Cadmium-Telluride Photovoltaic's (PV) Environmentally Sound?: Bill Kennedy (Jan, 2010)

We've all heard of NiCd (NiCad) batteries. We know from what we have heard that NiCd batteries contain cadmium (Cd). Through this we have learned cadmium is a toxic, carcinogenic, heavy metal and therefore requires special care during use and mandates proper battery disposal via recycling. We, the public, somewhat understand that in the US part of the price of a NiCd battery is a fee for its proper disposal at the end of its service lifetime. This we have been told is important as cadmium is a heavy metal that should be avoided due to its "deadly toxicity" to all forms of life, including our own. Some of us are also aware of RoHS (the European Union's "Restriction of Hazardous Substance Directive") wherein cadmium is banned for use in many countries and organizations for use in all types of electrical and electronic equipment. Here again we understand this ban as cadmium, being a heavy metal, can cause substantial pollution when dumped in landfills and/or incinerated. All in all, we the public have some understanding of the fact that cadmium pollution is bad, its proliferation is bad and that no matter how much we as individuals support recycling programs, that they are in reality poor, cost money and in are in a education and catch-up mode trying to entice more cooperation. All this, yet we continue to proliferate Cadmium into new applications, increasing its use and level of threat.

From time to time, if we dig hard enough or more recently seen articles carried more prominently, we see news articles regarding cadmium. Kid's toys, for example, have recently caught headlines. It seems that China companies are producing toys, pins, charms for girl's bracelets, etc., have recently been prominent in the news, with companies here, including Disney and other watch groups complaining about high cadmium levels in these products, with major recalls and other actions on going. In reality Cadmium (Cd) is not a new problem in modern society, but as with many other pollution threats, ranging from toxic chemicals to mercury, lead and other carcinogenic pollutants, increasing geometrically we need to do not only a better job in understanding its cumulative effects on us and our bio-system, but also in it in combination with other pollutants combined against our health. We read about the global proliferation of these pollutants which, for example can be born in China and travel the jet stream to the Western United States, making these contaminants a worldwide threat. We also lean that these contaminants taken individually or as a combined threat, cause significant long term deleterious effect on the entire bio-system as these chemicals bio-accumulate in all living organisms and tend to concentrate in our vital organs.

For many years the threat of Cd proliferation has been seen, here are two examples (many others & lawsuits online):

- "Since the 1970s, at least 200 hectares (ha) of farmland [Taiwan]has been polluted by the heavy metal cadmium (Cd).Consequently, the Cd pollution has led to contaminate the rice production and caused acute social panic. According to the recent investigation results performed by the Taiwan Environmental Protection Administration (TEPA), it is indicated that most of the Cd pollution incidents in Taiwan resulted from the wastewater discharge of stearate Cd factories. To prevent the Cd pollution incidents from spreading, the TEPA has either forced these factories to close down or assisted them in improving their production processes since the 1980s. Unfortunately, accidental incidents of Cd pollution still emerge in an endless stream, despite the strict governmental controls placed on these questionable factories (I-Cheng Chang, Teng-Yuan Hsiao, Yue-Hwa Yu and Hwong Wen Ma, Volume 14, Number 1 / January, 2007, ISSN 0944-1344Springer Berlin / Heidelberg).

- "Chinese Factory Closes Following Cadmium Pollution Protest", by Ryan King, special to mongabay.com, August 05, 2009: The Xianghe Chemical Factory in China was closed after protests from local residents in the central Human Province. The plant had recently been the target of several widely-covered "mass-incidents" of violent protest. Nearly 1,000 protestors called for immediate closure of the plant last week. The factory had produced industrial chemicals for the past six years. Autopsies of near-by villagers who had died earlier this summer indicated high levels of cadmium. Post-mortem testing found high internal cadmium levels in more than 500 of the almost 3,000 neighboring citizens. The municipal Environment Protection Bureau was attacked by protestors. Six of the locals were arrested during the events and at least one was severely beaten by police. The plant is reported to be closed "forever" following the outrage by locals and media coverage (Reuters).

Worldwide we must, more and more understand Cd is a significant and growing problem not only to humans, but to the environment we live in and the food we eat and with this understanding try to establish methods and techniques to manage this carcinogen into decreasing levels that, if trends continue, will affect our own lives more and more. It should be understood that prior to the turn of the 20th century, cadmium was a rather rare metal nearly always associated with zinc, little used industrially, a metallic curiosity with a bluish-white luster quite impervious to corrosion, like tin. Now we are literally bombarded with cadmium. Many branches of the US Government are concerned about Cd and trying to educate and warn against proliferation. On the other hand, other branches of the US Government have not only provided waivers for products that use Cd in their construction, but are also busy promoting these products and incentivizing their sale to the public (example: Cadmium-Telluride Photovoltaic Solar Panels, various Quantum Dot and Nanotechnologies that use Cd as a base material due to its ease of use, etc.).

Doctors concerned with diseases have long known that cadmium is poisonous. Pharmacologists, also, have known that small doses lead to bizarre effects in animals. Indeed, one of the most insidious pollutants in our environment is the heavy metal element Cadmium (Cd). An important new study is the first research report [“Cadmium Increases Human Fetal Germ Cell Apoptosis”, Gaëlle Angenard, Vincent Muczynski, Hervé Cofgny, Catherine Pairault, Clotilde Duquenne, René Frydman, René Habert, Virginie Rouiller-Fabre, and Gabriel Livera. Journal: Environmental Health Perspectives.doi: 10.1289/ehp.0900975] focused on the effects of Cadmium on human fetal sex organ tissues. The authors observe: “Exposure to Cadmium is usually the result of environmental contamination by waste from human activities such as the residues found in mining waste, those released by the combustion of fossil fuels and industry, and the run-off from agricultural land [landfills, et al]. Cadmium occurs in nature at low concentrations, but its widespread occurrence means that it is now present in almost everything that we eat, drink, and breathe. Tobacco smoke is one of the most common sources of Cadmium contamination in the general population, with an estimated assimilation of 0.2 to 1.0 micrograms of Cadmium per cigarette. Cadmium has a very long biological half-life of 15 to 30 years, mainly due to its low rate of excretion from the body, and it accumulates over time in the blood, kidney, and liver, where it has numerous undesirable effects on health. In addition, a wide spectrum of damaging effects on reproductive tissues has also been described.” (Note: the term "apoptosis" refers to programmed cell death, a process that ends with the death and dissolution of a living cell. It's a common consequence of exposure to chemicals toxic to living systems.)

Cd is a common environmental pollutant and a major constituent of tobacco smoke. Adverse effects of this heavy metal on reproductive function have been identified in adults however no studies have examined its effects on human reproductive organs during development. Cadmium, at concentrations as low as 1 µM, significantly decreased the germ cell density in human fetal ovaries. This correlated with an increase in germ cell apoptosis while there was no effect on proliferation. Similarly, in the human fetal testis, Cd (1 µM) reduced germ cell number without affecting testosterone secretion. In mouse fetal gonads, Cd increased only female germ cell apoptosis.

From all of this we know: a)Cd is a non-essential element that has high rates of soil to plant transference compared with other non-essential elements, and certain plant species accumulate large amounts of cadmium from low cadmium content soils; b)Exposure levels of 30–50 µg per day have been estimated for adults and these levels have been linked to increased risk of bone fracture, cancer, kidney dysfunction, hypertension

“***The Poisons Around Us, Toxic Metals in Food, Air, and Water***”, by Henry A. Schroeder, M.D. (Published about 1974) “…… tobacco smoke, burning oil, automobile tire dust, cadmium batteries, canned foods, dried foods, cola drinks, processed coffee, decaffeinated coffee, milk (from galvanized dairy cans, butter, olive oil, lipstick, silver polish residue on eating utensils, metal ice trays, processed meats, pottery, plastic wrappings, wheat gluten, the electric elements that are put directly into containers to heat water for soups, teas, and coffees, and many other sources. When we swallow cadmium, only a small amount is absorbed into the body from the gut, perhaps 10%, most of which is excreted in the urine. When we breathe cadmium, we retain about half of it, absorbing it from the lungs. A pack of cigarettes contains 16-24 micrograms of cadmium, and a smoker can contaminate a whole roomful of people. Others with more than 1 ppm are smoked kippers, canned anchovies, lamb chops, chicken, olive oil, instant coffees and teas, tea leaves, and caffeine-free coffee; some with more than 0.5 ppm are all seafood, meats, wheat gluten (cadmium goes with the gluten in grains), oils and fats, margarine, Purina Chow, molasses, honey, black pepper, cocoa, butter, and nonfat dried milk, most of them processed.”

“Although most of the cadmium we encounter comes from food, only small amounts are absorbed by the intestinal tract, and even those are lessened when the diet contains plenty of zinc. It is highly likely that the largest part of the cadmium in our bodies comes from air-from tobacco smoke, polluted air, and dusts-for most of the cadmium inhaled is absorbed directly from the lungs into the body. As little as 1 mcg per day retained would build up a body burden of 14.6 mg in 40 years, over a third of the average amount, 38 mg, in all tissues. A pack of cigarettes contains 20 mcg, of which 10 mcg are absorbed from smoke. So it is easy to get enough cadmium to cause illness.”

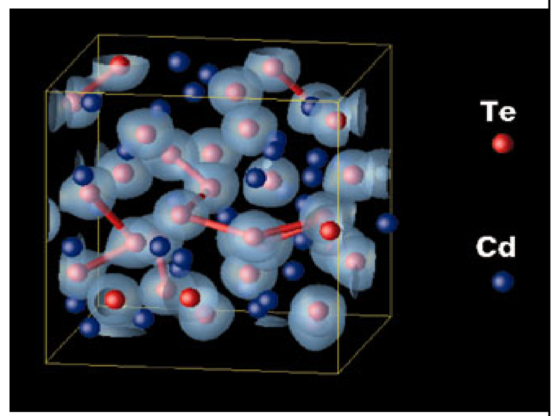
“The pattern of storage of cadmium in the body differs according to the route of entry (Table VII-6). Workers exposed to heavy dusts, as in cadmium-nickel battery plants, had large amounts in their livers, with ratios of concentrations in liver to kidneys usually greater than 1.0. Total amounts stored, of course, were much larger, for the average liver weighs six times as much as the kidneys. Persons with high blood pressure had twice as much cadmium in their kidneys as did normal people, but no more in their livers. Japanese with ouch-ouch disease got their cadmium by mouth, and they actually had less than did those exposed to dusts in factories. The total amount of cadmium stored in the livers and kidneys of exposed workers was nearly 350 mg, the total in those organs of hypertensive persons was only 20 mg, and the total in normal persons was about 12 mg. Therefore, a little cadmium goes a long way.”

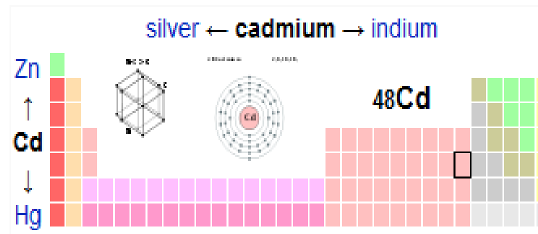
“Cadmium is a perfect example of an accumulative abnormal and subtly toxic trace metal in the environment causing widespread and serious human diseases, most of which are fatal. As such, cadmium is the worst of the bad actors among the metals.”

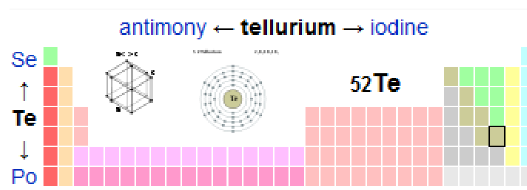
and other factors; c) Cd is bio-accumulative, has a long half-life in humans and reacts to other chemicals in our systems and other pollutants; d) Increased mortality is found among individuals showing signs of cadmium renal toxicity compared with those without such signs, suggesting that renal toxicity may be an early warning of complications, sub-clinical or clinical morbidity. We also know, in contrast to all of the efforts to understand Cd better and control its proliferation as a pollution, several US companies, universities, research laboratories, et al, in conjunction with the US Government's Department of Energy (for example), is actively pursuing its use in new products providing waivers that enables its use, tax incentives and/or rebates to support its sale and use, development funding, elimination of recycling fees for these products disposal, and other means to promote its proliferation.

OSHA says: "OSHA does not separate one cadmium compound from others for regulatory purposes, and the well-established effects of Cd carcinogenicity are assumed also to pertain for CdTe."

From Wikpedia: "Cadmium telluride (CdTe) is a crystalline compound formed from cadmium and tellurium. It is used as an infrared optical window and a solar cell material. It is usually sandwiched with cadmium sulfide to form a p-n junction photovoltaic solar cell. Typically, CdTe cells use a n-i-p structure. Cadmium (pronounced /□kædmiəm/, KAD-mee-əm) is a chemical element with the symbol Cd and atomic number 48. The soft, bluish-white transition metal is chemically similar to the two other metals in group 12, zinc and mercury. Similar to zinc it prefers oxidation state +2 in most of its compounds and similar to mercury it shows a low melting point for a transition metal. Cadmium is a relatively abundant element. Cadmium was for a long time used as pigment and for corrosion resistant plating on steel. Cadmium compounds were used to stabilize plastic. With the exception of its use in nickel-cadmium batteries, the use of cadmium is generally decreasing in all other applications. This decrease is due to the high toxicity and carcinogenicity of cadmium and the associated health and environmental concerns. Although cadmium is toxic, one enzyme, a carbonic anhydrase with cadmium as reactive centre has been discovered. Cadmium poisoning is an occupational hazard associated with industrial processes such as metal plating and the production of nickel-cadmium batteries, pigments, plastics, and other synthetics. The primary route of exposure in industrial settings is inhalation. Inhalation of cadmium-containing fumes can result initially in metal fume fever but may progress to chemical pneumonitis, pulmonary edema, and death.[21], renal abnormalities, including proteinuria and glucosuria.[23]Cadmium is also a [potential] environmental hazard. Human exposures to environmental cadmium are primarily the result of the burning of fossil fuels and municipal wastes.[22] However, there have been notable instances of toxicity as the result of long-term exposure to cadmium in contaminated food and water. Cadmium and several cadmium-containing compounds are known carcinogens and can induce many types of cancer.[24] Research has found that cadmium toxicity may be carried into the body by zinc binding proteins; in particular, proteins that contain zinc finger protein structures. Zinc and cadmium are in the same group on the periodic table, contain the same common oxidation state (+2), and when ionized are almost the same size. Due to these similarities, cadmium can replace zinc in many biological systems, in particular, systems that contain softer ligands such as sulfur. Cadmium can bind up to ten times more strongly than zinc in certain biological systems, and is notoriously difficult to remove. In addition, cadmium can replace magnesium and calcium in certain biological systems, although these replacements are rare.Tobacco smoking is the most important single source of cadmium exposure in the general population. It has been estimated that about 10% of the cadmium content of a cigarette is inhaled through smoking. The absorption of cadmium from the lungs is much more effective than that from the gut, and as much as 50% of the cadmium inhaled via cigarette smoke may be absorbed.[25] On average, smokers have 4-5 times higher blood cadmium concentrations and 2-3 times higher kidney cadmium concentrations than non-smokers[26]……………."







Now we have the Los Angeles Department of Water & Power's Interim Chief, David Freeman envisioning a gigantic solar array of photovoltaic cells that could cover 80 square miles of Owens Valley land, roughly the size of Cleveland. This is a "reasonable" vision as it would provide 10% of all the power produced in California while simultaneously calming the region's fierce dust storms. Yet it is important to ask ourselves, is this dream filled with "Cadmium"?

Well, unbelievably it could be due to man's short-sightedness. Similar to the Flurorescent/CFL Mecury (Hg) controversy from the US Government which is on one hand trying to stop mercury pollution, while on the other hand is promoting the use of mass-produced mercury-laden lighting (See EnviroIntel Paper Dated December 2009 for more information), similarly the case with cadmium (Cd). For example:

(December 21, 2009 6:48 AM PST) **First Solar Opens Utility-Scale Power Plant** , by Martin LaMonica

First Solar employees work on the solar power station in Blythe, Calif. (Credit: First Solar)

“Solar module maker First Solar on Monday opened the largest photovoltaic solar power station in California, which the company plans to replicate in order to expand its utility business. The plant in Blythe, Calif., which First Solar purchased from energy developer NRG, will have the capacity to generate 21 megawatts of electricity, or enough to power about 17,000 homes. It will supply electricity to Southern California Edison under a 20-year purchase power agreement.”

“It's one of a number of projects that First Solar is pursuing as it seeks to expand in the utility-scale solar business. A deal to build a 48-megawatt plant in California to supply Pacific Gas & Electric was approved last week "The development, project finance and construction of this solar plant demonstrate First Solar's capabilities in utility scale projects," Bruce Sohn, president of First Solar, said in a statement. First Solar's panels, which use thin film solar cells made from **cadmium telluride**, are considered the lowest cost solar panel in the industry. The company's relatively low cost and the technology's track record make it attractive to utilities that need to meet the California Renewable Energy Mandate”[(WSG July 2009: California officials are beginning to worry that the state's focus on transitioning to renewable-energy sources could lead to power shortages in the near term. The state has been so keen to develop renewables that relatively few conventional power generators, such as gas-fired plants, have been built lately. That risks a possible energy shortfall in certain places if the economy rebounds any time soon. California's utilities are barreling ahead to try to meet a state mandate to garner 33% of their power from renewable sources by 2020, and some officials are concerned the effort might push up electricity prices and crimp…..)].

What can we infer from this Blythe California installation? The article confirms that it was approved by PG&E and this infers that it was OK’d by all of California’s agencies and regulatory bodies. This in turn means that California for some reason accepts cadmium (Cd) based products in large scale projects with no concern for issues relating to its content of Cd (acres of panels spread across the desert); the process of where the Cd comes from and how the Cd got into the PV solar panels (was there any contamination along the way?); the replacement of these panels as they diminish in output or fail, nor the process of disposal of failed panels or who is responsible for their “recycling” (no fee for this applies per waiver, will it be left up to the tax payer?) . The article also includes the phrase “…….[Cd] are considered the lowest cost solar panels……….”, yet this also is somewhat a misnomer as the Cd-Te technology is not as efficient sunlight to electrical energy converter as compared to many other technologies used for PVs which have significantly higher conversion efficiencies and are not laden with toxic materials , hence lower efficiency of the Cd-Te means you need more PV panels, and more Cd-Te. It seems California is following the “waiver” that the US Department of Energy is waiving in their face after providing a "waiver" to produce Cd-Te PVs solely to First Solar and is pur-suing what they think is the "cheapest, lowest cost" solution, yet do not consider the "respon-sibility" that acres of Cd will fully haunt this insta-llation. The question is, will the L.A. Depart-ment of Water & Power also make this same mistake?

Yet we also have First Solar now having comp-leted a 2.4 MW rooftop installation as part of a Southern California Edison program [read rebates / incentives] to install 250 MW of rooftop solar panels throughout Southern California over by 2013, as the following article stipulates: "**California Utility to Install 250MW of Roof-Top Solar**", 03/27/2008 08:06 AM, Sustainable Business.com News: "Southern California Edison (SCE) plans to install 250 megawatts (MW) worth of solar cells, capable of powering some 162,000 homes, on the roofs of commercial buildings. It is the first time a major utility company has heavily invested in distributed power. In addition, the number of solar cells required will be greater than the total U.S. solar output in 2006, which could help to drive down the price of solar panels, as economy of scale kicks in. The $875 million dollar initiative will connect clusters of solar arrays, covering a total two square miles of rooftop, to existing grid circuits in neighborhoods with growing demand. This decentralized app-roach avoids the costs and difficulties of building exten-sive transmission lines to move power from a centrally located power plant--be it solar, gas-fired, geothermal or other. "These are the kinds of big ideas we need to meet Califor-nia's long-term energy and climate change goals," said California Governor Schwarzenegger. "I urge others to follow in their footsteps. If com-mercial buildings statewide partnered with utilities to put this solar technology on their roof tops, it would set off a huge wave of renew-able energy growth." The utility plans to begin install-ation work immediately on commercial roofs and hopes to work at a pace of about 1 MW per week. "We hope to have the first solar roof tops in service by August. The sunlight power will be available to meet our largest challenge - peak load demands on the hottest days," John E. Bryson, Edison International chairman and CEO, said. In a separate announcement, ProLogis (NYSE: PLD), said it will lease 607,000 square feet of roof space to SCE for an undisclosed amount.

Zinc: the fourth most widely used metal, following iron, aluminum, and copper. Zinc is mined mostly in Canada, the former USSR, Australia, Peru, Mexico and the US. In 1993, about 50% of the zinc mined came from Alaska. Tennessee, New York and Missouri are the top producers of zinc metal. The US is the world's largest consumer of zinc. Eighty percent is consumed in slab format, while 20% is consumed in compounds. Most zinc is used in the galvanizing steel process. Other uses include the automotive, construction, electrical and machinery industries. Zinc compounds include agricultural chemicals, paints, pharmaceuticals, and rubber. Primary Zinc Processing: Zinc concentration is usually done at the mine site, prior to reaching the zinc processing plant. The concentration includes crushing and flotation techniques. At the zinc processing plant, the zinc is first reduced using pyrometallurgical methods, including distillation, or hydrometallurgical methods, including electrowinning, calcination, leaching, or purification. The electrowinning process is most commonly used. Electrowinning uses an electrolytic cell to reduce the zinc. An electric current is run from a lead-silver anode through a zinc solution. The zinc deposits on an aluminum cathode and is harvested. The zinc is then melted and cast into ingots.

Pollution Sources and Prevention: Primary zinc production produces air emissions, process wastes and solid-phase wastes. Air emissions come primarily from the zinc roasting process and consist primarily of sulfur dioxide emissions. Most emissions are recovered on site in sulfuric acid production plants, where sulfuric acid is produced. Zinc roasters also produce particulate emissions. Particulate air emissions from primary zinc production often contain cadmium, lead and other compounds, depending on inputs. The slurry formed from the emissions control equipment is K066 hazardous waste. The electrowinning process produces waste heat. Rather than letting the hot gas escape into the environment, some is recovered and sent to cooling towers where the steam is collected for reuse. Wastewater is produced from leaching, purification and electrowinning. The water is usually treated and discharged. Reuse opportunities may be available. Solid wastes include acid plant slurries, sludge from electrolytic cells and copper cakes, a by-product of zinc production, from the purification cells. Much of the waste is considered RCRA hazardous waste. Anode slime from electrolytic cells consists of impurities not captured prior to the electrowinning process. The composition usually makes the slime a RCRA hazardous waste. Copper cakes are captured and sold to copper processing plants. Secondary Zinc Processing: Secondary zinc production uses process scrap from zinc slabs, zinc oxides and zinc dust. Selective melting may also be used to capture zinc if the zinc is mixed with other non-ferrous metals with higher melting points. Zinc is also often recovered from the furnace dust of galvanized steel making plants. Using pyrometallurgical refinement techniques, the zinc can be recovered. Once obtained, secondary zinc first undergoes a separation process. Magnetic separation, sink-float and hand sorting are usually used to remove the zinc from unwanted components. After separation, the zinc is melted with new scrap from brass plants, rolling zinc clippings or die casting. The zinc is melted in a kettle, crucible, reverberatory furnace or electric induction furnace. Flux is used to trap impurities and produces dross that is skimmed from the surface of the molten zinc. The zinc is then either poured into molds or sent to refiners. High quality scrap from dross, diecastings, and other zinc rich sources usually can be remelted without further refinement. The recovered metal can become galvanized brighten or alloy materials in copper, aluminum, magnesium, iron, lead, cadmium or tin production. Zinc helps to make the metals stronger. Medium to low grade skims, oxide dusts, ash and residues containing zinc require more refinement before melting. These may undergo reduction, or distillation using pyrometallurgical processes. The reduction upgrades the zinc for further processing to reach the desired standards.

Pollution Sources and Prevention: Secondary zinc processing produces air emissions and solid waste emissions. Air emissions come from sweating and melting. The emissions include particulates, zinc fumes, volatile metals, flux fumes and smoke, rubber, plastics and zinc scrap. Incomplete combustion products are also emitted, but are eliminated when passed through an after burner. Particulates are collected in emissions control equipment such as baghouses. The particulates are often refined for the metals. in distillation and oxidation processes, zinc oxides in the form of dust are produced. The oxides are collected in baghouse emissions control systems. Air emissions are also common from the pyrometallurgical processes. If simple remelting of the zinc is required, the emissions are not high. However, if the zinc requires reduction or other refinement, emissions are likely. The lower the quality of zinc scrap, the more air emission produced in the process. Air emissions are usually collected in ventilation systems. The emissions control dust is usually sold as fertilizer or animal feed. Solid waste is present in the form of slag. The slag from secondary zinc production usually contains copper, aluminum, iron and lead. Slag is generated during pyrometallurgical processes and may be hazardous. There are many zinc-related lawsuits concerning pollution and poisoning worldwide. There are on-going meetings discussing it mining ban, even though it is an essential metal. For example "Pennsylvania Zinc Plant Settles Pollution Lawsuit": AP December 2009, MONACA, Pa. — The largest zinc producer in the United States and an environmental group have settled a federal lawsuit claiming the company polluted the Ohio River. Under the settlement with Clean Water Action, Horsehead Holding Corp. of Monaca will pay $15,000 for past violations and will contribute $25,000 to two environmental projects. The settlement was approved Tuesday. Clean Water Action sued Horsehead a year ago under the Clean Water Act claiming it was sending illegal discharges of industrial wastewater. According to the settlement, Horsehead has already taken steps to reduce pollution.

What happens to all of the Cd loaded panels after the owner installs them or leases them? What happens in case of a fire that 'cooks" the panels and releases the Cd contained in them to the air our neighbors breathe and can they sue the homeowner for this? Does the homeowner insurance coverage extend to this kind of problem? Are their leaching effects from water wherein Cd migrates to the local "drain open to the ocean"? Is the homeowner responsible? First Solar seems to have a monopoly on Cd-Te PVs and has the US and State Governments along with allied PUCs as partners. They declare that they, Cd-Te PVs are the best, the lowest cost, the most "Green" and so-on. Yet, are they, and if so what is this based on? Indeed, why does the rest of the PV industry avoid this technology if it is so good?

"**Cadmium-Telluride Thin film Rather Than The More Expensive Crystalline Silicon**" an another article banner reads. It goes on to report: "Not all photovoltaic technologies are created equal; some, in fact, incur quite heavy environmental footprints - producing silicon [from sand], for example, consumes a lot of water [recycled/nonpolluting]and energy [very nominal in comparison/similar to very basic semiconductors used in all electronics] while refining zinc [Which is under regulatory controls and supervision due to its toxicity. OSHA regulates the amount of zinc individuals may be exposed to in the workplace. Sites which are contaminated often contain zinc, which leaches into the soil and contaminates drinking water as well] from which process most Cadmium is obtained produces a sizeable chunk of emissions [apparently forgot about Telluride]. *Environmental Science & Technology*'s Naomi Lubick reports that "Vasilis Fthenakis, a scientist at Columbia University and the Brookhaven National Laboratory, just finished a LCA of some of the leading technologies which determined that new thin-film cadmium-telluride (CdTe) materials come out on top".

Research from the U.S. Department of Energy's Brookhaven National Laboratory concluded:
*"Large-scale use of CdTe PV modules does not present any risks to health and the environment, and recycling the modules at the end of their useful life completely resolves any environmental concerns. During their operation, these modules do not produce any pollutants, and furthermore, by displacing fossil fuels, they offer great environmental benefits. CdTe PV modules appear to be more environmentally friendly than all other current uses of Cd."**
*** Source:** "RENEWABLE & SUSTAINABLE ENERGY REVIEWS", Vol 8, 2004, pp 303–334, V M Fthenakis, "Life Cycle Impact Analysis of Cadmium in CdTe PV Production", with permission from Elsevier.

The above "finding" forms the basis of the Government's "waiver" that enables the manufacturing and use of Cd-Te PVs. The article, goes on to point out: "Benefiting from its highly efficient energy conversion, CdTe photovoltaic systems consumed less energy and produced fewer emissions; in addition, when compared to its multicrystal and ribbon silicon competitors, the CdTe technology had the lowest cost. In order to obtain these results, Fthenakis and his colleagues compared data from more than a dozen solar companies, taking into account the manufacturing process, energy conversion and various components. Unfortunately, the assessment failed to shed light on the technologies' total environmental impact - "not telling you exactly what your impact is if you were to buy them," as Corinne Reich-Weiser, a graduate student at UC Berkeley, explained. For instance, she notes that the emissions produced during the transportation of components before production and assembly are only partly taken into consideration; moreover, the assessment is based on idealized European and U.S. grids even though most components are built in China. Still, it provides an effective means of "easily comparing" all of the available technologies, she says, deeming it "incredibly useful." New and future solar technologies should be able to bridge that emissions gap within the coming years as companies continue innovating and expanding their operations. Fthenakis notes that the one missing element from his assessment he hopes to amend soon is the end-of-life and recycling data; he believes this should help make the technologies' emissions profiles even better."

Wikipedia reports that First Solar is: "….the largest manufacturer of thin-film cells in the world[3] and world's second largest manufacturer of photovoltaic (PV)cells[4] with production capacity expected to reach over 1 GW per year by the end of 2009.[5][6] The process uses different materials than most other solar cells, is more economical, tolerant of a wide range of conditions, but less efficient at converting light to electricity[7]".

Let's recap what we have learned:

- The Government has provided a "waiver" for First Solar to use Cd-Te in mass production of PVs
- Cd is a carcinogen of the 1st order. The Government justification is being questioned as it may not take into consideration the full ramification of Cd in terms of its "cost to the environment and health".

- Cd-Te PVs are significantly less efficient than other conventional "environmentally friendly" PVs: hence it is not as claimed "optimal for converting sunlight to useful energy" as claimed by First Solar.
- The "lowest cost" claim for Cd-Te PVs does not take into consideration the full ramification of Cd mining and distillation, collection for recycling, recycling and waste disposal. Additional, Te is an element that has high volatility regarding cost/availability.

Let's now look into all of this a bit closer:

First Solar says: "The semiconductor material used [Cd-Te]in First Solar is primarily sourced from the byproducts of mining operations. First Solar is converting waste products from one manufacturing process into useful material used in the manufacture of the best solar module. Solar modules then produce clean, affordable energy reducing the environmental impacts of traditional fossil fuel generation and allowing us to make a significant contribution to the challenges of climate change." Meanwhile, they continue to tout that Cd-Te PVs are the lowest cost, best performing solar cells, in the industry bar none.

Rebuttal Regarding Cd (Some Observations):

1. As we have learned that Cd comes mostly from Zinc refining processes, while these processes are highly controversial and are hounded by lawsuits regarding pollution of many types. The Government noted (U.S. GEOLOGICAL SURVEY MINERALS YEARBOOK—2003) that "In the United States, only two companies produced cadmium in 2003—Pasminco Ltd. [Australian zinc miner Pasminco said it had agreed to sell its United States' Gordonsville and Clinch Valley mines and Tennessee facilities to Tennessee Valley Resources Inc. due to lawsuits and other reasons. TVRI is a soils, fertilizer and remediation specialist company who in turn sold the Clarksville operation to the Dutch mining/metals company Nyrstar NV who operate it now. Nyrstar reports: "The Clarksville smelter is located in Tennessee beside the Cumberland River, and is a relatively modern plant, commissioned in 1978. It is a medium-scale smelter, with a capacity of approximately 125,000 tonnes of zinc per year, and is currently the only primary zinc producer in the United States. The site's main products are SHG zinc and galvanizing alloys, supplied primarily to customers within one day's delivery distance from the plant. Historically, the Clarksville smelter was reliant on the nearby Tennessee Valley mines for a majority of its feed. When these mines closed in recent years, Clarksville sourced the majority of its concentrates from mines in Central and South America, Ireland and Australia. However, with the re-opening of the Tennessee Valley mines in 2007 and 2008, it is likely Clarksville will source an increasing proportion of its concentrates from local mines.]. [At completion of the deal between Pasminco and TVRI, Tennessee Valley took ownership of the Gordonsville mine which was placed on care and maintenance in May, 2003, with ownership of the Clinch Valley mine passing to Tennessee Valley when the mine is closed. Under the terms of sale the **rehabilitation costs** of both sites will be met by Tennessee Valley]produced primary cadmium as a byproduct of the smelting and refining of zinc concentrates, and the International Metals Reclamation Company Inc. (INMETCO) produced secondary cadmium from scrap, almost entirely from spent nickel-cadmium (NiCd) batteries. The total value of cadmium produced in the United States in 2003 was calculated to be about $737,000. Although definitive consumption data do not exist, the International Cadmium Association (ICdA) made the following estimates of cadmium consumption for various end uses in 2003: batteries, 79%; pigments, 12%; coatings and plating, 7.5%; stabilizers for plastics and similar synthetic products, 1%; and nonferrous alloys and other uses, 0.5%[all of these applications are seeking and/or using substitutes now in 2010] (Hugh Morrow, President, International Cadmium Association, oral commun., February 2004). This reduction in suppliers is a direct result of a campaign to discontinue the use of Cd from its traditional applications. The idea was that the use of and proliferation of Cd was not good to health and environment and should be over time eliminated, thus there were only 2 suppliers then. Now with the advent of Cd-Te PVs this could shift to creating a demand for Cd which in turn would increase the pollution created by these sources here and abroad (both from mining and distillation), increase the cost of Cd which would further entice its development as well as raise the price of Cd-Te PVs.

2. The processing of Cd is a very messy, pollution fraught multi-level process involving great amounts of electricity, chemicals and toxic waste. The Nyrstar NV Clarksville, TN, zinc smelter, is using an electrolytic process in which cadmium is recovered as a byproduct during the roasting and leaching of zinc concentrates. After removing various impurities, cadmium is processed to its final form by either refining or electrowinning. The whole process consists of

heating the zinc concentrate in fluidized bed roasters to produce an impure zinc oxide (calcine) suitable for acid leaching. Between 60% and 85% of the calcine, which contains cadmium and other impurities, is volatilized with the sulfur dioxide gas generated during the roasting process. Calcine and fume are separated from the gas and collected in waste heat boilers, cyclones, and electrostatic precipitators. The collected calcine dust is combined with the unvolatilized portion of the calcine and dissolved in sulfuric acid at a leaching plant. Generally, manganese dioxide is added to the leaching tank to remove iron and significant amounts of other impurities. These insoluble residues are sold to other smelters for further processing as iron cake. The leachate is sent to a series of cold and hot purification tanks, where cadmium and other remaining undesirable metals are removed from the solution. After the first stage of zinc sulfate purification, discharged impurities form a copper cake, which, like the previously captured leach residues, are sold for processing. The bulk of cadmium is precipitated in the second stage of purification, and the remainder is precipitated in a third stage. The cadmium precipitate is filtered and forms a cake containing about 12% cadmium, 25% zinc, and small amounts of other impurities. The cake is then redissolved in sulfuric acid. After two additional acid treatments, a cadmium sponge is produced and then is dissolved in another sulfuric acid bath; the solution, if sufficiently pure, is passed into electrolytic cells where the cadmium is deposited on cathodes. The resulting cadmium metal (more than 99.99% pure) is melted and cast into 50-millimeter (mm)-diameter ball anodes or 250-mm-long sticks or oxidized in a controlled atmosphere to produce cadmium oxide powder. Higher purity cadmium for special purposes, such as for semiconductors, can be produced by vacuum distillation (U.S. Environmental Protection Agency, 1987, p. 9).

3. Although the following information is somewhat outdated as it is derived again from the U.S. Geological Minerals Survey from 2003, it still applies today. However, it does not include the mass production of Cd-Te PVs in its outlook which has occurred since its publication: “While primary cadmium production is declining [which was the goal/now with Cd-Te = rising again], production of secondary cadmium has been increasing steadily over the past several years. There are three major industry collection and recycling programs in the world: the Rechargeable Battery Recycling Corp. (RBRC) in the United States and Canada, the Battery Association of Japan, and the CollectNiCad program in Europe. The amount of cadmium that is recycled, however, is difficult to estimate for a number of reasons. For example, cadmium from baghouse dust, which is generated at lead and copper smelters, enters the primary cadmium production circuit at zinc refining operations and may or may not be included in reported production statistics for primary cadmium metal. The reported amount of NiCd batteries collected is fairly accurate, but there are no firm data on the amounts of cadmium recovered from recycled batteries and other sources, such as electric arc furnace (EAF) dust, which contains about 0.05% cadmium, electroplating wastes, filter cakes, sludges, and other cadmium-containing materials. In 1995, INMETCO [formerly a subsidiary of the International Nickel Co./now Inco Ltd a Canadian firm, with most recent news of its Ellwood recycliong facility being(May 2008): “An international metals reclamation company in Ellwood City paid a $55,000 penalty for air emission violations. The penalty was included in a consent order and agreement last week between International Metals Reclamation Co. Inc. and the Pennsylvania Department of Environmental Protection to settle outstanding particulate emission violations. The agreement requires the company to install and test a baghouse, which will replace the current air pollution control device, to capture particulates. In addition, INMETCO will pay a monthly penalty of $3,500 until it demonstrates it is meeting the permitted particulate emission limit. Cory McPhee, INMETCO spokesman, said construction could take up to a year. A spokeswoman for the DEP said INMETCO contacted the department about testing new technology and was told to forward all test results to the state. Freda Tarbell said the company did not know its current control device, a wet scrubber, was not operating effectively, something the testing revealed. She said company officials reported the violation. “We are obligated to determine whether the violation merits a penalty,” Tarbell said. In this case, the DEP decided the penalty was justified because, “they came forward only because they were directed to do so.” The fine could have been much higher, Tarbell said, had the company been found to be uncooperative or willfully out of compliance. INMETCO had submitted an air plan application to the DEP in October for a new baghouse before the violations were identified. That plan, which will bring particulate emissions within state limits, was approved March 28. Tarbell said the six-month delay between INMETCO’s plan submission and the state’s approval was to allow for a substantial amount of engineering review that includes testing via computer models. She said four to six months is typical for such a review. The $55,000 penalty was deposited in the state’s Clean Air Fund, which supports air quality improvement projects throughout Pennsylvania.] began reclaiming cadmium from spent batteries at its Ellwood City plant, northwest of Pittsburgh, PA. The $5 million, high-temperature metal recovery addition to the Ellwood City plant was the first facility of its kind in the

world. It is capable of processing more than 2,500 metric tons per year (t/yr) of spent NiCd batteries. Cadmium recycling at the facility thus far has been practical only for NiCd batteries, some alloys, and EAF dust. The most difficult aspect of NiCd battery recycling has been the collection of spent batteries. Like all elements, cadmium is subject to physical and chemical laws that make its processing predictable and dependable. On the other hand, efforts to change the attitudes and habits of the public about recycling have proven to be much more complicated and difficult. Although large industrial batteries (containing about 20% of all cadmium used for batteries) are easy to collect and are recycled at a rate of about 80%, the small consumer NiCd batteries are usually discarded by the public. Therefore, voluntary industry-sponsored collection programs and Government agency programs are being devised to improve the collection of these small consumer batteries, because, in addition to improving the environment, economies of scale are very important—larger recycling operations lower unit costs. Several different collection programs have been developed by INMETCO to meet the varied needs of battery manufacturers and the numerous consumers, firms, organizations, and agencies that use the many diverse products containing NiCd batteries (cordless phones, personal computers, power tools, etc.). The most successful recycling program in the United States is operated by the RBRC. Established when INMETCO begun cadmium recycling in 1995, RBRC has organized a multifaceted collection program financed with proceeds from licensing its seal of approval to individual companies involved in the manufacturing, importation, and distribution of rechargeable batteries or battery-operated products. The RBRC recycling program contains several key elements that are specified in EPA regulations (40 CFR part 273), Federal law (The Mercury-Containing and Rechargeable Battery Management Act of 1996), and various State laws. These elements include uniform battery labeling, removability from appliances, a national network of collection systems, regulatory relief to facilitate battery collection, and widespread publicity to encourage public participation. For that purpose, RBRC has undertaken an extensive public education campaign and has established several collection sites in the United States and Canada. Another successful collection program is INMETCO's prepaid container program in which companies that generate spent batteries purchase a 14-kilogram (kg) container for collection and shipment of spent batteries. The fee for the container includes shipping by United Parcel Service of America Inc. handling, sorting, and processing. Additional collection programs, initiated by INMETCO, include mail-back envelopes, a small package program, and so-called "milk runs." Because most of the industrial NiCd batteries are not allowed to be discarded in municipal waste dumps, they are recycled through collection programs in which producers of these batteries collect and send their spent batteries to INMETCO (Money, Tomaszewski, and Bleakney, undated). The process of cadmium recovery from industrial and consumer sealed batteries differs only in the manner of battery preparation. Processing of industrial batteries that contain up to 7% cadmium consists of draining the sodium hydroxide electrolyte, cutting the tops off the batteries, and separating the nickel and cadmium plates. Small batteries that contain up to 16% cadmium must be handsorted because only newer batteries are color coded; very few of them carry bar codes, making optical scanning and other automated sorting very difficult.

4. In addition to the primary and secondary production, the availability of cadmium metal during the past decade was greatly affected by material available from stockpiles. The largest stocks during the past decade were held by the U.S. Defense Logistics Agency (DLA). About 693 t of cadmium was sold in 2002, and the remaining DLA stock was sold by the beginning of 2003. Less certain is the amount of stockpiled cadmium held by producers and traders. Because of low prices since 1996, many producers curtailed production of refined cadmium and may have stockpiled impure cadmium sponge against expectations of future improvements in price. For the same reason, many traders and investors stockpiled inexpensive cadmium, purchased mainly from DLA. The Government wants to divest itself of storage of Cd due to its liability. This is similar to mercury (Hg), however, with Hg we (the Government) has banned all mining and production and with new law mandates recycling and has established by law the need for a storage site to be maintained similar to spent nuclear wastes (see EnviroIntel's paper of Fluorescent/CFL Mercury problems).

5. *US Geological Survey, Cadmium Statistics and Information* cites that: "Cadmium is produced mainly as a byproduct from mining, smelting, and refining sulfide ores of zinc, and to a lesser degree, lead and copper. Small amounts of cadmium, about 10% of consumption, are produced from secondary sources, mainly from dust generated by recycling of iron and steel scrap." In recent decades, there have been extensive efforts to eliminate all elemental cadmium from personal electronics and from batteries and switching devices in general. RoHS specifically focuses on

eliminating cadmium-based items exported into Europe, for example. A major US toymaker recently reported plans for phasing out cadmium-based NiCad batteries in their products, citing high occupational exposures in China for mining and battery making employees as well as landfill disposal issues in the US. RoHS restrictions are very tough. It separates a product into individual parts of homogeneous materials. Each part must not contain the banned substance exceeding a maximum concentration limit. The limit is 1000 ppm (parts per million) for other 5 materials but only 100 ppm for cadmium. For example, if a radio contains one little screw which contains more than 1000 ppm of lead, the whole radio is banned for sale in the EU. No matter that the lead in the screw inside the radio is unlikely leaked out during usage. Clearly all products must fall into one of three categories: 1. It is in full RoHS compliance and hence not restricted; 2. It does not comply with RoHS, and hence must be put in a restricted product list; 3. It does not comply with RoHS, but an exemption is granted and is on the exemption list. Cadmium (Cd) is clearly on this list.

6. Telluride is derived from Tellurium which is an extremely rare element (1-5 parts per billion in the Earth's crust), and if Cd-Te were to be used in sufficiently large quantities (for example, to make Cd-Te PVs), tellurium availability will be a serious problem. Tellurium is also refined as a byproduct of copper and lead smelting through similar processes as cited above for Cd. The principal source of tellurium is from anode sludges produced during the electrolytic refining of blister copper. It is a component of dusts from blast furnaces from lead production. Treatment of 500 tons of copper ore typically yields one pound (0.45 kg) of tellurium. The anode sludges contain the selenides and tellurides of the in compounds with the formula M_2Se or M_2Te (M = Cu, Ag, Au). At temperatures of 500°C the anode sludges are roasted with sodium carbonate under air. The metals are reduced to the metals, while the tellurium is converted to sodium tellurite ($M_2Te + O_2 + Na_2CO_3 \rightarrow Na_2TeO_3 + 2M + CO_2$)The tellurites can be leached from the mixture with water. The tellurites normally are present as hydrotellurites $HTeO_3^-$ in solution. The selenates can be separated by adding sulfuric acid. The hydrotellurites are converted into the insoluble tellurium dioxide tellurium while the selenites stay in solution ($HTeO_3^- + OH^- + H_2SO_4 \rightarrow TeO_2 + 2SO_4^{2-} + 2H_2O$). The reduction to the metal is done either by electrolysis or by reacting the tellurium dioxide with sulfur dioxide in sulfuric acid ($TeO_2 + 2SO_2 + 2H_2O \rightarrow Te + SO_4^{2-} + 4H^+$). Commercial-grade tellurium is usually marketed as minus 200-mesh powder but is also available as slabs, ingots, sticks, or lumps. The year-end price for tellurium in 2000 was US$14 per pound. In recent years, the tellurium price was driven up by increased demand and limited supply. Tellurium and tellurium compounds are considered to be mildly toxic and need to be handled with care, although acute poisoning is rare. Cd-Te is toxic, if ingested, its dust inhaled, or if it is handled improperly (i.e. without appropriate gloves and other safety precautions). Cd-Te appears to be less toxic than elemental cadmium, due to its combination, however a recent study found that the highly reactive surface of Cd-Te quantum dots triggers extensive reactive oxygen damage to the cell membrane, mitochondria, and cell nucleus. Many nanoparticle chemicals have safety issues. In addition, the cadmium telluride films are typically re-crystallized into another toxic compound that of cadmium chloride. The disposal and long term safety of cadmium telluride is a known issue in the large scale commercialization of cadmium telluride solar panels, yet that commercialization remains full speed ahead here in the US.. The approach to Cd-Te safety in the European Union and China is much more cautious: cadmium and cadmium compounds are considered as toxic carcinogens in EU whereas China regulations allow Cd products for export only. The major concern for Cd-Te is inevitable presence of Cd during Cd-Te production and processing.

So, we capture Zinc, then process for Cd and for Te we capture Cu and Lead and process for Te, combine the two and end up with Cd-Te. All of these actions take tremendous amounts of water, electricity and cause vast amounts of pollution along the way.

Many risks are involved, many lawsuits occur, and this is happening day after day on a world-wide basis where in if we ban production in the U.S., it will simply be done overseas as in Malaysia where First Solar's major plant is located, with pollution travelling the jet stream back to the U.S. Indeed Cd-Te PVs are fueling a whole new level of Cd contamination after all the time, effort, and money we have put into its curtailment over the last 20 years.

Next we need to process the Cd-Te into PVs for solar cell use. Here again, First Solar hails their methodology which in reality is not so much "high-tech". They use conventional thin-film (CVD) techniques to deposit the Cd-Te to form p/n junctions on glass. In contrast to this they cite that poly-crystalline and mono-crystalline PVs are much more wasteful processes. It is true that poly- and mono-silicon is used, as this substrate is used for a huge amount of electronics. Indeed its use (Si) is commonplace and as a material is quite "non-toxic" in nature. Yes it takes energy and water (which is at-plant recycled and re-used), but the electronics industry has greatly improved the techniques with which it is made and it is deemed, along with the sources of Si material, to be very environmentally friendly. The CVD deposition techniques are quite similar and also "old" science that has undergone significant scrutiny and again is quite efficient. Yes the Si would not leach in acid rain or give out toxic substances due to catastrophic events such as fire, earthquake, tornado, etc, which is to say that Cd-Te could very well affect your health in such events. It is also very safe to say that Si-based panels are fully RoHS compatible and eaisly disposed of at end of life, unlike Cd-Te cells.

The argument that Cd-Te takes "less" to make than Si PVs, as reviewed above, is utter nonsense and if we are to understand this we must put it into the "political" rational that has established the "waiver" mentality that is propagating its use. First Solar states: "The semiconductor material used by First Solar is uniquely capable of producing high volume, low cost solar modules. With the smallest carbon footprint and fastest energy payback time of any PV technology on the market, First Solar combines the economic benefit of low-cost with superior environmental performance to provide truly sustainable energy solutions. When in operation, First Solar modules generate electricity with no air emissions, no waste production, and no water use." What gaul they have: a) Lowest Carbon footprint = not based on any real factual study that covers the creation of Cd and Te and Cd-Te from their base materials to end product, nor as it compares to good Si sourcing and production. In addition Si is more efficient in converting sunlight to electrical energy. Compare the Cd-Te current efficiency level of 10-12%, with that of Si at 18-19%. Low cost, sure it is lower cost, but only by about $0.20-0.25/Watt as compared to that of Si. So Si is a bit more expensive. So you need less Si and more Cd-Te to produce the same amount of electrical power. With this margin of difference in price, Si is actually less expensive already. Companies producing Si-based PVs are also spending large amounts of effort to increase its efficiency and decrease its production costs, with market forecasters predicating better pricing and higher performance as Si PVs move into higher volume. While Cd-Te not only runs the risk of higher costs due to Cd and Te rise in costs, it also runs the gauntlet of not having enough materials in the form of Te as well as the numerous litigation, recycling and disposal costs that will also need to be born. Yet the myth that it is lower cost, has higher efficiency, fastest payback time, and a smaller carbon footprint continues amongst their many touts and misnomers. Yet no one seemingly is challenging this marketing gruel. Cd-Te is "uniquely capable" as is First Solar, as they are literally the only company producing this type of product and if Cd-Te use is challenged, this sole-product company would be devastated. Is this the reason then, that First Solar is an American company (albeit with its main plant in Malaysia), providing "Green" jobs, and for a "Green" technology that of Solar Power that is used to rationalize this endeavor?

Cd-Te PV Solar Cell Collection: First Solar recognizes that their Cd-Te panels, once they are at end of life, need to be collected. First Solar has set-up a system for this, and states: "At any time, anyone in possession of First Solar module can request collection. Collection and recycling is an integral part of First Solar's product offering, therefore the collection and recycling program is designed to maximize collection rates and amounts of material recycled, at no additional cost. At the time each module is sold, sufficient funding is set aside to meet the estimated future collection and recycling costs of each module at the end of its useful life. The funds are placed into custodial accounts in the name of a trustee and can only be accessed for the purpose of collection and recycling. The financing structure is designed to ensure that sufficient funds will be available for module collection and recycling regardless of First Solar's financial status. The fact is that First Solar has set-up such as system as follows:

- At any time, anyone in possession of First Solar module may make a request for collection and recycling at no additional cost.

■ The original module owner is required to register their installation with First Solar so that we may maintain an accurate database of module installations. Installation records are used to estimate future collection costs, as well as to develop strategies that minimize the environmental impacts associated with collection and transportation.

■ First Solar provides packing materials, transportation, and recycling services at no additional cost. The owner's only requirement is to dismantle and package the modules in accordance with First Solar's instruction.

So, First Solar is financing a program to collect their Cd-Te panels. This means that First Solar recognizes the problems environmentally of the Cd-Te panels themselves, but denies any problems with obtaining the Cd and Te in the first place which is rife with energy, water waste and pollution, lawsuits. They see their problem with these materials void, that they are providing a service to use them, while denying any involvement in obtaining them regarding their pollution, carbon footprint, health issues, lawsuits, etc. They see themselves as fully “Green” rescuing these materials and applying them to Solar PVs. So what if First Solar goes bankrupt? Then their program goes away. Even if set-up as a separate “trust”, similar to company funded health programs, these “trusts” can be raided for funds and be dissolved quite easily. In addition, the recycling itself (the packaging materials, the transportation costs, etc.) all have carbon foot prints and costs associated with them. Of course the owner of these panels, not First Solar, has to take them “off your roof” and package them for transit: this is a cost you will bear if you buy them and First Solar remains solvent, otherwise you will also have to pay for their recycling as well. All of this cost money and carbon. Can we again ask ourselves, how can the Government and First Solar make these claims, that Cd-Te is the best, the lowest cost? It sure seems that these claims are resoundingly false.

First Solar states that it “….. has established the industry's first comprehensive, prefunded module collection and recycling program to encourage the recovery and reuse of module materials. The program enables the modules, including the glass and the encapsulated semiconductor material, to be treated and processed into new modules or other products. In this way, First Solar is preventing a waste management challenge for future generations.”

Here again, this involves energy and carbon as well as time and money. Once First Solar gets the panles returned they then process them at their prototype recycling facility in their Perrysberg, Ohio plant.

You have to ask yourself again, why are we going through all of this for Cd-Te PV Solar Panels? Why? We, the people, the taxpayer, our Government is providing a toxic waste “waiver” to a single company to procuce thes panels with lower performance and, albeit higher cost per watt, then recycling them at additional costs and no one knows if the recycling which is now in its prototype form can keep up, all the while with materials that are banned by most of the world and difficult to obtain. All this in comparison with Si-based panels and future CPV panels that are truly environmentally friendly, easy to obtain and dispose of as well as more cost effective. If it looks like a duck, quaks like a duck, then it must be a duck. The only possible reasons are profound denial, lack of insight and for political reasons, or maybe they have stock in tellurium producing companies that will surge in stock price as the global shortage of this metal is peaked by First Solar and Government success in producing and buying these products?

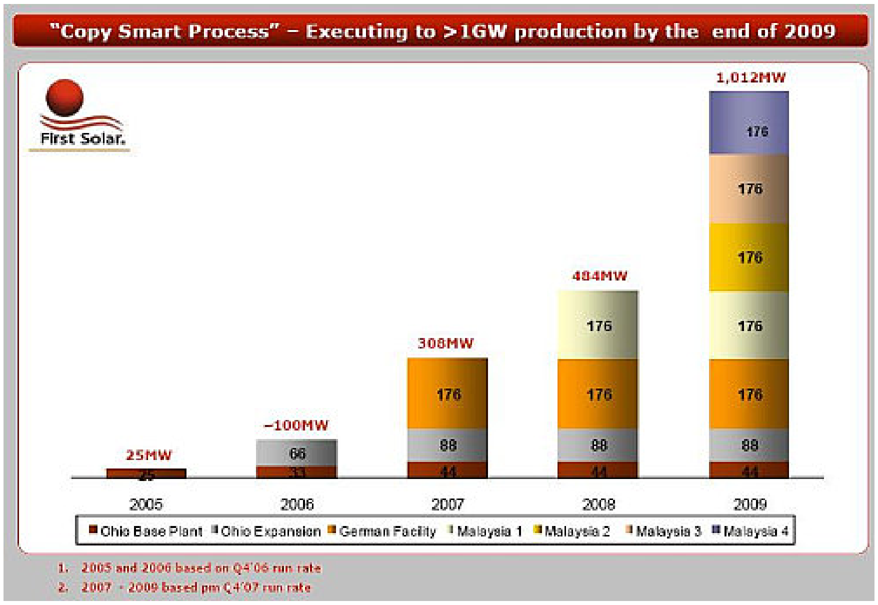
The First Solar “recycling operation” includes the following processes according to First Solar:

Collection: The modules are collected in hoppers and loaded by forklift into a shredder.
Shredder: The modules are reduced in size by the shredder, which breaks the glass into large pieces.
Hammermill: The hammermill crushes the broken glass into 4-5mm pieces, small enough to ensure the lamination bond is broken.
Film Removal: The semiconductor films are removed by the addition of acid in a slowly rotating, stainless steel drum.
Solid-Liquid Separation: The drum is slowly emptied into a classifier where glass is separated from the liquids. A rotating screw conveys the glass up an incline, leaving the liquids behind.
Glass-Laminate Material Separation: A vibrating screen separates the glass from the larger pieces of laminate material (which formerly sealed the two pieces of glass together).
Glass Rinsing: The glass is rinsed to remove any residual semiconductor material that physically remains on the glass. The cleaned glass is packaged for recycling, resulting in a 90% recovery of glass for use in new products.
Precipitation: The metal-rich liquids are pumped to the precipitation unit and processed in three stages at increasing pH. The precipitated materials are then concentrated in a thickening tank. The resulting metal-rich filter cake is packaged for processing by a third party to create semiconductor material for use in new modules, with the entire process resulting in 95% recycling of semiconductor material.

The “third party” above also has to spend time, energy, carbon, water, etc., to further refine the “extract” prior to getting it into a format for re-use. This also has to be calculated into the Cd-Te cost/carbon footprint dilemma. First Solar is currently looking to fill a job position to head up its prototype recycling efforts:

> First Solar is a leader in the development and manufacturing of thin film solar modules used in grid-connected solar power plants. Our high growth and position in the renewable energy industry offers outstanding opportunities to individuals seeking an exciting work environment in one of the most important industries for the 21st century. Our culture is one where teamwork, continuous improvement, achievement of results, and environmental responsibility are core values. We are seeking new associates that are motivated to contribute their talents to making cost effective solar energy an important part of the world’s energy mix.
>
> Basic Job Functions: The primary responsibility of this postion will be to lead First Solar’s Recycling program development and implementation. This position will be directly responsible for working with the First Solar’s Strategic Materials group and the current Version2 PV panel recycling demonstration system and developing and implementing a plan, with support from Corporate Engineering, to propagate the technology and systems installation world wide to support global production changes. They will be responsible for working with First Solar’s Development group to define impacts and changes to the recycling systems necessary to support changes in technology and chemistry of First Solar’s solar panels. They will be responsible for leading and supporting the worldwide team of recycling managers, supervisors and operating personnel in implementing changes to standardize all of First Solar’s recycling systems to standard and consistent throughputs and component relaibility. They will ensure that First Solar is effectively sharing recycling Best Practices globally. This position will be involved with cross site, global environmental teams and EHS initiatives. The candidate must also interface with key operational and functional EHS groups to ensure the successful development and integration of environmental strategies in recycling. Candidates must be able to positively represent EHS to internal and external stakeholders. The candidate must have proven EHS leadership skills. Excellent oral and written communication skills and a demonstrated ability to lead and contribute in a team-based work environment are required. Experience:
> * At least 15 years of EHS experience with progressively increasing scope and responsibility.
> * Frequent travel internationally is expected – up to 50% travel.
> * Extensive project management experience taking project from concept through design and to final implementation
> * Hands-on experience in system start-up and trouble shooting
> * Chemical process design experience required
> * Material handling process design, preferably with glass or granular materials, required
> * Detailed understanding of EHS/ Environmental regulations, standards and requirements
> * Proven track record of providing functional leadership in the definition, communication and execution of high impact Environmental programs, systems and initiatives

Just like nuclear, mercury and other hazardous waste storage sites needed for industry do you want a Cd storage site near your backyard? Yet, First Soar plans to expand this operation as well. Combined First Solar is planning on 24 operating lines with a capacity worldwide capacity of 1.152 GWp. Perrysburg, Ohio….are you getting this: more production for you and First Solar's main recycling center, yet there seems to be no NIMBY, rather there is tax incentives, low cost loans, rebates, and other incentives to do this expansion, all justified as important due to it being "Green & Great".



First Solar is, as stated, a single product company that operates on "waiver" here and in Europe. For years the whole world worked to diminish the use of Cd and ween ourselves from its use in a managed manner. Much money and effort was spent, born by the taxpayer, to do this. Much success was derived, many companies supported these initiatives. Now First Solar has and is developing further manufacturing capacity to reverse this work which has cost the world billions of dollars. First Solar for example is aware of its position vis a vie RoHS. RoHS is a European Union environmental regulation that took effect on July 1, 2006 (see appendix). It is a regulation or tool with which to eliminate and manage hazardous materials with Cd at the top of the list. Restrictions and enforcement are severe. First Solar's Aug. 13, 2007 SEC filing 424B3, page 17, regarding the risks with the RoHS directive cites: "The use of cadmium in various products is also coming under increasingly stringent governmental regulation. Future regulation in this area could impact the manufacture and sale of cadmium-containing solar modules and could require us to make unforeseen environmental expenditures or limit our ability to sell and distribute our products. For example, the European Union Directive 2002/96/EC on Waste Electrical and Electronic Equipment, or the "WEEE Directive", requires manufacturers of certain electrical and electronic equipment to be financially responsible for the collection, recycling, treatment and disposal of specified products sold in the European Union. In addition, European Union Directive 2002/95/EC on the Restriction of the Use of Hazardous Substances in electrical and electronic equipment, or the "RoHS Directive", restricts the use of certain hazardous substances, including cadmium, in specified products. Other jurisdictions are considering adopting similar legislation. Currently, photovoltaic solar modules in general are not subject to the WEEE or RoHS Directives; however, these directives allow for future amendments subjecting additional products to their requirements and the scope, applicability and the products included in the WEEE and RoHS Directives are currently being considered and may change. If, in the future, our solar modules become subject to requirements such as these, we may be required to apply for an exemption. If we were unable to obtain an exemption, we would be required to redesign our solar modules in order to continue to offer them for sale within the European Union, which would be impractical. Failure to comply with these directives could result in the imposition of fines and penalties, the inability to sell our solar modules in the European Union, competitive disadvantages and loss of net sales, all of which could have a material adverse effect on our business, financial condition and results of operations".
In summary, the Cd-Te solar panel does not comply with RoHS, the homogeneous material of the portion of CdTe layer contains 470000 ppm (47%) of cadmium, far exceeding the 100 ppm limit. By virtue of simply mentioning RoHS, First Solar implied that it is not in RoHS compliance. By mentioning a possible future need to apply for an exemption, First Solar confirms that the product does NOT comply with RoHS. First Solar made an incorrect statement that the product is

not subject to RoHS directives. Any product sold within the territory of European Union, of course, is subject to any regulation that EU imposes on its territory. What First Solar apparently meant to say is that the product currently is NOT explicitly listed in the restricted product list. It is certainly NOT in the exemption list either. Anything not RoHS compliant must be exempted and added to the exempt list, or be added to the restricted list. If it's on neither list, then it's an overlook and a loop hole to be plugged, and if it is that is the end of First Solar in the EU.

First Solar targets investor-owned utilities in the U.S., particularly those with government-imposed quotas of renewable energy they need to meet. For example, Arizona utilities are required to provide 15 percent of energy from renewable sources by 2025. What will the world look like regarding Cd pollution by 2025? What are we promoting without taxpayer dollars and what will we reap in terms of worldwide Cd pollution from this business? Why do we list Cd as dangerous and toxic material and have a worldwide effort to curtail its use, while on the other hand expand its use?

First Solar knows what it is doing. The Government knows as well. From your own perspective after reading this document, do you think they know what they are doing?

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION
Trade Name: Cadmium Telluride Formula: CdTe
Chemical Name: Cadmium Telluride Chemical Nature: Inorganic
Molecular Weight: 240 CAS #: 1306-25-8
II HAZARDOUS INGREDIENTS
Cadmium Telluride Wt. %: 99.9+
Permissible Air Concentration (mg/m3): OSHA: 0.005 as Cd/0.1 as Te
ACGIH: Cd and its cmpds-0.01 total, 0.002 resp. 0.1 as Te SARA Title III Sect. 313 Chem: Yes
III PHYSICAL DATA
Appearance and Odor: Black cubic crystalline powder Melting Point (oC): 1041
Boiling Point (oC): N/A Specific Gravity: 6.2 (H2O=1)
Vapor Density (Air=1): N/A Solubility in Water: Insoluble
Vapor Pressure: N/A pH: N/A
Evaporation Rate: N/A
IV FIRE AND EXPLOSION HAZARDS DATA
Flash Point (Method used): N/A Autoignition Temperature: N/A
Flammable Limits in Air: N/A
Fire Extinguishing Agents to Avoid: No specific agents
Fire Extinguishing Agents Recommended: No special agents recommended
Unusual Fire & Explosion Hazard: Finely divided powder may burn if ignited with evolution of hazardous CdO fume.
Special Firefighting Procedures: Use NIOSH/MSHA approved self-contained breathing apparatus and full protective clothing if involved in fire.
V HEALTH HAZARD INFORMATION
Primary Route of Entry: Inhalation
Carcinogenicity: IARC classifies cadmium and certain cadmium compounds as Group 2A carcinogens (probably carcinogenic to humans). NTP classifies these materials as "...substances that may reasonably be anticipated to be carcinogens."
Acute Overexposure (Symptoms and Effects): Inhalation of dust of fumes from cadmium or its compounds may cause irritation of the nose and throat. If high concentrations are inhaled (especially freshly formed fume), a delayed reaction of coughing, chest pain,sweating chills, shortness of breath and weakness may develop. In severe cases, death may result from pulmonary edema. Ingestion of cadmium may cause nausea, vomiting, diarrhea and abdominal cramps. Acute exposure to tellurium may cause garlic odor of the breath and perspiration, dry mouth, metallic taste, sleepiness, loss of appetite and nausea.
Chronic Overexposure (Symptoms and Effects): Long term overexposure may cause lung injury (emphysema) and kidney dysfunction (proteinuria). Bone lesions characterized by pain in the back and extremities have also been reported. Inhalation of cadmium and its compounds may pose an increased risk of lung cancer and possibly other forms of cancer. Chronic overexposure to tellurium may cause garlic odor of breath, perspiration, dry mouth, metallic taste, sleepiness, loss of appetite and nausea. Oral administration of tellurium has been reported to produce kidney and nerve damage in experimental animals and teratogenesis in pregnant rats.
Medical Conditions Possibly Aggravated: Diseases of the lung and kidney
EMERGENCY AND FIRST AID MEASURES:
INHALATION: Remove from overexposure individual under care of a physician.
INGESTION: Induce vomiting in conscious individual and call a physician.
SKIN OR EYES: Flush with plenty of water. If symptoms develop, consult a physician.
VI REACTIVITY DATA
Stability: Stable
Conditions to Avoid: N/A
Incompatibility (Material to avoid): None Known
Hazardous Decomposition Products: At temperature above the melting point, metal oxide fumes may be evolved.
Hazardous Polymerization: Will not occur
Conditions to Avoid: N/A
VII SPILL OR LEAK PROCEDURES
Normal Handling: Use of approved respirators is required for applications where adequate ventilation cannot be provided. Activities which generate dust or fume should be avoided. When melted, the temperature should be kept as low as possible.
Spill or Leak: Any method which keeps dust to a minimum is acceptable. Vacuuming is preferred for dust. Use approved respiratory protection if possibility of dust/fume exposure exists. Do not use compressed air for cleaning.
Engineering Controls: Local exhaust is recommended for dust and/or fume generating operations where airborne exposures may exceed permissible air concentrations.
Storage: General storage procedures acceptable.
Personal Hygiene: Avoid inhalation or ingestion. Practice good housekeeping and personal hygiene procedures. No tobacco or food in work area. Wash thoroughly before eating or smoking. Shower and change clothes at end of work shift. Do not wear contaminated clothing home. Do not blow dust off clothing with compressed air.
Special Precautions/Procedures/Label Instructions: There is currently no substance specific standard for cadmium and its other than air contaminant tables in 1910.1000.
VIII SPECIAL PROTECTION INFORMATION
Respiratory Protection: Where airborne exposures may exceed OSHA/ACGIH permissible air concentrations, the minimum respiratory protection recommended is a negative pressure air purifying respirator with cartridges that are NIOSH/MSHA approved against dust, fumes and mists having a TWA less than 0.05 mg/m3.
Eyes and Face: Safety glasses recommended where the possibility of getting dust particles in eyes exists.
Other Clothing and Equipment: Full protective clothing is recommended for exposure that exceed permissible air concentrations. All contaminated clothing should be removed before leaving plant premises.
IX SPECIAL PRECAUTIONS
Regulated by DOT: Not regulated
Waste Disposal Method (Must comply with Federal, State, and Local disposal or discharge laws): If hazardous under 40 CFR 261. Subparts B and C, material must be treated or disposed in a facility meeting the requirements of 40 CFR 264 or 265. If nonhazardous, material should be disposed in a facility meeting the requirements of 40 CFR 257.
RCRA Status of Unused Material: If discarded in unaltered form, material should be tested to determine if it must be classified as a hazardous waste for disposal purposes. Under specific circumstances, application can be made to the EPA Administration to have a particular waste designated non-hazardous.
WARNING: The State of California has listed cadmium as a known to cause cancer.
This material safety data sheet is offered solely for your information, consideration, and investigation, ESPI provides no warranties, either expressed or implied, and assumes no responsibility for the accuracy or completeness of this data sheet.
Prepared By: S. Dierks
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