

Economic Growth, Environmental Conservation and Energy Independence from Solar Equipment Manufacturing in the USA

By Paul Dailey and Raju Yenamandra, SolarWorld California, February 2008

1. Why Solar?

The benefits of solar energy are proclaimed every day from rooftops around the world. Solar energy is dependable. Solar energy emits no pollution or greenhouse gasses. Solar energy generation peaks in the same places and times as major residential and industrial loads. Solar photovoltaic (PV) systems are highly modular, making them suitable for use on the demand side of the electric meter. Solar PV panels last for over 30 years. All of these benefits are maximized when the solar PV equipment is made near where it will be used.

The solar PV value chain

As one of the largest vertically integrated PV manufacturers on the planet, SolarWorld is intimately involved with every step of the solar PV value chain from raw silicon to installed systems to end of life recycling. Figure 1 is a graphical representation of the PV value chain.

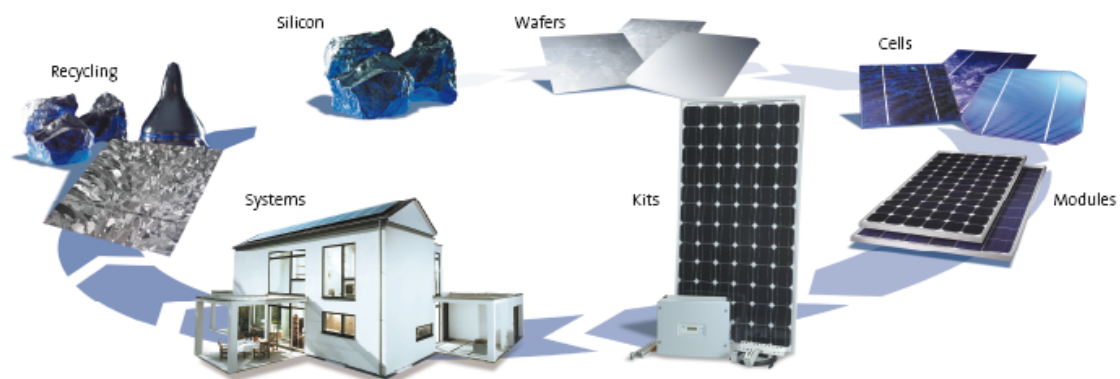


Figure 1. The solar PV value chain

Silicon refining and ingot growing

Silicon is the most plentiful element found in the Earth's crust. Pure silicon is generally refined from naturally occurring oxides such as quartz sand. Once purified, the silicon is then melted in a large crucible and grown into a single crystal for monocrystalline solar cells and integrated circuits or cast into a multicrystalline ingot for polycrystalline solar cells. SolarWorld produces single crystal silicon ingots for monocrystalline cells in its US facilities.

Wafer cutting

The silicon ingot is shaped and then cut into thin wafers by wire saw. These wafers are then cleaned and become the starting point for solar cells.

Cell production

The clean wafers are chemically doped using a vapor deposition process in order to form the anode and cathode needed to generate electric current. The cells are then treated with various surface optimizing and anti-reflective coatings to enhance their ability to capture photons and convert them into electrons. Finally, metal electrodes are screen printed onto the cells to transport the electrical energy to an electrical bus. The cells are then tested and sorted according to their power output.

Module assembly

Finished cells are connected in series and soldered together to form a complete circuit. These strings of cells are then carefully laid out and laminated between antireflective tempered glass and a durable polymer back sheet. A junction box is added that extends the electrical connections to the back of the laminate. This assembly is then tested using a controlled light source and labeled according to its power output. Finally, the laminate is glued into an anodized aluminum frame and prepared for shipping. The resulting module is completely weather proof and their power production is warranted for 25 years.

Sales as modules, kits and systems

Completed modules are sold in bulk to distributors and integrators, as kits to electrical contractors, or as whole systems to end users. Kits include appropriate inverters to connect the modules to the grid as well as mounting hardware to attach the modules to the roof. Systems are installed on a customer's building or site and fully commissioned.

Recycling

SolarWorld is the first company to cost-effectively recycle crystalline PV modules and cells. Given the long life of PV modules, recycling activities are mostly focused on production waste, but end-of-life recycling will become increasingly important as modules are replaced in 30 to 40 years.

2. Where solar PV equipment is made

Like most high-tech products, solar PV is made by companies all over the world. SolarWorld has the unique strategy of establishing production near the markets where our products will be sold. This means that what SolarWorld sells in North and South America is made in the USA.

Myth: Making solar products in China is cheaper than making them in the USA.

Fact: Making PV products in the USA is environmentally beneficial and economically competitive.

While labor costs are lower in China, India and the Philippines, it is important to remember that labor makes up only about 10% of the cost for PV products. Most of the cost associated with manufacturing PV wafers, cells and modules is in raw materials like silicon, glass, and aluminum. Because of advanced automation technology and the skilled workforce available in the USA, fewer workers are needed to produce the same amount of product. There is also a substantial quality advantage to making high-tech products in the USA vs. China, for example.

In addition to the higher quality level of production in the US, economic and environmental costs of overseas shipping are avoided. When the cost advantages of sourcing production near the market are accounted for, it is rarely cheaper to import PV products from Asia. This is one of the reasons SolarWorld chooses to manufacture in the USA from locally sourced raw materials with a highly skilled labor force.

Table 1 shows the manufacturing locations for the major suppliers to the US solar PV market. Led by SolarWorld, a substantial amount of PV manufacturing takes place in the USA because of superior automation technology and employee productivity as well as avoided shipping expenses. However, manufacturing in the US is only competitive when the domestic market is relatively strong.

Company	Location (in descending order by capacity)
SolarWorld	USA, Germany & Sweden
Evergreen	USA & Germany
Sunpower	Philippines
BP Solar	India, Spain, USA, Australia & China
First Solar	Malaysia, Germany & USA
Sharp	Japan
Sanyo	Japan
Kyocera	Japan
Mitsubishi	Japan
Suntech	China
Solarfun	China
ET Solar	China
Trina Solar	China
Yingly Green Energy	China
Shenzhen Sunshine Electronics	China

Table 1. – Vertically integrated manufacturing locations for major PV manufacturers

3. How making solar equipment in the USA benefits the economy

Like most manufacturing, solar PV production benefits the local economy where it's made. Beyond creating local jobs for professionals and skilled laborers, US manufacturing creates additional economic activity both upstream and downstream.

Jobs for American workers

Solar Manufacturing creates high-tech jobs for professionals and skilled labor. The skills required for manufacturing solar PV are similar to the skills needed by semiconductor industry to fabricate and process silicon wafers. SolarWorld located its new cell factory in the Portland, OR area in part because of its proximity to silicon forest companies such as Intel. SolarWorld's factory benefits the local area by providing some employment stability for specialized jobs.

Between 700 to 1,000 employees will be producing solar cells at SolarWorld's Hillsboro, OR factory by the end of 2009. This will include a mix of professional positions, engineers, managers, etc., and skilled labor positions such as machine operators, technicians, etc. An additional 500 employees will be assembling modules at SolarWorld's Camarillo, CA factory in that time. A US work force is much better suited to produce high quality highly technical products using statistical process controls than a low wage labor force accustomed to low tech assembly of toys and simple consumer products.

Opportunities for American suppliers of services and raw materials

SolarWorld operations in the USA generate tens of millions of dollars in revenue per year for local service companies and American suppliers of materials and equipment. Aside from common business services like janitors, delivery services and consultants, SolarWorld purchases much of its raw materials and specialized equipment from US suppliers. In addition, local operations generate important tax revenues for federal, state and municipal governments.

Opportunities for American distributors, dealers and installers

SolarWorld's module sales generate up to \$250 million for US distributors, freight companies and local installers. PV installation in particular provides needed jobs in the construction sector, especially as homebuilding activity has declined recently. These jobs depend on a strong domestic solar market as well as steady supply from manufacturers like SolarWorld.

In addition to simple module sales SolarWorld has also created a kit product that lowers the barrier to entry for small service businesses to enter or create their local solar market. SolarWorld provides training and services to these small business people which enables them to sell and install solar PV systems on homes and business rooftops, giving them a new avenue to grow their businesses.

4. How making solar equipment in the USA benefits the environment

Solar energy deployment offers a sustainable pollution-free alternative to the coal, gas and nuclear energy sources that are otherwise needed to maintain our standard of living. Manufacturing solar PV products in the USA further benefits the environment by vastly reducing the amount of shipping required to get the products to market. This makes for a much smaller carbon footprint of the product delivered to the consumer.

Solar energy avoids pollution and greenhouse gas emissions

A recent study by the Brookhaven National Laboratory concluded that “At least 89% of air emissions associated with electricity generation could be prevented if electricity from photovoltaics displaces electricity from the grid.” [1] The Brookhaven study included a complete life cycle analysis of manufacturing and installing the PV equipment. This is a powerful statement and highlights the primary environmental advantages of solar energy.

Detailed research has been performed by NREL and other researchers that details the short energy payback of PV solar energy deployment, which was already less than 4 years back in 2000. [2,3] the energy balance has only improved in recent years thanks to thinner silicon wafers and more efficient processes.

Locating silicon refining and PV production in regions like the Northwestern United States, where most of the grid power comes from hydroelectric and wind resources further reduces the environmental impact of solar production – most of which is from the generation of power used to run the factory. SolarWorld’s new 500 MW factory is located in a renovated semiconductor facility near Portland, OR.

US production avoids shipping and related emissions

Overseas shipping is a significant emitter of harmful and uncontrolled airborne pollutants like smog-forming oxides of nitrogen and sulfur, not to mention greenhouse gases like CO₂. Large ships generate nearly a third of the world’s nitrogen emissions and nearly a fifth of the world’s sulfur emissions.

By producing products near the markets where they will be used, SolarWorld eliminates much of the transportation-related emissions compared to products imported from Asia or Europe. SolarWorld packaging innovations further reduce the transportation emissions from domestic shipping by fitting more product on each pallet and vehicle.

5. How making solar equipment in the USA improves our energy independence

Any energy source sustainably gathered in the USA helps to improve our nation’s energy independence. Acquiring fossil fuels like oil and gas have often dominant

impacts on US foreign policy and national security concerns. Because our nation is not meeting its own energy needs, our government is forced to militarily protect fuel resources abroad and money from US consumers flows into unfriendly governments. Solar energy can help free America from its dependence on foreign oil and natural gas.

Reduced dependence on foreign fossil fuels

President Bush has said repeatedly that our nation is addicted to foreign oil. Our nation imports about 10 million barrels per day, about 60% of what we use. [4] Other fuels, such as natural gas and even uranium nuclear fuel, present similar problems in that they must be imported from unstable or unfriendly trading partners. Domestic gathering of fossil fuels, such as coal and oil, imposes difficult political and environmental challenges and is ultimately not sustainable in the long term.

Solar energy has the potential to replace much of the fossil fuel based energy our nation currently uses, allowing us to depend less on foreign suppliers and conserve domestic resources for high-value applications. Every kWh generated from solar avoids the equivalent amount of natural gas, oil or coal that would otherwise be used to generate electricity. Solar PV also helps to enable new transportation paradigms like plug-in hybrids and fuel cell cars that would otherwise add loads to the already overburdened electrical grid.

Distributed generation reduces need for large power plants

The current US electrical infrastructure is barely able to support peak electrical loads, as evidenced by several recent blackouts and related events around the nation. Even small residential PV installations help reduce peak power demands by providing energy when and where it is needed most. Solar PV generation typically peaks at the same time as air conditioning loads, which is a primary driver of peak power demands. Rooftop PV installations also have no significant transmission losses, which account for up to 10% of the load on central power stations. By installing distributed generation in the form of on-site solar PV systems, it is possible to offset enough energy use that new centralized power plants can be postponed or avoided all together. And the PV systems are paid for largely by the building owner.

Proposed coal and nuclear plants all over the country are being blocked by local constituencies for a variety of reasons, mostly having to do with safety and environmental concerns. Surveys have shown that almost no one is opposed to locating solar energy near their home and many paying to put it on their own rooftops.

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