin plastic layers, the plastic junction box, and the insulation on its wires. The inverters are also capable of igniting, however like PV modules, they consist primarily of non-flammable materials. The inverters and transformers are located on concrete pads or raised steel platforms that are isolated from other equipment and vegetation, so a fire in this equipment poses little threat of spreading.

Heat from a small flame is not adequate to ignite a PV panel, but an intense fire or an electrical fault can ignite a PV panel. One real-world example illustrating the low flammability of PV panels occurred during July 2015 in an arid area of California. Three acres of grass under a utility-scale PV facility burned without igniting the panels mounted just above the grass.[3] Another example occurred recently (2022) in Florida, where there was a 5-acre grass fire under a portion of a 400-acre PV facility that did not ignite any modules.[4]

The most significant fire hazard at a utility-scale solar facility may be the oil in the transformers. There are medium voltage transformers dispersed throughout the site located by each inverter, called inverter step-up ("ISU") transformers, and there is a large transformer in the interconnection substation, known as the generator step-up ("GSU") transformer. Traditionally these types of transformers are filled with a mineral oil, which is derived from petroleum, and is electrically insulating but flammable. An alternative to mineral oil is a transformer fluid made of vegetable oil, which is much less flammable and will not continuously burn if ignited. Mineral oil, however, will keep burning for hours when ignited, with no feasible way to stop it until all the oil is consumed. However, neither mineral oil- or vegetable oil-filled transformers create a fire hazard for the community or property surrounding the solar facility because even in a worst-case scenario of a transformer fire this equipment is located in the middle of a field, far from other flammable materials and far from neighboring properties.

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[3] Matt Fountain. The Tribune. Fire breaks out at Topaz Solar Farm. July 2015. www.sanluisobispo.com/news/local/article39055539.html
[4] WBMM News 13, Fire breaks out at Jackson Co. solar farm. August 2022, www.youtube.com/watch?v=byE_BpUX2mc

Typically, the only thing at risk of being ignited by a transformer fire in a utility-scalar facility is the groundcover (i.e. grass, clover, etc.), which is only a risk in particularly dry conditions. A grass fire is relatively easy to control and poses negligible fire risk to the community.

No special equipment is required to respond to a fire incident at a utility-scale PV facility. There are multiple automatic and manual electrical disconnect switches in PV systems which allows problem areas to be electrically isolated quickly, although the solar panels may still produce voltage dangerous to touch until the sun goes down. The International Association of Fire Fighters (IAFF) provides online training on responding to fires at PV facilities at www.iaff.org/solar-pv-safety. **Copper Box Solar has committed to providing annual training to local first responders to ensure that the staff that would respond to a fire is familiar with the facility and trained on the best practices for responding to a fire at the facility.**

Risks of fire associated with ground cover and perimeter vegetation are reduced by landscaping plans that are developed with this specific goal. First responders can safely extinguish grass fires inside of the facility, or monitor and protect the areas surrounding the facility, to ensure the fire does not spread to surrounding areas. The solar facility owner remotely monitors the system around the clock and has personnel available for emergencies.

Sources for Further Reading on Fire and Emergency Response:

- Duke Energy: Fire Safety Guidelines for Rooftop- and Ground-Mounted Solar Photovoltaic (PV) Systems, Sept. 2015
- North American Electric Reliability Corporation (NERC): Lessons Learned, Substation Fires: Working with First Responders, February 2019

Toxicity (Equipment and Operations)

Toxicity is probably the most common health and safety concern with PV systems that members of the public have, although as detailed below, the systems do not pose a material toxicity risk to the public or the environment. This report examines all possible sources of toxicity, from site construction to decommissioning at the end of the project life. The potential sources of toxicity are organized into two categories: (1) equipment and (2) operations and maintenance (O&M).

Toxicity: Equipment

The main equipment at a solar facility is PV modules (a.k.a. solar panels or PV panels), metal structures for mounting the solar panels, and wiring to collect the electricity they produce. The other major components are inverters and transformers. Inverters are enclosed power electronic equipment that generally do not contain liquids (a minority of models contain an antifreeze liquid coolant) and are treated like other electronic waste at the end of their life. Transformers contain non-toxic mineral oil or vegetable oil and are no different than the typical transformers outside of most residences, schools, and shopping centers. Solar panels have raised most public concerns related to toxicity, so they are covered in depth below, but since transformers contain liquid, they are also addressed. The other components in the facility include the steel racking, the conduits (PVC plastic and galvanized steel), and copper and aluminum wires. The conduit and wires are normal construction materials. The racking for the PV panels is generally galvanized steel posts with galvanized steel or aluminum cross members. None of these supporting materials (wire, conduit, and racking) create a toxicity concern. The galvanized coating on the steel is a zinc coating, and zinc is a vital mineral for human health. PVC plastic and galvanized steel conduits and all types of copper and aluminum wiring have been building staples for many decades. These materials have not caused a toxicity concern in buildings where people are close to this equipment day and night so there is no reason to think they have any risk of creating a toxicity concern when used at a utility scale solar facility.

Contents of PV Panels

The Copper Box project will use silicon-based PV panels, and thus will not be using the other utility-scale PV technology, cadmium telluride (CdTe). Silicon-based PV panels do not contain any cadmium. The PV panels at Copper Box Solar will be sourced from a manufacturer meeting established criteria including third-party ratings for performance, reliability, and bankability (Bloomberg Tier I[5], the highest rating). Specifically, the project plans to use a bi-facial monocrystalline silicon module manufactured by VSUN, but other manufacturers make equivalent modules. The PV panels are the most expensive and most important component in a solar facility, so the owner performs due diligence to ensure that the panels selected and delivered to the project are properly manufactured, certified, and tested.

The diagram below shows the components of a typical single-glass silicon PV panel, including a closeup of the solar cells and the electrical connections. Over 80% of the weight of a PV panel is the tempered front glass cover (or, front and back heat-strengthened glass) and the structural aluminum frame, which work together to create a strong, durable panel that outlasts its typical 25 to 30-year performance warranty. The encapsulation films are clear plastic lamination layers that protect the cells and electrical contacts from moisture for the life of the panel. These layers also maintain the panel as a single unit in the event of breakage of the glass cover(s), similar to the film in auto windshields that keeps them watertight and from fragmenting if the windshield shatters.

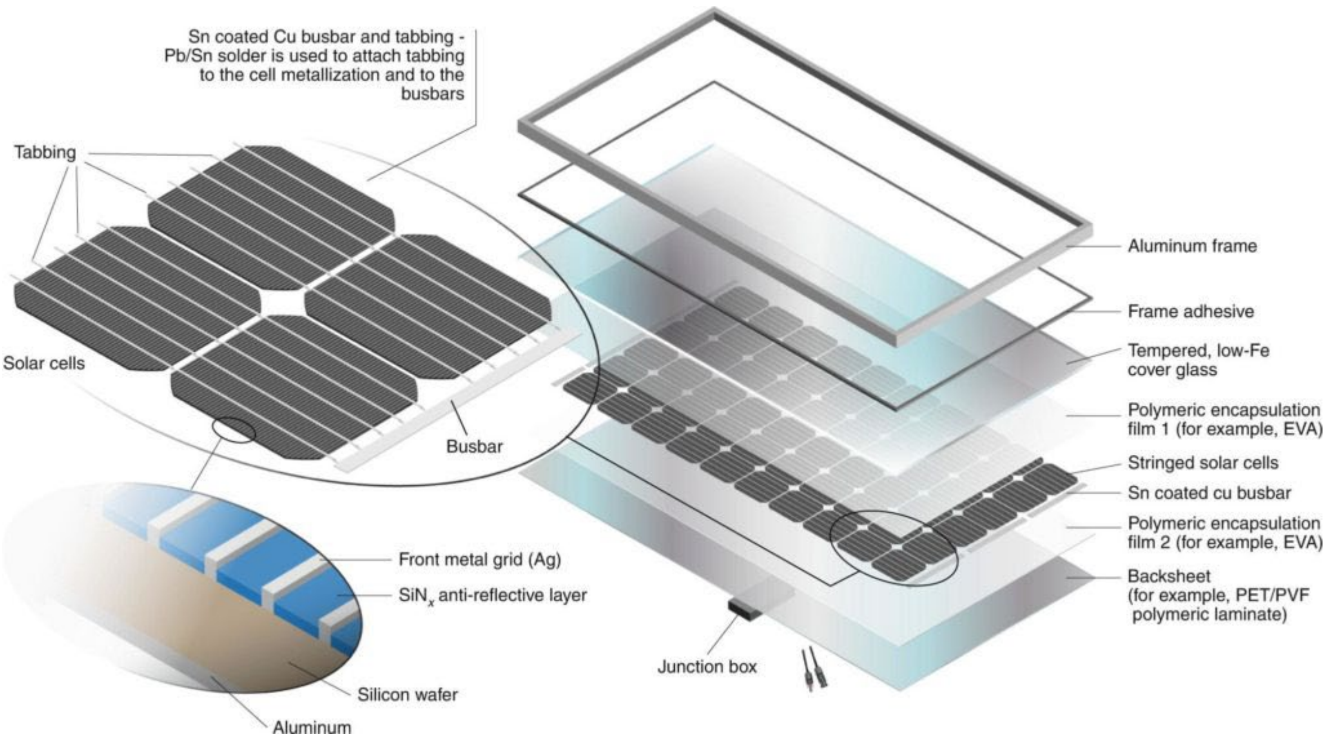

Figure 2. Contents of Framed Crystalline Silicon Panels (Source: NREL)

As can be seen in Figure 2, there are no liquids to leak from a broken panel. The glass and plastic layers are inert. The silicon PV cells are nearly 100% silicon, which is harmless and is the second most common element in the earth's crust. The only component of a PV panel that has any potential of toxic impact is the lead in the solder, which is the same tin-lead solder (~36% lead) that is standard in the electronic industry. This solder is used to connect the solar cells together, by connecting the thin strips of silver that collect electricity from each cell to the next solar cell and to the busbars at the end of the circuit.

[5] The financial information firm Bloomberg developed a bankability tiering system that is the PV industry standard to differentiate the hundreds of PV module manufacturers. Tier 1 is the highest of three tiers, defined by banks' confidence in a manufacturer's PV panels, demonstrated by their willingness to supply project financing backed only by the assets of the project.
https://data.bloomberglp.com/bnef/sites/4/2012/12/bnef_2012-12-03_PVModuleTiering.pdf

The panels do not contain any arsenic.[6] The tiny amount of silver in a panel does not create a toxicity hazard, but it does add potential recycling value.

Even though there is only a tiny amount of lead in each panel, the total amount of lead in all the PV modules in a utility-scale project adds up to a considerable amount of lead. However, these PV panels are spread out over a large area and when the amount of lead in the PV panels is compared to the amount of lead naturally occurring in the soil under the PV array, it is obvious that even if all the lead somehow leached out of every module (which as explained below is impossible), the increase in total lead in the soil would be less than the naturally occurring difference between different soils in the region. Across the US soils naturally have between about 10 and 50 mg of lead per kg of soil, with the average being somewhere in the 20s. Across the 56 USGS survey locations in Indiana, the lead values ranged from 8 to 259 mg/kg with an average of 29 and a median of 22.[7] For a location that naturally has 15 mg of lead per kg of soil, all the lead in all the PV modules in the facility would have the same amount of lead as just the top 4 inches of soil at the site.[8]

Both silicon PV panels and cadmium telluride PV panels have been in use for decades, and their potential for creating a health hazard has been studied as long. As shown in the sections below and in the reading resources linked at the end of this section, PV panels are extremely safe and do not risk public health and safety, including when installed in large numbers.

Damaged PV Panels

There is zero risk of toxicity escaping from undamaged PV panels because any lead is sealed from air and water exposure. Individual panels damaged during the life of the solar facility are identified in days to months through either remote monitoring of system performance or from visual inspections during maintenance by onsite staff. In 2019, an international team of experts conducted an International Energy Agency ("IEA") - Photovoltaic Power Systems Programme ("PVPS") study to assess if there is a public health hazard caused by lead leaching from the broken silicon PV panels or cadmium leaching from cadmium telluride PV panels during the life of a utility-scale solar facility utilizing conservative assumptions to evaluate extreme scenarios.[9] The study examined worst-case exposure routes of soil, air, and ground water for a typical 100 MW_{AC} PV facility for both module types (crystalline and cadmium telluride). For example, the worst-case residential groundwater exposure assumed that all broken panels from the entire array were within 25 feet of the groundwater well, and the chemicals released from every broken panel transported to the same groundwater well. The study found that worst-case lead or cadmium exposure via air, soil, and water were each orders of magnitude less than the maximum levels defined by the EPA to have no adverse health effects. In the case of water, the health-screening level is the same as the maximum concentration level (MCL) set by the EPA for water quality in public water systems. This study demonstrates that there is no risk to public health from lead leached from broken PV panels.

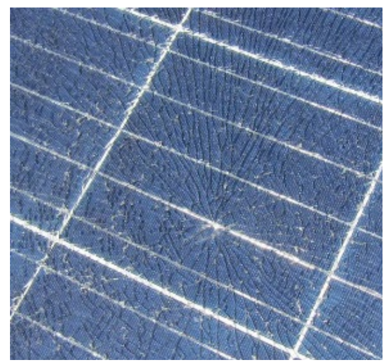

Figure 3. Close-up photo of impact point that broke the glass front of this PV panel

PFAS

Some solar opponents have raised questions about the possibility of per- and poly-fluoroalkyl substances (PFAS) chemicals being emitted by solar panels. PFAS chemicals are a group of man-made chemicals informally known as "forever chemicals" due to their durability in the environment. These chemicals have been used in many industrial and consumer products for

[6] A detailed bill of materials for crystalline silicon PV modules is provided in Table 2 of the International Energy Agency (IEA) PVPS's report entitled: Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems, December 2020 https://iea-pvps.org/wp-content/uploads/2020/12/IEA-PVPS-LCI-report-2020.pdf

[7] Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L., 2013, Geochemical and Mineralogical Data for Soils of the Conterminous United States: U.S. Geological Survey Data Series 801, 19 p., http://pubs.usgs.gov/ds/801/

[8] PV: 12 g of lead (per panel) per 65 ft^2 (panel footprint of 21.5 ft^2 / ground coverage ratio of 0.40) = 0.223 g of lead/ft^2
Soil: 15 mg of lead per kg of soil * 45 kg of soil per ft^3 * 4 inches (0.333 ft) soil depth * 65 ft^2 = 14.61 g of lead / 65 ft^2 = 0.225 g of lead/ft^2

[9] P. Sinha, G. Heath, A. Wade, K. Komoto, 2019, Human health risk assessment methods for PV, Part 2: Breakage risks, International Energy Agency (IEA) PVPS Task 12, Report T12-15:2019. ISBN 978-3-906042-87-9, September 2019

over 60 years, including food packaging materials, firefighting foam, waterproof clothing, and stain resistant carpet treatments.

As explained in a fact sheet from the University of Michigan entitled "Facts about solar panels: PFAS contamination", PV panels do not contain PFAS materials.[10] Neither the self-cleaning coating on top of the solar panel, the adhesives in the panel, nor the front or rear covers/substrates contain PFAS. The "backsheet", or traditional rear substrate of a silicon PV panel, is the thin opaque plastic layer on the rear of a single-glass PV panel that provides electrical insulation and physical protection for the rear of the PV cells. Polyvinyl fluoride (PVF) is the base material for the most common backsheet material (Tedlar), but several other materials have also been used as backsheets, some consisting of multiple layers. Depending on which definition of PFAS that is used, PVF may be classified as PFAS, however the most recent and applicable definition of what is and is not a PFAS material was created by the Organization for Economic Co-operation and Development (OECD)[11] in 2021 and PVF does not meet this modern PFAS definition[12].

However, not all PV panels even have a backsheet, in fact the trend in PV module design is to replace the backsheet with a thin sheet of glass so that the module has thinner front and rear sheets of glass instead of thicker sheet of front glass and a thin plastic backsheet. **Bi-facial modules like those planned for Copper Box, require a clear glass covering on their back to allow light to reach the rear of the PV cells and therefore do not have a backsheet. Thus, the bi-facial modules at Copper Box Solar should not contain any PFAS, by any definition of PFAS.**

PV Panel End-of-Life

PV panels last a very long time, but they do not last forever. Their output declines slightly each year, but panels rarely fail in less than 40 years. The expected economic life of utility-scale PV panels is 30-40 years, at which point they may be replaced by new panels, or the entire project may be decommissioned, returning the land back to how it was before the solar facility was installed. In both instances, the original PV panels are removed from the site. At a typical solar facility, there are three possible fates for solar panels at the end of their economic life at a project, described below. At a minimum in all cases, waste management laws require that the facility owners handle and dispose of the equipment and other facility components in conformance with federal, state, and local requirements. To help assure that the project is fully and properly decommissioned, without putting any cost burden on the landowners or the county, and as described in the project's decommissioning plan, Copper Box Solar will provide a decommissioning bond or other surety meeting the Montgomery County ordinance requirements.

Solar panel end-of-life options:

- **Reuse**: It is most likely that when the PV panels at the Copper Box project are decommissioned, they will still produce at least 80% of their original output and have another decade of productive life, making them viable to be reused as solar panels on rooftops or ground-mounted applications. Markets for used solar panels exist today and are likely to be much more mature in 30-40 years when the project's PV panels near the end of their life.

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[10] "Clean Energy in Michigan" Series, Number 12, Facts about solar panels: PFAS contamination, By Dr. Annick Anctil, https://graham.umich.edu/media/pubs/Facts-about-solar-panels--PFAS-contamination-47485.pdf

[11] OECD is an intergovernmental organization with representatives of 38 industrialized countries. OCED developed the updated definition in response to an international call for "programmes and regulatory approaches to reduce emissions and the content of relevant perfluorinated chemicals of concern in products and to work toward global elimination, where appropriate and technically feasible." OECD Portal on Per and Poly Fluorinated Chemicals: www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/

[12] OECD (2021), Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance, OECD Series on Risk Management, No. 61, OECD Publishing, Paris. www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/terminology-per-and-polyfluoroalkyl-substances.pdf

- **Recycling**: Any panels that are not reused as working panels could be recycled. Currently in the US, it is possible to recycle the largest constituents of silicon PV panels using the existing glass and metal recycling infrastructure. Today this recycling comes at a cost premium to disposing the panels in a landfill. However, as PV recycling technology improves and the number of panels reaching end-of-life increases dramatically, it is possible that in the future recycling PV panels will more than pay for itself. Recycling plants built specifically to recycle PV panels can recycle nearly 100% of the panel, including the valuable silver and refined silicon they contain, and can be optimized for the task, significantly reducing the cost to recycle each panel. Only recently was the first industrial-scale PV-specific recycling plant built, in France, but in the coming decades it is expected that PV-specific recycling plants will become commonplace. PV recycling technology is clearly still in its infancy. However, it is expected that when the Copper Box PV panels reach the end of their useful life in 30+ years, the US PV recycling infrastructure will be robust, such that reuse or recycling of the PV panels will be the preferred options or required by new U.S. regulations, as it has been for years in Europe.

Figure 4. PV Panels Waiting to be Recycled (Source: LuxChemtech GmbH)

  The Solar Energy Industries Association (SEIA) started the SEIA National PV Recycling Program several years ago to accelerate PV recycling in the US. Currently the program aggregates the services offered by recycling vendors and PV manufacturers, making it easier for the industry to select a cost-effective and environmentally responsible end-of-life management solution. **The program identifies Preferred Recycling Partners through an evaluation process. These partners are capable of recycling PV modules, inverters, and other related equipment today**. The current SEIA PV Recycling Partners are listed on the program's website, and full access to the program and the Preferred Recycling Partners is available to SEIA members.

- **Disposal**: For most solar facilities, if panels are not reused or recycled, federal waste management laws (Resource Recovery and Conservation Act, "RCRA") require that PV panels, like any other commercial/industrial waste, be disposed of properly, which is typically in a landfill. In order to determine the proper disposal method, RCRA requires that all commercial/industrial waste be identified as either hazardous or non-hazardous waste, which for PV panels is determined using the Toxic Characteristic Leaching Procedure (TCLP) test developed by the EPA. This test seeks to simulate landfill conditions and check for leaching of 8 toxic metals and 32 organic compounds from a wide variety of commercial/industrial waste. Little data has been published about the TCLP test results of solar panels, but it is known that some early silicon panels that contain more lead than modern panels exceed the TCLP test limits for lead. Researchers at Arizona State University's Photovoltaic Reliability Laboratory have done the most robust investigation of methods for conducting accurate TCLP tests on PV panels, and their latest research found that all three of the PV panels tested (all 3 were crystalline silicon) passed the TCLP test, classifying them as non-hazardous waste.[13]

  A worst-case scenario would be all of a facility's PV panels being disposed of in a non-sanitary landfill, which is essentially a huge pile of garbage with little to no effort to minimize leaching from the waste that is illegal in many world regions, including in Indiana. A 2020 IEA-PVS research study on silicon and cadmium telluride PV panels disposal risks used this worst-case situation to evaluate the potential for cancer and non-cancer hazards through comparison of predicted exposure-point concentrations in soil, air, groundwater, and surface water with risk-based screening levels created by the EPA and the World Health Organization (WHO).[14] One of the report's authors, Gavin Heath with the US Department of Energy's National Renewable Energy Laboratory (NREL), summarized their findings about lead in silicon PV panels and cadmium in cadmium telluride PV panels this way: "under the worst-case conditions, none of them exceeded health-

[13] Tamizhmani, G., et al. (2019). Assessing Variability in Toxicity Testing of PV Modules. In 2019 IEEE 46th Photovoltaic Specialists Conference (pp. 2475-2481). Institute of Electrical and Electronics Engineers Inc.. https://doi.org/10.1109/PVSC40753.2019.8980781 Publicly-accessible version: https://dev-pvreliability.ws.asu.edu/sites/default/files/93_assessing_variability_in_toxicity_testing_of_pv_modules.pdf

[14] P. Sinha, G. Heath, A. Wade, K. Komoto, Human health risk assessment methods for PV, Part 3: Module disposal risks, International Energy Agency (IEA) PVPS Task 12, Report T12-16:2020. ISBN 978-3-906042-96-1, May 2020

screening thresholds, meaning they're not deemed to potentially have significant enough risk that you'd want to do a more detailed health risk assessment."[15] The worst-case scenario defined in the research has many conservative assumptions, and thus likely overestimates the risk of disposal in a *non-sanitary* landfill. **It is important to stress that Indiana only allows solid waste disposal in sanitary landfills, which are engineered facilities with plastic liners, leachate collection systems, and covers, all of which dramatically reduce the potential for human exposure compared to non-sanitary landfills**.[16] This and other research show that if the Copper Box PV panels are disposed of in a landfill, they will not create a negative public health impact.

In 2019 the North Carolina legislature passed HB 329 (S.L. 2019-132), requiring the NC Department of Environmental Quality (DEQ) to prepare a report to guide rulemaking regarding decommissioning of solar PV and other renewable energy facilities and proper disposal of their equipment. While the policy recommendations in the final report do not apply to Indiana, the information is likely to be useful in Indiana. The report, issued January 1, 2021 and titled *Final Report on the Activities Conducted to Establish a Regulatory Program for the Management and Decommissioning of Renewable Energy Equipment*[17], provides a thorough discussion addressing many questions landowners and communities have about solar decommissioning in a state that at that time had more solar panels installed than any state other than California. NC DEQ compiled the input and commentary of numerous stakeholders, including the renewable energy industry, environmental organizations, and academia, including the author and NC State University's Clean Energy Technology Center. The report is well researched and very informative. NC DEQ provides several key findings and recommendations, but no recommendations for changes in NC regulations of solar facilities. One of the report's key findings is that "According to Division of Waste Management experts, if every end-of-life PV module is disposed of in landfills, landfill capacities will not be negatively impacted."

Transformer Oil

While PV modules and inverters do not have any liquids that could leak into the environment, the GSU transformer in the substation and the ISU transformers located with each inverter do contain oil. Several types of oil can be used in transformers to provide the needed electrical insulation and cooling, but the most common type of transformer oil is mineral oil, which has been used in transformers since transformers were first manufactured in the 1890s. Due to the relatively large volume of oil contained in a GSU transformer, they are installed with a secondary containment structure under them to contain any oil leaked or spilled. The smaller ISU transformers are approximately the same size as the transformers located throughout every community; behind schools, shopping centers, apartments, etc., and they typically do not provide secondary containment. Ongoing monitoring of transformer temperature and pressure, and regular preventative maintenance, is likely to find the rare leak when it is still small before it has a chance to leak much oil.

Figure 5. GSU Transformer with Secondary Containment to Capture any Leaked Oil

There was a time when most transformer oil was toxic. From 1929 to 1977 polychlorinated biphenyls (PCBs), a man-made alternative to mineral oil, was commonly used as transformer oil instead of mineral oil. However, the toxicity of PCBs was eventually understood, leading to PCBs being banned in the US in 1979. Today, transformers either use mineral oil or vegetable oil, both of which are free of PCBs. Mineral oil is non-toxic to humans, in fact "baby oil" that is commonly used to soothe an infant's skin is a scented mineral oil. Although non-toxic to humans, mineral oil is an environmental contaminate and harmful to aquatic ecosystems, so any release to the environment should be avoided. The potential for negative environmental impact from spilled vegetable oil is much less because these oils are biodegradable, so the time they impact the environment is short-lived. Federal regulations dating back to the Clean Water Act of

[15] Green Tech Media, Landfilling Old Solar Panels Likely Safe for Humans, New Research Suggests, April 2020, www.greentechmedia.com/articles/read/solar-panel-landfill-deemed-safe-as-recycling-options-grow
[16] Indiana Department of Environmental Management: Landfills and Land Disposal Units: www.in.gov/idem/waste/waste-industries/landfills/, accessed April 2023
[17] https://deq.nc.gov/h329-final-report

1973 require that facilities with significant quantities of oil prevent pollution of water.[18] The current EPA regulations require that facilities with over 1,320 gallons oil, and with the potential for spilled oil to impact surface water, develop and implement an oil spill prevention, control and countermeasure (SPCC) plan. While the risk of negative environmental impact from a transformer oil spill/leak cannot be eliminated entirely, these regulations along with standard industry practices, result in a low probability for a substantial spill and a high probability for a quick clean-up response to minimize any possible impact.

Toxicity: Operations & Maintenance

Unlike most other electricity generation facilities, PV systems do not produce any air emissions. The only way they could produce emissions is in the case of a fire. The potential human health impacts from contact with smoke from burning PV panels was studied by the IEA-PVPS in their first report on human health risk assessment. In that study they did not study ground-mounted PV, presumably because of the extremely low risk of significant fire, but they did investigate the potential health impacts of lead in silicon modules and cadmium in cadmium telluride modules dispersing in smoke from a fire in a building that is covered in rooftop PV modules. The study considered several worst-case scenarios for different size buildings and different environments and found no risk of harmful health impacts from the smoke from PV panels.[19]

The only other two aspects of O&M that have raised concerns about toxicity are the fluids used to wash panels and herbicides used to maintain vegetation.

- **Panel Washing** – Across Indiana there is usually ample rain to keep the panels clean. If the panels do need to be washed, it would occur infrequently and typically with use of deionized water and cleaning brushes.
- **Herbicides** – The industry standard practice for maintaining the vegetation at solar facilities is similar to how most cities maintain their parks, which is they primarily rely on mowing and string trimmers for vegetation and use herbicides along fences, on roads, and under some equipment. Parks and solar facilities also use herbicides to strategically remove problem weeds, especially woody weeds, to maintain a healthy cover of the desired species of grasses and other low-growing vegetation. This mode of herbicide use applies significantly less herbicide volume than is commonly applied in US agriculture. For example, Round-Up-Ready crops are common row crops that have been engineered for the entire field to be sprayed with Round-Up (glyphosate) several times each season. Unlike many types of farming, solar facilities pesticides to their fields are not required to be certified or licensed, but a IN commercial pesticide applicators license is required to apply any herbicide to a solar facility.

Sources for Further Reading on Toxicity:

- International Renewable Energy Agency (IRENA): End-of-life management: Solar Photovoltaic Panels, June 2016
- Electric Power Research Institute (EPRI): Solar PV Module End of Life: Options and Knowledge Gaps for Utility-Scale Plants, December 2018
- EPRI: Feasibility Study on Photovoltaic Module Recycling in the United States, April 2018
- EPRI: Solar Photovoltaics: End-of-Life Management Infographic, March 2021
- National Renewable Energy Laboratory (NREL): A Circular Economy for Solar Photovoltaic System Materials, April 2021
- Solar Energy Industries Association (SEIA): SEIA National PV Recycling Program, with factsheet, checklist, and peer-reviewed article, (accessed December 2021)
- North Carolina Department of Environmental Quality: Final Report on the Activities Conducted to Establish a Regulatory Program for the Management and Decommissioning of Renewable Energy Equipment, January 2021

[18] Environmental Protection Agency, webpage: Overview of the Spill Prevention, Control, and Countermeasure (SPCC) Regulation, www.epa.gov/oil-spills-prevention-and-preparedness-regulations/overview-spill-prevention-control-and

[19] P. Sinha, G. Heath, A. Wade, K. Komoto, 2018, Human Health Risk Assessment Methods for PV, Part 1: Fire risks, International Energy Agency (IEA) PVPS Task 12, Report T12-14:2018, https://iea-pvps.org/wp-content/uploads/2020/01/HHRA_Methods_for_PV_Part1_by_Task_12.pdf

Electromagnetic Fields (EMF)

Exposure to EMF, or electric and magnetic fields, is a fact of everyday modern life. Electromagnetic fields come in many different frequencies, ranging from grid electricity with a frequency of 60 hertz to x-rays and gamma rays that are billions of billions of times faster. The faster the frequency, the stronger the EMF. The EMF coming from grid electricity, including from the inverters, transformers, and AC wires to be used at the Copper Box project, has a much lower frequency and therefore much lower energy than the EMF from cell phones, wireless internet, and even radio and TV towers. The solar panels and the wire connecting them to the inverters carry direct current (DC) electricity, which has a frequency of zero hertz, and thus produces static electric and magnetic fields. The voltage and current in these circuits are small, so the electric and magnetic fields they produce are both rather weak. The static magnetic fields the PV panels generate are much weaker than the earth's natural static magnetic field, which can be demonstrated by a compass still pointing north when placed near the panels.

Electric fields are created around wires and equipment wherever a voltage exists, however it is easily blocked with common materials such as metal, wood, and soil. The 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. [20] This frequency range includes both grid electricity that operates at 60 Hz and the PV panels that operate at 0 Hz. The proposed solar project does not produce any voltages higher than the voltage of the existing power lines, and therefore does not produce any electric fields not generally encountered by members of the public.

Magnetic fields are the other aspect of EMF, and they are created by electric current. Typical Americans are exposed to about 1 milligauss of magnetic field from grid electricity (60 Hz) on average during their day, primarily from sources at homes and work[21]. The primary source of magnetic fields in a solar facility are the inverters and the few feet of wire between each central inverter and its step-up transformer. To convert direct current to alternating current (AC), inverters use a series of solid-state switches that turn off and on several thousand times a second, creating EMF in the range of 5 kHz to 100 kHz, which is much faster than the 60 Hz of grid electricity but still much slower than even the lowest frequency radio signals and much lower than wifi or cell signals.

The highest electrical current of any portion of the solar facility occurs in the inverters, ISU transformers, and the few feet of wire between them, making this the source for the strongest magnetic fields in the facility. Yet, because the strength of a magnetic field decreases dramatically with increasing distance from the source, these magnetic fields only extend about 100-500 feet from the inverter and ISU transformer, at which point the magnetic fields would be expected to measure less than 0.5 milligauss, which is less than half the typical American's average 60 Hz EMF exposure over a day.[22] The locations of the inverters and ISU transformers at the Copper Box project have been preliminarily identified, with the inverters generally located very far from the closest home, but in no cases is an inverter planned to be closer than 750 feet from a home, which is expected to result in effectively zero EMF extending onto any residential property. Similarly, the magnetic fields from substations generally do not extend far enough to leave the fence around the substation, so the same can be expected for the project's substation.[23] The new 138 kV lines between the project substation and the utility switchyard are within about 150 ft of two homes. At this distance these homes could expect to experience up to 1 milligauss of magnetic fields during sunny hours, which is not a significant increase in EMF exposure.[24]

The bottom line is that the EMF from the Copper Box project will not increase the EMF exposure of any neighbors, except for possibly the two homes near the new line between the substation and switchyard where an insignificant increase in EMF is

[20] WHO factsheet: Electromagnetic fields and public health, Exposure to extremely low frequency fields, June 2007, www.who.int/teams/environment-climate-change-and-health/radiation-and-health/non-ionizing/exposure-to-extremely-low-frequency-field
[21] World Health Organization (WHO), webpage: Electromagnetic Fields – Typical exposure levels at home and in the environment, www.who.int/peh-emf/about/WhatisEMF/en/index3.html
[22] Study of Acoustic and EMF Levels from Solar Photovoltaic Projects. Tech Environmental, Inc., December 2012, www.co.champaign.il.us/CountyBoard/ZBA/2018/180329_Meeting/180329__Massachusetts%20Acoustic%20Study%20for%20PV%20Solar%20Projects.pdf
[23] www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf
[24] www.bchydro.com/safety-outages/power-lines-and-your-health/electric-and-magnetic-fields-from-power-lines/emf-calculator.html, www.emfs.info/sources/overhead, and www.bchydro.com/safety-outages/power-lines-and-your-health/electric-and-magnetic-fields-from-power-lines.html

possible. If some EMF from the PV facility extends beyond the PV site, there would still be no public health impact because low levels of 60 Hz EMF exposure are not harmful to humans. After extensive study of the potential health impacts of EMF from grid electricity, the WHO concludes:

> *"Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health."*[25]

Sources for Further Reading on EMF:

- Electric Power Research Institute: EMF and Your Health: 2019 Update, December 2019
- World Health Organization: Electromagnetic Fields (accessed September 2022)

Heat Island Effect

The localized micro-climate effects of utility-scale PV facilities are understood well enough to determine that they do not create a heat island effect similar to the well-documented urban heat island effect from dark, massive, surfaces in urban environments, such as asphalt paved streets and parking lots, that cause urban areas to be significantly warmer than the surrounding rural area during the day and night. The changes that solar panels may make to the way land absorbs, reflects, and emits the energy from sunlight are minimal compared to the changes created by buildings, vehicles, and many miles of concrete and asphalt. By comparison, solar panels absorb and reflect a similar amount of solar energy as vegetation and soil. Solar panels are lightweight and can only store tiny amounts of thermal energy, and the ground remains covered in vegetation with its natural exposure to air and water. Additionally, the solar panels remove about 20% of the solar energy that strikes them as electricity sent to the grid.

Initial research into the potential for PV systems to cause a heat island effect has used a variety of techniques, including conceptual energy flow calculations, advanced fluid dynamic computer simulations, and field measurements of temperature.[26, 27, 28] This research found a range of different effects on temperature, but none indicate that a large PV system could affect the temperature of the surrounding community. Most found that compared to similar undeveloped land the air temperature in a solar facility increases during the day, but the nighttime results were mixed. Some studies found PV sites to be cooler than non-PV sites at night, but others found them to be warmer. Much of this variation is likely explained by the different climates studied but may also be due to the different methods of the studies. Much of the research on solar heat island effect occurred in arid regions of the U.S. southwest where the results are unlikely to translate perfectly to wetter climates in the Midwest. In a written statement of evidence Greg Barron-Gafford, leading solar heat island effect researcher, says that he expects that when the area under the PV array is vegetated with grass, the localized heat island effect will be greatly reduced relative to what his research found in dry climates.[29]

The available studies agree that the slight increase of air temperature inside the PV site dissipates quickly with height and distance from the panels as natural processes remove and spread the heat. As a result, any temperature increase that may occur at the Copper Box project during the day will be limited to the site and will not increase the temperature of any of the surrounding community.

Sources for Further Reading on Heat Island Effect:

- EPA: Learn About Heat Islands, (accessed September 2022)

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[25] World Health Organization (WHO), webpage: Electromagnetic Fields – Summary of health effects, www.who.int/peh-emf/about/WhatisEMF/en/index1.html

[26] Broadbent, Ashley & Krayenhoff, Eric & Georgescu, Matei & Sailor, David. (2019). The Observed Effects of Utility-Scale Photovoltaics on Near-Surface Air Temperature and Energy Balance. Journal of Applied Meteorology and Climatology. 58. 10.1175/JAMC-D-18-0271.1.

[27] Barron-Gafford, G. A. et al. The Photovoltaic Heat Island Effect: Larger solar power plants increase local temperatures. Sci. Rep. 6, 35070; doi: 10.1038/srep35070 (2016).

[28] V. Fthenakis and Y. Yu, "Analysis of the potential for a heat island effect in large solar farms," 2013 IEEE 39th Photovoltaic Specialists Conference (PVSC), Tampa, FL, 2013, pp. 3362-3366, doi: 10.1109/PVSC.2013.6745171.

[29] G. Barron-Gafford, Statement of Evidence by Greg Barron-Gafford on Solar Heat Islanding Issues, May 2018, www.planning.vic.gov.au/__data/assets/pdf_file/0024/126555/301-Expert-Witness-Statement-of-G-Barron-Gafford-PVHI-May-2018-Lemnos.pdf

Glare

PV panels are designed to absorb, and thus not reflect, the solar energy that they receive. However, when sunlight strikes the glass front of a solar panel at a glancing angle, a significant portion of the solar radiation is reflected, which can potentially lead to solar glint (a brief flash) or glare. Glint or glare can temporarily impact a person's vision, including pilots landing aircraft, or motorists driving vehicles. However, the conditions required for a PV project to create glare rarely occur.

PV facilities, such as Copper Box, that utilize single axis trackers to slowly rotate the solar panels to follow the sun have even less potential to create glare because the trackers help avoid a situation where sunlight hits the panels at a glancing angle. Most modern trackers implement an advanced control strategy known as "backtracking" that increases the electricity production of the site by flattening the tilt of the panels early and late in the day to keep the rows of solar panels from shading one another. Backtracking can result in brief periods near sunrise and sunset where the sun strikes the panels at a glancing angle, creating a situation that could result in a few minutes of visible glare at sunrise and sunset. For anyone to see this glare they must be looking across the solar panels in the direction of the rising or setting sun, which is a situation where the sun obviously will create significant glare for the viewer with or without the solar project.


Figure 6. 20 MW PV System at Indianapolis International Airport (Photo source: inhabitat.com)

A clear indication of the ability to avoid glare problems from large ground-mounted PV systems are the PV systems installed on airports across the U.S., including Denver International and Indianapolis International. While there is the potential for a PV system to create glare, there is also the ability to predict when and where a system may create glare and incorporate any needed mitigation before construction. The Federal Aviation Administration (FAA) and the U.S. Department of Energy (DOE) developed specialized solar glare analysis software to predict when and where a PV project may produce glint or glare for sensitive receptors nearby. That original software technology has been licensed to a third-party firm (Forge Solar) that continues to improve and refine the software, which has been validated to accurately predict solar glare.

In May of 2021, the FAA replaced the long-standing interim solar glare policy with a (final) policy that no longer restricts solar developed on airport property from creating glare visible to pilots. The policy explains that the new acceptance of glare visible to pilots is in recognition that pilots often experience glare during landing from bodies of water and that glare from solar is not meaningfully different.[30] The new policy does still prohibit on-airport PV systems from creating any glare visible in an air traffic control tower. While the FAA policy only applies to PV developed on airport property, it is reasonable to follow the same policy for PV plants sited near airport property.

There are two airports in the National Plan of Integrated Airport Systems (NPIAS)[31] in the vicinity of the Copper Box project; the Crawfordsville Regional Airport (CFJ) about 10 miles south-southwest of the closet solar panel and Frankfort Clinton County Regional Airport (FKR) about 16 miles northeast. They are both small airports without an air traffic control tower.

[30] "Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports", https://www.federalregister.gov/documents/2021/05/11/2021-09862/federal-aviation-administration-policy-review-of-solar-energy-system-projects-on-federally-obligated

[31] The National Plan of Integrated Airport Systems (NPIAS) identifies nearly 3,310 existing and proposed airports that are included in the national airport system. The NPIAS contains all commercial service airports, all reliever airports, and selected public-owned general aviation airports. www.faa.gov/airports/planning_capacity/npias

Considering the distance of the airports from the project, and their lack of air traffic control tower, no aviation glare hazard is expected.

It is also possible for utility-scale PV facilities to cause brief periods of glare visible to motorists driving toward the rising/setting sun on nearby roads. However, like pilots, motorists are accustomed to occasionally seeing glare near the rising or setting sun, both from the sun itself and from reflection off flat objects such as a body of water or the windows of a building or vehicles, and motorists regularly safely adjust to this visual challenge. While it is difficult to accurately predict the existence of glare without the use of software, such as Forge Solar SGHAT, it can be assumed that a PV array with backtracking arrays might cause glare on portions of County Road 800 N and other roads around sunrise and sunset during a few months of the year. So, it must be assumed that motorists passing by the Copper Box solar facility might occasionally experience some glare near sunrise and/or sunset, although it is very unlikely for such glare to create a safety hazard. A glare study could be conducted to determine the potential for significant glare for motorists and to provide an opportunity to mitigate any hazardous glare in the design phase, alternatively, adjustments to the tracking controls and/or additional visual buffers could be implemented after the project is constructed to mitigate any problematic glare, if any occurs.

Sources for Further Reading on Solar Glare:

- National Renewable Energy Laboratory (NREL): Research and Analysis Demonstrate the Lack of Impacts of Glare from Photovoltaic Modules, July 2018
- ForgeSolar: PV Planning and glare analysis software help documentation, (accessed September 2022)

Noise

Solar panels are silent, but some of the other components of a PV system produce some sound, although they are rarely heard by anyone outside of the project fence. The loudest equipment is the inverters, but the transformers and tracking motors also make some sound. These numerous sources of sound are dispersed throughout the facility, but the physics of sound are such that these dispersed sources of sound are non-additive. For example, if there are 50 inverters spaced across a utility-scale solar facility and you are close enough to hear some inverter noise, you could turn off the 49 inverters farthest from you and you likely wouldn't notice the difference between the sound from 1 inverter and the sound from 50 inverters. Even if two inverters are right next to each other and an even distance from you, the perceived volume of the sound coming from the two inverters is very similar to the sound from just one inverter. So, the potential for someone offsite to hear any sound generated inside a utility-scale PV project is determined by the closest and loudest source of sound. Thus, some simple analysis of the sound coming from the closest sources to a point of interest, such as a home, can effectively estimate the level of sound from the PV project at that location.

Before providing site-specific analysis of the potential for noise impacts from the Copper Box project, it is useful to put the sound from the PV project in context. Our world is full of sounds, day and night, even in quiet rural areas, and any sounds from the PV project would be in concert with the existing sounds. The appropriate analysis metric is not if the sounds are audible, but if they are noticeable or bothersome, and US and international organizations have published guidance on this topic based on research on how sound impacts the public.

In 1972, the US passed the Noise Control Act, which required the EPA to define criteria for protecting the public health and wellbeing from noise interference. In response, the EPA developed guidance that included recommended sound levels limits at residential structures (or places in which quiet is a basis for use)[32]. This guidance recommends that noises at residences be limited to 55 dBA L_{dn}, where L_{dn} is the average sound level of a 24-hour period with the inclusion of a 10-dB penalty during the nighttime hours of 10PM to 7AM. So, the 55 dBA L_{dn} limit could be met with 55 dBA daytime noise and 45 dBA nighttime noise, or a 24-hour noise (L_{eq}) of 48.6 dBA. In addition to the EPA guidance, the United Nations WHO published "Guidelines for Community Noise" (1999) which suggested daytime and nighttime protective noise levels, which are to be applied outside

[32] US Environmental Protection Agency (EPA), "Information on Levels of Environmental Loise Requisite to Protect Public Health and Welfare With An Adequate Margin of Safety", 1974, https://nepis.epa.gov/Exe/ZyPDF.cgi/2000L3LN.PDF?Dockey=2000L3LN.PDF

the bedroom window.[33] During the day (7AM to 11PM), the equivalent continuous sound level threshold to protect against serious annoyance is 55 dBA L_{eq}, and 50 dBA L_{eq} to protect against moderate annoyance. During the night (11PM to 7AM), the averaged equivalent continuous sound level threshold is 45 dBA L_{eq}. So, the EPA and the WHO recommend similar daytime noise limits (~55 to 48.6 dBA and 55 to 50 dBA, respectively), and similar nighttime limits as well (~45 to 48.6 dBA and 45 dBA, respectively). However, Montgomery County has a Maximum Noise Levels requirement in Section 13: Solar Farm and Facilities of its Zoning Ordinance that is much stricter than these national and international guidelines. The county ordinance requires "No system will produce sound levels that are more than 32 decibels as measured on the dB(A) scale at the property lines of the system site."

The original issue of this health and safety assessment report included a preliminary screening-level noise assessment as an early indicator of potential noise impacts, with the knowledge that a more detailed noise assessment using sound propagation software will be conducted by a sound specialist as required by the county ordinance. In December 2025, Jacobs Engineering Group provided the required sound assessment, entitled "Copper Box Solar Project Sound Assessment". That assessment used sound assessment software and an updated project design that includes sound barriers next to numerous sound-producing equipment to provide the required assessment of the noise level expected at potentially-affected residences and other nearby land uses. With that sound assessment and the updates to the project design since the preliminary noise assessment in the original issue of this health and safety assessment report, this revision in December 2025 does not include a preliminary noise assessment. The Author has reviewed the new Jacobs Engineering Group sound assessment and is comfortable referring to it for assessment of potential noise impacts from the Copper Box Solar project. Based on the Jacobs December 2025 sound assessment, including the updated project design it considers, the Author's conclusion that the Copper Box Solar Project will not create bothersome noise is still valid.

Sources for Further Reading on Noise:

- World Health Organization (WHO), Guidelines for Community Noise, 1999

Conclusions

Based on my knowledge of science and engineering, personal experience with PV technology, review of academic research, analysis of the proposed project, and review of materials provided by the project developers about the proposed Copper Box Solar project in Montgomery County, Indiana, my conclusions are summarized as follows:

- The Copper Box Solar project will result in a significant reduction of regional air pollution.
- The Copper Box Solar project will not materially endanger public health or safety.
- The Copper Box Solar project will not increase the temperature of the area surrounding the site.
- The Copper Box Solar project will not create a glare hazard for aviation.
- The Copper Box Solar project will not create bothersome noise for any neighbors.

Version History:

Version:	Date:	Change Notes:
Original issue	10/12/2023	--
Revision 1	12/19/2025	Update of sound section due to project design changes and new 3rd party sound assessment study by Jacobs Engineering Group, including removal of outdated preliminary screening-level noise assessment

[33] World Health Organization (WHO), "Guidelines for Community Noise", 1999, https://apps.who.int/iris/handle/10665/66217