The Solar PV Market

Challenge For Investors

Following a large increase in the price of the stock of Sunpower (NASDAQ:SPWR) and First Solar (NASDAQ:FSLR), solar investment is under the magnifying glass again. In the present essay I would like to elaborate on my forecast in a previous article on Solar PV: that the cost of PV -generated electricity will decrease toward $0.01/kWh by the middle of the century. I would further like to connect the macro view expressed in that article to the realities of PV trading today.

In this article the sun as the source of our energy is discussed, followed by a look at some of the negative effects of the energy industry, including PV, on our environment. Next, we examine the investment climate surrounding solar PV and try to explain why there is no Exxon presently in this field, commenting on some existing companies. Finally, we outline forward opportunities for investment, where solar PV can be a vehicle to make a lot of money and do some good at the same time. The approach in this article is to outline some of the underlying forces determining the progress of PV rather than cataloging the details of the history or the detailed present state of individual companies.

Here Comes The Sun

The PV industry is already a half of a century old. During most of this time, the industry was engaged in R&D to develop the right technology. This process still is not completed. In spite of the fact that R&D is still continuing, the commercial phase of the PV industry is well under way. In the last decade the industry grew from sales under $1 billion to over $100 billion in 2012 and isforecast to grow another 100 fold before the middle of the century. Cumulative installed PV power generation capacity worldwide reached 100 GW in 2012.

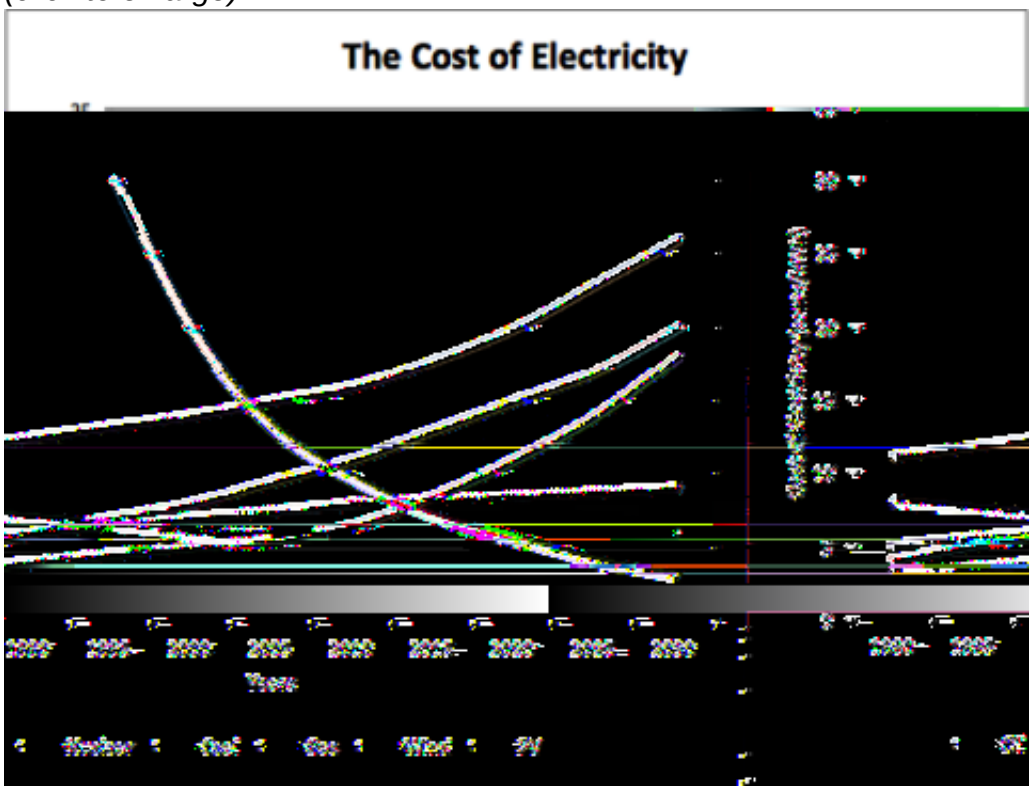
Man's economic progress is primarily characterized by how much energy he uses to live his life. Worldwide, the average power a human being consumes today is 100 watts, equivalent to 1000 kWh energy in a year. Let us call this "100 watt servant equivalent" 1 Holon (from Arthur Koestler's notion of the autonomous subunits of a society). Our average energy consumption per person in the U.S. is 10,000 kWh per year, or 10 Holons serving us day and night throughout the year. In some parts of the developing world, people only have 0.2 Holon helpers, their per capita use of energy just one fiftieth of ours in the U.S. Our use of energy also determines our interference with nature. This is the intersection where we poison our water, pollute our air and overheat our globe.

With the exception of nuclear and geothermal energy, all our energy comes from the sun. In an article, "Solar energy, a global view", the effectiveness of the sun's efficiency (defined as the energy that can be extracted from different products of photosynthesis divided by the sun's energy falling on the product) is listed in growing the different crops by photosynthesis. The most efficient

biomass (like algae) has an efficiency of the order of 1%. On the same scale, the efficiency of forests is 0.1%, of crops (like corn) 0.01% and meat 0.001%. Note the PV efficiency, direct conversion of the sun's energy into the most usable form of energy, electricity, is 10% to 50%. The conclusion is that to harvest biomass energy will require at least an order of magnitude larger land area than to harvest the electrical energy by PV. Another interesting comparison is that when we convert crops to biofuels thereby introducing an additional factor of efficiency loss, we use the sun 10,000 times less efficiently than when we use Solar PV.

The Cost of Electricity From Different Sources

(click to enlarge)



This basic fact of solar PV's relatively high efficiency can be seen in figure 1, which compares the cost of electricity generation from different sources. The cost of PV depends on the insolation of the location and can vary more than a factor of three (800 hours for Alaska vs. 2400 hours for parts of Arizona). The PV curve on figure 1 is for insolation 2000 hours of equivalent peak sunshine per year.

The Energy Industry and the Environment

All energy sources have to be subject to the same rules and limitations. They have to provide the

lowest cost energy with the least adverse effect to the globe. Comparative costs were discussed in the article mentioned above and shown in figure 1. The use of any of the sources of energy have environmental consequences. Nuclear fuels are still waiting for their graveyards. Fossil fuels are spewing their pollution directly into the air, mostly as CO2, while they heat the planet. Solar PV may also cause disaster unless we recognize and guard against contamination at this relatively early stage of the industry. The first world conference on environmental problems in Solar PV took place in Fukuoka, Japan. The findings are published in a paper from University of Stuttgart. Two toxic ingredients are identified in the use of PV, lead (PB) in cSi and cadmium (Cd) in CdTe.

To fully understand potential contamination by the use PV, we have to address the end of life issues of PV projects. If PV will end up as a dominant component in the energy mix, the industry will have to be accountable for its complete cycle. Ultimately, PV installations may cover 1% of the world's land area, which translates in the U.S. into approximately 100,000 square km (half the area of Arizona). At the end of the life of the PV installation, the field will either have to be dismantled, or it will go into the landfill. The dismantling cost of a PV field is comparable to the installation costs, presently about $0.4 per watt. Today the owner of the PV field is responsible for this cost. So far, no manufacturer has accepted this obligation. (FSLR has a recycling program, but it does not include dismantling the installation). Recycling will only take place if it is economical . For cSi modules, the value of wafers is about $0.25. The dismantling cost is substantially higher. For CdTe, the value is less than $0.1 per watt, even less economical than cSi. The overall conclusion is that the dismantling of PV modules will consist of removing them for landfills. Hence, it is absolutely essential that the PV modules destined for the landfills do not contain water soluble pollutants, not to contaminate our water tables.

Where is the Exxon of the Photovoltaic industry?

In this section, we examine the complex nature of PV technology, influenced by the politics of the energy industry and the large reward associated with the potential of finding the primary replacement for fossil fuels.

To harvest the sun's energy, man has devised many different tools, all part of the renewable energy industry. Wind energy, hydro energy, ocean tidal waves, solar thermal process, concentrating solar thermal (power towers), concentrating PV (CPV), and solar PV are all renewable technologies in use today. Photovoltaics are made with a number of different materials, grouped into two categories: crystalline Silicon (cSI) and thin film PV. Among the thin films, there are amorphous Silicon (aSI), cadmium telluride CdTe and copper indium gallium diselenide (CIGS). There are different type of thin film devices, single junction and multi junction. There are other set of PV materials and devices as well, specially developed for the space industry. This is the matrix from which we have to pick a winner.

Modern PV R&D goes back to work carried out after the Second World War. Most of the R&D was funded by the U.S. government in the industrial laboratories on the East coast of the U.S., including

Bell Labs, IBM (NYSE:IBM), GE (NYSE:GE) and RCA, and in universities across the country. Crystalline PV, an outgrowth of the semiconductor industry, was first commercialized and used in the space program. The first large scale commercial players in the industry were oil companies like Amoco who picked up Solarex. Arco, Shell (NYSE:RDS.A) and Chevron (NYSE:CVX) followed the pattern. The oil companies did not have the patience to stay until the industry matured and the PV effort was passed on to technology companies like Siemens (SI), glass companies and utilities.

The first thin film technology was developed at RCA and commercialized by two companies, Chronar (in a glass to glass sealed package) and ECD (on a stainless steel substrate). ASi has the flaw that, due to light induced degradation, the stabilized efficiency leveled off at around 7%, not competitive in the power market of today. Both companies are out of business, though a number of companies make aSi today, including Schott Solar, Masdar PV, and others.

First Solar, a CdTe based thin film company, was founded in 1996. It became the largest thin film company (and for a while the world's largest PV company), trading on the Nasdaq. FSLR has manufactured and installed over 6GW of PV, spreading 1 million Kg of cadmium across the globe in the process. The main funding for FSLR came from the Walton family, founders of Wal-Mart (NYSE:WMT). CIGS companies have been funded primarily by venture capital from Silicon Valley. It is shocking to realize how unsuccessful their efforts have been. After investing more than $2 billion into companies like Nanosys, Nanosolar, Miasole, Solyndra and others, not one winner was found.

Governments have also played an important role in the development of this new energy industry. Until 1990 the U.S., where most of the technology was invented, was the unquestionable leader of the industry. Next Japan started a major commercialization called the Sunshine Project. Following that, Germany introduced a very successful Feed In Tariff (FIT) and over five years, 30 GW PV was installed, currently representing about 5% of German electricity generation. Finally, with the help of government funding, a dozen companies in China have built about 40 GW of PV module manufacturing, gaining about 60% of the world's production capacity. This rapid expansion of capacity caused an imbalance between supply and demand, the prices of PV modules collapsed, and today all cSi manufacturers are operating at a loss. In spite of the current chaos, we should not forget that PV electricity generation today is often competitive with other sources and heading towards becoming the lowest cost source of electricity. The industry worldwide employs over 1 million workers and its total sales volume is over $100 billion. In comparison, the combined employment of Google (NASDAQ:GOOG), Facebook (NASDAQ:FB) and Yahoo (NASDAQ:YHOO) is less than 100,000 and their combined annual revenues are $85 billion.

The first 40 years of the PV industry is a story of waves of investment by large industrial capital concentrations, oil companies, technology companies and Silicon Valley venture capital, only to lead finally to the domination of the industry by today's most effective concentration of capital and political power, China.

The story of Solyndra might be instructive as a case study in picking a winner. It started in Silicon Valley as a stealth startup. It was heralded as the "destructive game changing" technology in PV. It was not the government that picked Solyndra as a winner, but Silicon Valley venture capital that invested over $1 billion in the company before it had a mass producible product. One fatal flaw in Solyndra was a primitive technology error, that neither the investors nor the Nobel Prize winning science advisor to the President picked up. That technology error was evident in the first filing to the SEC: its device was made of an array of cylindrical tubes, that only covered half the illuminated area, claiming to collect more light than a continuous flat plate that covered all the area. As it turned out, it only collected about 70% of the available light. It is no wonder that with this 30% handicap, it ended up in bankruptcy.

Solar PV seems simple. Light falls on one side of a glass sandwich and two wires carry out around 200 watts of electricity for every square meter. But in the current market, it is not so simple to pick a winner. First a selection has to be made from a 10x10 matrix of technologies (e.g., solar thermal vs. CPV vs. PV?). Let us assume that one was smart enough to pick solar PV. Next comes another 10x10 matrix within solar PV to pick the right material, the right devices, the right structures and the best manufacturing processes. Next pick the right business strategy and finally pick the right country and political system, which will best help you to replace fossil fuel in the energy mix. May the best matrix win.

This is a very different scenario from the knowledge economy, where a bright teenager writes a suitable computer program, venture capital blesses it by putting up more funding than the young man needs, at the same time arranges with Wall Street a suitable exit scenario making an untold number of new millionaires in the process. Take Facebook as an example. It has raised $16 billion in a public offering, valuing the company more than 20 times sales. It employs 4000 people. Solar PV is not this type of investment. Investors at different stages of the solar PV company do not have control up to the point that they can exit. These factors may explain why at this stage there is no Exxon of solar PV.

The Present Investment Vehicles ("The Dark Side of Solar")

A major article came out in the

from the present 1% penetration of the energy market is heading to be the largest component in the world's energy mix

On the dark side, the industry is in total chaos and a major trade war is looming. But another great danger comes from the largely overlooked end of life issues for PV systems. Many PV modules contain significant amounts of toxic materials, principally Lead and Cadmium. 1000 tons of toxic Cd is already spread over 100 square km (EPA allowed levels are 5 micrograms/liter. 1000 tons of Cd is adequate to contaminate the total U.S. fresh water supply above this limit). Some cSi products

Two potential competitors of FSLR, GE's Prime Solar in Colorado and Abound Solar, also of Colorado, have abandoned the market. The two have invested well over $1 billion. At this point, GE has no plans to start production and Abound Solar has declared bankruptcy. More worrisome news is that Colorado health and environment officials have designated the Abound site as ahazardous waste site due to Cd, and suggested encasing the modules in inventory in concrete, similar to nuclear disposal procedures.

On the First Solar financials, the liabilities associated with the use of hazardous CdTe show up as an approximate $0.02 per watt of set aside (at the end of 2012, this represented $212 million). This amount, which directly affects the true cost of the First Solar modules, does not include the dismantling (decommissioning) cost, which far exceeds the set aside. In the long term, investors should be aware that the liability associated with the choice of a toxic material is a most serious and tragic flaw, a major disaster for the environment and unforgiving to the balance sheet of the company and its shareholders.

Even if not in the public markets, the PV industry has been an excellent opportunity as an investment vehicle for project financing. In the last decade, 100 GW of cumulative PV power has been installed worldwide. This represents about $500 billion total project financing, of which about $200 billion came from subsidies. The primary beneficiaries of this industry were the institutions providing the funding. In addition to profits associated with the construction of these projects, the 20 year guaranteed payments under the feed in tariffs (FIT) resulted in some cases in long-term RRI in excess of 20%. This investment opportunity remains in the future. Goldman Sachs (NYSE:GS) recently announced that they will participate in this business in Japan.

Solar PV in the Future (the ability to do good while making money)

If the forecasts for the PV industry are correct, we are at the very beginning 1% of the industry (installed 100GW of the eventual 10,000GW to be installed). How can we participate in this largest of all industries?

Let us call the Crystalline Silicon technology the first generation PV, the existing single junction thin film PV, the second generation PV, and the coming multi junction thin films as the third generation PV. The first generations have brought us to about $0.10/kWh cost, the second generation with 20% efficiency will bring us to $0.05/kWh by 2020, and in the second half of the century with above 40% efficiency thin films we should reach $0.01/kWh PV electricity cost. This vision will only happen if there is political and financial support of the development of this third generation technology. Third generation multi junction thin film PV companies are not yet public. There are some known private companies as examples, like Stion Solar working on multi junction thin film PV products based on CIGS, Alta devices working on GaAs, and others. Finding and funding these early third generation PV companies will be one of the great opportunities in PV Solar. I hope to introduce some of these companies to SA readers.

The main conclusion of this essay is that we only now are embarking on the largest opportunity of this century, replacing the majority of fossil fuels with clean, sustainable renewable solar PV. Clearly such a major shift will affect our social fabric in many ways. One of the great challenges of our time is job creation, and solar PV is one of the greatest sources of new jobs of this century. Slowing climate change depends on our use and sources of energy. How and where is the energy produced and delivered, whether we continue to use the centralized model of the utilities or we focus on distributed power generation, all needs to be reexamined. How rapidly can we move to the large scale use of solar PV will depend on available capital and political will. Members of the financial community and readers of SA will play an important role in determining this future. Whatever our political affiliation or social status, we all are part of the human community and we should accept the responsibility not to poison our air and water as we develop the needed energy resources for future generations.

Disclosure: I have no positions in any stocks mentioned, and no plans to initiate any positions within the next 72 hours. I wrote this article myself, and it expresses my own opinions. I am not receiving compensation for it. I have no business relationship with any company whose stock is mentioned in this article.

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