Environment Protection Engineering

Vol. 32 2006 No. 1

ARNULF JÄGER-WALDAU*

PHOTOVOLTAICS – MARKETS AND BENEFITS**

In 2004, the photovoltaic industry production broke the 1 GW production barrier and became a 5.8 billion € business. European market share rose from 1999 to 2004 from 20% to 26% reaching about 310 MWp in 2004. With a growth rate of more than 40% during the last 5 years, photovoltaics is one of the fastest growing industries worldwide. In order to maintain this growth rate, the photovoltaics industry needs not only reliable political framing conditions to ensure a return on investment, but continuous innovation and research. This leads to the search for new development with respect to material use and consumption, device design, reliability and production technologies as well as new concepts to increase the overall efficiency.

1. WORLDWIDE PRODUCTION

In 2004, the photovoltaic industry delivered worldwide some 1,200 MWp [1] of photovoltaic generators (figure 1) and became a € 5.8 billion business. In the past 5 years, the average annual worldwide growth rate was above 40%, resulting in a further increase of production facilities and attractive investment for the industry. An investment report published by Credit Lyonnais Security Asia forecasts that the photovoltaics sector has a realistic potential to expand from € 5.8 billion in 2004 to € 25 billion in 2010 corresponding to 5.3 GWp in annual sales [2]. According to the European Photovoltaic Industry Association (EPIA), the worldwide solar electricity industry already provided employment for over 35,000 people in 2003 [3].

* European Commission, Joint Research Centre; Renewable Energies Unit, Via E. Fermi 1, TP 450, I-21020 Ispra (VA), Italy, tel. +39 0332 789119, fax +39 0332 789268, e-mail: arnulf.jaeger-waldau@cec.eu.int

** The views expressed in this paper are those of the author and do not necessarily represent European Commission policy.

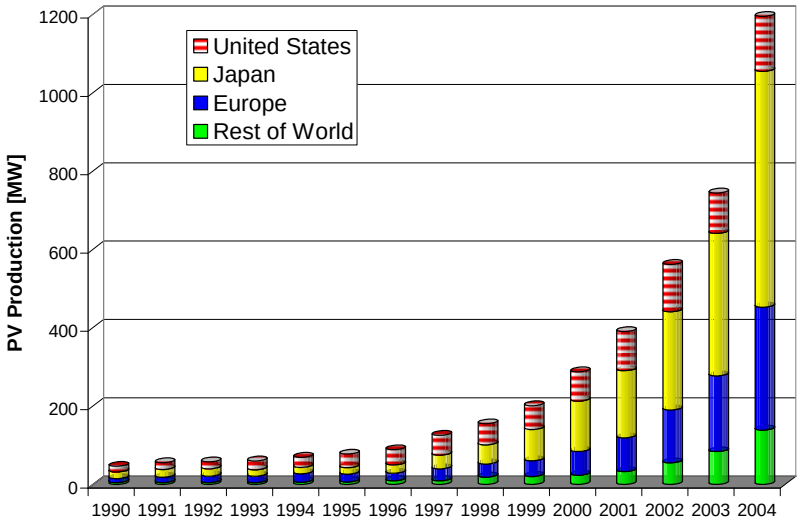

Fig. 1. World PV cell/module production from 1990 to 2004 (data source: PV News [1])

2. PV-TECHNOLOGY

About 90% of the current production uses wafer-based crystalline silicon technology. This is a well-established product, which achieves a sufficient efficiency for at least 20 years of lifetime and constitutes a low-risk placement with high expectations for return on investments.

The current temporary shortage in silicon feedstock is triggered by the extremely high growth rates of the photovoltaics industry over the last years, which was not followed by the silicon producers. Three developments can be observed at the moment:

- Silicon producers have now reacted and are in the process of increasing their production capacities, which will ease the pressure on the supply side within the next two to three years. This indicates that they have recognised PV as a fully fledged industry that provides a stable business segment for the silicon industry as opposed to being strongly dependent on the demand cycles of the microelectronics industry.
- PV companies accelerate the move to thinner silicon wafers and more efficient solar cells in order to save on the silicon demand per Wp.
- New thin film manufacturers are entering the market to supply the growing demand for PV modules and significant expansions of production capacities which could triple the 60 MW thin film shipments in 2004 by 2006 are under way.

If thin film should supply 25% of the photovoltaic devices by 2010, the growth of production capacities must be about double as high as the rest of the industry, assuming that total PV growth continues at a constant of 32% per year as predicted by the

Credit Lyonnais Security Asia study. By then, silicon technology would deliver about 4,000 MWp per year, requiring 40,000 metric tons of Si-feedstock, about 40% more as today's entire world production capacities of semiconductor silicon (28,000 metric tons). Even the more conservative EPIA scenario of 27% growth would result in a silicon demand of 30,000 metric tons of Si-feedstock [3].

These scenarios show that in order to maintain such a high growth rate different pathways have to be pursued at the same time:

- Drastic increase of solar-grade silicon production capacities.
- Accelerated reduction of material consumption per silicon solar cell and Wp, e.g., higher efficiencies, thinner wafers, less wafering losses, etc.
- Accelerated introduction of thin-film solar cell technologies into the market and capacity growth rates above the normal trend.

Further cost reduction will depend not only on the scale-up benefits, but also on the cost of the encapsulation system, if module efficiency will remain limited below 15%, stimulating strong demand for very low area-proportional costs.

3. PHOTOVOLTAICS MARKETS

The photovoltaic world market grew by 58.5% in 2004. Almost half of this growth was due to the exorbitant growth of the German market of more than 235% from 153 MW newly installed solar systems in 2003 to 363 MW in 2004 [4]. The driver for

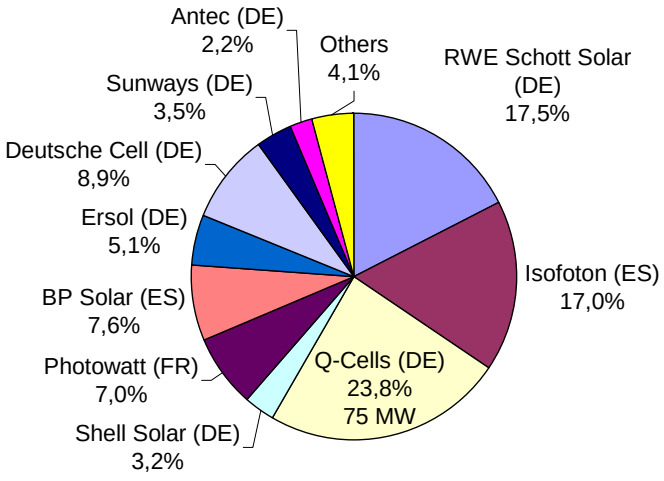

Fig. 2. Shares of the European PV companies in European production (2004: 314 MW, this corresponds to 26.3% of the worldwide sales) [1]

this growth was the new feed-in law, which went into effect in 2004 [5]. This development made Germany the biggest market worldwide, surpassing Japan and accounting for 88% of the European market volume. Despite the fact that the European PV production grew by 50% and reached 314 MW the extreme growth of the German market made Europe after two years of producing roughly the same amount that was installed a net importer of photovoltaics again (figure 2). The ongoing capacity expansions might change this again this year.

3.1. EUROPE

Between 2001 and 2004 PV installations in the European Union more than tripled to reach 1 GW cumulative installed capacity at the end of 2004. Almost 80% of the total PV installations in the EU were done in Germany. However, Spain and Austria also doubled their installed PV power, whereas Luxembourg propelled itself to World Champion and leads statistics in terms of installed PV with 58.5 Wp *per capita*. If the enlarged European Union as a whole were to follow this example, 26.4 GWp installed PV or about 26.4 TWh (0.93% of total EU energy consumption in 2002) per year could be achieved.

It is interesting to note that 16 out of 25 Member States have already introduced feed-in tariffs. However, the efficiency of this measure to increasingly exploit these countries' PV-potential varies considerably in function of the details in each national regulation. In those states where the tariff does not cover the expenses, its impact is very limited. In some other states, there is a motivating tariff, but its effectiveness is limited due to

- too early a fulfilled cap,
- too short a period of validity for the guaranteed increased tariff, or
- administrative requirements being too complicated or even obstructive.

3.2. JAPAN

The second biggest market with 268.8 MW of new installations was Japan with a 25.5% growth rate compared to 2003. 85% or 238.9 MW of the new installations were grid-connected residential systems bringing the accumulated power of solar systems under Japanese PV residential programme to 834 MW out of 1,132 MW total installed PV capacity at the end of FY 2004 [6]. At the same time Japanese exports more than doubled to reach 318.8 MW with more than 224 MW being exported to Europe [7]. Photovoltaic devices manufactured in Japan had a world market share of just over 50% and four of the top 10 companies are Japanese (figure 3).

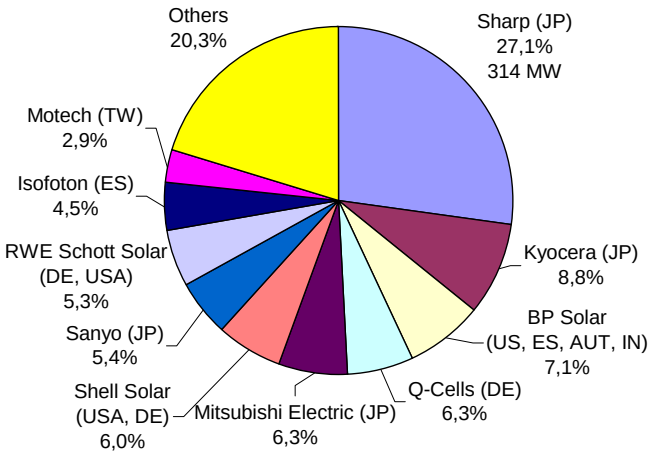

Fig. 3. Top 10 photovoltaic companies in 2004 (total shipments in 2004: 1195 MW) [1]

3.3. USA

The third largest market was the USA with roughly 90 MW of PV installations with California alone contributing 30 MW in 2004. There is no single market for PV in the United States, but a conglomeration of regional markets and special applications for which PV offers the most cost-effective solution. Until recently, the US PV market was dominated by off-grid applications, such as remote residential power, industrial applications, telecommunications and infrastructure, such as highway and pipeline lighting or buoys. Now the grid-connected market is growing much faster due to a wide range of "buy-down" programmes, sponsored either by States or utilities. In 2004 the ratio was about 55 MW grid connected and 35 MW off grid.

3.4. EMERGING MARKETS

It is interesting to note that for the first time a Chinese (Taiwan) company MOTECH reached the top 10 list. The Peoples Republic of China and Taiwan together produced almost 75 MW, which is already more than half of the US production of 139 MW. The market in the PRC is still quite small, but is expected to grow drasticly within the next few years. To goal is to supply 10% of the total primary energy in 2020 by renewable energy. To reach this goal the buildup of a renewable energy and photovoltaics industry is supported by a renewable energy industry policy as well as a feed-in law for electricity from renewable energy.

4. BENEFITS

Solar photovoltaics has more benefits for society than generating electricity from the sun. They can be classified as macro-economic, socio-economic and environmental benefits.

The environmental benefits are those, which are the easiest to explain. Each kWh generated by solar photovoltaics can substitute a kWh, which otherwise is very often generated from fossil fuels. Depending on the energy mix used in a given country, the CO_2 avoidance effects can be calculated straight forward.

The macro- and socio-economic effects are more difficult to see and therefore are often neglected. So far the traditional energy analysts overestimate the cost of renewable-based electricity and significantly underestimate the projected costs of fossil fuel expenditures and the impact of energy-price increases on GDPs [8]. This study estimates that the introduction of a 10% renewable energy share into the US and EU-15 energy supply could have a GDP effect of $ 50 to 100 billion just by stabilising fossil fuel prices and reducing price fluctuations. This is on top of the avoided fuel costs, which for EU-15 are in the order of € 100 to 150 billion if renewable energies would increase their share from 10% to 20% by 2020.

The introduction of renewable energies and solar electricity as one example into existing energy supplies reduces the supply risk and can, despite a higher "stand alone" kWh generating cost, lower the overall costs of an optimised energy portfolio mix.

Additional benefits are job and wealth creation by production, installation and maintenance of solar systems as well as the resulting electricity production. The effects are positive for every country, as most of the jobs are created locally for installation, maintenance and marketing. If countries have to import their fossil energy, about 80% of the money is exported. On the other hand, if solar photovoltaics is used, most of the money is spent within the respective economic system.

4.1. SOCIAL BENEFITS

Job creation and local wealth creation are two keywords for photovoltaics. A vast number of studies on job creation effects has already been published, but this argument has not taken hold of the public opinion yet. Different from other jobs, these jobs cannot be "globalised" in the same manner as other ones. Even if a country would import 100% of its solar modules and electrical components, a significant number of jobs is created locally, necessary for sales, installation and maintenance of the systems.

In June 2004, the European Photovoltaic Industry Association (EPIA) published its recent photovoltaics roadmap and stated therein: *Failure to act on the recommendations of this Roadmap will be a huge missed opportunity. Europe will suffer the loss of its current strong market position and potential major industry for the future. The PV*

industry can be of great importance to Europe in terms of wealth and employment, with 59,000 PV related jobs in the EU in 2010 if the targets are met, and a figure of 100,000 jobs would be realistic if export opportunities are exploited [3].

According to EPIA new PV production facilities create about 20 jobs per MW of capacity adding about 30 additional jobs per MW installed capacity in the wholesale, retail, installation and maintenance services sector. These latter jobs are mostly located on a regional level near to the final customer. The goals set by EPIA in its roadmap are cumulatively installed photovoltaic systems with 3.6 GWp electricity generation capacity in Europe by 2010, and the respective job numbers mentioned above would correspond to roughly 1.2 GW per year production capacity of cells and systems in the first case and roughly double in the export case. These figures look quite realistic if the planned expansions of production capacities in the order of 900 MW for 2006/7 in Europe are added to the realised production of 314 MW in 2004.

Since the introduction of the feed-in law in Germany employment in the renewable energy sector has more than doubled compared to 1998. The latest figures given by the German Renewable Energy Association (BEE) in June 2005 count more than 140,000 people employed in this sector (including Services and R&D) with approximately 20,000 in photovoltaics [9]. According to an industry survey amongst renewable energy companies in Germany every second company plans to increase the number of employees by 30 to 100% within the next 5 years. Photovoltaic companies are amongst the most optimistic ones and in total they expect a doubling of employment by 2010. In 2004, photovoltaics accounted for a turnover in Germany of € 1.5 billion and 70% of the added value remained inside Germany.

It is interesting to note that since 1999, the majority of investments in solar cell production facilities in Europe were made in Germany and Spain – the two countries that offer the most stable and realistic legal framework conditions for citizens investing in a PV system. For the whole of Europe, one can estimate current employment figures in photovoltaics in the range of 25–27,000.

It is no wonder that New Energies and PV were identified by the Japanese "Prime Minister's Advisory Committee on Competitiveness" as a high-potential new market. PV manufacturing is now rated by the Japanese Industry as a "key industry" which should not be shifted to other countries, but done in Japan. These comments and findings reflect the emotional change in Japanese industry and politics towards PV since 1997.

4.2. ECONOMIC BENEFITS

The rising oil price and along with it a general increase in energy prices show the vulnerability and dependence of most economies on energy imports. An increasing number of analysts predict that oil prices could well hit the 100 $/bbl barrier by 2010 [10] or even exceed it as stated by Matthew Simmons, the member of the Energy Task

Force of US Vice-President, Dick Cheney.

The reason for this development is not that no oil would be available, but that the growing world-wide demand and the limited capacities of oil production facilities are pushing the price. In addition, the cheap and easy deliverable oil is coming to an end and the remaining stocks are more expensive to pump out.

The European Commission predicts, that a 10 $/bbl price increase of oil from 50 to 60 $/bbl would cost the Union about 0.3% growth and the US, 0.35%. For the European Union the negative GDP effect would be in the order of € 41.9 billion in 2005–2007. Further price increases would worsen the situation.

Planning the energy processes, we have to realise that the "least cost" planning procedures, which functioned very well during times of relative cost certainty, low rates of technological progress, technologically homogeneous generating alternatives and stable energy prices, are no longer an option. Energy portfolio optimisation locates efficient portfolios even if they include renewable energy sources, which might have higher stand alone cost, they can reduce the portfolio energy price.

Therefore, photovoltaics has a long-term potential to stabilize the energy prices and ease the effects of rising energy prices. This is in addition to the economic benefits of avoided fuel cost and external costs (GHG), money which can be spent inside the economy and be used for local wealth creation.

5. CONCLUSION

Europe is on track to fulfil its own – though not very ambitious – targets for 2010. The European market is still dominated by Germany, where the introduction of the Feed-in Law in 1999 led to a significant change in the frame conditions for investors.

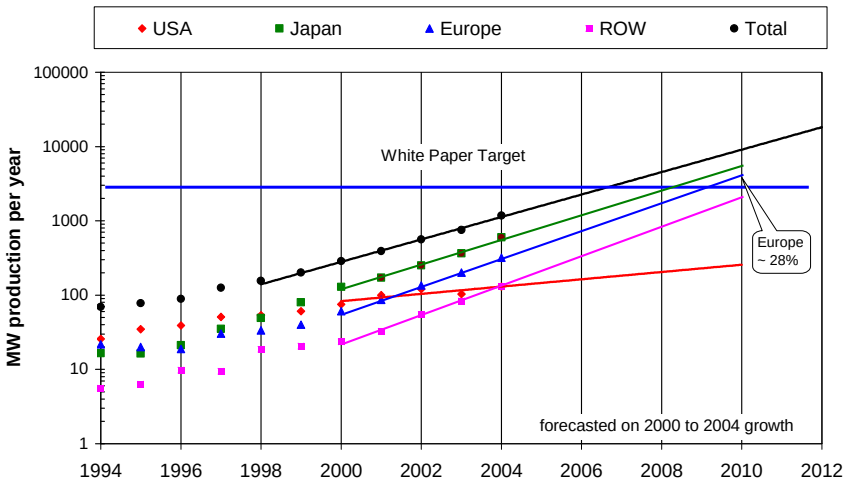

Fig. 4. Extrapolated increase of production capacities until 2010 using the growth rates since 2000

Since then European PV production grew on average by 50% per annum and has reached 315 MW in 2004. European market share rose in the same time from 20% to 26%, whereas the US share decreased due to a weak home market and the Japanese share increased to around 50%. European PV industry has to continue this growth over the next years in order to maintain this level (figure 4).

Solar photovoltaics has more benefits for society than just generating electricity from the sun. The photovoltaic community must not only further improve the technical side of it, but be advocates and ambassadors to spread the news about the job and local wealth creation potential of this clean energy technology. The important task is now to spread the message and muster public support because solar photovoltaics still has a long way to go and grow until all its benefits can make an appearance.

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FOTOOGNIWA – RYNEK I KORZYŚCI

Światowa produkcja przemysłu fotowoltaicznego w 2004 roku przekroczyła 1 GW i osiągnęła wartość 5,8 miliarda euro. W latach 1999–2004 udział rynku europejskiego w tym przemyśle zwiększył się z 20 do 26%, osiągając wartość 310 MWp w 2004 r. Przemysł fotowoltaiczny, przekraczając szybkość wzrostu o 40% w ciągu ostatnich 5 lat, jest jednym z najbardziej dynamicznie rozwijających się na świecie. Aby utrzymać takie tempo wzrostu, przemysł fotowoltaiczny wymaga nie tylko stabilnych warunków politycznych, które zapewniłyby zwrot nakładów, ale również ciągłych badań. Prowadzi to do po-

szukiwania rozwiązań w zakresie stosowanych materiałów, projektowania urządzeń, niezawodności i technologii produkcji.