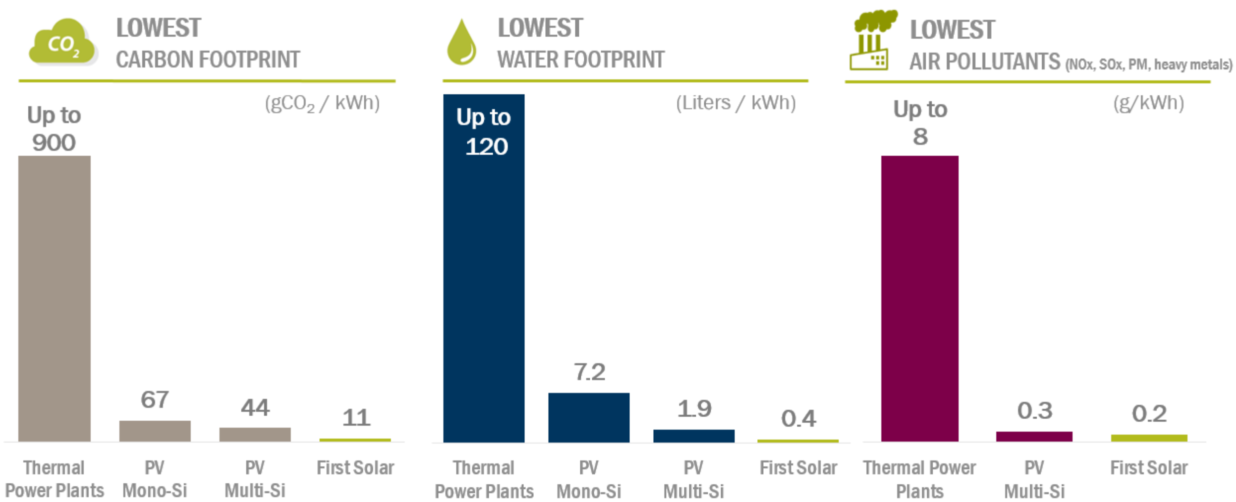
CdTe PV FAQ

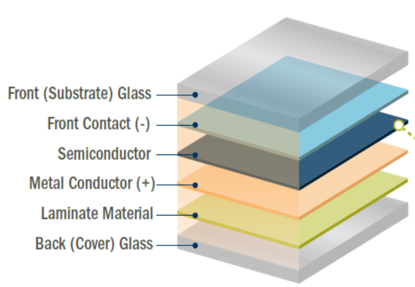
What are the environmental benefits of First Solar's thin film PV technology?

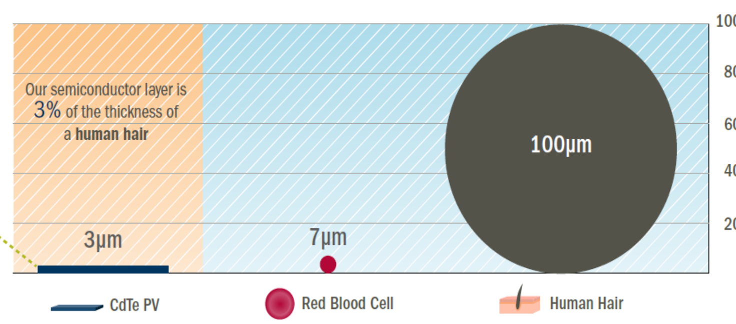
First Solar's advanced thin film PV solutions are the industry's leading eco-efficient technology due to their superior energy yield, competitive cost and smallest life cycle environmental impacts. [1] By using less grid electricity during manufacturing, First Solar thin film modules have the smallest carbon footprint and lowest life cycle water use and air pollutants of any PV technology on the market. [2] [3] [4] [5] [6] According to a study by UNEP, CdTe PV has the lowest life cycle human health and ecological impacts of all PV technologies per kWh of electricity produced. [7]



What is cadmium telluride (CdTe)?

CdTe is a semiconductor material used in First Solar PV modules that is ideal for absorbing and converting sunlight into electricity. Because CdTe is almost perfectly matched to the solar spectrum, First Solar modules require 98-99% less semiconductor material than conventional crystalline silicon modules. The semiconductor layer in First Solar modules is a few microns thick, equivalent to 3% the thickness of a human hair or less than half the thickness of a red blood cell.



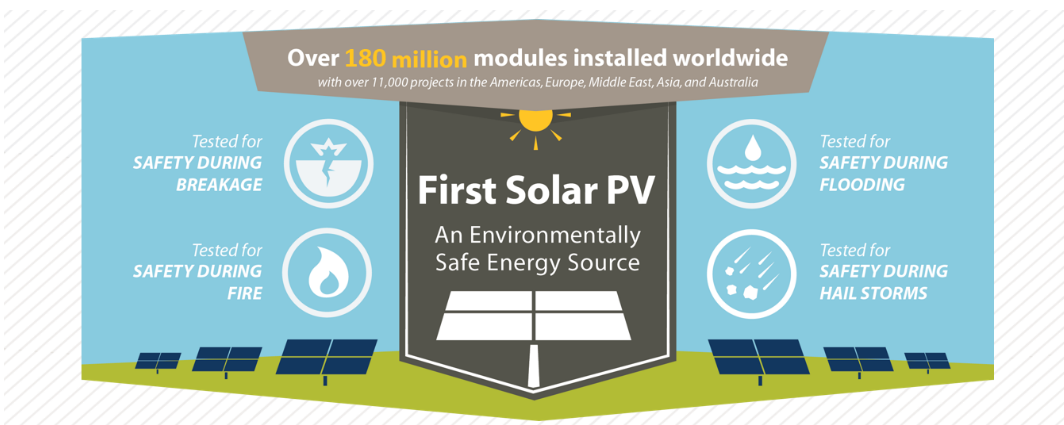


Is CdTe the same as cadmium?

No, third-party research studies have shown that CdTe differs from cadmium (Cd) due to its extremely high chemical and thermal stability. [8] CdTe is a stable compound that is insoluble in water, has a melting point (1041°C) and boiling point (1050^{0}C), and a low evaporation rate. In addition, First Solar's thin film semiconductor is encapsulated between two sheets of glass and sealed with an industrial laminate, which further limits the potential for release into the environment in the event of fire or breakage.

Does CdTe PV technology pose a risk to human health or the environment?

No. More than 40 researchers from leading international institutions have confirmed the environmental benefits and safety of First Solar's thin film PV technology over its entire life cycle; during normal operation, exceptional accidents such as fire or module breakage, and through end-of-life recycling and disposal: http://www.firstsolar.com/Resources/Sustainability-Documents?ty=Peer+Reviews&re=&ln=%20. First Solar thin film modules have been tested for safety during breakage, fire, flooding and hail storms and meet rigorous performance testing standards, demonstrating their durability and reliability in real-world environments. With over 17,000 MW deployed worldwide, First Solar thin film modules have a proven record of safe and reliable performance.



"CdTe modules do not represent any risk for human health nor for the environment, during normal operating conditions and in the exceptional case of fire or breakage." [9]

- National Renewable Energy Centre (CENER)

"Research demonstrates that [CdTe PV modules] pose negligible toxicity risk to public health and safety while significantly reducing the public's exposure to cadmium by reducing coal emissions." [10]

–North Carolina State University

"…replacing coal generation with [CdTe] PV will prevent Cd emissions in addition to preventing large quantities of CO2, SO2, NOx, and particulate emissions." [11]

- National Renewable Energy Laboratory and Brookhaven National Laboratory

Are First Solar modules certified to EHS, quality and durability standards?

All First Solar manufacturing plants are certified to ISO 14001 for Environmental Management, ISO 9001 for Quality, and OHSAS 18001 for Occupational Health and Safety. First Solar modules are certified to regional standards including UL for North America, CEC for Australia, Golden Sun for China, MCS for the U.K. and JET for Japan. First Solar PV modules also meet rigorous performance testing standards, demonstrating their durability and reliability in real-world environments.

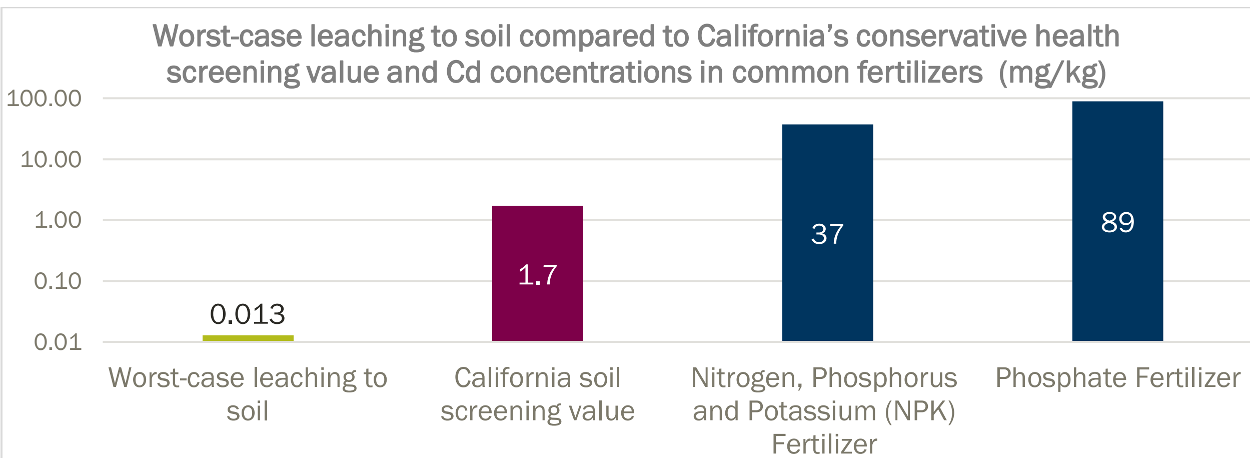
Test	Description	Results
IEC 61646/ IEC 61730 Certification	Basic industry market entry certifications	PASS *1500V certification level*
UL 1703	PV module electrical safety	PASS
Fire rating	Flammability testing	Class A Spread of Flame Class B Burning Brand
Thresher Test	Multiplies basic IEC 61730/61646 test cycles and durations 2X to 4X	PASS *<5% Power Output drop*
Long-Term Sequential Test	6-month accelerated protocol to evaluate long-term harsh climate durability	PASS *1st thin film module, and one of only 5 modules in the*
Atlas 25+ Certification	12-month weathering-intensive certification through projected 25+ year harsh climate field lifetimes	PASS *One of only 4 modules in the world to pass.*
IEC 62804 PID-Resistant Certification	Demonstrates high resistance to potential induced degradation at extreme ± 1500V voltages at most extreme 192hr 85C/85% RH test levels, enabling confident floating and grounded applications	PASS *1500V*
IEC 60068 Certification Desert Sand Resistance	Demonstrates minimal power loss and package integrity resistant to wind-blown particulates	PASS
Fraunhofer PV Durability Initiative	Durability benchmarking program rates modules according to their likelihood of performing reliably over their expected service life based on accelerated stress testing and long-term outdoor exposure	PASS *Best-in-class long term durability*
VDE Quality Tested	Quality certification for entire PV power plant enhances performance, ensures electrical and mechanical safety of the system and provides independent verification to investors, lenders and insurance companies.	PASS 1st PV company to achieve certification

What could happen if modules break?

Module breakage is rare and occurs only in approximately 1% of modules over 25 years or 0.04% per year. More than one-third of breakages occur during shipping and installation, therefore the broken modules are removed prior to plant operation. During operation, most breakages consist of impact fractures in which the module is still bound together by the industrial laminate.

Even in a worst-case leaching scenario, which assumes all the CdTe from broken modules were to leach as cadmium into the rainfall, Cd concentrations in soil, air, and groundwater are still below conservative human health screening levels in California. [12]

Modelled results for worst-case leaching to soil are up to 7,000 times lower than cadmium concentrations in common fertilizers.



What could happen in the event of a fire?

Independent analysis indicates potential Cd emissions from CdTe PV modules involved in a fire would be negligible as the majority of CdTe would remain encapsulated in glass. Heating experiments simulating residential fires showed that 99.96% of the Cd content of CdTe PV modules would be encapsulated in molten glass under the high temperatures of a building fire (800 to 1100˚C). [13] For ground-mount systems, the short-lived maximum fire temperatures (1000°C) are below the melting point of CdTe (1041°C), limiting release. [14] Even in a worst-case scenario that assumes a maximum Cd content (66.4 g/m^2) more than four times the amount of CdTe contained in First Solar modules, a large fire area, and the shortest distance from the emission site, the calculated Cd emission concentration is still below conservative air pollution exposure limits for the public and emergency responders. [15]

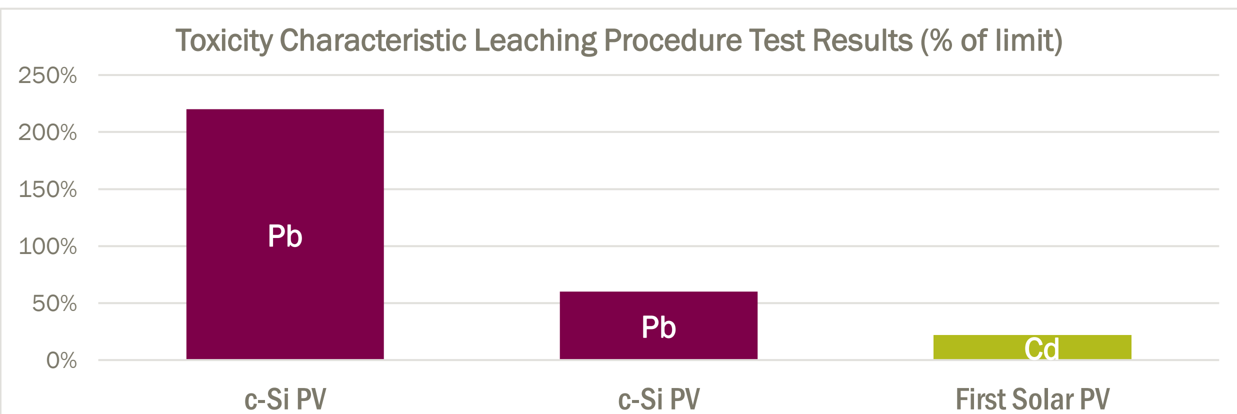
For perspective, potential accidental emissions occurring during fires are up to three orders of magnitude lower than routine emissions from coal and oil power plants. [16]

Does CdTe PV lead to an increase of cadmium in the environment?

No. Cadmium is generated as an unavoidable by-product of zinc production for steel products, regardless of its use in PV. Increased steel demand for building, construction and automobiles is expected to lead to a potential oversupply of cadmium. [17] When combined with tellurium, cadmium is converted into a stable compound, which is used to generate clean electricity for 25+ years. Cadmium exposure to the general population primarily occurs via smoking, followed by ingestion of Cd-containing food. Phosphate fertilizers represent the major source of cadmium in agricultural soils and the combustion of fossil fuels represents the primary source of Cd emissions to air. [18] [19] Whenever CdTe PV replaces coal in power generation it lowers the associated Cd emissions to air by 100–360 times. [20]

Does CdTe PV technology have unique end-of-life management requirements?

No. Responsible end-of-life management is important to the whole PV sector in order to maximize resource recovery and manage environmentally sensitive materials which are common in the industry. Both CdTe and crystalline silicon PV modules contain comparable quantities of heavy metals. Leaching tests results found that crystalline silicon PV modules released a range of 3-11mg/L of lead (Pb), which corresponds to 60%-220% of the federal U.S. waste characterization test (TCLP) limit. [21] Potential environmental impacts from end-of-life disposal of crystalline silicon PV modules are therefore comparable to or greater than that of CdTe PV.



Can First Solar modules and PV power plants be recycled at end-of-life?

Yes. Over 90% of a First Solar PV power plant is recyclable. First Solar has a long-standing leadership position in PV recycling and provides global PV module recycling services that enable PV power plant owners to meet their decommissioning and end-of-life (EOL) requirements simply, cost effectively and responsibly. First Solar's high-value recycling process recovers approximately 90% of the glass for reuse in new glass products and over 90% of the semiconductor material for reuse in new modules. The remainder of the recycled module scrap (approximately 5 to 10%) which cannot be used in secondary raw materials is handled using other responsible waste treatment and disposal techniques. Due to the shredding, crushing and heating typically involved in recycling processes, material losses are inevitable and the recovery ratio is always less than 100%. [22]

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