



Hire Electric Company

Solar Recycling Report

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One: Growing Pains



Photo by SolarWorld 1

Imagine for a moment standing there in the garage with Steve Jobs and Steve Wasiak, geeking out at their little green display and you say, “What’s going to happen in ten years when millions of people are throwing these obsolete things away? Do you have a recycling plan?” Of course they would have given you that “what planet are you from” look and gone on tinkering. Even these creators of the future couldn’t imagine a world with over one billion personal computers. They never thought we’d be throwing PCs by the truckload in our landfills. That “recyclers” would take them apart and ship the toxic components overseas to be baked down in the mud huts of India and Africa for the rare metals (if you don’t know about this practice please follow the footnote and make sure you recycle your computer equipment responsibly).¹

Globally the solar (photovoltaic) industry has grown at an average annual rate of 60% since 2005 with a record breaking 81% growth rate in 2010.² There are more than 200 million solar modules installed throughout the world today³. Assuming a 25 to 30 year useful lifespan we’re looking at a great deal of waste to process by the year 2035. If the industry continues to grow at current rates the waste stream will also grow in a parallel curve beyond the year 2035.

The temptation for every emerging industry is to live in the moment, the new stuff, the profit (or lack of it), and to ignore future implications. This is the natural process of innovation. Innovators live in that tenuous space between screaming success and abysmal failure. Only once a given innovation has reached a certain level of scale and acceptance and maturity can it sit back and think more strategically about implications. The solar industry is at such a juncture. After decades of foundering under the whims of fossil fuel based energy policy, photovoltaics have only recently become a serious contender in the race for energy independence and sustainability. The industry has moved out of the garage.

There is a big difference however between solar energy and the tech-gadget world: Even in the garage (or the lab), the solar industry was ultra self conscious about its sustainability and global impact. Aside from being extremely effective for space programs and satellites, solar’s primary terrestrial sales strategy has been its greenness. The photovoltaic process is completely clean.

¹ http://www.pbs.org/frontlineworld/stories/ghana804/video/video_index.html

² http://www.ren21.net/Portals/97/documents/GSR/REN21_GSR2011.pdf

³ Using 2010’s 40GW global installed capacity and an average module size of 200 watts.

When sunlight hits the semiconductor, electricity is magically produced with no moving parts and no emissions.

Two: An Industry with Big Dreams

Being birthed on the heels of the industrial revolution and slip-streaming the high tech bubble, the solar industry has learned from mistakes made by thoughtless growth and senseless waste. And with its roots in the environmental marshes of the 1970's - acid rain, nuclear fears, oil embargoes and energy crisis - solar has poised itself as the ecological and energy savior of the planet.

In order to live up to this Messianic loftiness the solar industry is thinking ahead about every aspect and implication of its current practices and growth rate: To learn from the computer/tech industry and avoid many of their mistakes; to prepare now for the time when the one billion solar modules are reaching the end of their affective life cycle; and to make harvesting energy from the sun the cleanest (and cheapest) energy option. No small task.

The Solar Energy Industries Association has laid out “Environmental Health and Safety” as its top policy with these specific priorities:

- **Worker Safety:** The health and safety of workers, both pre- and post-manufacture, is an important component of social sustainability. The solar industry is developing best practices that ensure worker health and safety, and focus on awareness and compliance with US laws and regulations.
- **Solar Panel Collection & Recycling:** Solar photovoltaic systems, solar thermal and concentrating solar power technologies have a life expectancy of 30 years. As the volume of solar installations in the US grows, the industry is planning ahead to create panel recycling programs.
- **Fire Safety:** Firefighters often must access roof space in the course of fighting a fire. Therefore, the solar industry is researching best practices to ensure fire-fighter safety, and tracking fire incidents involving solar panels to further address concerns.
- **Managing Greenhouse Gases:** Recent EPA rules have mandated tracking and reporting of identified greenhouse gas emissions. While it appears that the vast majority of solar companies are well below EPA tracking thresholds, the solar industry is developing tracking mechanisms and developing best practices to ensure awareness and compliance.
- **Lifecycle Materials Assessment:** To ensure a sustainable supply chain, all materials and labor involved in creating the final product must be both socially and environmentally sustainable. Thus, the solar industry is developing best practices, researching alternate methods and materials, and lowering environmental impacts, to create a wholly sustainable product.⁴

Recycling is just one small piece in the whole picture of what the industry wants to accomplish.

⁴ http://www.seia.org/cs/solar_policies/environment_health_safety

Three: Bad Rap and the Dirty Truth

If a solar manufacturing facility pollutes in China does anybody hear?

Unfortunately the industry does not always live up to its goals. In September of 2011 hundreds gathered outside the gates of a solar manufacturing plant in Zhejiang, China to protest the alleged pollution of the local river.⁵ Another Village in the Henan Province was reported as being deluged with silicon tetrachloride, a byproduct of the polysilicon manufacturing process.⁶ Although these cases of blatant pollution would not be possible in Europe or the United States the facts of



Photo by SolarWorld 2

globalization make it possible for a “clean” company in a “clean” industry to hide some of its dirty work behind a curtain (so to speak).

Two common beasts preside over this clean tech heresy: Greed and Growth. Ingot to module manufacturing is done in the US and Europe but at a much greater cost than in the developing world. Chinese manufacturing is attempting a heroic scale-up of their silica and solar module manufacturing capacity and they are cutting every corner possible to do it.⁷ China is about two years away from being the largest producer of solar in the world.⁸

Energy in the Stanford Journal of International Relations, claims that end-of-life solar recycling commitments by solar manufactures are simply a red herring that tries to mask the real issues of pollution and environmental risk that exist in the solar industry today. If an effective recycling infrastructure or at least recycling commitments are put in place 30 years ahead of the true need for

Ishan Nath in his very compelling article *Cleaning Up After Clean*

⁵http://www.nytimes.com/2011/09/19/world/asia/chinese-protesters-accuse-solar-panel-plant-of-pollution.html?_r=2&ref=asia#

⁶<http://www.washingtonpost.com/wp-dyn/content/article/2008/03/08/AR2008030802595.html>

⁷ Ibid.

⁸http://www.usatoday.com/money/industries/energy/environment/2009-11-17-chinasolar17_CV_N.htm

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recycling, while the industry is polluting and harming villages and workers it does seem like a sham.

Nath goes on to conclude that even with the side effects and pollution of solar module production, “solar energy remains far cleaner, for the atmosphere and for human health, than burning coal.”⁹

There are a number of solar watchdog groups trying to ensure that the industry stays green from start to finish. SolarScoreCard.com, a project of the Silicon Valley Toxics Coalition has set up an annual report and scoring system for solar manufactures. They scored companies based on their practices and transparency in the areas of: Recycling (pre & post production & end of life), green jobs (worker safety), toxics and disclosure. The hope is that honest reporting will drive public demand and pressure the entire industry into making a truly green product. Whether reporting alone, without some brave global environmental policy, will make a difference to the beasts of Greed and Growth...only time will tell.

Four: The Christmas Valley Horizons Project

SolarWorld Manufacturing:

Sustainability was a major goal in the RFP for the Oregon Military Department’s Phase One solar project in Christmas Valley, Oregon. SolarWorld modules were chosen both because they were made in state and that SolarWorld manufacturing meets some extremely high standards for sustainability:



- The chosen SolarWorld 235 Watt Poly modules were manufactured from start (ingot) to modules shipping in Hillsboro, OR.
- The electricity at the Hillsboro plant is from 22% hydro and 11% wind sources¹⁰
- SolarWorld is installing a megawatt of solar on the plant’s roof in 2012 to ensure that even more of their usage comes from renewable sources.¹¹
- SolarWorld received the highest number of points (91) of any solar manufacture in the www.solarscorecard.com 2011 report.

⁹ www.stanford.edu/group/sjir/pdf/Solar_11.2.pdf

¹⁰ http://www.portlandgeneral.com/our_company/corporate_info/how_we_generate_energy.aspx

¹¹ <http://www.solarworld-usa.com/news-and-resources/news/solarworld-showcases-more-than-1-megawatt-of-solar-projects.aspx>

Modules on site:

The trip from Hillsboro to Christmas Valley is much shorter than from Berlin or Henan Province so the transportation impact was minimal. The modules arrived on pallets that were sturdy, providing adequate protection for the modules while minimizing packaging waste. The pallets were re-used as hay storage racks in one of the workers barns. Plastic packaging clips that held the modules securely together have been delivered back to the Hillsboro plant by North Coast for recycling. A single sheet of cardboard covered the top module (these are being re-used as seedling mulch in a Klickitat County re-forestation project). In all, construction waste was kept to a minimum because of the thoughtful packaging SolarWorld provided.



In the course of construction a solar module was broken at the Christmas Valley project. Danny Hytowitz, Product Training Specialist at SolarWorld Americas helped initiate the recycling process. SolarWorld will issue an RMA (Return Merchandise Authorization) number to track the return and provide shipping/drop off info. SolarWorld does not pay for shipping at this time and encourages returns via normal supply channels. The broken module has been dropped off at North Coast Electric, a SolarWorld distributor. North Coast transported the module to SolarWorld's

Hillsboro plant while picking up their next supply of modules. No additional driving or fuel will be necessary to deliver the module.

Mr. Hytowitz said that at this time SolarWorld does not have a dedicated recycling facility in the United States. They store the broken or end of life modules until they have a complete container full. Then, as part of their container return system (so to speak) they send the modules to be recycled at the PVCycle recycling facility in Freiberg, Germany. SolarWorld spun off PVCycle in Europe several years ago.¹²

SolarWorld will recycle modules from all their previous brands: Arco, Siemens and Shell Solar. The early Arco modules were made in 1977, making them 35 years old. SolarWorld does not take modules from other manufactures into their recycling stream because some modules contain hazardous waste and SolarWorld cannot take on that liability. Several manufactures have signed recycling agreements with PVCycle and hopefully more will follow in the future. Some manufactures have their own recycling program.

¹²http://www.pv-magazine.com/news/details/beitrag/new-jv-established-to-recycle-pv-modules_100004287/

Five: On the Roof in 2035

End of life and solar recycling is often viewed as a negative challenge to the burgeoning solar industry: A future liability. It seems as if people imagine a phone call 20 years from now saying, “Get out here and take these solar panels off my roof.”

However, the system end of life is one of the solar industry’s greatest assets. A marketing powerhouse. Here’s a breakdown:

1. Module prices are projected to go down to as low as \$.50 per watt in the next 20 years.¹³
2. Module efficiencies are projected to double over the same period.¹⁴
3. Inverter efficiencies, reliability and iPhone-app-ability are also steadily increasing
4. Labor, wiring and racking prices will drop, as the industry reaches scale but not as dramatically as module prices.
5. Coal and oil scarcity will continue to drive up prices of these competing energy sources.
6. At some point along the solar price plummet, clean, quiet solar modules will be the price leader for future energy.
7. It will only make sense to burn carbon when the sun’s not shining and hopefully smart grid and storage solutions will be there to replace all carbon except in the most dire emergencies.

What does this rosy solar picture have to do with the roof of 2035? It’s all about the phone call. Everyone knows a repeat customer is gold. How about a repeat customer with proven solar access (good orientation and angle), a racking system already installed, some pre-wiring and an inverter location already picked out. Imagine this phone call in 2035: “Hello, is this Jonny’s Solar? Yeah, your grandpa was out here and put up some solar for my dad a while back...Yeah, yeah it’s workin’ fine. I just keep hearin’ about these newer panels and I’d like to know if I could get a little more bang for my roof. If you know what I mean. Oh, and we need to replace those shingles while were at it - can you help me with that?” So, the solar installer/roofing company of 2035 calls up his local solar manufacturing/recycle plant to see what kind of purchase&return combo deal they have going at that given time. The solar delivery truck meets the installer at the site to drop off fancy new modules and pick up the old ones. After new roofing goes down the mounting rails and electrical raceway are re-used and the new modules go up. The new inverter is commissioned via Twitter and everybody’s happy.

On the flip side of this picture of solar utopia is the reality of the solar thermal market of the 1980’s. The US was in a horrible energy crisis with lives and money at stake and we chose to attack that crisis head on. An aggressive incentive program was adopted by the federal government and by many states. Solar water heating companies sprouted up like mushrooms.¹⁵ The White House installed its famous solar collectors. But by the mid 80’s the crisis was over. Fuel prices plummeted, tax credits expired and the White House had its solar collectors taken down. Business

¹³ <http://blogs.scientificamerican.com/guest-blog/2011/03/16/smaller-cheaper-faster-does-moores-law-apply-to-solar-cells/>

¹⁴ Ibid.

¹⁵ http://energytrust.org/library/reports/040521_Solar_Thermal.pdf

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after business collapsed leaving no one to repair or maintain these systems. Roofs were left with ugly, non-functioning liabilities that were often sent to landfills when the roof needed to be replaced. Any hope of proper recycling of today's solar PV modules is dependant on a robust industry that continues to grow and thrive well beyond 2035.



Solar panels can be recycled, but it takes specialized equipment to separate out all the potentially toxic materials. Photo courtesy of SolarWorld.

Six: Conclusion - Future Ready

Hire Electric has been installing solar modules since 2003. We often work on repairing systems with modules from the 70's. Most of the vintage modules we encounter are still working fine, producing well above 80% rated capacity and simply need some system wiring repairs. We have 5 modules at our warehouse that were broken during transport or installation. We plan to store broken modules until a robust US recycling facility is in place. Modules that are orphaned because of manufacture bankruptcy or from company's that do not participate in a recycling program can still be recycled but typically at a cost. We have always avoided using modules from risky ventures and all the manufactures we currently use have a full life-cycle plan in place.

By taking a look at Hire Electric's current installation labor to equipment burden we can get a good picture of what the recycling or de-commissioning of a given array might look like in the future:

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Roof Mounted PV per KW (assume average 6kW system)

	Labor Hrs	Material Cost	Recyclable	Reusable
Roof Attachment	2	\$150	YES	YES
Racking System	.5	\$850	YES	YES
Module Instal	.5	\$2700	YES	NO
Module Wiring	.25	\$80	YES	YES
DC Wiring to Inverter	4	\$120	YES	YES
Inverter Instal	2	\$1700	?	?
AC Wiring	2	\$250	YES	YES

Ground Mounted PV per KW (assume average 30kW system)

	Labor Hrs	Material Cost	Recyclable	Reusable
Excavation/Site Work	6	\$800	YES	YES
Racking System	3	\$1200	YES	YES
Module Instal	1	\$2700	YES	NO
Module Wiring	.25	\$80	YES	YES
DC Wiring to Inverter	4	\$120	YES	YES
Inverter Instal	2	\$1700	?	?
AC Wiring (underground)	2	\$500	YES	YES

There are many variables to the figures in these charts but the obvious implication is that much of the emended cost of a system could potentially be reused when that system is upgraded. Code changes and radical technology shift could make even more of the original equipment obsolete. Thoughtful business models based on the retrofit market could overcome any of these hurdles.

Hire Electric recently had a customer who wanted to upgrade their 6kW system to 12kW. The only way to add the additional capacity was to take down the existing modules and rack and

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reinstall everything in a new orientation. We were surprised at how quickly the tear down happened. Easily half the time it took us to install these modules originally. Part of the reason is that during installation extra time and care is taken to make sure everything is straight and torqued. Because module prices had dropped by almost 30%, the customer was able to get his additional 6kW - including relocating the original 6kW for less than he paid for his first system.

Solar recycling will become more and more a part of photovoltaics sustainability and value proposition. We can only speculate about the reuse and recycling of the systems we are installing today but we do have opportunities now that will make those transitions easier. By taking this issue seriously and preparing today for recyclings inevitability the solar industry is making itself future ready.

I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that.¹⁶

-Thomas Alva Edison 1931



Photo courtesy of SolarWorld.

¹⁶ In conversation with [Henry Ford](#) and [w:Harvey Firestone](#) (1931); as quoted in *Uncommon Friends : Life with Thomas Edison, Henry Ford, Harvey Firestone, Alexis Carrel & Charles Lindbergh* (1987) by James Newton, p. 31

Appendix:

1. Recycling Policy Email from Daniel Hytowitz of SolarWorld USA
2. Silicon Valley Toxics Coalition, Solar Scorecard 2011
3. PVCycle
4. <https://sites.google.com/a/hireelectric.com/solar-recycling/documents>