Trends in photovoltaic applications – latest results from the IEA-PVPS Programme surveys

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ABSTRACT: The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects (tasks) concerning the applications of photovoltaic conversion of solar energy into electricity. IEA PVPS Task 1 has the responsibility to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual Trends in photovoltaic applications report[1]. This report gives information on trends in PV power applications in the PVPS member and other countries and is largely based on the information provided in the national survey reports which are produced annually by the nineteen participating countries. In a PV market environment of increased stimulation of demand and tightening of supply, this paper presents the latest available information from the 2006 round of surveys, compiled and analyzed shortly before the Dresden conference, and includes the topics of market growth, public budgets, the industry value chain, prices, economic benefits and new initiatives. This information covers calendar year 2005 and is presented in greater detail in the 2006 Trends report.
Keywords: Funding and incentives, national programme, PV market

1 TRENDS REPORT SCOPE AND OBJECTIVE

As part of the work of the IEA PVPS programme, annual surveys of photovoltaic (PV) power applications and markets are carried out in the nineteen participating countries. The objective of the series of annual Trends reports is to present and interpret developments in both the PV systems and components being used in the PV power systems market and the changing applications for these products within that market. These trends are analyzed in the context of the business, policy and non-technical environment in the reporting countries.

The report is not intended to serve as an introduction to PV technology. It is prepared to assist those responsible for developing the strategies of businesses and public authorities, and to aid the development of medium term plans for electricity utilities and other providers of energy services. It also provides guidance to government officials responsible for setting energy policy and preparing national energy plans.

The latest report presents the results of the eleventh international survey. It provides an overview of PV power systems applications, markets and production in the reporting countries and elsewhere at the end of 2005 and analyzes trends in the implementation of PV power systems between 1992 and 2005.

2 SURVEY METHOD

Key data for this publication were drawn mostly from national survey reports and information summaries, which were supplied by representatives from each of the participating countries. Information from the countries outside IEA PVPS are drawn from a variety of sources and, while every attempt is made to ensure their accuracy, confidence in these data is somewhat lower than applies to IEA PVPS member countries.

Most national data supplied were accurate to ±10 %. Accuracy of data on production levels and system prices varies depending on the willingness of the relevant national PV industry to provide data for the survey.

3 MARKET GROWTH

Yet another landmark was passed in the IEA PVPS reporting countries during 2005 with the installation of over 1 GW of PV capacity during the year, which brings the total installed to 3,7 GW. As in recent years, by far the greatest proportion (85 %) was installed in Japan and Germany alone. Particularly with the recent levels of growth seen in IEA PVPS member countries, this reported installed capacity represents a significant proportion of worldwide PV capacity.

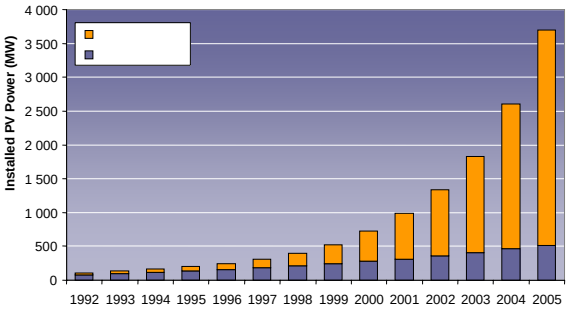

Figure 1: Cumulative installed grid-connected and off-grid PV power in the reporting countries – Years 1992-2005

The annual rate of growth of cumulative installed capacity in the IEA PVPS countries remained fairly steady at an impressive 42 %, with Germany's cumulative installed capacity growing at 80 % (similar to the previous year) and Japan's growth rate also quite steady at 26 %. The corresponding figures for growth of the annual markets are 40 % for IEA PVPS countries, 75 % for Germany and 6 % for Japan. These growth rates have resulted in Germany now overtaking Japan with the highest level of installed capacity both in terms of total capacity (1 429 MW) and installed capacity per capita (17,3 W/capita). An important factor behind the levels of growth experienced by these two countries in particular was the stable market support mechanisms that initially

concentrated on residential grid-connected applications.

4 PUBLIC BUDGETS

The public budgets for market stimulation, research and development, and demonstration and field trials in 2005 in the IEA PVPS countries vary widely, with the total public expenditure being quite similar to that for 2004 at around 1 billion US dollars. In about half the countries the total budget showed an increase from the previous year, particularly evident for Korea.

2005 saw a leveling of the previously steady yearly increase in total budget and a slight decrease in the support for both R&D and Demonstration / Field Trials compared to 2004. The following general long-term trends and observations for the IEA PVPS countries can be reported: over the previous decade, public spending on PV has doubled; initially this spending was largely focused on RD&D; the amount spent on market stimulation increased at the expense of RD&D (in both absolute and relative terms) until 2001; 2004 saw the previously steadily increasing budgets for market stimulation decrease for the first time in a decade.

5 INDUSTRY VALUE CHAIN

In 2005 there were seven companies and ten plants producing PV grade silicon in four IEA PVPS countries. Outside the IEA PVPS countries the production of silicon was negligible. The total production capacity of about 30 000 metric tonnes (t) was probably close to the actual output, of which about 11 000 t were sold to the PV industry.

The total consumption of silicon by the PV industry was in all likelihood close to 15 000 t (enough to produce roughly 1 150 MW of crystalline silicon PV cells) in 2005, the balance being provided by remaining inventories and rejects from the semiconductor industry (recycled wafers, pot scrap, tops and tails etc).

With five plants, the USA is the largest producer of silicon (15 750 t) and worldwide supplier of this product to the PV industry (6 300 t). Most of the production is exported to Europe and Japan. The USA is followed by Japan with three plants producing 8 000 t, of which only a minor part goes to the PV industry (1 300 t to 1 400 t). In Europe the German company Wacker is the second largest worldwide producer (5 200 t to 5 500 t). This company seems to have allocated more than half of its production to PV in 2005 (3 000 t).

The trends in the ingot and wafer business are determined by two factors: the continued strong demand for products downstream (cells, modules, systems) and the availability of low cost silicon feedstock upstream. The companies having their own feedstock or having secured long term contracts are those best able to grow. On the technology side, single-crystal technology is regaining ground. Ribbon technologies are represented by two companies whose importance remains moderate. A very interesting trend is the impressive decrease of wafer thickness, probably strongly motivated by the rising price of silicon feedstock and an ongoing focus on improving manufacturing efficiency.

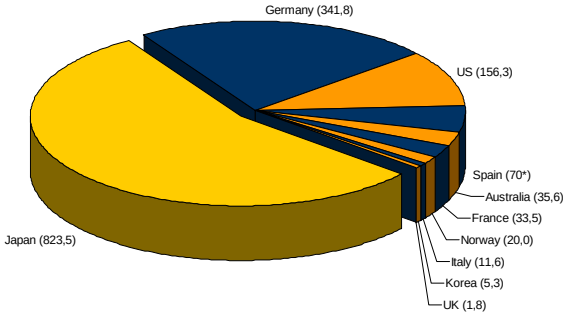

Figure 2: PV cell production (MW) by country in 2005

The total photovoltaic cell production volume for 2005 in the IEA PVPS countries was reported to be 1 500 MW, up from 1 109 MW in 2004, or an increase of 35 %. In reality global growth is even stronger since production is also increasing rapidly outside the area covered by the reporting countries. The largest growth in absolute numbers took place in Japan (220 MW) and Germany (143 MW). However, the growth rate in Germany (72 %) outpaced the rate in Japan (36 %).

Japan is the leading producer of cells (824 MW) and modules (773 MW). Production of cells and modules in this country accounted for 55 % and 50 % respectively of the IEA PVPS countries' production in 2005, with Germany in second place with 23 % and 18 % of production respectively. In the USA, the third largest producing country, production of cells and modules increased by 13 % and 42 % respectively from 2004. However, US output of crystalline silicon cells actually decreased in 2005, while thin-film technologies saw an increased output of 25 MW, up 109 %.

The production capacity, defined as the maximum output of a manufacturing facility, for cells increased by 91 % in Europe (mainly in Germany) and by 65 % in Japan in 2005. The worldwide capacity gain was 66 %. The increase in capacity is significantly larger than the increase in output as a consequence of the new capacity coming online. Utilization, down from 86 % in 2004 to 70 % in 2005, has been affected not only by part-year production and teething troubles, but also by lack of wafers.

Outside the IEA PVPS countries both China and Taiwan consolidated the significance of their contribution to global PV production with further strong growth in 2005. Although industry analysts show some disagreement over individual companies' production figures, there is fairly close agreement on the total cell production from China, at approximately 150 MW. Cell production capacity in 2006 has been estimated to exceed 500 MW. Taiwan further increased its cell production, with 2005 output up by over 70 % to 60 MW. The Philippines and Thailand together delivered a further 23 MW of cells in 2005. Due to the sheer number of PV companies emerging in China it is difficult to definitively state the total Chinese module production. Depending on the source, China's total module production in 2005 is reported as anywhere between 260 MW and 400 MW.

However, based on known cell and module production in IEA PVPS countries, coupled with the limited cell production outside of the IEA PVPS countries, even the lower of these figures appears to be considerably optimistic, perhaps by as much as 80 to 100 MW. India's total module production (around 30 to 37 MW) was largely unchanged compared to 2004, although module production capacity expanded by close to 80 %. Thailand delivered about 12 MW of modules in 2005 from two plants.

From a cost perspective, balance of system (BOS) components (the components that are not the PV modules) account for between 20 % (grid-connected) and 70 % (off-grid) of the total PV system installation costs. Accordingly the production of BOS products has become an important sector within the wider PV industry. Particularly with the rapid expansion of the worldwide market for grid-connected PV systems, inverters are currently the focus of interest and manufacturers of PV inverters for these applications again reported impressive growth rates in 2005.

6 PRICES

Reported prices for entire PV systems vary widely 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.

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 2005 the lowest system prices in the off-grid sector, irrespective of the type of application, ranged from about 10,0 USD to 20,0 USD per watt. The large range of reported prices is a function of country and project specific factors. As in 2004, the average of these system prices is about 13,0 USD per watt.

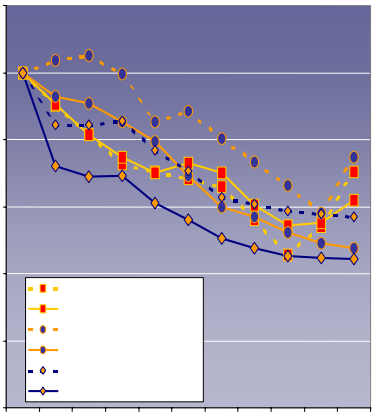

Figure 3: Evolution of price of PV modules and systems in selected reporting countries accounting for inflation effects - Years 1995-2005 (Normalized to 1995)

The lowest achievable installed price of grid-connected systems in 2005 also varied between countries. The average price of these systems was 6,5 USD and 6,6 USD per watt in 2004 and 2005 respectively. Similar to 2004, the lower reported prices in 2005 were typically around 5,5 USD to 6,5 USD per watt. 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.

Photovoltaic modules continue to make up about two-thirds of the lowest achievable grid-connected system prices that have been reported. In 2005 the average price of modules in the reporting countries was around 4,5 USD/W, an increase of less than 5 % over the corresponding figure for 2004. Interestingly, a number of countries reported a decrease in module prices from 2004 – Canada, Japan, and Korea - while other countries reported almost no change – Australia, Austria, Denmark and the UK. It is worth noting that the widely discussed increase in module prices was largely a European phenomenon in 2005, possibly due to the local pressures on demand.

7 ECONOMIC BENEFITS

Three-quarters of the countries reporting on economic benefits estimated that the net business value increased by over 30 % over the year. All countries reporting on this topic reported a positive trade balance in PV equipment. However this should be treated with some caution, as locating accurate information on the import of equipment has proved problematic.

With respect to labour places the data collected are
nerally more complete but again are potentially subject
more generalized estimation. Total direct employment
now reported to be at least 55 000 persons across
earch, manufacturing, development and installation,
l has increased by around 17 % compared to 2004.
e majority of this increase has been within Germany
l Japan, but Denmark, France, Switzerland and Austria
o showed significant increases related to the
plementation of specific programmes during 2005. A
nd for labour intensive manufacturing activities, such
module assembly, to move to low cost base economies
ı be observed. Many manufacturing companies in
rope have continued to benefit from the strong level of
mand within Germany, even when their domestic
ırkets have diminished due to the ending of specific
›grammes.

NEW INITIATIVES

The main fiscal instruments being used to publicly support or promote PV in the IEA PVPS countries continue to be the direct capital subsidies and the

enhanced feed-in tariffs. In practice, public support can involve a combination of measures and will usually function more effectively when this is the case. Funding issues are significant and are critical to the success of any mechanism.

Various forms of tax credits appear to be emerging in a number of countries as an attractive support measure.

Also, as the PV market matures and opportunities for business are identified, various non-utility as well as utility-based commercial initiatives are emerging. These include activities such as preferential home mortgage terms and green loans from commercial banks, share offerings in private PV investment funds plus other schemes that all focus on wealth creation and business success using PV as a vehicle to achieve these ends.

Many governments turning their attention to longer-term approaches to climate change and energy security issues are implementing or considering the regulatory approach commonly referred to as the 'renewable portfolio standard' (RPS) to increase renewable energy deployment in their countries. In the absence of a national strategy for PV or at least some concrete targets for installed capacity of PV, the RPS is unlikely to have a positive impact on PV deployment and may even have unforeseen negative implications. However a number of PV-specific regulatory approaches have emerged.

Other regulatory measures to promote renewables reported by participating countries include disclosure on electricity bills, tradable certificates, and branding and labels, although their application is not widespread.

Within the electricity utility sector different business models of PV promotion are emerging, partly in response to public policy and regulation and partly to realize business opportunities. There are a number of 'green power' schemes offered by electricity businesses in which customers can purchase green electricity. In principle, these rely on part of the customer base giving some environmental or other value to renewable energy – and paying a premium for the privilege. Green power schemes, especially in their infancy, are often characterized by the same problems for PV seen in the government-driven RPS schemes. However, as with the RPS approach, a number of PV-specific green power schemes have emerged – partly in response to a particular utility's approach to its customers and PV, and partly as a function of market diversity and competitive pressures.

9 REFERENCES

[1] IEA PVPS Programme (2006), Report IEA-PVPS T1-15: 2006