

Solar Farm Development & Operation



Technical Overview

Solar photovoltaic technology has been in use for well over 50 years. While PV materials and technology have improved over time to be more efficient and cost effective, installation and operation have remained unchanged.

“Photovoltaic,” commonly abbreviated as PV, is simply the technical term for converting the sun’s light into useable electric current.

Solar facilities, often referred to as “solar farms,” passively capture naturally occurring sunlight and convert it to clean, renewable energy on a scale large enough to supply electricity for daily living in our homes, businesses and schools. Each solar farm is a collection of solar panels arranged to gather maximum amounts of sunlight during the day. The panels are linked to inverters and transformers that convert the sunlight into useable electricity, which is then transferred to the existing electrical grid.

Equipment and Construction

Solar facilities are simple constructions that employ the following basic equipment:

- Solar PV panels
- Inverters
- Transformers
- Wires and conductor cables
- Structural racking system for PV modules
- Perimeter fencing

Most sites require minimal grading, and an entire facility can often be installed with minimal soil disturbance. Structural frames (called racks) are driven into the ground with steel beams (called piles), on which PV panels are mounted. The

inverters and transformers, which receive the power from the solar panels, are mounted on top of concrete pads.

The electricity-making process starts with sunlight striking the solar panels. The energy from this action is converted into low-voltage DC electricity. This low-voltage DC electricity is fed into the inverters where it is converted into low-voltage AC electricity, which is then fed into the transformers where the electricity is converted into medium-voltage AC electricity. The medium-voltage electricity is connected to the grid through underground cables.



Solar Panel Technology

Cypress Creek Renewables uses several solar PV panel technologies: Crystalline Silicon (C-Si) and Thin Film (TF). Each type of technology uses slightly different materials, work identically, and are of similar construction.

Crystalline Silicon modules are produced by sourcing extremely high quality, pure silicon or quartz. The silicon is heated until it melts, after which a crystal is grown from a source ingot. The silicon crystal is sliced into thin wafers, mounted onto a durable backing material and encapsulated by tempered glass and an aluminum frame. Thin-film solar modules are made by depositing thin film photovoltaic materials into crystalline layers that are bonded to tempered glass, after which the module is encapsulated by the aluminum frame.

Once finished, the solar PV panels function as a solid-state inert crystal, most similar to a pane of solid glass. The solar panels are expected to work upwards of 40 years before they are recycled to recover the valuable materials contained inside. Encapsulation of the modules prevents penetration of air and moisture from entering the cell and conversely prevents the release of materials out of the module and into the environment.

Source: N.C. Clean Energy Technology Center. Health and Safety Impacts of Solar Photovoltaics. Raleigh: N.C. State University, 2017. https://ncleanetech.ncsu.edu/wp-content/uploads/Health-and-Safety-Impacts-of-Solar-Photovoltaics-2017_white-paper.pdf

Sound

The facility's inverters and transformers produce a sound when operating during the hours of peak power production, typically between 10am-2pm. At 150 feet, this sound is inaudible above natural ambient noise in rural areas. The sound created by the inverter during peak power production is typically in the low-range of 65 decibels at a distance of 30 feet—the equivalent of

the sound created during normal conversation. The rest of the facility's equipment does not produce any audible sound and no sound is produced at night.

Source: Peter H. Guldberg. Study of Acoustic and EMF Levels from Solar Photovoltaic Projects. Boston: Massachusetts Clean Energy Center, 2012. <http://files.masscec.com/research/StudyAcousticEMFLevelsSolarPhotovoltaicProjects.pdf>.

Reflection

Solar panels are designed to absorb light from the visible spectrum, not to reflect it, although some upward reflection does occur. To assist light absorption, each PV panel is treated with an anti-reflective coating. Naturally occurring ponds and streams, snow, and even certain kinds of soil and vegetation are similarly reflective. In fact, the sunlight that is reflected away from solar panels produces the same amount of glare as a flat pond or lake.

Additionally, solar panels are mounted at an angle that allows for maximum light to be absorbed throughout the year, which results in the panels facing the sky at shallow angles (typically less than 25 degrees). As a result, what little light is reflected is not visible to ground-level observers.

All solar farms are required to be approved by the FAA as potential glare hazards for aviators. To date, no PV array has been deemed a glare hazard. In fact, there are a significant number of PV power plants built next to highways and around airports.

Source: Evan Riley and Scott Olson. "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems." ISRN Renewable Energy (2011), <https://doi.org/10.5402/2011/651857>.



Electro-Magnetic Fields (EMF)

The International Commission on Non-Ionizing Radiation Protection has established 833 milli-Gauss (mG) as the limit for prolonged exposure to electro-magnetic fields. The inverter is the strongest source of magnetic fields in the solar facility with levels varying from 150–500 mG within one to two feet. As an unmanned facility, prolonged exposure is never an issue. The level of EMFs noticed 1–2 feet away from our equipment pad is similar to standing next to your television. At 150 feet, the inverter's magnetic field levels drop below 0.5 mG or less, often falling to the background level of earth's magnetic field of 0.2 mG.

No other solar PV component emits EMFs that are measurable above the earth's magnetic field. There are no EMFs emitted at night.

*Sources: Peter H. Guldberg. *Study of Acoustic and EMF Levels from Solar Photovoltaic Projects*. Boston: Massachusetts Clean Energy Center, 2012. <http://files.masscec.com/research/StudyAcousticEMFLevelsSolarPhotovoltaicProjects.pdf>*

Soil Protection

Minimal ground disturbance only occurs during the construction period. Heavy equipment and traffic is restricted to perimeter roads, which comprise less than 0.03 percent of the site area during construction. To further protect against erosion, most roads on the site are re-seeded with vegetation after construction unless otherwise required by the soil conditions or indicated by the jurisdiction.

A detailed erosion and sedimentation control plan is developed for every project so that water-borne runoff is prevented from entering the surrounding environment. Control measures typically include straw bales, hay coil logs, run-off channels, silt fencing, and sediment basins or other state approved soil stabilization control measures. Once constructed, natural vegetative growth is encouraged within the facility to prevent erosion, and the areas where panels are located are not considered impervious.

Dust and Weed Control

During construction, dust levels are kept to a minimum by limiting heavy equipment and traffic to designated perimeter roads and points of site entry. During dry seasons, roads are regularly kept wet to reduce dust. Wet seasons naturally keep dust levels down.

To minimize the encroachment of weeds following construction native grass is planted across the site. The grounds are watered as needed, and weeds are removed during regular maintenance activities.

*Source: Jordan Macknick, Brenda Beatty, and Graham Hill. *Overview of Opportunities for Co-Location of Solar Energy Technologies and Vegetation*. National Renewable Energy Laboratory, 2013. <https://www.nrel.gov/docs/fy14osti/60240.pdf>.*

Wildlife Protection

Wildlife is protected by using perimeter fencing to prevent access for large mammals, such as deer. Large animals are excluded from the site because they can interfere with equipment, damage wiring, or injure themselves. In cases when barbed wire is not used, perimeter fence height is increased.

Smaller animals, such as squirrels and birds, can pass throughout the facility following construction. The environment in the solar facility is often conducive to a wildlife habitat because of its natural vegetation, significant amount of shade and relative lack of human disruption.

Wildlife access to electrical equipment is prevented with conduit protection for wires and foam sealing at all equipment entry points.

*Source: Damon Turney and Vasilis Fthenakis. "Environmental impacts from the installation and operation of large-scale solar power plants." *Renewable and Sustainable Energy Reviews* (August 2011): 3261-3270.*



Decommissioning

Cypress Creek is committed to responsibly decommissioning all of our projects at the end of their useful lives. Although the mechanism for doing so are market-specific based on local needs and regulations, every project is contractually obligated to decommission per our lease/purchase agreements with our landowner partners. Decommissioning and dismantling of the solar PV power plant is not expected to occur until approximately thirty years after the facility is constructed. The system's equipment, including wires, conductors, and racking, has significant salvage value since it is comprised of useful metals such as copper, aluminum and steel. The PV panels are valuable for their semiconductor materials and rare metals such as silver. At the end of the facility's lifetime, a solar reclamation firm will collect the modules for recycling, the inverters for refurbishing, and the hardware for salvage.

The land is then reseeded with a local seed mix and can be repurposed for agriculture or other uses.

Maintenance

Once constructed, solar farms require minimal maintenance. As such, there is no need to build travel infrastructure to accommodate traffic. Electrical engineers will service the inverters and transformers on average once per quarter. Solar PV panels have a very low failure rate (approximately 1 in 10,000 per year), and are easily replaced from inventory stores.

The panels require no on-site water or chemicals to keep clean. Natural weather conditions, such as snow and rain, occur with enough frequency and quantity to naturally keep the panels clean.

Grass is kept under control by mowing. To maintain weeds, application of weed control products is completed by a licensed herbicide applicator, in accordance with the manufacturer's requirements (incl. Safety Data Sheet); as well as local, State, and Federal regulations. In some regions, sheep grazing within the facility are used to control vegetation. Sites are maintained approximately 5-9 times per year during the growing season, depending on location.

Source: National Rural Electric Cooperative Association. Cooperative Utility PV Field Manual. Department of Energy, 2017. <https://www.cooperative.com/programs-services/bts/documents/sunda/nreca-cooperative-utility-pv-field-manual-vol-ii-final.pdf>.

Safety

Solar facilities do not generate more than one to three vehicle visits per quarter on average, making them insignificant traffic generators that do not create safety issues for the surrounding road networks. By contrast, the average American household generates ~6 vehicle trips per day.

Additionally, solar PV power plants are constructed according to all required building and electrical codes and safety measures. Site plans are approved by local authorities, and regularly visited throughout construction as required by local ordinance or state building code.

Interconnection agreements are carried out as specified by the local utility. Energized system components, such as inverters, are commissioned by the manufacturers' technicians. Solar facilities employ required lock-out measures and safety warnings. A perimeter security fence prevents trespassing and vandalism.

The regular vegetation control methods prevent buildup of debris that could otherwise pose risk of fire material. As such, solar PV facilities pose no increased risk of fires to the surrounding areas.

Vegetation management prevents buildup of debris that could otherwise pose risk of fire material. As such, solar PV facilities pose no increased risk of fires to the surrounding areas.

Sources: Jeff Court, "Photovoltaic Solar Safety Management for Utilities," Incident Prevention Magazine, October 16, 2014, <https://incident-prevention.com/ip-articles/photovoltaic-solar-safety-management-for UTILITIES>.

National Fire Protection Association, National Electrical Code, 690.1-91, 370.1-120, 376.1-120, 408.1-58, 450.1-48, 480, 490.1-74, 705.1-135, 728, 750.

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