The Safety of Photovoltaics

Photovoltaics is **safe!** It has far fewer risks and environmental impacts than conventional sources of energy. None-theless, there are some environmental, safety, and health (ES&H) challenges associated with making, using and dis-posing of solar cells.

Is Today's PV Safe to Make and Use?

Yes conditionally.

Today's chief PV technology is based on *silicon*, the same semi-conductor material that dominates the electronics and com-puter industries. Although silicon is essentially quartz the main ingredient in glass there are some things to be careful of:

❑ The most notable ES&H risk posed by the PV industry is hazards for its workers. This stems mostly from using solvents, toxic or explosive gases and, to a lesser degree, from inhaling dust. *By using well-designed industrial processes and careful monitoring, PV manufacturers have minimized risks to where they are far less than those in most major industries. All of these risks fall well within the range already protected by OSHA and similar regulations.*

❑ Other than falling off a roof or being electrocuted because of improper practices, hazards associated with installing, using, and disposing of PV modules are nil. *Besides, manufacturers have already minimized these risks by certifying their components and making systems in accordance with strict national safety regulations.*

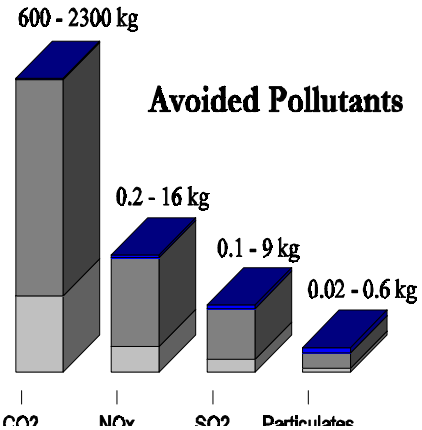
By following the proper procedures, PV installation is quite safe

Is PV Safe for Our Environment?

Again **yes!**

Especially when compared to conventional (fossil) sources of electricity, which are among the biggest contributors to environmental degradation. Fossil fuels produce acid rain, particulates, noxious fumes, carbon dioxide, and small amounts of heavy metals. In addition, the industries used for extracting fossil fuels present substantial ES&H concerns.

PV, on the other hand, produces no pollutants during operation, making it a preferred option for offsetting emissions that result from fossil fuel use. In fact, an EPA study (*Demonstrating Pollution Reduction Capability of Photovoltaic Systems*) showed that 1 kW of PV could offset between 600 and 2300 kg of CO_2 per year, as well as substantial amounts of other pollutants.



Compared to fossil-generated electricity, each kW of PV could save substantial emissions yearly. (Offset amounts vary with regional fossil fuel mix and solar insolation. Typical savings are close to higher values.)

And PV manufacturing only produces *modest* impacts, almost all from the energy needed to manufacture PV modules and systems. This energy is a problem only because it comes from conventional energy sources! *Indeed, these initial energy costs of PV systems often can be paid back by PV-generated electricity in under 5% of a PV system's lifetime outdoors. (See, for example, our FAQ: "Energy Payback: Clean Energy from PV.")*

Will Tomorrow's PV be Safe, too?

Once more **yes!**

New PV technologies, being developed to meet long-term, low-cost demands, use materials and techniques that pose new

ES&H challenges, which the NCPV is already addressing. Although the PV industry will always use far smaller amounts of hazardous chemicals than many other industries, such chemicals are responsible for the industry's major occupational hazards. So, the industry is adopting technologies and procedures *to minimize risks for each advanced PV option:*

❑ **Amorphous Silicon.** Silane an explosive gas is used to make amorphous silicon. Toxic gases such as phosphine and diborane are used to electronically "dope" the material. *To minimize explosion and toxicity risk, manufacturers use sophisticated gas-handling systems.*

❑ **Copper Indium Diselenide.** Toxic hydrogen selenide is sometimes used to make copper indium diselenide, a thin-film PV material. *Manufacturers use gas-handling systems to reduce risk, and use careful engineering and administrative controls to prevent exposure of workers or the public. Careful system design and gas detection systems can also effectively prevent exposure.*

❑ **Cadmium Telluride.** Cadmium and its compounds, used to make cadmium telluride cells, can be toxic at high levels of lung exposure. Inhalation of fine fumes or particles, more than ingestion or skin absorption, is the primary exposure of concern. *Manufacturers have effectively minimized exposure with engineering controls, personal protective equipment, and work practices. Biomonitoring of contaminant levels in workers is also a key defense against chronic toxicity.*

A safe tomorrow: NCPV staff, shown inspecting a gas monitoring system, are helping to resolve ES&H issues of advanced PV technologies.

Disposal and Recycling. Because solar cells have useful lives of 20-30 years, waste generation will lag behind industry growth. Landfill leaching is a modest concern only, because PV materials are largely encased in glass or plastic and many are insoluble. Because of dispersed use, and small amounts of semiconductor material per cell, PV recycling will be challenging. *Machinery for dismantling modules for recycling has been developed, and recycling systems for batteries and electronics provide useful models.*

Where Can I Find More Information?

The NCPV's Photovoltaic ES&H Project at Brookhaven National Laboratory has researched PV related safety issues. A bibliography of more than 100 articles can be found at http://www.pv.bnl.gov/biblio.html. The Project can also be contacted at 516/344-2830 (4486 fax).

❑ **General** Moskowitz, P.D. "An Overview of EH&S Issues in the Photovoltaic Industry." Chapter 18, pp. 391-416, in *Solar Cells and Their Applications* (ed. L.D. Partain), Wiley, New York, 1995.

❑ **Explosions** Fthenakis, V.M., and Moskowitz, P.D. "An Assessment of Silane Explosion Hazards." *Solid State Tech. 33(1)*:81-85, 1990.

❑ **Hazardous Gases** Fthenakis, V.M. "Prevention and Control of Accidental Releases of Hazardous Materials in PV Facilities." *Progress in Photovoltaics: Research and Applications, Vol. 6*, pp. 91-98, 1998.

❑ **Thin-Film PV** Fthenakis, V.M., and Moskowitz P.D. "Thin-Film PV Cells: Health and Environmental Issues in their Manufacture, Use, and Disposal." *Progress in Photovoltaics, Vol. 3*, pp. 295-306, 1997.

❑ **Fires** Moskowitz, P.D. and Fthenakis, V.M. "Toxic Materials Released from Photovoltaic Modules During Fires: Health Risks." BNL 44662, Upton, NY, 1990. *Solar Cells, 29*:63-71,1990.

❑ **Disposal and Recycling** Fthenakis, V.M., Eberspacher, C., and Moskowitz P.D. "The Feasibility of Recycling Solar Cells." Prepared for *IEEE Spectrum*. 1998.

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