SOLAR PHOTOVOLTAIC EMPLOYMENT IN EUROPE

The role of the European PV industry for Europe's jobs and education today and tomorrow

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CONTENT

1. EXECUTIVE SUMMARY

The solar photovoltaic market has been booming over the last decade. In 2008, with around 5.8 GW, the Global Photovoltaic (PV) market had more than doubled compared to 2.4 GW in 2007. This impressive progression in 2008 is mainly due to the development of the European market. The PV industry has been following this trend with a sustained growth of over 50% Compound Annual Growth Rate (CAGR) for the last decade.

This development is turning the PV sector in a major new employer for Europe.

In 2008, EPIA estimates that over 130,000 people were employed directly by the European PV industry and 60,000 people indirectly.

The study carried out within the PV-Employment project shows that in the long run PV is going to be an increasingly more important job provider, as new workers are needed already throughout the production value-chain: from the raw material production, PV cells manufacturing until the installation and maintenance of PV systems.

The PV-Employment study demonstrates that the PV sector could bring jobs to nearly **2.2 million person years by 2030**.

Of course this cannot come alone. Important changes in education programmes are required already from today. Education institutions should already put in place adapted programmes to ensure that Europe can provide properly trained workers and take the challenge of solar energy and the benefits it can bring to the European society not only in terms of sustainable energy but in terms of wealth and social benefits.

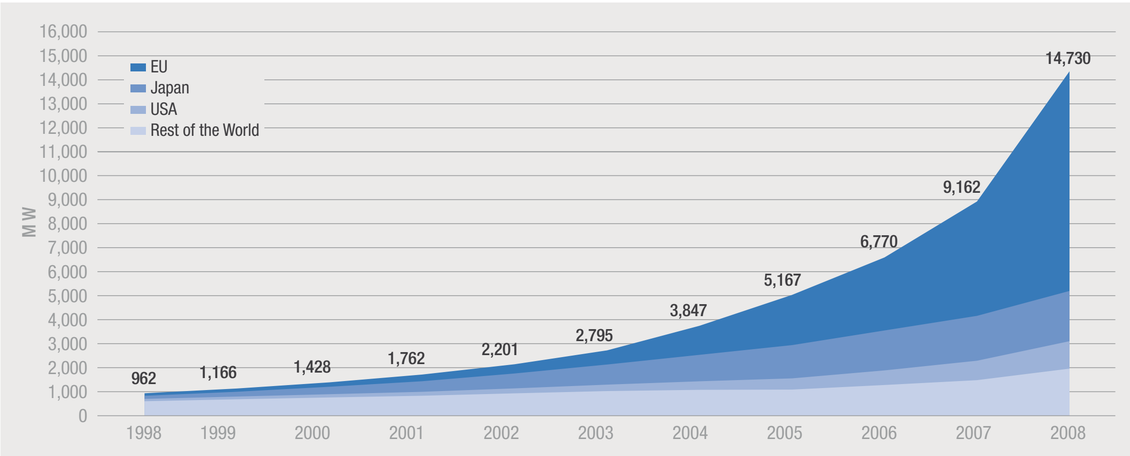
This report brings a clearer picture, quantitatively and qualitatively, of the future workforce that the European PV industry already needs in terms of trained and skilled professionals. Acting today is key to ensure **tomorrow's sustainable energy future**.

2. PHOTOVOLTAIC MARKET AND INDUSTRY

2.1. GLOBAL AND EUROPEAN MARKETS

The solar photovoltaic market has been booming over the last decade. By the end of 2008, the cumulative PV power installed of all PV systems around the world almost reached 15 GW. This compares with a figure of 962 MW in 1998. The market value of the solar PV market reached an annual €20-25 billion in 2008. Competition among the major manufacturers has become increasingly intense, with new players entering the market as the potential for PV opens up.

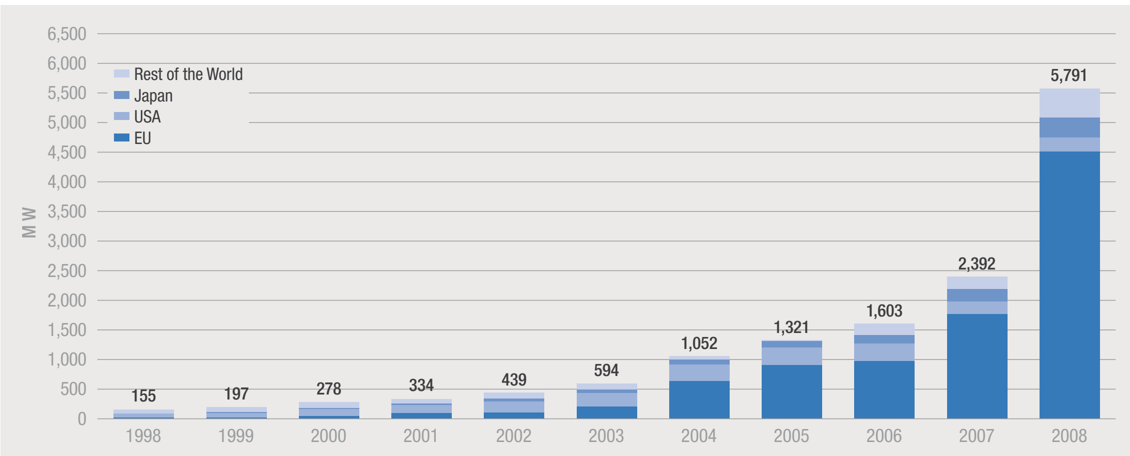
Fig 1. Global cumulative PV power installed



Source: Global Market Outlook for Photovoltaics until 2013, EPIA, 2009

In 2008, with around 5.8 GW, the Global PV market had more than doubled compared to 2.4 GW in 2007. This impressive progression in 2008 is mainly due to the development of the European market.

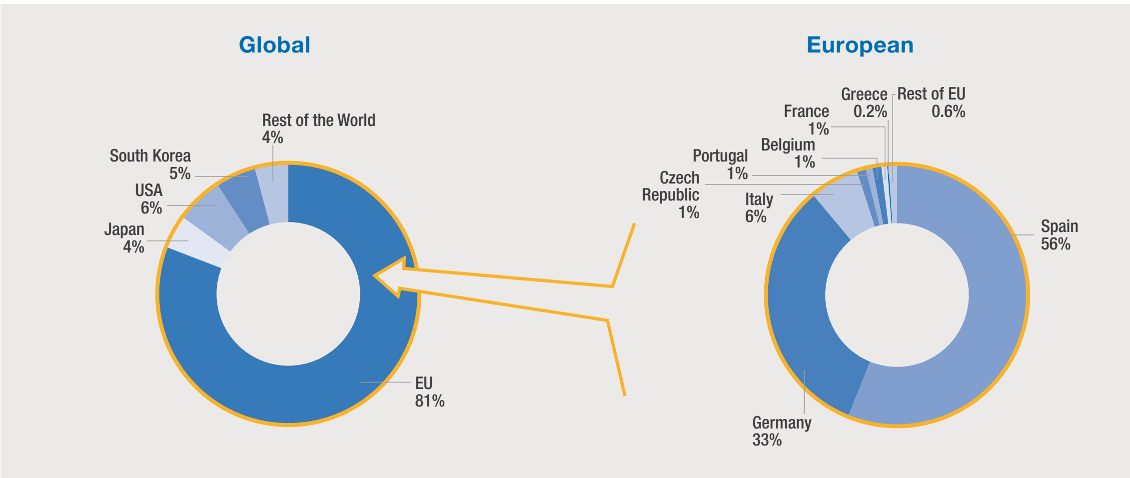
Fig 2. Regional development of the Global annual PV market



Source: Global Market Outlook for Photovoltaics until 2013, EPIA, 2009

In 2008, Europe represented over 80% of the Global PV market. Among European countries, Germany has been leading the way for several years but for the first time and due to exceptional conditions, the Spanish market surpassed the German market. Spain represented around 45% of the global market and 56% of the European market in 2008Numerous countries are developing environment schemes for PV, out of which Italy and France are emerging as the new high-potential markets. Some, such as the Czech Republic, Belgium, Bulgaria, Portugal and Greece among others, are following with promising support environment.

Fig 3. Regional distribution of Global and European annual PV market in 2008



Source: Global Market Outlook for Photovoltaics until 2013, EPIA, 2009

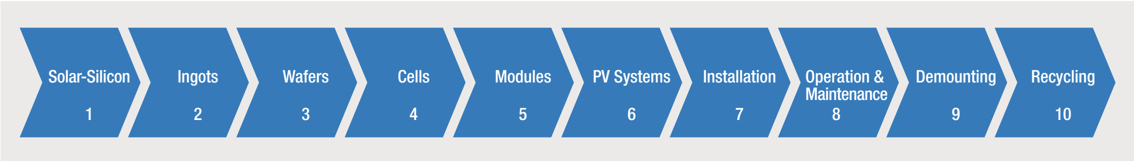
2.2. INDUSTRY

2.2.1. PV PRODUCTION VALUE CHAIN

The European PV market and industry can be broken down into one complete process from the first production steps for metallurgical silicon to the ready turn-key system at the end customer, including all services linked to such systems. There is a need to differentiate the various technologies within the European PV Industry such as crystalline and thin film technology, which differ significantly in the production process. The value chain for crystalline silicon production and thin film production has been defined with a detailed analysis of the production function of each step.

The value chain for **crystalline silicon** production is presented as follows:

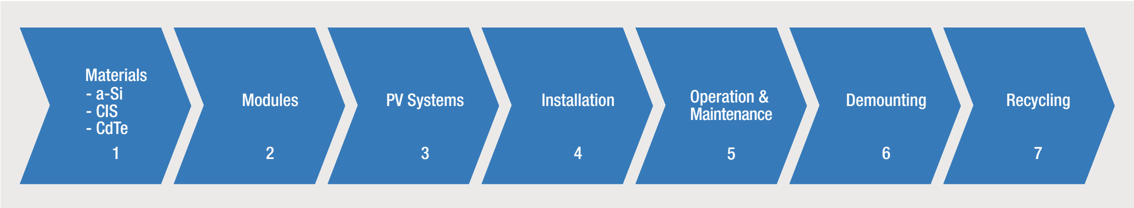
Fig 4. Value chain: crystalline silicon



Source: PV-Employment 2009

The value chain for **thin film** technology is defined as follows:

Fig 5. Value chain: thin film



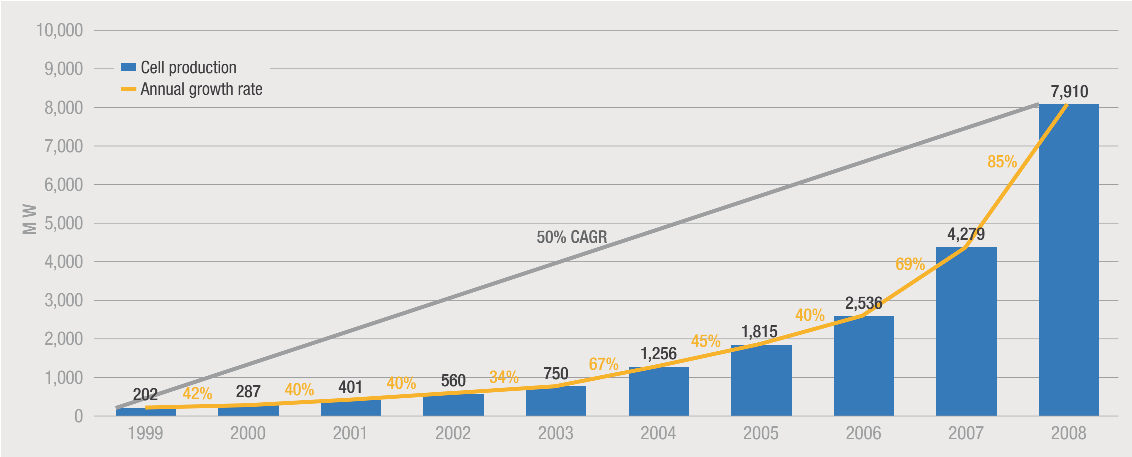
Source: PV-Employment 2009

Thin-Film (and others) technologies represented around 14% of the Global photovoltaic market in 2008. Their share is expected to increase progressively in the future.

2.2.2. PV INDUSTRY DEVELOPMENT

The Global PV industry is characterised by an impressive growth over the last decade with a CAGR of 50% over the period 1999-2008. It rose an amazing 85% in annual growth in 2008 compared to 2007 with around 7.9 GW of cell production.

Fig 6. Global cell production from 1999 to 2008



Source: EPIA with data from Photon International 2009

2.3. EMPLOYMENT

In 2008, EPIA estimates that over 130,000 people were employed directly by the European PV industry and 60,000 people indirectly.

The photovoltaic sector is particularly promising in terms of job and local wealth creation, whether this is direct or indirect occupations.

Direct occupations:

→ Jobs created in the production, installation and maintenance of photovoltaics:

- Solar silicon, ingots and wafer producers
- Solar cell and module producers
- Photovoltaic equipment producers
- Balance of systems producers and suppliers
- System integrators and assemblers
- Suppliers and distributors
- Installers
- Service and repair technicians (Operations, maintenance and demounting)
- Site Surveyors and assessors
- Managers and entrepreneurs
- Sales Representatives, marketers and estimators
- Engineers
- Project developers
- Designers
- Researchers and scientists
- Trainers and educators

Indirect Occupations:

→ Jobs created in the production of all inputs into the photovoltaic industry on all intermediate levels of production:

- Architects and planners
- Builders
- Commodity suppliers – chemical industry, machinery industry, glass industry, electronic device producers, plastics and polymer industries, equipment suppliers, wire and cable makers, and steel, aluminium, copper, and other metal industries
- Trade and Skilled labourers – roofers, electricians, heating, ventilating, and air conditioning installers
- 'Energy exchange pool', energy authorities and electric power utility employees
- Financers and investors
- Media and publishers
- Policy and programme managers
- Employees at local and regional municipalities

3. PV-EMPLOYMENT PROJECT

3.1. OBJECTIVES AND METHODOLOGY

The future employment opportunities offered by the European photovoltaic industry are crucial aspects in order to receive support for the implementation of the technology and the industry within the European society. In order to establish photovoltaics as a mainstream sustainable European industry with tremendous opportunities, it is essential to gain realistic numbers in terms of future job creation.

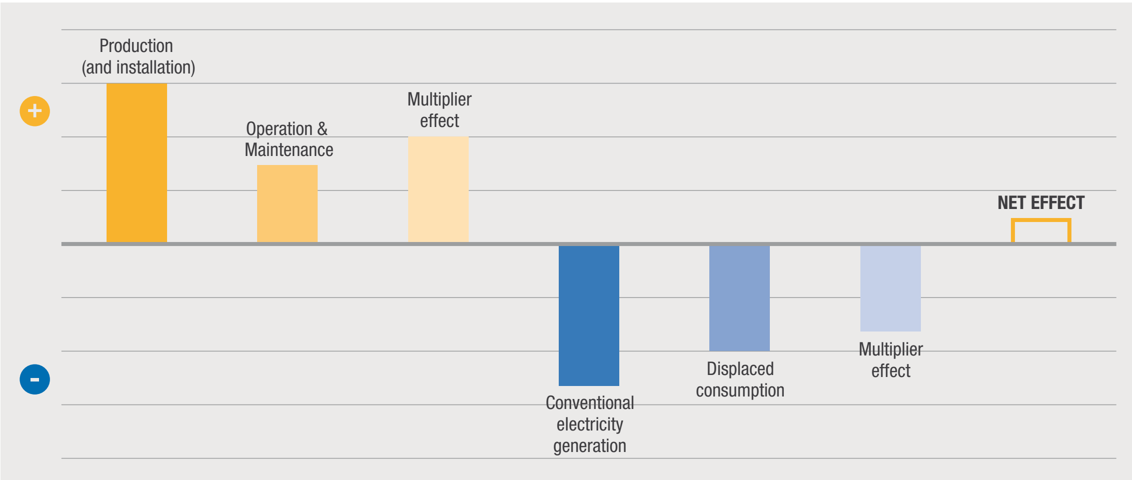
To give a fair picture of the employment effects to be expected, the project's focus has been on net employment effects.

On one hand, we have a direct job creation throughout the whole PV value chain from the raw material production to the installation of the PV systems, their operation, maintenance, dismantlement and recycling. The direct job creation has a multiplier effect in the economy and generates indirect jobs.

On the other hand, PV electricity generation replaces jobs in the conventional electricity generation sector and prevents the creation of new jobs in other industries due to the higher cost of PV compared to conventional electricity sources (at least during the first period). The direct job loss has a multiplier effect in the economy and generates an indirect job loss.

The difference between the positive effects and negative effects results in the net amount of jobs created by the European photovoltaic industry. This approach allows an analysis of the real value of the European photovoltaic industry for the European Union in terms of job creation.

Fig 7. Calculation to obtain the net employment creation



Source: PV-Employment 2009

To assess the net job creation and the impact on the economy, two different economic models have been developed.

An input-output model with special emphasis on the production structures of the different stages of PV production, installation, operation and maintenance has been developed by the University of Flensburg.

An important aspect of this model is the consideration of import export effects. The PV industry is a truly global industry. For example, wafers might be exported from Europe to Japan, where they are processed into solar cells and then shipped back to Europe where they will be assembled to PV modules and maybe sold to the USA. The final model allows changing on the import share of the European PV industry. This allows introducing the import and export share of the European PV industry as a parameter for the job development within the European PV industry.

To gain information about the influence of a raising share of solar electricity in Europe with all its consequences for all other industries a general equilibrium model (GEM) has been developed by the National Technical University of Athens.

The combination of the results of both models leads to a non-biased and realistic evaluation of today's net amount of jobs linked to European PV industry and its forecast up to the year 2030.

Another key result about the European PV industry is the qualification profiles of its employees. These profiles combined with the predicted job numbers created by the European PV industry allow clear recommendations to the higher education institutions about the skills and qualifications that will be requested from the European PV industry for its further expansion.

3.2. MARKET DEVELOPMENT SCENARIOS

Historical PV market data for Europe has been collected until 2006, going back in time as far as 1990 when possible.

Assumptions on the European photovoltaic market have been made in order to generate market saturation curves for each EU member state. Under such assumptions the annual sales volume of new systems follows roughly a Gaussian normal distribution.

For the needs of the PV-EMPLOYMENT project, two scenarios on the development of additional photovoltaic capacity (MWp per year) have been developed:
- PV-EMPLOYMENT moderate implementation scenario
- PV-EMPLOYMENT advanced implementation scenario

PV-Employment moderate implementation scenario assumes that in the year 2030 there will be a cumulative installation of 274 GW in EU27. PV Employment advanced implementation scenario assumes reaching a maximum total installation of about 961 GW in the EU27 year 2030.

Table 1. Scenarios on market development of Photovoltaics in the EU27

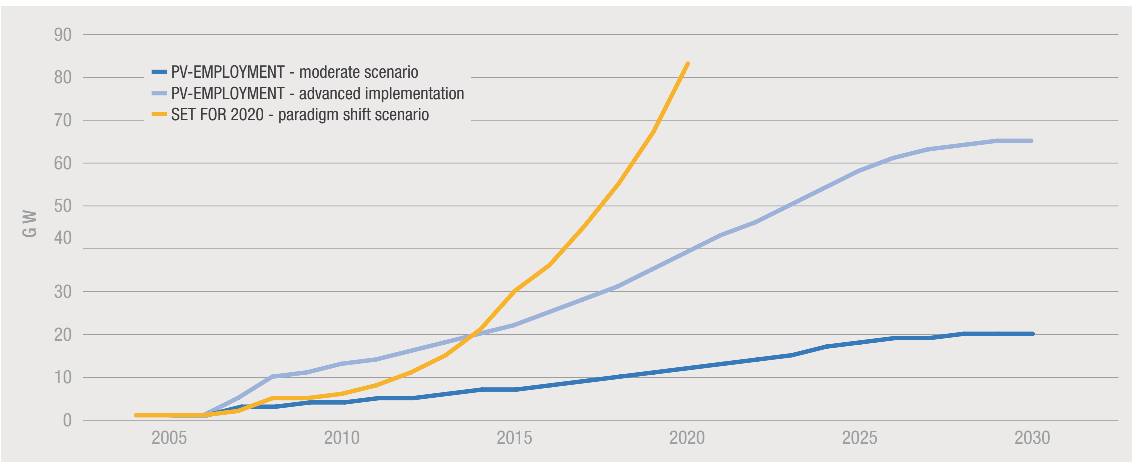
	Annual PV power installed		Cumulative PV power installed	
	Moderate implementation	Advanced implementation	Moderate implementation	Advanced implementation
Year	[GW]	[GW]	[GW]	[GW]
2005	0.9	0.9	2	2
2020	12	43	112	334
2030	20	65	274	961

Source: PV-Employment 2009

Beside the PV-EMPLOYMENT project, the European PV industry has recently elaborated under the SET FOR 2020 study a possible PV deployment scenarios in order to produce with photovoltaics up to 12% of the final EU electricity consumption in 2020. This **Paradigm Shift Scenario** requires the rapid and wide spread adoption of storage and control technologies, besides the optimization of supply chain, operations and marketing strategies of the PV industry.

For comparison, the PV-EMPLOYMENT and SET FOR 2020 scenario curves are in figure X and figure X.

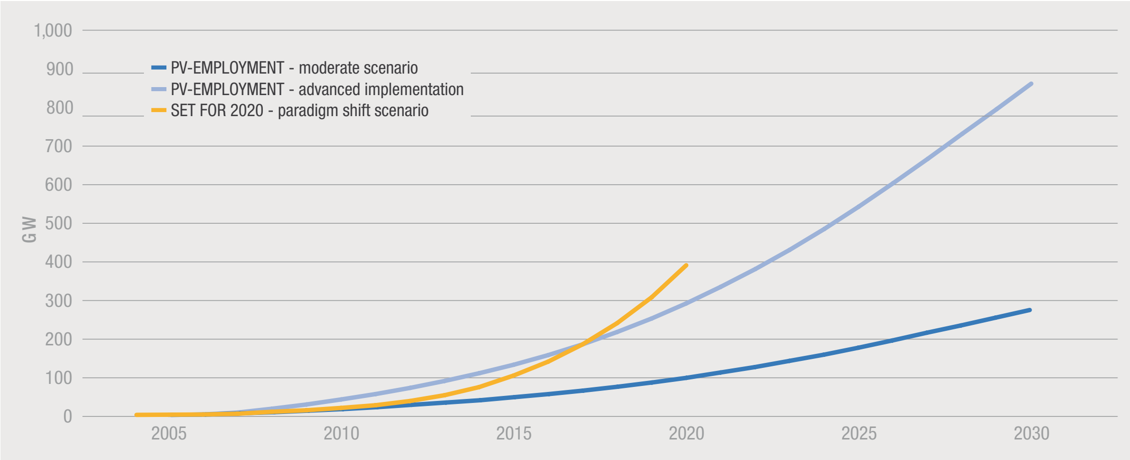
Fig 8. Annual PV power installed (EU27) market scenarios 2005 - 2030[1]
Comparison between PV-EMPLOYMENT and SET FOR 2020



Source: PV-Employment 2009

1: Note that these are historical figures until 2006 and market scenarios from 2007 and onwards.

Fig 9. Cumulative PV power installed (EU27) market scenarios 2005 - 2030 Comparison between PV-EMPLOYMENT and SET FOR 2020

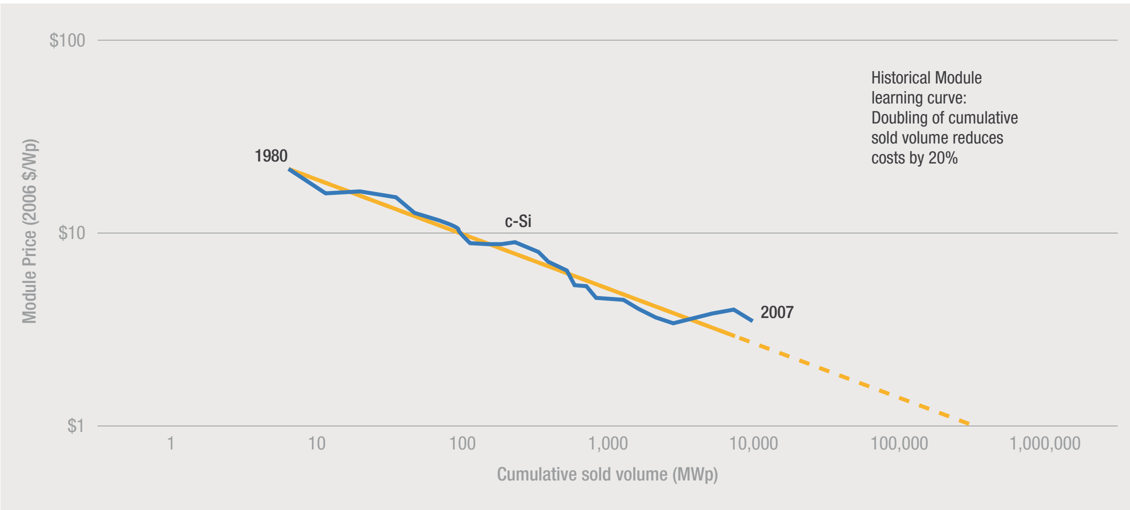


Source: PV-Employment 2009

3.3. PHOTOVOLTAIC SYSTEM PRICES DECREASE

Photovoltaic (PV) solar energy is a technology driven Industry and follows a learning curve which showed over almost 3 decades a 20% module price reduction each time the cumulative PV power installed was doubled.

Fig 10. Price Experience Curve (Module price/Watt)



Source: PV-Employment 2009

The assumptions of future cost development of PV systems based on the assumption that annual production volumes follow this technological learning curve, which have been derived on the literature and intensive discussions with experts from the PV industry. In order to generate price development figures, system cost and assumed learning curves for the most important PV system components (modules, balance of system) have been taken into account.

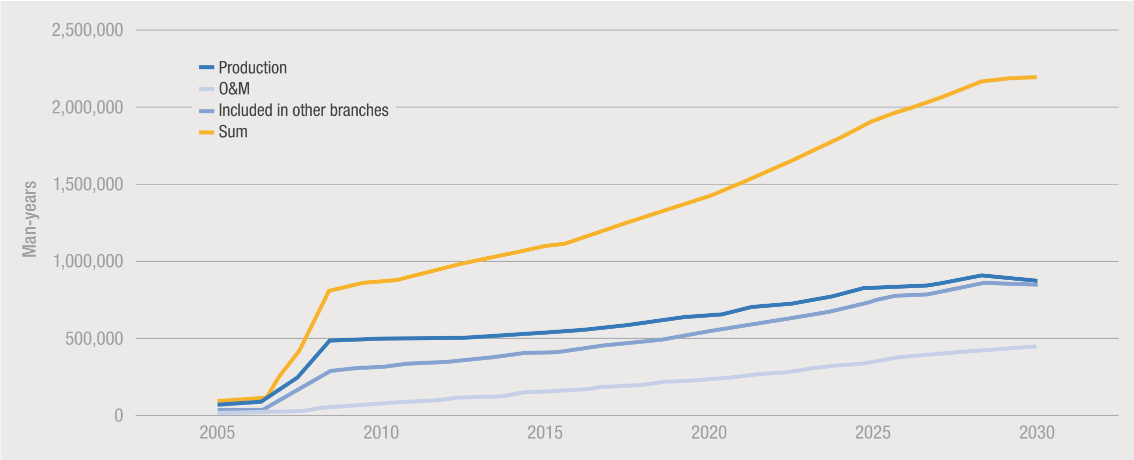
4. MAIN RESULTS OF PV-EMPLOYMENT

4.1. EMPLOYMENT PROSPECTS UNTIL 2030

4.1.1. GROSS EFFECTS

Considering only the positive employment effects (gross effects) in producing, installing and operating PV systems, the amount of jobs generated by the PV sector reaches up to 2.2 million person years in 2030 under the PV-Employment advanced implementation scenario and up to 950 000 person years for the moderate implementation scenario. Figure 11 shows the gross employment effects of the PV-Employment advanced implementation scenario in person years. The effects of the moderate implementation scenario show a similar structure at a lower scale.

Fig 11. Gross employment effects of the advanced implementation scenario (in person years)



Source: PV-Employment 2009

4.1.2. NET EFFECTS

Taking into account the employment lost due to reduced conventional electricity production and reduced general consumption as a result of increased electricity costs (until competitiveness is reached), the project has derived the net employment effects on the substantially increased use of PV.

Compared to the gross employment effects induced, the net employment effects are small and very sensitive to assumptions made. In general, the net effects of the large scale use of PV will be positive in the long run.

If we realistically assume only about 11% export and about 35% import along the whole value chain, Europe will already experience in 2010 a positive net effect on employment. These results are shown in Table 2. The last two rows of Table 2 show that comparatively small exports (between 11.4 and 6.5% of the assumed production for EU27) will be sufficient to balance the picture. Every export beyond this share will turn the net employment effects to positive results right from the beginning. As the model assumes open markets, very high levels of international trade and substantial shares of imports of PV system components, it seems fair to assume at least some export of PV systems from EU27 to the rest of the world.

As the reductions in PV system production costs depend upon the total global volume of annual PV production and as this global production volume was not analysed as part of this study, the length of the initial period with negative employment effects without exports is difficult to assess.

Table 2. Development of future PV gross (without O&M) and net employment effects as a function of production volumes and resulting price development and the respective exports necessary to balance the initial negative net employment effects.

Assumed PV installation	*MWp/a*	10 000	20 000	30 000	40 000	50 000
Gross EU27 employment effect (35% imports, 0% exports)	*in 1000 person years*	830	931	1 039	1 367	645
Net EU27 employment effect (35% imports, 0% exports)	*in 1000 person years*	-95	-102	-108	-88	+294
PV export to the rest of the world, sufficient to balance negative employment effect	*in MWp/a*	1142	2183	3133	2586	0
Necessary exports in % of assumed production		11.4%	10.9%	10.4%	6.5%	0%

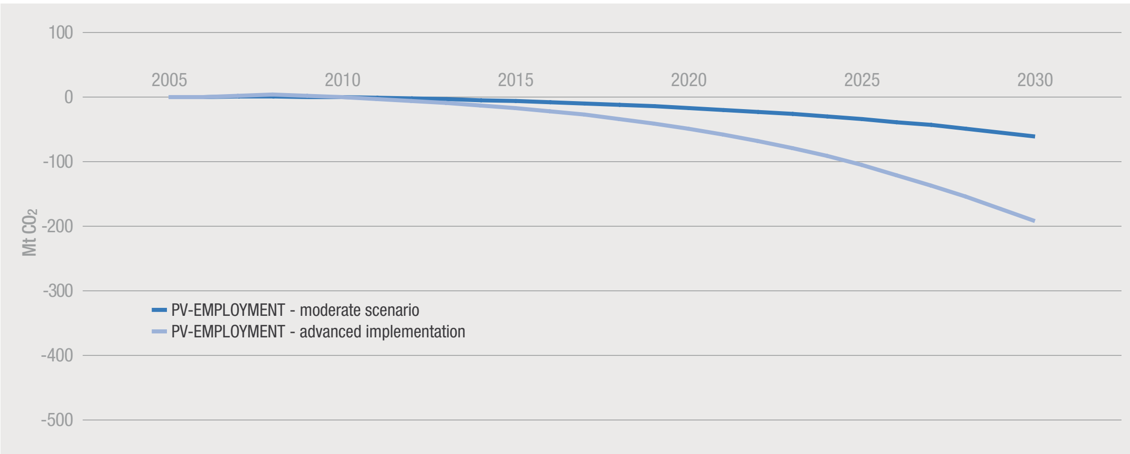
Source: PV-Employment 2009

4.2. CO_2 MITIGATION

As the central task of any future large scale use of PV is a reduction of green house gas emissions, the net emission reductions achieved by the increased use of PV was analyzed.

In the PV-Employment advanced implementation scenario, a net emission reduction of 192 Mt CO_2 per annum can be contributed in 2030.

Fig 12. Net changes in CO_2 emissions through the use of PV in the EU 27 until 2030 (in Mt of CO_2)



Source: PV-Employment 2009

In the long run the use of PV can lead to significant sustainable reductions in green house gas emissions in the European Union.

5. PV-EMPLOYMENT RECOMMENDATIONS

5.1. QUALIFICATION PROFILES AND SKILLS REQUIRED

Based on expert assumptions, not only will PV create jobs but the EU PV Industry will call for highly qualified people. The qualification profiles of these future employees will differ depending on their areas of activity within the PV sector value chain.

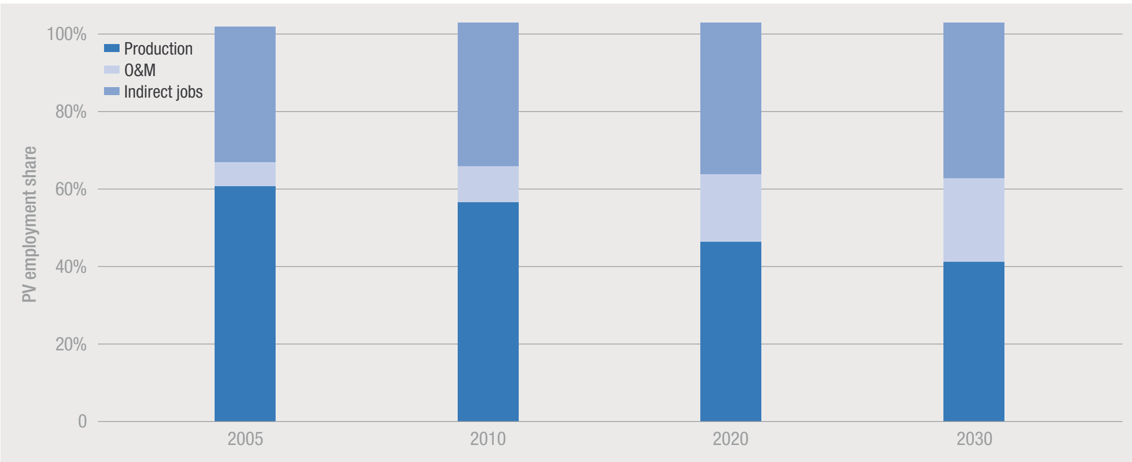
The workforce needed to satisfy this future demand for highly qualified personnel will partly consist of personal explicitly specialised in photovoltaics, or academics from relevant disciplines, trained within the PV sector. In the future, demand for PV specialists should be satisfied by highly skilled academics and skilled labourers, such as the following:

- Highly skilled academics: academics with university studies specialised in photovoltaics, and academics from other disciplines including mainly physics, chemistry, engineering and other technical backgrounds, but also business development, architecture, design, marketing or accounting.
- Skilled labourers: personnel such as technicians or electricians who have undertaken an apprenticeship during their education.

The current major source of employment stems from the production of PV systems – this trend is likely to continue until 2020. In 2005 the production sector witnessed an employment share of 60%, however as forecasts show, this number is likely to decrease to 55% by 2010. By 2020 its share is likely to drop to as low as 45% and is likely to lose shares to operation and maintenance (O&M) activities (see figure 13).

In the long term, most jobs will be created in the O&M of PV systems and in servicing activities. The creation of indirect jobs will also be considerably high, accounting for 39% of the total employment creation.

Fig 13. Evolution of the employment share per stage of the PV value chain



Source: PV-Employment 2009

Qualification profiles of the PV workforce

The qualifications required will differ depending on the stage of the value chain at which personnel to be employed in the PV sector will be active. Hereafter are listed the most relevant qualifications according to the steps of the PV value-chain:

- **Solar grade silicon production, ingots production and solar cell production:** skilled staff with a clear background in chemistry, physics or related academic studies with a great level of specialisation and knowledge in the PV sector.
- **PV system integrators:** technicians for the integration of roof top mounted systems and engineers for the integration of ground mounted systems. In addition, highly skilled staff are required to provide services such as management, contracting, design and marketing issues.
- **Installation:** qualified technicians.
- **Operation and maintenance:** no academic or scientific background required.
- **Recycling of PV modules:** qualified and trained staff in chemistry, physics or related academic studies and with a clear understanding of recycling issues in relation to solar cells, silver, glass, aluminium, foils, electrical components, copper and steel components.
- **Research and development:** experienced scientists and engineers with a high level of specialisation in photovoltaics.

Besides these general observations, companies active in the PV industry currently are setting basic requirements about the educational background of the employees working in the PV sector. According to these companies employees should have a multidisciplinary education, with detailed technical basic knowledge in one field (physics, electrical engineering, computer science, mechanical engineering) and an additional post-graduate training in photovoltaic energy. They highlight the importance of practical training in photovoltaics. They strongly recommend project oriented post-graduate education, lab courses where real practical experience can be obtained and external trainings in the industry.

5.2. THE NEED FOR APPROPRIATE PROGRAMMES FROM EDUCATION INSTITUTIONS

The current status of PV qualifications features that qualified staff is missing on all levels: generally, engineers are not qualified, installers are missing training for complex systems, very few researchers work on almost all topics, architects are not aware of possibilities, and the production sector is also missing highly qualified people. Consequently, capacity building is needed on all levels of education.

Appropriate programmes and measures are needed from education institutions:

- **Strengthen and adapt the quality of their current curriculums.** Academics and technicians attending the courses need to acquire a high level of specialisation.
- **Increase considerably the offer for specific courses in photovoltaics,** in order to meet the demand of 50,000 new direct jobs[2] created annually between 2006 and 2030.
- PV education should ideally be provided in the form of **specialised PV masters**, or as an additional **post-graduate training in photovoltaic energy**.
- The indirect effects of photovoltaics will play a very important role in the creation of employment, i.e. the creation of indirect jobs. This will generate a high demand for academics coming from different disciplines, who will have to **get specific training in renewable energies**.
- Experts highlight the importance of early practical training in photovoltaics. Project oriented education, external trainings in the industry, or/and lab courses where to get really practical experience are strongly encouraged.

2: under the advanced scenario.

5.3. PROPER FRAMEWORK CONDITIONS FOR PV DEPLOYMENT

A prerequisite to the sustainable and long-term development of photovoltaic markets in Europe is the adoption of pro-active policies by decision makers at European and National level. The wide deployment of PV would also be facilitated by stakeholders and utilities in particular:

Europe is today leading the development of renewable energies and in particular the development of photovoltaic markets. The following recommendations towards the stakeholders of the PV sector are essential if Europe is to keep this leadership and even further increase its independence:

- **EU bodies** should:
  - **Boost the European export potential** of PV technology by taking decisive action, in the context of the economic recovery package and beyond, on **PV integration** and facilitating **investment in EU-based production capacities**.
  - **Support PV R&D efforts and large demonstration projects**, with a focus on accelerated cost reduction and integrated approaches to making the necessary changes in the power distribution system.
  - **promote time-of-use electricity billing and net metering** to facilitate the penetration of renewable energy sources.
  - **Quality standards:** the EU **must further promote PV market deployment by supporting high and certified European quality standards which will help lowering the investment** barrier and enable differentiation and competitiveness of the EU industry.

- National governments should:
  - Act swiftly to **de-bottleneck administrative procedures**.
  - Ensure **sustainable levels of financial support by means of well-designed feed-in tariffs** to ensure continuous PV deployment;
  - Be proactive in **facilitating domestic investment in PV production** capacity;
  - **Supplying the required skilled workforce** through adapted education and training programmes.

- **Utility sector companies** should:
  - **Become proactive PV investors** and marketers to maintain or expand their market share by meeting customer demand and offering them advanced customer services.

- **Grid operators** should:
  - Help **decentralise the infrastructure**;
  - Become actively involved in **implementing the necessary smart grid technology** such as improved measurement and communication technology;
  - Help develop and install **storage technologies** to increase the absorption of distributed power in grids;
  - Collaborate with the renewable-energy sector to **ensure that regulators reflect the necessary investments in their distribution tariffs**.

CREDITS

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