The logic of the world of photovoltaics is not different than any other subdued to the laws of the free market. It might be about the most sustainable energy, the product has to sold at the lowest possible price in as large quantities as possible with as much as profit possible for the company, it's managers, it's shareholders. And governments tend to subsidize these PV-research programs which are most promising in terms of market share. Also, like in the pharmaceutical industries (a comparison that can be justified because PV-technology appears to have the potential to prevent further damage to the eco-system) the practice of patents is a crucial part of the game.

Scientists and engineers all over the world are exploring the potential for improved cell efficiencies and above all reduced production cost. Innovative processes and materials are promising increased flexibility, integration (printability) and lower costs of manufacturing, implementation and maintenance. Also other PV-related components such as mechanical support (including integration techniques), regulators, dc/ac inverters, batteries, etc. are improved. Besides technological improvement-, scaling up of production is a prerequisite for cheaper products hence solar companies invest in mass production, creating new production plants worldwide, but also acquiring -or merging with- existing companies.
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CocaVoltaics

PV power is doubling worldwide every two years and could provide energy for more than 1 billion people, creating over 2 million jobs by 2020, and 26% of global energy needs by 2040

In this section a closer look is taken on the specificity of photovoltaic technologies as a product produced and sold at the global free market.

Contents

The drivers of the PV-bizz

Solar energy is receiving worldwide attention due to the rising global warming awareness in the first decade of the 21st century and due to the oil rizing oil prices now that the oil peak is approaching. The photovoltaics industry is rapidly expanding with manufacturing plants of increased capacity *and implementations materializing.*

Besides technological improvement, scaling up of production is a prerequisite for cheaper products hence solar companies invest in mass production, creating new production plants worldwide, but also acquiring -or merging with- existing companies.

The market of BIPV is receiving much attention, as using photovoltaic cells in this way minimizes land use and offsets the high cost of manufacture by the cells (or panels of cells) acting as building materials. Although crystalline Si solar cells were the dominant cell type used through most of the latter half of
the last century in this field, other cell types have been developed that compete either in terms of reduced cost of production (solar cells based on the use of multicrystalline Si or Si ribbon, and the thin-film cells based on the use of amorphous Si, CdTe, or CIGS) or in terms of improved efficiencies (solar cells based on the use of the III-V compounds).

Although the use of crystalline Si cells has continued to increase rapidly, the most successful technology at present is based on the use of multicrystalline Si, which has expanded even faster. The key aim of all the technologies is to reduce production costs to 1 $/peak Watt (1 $/Wp) to compete on cost with other forms of power generation. Cells based on the use of crystalline and multicrystalline Si cost more than four times this amount.

The technologies also need to have acceptable **energy payback times** – this is the time taken for a device to generate as much energy as was needed for it's fabrication. Crystalline and multicrystalline devices typically have energy payback times of 3–4 years and the thin-film technologies, 12–18 months. Of course in practice this depends heavily on the site-specific context where the system will be used.

Thin film-PV (TFPV) is gaining market share rapidly now because of its inherent advantages of being low cost and low weight and for the possibility of a cheap production process. In december 2007 Nanosolar presented it's thin film PV crossing the 1$/Watt 'magical border' in the energy market. First Solar, Fuji Electric, Nanosolar, Sanyo, Uni-Solar and G24i are building plants with more than 100 MW in capacity.[1]

Another advantage of TFPV is that it can be manufactured (printed) on various flexible substrates (glass, metal, concrete...). This allows PV-cells to be embedded into walls, roofs and windows/façades which can be made transparent to a certain degree. These technologies also have the ability to operate under low light conditions, though still with more limited efficiencies.

1 http://www.nanomarkets.net/news/pr_detail.cfm?PRID=215

In this vision of the future, a thin film covered city
might drive the electrical grid itself,
essentially functioning as its own powerplant.
Increasingly you will see it everywhere, or,
you won't see it but it will be everywhere,
powering your life exactly the way you live it today.[2]

Buzz! and bubbles?

Hurray announcements of PV tech developers tend to start with the creative succession of the following words: “To decrease the cost of crystalline Si solar cells and at the same time increase the efficiency, we developed...” The fact that hereby exaggerations of efficiencies are communicated is criticized by numerous researchers as -in the end- it creates unrealistic expectations with the end-user which might lead to a disbelief in the overall possibilities of converting light into electricity.

But whatever the efficiencies might be, PV technologies are at a stage where they could have been more than 10 years ago (and wouldn't it have been for the successive wars and it's economies much more). But after the oil crisis, the financing of PV-R&D that took of at the start of the crisis was reduced drastically. Also, governments failed not wanting to support PV-companies nor research centers ("solar energy? but we don't have that much sun here sir...").

And those with the newest and above all the cheapest tech -gaining popularity at nanospeed- sell only to a 'selected 'audience' because of high demands. Some of them are specifically designed for utility-scale power plants, e.g. the Nanosolar utility panel launched by this US company on December 18, 2007 as the 'World's lowest-cost solar panel ': “As far as the first three of our commercial panels are concerned: “Available wholesale to select system integrators and electric utilities. Panel #1 will remain at Nanosolar for exhibit. Panel #2 can be purchased by you in an auction on eBay starting today. Panel #3 has been donated to the Tech Museum in San Jose.” The message that 'the order book for 2008 is filled' is strengthened by the note on their contact page:

“Note: Please do not inquire via phone; use email. We read every email we receive and follow up promptly if there is a match. Due to the quantity of inquiries we receive, we're afraid we cannot answer emails for which there is no match.”[3]

One day after the E-bay launch the bid was already 1000$...
Freshly made, on E-bay and a museum piece. Interesting marketing strategies, these solar boys.

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2 Nanosolar's Vice President of Engineering - July 3, 2007 - www.kqed.org/quest/television/fullscreen?id=399
3 http://www.nanosolar.com

More PV for more electricity using more land

not Wanted!
New products means new and more components mains more resources means more energy needed and more CO^2-emission.
For example: the industry will provide us with MP3-players, camera's, mobile phones etc. with integrated PV-panels for battery-charging. In the meantime, the massive amount of electronic gizmo's can be equipped with 'solar chargers'. Everybody should be able to use the laptop, phone etc. far from the grid and/or really show a deep concern with the global warming, and then, a year later when the intimate electronics have to be replaced, they can buy the ones equipped with the integrated PV-panel. And the solar battery chargers will end up... in African hands, lungs and stomachs maybe?

More damaging for the image of the PV-technology -as one researcher explained- is done by bad quality products which have entered the mainstream shops now such as garden lights with PV-cells etc... A lot of these products are of a bad quality and tend to survive not longer than one year (or winter). Bad for the environment and bad for the image of photovoltaics.

Global co-opetition
The question is if research -the PV-technology- can reach its full potential in a capitalist, free market context, to which also governments obey, characterized by companies which primary goal is to grow -for the sake of the shareholders and funders- and who are unwilling to share their knowledge (get your patent!). Where even at some universities between departments involved in PV-research there is no optimal communication due to the 'fishing in the same funding pots'. Obvious questions are being posed: Would this technology develop more rapidly in an open source, knowledge sharing environment? What if all the scientists, researchers involved would focus on a utterly 'green' technology, based on the cradle to cradle principle? Utterly utopia as we are about to enter the period of the Fifth Sun...
The most advanced, youngest technologies with best quality/price mix are less easy to purchase due to high demand. Information tends to be -especially for the experimental -hence more uncertain technology- much less accessible. Also the request for samples is rather a useless waste of time and energy due to protection of the in-house knowledge.

The logic of the world of photovoltaics is -of course- not different than any other subdued to the laws of the free market. It might be about the most sustainable energy, the product has to be sold at the lowest possible price in as large quantities as possible with as much as profit possible for the company, it's managers, it's shareholders. And governments tend to subsidize these PV-research programs which are most promising in terms of market share. Also, like in the pharmaceutical industries (a comparison that can be justified because PV-technology appears to have the potential to prevent further damage to the eco-system) the practice of patents is a crucial part of the game. One could ask oneself if it would not be advisable -due to the promising nature of this technology- to invest much more in it in an open source knowledge sharing culture, co-ordinated maybe by an international foundation... As said before, the technology is now where it could have been 10 years ago, or maybe even much earlier if it hadn't been for the World Wars, the oil...

Top research
According to an independent and worldwide respected renewable energy consultancy company world's top research centers are the 'School of Photovoltaic and Renewable Energy Engineering'. University of New South Wales, Sydney; The 'Fraunhofer Institut ISE' in Freiburg, Germany and the 'Interuniversity Microelectronics Center Research Group Solar Cells (IMEC)' in Leuven, Belgium. The world acclaimed authority in environmental impact studies of PV systems is Drs. E.A. Alsema, Department of Science, Technology and Society. Utrecht University, Holland.

PV-grade silicon supply
In 2006 there continued to be four major producers of solar photovoltaic grade silicon and between them they produced about 60 % of the feedstock required by the PV industry in 2006. The balance was sourced from a handful of smaller companies, emerging producers outside the IEA PVPS countries and remaining inventories and rejects from the semiconductor industry.

System prices
Reported prices for entire PV systems vary widely (Table 6) and depend on a variety of factors including system size, location, customer type, connection to an electricity grid, technical specification and the extent to which end-user prices reflect the real costs of all the components. For more detailed information, the reader is directed to each country's national survey report.

On average, system prices for the lowest price off-grid applications are double those for the lowest price grid-connected applications. This is attributed to the fact that the latter do not require storage batteries and associated equipment. In 2006 the lowest system prices in the off-grid sector, irrespective of the type of application, ranged from about 9,5 USD to 15,0 USD per watt. The large range of reported prices is a function of country and project specific factors. The average of these system prices is about 12,5 USD per watt, slightly lower than the 13,0 USD per watt reported in 2005.

The lowest achievable installed price of grid-connected systems in 2006 also varied between countries as shown in Table 6. The average price of these systems was 6,8 USD per watt (compared with 6,5 USD and 6,6 USD per watt in 2004 and 2005 respectively). The lower reported prices in 2006 were typically around 6,0 USD to 6,5 USD per watt, also slightly higher than the prices reported for 2004 and 2005. Large grid-connected installations can have either lower system prices depending on the economies of scale achieved, or higher system prices where the nature of the building integration and installation, degree of **innovation, learning costs in project management and** the price of custom-made modules may be significant factors.

On average, the cost of the PV modules continues to account for about two-thirds of the lowest achievable prices that have been reported for grid-connected systems. While this is the case in most countries, there are a couple of examples (Denmark and Germany) where it appears that the nature of the program in place or the market environment can result in lowest system prices close to the reported module prices.

In 2006 the average price of modules in the reporting countries was around 4,6 USD/W, a marginal increase compared to the corresponding figure for 2005, which in itself represented a marginal increase from 2004.

Table 7 shows the change in module (current) prices in some of the reporting countries from year to year. The breakdown of number of countries showing a marginal increase, no change and marginal decrease in module prices from 2005 to 2006 was roughly 50 %, 25 % and 25 % respectively. In the period 2004 to 2006 the PV market size has approximately doubled. Learning curve theory suggests that the underlying cost (if not the market price) of modules in the IEA PVPS countries should have decreased by 15 to 20 % over this period.

Table 7

Besides the effects on costs and prices caused by the dynamics of market demand, tight solar photovoltaic grade silicon feedstock supply and development and competition in the industry, it is worth noting that 70 % of the production costs for a PV module are due to the materials required, including such things as aluminium, copper and other minerals. It appears that there are many companies that have not secured 100 % of needed raw materials, which they must then buy on the open market. Figure 8 and Figure 9 show the evolution of normalized and actual prices respectively for modules and systems, accounting for inflation effects, in selected key markets. It is interesting to note that, over a decade, system prices have decreased by probably more than 40 % while module prices have decreased by less than 30 %.

To integrate.

About high purity poly-Si production shortage
2005: 31.000 tons
Solar: 12.650 tons
Electronics industry: 16.800 tons

Ex. Hemlock Poly-Si plant **(US); Wacker/Berghausen (Germany)**
Since 10 years they cannot follow production and do not take PV seriously.
It takes 3 years to build a new Poly-Si plant. Three are being built in China since 2006. - Dr. Richard Swanson, President and CTO of SunPower
www.parc.com/cms/get_article.php?id=543
NanoMarkets.net

global solar glass companies The lead times for ordering solar glass are getting longer while the prices are increasing -

It is expected that by 2015, 18% of new electric generation capacity worldwide will be from PV. PV will then begin taking its place as a major contributor of clean energy. ... China will be the epicenter of PV (the richest person now in China is the owner of Suntech PV company.) www.parc.com/cms/get_article.php?id=543 (mms://216.93.180.194/parc_forum/v1134.wmv)

Why wafered Si still dominates? (95% of the market)
One never envisioned

1. the dramatic cost reduction potential
2. the dominance of residential and commercial grid connected markets

www.parc.com/cms/get_article.php?id=543
(mms://216.93.180.194/parc_forum/v1134.wmv)

- Cell lifetime: unknown; millennia; lifetime of packaging is a problem because of plastic and of the solder joints because of thermally cycling fatigue is right now warranty is 25 years.

www.parc.com/cms/get_article.php?id=543
(mms://216.93.180.194/parc_forum/v1134.wmv)

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