MSc Program
Renewable Energy in Central and Eastern Europe

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How to increase the competitiveness of the Austrian Photovoltaic industry on global scale –

Analysis of the legal and economic framework in Japan, Spain and Germany to screen best practises for the transfer to Austria.

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Vienna, November 15, 2010

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Affidavit

I, **Mag. Tatjana Rössler**, hereby declare

1. that I am the sole author of the present Master Thesis, "How to increase the competitiveness of the Austrian Photovoltaic industry on global scale - Analysis of the legal and economic framework in Japan, Spain and Germany to screen best practises for the transfer to Austria.", 95 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master Thesis as an examination paper in any form in Austria or abroad.

Vienna, 10.11.2010 ___________________________

Abstract

Photovoltaic is in the position to contribute significantly to the Austrian electricity generation. Therefore, clear political commitment to this technology and a long term supportive framework is required. Austria´s competitive advantage on global scale is to find either in niche products where technology leadership has to be developed quickly or in the maintenance of leadership already obtained, such as in the inverter or tracking industry. Any investment in Austria´s PV industry pays off as a lot of new labour places can be created and an attractive business value for Austria can be generated. In concrete numbers, quick political actions to create a supportive framework now have the potential to generate a value added of up to 7 billion EUR a year and at least 36,000 labour places in Austria by 2020 according to Photovoltaic Austria.

Severe price drops in solar technology have taken place since late 2008. Combined with the rising costs of fossil fuels, this makes investments in PV applications increasingly attractive and grid parity is estimated to be achieved already between 2015 and 2018 in Austria. However, until grid parity is achieved, the Austrian government has to set some actions to foster PV deployment and establish a competitive PV industry. Germany, Japan and Spain are leading countries in terms of installed capacities, export of PV cells or modules and R&D efforts. The Austrian PV industry produces PV components almost exclusively for the export due to the lack of a home market. The Austrian government has a central role to enable further success of the Austrian PV industry. At present it seems to be more an issue of not blocking the development because all other stakeholders are very much aware of the huge potential PV has for Austria and are ready to go for it. It is crucial to understand for the Austrian government that PV is a mature sustainable technology which has its market demand on national and international level for the Austrian PV industry, and which requires R&D support and a stable legal and economic framework for its deployment, conditions which the Austrian government ought to provide now.

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List of abbreviations

AC	Alternating Current
AEF	Spanish Photovoltaic Business Association
ANPER	Spanish Association of Renewable Energy Producers
ANRE	Japanese Agency for Natural Resources and Energy
APPA	Spanish Renewable Energy Association
approx.	approximately
ASIF	Spanish Photovoltaic Industry Association
a-Si	Amorphous Silicon
BIPV	Building Integrated Photovoltaics
BMBF	German Federal Ministry of Education and Research
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMVIT	Austrian Federal Ministry of Transport, Innovation and Technology
bn	billion
BOS	Balance Of Systems
BSW	German Solar Industry Association
Btu	British thermal unit
c-Si	Crystalline Silicon
CdTe	Cadmium Telluride
CIS	Copper Indium Selenide
CNE	Spanish National Energy Commission
CSP	Concentrated Solar Power systems
DC	Direct Current
EC	European Commission
ECF	European Climate Foundation
EEG	Austrian Energy Economics Group
EEG	German Renewable Energy Sources Act
EPBD	Energy Performance of Buildings Directive
EPIA	European Photovoltaic Industry Association
EREC	European Renewable Energy Council
EU	European Union
EU PV	European Photovoltaic Platform
EUR	Euro(s)
FEPC	Japanese Federation of Electric Power Companies
FIT	Feed-In-Tariff
FX	Foreign Exchange Rate
FY	Fiscal Year
GEA	Austrian Green Electricity Act
GW	Gigawatt
GWh	Gigawatt hour
GW_p	Gigawatt peak
ICO	Spanish public promotion bank
IDAE	Spanish national energy agency
IEA	International Energy Agency
IEEJ	Japanese Institute of Energy Economics
IEO	International Energy Outlook
IIASA	Austrian International Institute for Applied Systems Analysis
JPEA	Japanese Photovoltaic Energy Association
JPY	Japanese Yen
JRC	Joint Research Centre
JREPP	Japanese Renewable Energy Policy Platform
KfW	German bank
kg	kilogram

KliEn	Austrian Fund for Climate and Energy
kWh	Kilowatt hours
mc-Si	Multicrystalline Silicon
MAFF	Japanese Ministry of Agriculture, Forestry and Fisheries
max.	maximum
mc	multicrystalline
MCyT	Japanese Ministry of Science and Technology
MEC	Japanese Ministry of Education and Science
METI	Japanese Ministry of Economy, Trade and Industry
MEXT	Japanese Ministry of Education, Culture, Sports, Science and Technology
Mio.	Million
MLIT	Japanese Ministry of Land, Infrastructure and Transport
MOE	Japanese Ministry of the Environment
MW	Megawatt
MWh	Megawatt hours
MW_p	Megawatt peak
NEDO	Japanese New Energy and Industrial Technology Development Organization
NEF	Japanese New Energy Foundation
NREAP	National Renewable Energy Action Plan
OECD	Organization for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PER	Spanish Renewable Energy Plan
PR	Public Relation
PV	Photovoltaic(s)
PV-TRAC	Photovoltaic Technology Research Advisory Council
PVA	Photovoltaics Austria
R&D	Research and Development
RD	Royal Decree
RES	Renewable Energy Sources
RPS	Renewable Portfolio Standard
sc	single crystalline
SEII	Solar Europe Industry Initiative
SET	Strategic Energy Technology Plan
SHS	Solar Home System
Si	Silicon
SMEs	Small and Medium sized Enterprises
SRA	Strategic Research Agenda
TBC	Technical Building Code
to/yr	tons per year
TU	Technical University
TWh	Terawatt hours
U.S.	United States
W	Watt
yr	year

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1 Introduction

Solar Photovoltaic is a convincing mature and sustainable technology which has at present huge success in several countries in the world. By the end of 2009, the global solar PV electricity market saw about 7.2 GW of new capacity installed, bringing the total global cumulative installed capacity to around 23 GW worldwide. The leading countries at that time were Germany (9.8 GW), Spain (3.4 GW) and Japan (2.6 GW). By the end of 2009, PV accounted for 3 % of the electricity generation in Spain and for about 2 % of the electricity generation in Bavaria, a federal state of Germany, whereas in Austria this ratio was close to zero percent.

As evidenced in the EPIA SET for 2020 study published in 2007, PV could provide up to 12 % of the EU's electricity demand by 2020, provided specific boundary conditions are met. According to the Global Market Outlook for Photovoltaics until 2014 published by EPIA in 2010, the global PV market could reach in a policy driven scenario up to 30 GW in 2014 based on favorable conditions established by policy makers, regulators, and the energy sector at large. In the current pre-competitive phase, PV market deployment is to a large extent dependent on the political framework of any given country. Support mechanisms are defined in national laws. The introduction, modification or fading out of such support schemes have profound consequences on PV markets and industries. The Austrian PV industry has a clear potential to participate in this worldwide *PV boom* generating labour places and business value for the country. Thus, the present work investigates how the Austrian PV industry can become more competitive on global scale.

First, a quick overview of the current energy situation in the world will be provided in terms of energy consumption, electricity generation and regarding the role solar photovoltaic plays so far among Renewables. Then, the solar photovoltaic landscapes of Japan, Spain, Germany and Austria will be looked at regarding the historic market development, policies in place and the present PV industry in order to screen best practices and to highlight learning outcomes. Afterwards, a comparison between these four countries is accomplished, and finally, recommendations for the Austrian Stakeholders are given.

2 World energy snapshot

2.1 Current energy mix

In 2009, Renewable energy supplied around 19 % (an estimated 1,230 GW) of the **Global Energy Consumption** according to the Renewables 2010 Global Status Report published by REN21. Further, the Global Energy demand is served by 78 % Fossil fuels and 3 % Nuclear power. The contribution of Solar Photovoltaic energy to the current global energy mix amounts to less than 0.5 % and is not yet very present.

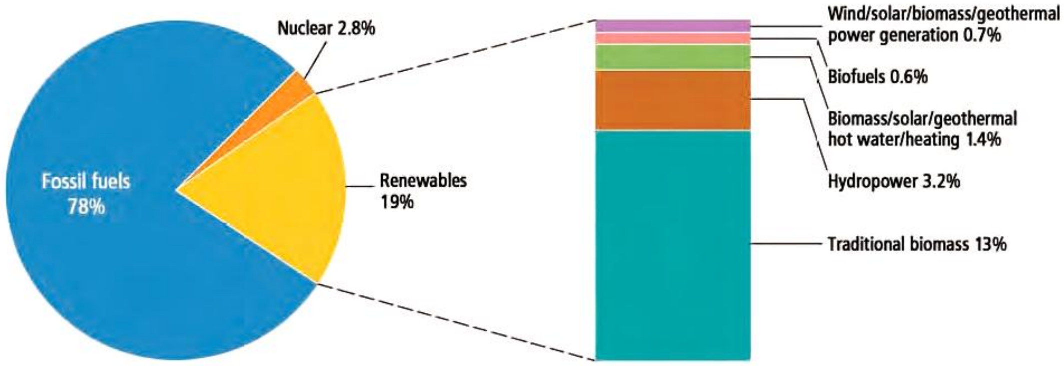


Figure 2-1: Renewable Energy Share of Global Final Energy Consumption 2009 (Sawin, J.L. & Martinot, E. 2010, REN21)

Looking at the **Global Electricity Generation**, around 70 % are contributed by Fossil fuels, 13 % by Nuclear power (!) and 18 % are provided by Renewables, mainly Hydropower. The contribution of Solar Power amounts to less than 0.1 %.

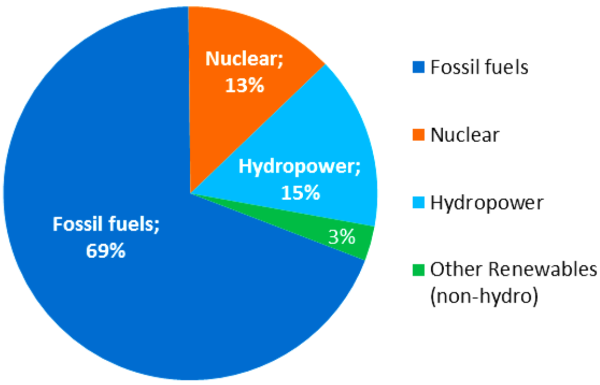


Figure 2-2: Share of Global Electricity Generation from Renewable Energy 2009 (Redrawn from Sawin, J.L. & Martinot, E. 2010, REN21)

However, Solar Photovoltaics accounted for about 16 % of all *new* electric power capacity additions in EU-27 in 2009. Thus, Solar Photovoltaic Power is to comprehend as a huge potential to replace conventional power technologies in the near future.

2.2 Energy Consumption Outlook

Global Energy Consumption is set to grow 49 % from 495 quadrillion Btu in 2007 to 739 quadrillion Btu in 2035, driven by economic growth in the developing nations of the world, according to the Reference case projection from the International Energy Outlook 2010 (IEO2010) released in May 2010 by the U.S. Energy Information Administration. The total energy demand in non-OECD[1] countries increases by 84 %, compared with an increase of 14 % in OECD economies. That means the Non-OECD energy use increases by 2.2 %/yr and the energy use in the OECD countries grows by 0.5 %/yr.

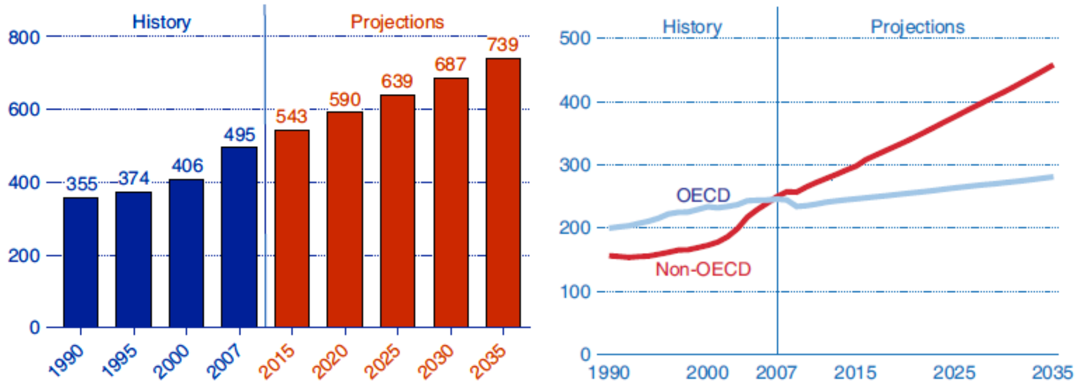


Figure 2-3: World Energy Consumption 1990-2035 in quadrillion Btu (IEO2010)

China and India, which accounted for about 20 % of total world energy consumption in 2007, will continue to lead the world´s energy demand. Thus, assuming strong economic growth in both countries over the projection period, they account for 30 % of world energy use in the IEO2010 Reference case.

Renewables are the fastest-growing source of world energy, with consumption increasing by 2.6 %/yr. The projected increased oil prices as well as concern about the environmental impacts of Fossil fuel use and strong government incentives for increasing the use of renewable energy improve the prospects for renewable energy sources worldwide in the IEO2010 outlook.

[1] Current OECD member countries (as of March 10, 2010) are the United States, Canada, Mexico, Austria, Belgium, Czech republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, Japan, South Korea, Australia, and New Zealand. Chile became a member on May 7, 2010, but its membership is not reflected in IEO2010.

2.3 Electricity Generation Outlook

The IEO2010 further reveals an increase of the **Global Electricity Generation** by 87 %, from 18.8 trillion kWh in 2007 to 25.0 trillion kWh in 2020 and to 35.2 trillion kWh in 2035. In OECD countries, where electricity markets are well established and consumption patterns are mature, the growth of electricity demand is slower than in non-OECD countries, where a large amount of potential remains unmet. Thus, the total net generation in non-OECD countries increases on average by 3.3 %/yr and in OECD economies by 1.1 %/yr.

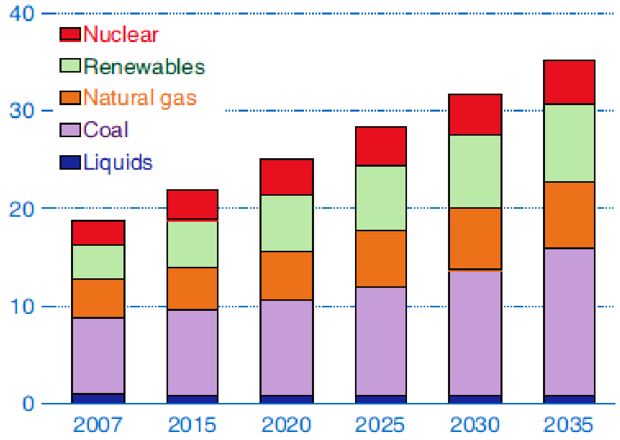


Figure 2-4: World net electricity generation by fuel 2007-2035 in trillion kWh (IEO2010)

From 2007 to 2035, the **Global Renewable Energy Use for Electricity Generation** grows by an average of 3.0 %/yr and the renewable share of world electricity generation increases up to 23 % in 2035. However, in order to reach this forecast, it has to be kept in mind that Renewables are still very much dependent on national policies in place in the upcoming years.

2.4 Solar Photovoltaic Electricity Generation

Looking at the years 2004-2009, **Global Renewable Energy Capacity** grew at an average rate of 40 % annually according to the Global Status Report by REN21. In the last two years, in both the United States and the European Union, more renewable power capacity was newly installed than conventional power capacity. From all renewable technologies **Solar Photovoltaic Power** has been increasing fastest with growth rates above 60 % over the past five years. In 2009, Solar PV provided almost 0.1 % of total global electricity generation.

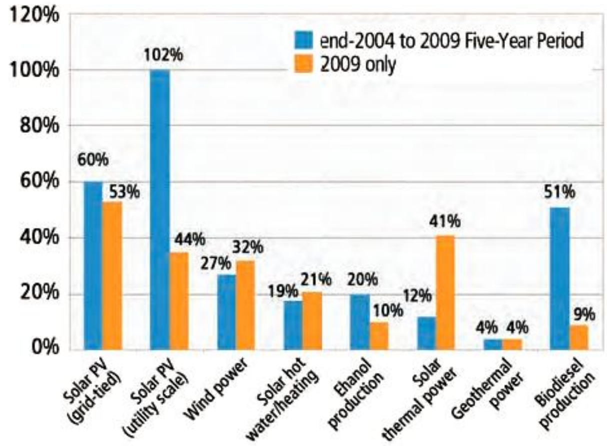
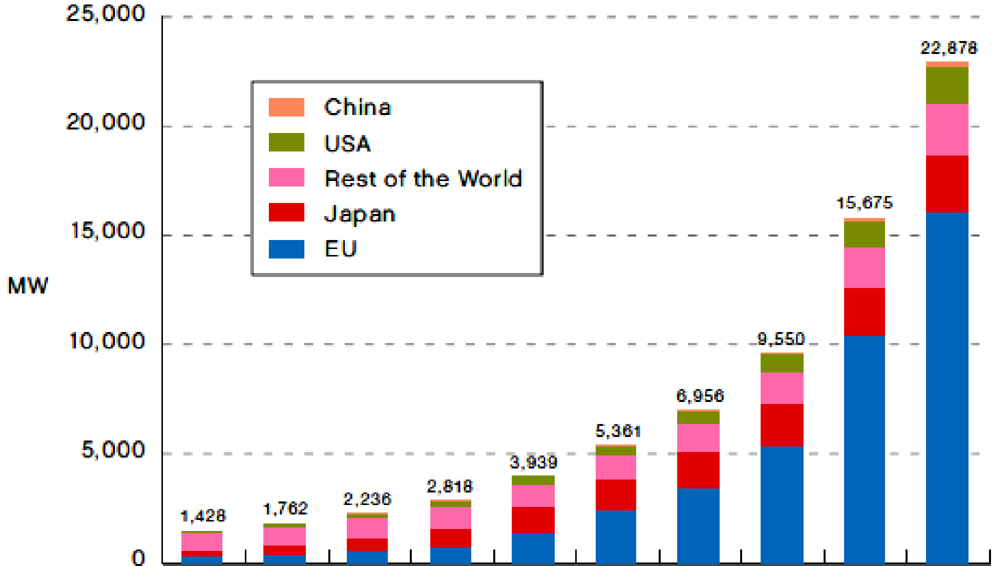


Figure 2-5: Average Annual Growth Rates of Renewable Energy Capacity 2004 to 2009 (Sawin, J.L. & Martinot, E. 2010, REN21)

By the end of 2009, the world cumulative PV power installed was around 23 GW, which produce about 25 TWh of electricity on a yearly basis.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
China	19	30	45	55	64	68	80	100	145	305
USA	139	168	212	275	365	479	624	831	1,173	1,650
ROW	763	825	913	1,000	1,044	1,051	1,235	1,422	1,870	2,347
Japan	318	452	637	860	1,132	1,422	1,708	1,919	2,149	2,633
EU	189	286	429	628	1,334	2,341	3,309	5,279	10,338	15,943
Total	1,428	1,762	2,236	2,818	3,939	5,361	6,956	9,550	15,675	22,878

Figure 2-6: World cumulative PV power installed in main geographies (Despotou, E. et al. 2010, EPIA)

The biggest contribution comes from the European Union with almost 16 GW installed capacity corresponding to roughly 70 % of the world cumulative PV power installed. The top markets in terms of cumulative installed capacity in 2009 were

Germany (9.8 GW), Spain (3.4 GW) and Japan (2.6 GW). The relative shares are displayed in the figure below.

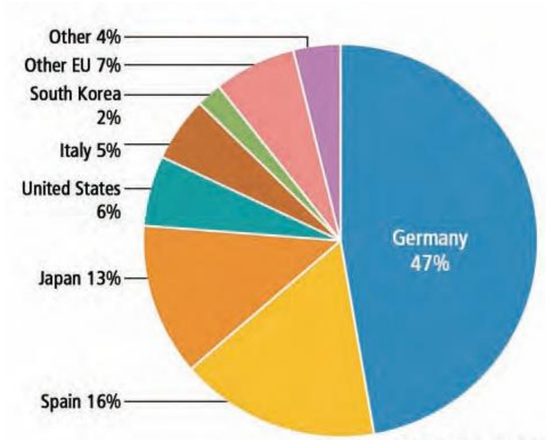


Figure 2-7: Solar PV Existing Capacity, Top six countries (Sawin, J.L. & Martinot, E. 2010, REN21)

Looking at the yearly installed capacity, the annual market has developed from less than 1 GW up to 2003 to a record high of more than 7 GW in 2009 in spite of the difficult financial and economic circumstances. The biggest contribution was made by Germany with 3.8 GW newly installed capacity.

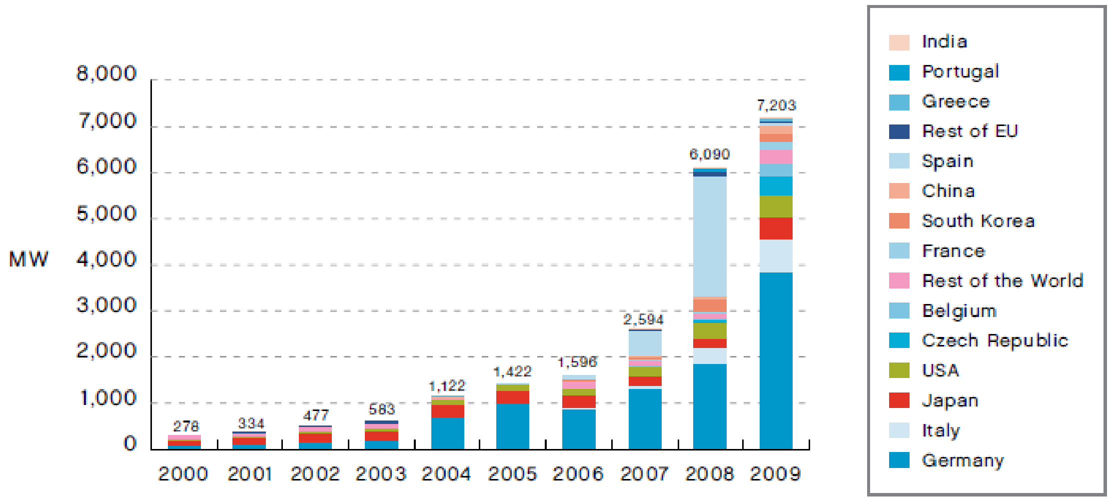


Figure 2-8: World PV power installed per year and countries (Despotou, E. et al. 2010, EPIA)

From 2007 to 2008, the new installed capacity was more than doubled mainly due to the exceptional development in the Spanish market, which almost increased five-fold from 560 MW in 2007 to about 2.7 GW in 2008 due to a very favorable national support system. In 2009, the Spanish Government introduced a cap of 500 MW on the yearly installations, which led to a strong reduction of new installations.

As the newly installed solar capacity in Germany increased by 3 GW in the first half of 2010, the German Government decided to cut its national support further. However, by the end of 2010 a new installed capacity of 8 GW is estimated.

2.5 Global Solar Photovoltaic industry

Another noteworthy development is the fact that the market share of the ten largest solar cell manufacturing companies together further decreased from 80 % in 2004 to 50 % in 2008. That means an increasing number of solar cell manufacturers are entering the market. The most rapid expansion of production capacities has been observed recently in China and Taiwan. Other countries like India, Malaysia and South Korea are following the example to attract investment in the solar sector (Jäger-Waldau, A. et al. 2009).

2.5.1 Leading solar cell manufacturers

The top 15 manufacturers produced 65 % of the solar cells produced in 2009. Firms in mainland China and Taiwan produced the biggest part (31 %) of the global total, followed by the United States (14 %), Japan (12 %) and Europe (5 %). First Solar from the U.S. became the first PV manufacturer to produce more than 1 GW in a single year in 2009. Most of the modules are produced in China.[2]

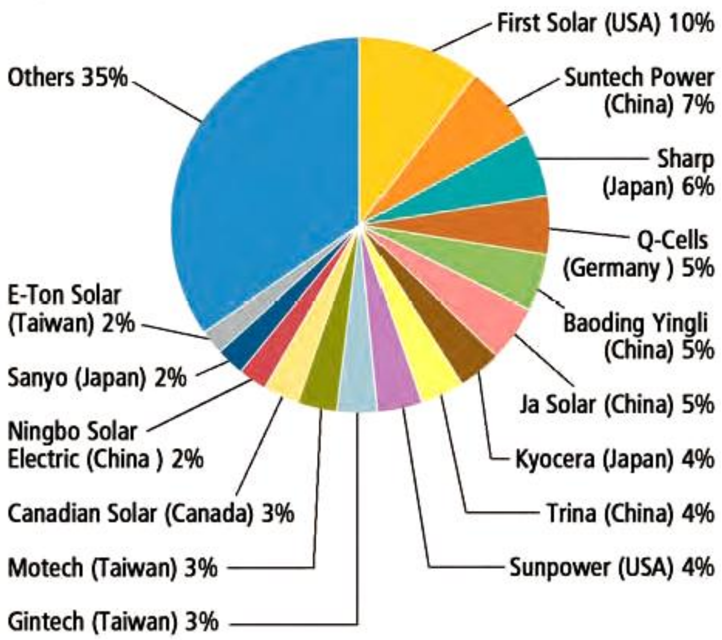


Figure 2-9: Market Share of Top 15 Solar PV manufacturers (Sawin, J.L. & Martinot, E. 2010, REN21)

[2] The top ten module manufacturers in the period 2008-2010 are according to iSuppli Corporation (photovoltaic 06/2010): 1. Suntech (CN), 2. Sharp (JP), 3. Yingli (CN), 4. SunPower (U.S.), 5. Trina Solar (CN), 6. Canadian Solar, 7. Solarfun (CN), 8. Kyocera (JP), 9. Sanyo Electric (JP), 10. Solarworld (DE).

However, looking at the 35 % of *Others* and having in mind that the market shares of the biggest companies tend to decrease there seems to be plenty of space for smaller sized companies to compete on global scale in PV niche markets.

2.5.2 Solar cell supply and demand

In 2006 and 2007, supply and demand are closely matched. During 2008 it happened that prices had risen rather than fallen due to the peak demand from Spain, since project developers were keen to complete their major projects quickly before the end of the favorable FIT in September 2008 (Koot, E. 2010). Thus, from 2008 onwards the supply side finally was growing more rapidly than the demand side of the PV market. Additionally, the demand in the PV industry was quite unbalanced, as 78 % of global shipments went to Europe, primarily to Spain and Germany. With Spain essentially closed as a market in 2009, due to the strong reduction of national support schemes, and Germany facing a decline in its Feed-in Tariff[3], as it was oversold in 2009, a situation of oversupply was built up after all.

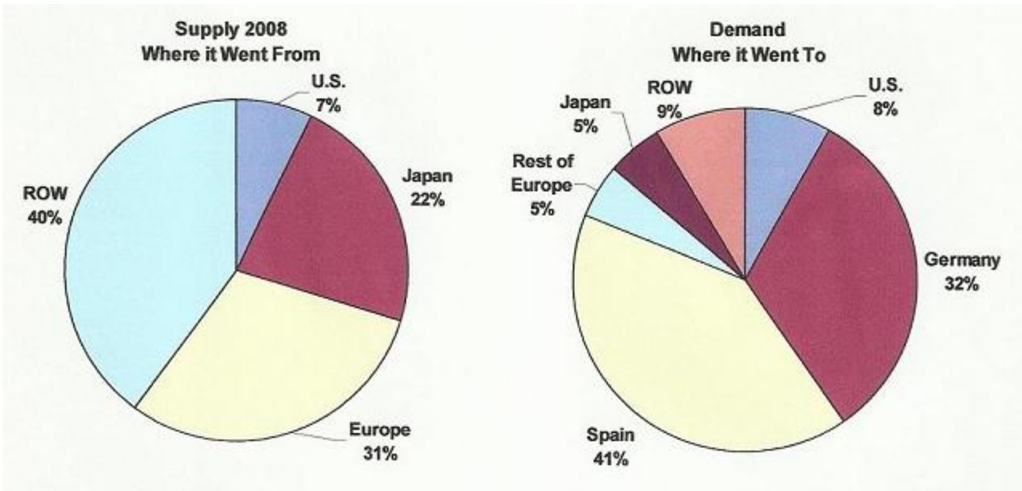


Figure 2-10: Supply and Demand for the PV industry in the world (Navigant Consulting 2008)

The overcome of such a situation is highly dependent on the available subsidies and national support schemes available in leading countries like Germany or Spain as well as on the development of the retail price of electricity. The oversupply situation could have two important consequences for the PV market: First, a price decrease for solar modules, and second, a consolidation in the PV industry. As a consequence, grid parity will be reached in several markets and lead to another

[3] A *Feed-in Tariff (FIT)* is a policy that (a) guarantees grid access to renewable energy producers; and (b) sets a fixed guaranteed price over a fixed period of time at which power producers can sell renewable power into the electric power network. Some policies provide a fixed tariff while others provide fixed premiums added to market- or cost-related tariffs.

increase in growth on the demand side. At that time, the global demand will no longer be dependent on any governmental financial support.

2.6 Solar Photovoltaic Outlook

The International Energy Agency estimates in its Roadmap Vision Scenario published in the Technology Roadmap 2010, that PV provides 5 % of global electricity generation in 2030 and 11 % by 2050, which corresponds to 3,000 GW installed PV capacity generating 4,500 TWh per year.

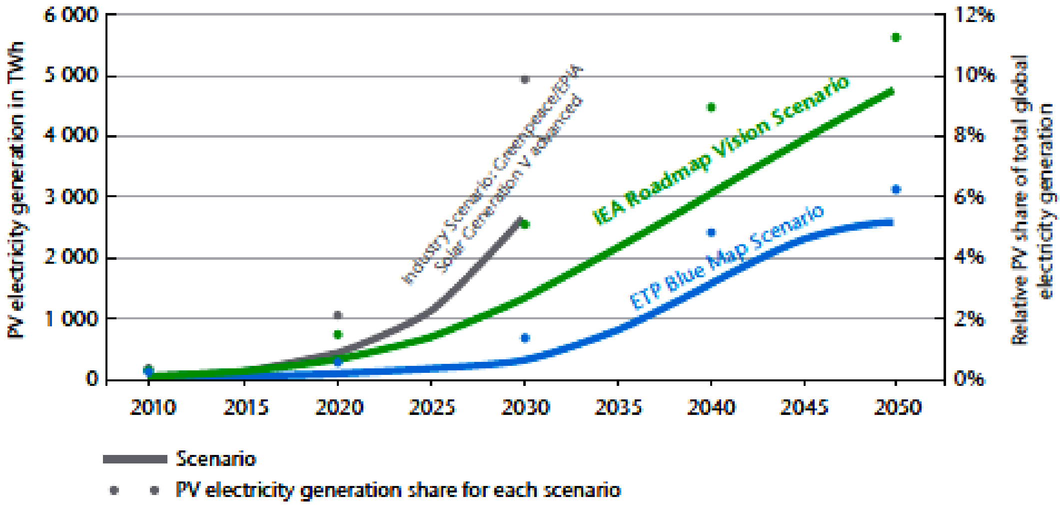


Figure 2-11: Global Solar PV power generation share of total electricity generation (IEA, 2010)

However, this will be achieved only if supporting policies are established by the national governments *in the present decade*, a topic which will be discussed in the country sections into more detail. In the following, the solar photovoltaic technology itself will be looked at briefly.

3 Solar Photovoltaic technology snapshot

The basic building block of a PV system is the PV cell, which is a semiconductor[4] device that converts solar energy into direct-current (DC) electricity. When light shines on the cell it creates an electric field across the semiconductor layers, causing electricity to flow. PV cells are interconnected to form a PV module, typically up to 50-200 Watts (W). The modules performance is very high providing over 80 % of the initial power after 25 years, which makes PV a very reliable technology in the

[4] A semiconductor is neither an insulator like glass, nor a conductor like copper, but something in between. Silicon in its pure state, for example, is referred to as an intrinsic semiconductor. At low temperatures it acts as an insulator, at higher temperatures, when sufficient light shines on the crystal, it becomes a conductor with support of a special semiconductor junction, a mechanism called *p-n junction*.

long term. The degradation of PV modules varies from the type of PV modules installed. The loss of power production within the lifetime of 20-25 years is estimated to 10-20 % for crystalline PV modules. The energy pay-back time, the time needed for a PV system to repay the energy spent for its manufacturing, is approx. 2 years.
Looking into more detail in the solar cell technology, there are three key elements in a solar cell which form the basis of their manufacturing technology: The first is the semiconductor, which absorbs light and converts it into electron-whole pairs. The second is the semiconductor junction, which separates the photo generated carriers (electrons and holes). The third is the contacts on the front and back of the cell that allow the current to flow to the external circuit. There are two main categories of technology defined by the choice of the semiconductor: either Crystalline Silicon in a *wafer* form or Thin-film Silicon including other materials. Crystalline Silicon[5] solar cells currently account for more than 80 % and Thin-film solar cells for around 20 % of the global annual market today.

3.1 Crystalline Silicon (c-Si)

Crystalline Silicon solar cells, when operated in strong sunlight, have the highest efficiencies[6] of all cells commonly used in terrestrial PV systems. They are approximately 200 µm thick and are stable with guarantees lasting up to 25 years. Fortunately, Silicon in the form of Silicon dioxide (quartz sand) is a very common component in the Earth´s crust and is essentially non-toxic. During the fabrication process of Silicon wafers, unfortunately up to 60 % of the original material gets lost. Consequently, the wafer costs amount to roughly 50 % of the overall manufacturing costs of the Crystalline Silicon solar cell. In the following, Monocrystalline and Multicrystalline Silicon solar cells are described briefly.

Monocrystalline Silicon: This cell – the most efficient type – is made from a very thin slice (*wafer*) of a large single crystal obtained from pure molten Silicon. The circular wafers often have a diameter of 15 cm and are trimmed to a hexagonal shape so that more can be fitted into a module. Monocrystalline Silicon solar cells require a careful and expensive manufacturing process. Typical commercial module

[5] In 2008 the Silicon price reached a peak of approx. 400 U.S. dollars per kg and had dropped by the third quarter of 2010 to approx. 80 U.S. dollar per kilogram (pv magazine 09/2010).

[6] The efficiency of a solar cell or module (also known as a *PV panel*, which contains several series-connected solar cells) is the percentage of solar radiation it converts into electricity. The higher the efficiency, the smaller the surface area for a given power rating. This has to be considered especially when space is limited and also because some of the additional costs of PV systems, especially mounting and fixing modules, are area related. Module efficiencies are slightly lower than cell efficiencies because a module´s surface area cannot be completely filled with cells and the frame also takes up space.

efficiencies fall in the range 12-16 %. The required module surface area to generate 1 kW_p using Monocrystalline Silicon Cells is about 7 m^2/kW_p.

Multicrystalline (mc-Si), also called Polycrystalline Silicon (*poly-Si*): This cell is also produced from pure molten Silicon, but using a casting process. The result is a large irregular multicrystal which is then cut into thin square or rectangular slices to make individual cells. Their random crystal structure is less ideal than with monocrystalline material giving slightly lower cell efficiencies in the range 11-15 %, a disadvantage, which is offset by lower wafer costs. The module surface area is about 8 m^2/kW_p. Multicrystalline Silicon solar cells have overtaken their monocrystalline cousins in volume production over the recent years.

3.2 Thin-film

Thin-film cells are constructed by depositing extremely thin layers of photosensitive materials of 1-2 µm onto a low-cost backing, such as glass, stainless steel or plastic. Compared to manufacturing temperatures of up to 1,500°C for Crystalline Silicon solar cells, Thin-film solar cells require deposition temperatures of between 200°C and 600°C only. The lower material and energy consumption as well as the capability for high automation of module production offer considerable cost savings. Another advantage of Thin-film technologies is their good performance in diffuse light (cloudy conditions). However, the efficiency is lower than for Crystalline Silicon technology, requiring a larger area to achieve the desired power. In the following, the most common Thin-film cells Amorphous Silicon, Copper Indium Diselenide and Cadmium Telluride are described briefly.

Amorphous Silicon (a-Si): Amorphous is referring to the microscopic physical state of a solid in which the atoms are not arranged in the orderly pattern of the crystalline form. Amorphous Silicon solar cells are cheaper than Crystalline Silicon solar cells, but have much lower efficiencies, typically 6-8 %. They are used when space is not at a premium, for example on building facades, or in climates with significant cloud cover and plenty of diffuse light. The surface area required is about 16 m^2/kW_p. A disadvantage of a-Si solar cells is that they degrade their efficiency in the first thousand hours of operation under solar radiation.

Copper Indium Diselenide (CIS): This compound semiconductor offers excellent light absorption in small-grained layers a micrometer or two thick, as well as an efficiency of around 10 %, which is higher than the one of a-Si. The surface area required is about 9 m^2/kW_p. Indium is a comparatively rare element of the Earth´s crust, so availability might become a problem.

Cadmium Telluride (CdTe): Modules of this cell type have the lowest production costs among the current Thin-film technologies and accounted for over 6 % of the world production in 2008, more than any other Thin-film technology (Lynn, P.A., 2010). Their energy pay-back time of 8 months is the shortest time among all existing PV technologies. CdTe modules currently offer efficiencies of around 11 % and require a surface area of approx. 12 m^2/kW_p. Cadmium itself is a heavy metal with environmental issues; however, the chemical form as CdTe is a very stable, non-toxic compound. Furthermore, manufacturers take back these modules at the end of the life for controlled recycling.

3.3 Summary solar cell efficiencies and area requirements

In the figure below, the efficiencies and area requirements of the former mentioned solar cells are summarized:

Type	Typical cell efficiency	Area requirement
Monocrystalline Silicon	12-16 %	7 m^2/kW_p
Multicrystalline Silicon	11-15 %	8 m^2/kW_p
Amorphous Silicon	6-8 %	16 m^2/kW_p
CIS	10 %	9 m^2/kW_p
CdTe	11 %	12 m^2/kW_p

Figure 3-1: Summary of cell efficiency and area requirement (based on data of Lynn, P.A.)

3.4 Solar cell performance and price development

Of course, price matters. PV has high up-front capital costs deriving mainly from the solar cells and very low running costs. The high up-front costs are the main reason why Solar PV cannot compete with retail electricity prices in the market yet and has to be subsidized by national governments. Decreasing solar electricity generation costs and increasing costs for conventional electricity (due to oil and gas prices) are needed that solar power systems will equally become increasingly economic during the next few years and reach **grid parity**. According to the IEA Technology Roadmap 2010, achieving grid parity will require a strong and balanced policy effort *in the present decade* to allow for optimal technology progress, cost reduction and ramp-up of industrial manufacturing for mass deployment.

There are two strategies to cut down the costs for solar cell fabrication which represent half of the costs of a PV system: First, to increase the efficiency and second, to produce the solar cells with less costs by either using a cheaper base material or developing a less cost intensive fabrication process. The first strategy, to increase efficiency, could be realized. Continuing improvements in cell and module efficiencies over the past years have enabled steady reduction in costs. The **learning curve for world PV production** over the period 1987-2009 is shown in the figure below, plotted on logarithmic scales in terms of EUR per peak watt (EUR/W_p) against cumulative peak megawatts (MW_p). Thus, the cost per peak watt fell from about EUR 11 in 1987 to around EUR 5 in 1999 and to almost EUR 2.5 in 2009. This trend corresponds to an average cost reduction of about 20 % for every doubling of cumulative production.

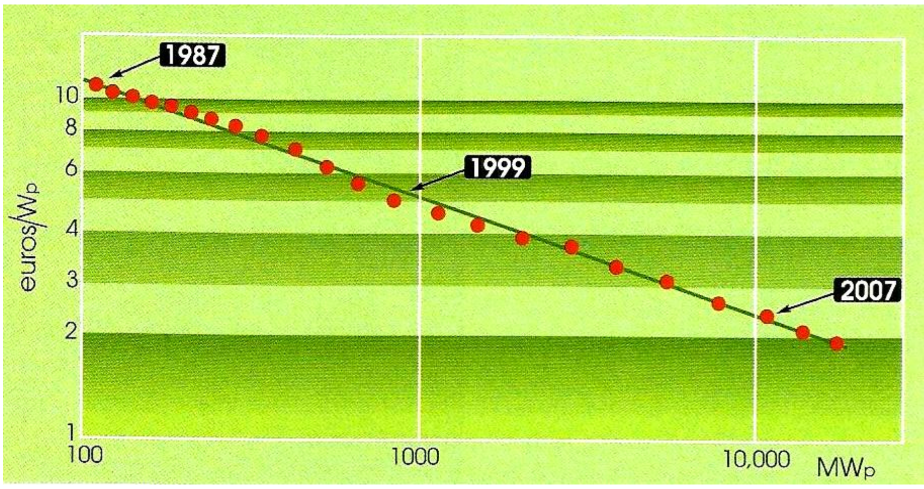


Figure 3-2: The learning curve for cumulative PV production (Lynn, P.A., 2010)

The Solar PV industry saw major declines in module prices in 2009 dropping around 50 % from highs averaging $3.50 per watt in 2008 to below $2.00 per watt in 2009 according to the Global Status Report by REN21. At the beginning of 2010, one Watt of energy generated from photovoltaic sources costs between € 2.50 and € 3.00 in Germany, the Solar PV leading nation. As the degression factor, which reduces the Feed-in-Tariffs each year, encourages technical innovation and cost cutting, further price reductions are inevitable and grid parity comes closer.[7]

The cost of a PV system also depends on balance-of-system (BOS) components, which are all other parts of a PV system than the PV module itself (e.g. wiring, isolators, inverters, etc.). Fortunately, most of these costs are falling in line with cumulative PV production and still represent about half of total system costs.

The decreasing costs for Solar PV enable a substitution with nuclear energy already now. Blackburn and Cunningham announced in July 2010 the Historic Crossover between Solar and Nuclear Costs which has profound implications for North Carolina´s energy and economic future: Solar PV system costs have fallen steadily for decades and they are supposed to fall further in the upcoming years.

[7] Remmers, K.H. & Hansen, S. (2010): PV power plants 2010.

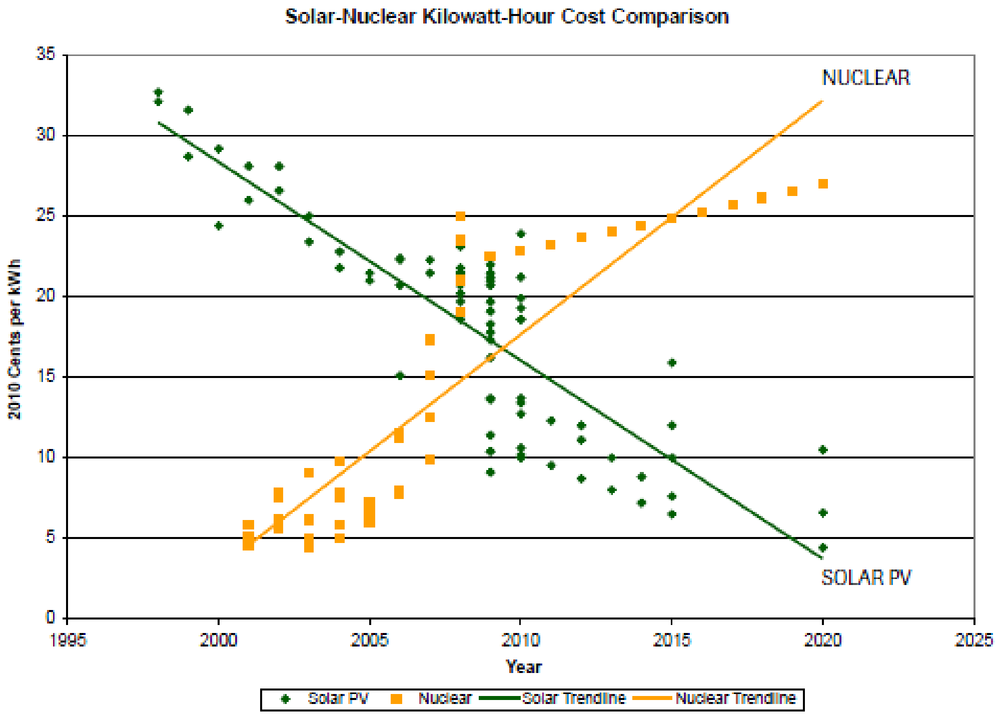


Figure 3-3: Solar-Nuclear kWh cost comparison (Blackburn J.O. & Cunningham, S., 2010)

The projected costs for the construction of new nuclear plants have risen steadily over the last decade and a further increase is assumed. Thus, electricity from new solar installations is now cheaper than electricity from proposed new nuclear plants. The report outlines that both new solar and new nuclear power will cost more than present electricity. Thus, solar electricity without subsidies will be competitive on the market soon. To conclude, the contribution for global electricity generation by nuclear power of 13 % in 2009 could be substituted successively by Solar PV already from 2010 onwards.

In the following, the development of the Solar Photovoltaic landscapes in the three leading PV nations will be looked at into more detail in order to learn more about how this leading position was obtained and to derive best practices which might be transferred to the Austrian situation with the purpose to make the Austrian PV industry more competitive on global scale.

4 Solar Photovoltaic landscape Japan

4.1 Historic market development and PV power installed

Japan´s PV industry reached its worldwide leading position by end of 2004 representing about 30 % of global PV sales and over 60 % of overseas exports of its PV module production. In 2005, this trend was successfully continued as approx. 47 % (833 MW_p) of the solar cells sold worldwide were produced in Japan (PV Status Report 2006, A. Jäger-Waldau). The favorable preconditions for this development were Japan´s highest grid electric costs in the world, increasing domestic energy consumption and high dependence on primary energy imports. Thus, the Japanese government was somehow forced to set actions in this respect (Japan Photovoltaics Market Overview 2005, R. Foster). The idea to use the energy of the sun to generate electricity was born soon as Japan´s solar radiation was high enough (map enclosed in Appendix 11.1.) and PV plants could generate a specific energy yield ranging from 1,000-1,100 kWh/kW_p.
In terms of the historic market development, Japan´s long-term PV research and development started in 1992. Thus, Japan was somehow worldwide *first mover* for remarkable PV R&D and deployment. The successful *New Sunshine Project – 1st stage* (1993-2001) was reviewed in 2000 which led to the outline of the new PV technology program called *Advanced PV Generation* having the basic guidelines to reduce the dependence on petroleum imports and to show commitment to the Kyoto Protocol. By the end of 2004, Japan had already passed the 1 GW benchmark of cumulative installed PV capacity and turned to be the number one on the global market showing a stable market growth of 20-30 % per year. In 2005, another stable market growth followed and Japan dominated the market for PV cells and modules with a share of approx. 47 % of the world´s production. In 2006, the domestic PV market barely grew at all and even fell in 2007 due to the discontinuation of a national subsidy scheme and the increased export to European markets. In 2008, approx. 17 % only of the solar cells produced worldwide were delivered from Japanese companies due to the doubling of worldwide production. Consequently, Japan decided to set some efforts to accelerate the widespread installation of PV from 2009 onwards which were successful: In 2009, the domestic market reached a new installed capacity of 500 MW and the production volume of solar cells and PV modules increased 13.7 % in comparison to the previous year (IEA-PVPS 2010).

Looking at the market segmentation, more than 90 % are grid-connected and less than 10 % are off-grid systems, as the Japanese regulations are mainly pushing the grid-connected market segment. The domestic market is dominated by approx. 85 % residential PV systems having a size of 3.8-4 kW_p. Around 80 % of the residential installations are on existing houses and 20 % are on newly built houses.

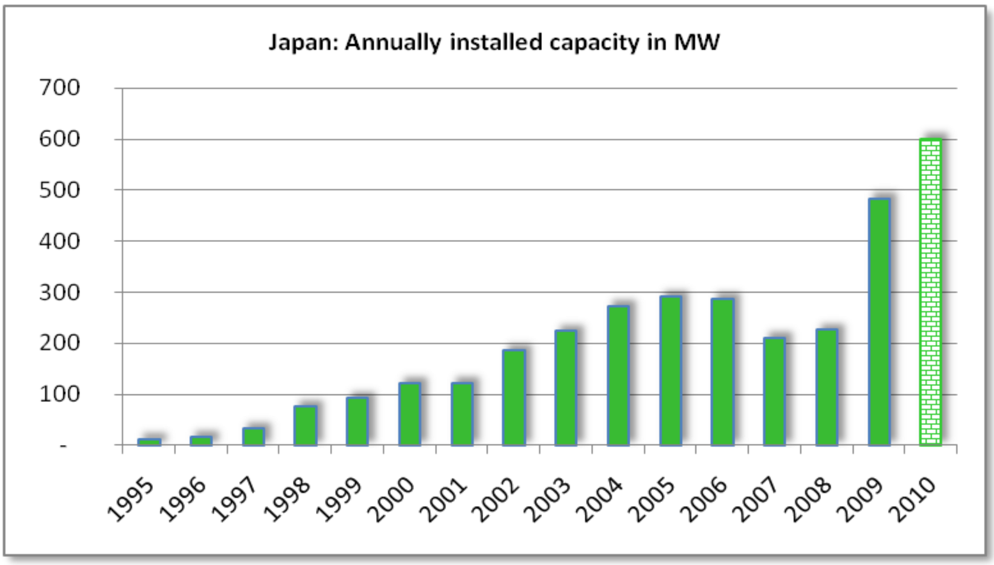


Figure 4-1: Japan´s annually installed capacity in MW
(Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

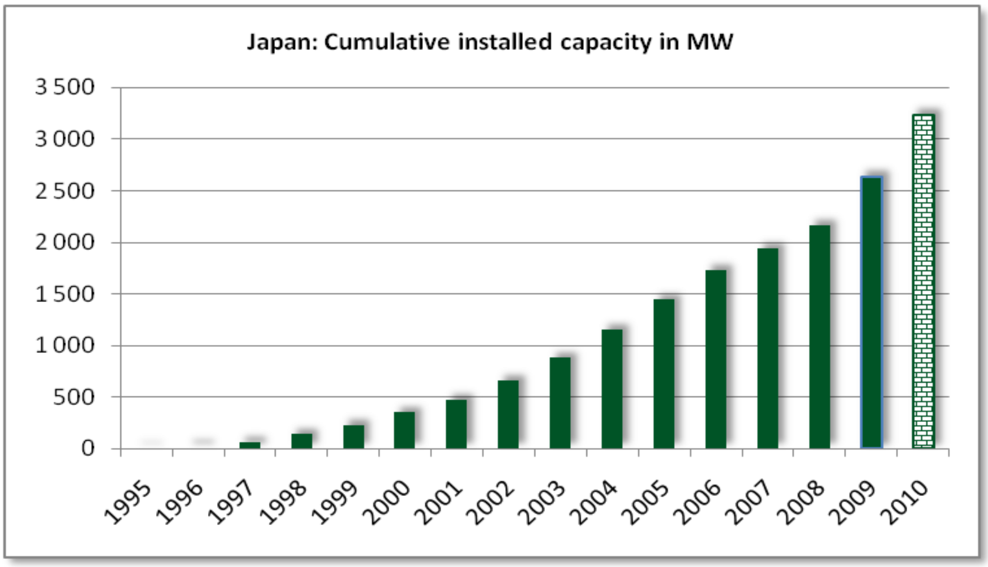


Figure 4-2: Japan´s cumulative installed capacity in MW
(Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

PV is highly accepted in Japan among the customers who focus their attention on economic efficiency and environmental impact. The Japanese culture has always had strong ties to nature and a unique relationship with the sun reflected on their national flag as the Land of Rising Sun. Thus, many Japanese view the use of solar energy as in keeping with their cultural traditions. The signing of the Kyoto Protocol on Global Warming is a matter of pride for the Japanese and it is self-evident to meet the agreed targets on limiting CO_2 emissions. Solar Energy is seen as an important part of the solution to achieving these objectives. This attitude rooting in Japanese culture is highly important for the introduction and dissemination of PV systems. Last but not least, the Japanese government set a good example and mounted PV arrays on the rooftops of many key government buildings.

4.2 Policies and instruments for PV promotion

The principles of Japan´s *New Energy Policy* are to ensure security in energy supply, develop a market mechanism for renewable energy and reduce CO_2 emissions. The PV system market is expected to expand and grow to be a self-sustainable market in the near future, by achieving cost reduction with the government´s support for research, development and introduction of PV systems.
The strategic promotion of PV is based on a combination of different instruments which are net-billing[8], subsidy schemes, fiscal incentives and quota regulations for utilities as well as R&D support. The implementation of national PV strategies is carried out by the Ministry of Economy, Trade and Industry (METI). Under the direction of METI, the New Energy Foundation (NEF) is responsible for the support schemes for residential PV systems and the New Energy and Industrial Technology Development Organization (NEDO) for the support schemes for public and industrial uses. Additionally, local governments may provide their own subsidies and preferential loans to promote PV systems. In the following, national PV incentive tools to promote PV systems carried out by national or local governments and electric utilities are described into more detail.

4.2.1 PV investment support mechanisms - programs

The start was made with the *Monitoring Program for Residential PV Systems* from 1994-1996 being the first program supporting PV installations for homeowners. The subsidy at first covered 50 % of the costs for PV modules, BOS, as well as installation, and was reduced yearly. It was followed by the *Residential PV System Dissemination Program* from 1997-2005 which fulfilled its target to encourage mass production for PV systems leading to a total number of 200,000 PV systems installed. The subsidy scheme focused on residential, grid-connected PV systems and was administrated by NEF. The funding was provided by METI and ANRE. The

[8] Net billing: The electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity fed into the grid is valued at a given price.

total budget for this program was approx. 23 bn JPY in 2001 and 2002. Then, the budget was cut in a half year by year until the program phased out at the end of 2005. Detailed figures are available in Appendix 11.2. With this program, the residential PV market size has expanded to the annual sales of over 60,000 systems (Japan – Photovoltaic technology status and prospects 2004, IEA). In order to qualify for the subsidy, the system capacity had to be below 10 kW and the system installation work had to be completed after the date of receipt of subsidy application. After two years of installation of the PV system, the subsidized user was required to report on system operation on a regular basis, as the program also targeted to collect data of PV operation.

The *Photovoltaic Power Generations Systems for Industrial and Other Applications* program from 1998-2002 targeted private companies and public organizations. Thanks to above mentioned initiatives, PV installations increased to 1.4 MW_p by 2005 of which nearly 80 % were in homes. The following chart summarizes the average PV system price including the corresponding national governmental subsidies for the period 1993-2004.

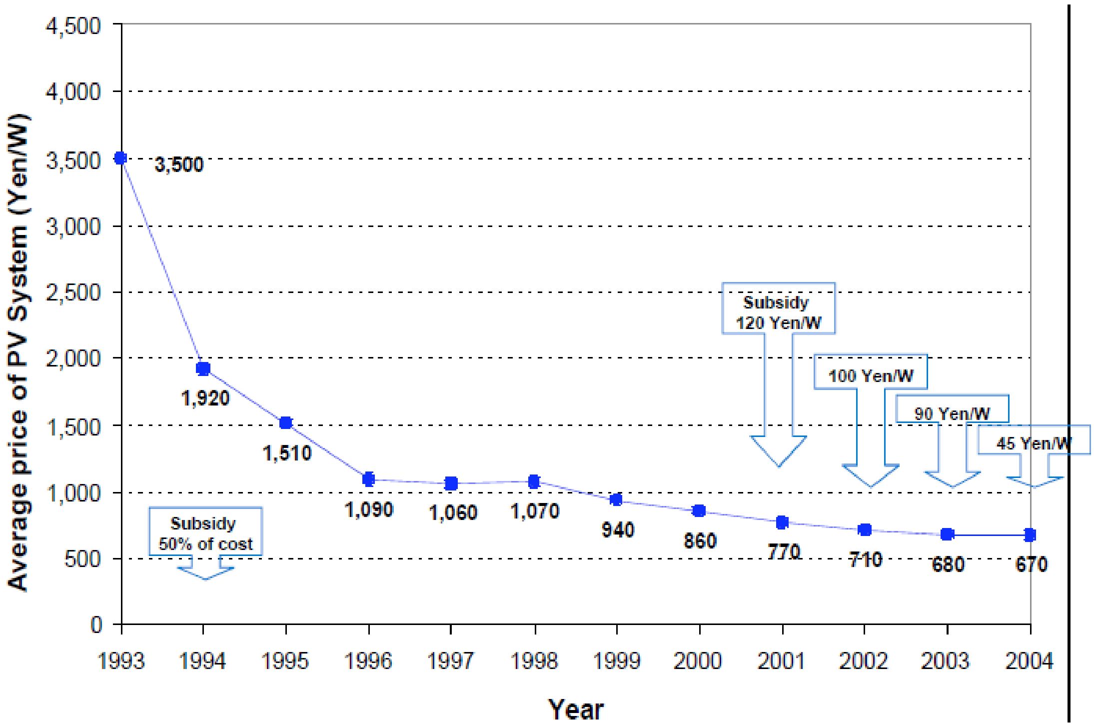


Figure 4-3: Average PV system price and national governmental subsidies in Japan 1993-2004
(Japan Photovoltaics Market Overview 2005, R. Foster)

The average price for $1KW_p$ in the residential sector fell from approx. 2,000,000 JPY/kW_p in 1994 to 670,000 JPY/kW_p in 2004. Therefore, the Japanese government reduced the subsidy program step by step every year from 120 JPY/W in 2001 down to 45 JPY/W in 2004. Notwithstanding the decrease of METI subsidies, the number of residential PV systems in Japan increased considerably during the lifetime of the *Residential PV System Dissemination Program* (1997-2005). Following reasons which contributed to the dissemination of PV systems were identified (PV Status Report 2006, A. Jäger-Waldau):

1- The number of municipalities offering additional subsidies and soft loans for residential PV systems increased substantially.
2- More and more municipalities adopted PV systems for public buildings.
3- PV companies were developing and commercializing systems which are especially adopted for roofs with small areas and complicated shapes.
4- The market for houses which use electricity as the only energy source is increasing and PV systems were adopted as a key item for these *all-electrification* houses.
5- Several housing manufacturers developed *zero-energy houses* which combine PV installation, energy efficient water supply and an airtight housing structure that maintains a constant temperature inside the home. In addition they trained their sales staff to understand the functionality of PV systems.
6- More and more solar cell and house manufacturers promoted PV systems through TV commercials, which lead to an increasing number of consumers who understand PV systems and which influenced their purchase intention.
7- An increasing number of customers focused their attention on economic efficiency as well as an environmental impact.
8- The electricity production in Japan was on averages 950 kWh/kW$_p$ per year, which corresponded to electricity savings of 23,400 JPY/kW$_p$.

In June 2004, the aggressive Japanese *PV Roadmap towards 2030 (PV2030)* was published and developed in collaboration among academic, business and governmental circles with the purpose of *unrestricted mass introduction of PV systems*. This had to be realized in four main areas which are: 1) Economic Efficiency Improvement of PV Power Generation, 2) Enlargement of PV System Application Area, 3) Securement of Raw Material Supply (Silicon, etc.) and 4) Industrial Infrastructure Enhancement. The set target for 2010 was 4.8 GW installed PV capacity. A cumulative capacity of 83 GW of PV in Japan is seen as achievable by 2030, by which time PV could meet 50 % of residential power needs, which is equivalent to about 10 % of Japan´s entire electricity supply. The PV price targets to be achieved by means of R&D, large scale deployment and export sales are 23 JPY/kWh by 2010 (residential rate), 14 JPY/kWh by 2020 (commercial rate) and

7 JPY/kWh by 2030 (industrial rate). The crucial point is to make PV competitive with conventional energy. All price goals are defined in terms of 2002 JPY (FX: 1 EUR = 124.67 JPY, Vienna Stock Exchange 31.12.2002).

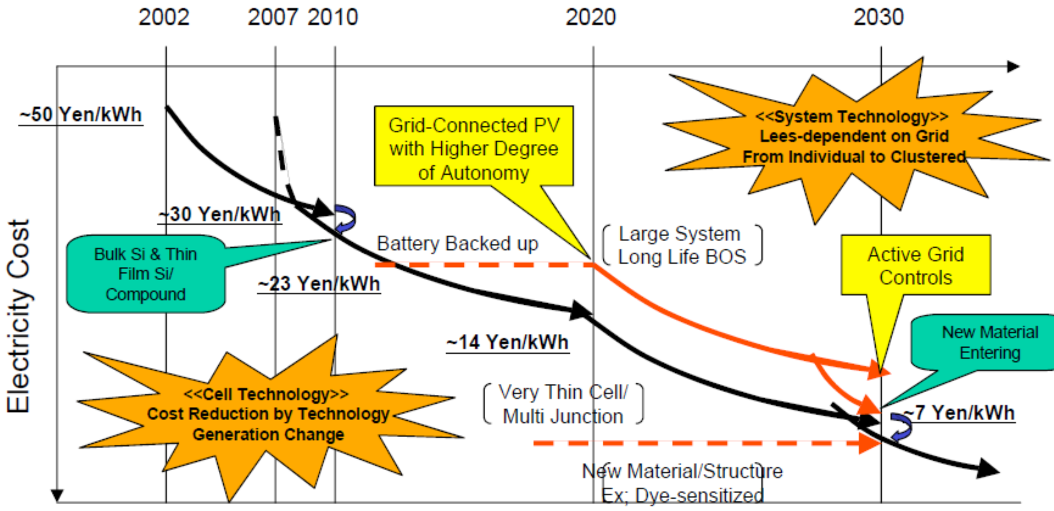
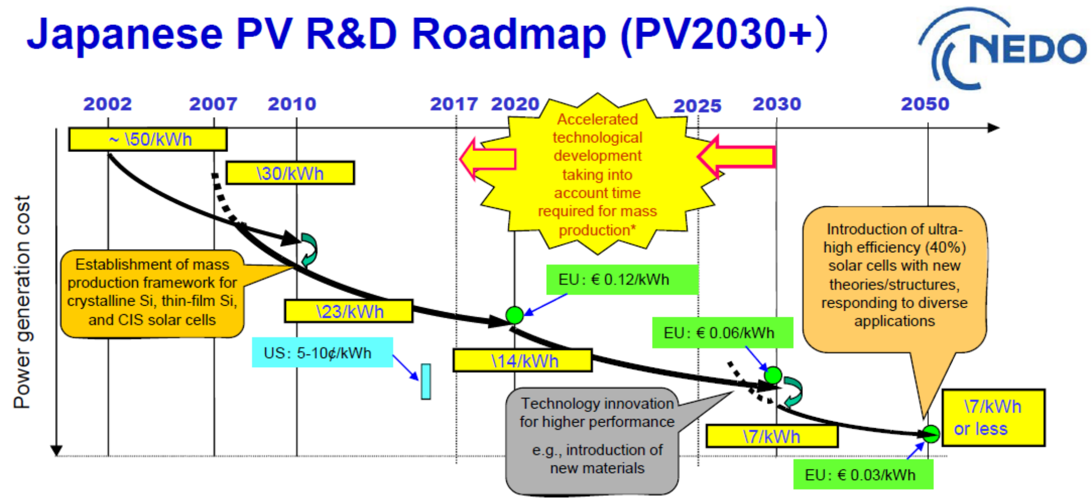


Figure 4-4: Japan´s PV roadmap and system price goals to 2030 (Overview of PV Roadmap toward 2030, NEDO, 2004)

The module manufacturing cost targets are 100 JPY/W in FY2010, 75 JPY/W in FY2020 and 50 JPY/W in FY2030. They are supposed to be achieved through cell efficiency improvement and technological innovations in the manufacturing process. An overview of the technological targets toward 2030 is provided in Appendix 11.3. In May 2006, METI formulated the New National Energy Strategy containing a New Energy Innovation Plan with the target to reduce the solar energy power generation costs to the level of thermal power generation by 2030. In order to realize this target, a new 4-year program *R&D for Next Generation PV systems* was established with a budget of 1.965 bn JPY. After the stagnation of newly installed capacities in the domestic market in 2006 and a significant drop in 2007, the former Japanese Prime Minister Fukuda developed in the *Fukuda Vision* an *Action Plan for Achieving a Low Carbon Society,* containing the goal of the realization of a Solar Society, and set the targets of 14 GW installed capacity in 2020 and 50 GW in 2030. The 2020 target was doubled in April 2009 to 28 GW by the government´s *J-Recovery plan*.

In 2009, the Roadmap PV2030 from June 2004 was reviewed (*PV2030+*) based upon the concept of *making PV power generation one of the key technologies, which plays a significant role in reducing* CO_2 *emissions by 2050, so that it can contribute not only to Japan but also to the global society*. PV2030+ has the aim of further expanding PV usage and maintaining the international competitiveness of Japan´s industry. In the figure below, the details for PV2030+ are shown.



Target (completion of development)	2010 or later	2020 (*2017)	2030 (*2025)	2050
Power generation cost	Equivalent to residential electricity rates (\23/kWh)	Equivalent to commercial electricity rates (\14/kWh)	Equivalent to thermal power production costs (\7/kWh)	PV used as general power source (\7/kWh or less)

Figure 4-5: Japan´s PV R&D Roadmap (PV2030+)
(PV R&D Roadmap (PV2030+), NEDO, 2009)

The target year for the goal of covering up to 10 % of domestic demand for primary energy by PV power generation was extended from 2030 to 2050. For overseas markets it is assumed that Japan can supply approx. one-third of the required volume. The generation cost targets are the same as in PV2030, there was just added another goal of achieving generation cost of below 7 JPY/kWh in 2050. In order to achieve these goals, the usage of PV power generation has to be expanded focusing on following main areas: 1) improvement of economic efficiency, 2) expansion of PV applications, 3) establishment and improvement of infrastructure, and 4) securing the international competitiveness. Additionally, the target of conversion efficiency of PV modules for R&D was reviewed and modified to 20 % in 2017, 25 % in 2025 and 40 % in 2050. The targets for the module production costs are 75 JPY in 2017, 50 JPY in 2025 and less than 50 JPY in 2050. The module lifetime is expected to be 20 years in 2017 and 30 years in 2025. The installation costs are supposed to be up to 200 JPY/W. The targeted steps for PV dissemination from the technological point of view are summarized in Appendix 11.4. The targeted PV cells/modules efficiency in % is outlined in Appendix 11.5.

In January 2009, a new investment subsidy system was introduced by METI under a supplementary budget for FY2008 of 9 bn JPY (69 million EUR, support for approx. 35,000 households) and of 20.05 bn JPY (154 million EUR, support for approx.

80,000 households) for FY2009 (METI´s total budget for FY2009 amounted finally to 42.05 bn JPY). The subsidy amounts to 70,000 JPY/kW$_p$ (540 EUR/kW$_p$) for PV systems <10 kW$_p$ which cost below 700,000 JPY/kW$_p$ (5,400 EUR/kW$_p$). The number of applications for the subsidy exceeded 100,000 already in November 2009 and is steadily increasing. The program will be continued in 2010.

In July 2009, the law on the *Promotion of the Use of Nonfossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers* was enacted which led to the *New buyback program* introducing a FIT scheme for the first time in Japan described in the next section. In Appendix 11.6., an overview of the budgets for the major national PV programs implemented in FY 2009 is provided.

In addition to the National Government, also Local Governments announced implementation plans and investment incentives. Most of the programs provide subsidies ranging from 20,000 JPY/kWh to 50,000 JPY/kWh. The Tokyo Metropolitan Government announced a more ambitious plan (*Tokyo in 10 years*) to install 1 GW within the next 10 years and supports the installation of residential PV systems with an additional 100,000 JPY/kW$_p$ in FY2009 and FY2010. This initiative will provide support for the introduction of solar energy devices at 40,000 households within two years.

Moreover, electric utilities announced plans to construct approx. 18 PV power plants with the total capacity of more than 100 MW at 30 locations across Japan by 2020.

In terms of Japan´s PV future, JREPP published in July 2008 the *Renewable energy vision in 2050,* which estimated a potential share of Solar PV electricity of 18 % by 2050 (Renewables Japan Status Report 2010, JREPP).

4.2.2 Feed-In-Tariff

In November 2009 Japan introduced its first FIT. The new national *buyback program for Photovoltaic generation* requires electric utilities to buy excess solar power supplied from residential and commercial sites at a fixed premium rate. Thus, the cost burden is shared among all electricity customers. Eligible for the fixed price are PV systems on residential and non-residential buildings which are grid connected and have contracts with an electricity utility company. PV systems designed for power generation and systems larger than 500kW$_p$ are excluded. For FY2009, the fixed prices are 48 JPY/kWh (0.37 EUR/kWh) for PV systems <10 kW on residential houses – which was twice the normal residential daytime electricity tariff of 24 JPY/kWh – 39 JPY/kWh (0.30 EUR/kWh) for residential houses with double power generation (e.g. PV + fuel cells, etc.) and 24 JPY/kWh (0.18 EUR/kWh) for PV systems on no-residential houses. At the beginning of the program, the premium rates are fixed for 10 years. The starting price for the purchase will be decreased yearly (PV Status Report 2009, A. Jäger-Waldau).

The FIT became a strong selling tool for residential PV, since most families weren't home during daytime, the lion's share of the PV generated electricity would end up being fed to the grid making it a big potential money earner for homeowners that went solar. A full-scale feed-in tariff is in discussion for 2011.

4.2.3 Fiscal incentives

There are fiscal incentive programs for government buildings and schools. Some house manufacturers offer interest reduced mortgages for homes with PV systems included. The reduction in interest rate is 1 to 2 per cent and is not only available for the financing of the PV system, but often for the whole mortgage. (PV Status Report 2004, A. Jäger-Waldau)

4.2.4 Renewable Portfolio Standard (RPS)

The RPS law was enacted in April 2003 and imposes an annual obligation on electricity retailers to use a certain amount of their retailing electricity from renewable energy sources. The electricity retailer may choose to meet its obligation 1) by generation of electricity oneself, 2) by purchasing the new energy electricity from another party or 3) by purchasing New Energy Certificates from another party. Sellers of green electricity certificates are certified by the Green Power Certification Council. As of March 2008, approx. 270 renewable energy-generating facilities obtained council verification.

4.2.5 R&D support

Japan´s METI supports Japanese companies in areas of R&D, establishing standards and accreditation systems, awareness creation and promoting international cooperation. NEDO is responsible for supporting the industry through research in cell technology, advanced manufacturing technology and developing innovative PV technologies. An important target of NEDO is to reduce the cost of PV cells and systems to create a mass market for PV.

The budget allocated for R&D related to PV power generation in FY 2008 amounted to 3.7 bn JPY and in FY2009 to 4.16 bn JPY (IEA-PVPS 2010). In the figure below, the progress of R&D development in relation to the global PV module shipments is displayed.

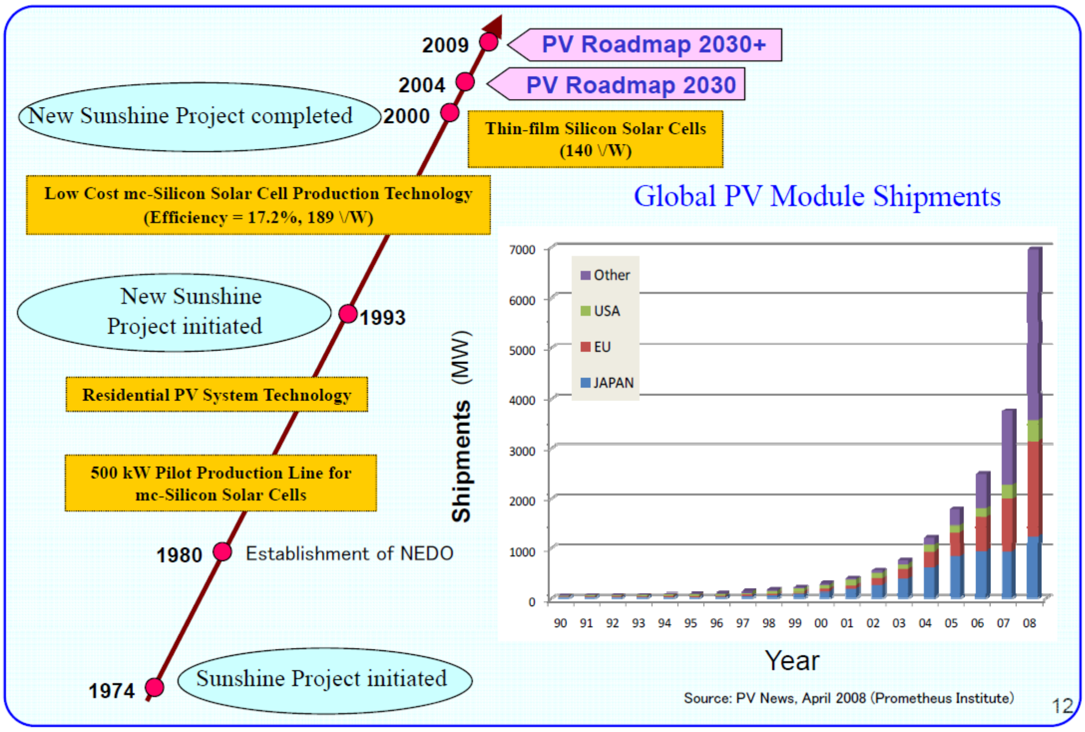


Figure 4-6: Progress of PV R&D in Japan
(PV News, April 2008)

The largest proportion of governmental funding for the dissemination of PV systems goes to field testing which had been steadily increasing until FY2007, where it amounted to 14.6 bn JPY. Then it was reduced to 12.17 bn JPY in 2008 and to 2.35 bn JPY in 2009 (IEA-PVPS 2010).

4.3 Japan´s PV Industry

PV has become an important industry in Japan. In 2009, the total production amounted to approx. 1.5 GW of PV cells (max. annually production capacity 2 GW) and to approx. 1.3 GW of PV modules, which corresponds to the maximum annually production capacity (IEA-PVPS 2010).

4.3.1 Key manufacturing companies

In the following, the most relevant companies involved in the manufacturing process of PV systems are listed: There are four companies manufacturing polysilicon (semiconductor grade) for the feedstock for solar cells which are Tokuyama (production capacity 9,200 to/yr), Mitsubishi Materials (production capacity 1,800 to/yr), Osaka titanium technologies (production capacity 1,400 to/yr), and M.Setek (production capacity 3,000 to/yr). Five companies specialize in manufacturing solar Si ingots and wafers, namely M.Setek, Sumco, JFE Steel, Dai-ichi Dentsu and Mitsubishi Materials. Japan hosts some of the world´s biggest cell producers. In 2009, there were 11 companies listed as PV cell/module manufacturers. The most important ones are Sharp, Kyocera, Sanyo and Mitsubishi Electric, which are all vertically integrated and produce PV cells and modules. A short overview of each company is given in Appendix 11.7. Many Japanese PV manufacturers are also involved in PV installation or systems integration which provides an increased value added to the PV system with installation. Additionally, maintenance services are mostly provided. A normal PV system is warranted for 3 years. Module warranties are granted for 10-25 years depending on the manufacturer. Most Japanese companies are very responsive if there is any claim as it is a matter of honor and pride for them to do a good job (Japan Photovoltaics Market Overview 2005, R. Foster). Another characteristic of the Japanese market is the strategic alliance developed between the module manufacturers and companies involved in constructing houses. New homes in Japan are mostly prefabricated and mass-produced which provides an opportunity for module manufacturers to incorporate BIPV during prefabrication, significantly reducing the cost of a PV system.

4.3.2 PV value chain

Japan is dependent on imported Silicon for their ingots and wafers as well, since the domestic production is insufficient to meet the demand from the industry. PV modules have to be imported only by smaller players in the industry, e.g. Kobe Steel imports modules from Germany´s Schott Solar, and bigger players are vertically integrated. Japan exports PV cells and modules mainly to Europe and the U.S. (PV policy group 2006).

4.3.3 Business value

The business value of the PV system market over the past years is shown in the figure below in billion JPY. In 2009, it amounted to approx. 2.2 bn EUR.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Business value	84,9	110	150	170	200	215	205	150	152,3	290,4

Figure 4-7: Japan´s business value 2000-2009 (IEA-PVPS 2010)

The PV-related labour places in Japan´s PV industry increased from approx. 11,300 in 2003 to approx. 9,000 in 2005 and finally to a total of approx. 26,700 in 2008. The figure below shows the fields of the labour places in 2008.

Estimated PV-related labor places in 2008

Research and development (not including companies)	ca. 700
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	ca. 8 000
Distributors of PV products	
System and installation companies	
Utilities and government	
Other	ca. 18 000
Total	ca. 26 700

Figure 4-8: Japan´s estimated PV-related labour places in 2008 (IEA-PVPS 2010)

4.3.4 PV module and system prices

The average price for PV modules for residential PV systems dropped from 440 JPY/W (approx. 3.3 EUR/W) in 2008 to 402 JPY/W (approx. 3 EUR/W) in 2009. Overall, the PV system price was decreasing over the past years as shown in the figure below.

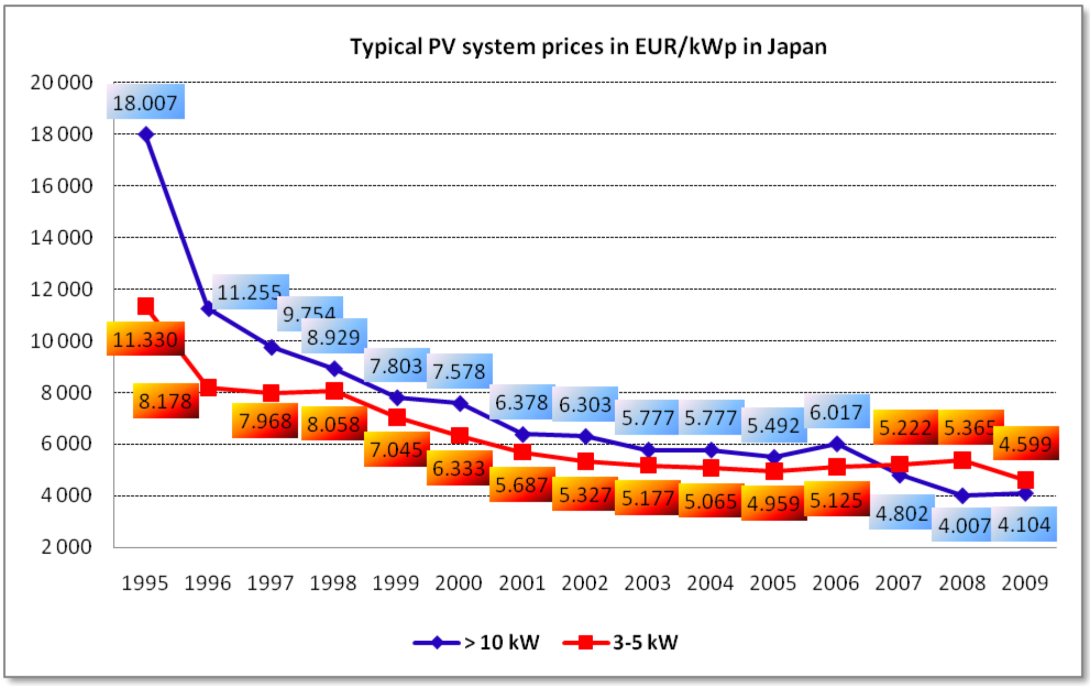


Figure 4-9: Japan: PV system price development 1995-2009 (Based on IEA-PVPS 2010, FX 31.12.2009)

4.4 Summary and learning's Japan

First of all, in Japanese society, the use of PV is seen as important and necessary from a social, cultural and ecological perspective. Japanese leaders and industry see PV as a revolutionary technology that can make significant contributions to the electric power sector while making good business sense. A combination of R&D support and installation subsidies support has proven to be an effective strategy to promote PV technology introduction. Government involvement turned out to be crucial at the initial stage of technology introduction.

According to R. Foster (Japan Photovoltaics Market Overview, 2005), there are three key reasons why Japan became the global PV leader:

1- Aggressive and farsighted government policies promoting PV to help meet Kyoto goals
2- Tight R&D collaboration between industry, government and academia
3- Majority overseas exports helping to drive down PV manufacturing costs in the country

The strength of Japans national PV policy framework is that the policies are market-oriented and aim to establish a prospering market. Their long-term commitment enables the industry to rely on the policy and to perform the necessary investments. Housing manufacturers, for example, developed houses which combine PV installations with other new energy applications and offered reduced interest rates for homes with PV installations. Additionally, there is a strong focus on the establishment of international standards and the transfer of new Japanese business models worldwide. Last but not least, a considerable number of municipalities offer additional subsidies to promote PV systems.

A weakness of Japan´s national PV policy framework is any phase out of any subsidy scheme which may also end willingness of utilities to grant net-metering[9].

Lessons learned from Japan are that the combination of different policy instruments led to a successful PV market implementation, the time of their introduction has to be well coordinated and the long-term commitment is essential for the industry and investors.

[9] *Net metering* allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. The customer pays only for the net electricity delivered from the utility (total consumption minus self-production).

5 Solar Photovoltaic landscape Spain

5.1 Historic market development and PV power installed

First of all, looking at the natural conditions, Spain is an attractive country to go for solar energy due to its high solar radiation. The solar radiation map is enclosed in Appendix 11.8. The specific energy yield of PV plants ranges from on average 1,000 kWh/kW$_p$ in the North to 1,500 kWh/kW$_p$ in the South for systems without solar tracking. Since the publication of the national *Plan de Fomento (PFER)* in 1999, the Spanish government follows a clear strategy to promote PV and the Spanish PV industry played already a leading role in Europe even before the national market really took off. The first spectacular growth in the Spanish market took place in 2007 with approx. 500 MW$_p$ of newly installed PV capacity. In 2008, according to the National Energy Commission approx. 2,600 MW (roughly 30,000 installations) were connected to the grid reaching a cumulative PV power installed of more than 3 GW (approx. 50,000 installations) by the end of 2008. Spain was pushed up to first place in world ranking forming 45 % of the world´s PV demand and covering 1 % of Spain´s electricity demand. In 2009, PV covered approx. 3 % of Spain´s electricity demand. Afterwards, the domestic market in terms of new installations was paralyzed through new regulations from the Spanish government discussed later on. Looking at the market segmentation by the end of 2008, approx. 99 % of the PV installations was grid-connected and approx. 1 % was off-grid systems.

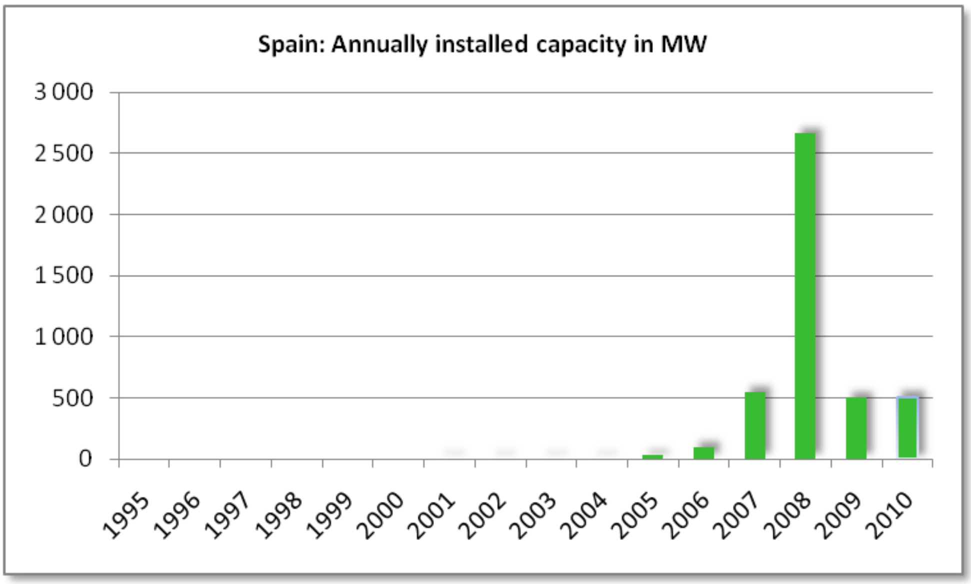


Figure 5-1: Spain´s annually installed capacity in MW
(Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

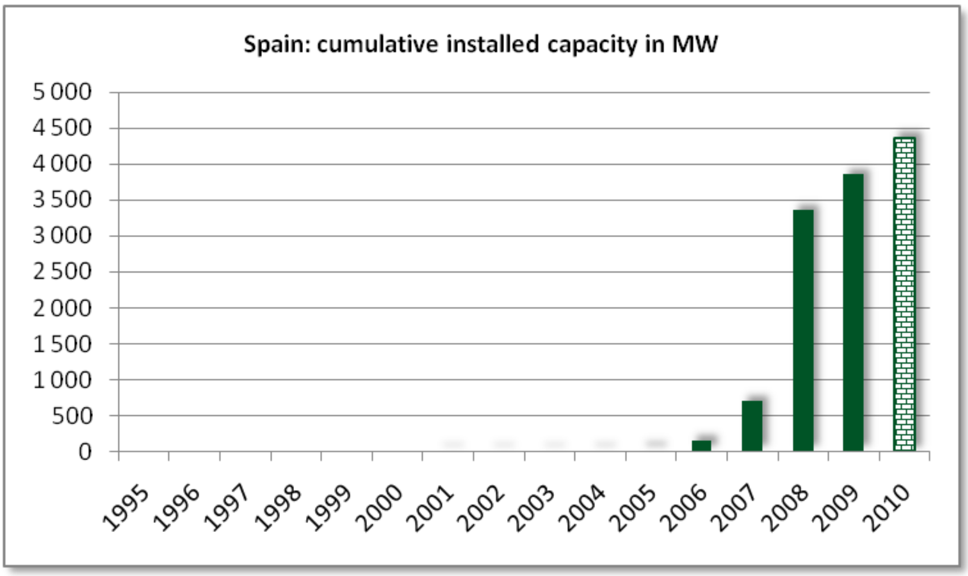


Figure 5-2: Spain´s cumulative installed capacity in MW
(Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

Another characteristic of the Spanish market is the amount of large-scale installations. There are a few plants with installed capacities ranging from 30 MW up to 60 MW as the *huertas solares*[10] concept enables MW projects by grouping a large number of 100 kW_p plants together. Plants with an installed capacity > 5 MW accounted for 44 % and plants with an installed capacity < 5 MW accounted for 56 % of the installations. Ground-mounted PV plants made up 98 % of the installations and roof-mounted plants accounted for approx. 2 % only (IEA-PVPS T1-18:2009). According to the PV legal status report 2010, the market segmentation changed to following picture recently: small-scale installations built on residential buildings up to 20 kW_p represented 7 %, small and medium installations built on commercial buildings up to 2 MW_p represented approx. 60 %, and finally medium and large scale ground mounted installations on open lands up to 10 MW_p represented approx. 33 % of the Spanish PV market in 2009-2010, where a cap of 500 MW has been in place.

5.2 Policies and instruments for PV promotion

Key elements of the Spanish regulatory framework is a Feed-In-Tariff combined with soft loans and direct subsidies granted by the national energy agency IDAE and regional counterparts.

[10] Huertas solares are solar power parks of a few megawatts.

5.2.1 PV investment support mechanisms – plans and programs

The national promotion *Plan de Fomento (PFER)* published in 1999 for the first time defined clear targets for the dissemination of PV systems including the goal of 135 MW_p total PV capacities installed until 2010, requiring total investments of EUR 122 million (PV Policy Group 2006). In the following *Renewable Energy Promotion Plan* for the period 2000-2005 Spain increased its target for 2010 to 150 MW_p of PV installations through various incentives, such as public subsidies or tax incentives for installing PV systems and funding for R&D to improve technologies.

In August 2005, the Spanish government implemented the *Renewable Energy Plan PER 2005-2010* which superseded the *Renewable Energy Promotion Plan*. The new plan raised the target of total PV installations once more to 400 MW_p by 2010. Subsidies continued to be in place for non grid-connected installations. For grid-connected installations, the Spanish government had the opinion that FITs – described into more detail in the following chapter – represented sufficient support and any other subsidies were eliminated due to experienced complicated time-consuming bureaucracy.

Since 2006, the *Technical Building Code (TBC)* was implemented establishing obligatory requirements to be met in the building sector. A section of the TBC regulates the incorporation of solar PV energy and enforces the installation of PV on new large buildings, such as offices, government buildings, hospitals, etc.

Spain´s *Renewable Energy Plan PER 2011-2020* targets a share of renewable energy sources of 20 % of Spain´s energy mix until 2020. The aim for PV installations is 8.5 GW.

5.2.2 Feed-In-Tariffs (Royal Decrees)

Based on the Spanish *Royal Decree (RD) 436/2004,* the FITs valid in 2005 were approx. EUR 0.41/kWh for PV systems < 100 kW_p and EUR 0.21/kWh > 100 kW_p. These tariffs are guaranteed for the operational lifetime of the plant which means maximum legal security for investors. A reduction of the tariffs takes place after 25 years at the earliest. The surplus cost for FITs are charged by electricity suppliers to final customers and the average payback period of the PV investments under above mentioned conditions are 8-12 years. The long term legal security of this RD is limited since FITs can be modified or even suspended by simple RD. However, a new RD never can be retroactive.

In 2007, the FIT regulations of RD 436/2004 have been refined with the *Royal Decree 661/2007.* The basic change is the decoupling from the market reference price, which increased with oil price increases and automatically increased renewable tariffs with the oil price. A new fixed tariff of 0.26 EUR/kWh is granted for CSP plants up to 50 MW for 25 years, increasing yearly with inflation minus 1 %. The CSP target was set to 500 MW by 2010.

In September 2008, the *Royal Decree 1578/2008* was published. The so far relative lack of residential PV installations in the Spanish market and the ability of locally produced PV products to compete with cheap imports (especially from China) influenced this new support scheme. To be entitled to the FIT, a plant must be recorded in the Register for *pre-assignment* of the tariff, which is a new subsection of the existing Administrative Special Register and is managed solely by the General Directorate for Energy and Mines of the Ministry of Industry, Tourism and Commerce. Registration in the Register for *pre-assignment* of Tariff is published by temporary announcements. Each announcement will fix the time and capacity limits for remuneration with the FIT. This new FIT is granted for 25 years and applicable to building integrated and roof-top systems < 20 kW_p (EUR 0.34/kWh), building integrated and roof-top systems > 20 kW_p up to 2 MW_p (EUR 0.32/kWh), and ground-based systems up to a maximum size of 10 MW_p (EUR 0.32/kWh). Additionally, a cap of 500 MW (267 MW rooftop and 233 MW open-space) annually installed capacity was introduced for the period 2009-2011. As a consequence, in 2009 only 2,488 installations were authorized, with a total capacity of 502 MW, which is a strong contrast to the capacity installed of around 2.6 GW in the previous year.

The exact amount of power installed each year is determined by the rate of the FIT reduction in an inverse proportion: the lower the FIT, the higher amount of photovoltaic installations will be allowed. With this regulation, the Spanish PV market, in a business as usual scenario, would reach approx. 11.5 GW cumulative installed capacity by 2020 (PV legal status report 2010).

5.2.3 Financing line ICO-IDAF

Since 1999, the *financing line ICO-IDAE* has been in place combining the instruments soft loans of public promotion bank ICO and direct subsidies of IDAE. Financed are grid-connected PV systems of private individuals or corporations. Supported is only 1 PV system per investor to a maximum of EUR 7,000/kW_p per plant and a maximum of EUR 0.6 million per investor and year. The ICO-IDAE financing line was seen as a great success, as in the two years 2003 and 2004 were approved more than 1,300 projects with a combined total of 7.52 MW_p and more than 1,800 projects with a combined total of approx. 30 MW_p. However, due to the limited budget, the program was suspended in summer 2004 already.

5.2.4 R&D support

Generally, public budgets for market stimulation, field test programs and R&D come from the European Commission, National or Regional Government.

Research in Spain is mainly funded by the Ministry of Education and Science (MEC) and by the Ministry of Science and Technology (MCyT). R&D activities are carried out by the research centers including universities and the PV industry. It is estimated that 12 Mio. EUR were dedicated to R&D in 2008. The National Plan for R&D&I 2008-2011 concentrates on following four areas: generating knowledge and capacities, fostering cooperation in R&D, industry-wide technological development and innovation, and finally, strategic actions (IEA-PVPS 2009).

In terms of regional R&D support, in many of the 17 Spanish communities there is a public budget for R&D available as well.

5.3 Spain´s PV industry

From 1999-2005 around EUR 290 million were invested in the PV industry. In 2008, Spanish PV industrial investment reached 16 bn EUR, which is 500 % more than in 2007. In 2008, the PV cell production amounted to approx. 200 MW (max. annual production capacity 260 MW) and the PV module production amounted to approx. 500 MW, whereas the maximum annual production capacity amounted to 900 MW (IEA-PVPS 2009).

5.3.1 Key manufacturing companies

Spain´s PV industry has in total over 80 manufacturers of cells, modules, inverters and tracking. There are four companies dedicated to PV cell production, which are Isofoton and BP Solar España, manufacturing sc-Si cells only, as well as Guascor Foton and Sol3G, manufacturing high concentration Silicon PV cells.

Isofoton, the leading Spanish player in the local industry, has ventured into several international markets and established sales offices and was involved in projects in Germany, Italy, U.S., China, Morocco, and Ecuador. Spain´s PV industry began when Isofoton became a commercial spin off from technologies developed by the Madrid University, which fabricated PV panels including cells in-house. The university continued to conduct research on PV technologies (conversion efficiency, testing of new materials, etc.) in collaboration with Spanish PV companies.

Among the companies producing PV modules, there are distinguished three groups. First, those manufacturing conventional PV modules, like Artesa and Siliken, producing mc-Si and sc-Si PV modules. Second, those that manufacture Thin-film modules, like T-solar, and third, those that manufacture concentrating modules e.g. Sol3G. Last but not least, there are at least 10 producers of PV components based in Spain, especially inverters, mounting, tracking or monitoring systems. Details regarding the main Spanish companies involved in PV are listed in Appendix 11.9.

5.3.2 PV value chain

In the past, the Silicon feedstock used to be imported and since 2009, Spain (Isofoton) also runs an own Silicon plant with a production capacity of 2,500 tons completing the vertical integration across the value chain.

Due to Spain´s small domestic market up to 2005, the industry depended on exports, mainly to Germany. Isofoton exported almost 80 % of its production in 2005 and reduced it to 65 % as the Spanish government introduced the Renewable Energy Plan *PER 2005-2010*. In 2008, the situation changed and only 16 % of the PV modules produced in Spain were exported, due to the high domestic demand.

Atersa and Siliken have to import mc-Si cells to produce their modules, sc-Si cells are provided by Isofoton. The Spanish PV module production capacity reached 500 MW in 2008. The development of the Spanish cell and module production over the recent years is displayed in the figure below.

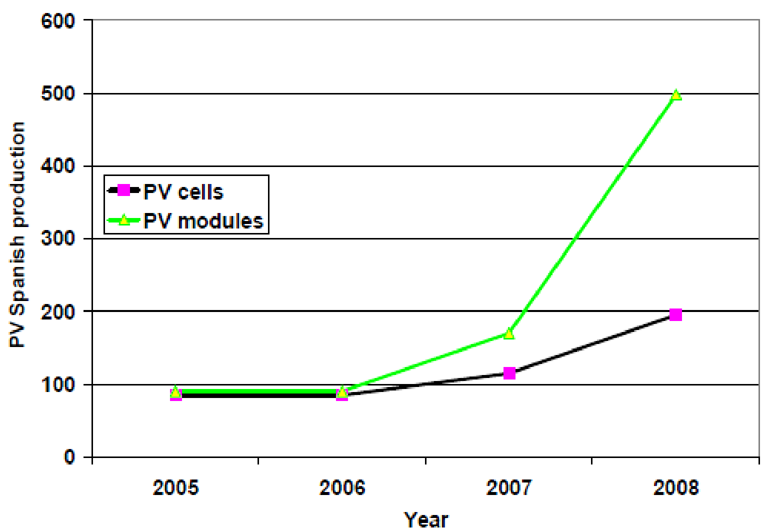


Figure 5-3: Spain´s PV cell and module production 2005-2008 in MW (IEA-PVPS 2009)

Imports are generally multi-year supply agreements. For example, Q-Cells entered into a supply agreement with Atersa to supply 73 MW_p of PV cells from 2006 to 2009 (Global PV industry research 2007). There are not only cells imported but also modules. Due to the attractive FIT, foreign module manufacturers and system integrators entered the Spanish market and bid for large scale PV installation projects. Thus, in 2007, China´s Suntech supplied 23.2 MW_p of modules to Atersa for the Photovoltaic Grid Connection Park in Extremadura, and Germany´s City Solar won a contract to construct a 2 MW_p solar farm in Alicante for a group of 200 individual investors.

5.3.3 Business value

The PV industry in Spain provided in 2004 approx. 4,000 and in 2005 more than 5,500 jobs in manufacturing, installation, wholesale and retail distribution, and turnkey manufacturing (PV Policy Group 2006). During peak production in spring-summer of 2008, the Spanish PV sector employed almost 42,000 people. However, many of them were temporarily employed, as visible in the chart below. They were hired for specific work of services, as independent contractors or subcontracted to business. The number of direct employees is estimated to 31,000. As a result of the RD 1578/2008, the number of employees was cut to less than a half.

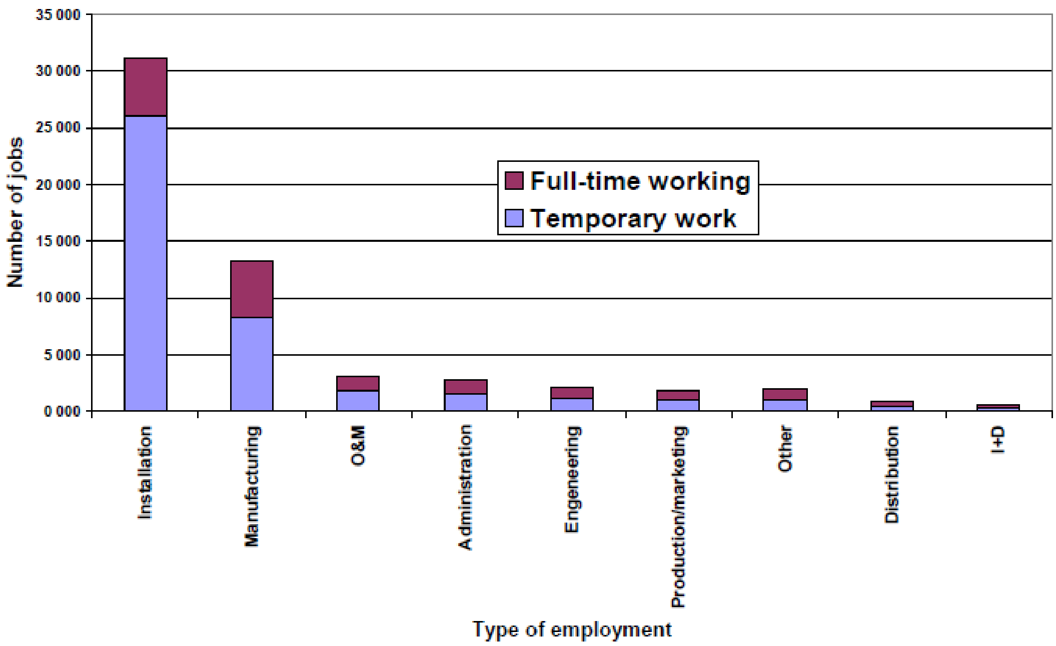


Figure 5-4: Spain´s jobs applied to PV business in 2008 (IEA-PVPS 2009)

5.3.4 PV module and system prices

The PV module prices varied in 2008 in a wide range from 2.3 to 3.5 EUR/W_p, depending on the type of applications (IEA-PVPS 2009). The PV system prices varied in 2008 from 5.7-14.4/W_p, depending on the application, as summarized in the figure below.

Category / Size	Spain´s PV system price in EUR per Watt in 2008
off-grid < 1 kW	14.4-11.4
off-grid > 1 kW	11.4-9.7
on-grid < 10 kW	7.5-7
on-grid > 10 kW	5.7-6
grid-connected	11.4-9.7

Figure 5-5: Spain´s PV system prices per Watt in 2008 (IEA-PVPS 2009)

In the first quarter 2010, the average PV system prices were approx. 4,000 EUR/kW_p for residential roof-top installations, approx. 3,000 EUR/kW_p for commercial roof-top installations and approx. 2,900 EUR/kW_p for ground-mounted PV systems according to the research company iSuppli in the pv magazine 09/2010.

5.4 Summary and learning's Spain

In terms of the strengths of Spain´s past national PV policy, the combination of the specific solar yields, the attractive FITs, loans up to 80 % of the installation costs, direct subsidies up to 20 % for grid-connected systems as well as 30 % for isolated systems and regional subsidies represented excellent conditions to boost the PV installations in Spain. Further, Spain defined clear targets to which relevant authorities on federal and regional level showed full commitment.

As weaknesses of the national PV policy are to mention the suspension of the whole ICO-IDAE program in 2004, bureaucratic application procedures for grants especially on regional level, investor´s single focus on subsidies or any public aid and the cap limiting the large-scale megawatt parks. Moreover, as the administrative procedures are the same for small, medium and large scale installations, the impact of the administrative process on small and medium rooftop systems is considered inappropriate according to the analyses of the PV legal status report 2010. In addition to this, problems in connecting to the grid due to rigid requirements based on lack of grid capacity, delays etc. affects PV development in Spain in these days. Improvements are already incorporated in the new RD draft.[11]

[11] According to PV legal (www.pvlegal.eu) as of April 2010, the following proposals have already been fed into the RD draft which is currently being discussed by the Spanish parliament: removal of the need to obtain an

Lessons learned from Spain are that subsidies can be abolished – which happened in Spain in 2006 – as FITs are enough for the adequate development of the market and a simple administrative procedure is basic for achieving a good development in the PV sector. A lesson the whole PV community has learned from Spain is that a significant and sustainable growth is better than a huge short term surge. Spain´s RD 661/2007 gave rise to a huge boom in Spain particularly for ground mounted installations. Further, the favorable FIT created attention and strong interest among international private investors for large-scale installations. A year of windfall profits followed. In 2009, the Spanish PV market broke down. By the end of 2009, Spain´s national budget was exceeded by more than one billion EUR deriving from Renewable energies (Sonne Wind & Wärme 13/2010, R. Raspe). Thus, the Spanish government started to negotiate a retroactive reduction in the tariffs paid to all PV power plants. Both the PV industry and banks – the latter invested approx. 3 bn EUR in Spain´s PV sector – vehemently opposed any proposed measures, predicting terrible consequences for the financial sector. Further, the credibility of Spain as an attractive country to invest in was questioned and the sector´s associations warned to take legal actions against retroactive tariff reductions (Photon International, July 2010, C.F. Saravia). The legal changes since September 2008 (RD 1578/2008) had a tremendous impact on the PV industry in Spain which was paralyzed since then:

- BP Solar closed its mill in Madrid and released jobs,
- Isofoton, Spain´s biggest PV company shut down machines, released jobs, has debts of EUR 250 million and is looking for an investor,
- Pevafersa released employees,
- Gamesa Solar closed its mill in Sevilla releasing jobs and was finally sold by Gamesa Group in 2009 to U.S. investors.

Within a very short time, more than 20,000 jobs were cancelled in the PV branch. The governing socialists had lost control of the financial side of the RD. In Spain, unlike in Germany, the state first pays the FITs, and then puts the cost on to the price of electricity. On account of the economic crisis and the high 20 % unemployment rate the government wanted to avoid any increase of the price of electricity. Thus, the government decided to reduce the costs by changing the FITs. According to the CNE statistics from June 2010, around 250 million EUR are paid out each month for PV FITs. The government finally stated that the development in

administrative permit for all PV installations < 100 kW and connected to the low voltage grid; simplification of the procedure for connecting PV installations < 20 kW to the grid provided the PV installation is associated to an electrical consumption of equivalent or higher power at the same connection point; reduction of bureaucracy for connecting PV installations of < 10 kW to the grid and located inside an internal electricity network, as it would be permitted to connect to the internal low voltage network, instead of connecting to the medium voltage.

2008 was “not normal” and actions had to be set. The PV industry was shocked and blocked by the new abruptly implemented regulations and looks to Germany where the FIT has been reduced step by step without any cap, demanding this for the Spanish market as well.

Javier Anta, president of ASIF, recommends relying on grid parity as Spain is not far from it and on the net metering as a reasonable way to increase the penetration of PV in Spain´s electrical system without requiring additional economic support. Javier García Breva, president of the PV section of APPA, criticizes especially the introduction of a cap system in the RD 1578/2008 which led to the loss of more than 15,000 jobs (approx. 27,800 according to IEA-PVPS 2009) and paralyzed the maturation of the national PV industry which had just started to take off. There is a big discrepancy between the annual cap of 500 MW which is less than the sixth part of the PV capacity installed in 2008 and the demand of the Spanish PV market. What APPA claims instead of a system of caps and registers of pre-allocation is the continuation of an approach based on fixed FITs and premiums which will be reduced according to the market development as well as the learning curve effects regarding the equipment and PV electricity generation costs (EPIA website, country focus Spain, 2010).

However, Spain´s solution for 2009-2011 to turn back to the way of sustainable growth was the loss of roughly 20,000 jobs, a 500 MW cap for newly installed capacities per year corresponding exactly to the *Spanish* PV module production in 2008 and the establishment of a better price for roof and facades installations which achieved its intended results: almost 50 % of the 500 MW newly installed capacities in 2009 were integrated in the built environment.

Spain´s *PER 2011-2020* continues to count on solar energy to fulfill its CO_2 obligations towards the EU. The IDAE announces that *grid parity* will be achieved in 2015 and estimates a stable growth up to 8.5 GW domestic PV capacity installed by 2020. Therefrom, two thirds of the total solar capacity are supposed to be roof-top installations and one third will be large-scale, open field systems. Looking back in 2008, around 90 % of capacity installed were ground mounted large-scale installations. Thus, the PV sector is going to be structured differently than previously going more in the direction of roof-mounted installations and small consumers enabling Spain´s PV industry to regain a sense of security and follow a “normal growth rate”. Thus, Spain still envisions a good frame for the deployment of PV.

6 Solar PV market environment Germany

6.1 Historic market development and PV power installed

Since 2004, Germany has been leading the world with the highest annual PV installation with exception of 2008 due to a one-time effect in Spain. In 2009, Germany´s newly installed power amounted to 3.8 GW corresponding to almost the half of the global cumulative PV power installed during that year. In 2010, the contribution of Solar PV electricity amounted already to approx. 2 % and a growth up to 10 % in 2020 is estimated (BSW-Solar, August 2010). Germany´s solar radiation is approx. 1,000 kWh/m^2 per year (map is enclosed in Appendix 11.10.) and the specific energy yield of PV plants ranges from 750 to 950 kWh/kW_p. In terms of the market segmentation approx. 40 % of the German PV systems were installed on residential homes (1-10 kW), 50 % were installed on commercial roof top systems (10 - 1,000 kW) and 10 % were installed as large scale ground mounted systems with more than 200 kW_p per plant and a total of approx. 700 MW_p installed (EPIA website, country focus Germany, 2010). In addition, there is a steadily growing request for off-grid systems which amounted to more than 5 MW installed in 2009. Last but not least, there is a broad awareness and acceptance of renewable energy and PV by the German public.

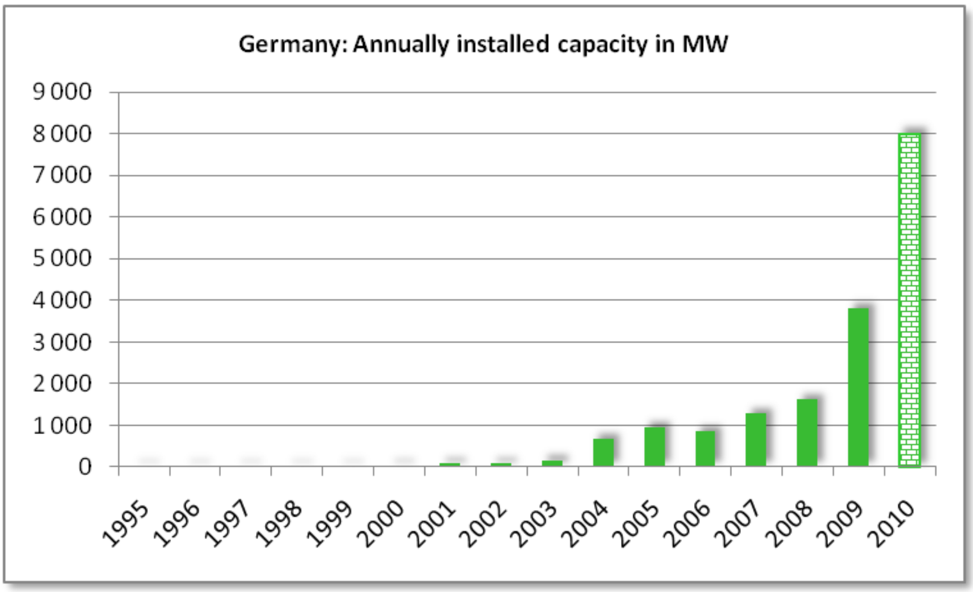


Figure 6-1: Germany´s annually installed capacity in MW (Based on figures from IEA PVPS 2009)

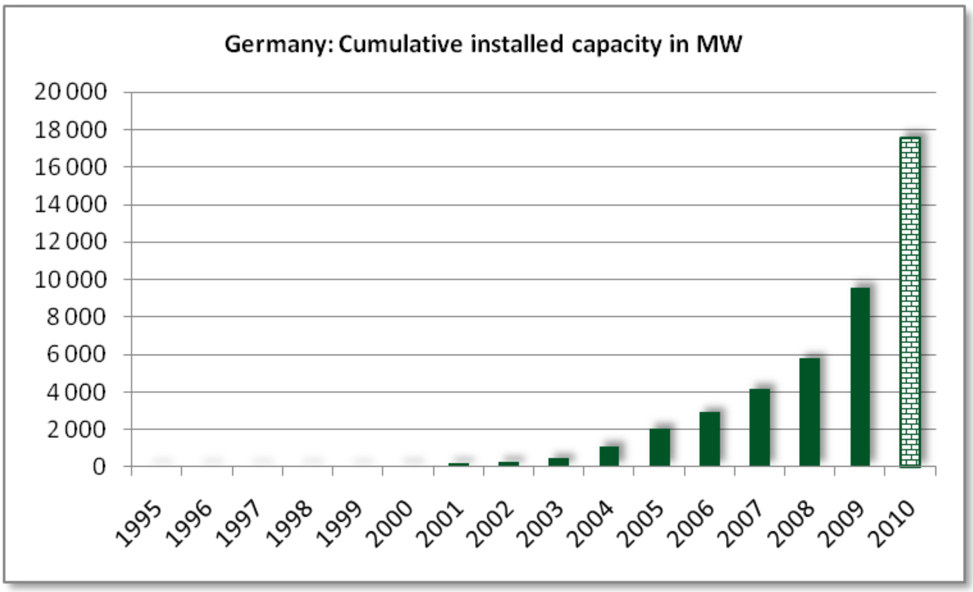


Figure 6-2: Germany´s cumulative installed capacity in MW (Based on figures from IEA PVPS 2009)

6.2 Policies and instruments for PV promotions

The successful policy of Germany is the *Renewable Energy Sources Act (EEG)* with its elaborated Feed-In-Tariff scheme.

6.2.1 PV investment support mechanisms

In January 1999, Germany´s federal government introduced the *100,000 Roofs program (1999-2003)* with a budget of one million EUR over the five years to stimulate demand for small grid-connected roof-top PV installations by offering low-interest loans. The loans were in the first year interest free but charged 1.9 % interest from 2000 to 2003. The maximum level of support was EUR 6,230/kW$_p$ for installations < 5 kW$_p$ and EUR 3,115/kW$_p$ for installations > 5 kW$_p$. The administration was managed by the public promotion bank KfW (PV Policy Group 2006). In 2000, the *Renewable Energy Sources Act (EEG)* was enacted where Germany introduced high *buyback rates* from the utilities companies which were guaranteed for 20 years. The EEG was amended in 2004 and 2008. Further details to the development of the FITs are summarized in the next chapter.

In addition to the EEG, PV in Germany receives support from local fiscal authorities providing tax credit for PV investments which are of limited relevance, the bank KfW providing loans for private or community PV investments or community infrastructure investments and several federal states providing grants or loans. Last but not least, there exists also a *Green pricing model* in Germany where various municipal utilities offer green offerings as a voluntary option for their customers to support Renewable Energy Sources by paying a premium on their electricity bills.

6.2.2 Feed-In-Tariffs

The German *Renewable Energy Sources Act (EEG)* enacted in 2000 governs FITs[12] for renewable electricity. It ensures priority purchase of solar power at the producer´s price and enables the system to be operated profitably. In the following, it will be looked at the amendments in the EEG 2009.

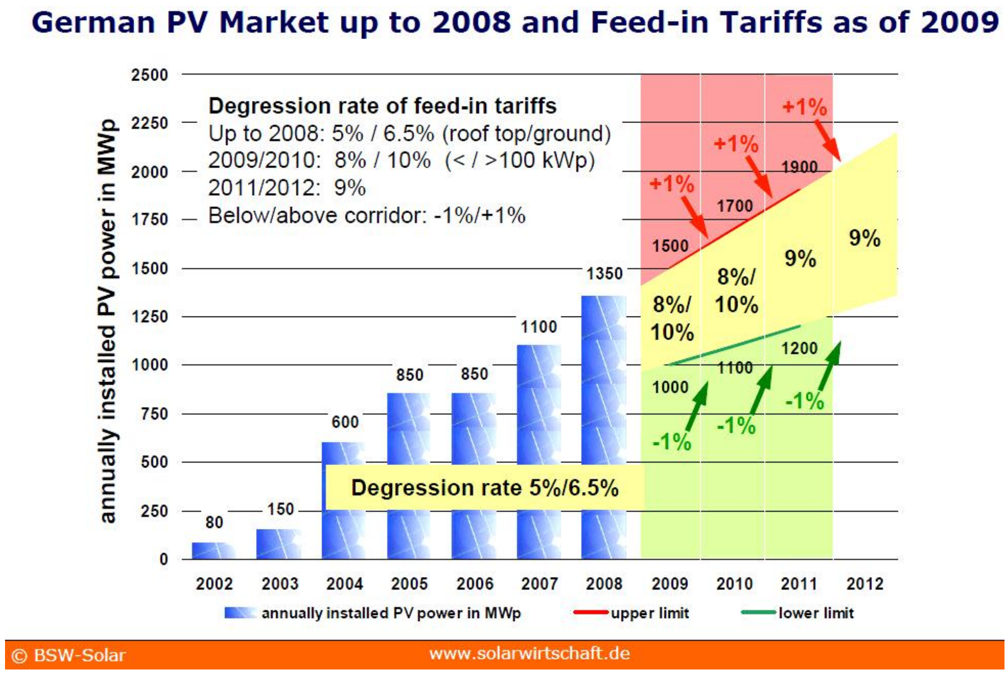


Figure 6-3: German PV market up to 2008 and FIT as of 2009 (BSW-Solar, 2010)

The FITs for new installations from 2009 onwards (IEA PV Status Report 2009) are:

System size < 30 kW	EUR 0.4301/kWh
System size < 100 kW	EUR 0.4091/kWh
System size < 1 MW	EUR 0.3958/kWh
System size > 1 MW	EUR 0.33/kWh
Ground based systems	EUR 0.3194/kWh

The annual degression rate of tariffs for new PV systems was raised for new systems as follows:

System size < 100 kW	2009: -8 %	2010: -8 %	2011: -9 %
System size > 100 kW	2009: -10 %	2010: -10 %	2011: -9 %
Ground based systems	2009: -10 %	2010: -10 %	2011: -9 %

[12] Feed-In-Tariff: For every kWh produced by a solar power system, the energy company pays a cost-covering fee. The costs are covered by a small surcharge on the kWh that all users in the market buy from the energy company.

Furthermore, the degression rate is going to be adapted to market conditions. Thus, if the market deviates from a predefined growth corridor, the degression rate will be increased or decreased by 1 % for the following year. The growth corridor was defined as follows: 2009: 1,000 – 1,500 MW

2010: 1,100 – 1,700 MW

2011: 1,200 – 1,900 MW[13]

An increase of the degression rate by 1 % in the next year is foreseen if the installed capacity exceeded the growth corridor in the former year and vice versa. As in 2009 the upper boundary was exceeded significantly (3.8 GW instead of 1.5 GW), in 2010 the preliminary degression rate is supposed to be 9 % instead of 8 % for installations < 100 kW. In order to monitor the annual new installations, owners of new PV systems are legally obliged to register their systems with the German Federal Network Agency since 2009. Only registered systems will receive the favorable FIT.

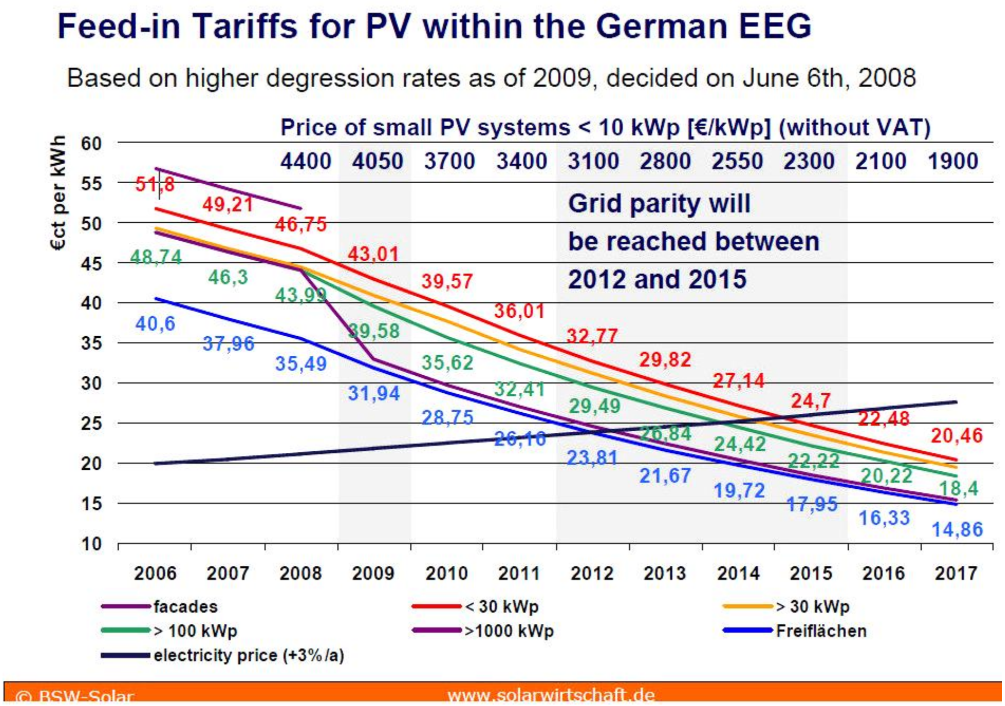


Figure 6-4: Germany´s FIT for PV within the EEG 2006-2017 (BSW-Solar, 2009)

According to BSW-Solar, grid parity may be reached already in the second half of 2012 at the earliest and until first quarter for 2015 at the latest. The price of an

[13] The target corridor for market growth in 2011 and subsequent years will be increased from the previous 1,200 MW_p to 1,900 MW_p and from 2,500 MW_p to 3,500 MW_p. Should the market volume develop during the assessment period within this range, this will result in a 9% degression for new systems put into operation as of 1.1.2011 (BSW Solar, 12.7.2010).

average PV system is meanwhile already below EUR 3,000/kW_p in 2010 as further outlined in chapter 6.4.

As of July 2010, new FITs between 0.24 EUR/kWh for ground based systems and EUR 0.33/kWh for roof-top systems are in place as module prices have dropped significantly in the recent months. Another FIT cuts followed in October 2010 (details on page 61) and further cuts are planned for beginning of 2011.

In the past, the steadily falling FIT was not a big obstacle to continued market growth as cost reduction programs by the industry contributed to the expansion. The trend in Germany was that the industry continued to counterbalance the reductions in the FIT with price adjustments, in a growing market. The continuity of the FIT has led to trust among consumers and industry as well as investors and purchasers and finally resulted in an extensive infrastructure of producers, system houses, installers and knowledge institutes. Despite cuts, further stable growth may be expected as the infrastructure of business and knowledge continues to grow and as long as German PV companies are still reporting healthy profits with room for price adjustments.

6.2.3 Direct consumption bonus

In 2009, a *direct consumption bonus* for small systems < 30 kW installed was introduced. It is paid for each kWh of solar power used by the system operators themselves or by a third party in the immediate spatial vicinity of the system (e.g. neighbors). The reimbursement amounted to 0.25 EUR/kWh in 2009 and is subject to the same annual decrease for new systems as the FIT remuneration.

Thus, system owners can cover some of their costs by using parts of the solar power which they produce for their own needs, which might be the first step towards self-sufficiency in terms of energy. Additionally, this incentive for decentralized use of PV power not only reduces the cost of EEG but also might give some new impulses to the PV industry to develop further control and storage technologies.

6.2.4 R&D support

In 2008, the R&D budget for PV projects by BMU amounted to approx. 40 million EUR (59 % for Si wafer technologies, 18 % for CIS technologies, and 13 % for Si thin film technologies). In 2009, the R&D budget by BMU amounted to approx. 33 million EUR (50 % for Si wafer technologies and 32 % for thin-film technologies). Further grants in the amount to ca 31 million EUR were contracted during 2009. The BMBF provided a public funding of 55 million EUR for the development of organic cells in 2008 and approx. 20 million for the development of thin-film technologies in

2009. Finally, the BMBF funds the development of the cluster "Solarvalley Mitteldeutschland" as part of the Federal High-Tech Strategy which compromises most of the Germany´s PV industry and received grants of 40 million EUR for four years (IEA-PVPS 2009).

Due to the relatively mature PV market in Germany, technically-oriented demonstration and large field test activities are no longer of much interest. Today, Germany´s industry focuses their activities on process optimization to reduce production costs and to increase the quality of their products as well as to the development of new technologies, such as Thin-film or organic solar cells. Recycling is also attracting more attention (IEA-PVPS T1-18:2009).

6.3 Germany´s PV industry

The German PV industry has been one of the fastest growing industries in the country and still experiences a period of solid growth. From 1998-2005, investments of 5 bn EUR in new production capacity and R&D were performed.

6.3.1 Key manufacturing companies

First of all, the range of companies dealing with PV is expanding along the whole value chain. Especially the capacity of Thin-film production facilities is growing significantly taking advantage of the global silicon supply shortage of the past years.

Companies in the Silicon feedstock business are Wacker, one of the world´s largest suppliers of silicon for the semiconductor and PV industry, Joint Solar Silicon, PV Silicon and Scheuten Solar World Solizium. From 2009 onwards, a production capacity of more than 17,000 tons equaling to 1.3 GW is reached. The main supplier for silicon wafers is Deutsche Solar AG. Companies producing PV cells are Q-Cells, Aleo Solar, Solar Factory, Solarwatt and Solon to mention the most important of them. In addition to this, there are several companies producing Thin-film modules (CIS, CdTe, etc.) and concentrating PV modules. In the inverter business the world leading company SMA Solar produces already more than 1 GW yearly. Further details to the most important manufacturers are listed Appendix 11.11.

6.3.2 PV value chain

In Germany, there are more than 200 manufacturers involved across the PV value chain from manufacturing silicon, wafers, PV cells, modules to inverters (BSW Solar, April 2010). Additionally, the PV industry has created business opportunities for installers of PV systems, turnkey manufacturers, wholesale and retail distributors, architectural and engineering companies. Germany´s export rate was over 45 % in

2009 and is expected to increase to approx. 70 % by 2013 (BSW-Solar, August 2010).

In Germany, there are no exports of PV modules, but imports. The production of PV modules requires higher use of labour compared to other sectors of the PV value chain. Germany imports nearly 60 % of the PV modules installed in the country due to Germany´s high cost of labour. Main imports are for modules from OEM outside Germany, produced by German companies in lower cost production countries such as the Czech Republic.

Many German companies have invested in overseas production facilities through their subsidiaries or joint ventures. For example, Solar World has plants in Sweden and the U.S. to produce PV modules. Solon entered into a joint venture to operate a solar grade silicon plant in France and invested in a plant in Austria to manufacture crystalline silicon cells. Schott Solar has a plant to produce silicon cells in the U.S.

Last but not least, Germany is the world´s leading producer of inverters and includes major companies such as SMA, Fronius, Studier and Siemens. German´s inverter production grew from an estimated 590 MW_p in 2005 to 910 MW_p in 2006 accounting for nearly half of the world´s inverter production in 2006 (Global PV industry research 2007) and reached in 2009 more than 4 GW (IEA-PVPS Annual Report 2009). An overview of the production capacities of the respective business areas of Germany´s PV industry in 2009 is provided in Appendix 11.12.

6.3.3 Business value

The German PV industry has become a significant sector of the country´s economy generating about 50,000 labour places (handicraft 47 %, wholesale 7 %, industry 46 %) by the end of 2008. In 2009, the labour places increased to more than 60,000 and have the potential to raise up to 100,000 labour places by 2020 (BSW-Solar, August 2010). The turnover from the industry increased from below 1 bn EUR in 2004 up to EUR 9 bn by 2009 (BSW-Solar, August 2010). Germany´s industry invested in 2008 approx. 2,150 million EUR in production capacity and produced 11,200 to of feedstock silicon, 710 MW_p of wafers, approx. 1.5 GW of PV cells (max. annual production capacity 2.3 GW), 1.2 GW of PV modules (max. annual production capacity 2.1 GW) and generated a solar electricity power of 4,300 GWh. The market share of German enterprises in the whole PV industry value chain for the world market is estimated by around 20 % (IEA-PVPS 2009).

6.3.4 PV module and system prices

Overall, PV module and PV system prices have the trend to decline. The development of typical PV module and system prices is summarized in the next two figures.

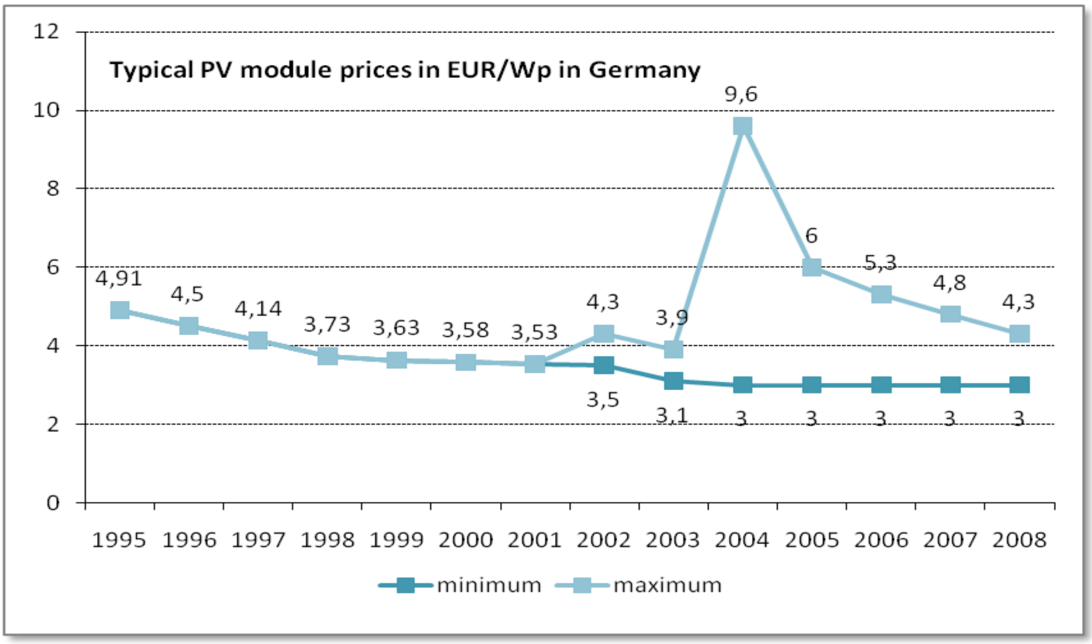


Figure 6-5: Germany´s typical PV module prices 1995-2008 (Based on data from IEA PVPS 2009)

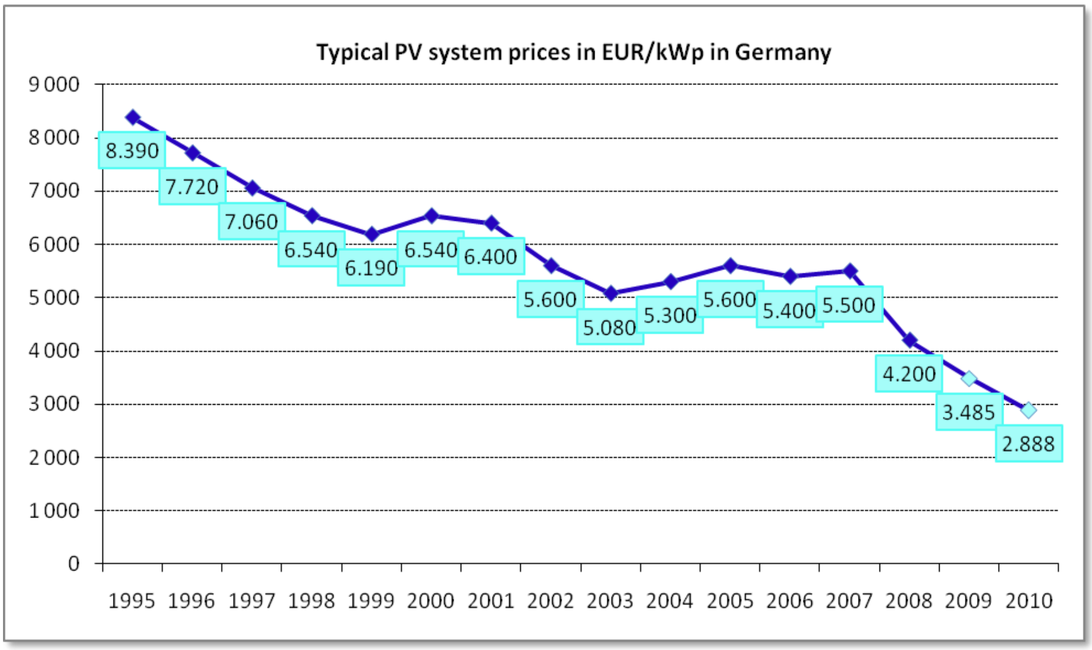


Figure 6-6: Germany´s typical PV system prices 1995-2010 (1995-2008 based on data from IEA PVPS 2009 and 2009-2010 based on BSW-Solar, August 2010)

According to BSW-Solar, the average price for PV rooftops systems < 100 kW arrived below EUR 3,000 EUR/kWh in 2010 already.

6.4 Summary and learning's Germany

Germany is the worldwide leading PV market, Germany´s PV industry is a global leader and Germany is a pioneer in the development of FITs. The EEG has inspired many countries all over the world. According to Karsten Körnig, managing director of the German solar industry association BSW-Solar, following three factors have facilitated the solar boom in Germany:

1. Solar energy is very popular in Germany as an active and visible contribution to climate protection. There is an excellent perception not only by the general public, but also by professionals and politicians of all parties.
2. The German Renewable Energy Sources Act (EEG) was crucial for the highly successful introduction of PV to the market being the most important engine of investment, innovation and growth for the PV industry. Since 2004, the EEG has offered operators of PV plants as well as the industry the same investment security (which was not given in the case of Spain). Over 50,000 jobs have been created in the German solar power sector and almost half a million German households operate PV systems as a result of refinancing via the EEG.
3. The close exchange of expertise between the German mechanical and plant engineering sector and around 50 German PV research institutions which is vital in the context of fast-paced growth and strong international competition (EPIA website, country focus Germany, 2010).

In terms of the strengths of the German PV policy framework, the EEG is the main driver of success enabling profitable operation of PV plants and providing long-term security of investments. Further, FITs are easier to handle than, for example, subsidies and avoid administrative burdens. Moreover, the EEG does not foresee any artificial limitation like a *cap* of market growth. Regarding the roof-top program, the possibility to finance up to 100 % of initial cost enabled many investors to face such a considerable investment.

In terms of the weaknesses, there are to mention the limited duration of the roof top program and the maximum level of support introduced.

Lessons learned from Germany are that for a successful FIT support scheme, the exact, country-specific calculation of the threshold for the profitable operation of PV plants (break-even point) + 5 % to 6 % risk surplus has to be known. Market demand does not respond proportionally to the amount of the FIT, but very sensitively to the smallest investment barriers. Further, subsidies programs can be a very effective tool to stimulate the market in the short run. However, the industry can rely on a sustainable promotion strategy and there is not any dependence on usual budget constraints of subsidy schemes.

According to the PV legal status report 2010, the German PV market shows the lowest legal-administrative barriers and represents the best practice at European level. Germany leads in terms of the newly annually installed capacity, the lowest market prices, the lowest share of administrative costs, the shortest project development durations and waiting times, and finally the most moderate labour requirements.

The outlook for Germany is very promising. Due to the Spanish cap which was set at 500 MW_p for 2009-2011, Germany is expected to keep and expand its number one position as the most mature market with a proven FIT scheme, good financing opportunities, and high potential for future development, skilled PV companies and good awareness of the PV technology. Germany's NREAP based on the EU guideline 2009/28/EC states a growth of up to 52 GW installed capacity by 2020. According to BSW-Solar this will correspond to a solar power share of up to 10 % in Germany's energy mix.

7 Solar PV market environment Austria

7.1 Historic market development and PV power installed

In the period from 2003 to 2007, Austria showed decreasing installed capacities, whereas the international market showed a tremendous increase in PV installations. Whereas in Bavaria (South Germany) the solar PV contribution to the electricity demand in 2008 amounted to 2 % already, in Austria it amounted to 0.04 % only (BMVIT, 2008). In 2009 finally, the Austrian market started to develop with a new installed capacity of 20 MW_p (4,850 installations) being the historical best performance in Austria. In 2010, a similar output is expected leading to a solar PV contribution of 0.1 % of the total electricity consumption in Austria (Haslinger, R., Sonne Wind & Wärme 14/2010). Austria´s solar radiation map is enclosed in Appendix 11.13. and the specific energy yield of PV plants ranges from 700 to 940 kWh/kW_p. Looking at the market segmentation, approx. 90 % are grid-connected and 10 % are off-grid systems. There is a clear dominance of small roof-top installations on private houses and little experience with larger-scale PV > 100 kW_p.

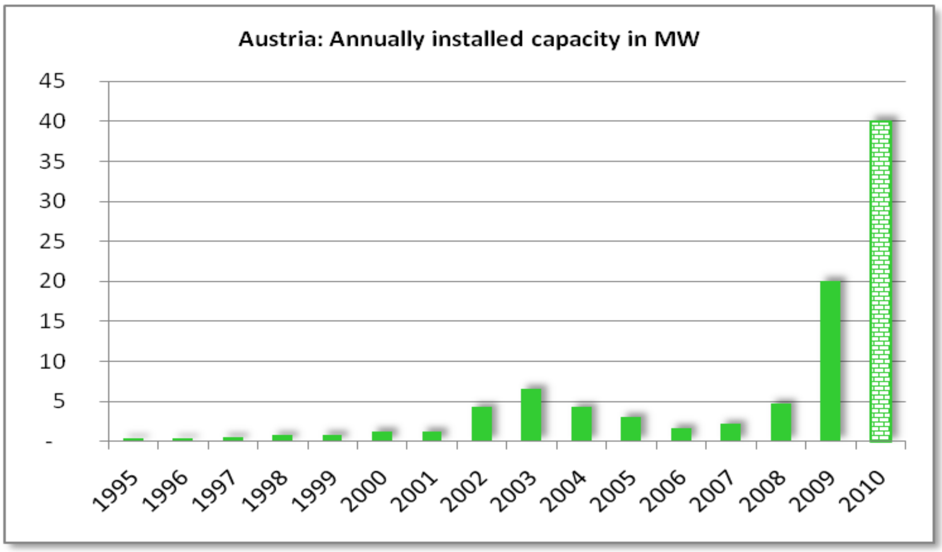


Figure 7-1: Austria´s annually installed capacity in MW
(Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

In the national action plan for renewable energy[14], Austria estimates 322 MW_p installed capacity corresponding to 306 GWh produced electricity by 2020 being a quite low target in comparison to other European countries and the potential of the

[14] According to the directive for RES 2009/28/EC („20/20/20" directive) of the European Union, the national target for Austria is a contribution of 34% of RES to the final energy consumption. The directive requires each member state to adopt a national renewable energy action plan.

country. In 2009, PVA announced that a target of 8 % solar PV electricity by 2020 is feasible in Austria.

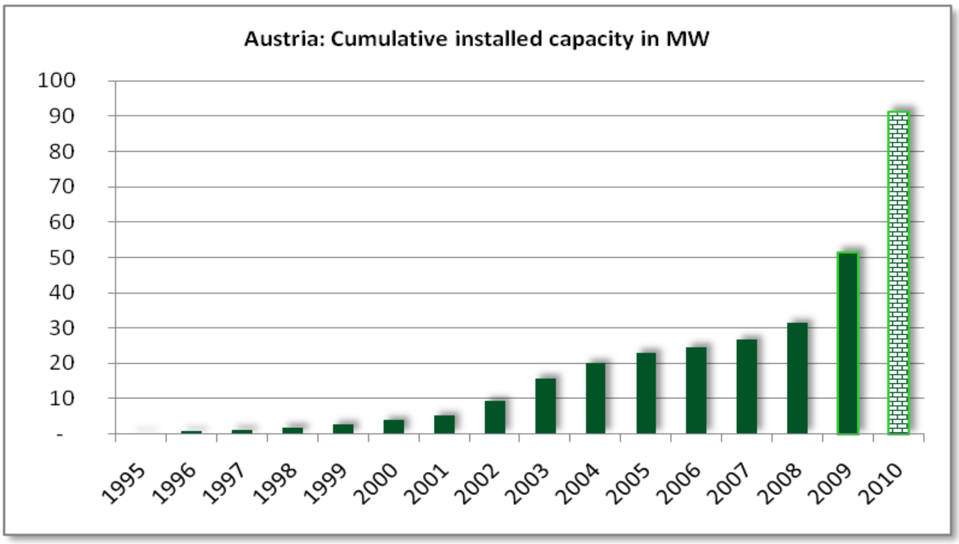


Figure 7-2: Austria´s cumulative installed capacity in MW
(Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

7.2 Policies and instruments for PV promotions

Although there have been several initiatives on federal and regional level to support PV in Austria, a sustainable market has still not been developed yet, mainly due to discontinuity of the various PV implementation programs.

7.2.1 PV investment support mechanisms

Generally, PV support is more seen as regional task than as federal task. However, the federal *Green Electricity Act (GEA)* offering preferential FITs for electricity from renewable sources together with a purchase obligation for green electricity was the favorable background for the raise in domestic PV installations in 2003. But, the availability of the FIT was capped to a national limit of 15 MW_p[15] installed PV only which was reached very quickly. PV operators are obliged to register their plants in the national register of *eco-electricity plants* which is managed and monitored by the E-control. In 2006, after three years without any federal support, Austria´s parliament passed a revision of the green electricity act which foresees specific shares of the support for the various energy sources being only 10 % for PV. Further, the provinces are requested to double the federal subsidy which makes the support system even more complex.

[15] Reinhold Mitterlehner, Austrian economics minister, argues that as long as PV is the most expensive renewable energy source in Austria, there isn't any reason to eliminate any cap (Sonnenzeitung 3+4 2009).

A major trend regarding Austrian PV projects in recent years is the optimal architectural integration of BIPV in newly constructed and refurbished buildings such as the ENERGYbase in Vienna. BIPV is the only PV application which has been object of R&D support on a project basis.

7.2.2 Feed-In-Tariff

PV FITs are defined on a yearly basis in a separate *Feed-In Decree,* called *eco electricity degree,* and are valid for 13 years. The FIT system is funded by supplements on the electricity price and an obligatory purchase price for Green Electricity which has to be paid by electricity dealers. Thus, this system is not financed by a public body but by all consumers of electricity instead. The development for the years 2006-2010 is summarized in the figure below.

Austrian FITs in EUR 2006-2010					
in EUR/kWp	**2006***	**2007***	**2008***	**2009****	**2010*****
< 5 kWp	0.49	0.4599	0.4599	0.46-0.4598	-
< 10 kWp	0.42	0.3999	0.3999	0.40-0.3998	-
> 10 kWp	0.32	0.2999	0.2999	0.2998	-
> 5 kWp < 20 kWp	-	-	-	-	0.35
> 20 kWp	-	-	-	-	0.25
BIPV > 5 kWp < 20 kWp	as above	as above	as above	as above	0.38
BIPV > 20 kWp	as above	as above	as above	as above	0.33
	* IEA-PVPS 2009			** PV-tech.org. 9.12.2009	*** BGBl. II Nr. 42 / 2010

Figure 7-3: Austria´s FIT in EUR 2006-2010
(2006-2008: IEA PVPS 2009; 2009: PV-tech.org; 2010: BGBl. II No. 42 / 2010)

The settlement procedure foresees a payment of 100 % of the specific tariff for the first 10 years. Afterwards, the tariff is cut to 75 % in year 11 and finally to 50 % in year 12. After this period, only the gross sale price for electricity is paid. The FIT paid for PV decreased from approx. 10.4 million EUR in 2008 per 70 % to approx. 3.2 million EUR in 2009. The average FIT decreased from 2008 to 2009 per 5 % to 0.5686 EUR/kWh.

Austrian FIT support 2008 and 2009			
data as per 31.12.	**2008**	**2009**	**change 2008/2009**
number of active contracts (pieces)	3,112	4,150	33%
cumulated installed capacity of active contracts (kW)	21,701	26,800	23%
FIT (kWh)	17,331,157	5,540,534	-68%
allowance net in EUR	10,407,032	3,150,462	-70%
average allowance in Cent/kWh	60,05	56,86	-5%

Figure 7-4: Austria´s FIT support 2008 and 2009
(Biermayr, P. et al. 2010)

The allowance in 2008 of around 10 million EUR corresponds to approx. 1.8 % of the overall allowance for renewable energy which underlines that PV is not in the focus of the federal policy.[16] The national FIT provided so far supported only 26.8 MW of the cumulative installed capacity of approx. 52 MW by 2009, corresponding to 50 % due to a co-financing obligation of the provinces which is cancelled from 2010 onwards. In 2010, for all installments < 5 kW_p an investment subsidy is provided instead of a FIT. For the first time, BIPV receive a separate and higher FIT. However, the maximum FIT paid is limited to 2.1 million EUR which was already consumed in early 2010 and corresponded to a maximum of approximately 40 MW installed capacity for this year.

7.2.3 Rebate program by KliEn

A new short-term initiative was launched since 2008 through the newly-founded national *Fund for Climate and Energy (KliEn)*. The initiative provides a fixed EUR/kW_p rebate up to 60 % of the total investment for newly installed private PV systems up to 5 kW_p. The federal budget of the KliEn amounted in 2008 to 10 million EUR and was used within 15 minutes only due to the high demand. In 2009, around 18 million EUR were budgeted and also used rapidly. The leading provinces in terms of installed capacities are Upper Austria, Styria and Lower Austria (Biermayr, P. et al. 2010). For 2010, KliEn announced a budget of 35 million EUR which has the potential for approx. 5,500 new installations. A rebate of EUR 1,300/kW_p is granted for free standing or roof-top installations and EUR 1,700/kW_p is granted for BIPV. In any case, the rebate is granted up to a maximum of 50 % of the total investment costs (Bründlinger, R. 2010). According to Niki Berlakovich, Austria's energy minister, this PV program will benefit Austria´s economy with an additional turnover in the range of 110 million EUR in 2010 (Sun, Wind & Energy 8/2010).

7.2.4 Regional investment grants

In most of the cases where the installation cannot be supported by the federal FIT, a regional investment support is granted by 4 out of 9 provinces in Austria. In 2009, Lower Austria made available approx. 20 million EUR investment grants leading to 8.5. MW_p newly installed capacity (1,750 installations). On second place, Upper Austria followed with approx. 3.3 MW_p newly installed capacity, whereas the figure for the investment support could not be investigated. On third place was Styria with 1 MW_p newly installed capacity and investment grants of approx. 520,000 EUR and finally, on fourth place, Burgenland has to be mentioned with approx. 235 kW_p installed capacity in 2009 and a regional support of approx. 250,000 EUR. All in all,

[16] In 2008, the biggest part of the federal allowances received solid biomass (45%) and wind energy (26%). PV received, as in the past, the by far smallest allowance (Sonne, Wind & Wärme, 4/2010).

the regional support led to a newly installed capacity of almost 14 MW_p in 2009, being 70 % (!) of the new installed capacity (Biermayr, P. et al. 2010). In 2010, following regional support programs are in place (Bründlinger, R. 2010):

- Lower Austria: Rebate of max. 50 % of the costs and max. EUR 12,000 per installation on residential buildings.
- Styria: Rebate of EUR 500 for 1^{st} kW installed, EUR 1,000/kW for up to 3 kW installed and EUR 250/kW for up to a maximum of 5 kW installed whereas the total rebate is not exceeding EUR 2,000.
- Burgenland: Rebate of EUR 1,100/kW installed for installations up to 5 kW and up to a maximum of 30 % of the installation costs.
- Vienna: Rebate of EUR 1,500/kW installed up to a maximum of 40 % of the installation costs and up to a maximum of EUR 100,000 per installation.

7.2.5 R&D support

Austrian PV research activities are mostly focused on a project basis. So, there isn't any national R&D program dedicated to PV. The only two national programs to mention in 2008 are the *New Energy 2020* program by the national Fund for Climate and Energy and the *Buildings of Tomorrow Plus* program by the Ministry of Transport, Innovation and Technology which include BIPV as a side issue. The public funding for PV related projects is estimated to approx. 1.6 million EUR in 2007, which corresponds to a 3-fold increase compared to the former year and is roughly the same figure as in 2005 (IEA-PVPS 2009). Recently, Austrian PV R&D is conducted in Thin-film technology, grid integration and building integration (Biermayr, P. et al. 2010). The budget for PV R&D projects in 2010 amounts to 2.2 million EUR, which corresponds to 9 % of the overall budget for renewable energy (Fechner, H. et al. 2010).

7.3 Austria´s PV industry

Despite the still small home market, Austrian PV industry could expand their production recently. The overall PV module production in Austria amounted to 47 MW in 2007 and 65 MW in 2008, which corresponds to an increase of approx. 38 %. The leading company producing PV inverters (Fronius) reported an output of 250 MW in 2007 and 450 MW in 2008 and 1 GW in 2009 where more than 99 % was exported.

7.3.1 Key manufacturing companies

The most important products manufactured in Austria are PV inverters, PV modules and tracking systems, as well as back-sheet laminates for module encapsulation or PV Ribbon Wires. Among the most important companies are beside Fronius (inverters) and Solon Hilber Technologie (PV module tracking systems), which are looked at into more detail later on, PVT Austria (standard and tailor-made PV modules), Energetica Energietechnik (standard framed laminates and glass-glass laminates), Kioto (solar thermal collectors), Ertex-Solar (safety glass products), SED (PV-roof tiles and small size modules for special applications), Isovolta (back sheet laminates for a total of 1.5 GW PV modules in 2008, worldwide leading), Ulbrich Austria (string- and bus-wires), and Plansee-Werke (metallic base materials for Thin-film solar cells). In terms of the industrial scale production of solar cells, Blue Chip Energy (sc-Si cells) and FalconCell (mc-Si) are to mention. Further details are listed in Appendix 11.14. Austria´s only producer of inverters, Fronius, is Europe´s second largest manufacturer of inverters for grid-connected PV systems and exports almost the whole of its production. The development of the production capacities and export rates are illustrated in the figure below.

	production		production capacity		export rate	
inverters	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
pieces	77,000	146,000	n.a.	n.a.	> 99 %	> 99 %
power in kW	448,000	1,000,000	650,000	n.a.		

Figure 7-5: Austria´s inverter production 2008-2009
(Translation from Biermayr, P. et al. 2010)

In 2009, a total of 146,000 inverters with a capacity of 1 GW were produced and the vast majority was exported. Generally, main export markets of the Austrian PV industry are Germany, Italy, Spain and Switzerland.

In terms of tracking systems, Solon-Hilber Technologie has developed a good market position. The figures for 2008 and 2009 are displayed below.

	production		production capacity		export rate	
tracking systems	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
pieces	3,800	n.a.	5,000	n.a.	100 %	100 %
power (kW)	31,000	16,000	n.a.	45,000		

Figure 7-6: Austria´s tracking system production 2008-2009
(Translation from Biermayr, P. et al. 2010)

The company had a production capacity of 45 MW available in 2009, but 16 MW only were finally produced and 100 % of this production was exported.

7.3.2 PV value chain

Austria hasn't got any production facilities for silicon feedstock or wafers so this has to be imported. Most of the modules produced include cells imported from various countries, such as Germany, Japan, the U.S., Taiwan and China. In 2009, the vast majority of the total module production of approx. 60 MW_p was exported and a very small amount of 5.6 MW_p was sold on the domestic market. There were produced approx. 63 % polycrystalline and 37 % monocrystalline modules.

7.3.3 Business value

The estimated business value increased from approx. 300 million EUR in 2008 to approx. 550 million EUR in 2009, corresponding to an increase of 83 %. In 2009, the estimated labour places are 2,870 people and correspond to an increase of 63 % in comparison to the former year (Biermayr, P. et al. 2010).

Austrian PV market: labour places 2006-2009						
	2006	2007	2008	2009	change 2008/2009	share 2009
PV-module production, installation, wholesale	271	445	748	1,400	87%	49%
inverter production	300	400	480	800	67%	28%
components & buildings	193	341	487	600	23%	21%
R&D	n.a.	43	47	70	49%	2%
Total	764	1,229	1,762	2,870	63%	100%

Figure 7-7: Austria´s labour places development 2006-2009
(Translation from Biermayr, P. et al. 2010)

7.3.4 PV module and system prices

Following the international trend, the typical PV module prices for the past years have dropped as visible in the figure below.

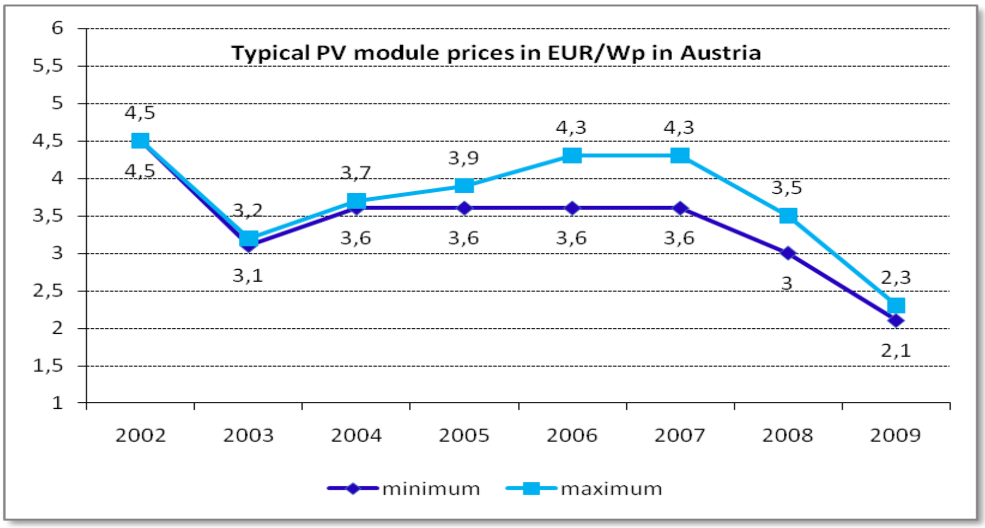


Figure 7-8: Austria´s typical PV module prices 2002-2008
(Data for 2002-2008: IEA-PVPS 2009; Data for 2009: Biermayr, P. et al. 2010)

The development of the PV system prices of a typical grid-connected PV system between 2 and 5 kW over the past years is displayed in the figure below. The average price of a grid-connected PV system (5 kW_p) decreased from 5,100 EUR/kW_p in 2008 to around 3,600 EUR/kW_p in 2010.

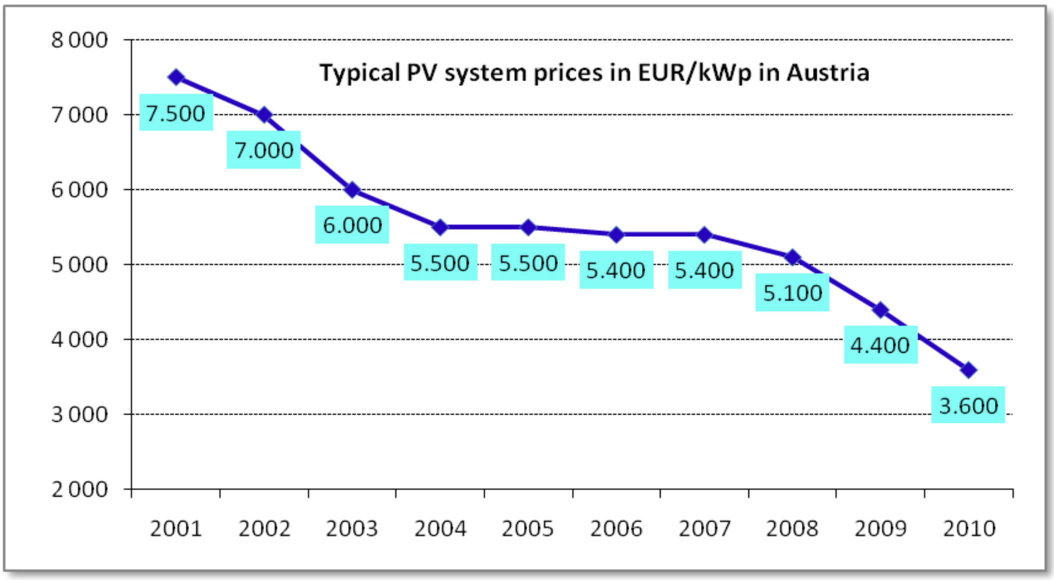


Figure 7-9: Austria´s typical PV system prices 2001-2008
(2001-2008 data: IEA-PVPS 2009; 2009-2010 data: Biermayr, P. et al. 2010)

Prices for specific BIPV systems which are common in Austria are typically considerably higher and depend on the specific case. Additionally, the average system price is highest for 1 kW_p installations, amounting to approx. 5,000 EUR/kW_p in 2009 and lowest for 10 kW_p installations amounting to approx. 3,900 EUR/kW_p in 2009 (Biermayr, P. et al. 2010).

7.4 Summary and learning's Austria

Austria has an internationally very successful PV industry in the inverter or laminates business with export rates up to 100 %, but almost no home market up to 2008, due to discontinuity in several supportive regulations or due to a period of even no federal support at all in the past.

As strengths of Austria´s PV policy framework can be mentioned the secured conditions for investors *within* the cap, stringent authorization procedures and a transparency of fed-in energy and cost (*support fee* on electricity bill). Further, there is a consistent and transparent data basis in the market covered with a FIT, due to centralized registration and monitoring via E-control. However, this data does not cover plants supported on regional level. A good sign to the market represents the higher FIT for BIPV for the first time in 2010.

The main weakness of the Austrian policy framework is the still present cap which limits domestic growth on a very low level. Additionally, the duration of the FIT ought to provide long-term security to win the trust of investors, and the installment of a decrease mechanism is to recommend, reflecting cost-reduction until reaching competitiveness with conventional technologies. Further, the funding through the climate and energy fund is criticized by some stakeholders as a short-term instrument which does not create a sustainable market. To continue, the fact that either a FIT on national level or a rebate on regional level is paid if the requirements are met can be seen as bureaucratic burden. Finally, a transparent and efficient political process for the (re-) definition of FITs ought to be established in order to avoid long consultation processes every year.

Thus, the outlook *seems* to be that Austria´s home market remains limited due to the constraint regulative framework in place and Austria´s PV industry has to continue its success abroad. Being convinced of the high potential of Austria´s PV industry, measures to change this environment will be discussed in the following chapter.

8 Comparison of the solar photovoltaic landscape in Japan, Spain, Germany and Austria

The development of the installed capacities on the domestic market is very closely tightened to the policies in place on the respective market. As soon as there is a policy in place which supports the domestic market implementation of PV, the annually installed capacity increases. Japan has shown a more or less stable development over the past years – including a stagnation in 2006 and 2007 – and Germany can look back on a stable and ambitious development in terms of annually new installations.

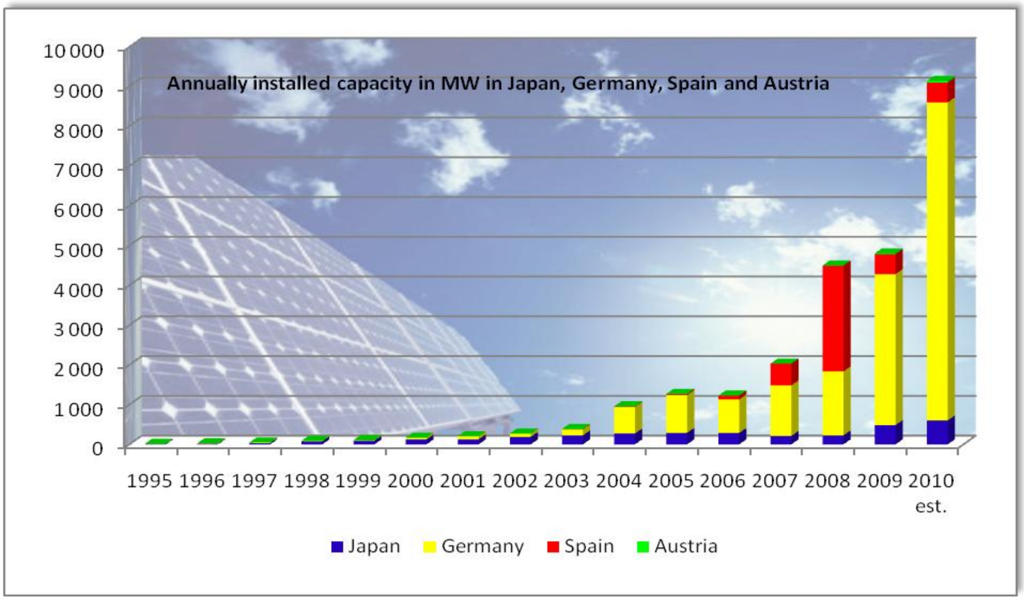


Figure 8-1: Annually installed capacity in MW in Japan, Germany, Spain and Austria (Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

The extraordinary increase of new installations in Spain during 2008, which pushed Spain to the worldwide number one in terms of installed capacities on the domestic market, was result of a very favorable FIT for large scale installations. Many foreign investors were attracted. As there wasn't any cap introduced at that time the Spanish government soon faced a FIT deficit. In the following, the Spanish government felt forced to introduce an annual cap on new installations which led to the collapse of Spain's market from 2008 to 2009, as the newly installed capacities immediately stopped due to the lack of any supportive policy. As a consequence, the global PV industry all of a sudden faced a huge oversupply situation. Thus, the Spanish policies led to a low value added for Spain, as more than 20,000 full time labour places quickly created in the country were as quickly lost and the FIT was consumed by foreign investors. As the FITs were granted for 25 years, Spain will have to pay for this policy for several years. In the end, the oversupply situation caused by Spain finally could be compensated by Germany, which was able to install huge capacities in the second half of 2009; reaching an impressive record of almost 10 GW cumulated installed capacity.

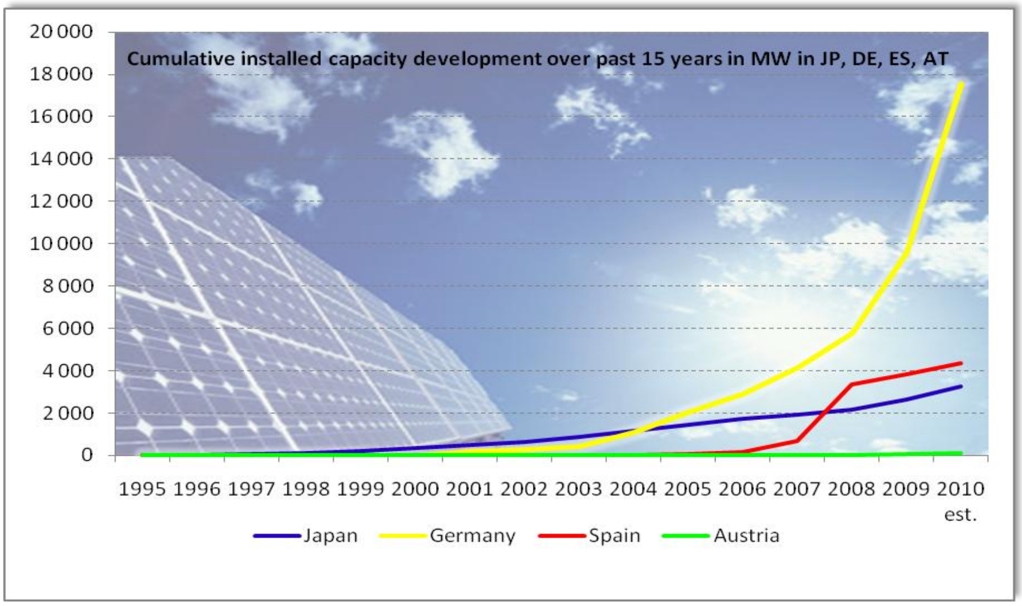


Figure 8-2: Cumulative installed capacity development over past 15 years in MW in Japan, Germany, Spain and Austria
(Summary from IEA-PVPS T1-T18:2009 and IEA annual report 2009)

The PV development in Austria has been totally different. Until 2008, while many other countries like Japan, Spain and Germany had been performing excellently in their home markets in terms of installed capacities, the domestic market situation of PV in Austria had remained quite unsatisfactory due to complex, unstable and low supportive frame conditions. A kind of cap has always been present until today for national installations and the Austrian PV industry has an export rate of almost 100 %. According to the EPIA report SET for 2020 published in 2007, the potential of PV deployment depends on six independent framework conditions, which are PV system integration, cost competitiveness, market deployment, policy framework and interaction with other renewable energy sources and the supply chain. Three years ago, a useful strategic agenda for PV deployment was already promoted within the EU and Austria still has shown a less than moderate development due to the political barrier since then. A new installed capacity of 20 MW in Austria can be highlighted for 2009 – a year in which Germany installed 3,800 MW. Although there has never been created a domestic market for PV in Austria, a handful of Austrian PV industry companies especially in the inverter and tracking system business managed to play a leading role on global scale. A strong home market would also support these companies to keep or strengthen their position on international level. In order to push domestic and international sales of the Austrian PV industry, governmental support is essential and also successful as proved in many other countries. The Austrian government either hasn't been aware of its important role in that respect yet or hasn't considered the PV industry as one which is in the position to add considerable value to Austria. Austrian policy makers must put a focus on PV and provide a stable framework for PV deployment. Looking at the development of the business value in Japan (more than 2 bn EUR in 2009) or Germany (more than 9 bn EUR in 2009), it clearly demonstrates that governmental PV support pays off. In Austria, a business value of 500 million EUR was achieved in 2009, which is already a big success in comparison to the former year where it was less than half of it.

	market size					market growth					market penetration	
	installed cumulative capacity 2007 in MW	installed cumulative capacity 2008 in MW	installed cumulative capacity 2009 in MW	installed cumulative capacity 2010 est. in MW	2020 target installed cumulativ capacity in MW	growth rate 2007/2008 in %	growth rate 2008/2009 in %	growth rate 2009/2010 in %	growth rate 2010/2020 in %	growth rate 2010/2020 in % per year	population in million (rounded)	installations per capita in MW in 2010
Austria	27	31	52	92	322	15%	68%	77%	250%	25%	8	12
Germany	4 153	5 762	9 779	18 562	52 000	39%	70%	90%	180%	18%	82	226
Japan	1 938	2 163	2 633	3 233	28 000	12%	22%	23%	766%	77%	127	25
Spain	691	3 352	3 854	4 354	8 500	385%	15%	13%	95%	10%	40	109

Figure 8-3: Comparison market size, growth and penetration 2007-2010 and 2020

	export	employment				R&D			PV system prices		business value	
	average export rate PV industry in %	employees in the PV industry in 2008	employees in the PV industry in 2009	employees in the PV industry in 2010	employees in the PV industry by 2020 est.	public R&D support 2008 in mio. EUR	public R&D support 2009 in mio. EUR	public R&D support 2010 in mio. EUR	average PV system price 2009 in EUR/kWp	average PV system price 2010 in EUR/kWp	business value in mio. EUR 2008	business value in mio. EUR 2009
Austria	> 99 %	1 800	2 900	3 000	20 000	1.6	2.0	2.2	4 400	3 600	300	500
Germany	> 50 %	50 000	65 000	70 000	100 000	95	53	100	3 400	2 900	7 000	9 000
Japan	> 80 %	26 700	29 000	34 000	50 000	100	80	20	4 100	4 000	1 200	2 200
Spain	> 80 %	42 000	14 000	9 000	10 000	12	n.a.	n.a.	7 000	4 500	900	600

Figure 8-4: Comparison export, employment, R&D, PV system price, business value 2008-2010 and 2020

In Austria, there are always plenty of arguments not to go for solar PV, like, for example, *Austria has not ideal geographical conditions for PV installations*. Looking at Germany, there are not only in the South but also in the North of Germany several PV plants in operation. In Bavaria, which is located in the north of Austria, solar PV contributes already 2 % to the overall electricity demand of the province, whereas in Austria it is 0.1 % only. Despite the success in Bavaria, Austrian´s decision makers used to consider the conditions for solar PV installations not as ideal enough to go for any solar PV applications and to allocate less than 10 % of the renewable energy budget for PV. Additionally, it is said that, *we have huge well performing hydropower plants in Austria* and *our renewable energy share is one of the best within the EU*, so, there is no need for any actions in the PV field. Other arguments claim that *solar PV technology is not yet mature* or *still too expensive* and we have *to wait until the efficiencies are better* and *PV systems are cheaper*. There is still no awareness that with this attitude we prefer to wait until everybody else makes the business.

PV cell or module efficiencies have been rapidly increasing over the recent years and continued R&D ensures further improvements and new innovative applications. In case *there is* any R&D accomplished. Japan has always focused on PV R&D in the past years, especially in the area of field testing. Germany announced 100 million EUR public R&D supports for 2010 if the PV industry invests further 500 million EUR. The Austrian federal government offers just a bit more than 2 million EUR for PV R&D, because the focus lies on hydropower and biomass. In Austria, we have the situation of a *total solar eclipse* as PVA put it in a nutshell. It seems that from decision makers to end customers people are still not yet well informed about the advantages and huge potential solar PV has also for Austria. Despite the fact that it is a small country, there are plenty of m^2 existing roofs and facades in Austria where PV applications can be installed, improving the energy balance of these buildings, reducing CO_2 emissions and generating green electricity. Moreover, PV system prices have been cut in half over the last eight years being already below 3,000 EUR/kW_p in Germany and at an average level of 3,600 EUR/kW_p in Austria.

PV is still somehow an early-stage technology. PV plants have a higher investment cost than competing technologies, but lower operating cost and no fuel price risk. The cost disadvantage is influenced by subsidies. The Swiss university of St. Gallen's Institute for Economy and Environment investigated the relative importance of policy attributes encouraging PV project developers in 2009. The resulting ranking was as follows: short duration of administrative process (26 %), a high enough level of FIT (24 %), no presence of FIT cap (19 %), solar policy changes (18 %) and long FIT duration (14 %). Thus, the FIT was mentioned three times (level, duration, and cap), and it is indeed the worldwide most important tool to support the PV industry and create a PV market. In the figure on the next page, the comparison of the FITs between the contemplated countries is summarized. In Germany, the FIT was designed in a way that around 80 % of Germany´s PV plants are installed on roof-tops. Spain, on the contrary, made no distinction between FITs for roof-mounted and free-standing installations in the strong year 2008. As a result, almost all PV power plants in Spain were free-standing. Additionally, most of the PV plants installed in Spain in 2008 were large-scale *huertas solares,* because the FIT in place enabled such large installations. Japan introduced its first FIT ever in November 2009 and distinguishes only between residential and no-residential installations with an upper limit of 500 kW implementing the learning's from Spain. Thus, in 2009 the installations in the residential sector in Japan amounted to more than 80 % and in Spain to 2 % only. The Spanish government reacted with an amended FIT and a cap to put a focus on smaller and roof-top installations.

	FIT in EUR/kWp 2010	Austria	Germany*	Japan	Spain
	validity in years	13	20	10	25
	cap in MWp	15-40	-	-	500
all except BIPV	> 5 kWp < 20 kWp	0.35	-	-	-
	> 20 kWp	0.25	-	-	-
BIPV	> 5 kWp < 20 kWp	0.38	-	-	-
	> 20 kWp	0.33	-	-	-
roof top only	< 2 MWp	-	-	-	0.33
roof and facade	< 30 kWp	-	0.3303	-	-
	> 30 kWp	-	0.3142	-	-
	> 100 kWp	-	0.2973	-	-
	> 1000 kWp	-	0.2479	-	-
residential	< 10 kWp < 500 kWp	-	-	0.37	-
no-residential	< 10 kWp < 500 kWp	-	-	0.18	-
ground mounted	< 10 MWp	-	-	-	0.32
	commercial areas near traffic routes	-	0.2426	-	-
	conversion areas, sealed areas	-	0.2537	-	-
direct consumption share < 30%	< 30 kWp	-	0.1665	-	-
	> 30 kWp	-	0.1504	-	-
	> 100 kWp	-	0.1335	-	-
direct consumption share > 30%	< 30 kWp	-	0.2103	-	-
	> 30 kWp	-	0.1942	-	-
	> 100 kWp	-	0.1773	-	-
			* as of 1.10.2010 (BSW Solar, 12.7.2010)		

Figure 8-5: Comparison FITs 2010

Austria grants in 2010 a maximum FIT of EUR 2.1 million, which was already consumed in the beginning of the year and lead to new installations of approx. 40 MW. A separate FIT for BIPV was introduced for the first time and installations between 5 kW and 20 kW are supported most. However, the limitation of the FIT blocks any further domestic growth and Austria's PV industry produces still mainly for the export. To conclude, the FIT turned out to be the most important tool to support the PV industry and PV dissemination.

Looking at all tools and actions fostering PV deployment which are in place in the analyzed countries, a rating is provided in the figure on the next page. At the very beginning of the success for PV deployment and business creation for the PV industry stands the awareness creation. Politicians, people involved in building construction and potential customers have to be aware of the huge potential solar PV has for Austria's economy, the environment and every individual itself.

There exists a broad range of financial support schemes fostering PV installations, such as various kinds of subsidies, bonuses, rebates, incentives or investment supports. In any case, applicants are confronted with an administrative procedure which ought to be simple and fast in order to be effective for the PV deployment.

PV industry companies and research centers are present in networks of international PV organizations, projects and on platforms in order to have access to state of the art technologies, best practices, empirical data and innovations. Further, an investment in R&D as well as education – from PV courses to academic lectures – is essential for the PV industry to be competitive on global scale. Last but not least, regulative policies steer the use of solar PV electricity.

Comparison of the tools and actions for PV deployment				
tool / action			**comments**	**rating**
Awareness	Awareness creation for PV		among decision makers, politicians, companies, utilities, architects, building industry, customers, etc. through media, exhibitions, etc.	+++
Financial support schemes	Direct consumption bonus		a fixed rate paid for each kWh of solar power used by the system operators themselves or any third party in the vicinity	+++
	Direct subsidies		financial support in local currency per kWp	+
	FIT	level	the height of the financial support in local currency	+++
		duration	the duration of the financial support in years	++
		degression rate	the amendment of the FIT based on past new installations	+++
	Rebates		a fixed financial investment support in local currency per kWp installed up to a given % of the total investment	++
	Tax incentives		fiscal incentive programs for government buildings, schools or a special customer segment	++
	Soft loans		financial support to cover investment costs at a low interest rate	+
Networking	national and international		in projects, on platforms, at exhibits, etc.	+++
R&D and education	R&D budget		for technology innovations, prozess optimations, and other provided by the federal public and the PV industry	+++
	Educational investments		skilled workforce from installers to PhD level has to be available on the labour market; investment in education	+++
Regulative policies	Building law directives		requirement to incorporate PV panels in every new built house or every public building	++
	Buyback program for PV generation		electric utilities require to buy excess solar power at a fixed premium rate	+
	Net billing		energy generators sell solar PV electricity back to the utility at a given price	+
	Net metering		the net electricity delivered from the utility which is total consumption minus self-production is paid by the customer	+++
	RPS		annual obligation for electricity retailers to use certain amount of their retailing electricity from RES	+
	Time-of-use electricity billing		higher (lower) electricity price when electricity demand is high (low)	+++
	+++ highly effective ++ important + supportive			

Figure 8-6: Comparison of the tools and actions for PV deployment

In the following, recommendations for Austrian stakeholders are given to strengthen the position of the Austrian PV industry on global scale.

9 Recommendations for Austrians stakeholders

Austria hosts some internationally successful PV industry companies which play a leading role on global scale already by now. Above all, the most important ones are Fronius (inverter production) and Isovolta (PV components, trackers). Austria also hosts companies producing modules and cells recently. A few companies could generate their profit in the PV business in the total absence of a home market, having an export rate of almost 100 %. The targets ought to be, first, to secure and expand the present position of these companies on international level, second, to add more companies in niche applications such as BIPV or PV components, in order to be internationally competitive and third, to create a strong domestic market. By doing so, a yearly business value of up to 7 bn EUR and approx. 36,000 labour places can be generated by 2020 (Fechner et. al., 2010). A well developed home market helps to support international reputation of Austrian PV companies. In order to achieve a significant PV penetration in the Austrian electricity market, the active involvement of the Austrian government and the energy industry stakeholders including the PV sector is required. Policy makers, regulators and the PV industry have to collaborate tightly to enable a PV mass-market penetration. Technological progress has to be fostered, costs reduced and an appropriate financial and regulatory environment has to be established. PV applications for sure will be mainstream one day. PV just requires *in the present decade* temporary support of policy makers to bridge the competitiveness gap. Public support can only be justified if the PV industry commits its own resources to this goal also being the reason why the German government announced public R&D supports of 100 million EUR, under the precondition that the German PV industry invests further 500 million EUR. In the following, the target audience consists of the Austrian government, utilities companies and grid operators, the PV industry and national PV associations, and the PV R&D community.

9.1 Austrian government

Long-term targets and supporting policies are crucial to build confidence for investments in manufacturing capacity and deployment of PV systems. The policy framework for PV should be designed in such a way that it optimizes both technology development and market support mechanisms (such as FITs), which stimulate the market as summarized in the figure below.

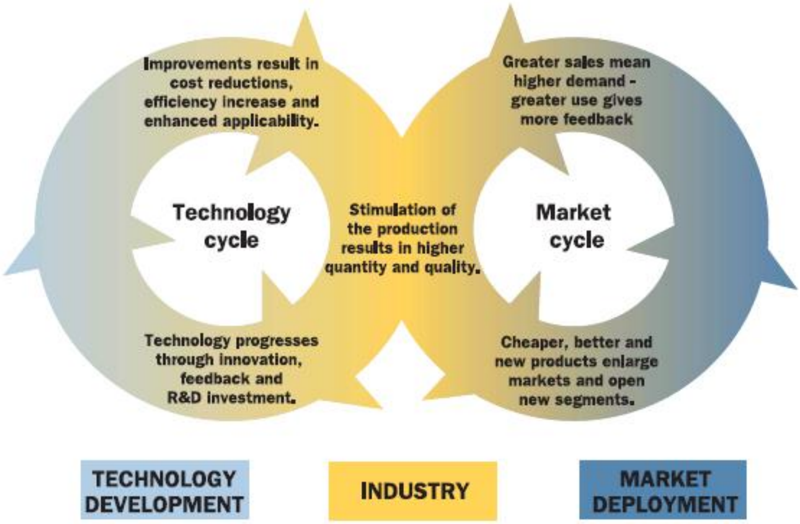


Figure 9-1: Technology development and market development (PV-TRAC, 2005)

If large solar cell companies use their cost advantages to offer lower-priced products, customers will buy more solar systems and it is expected that the PV market will show an accelerated growth rate. However, this development will influence the competitiveness of SMEs as well. To survive the price pressure of the big companies made possible by economies of scale, they have to specialize in niche markets with high value added in their products. The relevant role of the Austrian government in this respect is very important: The Austrian government has the target to attract as many elements of the PV value chain as possible to be present in the home market, in order to maximize the Austrian business value achieved. Quick action is required to make the business. The Austrian government ought to support PV deployment *in the present decade* by combined efforts in the R&D area, as well as market launch activities. Following actions are to recommend:

1. **Increase PV R&D efforts:** the focus has to be put on accelerated cost reduction as well as grid integration (smart grids) and longer-term innovations. Technology research can lead to efficiency improvements of 30 % by 2020, according to the SET 2020. Austria´s PV industry may develop to a strong specialist in BIPV, PV components (e.g. encapsulation) or storage technologies which become increasingly important as the PV mass-market takes off. Continued technical improvements in terms of tracker systems, inverters and grid integration have to be achieved in order to secure the dominant international market position. The durability and application range of PV components and systems have to be prolonged, respectively diversified. R&D has to be accomplished by universities (EEG of

the TU Vienna, Danube University Krems, etc.), applied research institutes (arsenal research, etc.) and the PV industry itself. Additionally, there is a need to foster international R&D projects, as well as to expand international collaboration and networking in PV research, development, capacity building and financing to accelerate learning and avoid duplicating efforts. Generally, R&D on a project basis only without any national budget will not achieve the just mentioned targets. Japan, for instance, has accomplished regular R&D investments with a long term perspective and achieved the position as leader in PV technology innovation, being closely followed by Germany. This enabled Japan being first mover in terms of new applications and especially cell technologies brought into the markets. Today, Germany takes a worldwide leading position in PV R&D. The Austrian pathway is more to find in PV market niches. In order to develop a *sustainable* home market and international growth of the Austrian PV industry, stable and reliable *long-term* strategies in research policy and energy policy measures are necessary. The relevant human capital, the required research and development infrastructures, as well as an investment security for production capacities, can only be built in such a policy environment. Further, these conditions enable a comparatively small economy like Austria to be successfully on global scale preferably in niches.

2. **Raise awareness for PV:** Awareness for the huge benefits of PV has to be created among decision makers, consumers, politicians, companies, utilities, architects, building industry and any potential business partners. The installation of demonstration projects, as for instance the Energy base in Vienna, is one way to raise awareness among the population regarding the technology itself.[17] More such innovative demonstration projects with even higher PR effect have to be build. Further supportive impact has any award or national prize for e.g. design or innovation, which raises reputation of Austrian firms. In any case, the right target groups have to be addressed continuously to ensure that Austrian quality and service is recognized. Austria has to put the focus on Austrian-based production capacities to raise the Austrian export of e.g. PV inverter or tracker technology in terms of volume and create business value for the country. Further actions to raise

[17] Following projects are already available as demonstration objects: Ökotherm-Fassade in Schörfling in Upper Austria (28kW$_p$), South-West facade of the Power Tower of the Energie AG in Upper Austria (polycristallyine modules, project of Ertex Solar, 66 kW$_p$), South side of AVL-List hall in Graz (polycrystalline modules, 35.6 kW$_p$, planned by Solartechnik).

the PV awareness is any kind of promotion, such as: solar campaigns, info-brochures, fairs, press, solar days, congresses and conferences (e.g. Austrian Photovoltaic conference), where national stakeholders are brought together to address the media, politicians and provide the public with newest developments in the PV sector, etc. Finally, information activities for the domestic PV industry, where innovative technologies and applications are presented and networking is possible, have to be organized.

3. **Form attitude of customers especially in the residential sector:** In Japan, every owner of a residential PV system is proud of it. This owner is proud to protect the environment of the planet and to generate green electricity. This owner is so proud of his PV system the new installation is even presented to friends, family or neighbors. This kind of attitude supports the PV dissemination a lot. Promotion programs in various media in Japan have made PV a mass-product which everyone has to own like a mobile phone or a notebook in every developed country. Being proud to contribute personally to the CO_2 emission reduction is a valuable intrinsic motivation. Austria has several resources it can be proud of: clean water, air, still good solar radiation for PV applications, and such a nice landscape that lots of tourists come to spend their vacation time in Austria. Every Austrian could also be proud of a residential PV system on the roof of the house or the roof of the garage for the car. The Austrian government has to set initiatives to promote sustainable electricity generation, energy self-sufficiency and to create awareness of the importance of every single person to contribute to it.
4. **Implement the model of the direct consumption bonus:** In order to demonstrate economic benefits for PV installation owners, the model of the direct consumption bonus in the style of Germany should be applied in Austria as well. A direct consumption bonus should be paid for each kWh of solar power used by the PV system operators themselves or any third party in the spatial vicinity of the system.
5. **Use time-of-use electricity billing and net metering** in order to facilitate the penetration of PV. The target of time-of-use electricity billing is to give people an incentive to use less electricity at times when demand is highest and supply is low. Consequently, more is paid when the electricity demand is high (e.g. during the day) and less is paid when the electricity demand is low (e.g. during the night). Using net metering, the customer pays only for the net electricity delivered from the utility (total consumption minus self-production).

6. **Ensure simple procedures in the financial support systems:** As already learned in the former chapter, it is crucial for fast and stable PV implementation to keep administrative procedures simple and to avoid any impression of a barrier. In general, a financial support system has to be easy to administrate for the authorities, reliable, long time guaranteed, stable and it has to provide investment security for investors. Further, it has to be easy to apply without any bureaucratic hurdles and it must have a sufficient level of support in solar e.g. 20-30 % of the total cost. Finally, a financial support is to comprehend as a public short term instrument to implement a new energy system.
7. **Ensure a sustainable FIT:** A well designed FIT in terms of level, duration and application for the time period of the competitive gap is essential to ensure continuous PV deployment. The FIT has to be effective, cost-efficient and has to decrease over time in order to foster innovation and technological improvement. The most important action to be taken by the Austrian government is the elimination of any tool working as a *cap*. Any cap, as also seen on the Spanish market, immediately paralyzes the market development of PV at present stage despite the big market demand potential. The German FIT model, including a degression rate, is supposed to be a successful way to go for Austria as well, and a similar design has to be implemented for Austria.
8. **Supplemental financial support systems:** In addition to the main financial support tool, the FIT, further tools help to support the PV deployments in niches, which are: direct subsidies, soft loans and tax incentives.
9. **Consider PV in the building law:** Any new building or any fundamental reconstruction of buildings can be obliged to have BIPV or PV in facades installed in order to meet energy efficiency targets. Public buildings should make the first step and implement PV on their roofs or facades to send a signal to the general public. Additionally, any subsidized housing can be granted only if PV is considered in the building construction or environment. PV can even be defined as a standard for new buildings in general.
10. **Ensure availability of skilled workforce:** As research and technological development has to continue, costs have to remain competitive, sustainable markets have to be created and innovative new applications have to be developed. Furthermore, a strong effort is required in the field of education and training at all levels, from installation technicians to PhD students. Awareness for PV and related RES applications can be formed starting at

school already. The Austrian government has to be careful to make sure that the required skilled workforce is available on the labour market. Up to date education as well as training programs for installers, architects, researches and any people involved in the PV sector has to be offered. An overview of the main PV courses currently available in countries analyzed in this work is provided in Appendix 11.15.

9.2 Utilities companies and grid operators

Utilities companies with generation assets and established end-user relationships must consider PV development as an opportunity and become proactive PV investors and marketers to maintain and expand their market share by meeting client demand and offering them advanced customer services.
Grid operators have to support the decentralization of the infrastructure and become actively involved in implementing the necessary smart grid technology, such as improved measurement, communication and control techniques. They also need to help develop and install storage technologies to increase the absorption of distributed power in grids, while collaborating with the renewable energy sector to ensure that regulators reflect the necessary investments in their distribution tariffs.

9.3 PV industry and national Photovoltaic Austria Association

PV industry companies have to maintain their strong R&D commitment to continue the dynamic PV cost reduction. Cooperation between national PV industry companies is essential to form a strong network of cooperation and gain competitiveness on international level.
The recently established national Photovoltaic Association *Photovoltaic Austria (PVA),* targets to create a national network for dissemination of information on PV and initiates awareness raising activities. Further, it aims at changing the legislative frame conditions for PV by introducing stable and supportive PV market incentives which are preferably based on FITs. Therefore, intensive *political lobbying work* is required as well as marketing actions, such as the introduction of a broad series of articles in newspapers related to PV. The *Austrian PV technology platform* is a tool to support the national PV industry by fostering national cooperation, enabling information sharing and tightening future collaboration. It brings together the most important Austrian PV industries to discuss their needs for a long-term strategy towards a national and international competitive positioning on the worldwide growing PV market. The national Photovoltaic Austria Association has to strive for close collaboration and networking with international Photovoltaic Associations,

such as EU PV and EPIA respectively. PV industry companies have to collaborate closely with R&D institutes to ensure high innovation in the end product.

9.4 PV R&D community

The PV R&D community has to deliver research results in line with the focus areas, such as improved cell efficiencies and system performance, reduced process costs, simple usage of the parts produced, increased life time of the products, improved recycling processes and electricity storage systems, energy saving and innovative tailor-made products to cover market needs. Austrian PV R&D has to seek for further collaboration in European or international projects, such as PV ERA NET or the IEA PVPS program, in order to be up to date, exchange experiences, get new insights and opportunities for the Austrian PV industry.

9.5 The Austrian pathway

The industrial value of any investments or efforts put into PV deployment is high. Establishing a PV support framework is a benefit for the local PV industry, the environment and the country itself. Any avoidance of fossil fuel imports already keeps the money in the country. The Austrian PV industry can make its success in niche applications, such as BIPV or Thin-film, as well as PV components. The global leading position in the inverter and tracking system business has to be kept and enhanced by Austrian R&D efforts. Currently, Fronius is a global player in the inverters business, Isovolta is a global player offering back sheet laminates for PV cells and modules, Solon Hilber leads with tracking systems, and Ulbrich made its success with PV ribbon flat wires. The photovoltaic company's in Austria ensure almost 3,000 labour places and generate added value to Austria already by now.

While in Austria a new installed capacity of 40 MW is achieved by the end of 2010, in Germany an estimate of 8 GW is going to be installed. The managing board of SMA Solar Technology, the worldwide leading company in the inverter business, expects a globally new installed capacity of 17 GW for 2010. The worldwide market share of SMA Solar Technology is expected to be more than 40 %, having a turnover of almost 2 bn EUR and an EBIT-margin of approx. 29 % (Solarserver.de, 18.9.2010). Thus, Germany has the by far biggest home market in the world and hosts an international very successful PV industry.

As there is a global *PV boom* – especially southern European markets show nice growth rates of PV installations – the Austrian PV industry has to be supported to develop a leading position on global scale by investing in R&D and showing higher commitment to the Austrian PV sector by the Austrian government. Depending on the growth scenario for Austria, a policy driven scenario means up to 36,000 labour places generation by 2020, assuming the target of 8 % electricity generation from solar PV is achieved. In any case, the Austrian government has to be aware of the central role it has to play in this respect: PV R&D funding has to be increased, awareness activities have to be set to change the attitude of potential customers and business partners, networking among national PV companies together with R&D institutions and the Austrian government has to be fostered, financial support systems have to be established, above all, a sustainable and simply applicable FIT in the style of the German EEG and a direct consumption bonus have to be offered, new regulations which require PV in new buildings or public buildings have to be implemented and up to date education and trainings to ensure a skilled workforce from installers to PhD students have to be granted. Additionally, international networking by Austrian PV companies and associations is required to get business in the country. Drivers for PV on the demand side are decreasing costs for PV systems and branding of PV applications. Costs of the installation of PV systems are brought down via higher efficiencies, new applications or innovations through R&D efforts. Branding is achieved with awareness creation. If people are proud of PV they also want to have it. Thus, it may be a promoter if friends, public buildings or popular companies for consumer goods have it implemented on their roofs or facades. The role of the Austrian government is to act as initiator *now* and to enable the PV industry to generate an attractive and sustainable business value for the country in the medium-term and long run.

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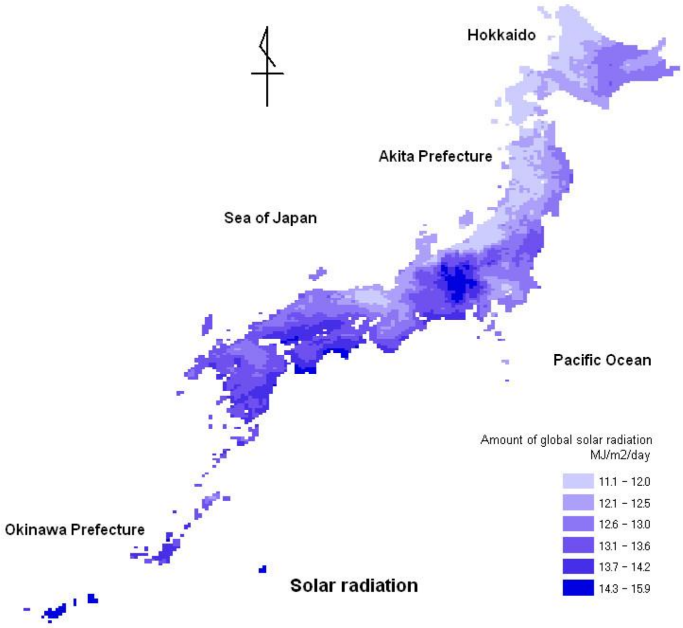
11 Appendix

11.1 Japan´s solar irradiation map



http://ij-healthgeographics.com/, 2010

11.2 Japan´s National Budget for PV Power Generation 2001-2005

National Budget of PV Power Generation [NEDO] ***Unit: Billion Yen***

Item	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
Residential PV system Dissemination Program	23.51	23.20	10.50	5.25	2.60
Field Test Project on New PV Power Gen Technology	-	-	3.50	5.03	9.23
PV Field Test Program for Industrial Use	1.99	4.50	0.26	0.14	0.11
PV Field Test Program for Public Facilities	0.07	-	-	-	-
R&D pf PV Power technology	5.05	7.30	5.09	4.60	2.84
Advanced Manufacturing Technology	1.31				
PV system technology for mass dissemination	-	-	1.26	1.14	0.71
PV system technology for dissemination acceleration	-	-	1.07	0.80	-
PV Power generation development	-	-	-	-	0.55
International Cooperative Demo of PV Systems	0.28	0.80	1.90	2.11	-
International Demo Project for Stabilized Grid	-	-	-	-	0.84
Demo of Grid-Interconnect of Clustered PV Systems	-	0.10	2.37	5.94	1.25
Total	**32.31**	**35.90**	**25.95**	**25.00**	**18.13**

(Japan Photovoltaics Market Overview 2005, R. Foster)

11.3 Japan´s Technological Targets toward 2030 (PV2030)

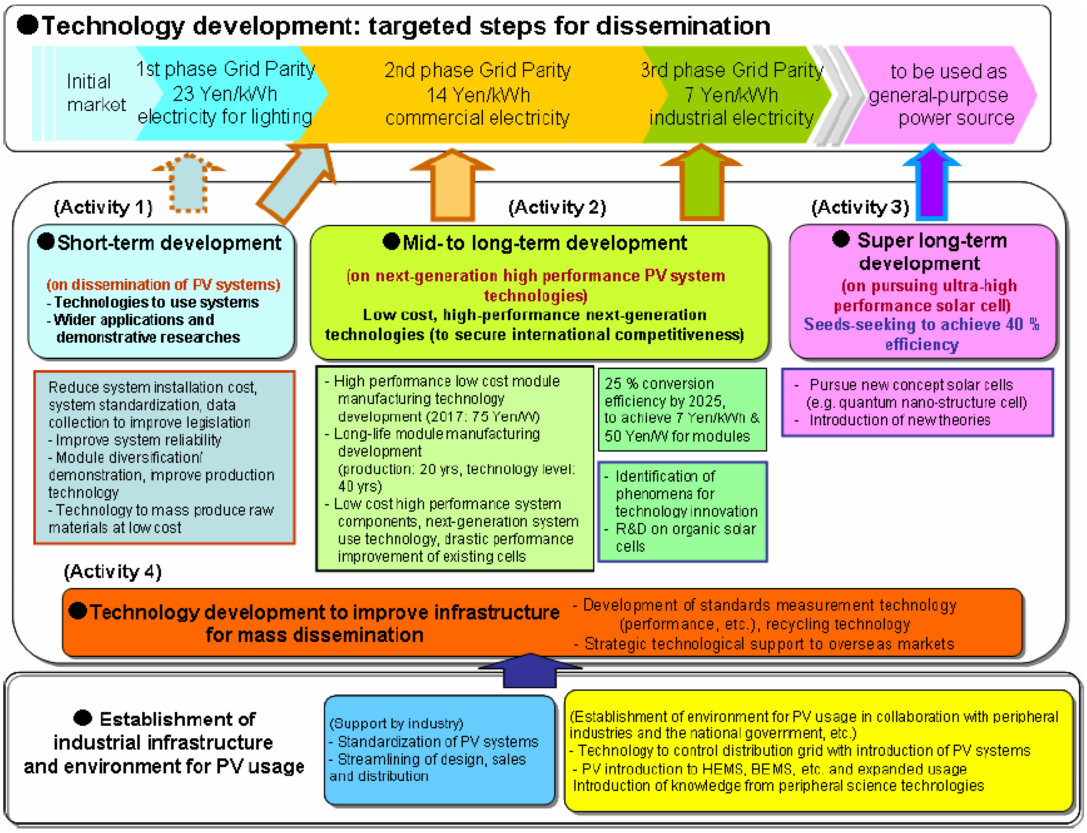
Item	**Present Status**	**Target by 2010 - 2030**
Production cost of PV module Conversion-efficiency of PV module	Production: 250 yen/W (2003) Expected development: 14 yen/W (2007)	100 yen/W (2010) 75 yen/W (2020) ＜50 yen/W (2030)
Durability of PV module	20 years	Service life 30 years (2020)
Silicon feedstock consumption	10～13 g/W	1 g/W (2030)
Inverter (power conditioner unit)	～30,000 yen/kW	15,000 yen/kW (2020)
Accumulator battery	～10 yen/Wh (for automobile)	10 yen/Wh (2020) Durability: 10 years

● **PV module conversion efficiency targets** *(cell efficiency targets)*

Solar Cell Type	**Present Status**	**Conversion efficiency target (%)**		
		2010	2020	2030
Crystalline silicon solar cell	13～14.8 *(18.4)*	16 *(20)*	19 *(25)*	22 *(25)*
Thin-film silicon solar cell	10 *(14.7)*	12 *(15)*	14 *(18)*	18 *(20)*
"CuInSe" solar cell	10～12 *(18.9)*	13 *(19)*	18 *(25)*	22 *(25)*
"III-V" solar cell	Concentrator *(38.9)*	28 *(40)*	35 *(45)*	40 *(50)*
Dye-sensitized solar cell	*(10.5)*	6 *(10)*	10 *(15)*	15 *(18)*

(Overview of PV Roadmap toward 2030, NEDO, 2004)

11.4 Japan´s Technological Targets toward 2050 (PV2030+)



(Outline of the Roadmap PV2030+, NEDO, 2009)

11.5 Japan´s PV cells/modules efficiencies in % (PV2030+)

Type	current status		2017		2025		cost , lifetime target at 2050		2050
	Module (%)	Cell (%)	Module (%)	Cell (%)	Module (%)	Cell (%)	Manufacturing cost (Yen/W)	Lifetime (Year)	Module (%)
Crystalline Si	~16	20	20	25	25	(30)	50	30(40)	Ultra-high 40 % efficiency solar cells (additional development)
Thin-film Si	11	15	14	18	18	20	40	30(40)	
CIS	11	20	18	25	25	30	50	30(40)	
Compound	25	41	35	45	40	50	50	30(40)	
Dye-sensitized	-	11	10	15	15	18	< 40		
Organic		7	10	12	15	15	< 40		

(Outline of the Roadmap PV2030+, NEDO, 2009)

11.6 Japan´s budget for major PV programs implemented in FY2009

The budgets for major national PV programs implemented in FY 2009 are as follows;

1) Subsidy for measures to support introduction of residential PV systems (FY 2008 supplementary budget): 9 BJPY
2) Subsidy for measures to support introduction of residential PV systems: 42,05 BJPY (FY 2009 budget: 20,05 BJPY + FY 2009 supplementary budget: 22 BJPY)
3) Technology Development of Photovoltaic Power Generation: 3,59 BJPY
   - Development of Technologies to Accelerate the Practical Application of Photovoltaic Power Generation System: 310 MJPY
   - Research and Development of Next-generation PV Generation System Technologies: 1,1 BJPY
   - Research and Development on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program): 1,5 BJPY
   - Research and Development of Common Fundamental Technologies for Photovoltaic Generation Systems: 350 MJPY
4) Field Test Project on New Photovoltaic Power Generation Technology: 330 MJPY
5) Verification of Grid Stabilization with Large-Scale PV Power Generation Systems: 2,02 BJPY
6) Development of an Electric Energy Storage System for Grid-connection with New Energy Resources: 1,7 BJPY (new)
7) Project for Supporting New Energy Operators: 3,007 BJPY
8) Project for Promoting the Local Introduction of New Energy: 6,26 BJPY
9) Promotion of regional energy development and utilization: 110 MJPY
10) Project for Establishing New Energy and Energy Conservation Visions at the Local Level: 540 MJPY

11) Project for developing technology to prevent global warming: 3,805 BJPY
12) Project to promote comprehensive measures to create low-car bon local communities: 990 MJPY
13) Project to promote the use of PV and other types of renewable energy: 1 BJPY

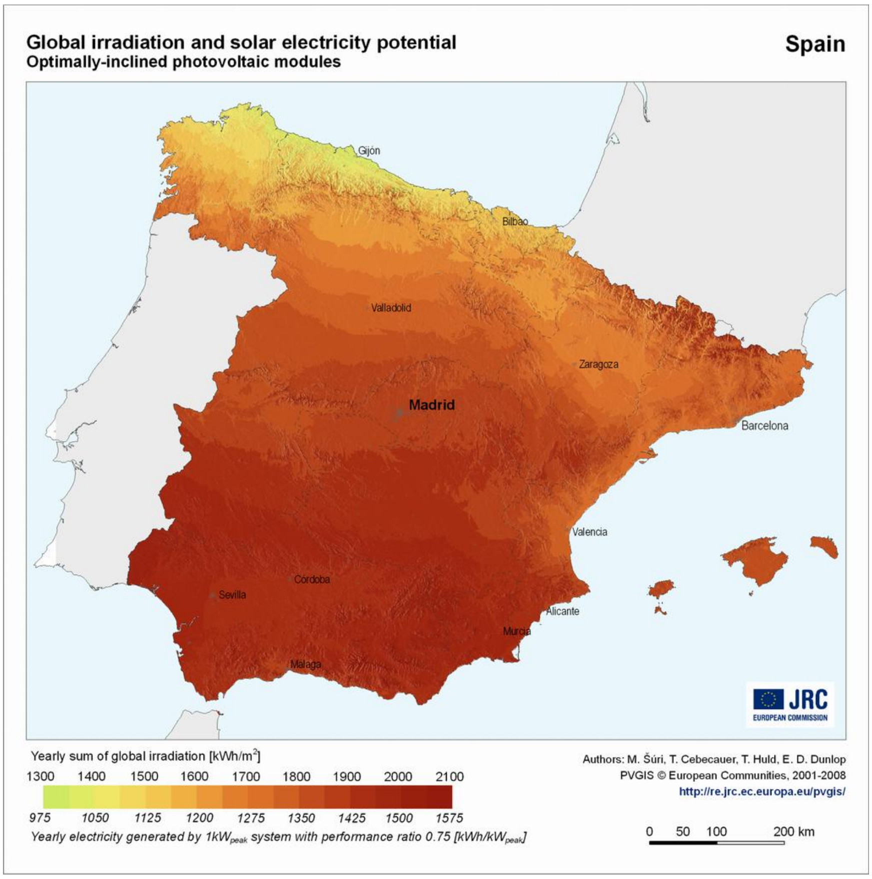
11.7 Japan´s most important manufacturers

Company	Overview
Sharp Solar	The company manufactures a range of mc-Si, sc-Si and a-Si cells. Sharp Solar is the world leader in the manufacture of PV cells and modules. Its share accounts for a quarter of the world's market and half of Japan's market. Besides Japan, Sharp also has plants manufacturing modules in the United States and United Kingdom. Sharp intends to increase its cell and module production capacity from 428 MWp in 2006 to 800-900 MWp by 2010.
Kyocera	The Solar Energy Division of Kyocera manufactures mc-Si cells and PV modules. Kyocera is the second largest manufacturer of PV cells and modules in Japan. The company has module plants in Mexico and the Czech Republic and a partnership with China's Tianjin Yiqing Group to manufacture modules in Tianjin China. Cell production capacity is expected to increase from 240 MWp in 2005 to 500 MWp by 2007.
Sanyo	Sanyo manufactures a-Si and a-Si/sc-Si hybrid cells for its modules. Besides Japan, the company has plants in Mexico and Hungary producing modules, receiving supplies of PV cells from its plant in Japan. Sanyo expects to increase cell production capacity from 260 MWp in 2006 to 600 MWp by 2010.
Mitsubishi	Two subsidiaries under Mitsubishi Corporation are involved in production of PV cells and modules. Mitsubishi Electric manufactures mc-Si cells for its modules and cell production capacity increased from 135 MWp in 2005 to 230 MWp in 2006. Mitsubishi Heavy Industries manufactures a-Si and a-Si/micro-Si cells for its modules and cell capacity increased from 10 MWp in 2005 to 50 MWp in 2006. Another subsidiary, Mitsubishi Materials manufactures mc-Si at its plant in Japan and the United States with a combined production capacity of 2,850 tons in 2006. Mitsubishi Materials confirmed plans to increase capacity by 300 tons at its plant in the United States.
Kaneka	Kaneka manufactures a-Si/mc-Si thin film cells and modules. The company plans to increase production capacity from 30 MWp in 2006 to 70 MWp in 2008. Kaneka also operates a PV module plant in the Czech Republic.

Company	Overview
MSK	MSK became a subsidiary company of Suntech, China, when it acquired a majority stake in MSK in 2006. MSK focuses on mc-Si modules and specialises in systems integration and production of building integrated modules. Acquisition by Suntech provides an opportunity for MSK to reduce its production and operating costs by transferring some of its production and back-end operations to China.
Kobe Steel (Kobelco)	Kobe Steel's in-house production capacity is less than 5 MWp but has partnership with Schott Solar to import modules. Current focus is systems integration for installations in public and industrial buildings in Japan.
Honda	Honda is a new market player in the Japanese PV industry entering the market in 2006. The company will begin full production from its 27.5 MWp capacity plant producing CIGS thin films.
Tokuyama	The fastest growing business of the Electronic Materials Business of Tokuyama Corporation is manufacturing and marketing of mc-Si to PV cell manufacturers. Due to growth of the PV market, Tokuyama announced plans to increase production of mc-Si at its plant in Higashi from 4,800 tons to 5,200 tons. Tokuyama also has plans to construct and operate a 200 tons verification plant to produce mc-Si using vapour-to-liquid deposition technology.
Sumitomo	Sumitomo Titanium's mc-Si was initially targeted for the semiconductor industry. With growing demand for silicon from the PV industry, Sumitomo announced its production capacity would increase from 900 tons in 2006 to 1,300-1,400 tons by 2007.
JFE Steel (formerly Kawasaki Steel)	JFE Steel manufactures mc-Si ingots for PV cell manufacturers in Japan. Annual production increased from 920 tons in 2004 to 1,200 tons in 2005 equivalent to 120 MWp of PV cells. Currently pursuing technologies to develop and produce wafers.

(Pusat, T. Global PV industry research, 2007)

11.8 Spain´s solar irradiation map

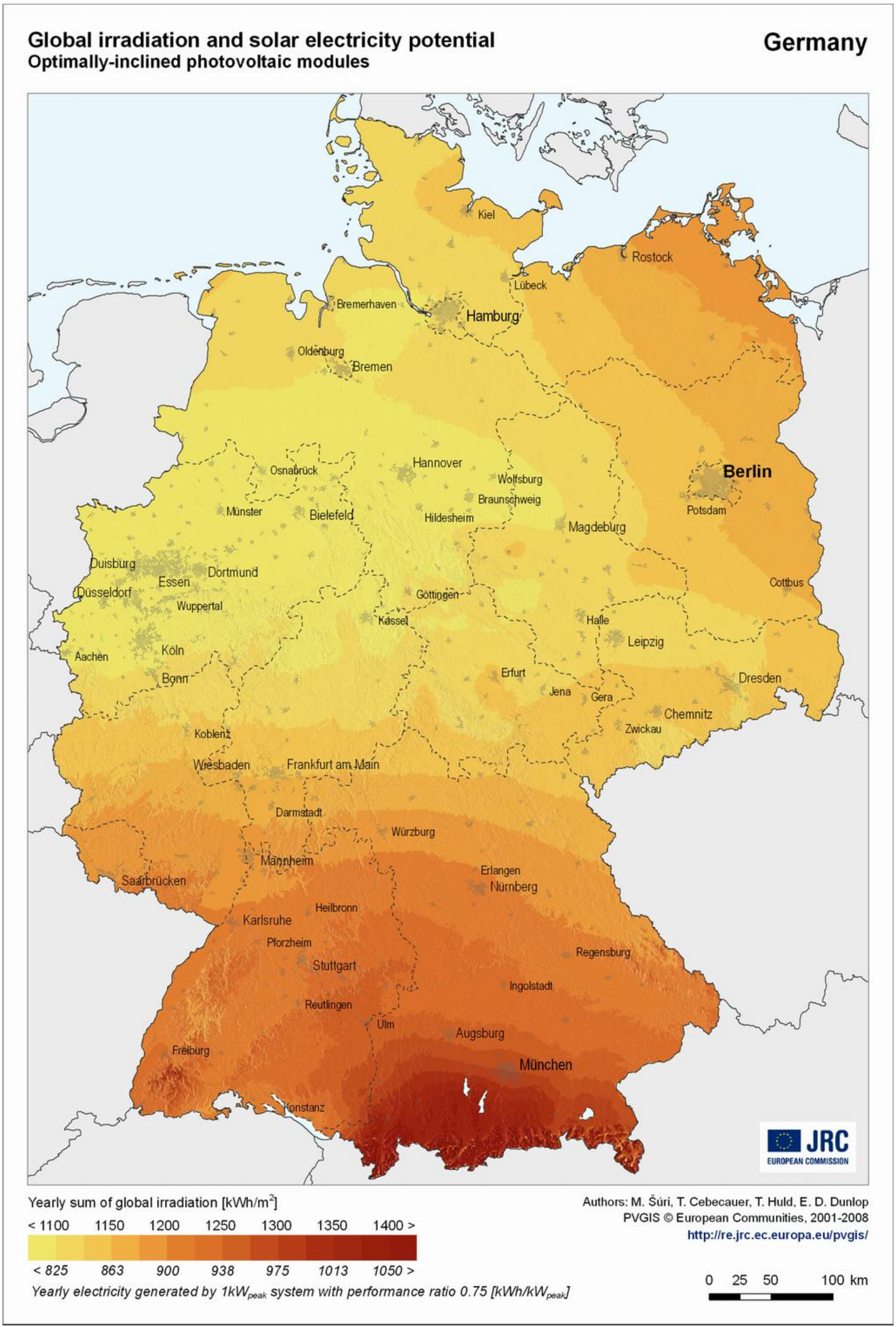


11.9 Spain´s most important manufacturers

Company	Overview
Isofoton	Isofoton is Spain's largest manufacturer of silicon cells and PV modules. The company manufactures sc-Si cells and modules at its plant in Malaga. Isofoton plans to increase cell and module production capacity from 90 MWp in 2005 to 160 MWp by 2007. Isofoton will operate a silicon plant (Silicio Energia) by 2009 with an initial capacity of 2,500 tons.
BP Solar España	Part of the BP Solar Group based in the United Kingdom. BP Solar España manufactures mc-Si cells and modules. Depending on the availability of silicon, BP Solar España intends to increase its cell production capacity from 70 MWp in 2006 to 200 MWp by 2008.
Atersa	Atersa began its business in 1979 and manufactures both mc-Si and sc-Si modules. It is also involved in turnkey installations and production of machineries for modules. The company increased capacity from 6 MWp in 2005 to 18 MWp in 2006 and will increase further to 25 MWp by 2007.
Siliken	Siliken manufactures mc-Si and sc-Si PV modules besides manufacturing equipments for module manufacturing plants. Besides flat panel modules, Siliken also manufactures custom made building integrated modules. The company increased capacity from 10MWp in 2005 to 25 MWp in 2006 and will increase further to 40 MWp by 2007.

(Pusat, T. Global PV industry research, 2007)

11.10 Germany´s solar irradiation map



11.11 Germany´s most important manufacturers

Company	Overview
CSG Solar	CSG Solar began manufacturing crystalline silicon on glass (CSG) in 2006 at its plant in Thalheim and current production capacity is 25 MWp. CSG acquired the technology from Pacific Solar, Australia.
Solon	Solon's plants in Germany and Sweden produce only mc-Si and sc-Si modules. Combined production capacity increased from 90 MWp in 2005 to 110 MWp in 2006. To ensure a reliable supply of PV cells for its modules, Solon signed a 10-year contract with Ersol and 5-year contracts with Q-Cells and SunPower beginning in 2006.
SolarWorld	SolarWorld's business activities in PV, including activities of its subsidiaries and joint venture companies, range from production of silicon to installation of modules. In 2006, SolarWorld acquired from Shell Solar its silicon, cell and module production facilities in the United States. As a result, SolarWorld's cell production capacity increased from 158 MWp in 2005 to 230 MWp in 2006 and module capacity increased from 175 MWp to 210 MWp during the period. Solar World manufactures mc-Si, sc-Si as well as CIS thin film modules.
Deutsche Solar	Deutsche Solar is part of the SolarWorld group and is one of the largest producers of mc-Si and sc-Si wafers in Europe. In 2005, the company produced 102 MWp of silicon wafer accounting for 6% of the world's production.
Q-Cells	Q-Cells is principally involved in manufacture and marketing of mc-Si and sc-Si cells. The company's cell capacity increased from 290 MWp in 2005 to 350 MWp in 2006 with further expansion to 510 MWp by 2007. The company also has investments in CSG Solar in Germany to produce crystalline silicon on glass modules and in EverQ in the United States to produce cells using ribbon technology.
Schott Solar	Schott Solar manufactures mc-Si cells as well as a-Si thin film modules. Outside of Germany, the company has plants in the Czech Republic and the United States. From 2006 to 2007, cell production capacity would increase from 130 MWp to 170 MWp while module capacity from 80 MWp to an estimated 110 MWp. Schott Solar will operate a new 30 MWp plant in Germany in 2007 to manufacture a-Si thin film modules.
Solar Watt	Solar Watt produces both mc-Si and s-Si cells but its plant production capacity is relatively small, increasing from 5-6 MWp in 2005 to 11 MWp in 2006. Its module capacity is sizable with a production capacity increasing from 60 MWp to 100 MWp during the same period.

Company	Overview
ErSol Solar Energy	ErSol manufactures and markets mc-Si and sc-Si cells and modules. The company plans to increase production capacity from 45 MWp in 2005 to 220 MWp by 2009. ErSol entered into a joint venture with China's Shanghai Electric Solar Energy to manufacture modules in China using cells produced by ErSol in Germany. The company is also diversifying into thin films.
Wacker Polysilicon	Wacker is one of the largest producer and supplier of polycrystalline silicon for the semiconductor industry and cell manufacturing. Due to increasing demand for polycrystalline silicon for cell manufacturing, Wacker will increase the production capacity of its plant in Burghausen from 5,500 tons in 2005 to 6,500 tons by 2007. Capacity will increase further to 9,000 tons by 2009.

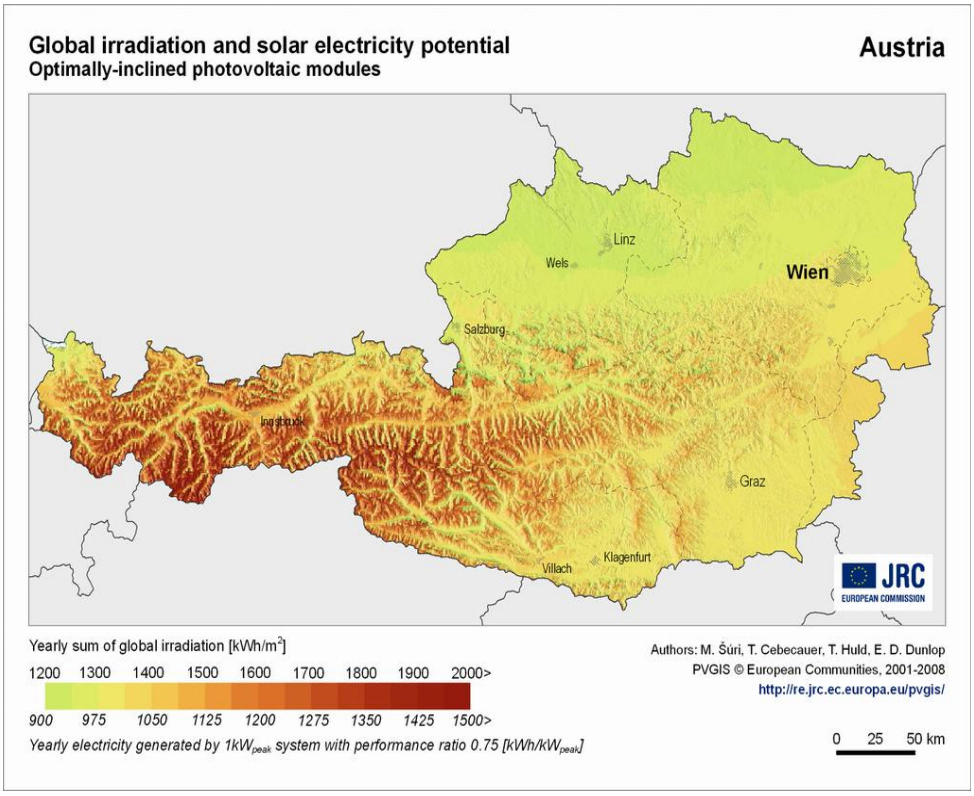
(Pusat, T. Global PV industry research, 2007)

11.12 Germany´s production capacities of main business areas in 2009

	NUMBER OF ACTIVE COMPANIES	PRODUCTION CAPACITY 2009
Silicon Wafer Technologies		
Silicon feedstock	5	17 000 t
Wafer production	8	2 000 MW
Solar cell production	11	2 000 MW
Module production	> 21	~ 2 000 MW
Thin-film technologies		
Silicon thin film	10	330 MW
CIS technologies	11	230 MW
CdTe	3	225 MW
Concentrated PV (CPV)		
CPV cells	1	100 MW
Systems	2	25 MW
System technology		
Inverter for grid-connection	> 15	> 4 000 MW

(IEA-PVPS Annual Report 2009)

11.13 Austria´s solar irradiation map



11.14 Austria´s most important manufacturers

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production 2008 (2007 figures) (MW)		Maximum production capacity 2008 (2007 figures) (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
BlueChip Energy	sc-Si	N/A	-	N/A	-
FalconCell	mc-Si	N/A	-	N/A	-
SOLON Hilber Technologie	mc-Si / sc-Si	-	31,2 (25)	-	N/A (29)
PVT Austria	mc-Si / sc-Si	-	15,0 (10)	-	N/A (N/A)
Energetica	mc-Si	-	10,75 (7,0)	-	N/A (N/A)
KIOTO Photovoltaics (former RKG)	mc-Si	-	8,0 (5,0)	-	N/A (N/A)
ERTEX Solar	mc-Si / sc-Si	-	0,40 (0,37)	-	N/A (N/A)
SED	mc-Si / sc-Si	-	0,113 (0,033)	-	N/A (1)
Thin film manufacturers					
-	-	-	-	-	-
Cells for concentration					
-	-	-	-	-	-
TOTALS		N/A	65,4 (47,4)	N/A	N/A

(IEA-PVPS 2009)

11.15 Main PV courses – university classes and professional trainings

Main PV courses - university classes and professional trainings		
country	**university / institution**	**course**
Austria	Danube University Krems	Master Course in Advanced Studies - Solar Architecture
	Energy Institue Vorarlberg	Professional trainings (Renewable Energy Sources including PV)
	Vienna University of Technology	Postgraduate Master Program Renewable Energy in Central and Eastern Europe
	University of Applied Sciences Technikum - Vienna	Bachelor Program in Urban Renewable Energy Technologies
	University of Applied Sciences Technikum - Vienna	Master Program in Environmental Engineering and Management
	University of Applied Sciences - Pinkafeld	Bachelor and Master Program in Energy and Environmental Management (EEM)
	University of Applied Sciences - Pinkafeld	Master Program in Sustainable Energy Systems (SES)
	University of Applied Sciences - Pinkafeld	Master Program in Building Technology and Building Management (BTBM)
	Upper Austria University of Applied Sciences	Bachelor Program in Eco-Energy Engineering
Germany	Technische Universität (TU) - Berlin	Postgraduate International Master Course in Global Production Engineering for Solar Technology (GPE Solar)
	University of Applied Sciences (FHTW) - Berlin	Environmental Technology and RES degree programme, RES Masters
	University of Kassel	Postgraduate course in Rational Use of Energy
	University of Applied Forest Sciences - Rottenburg	Postgraduate Master´s Degree in Sustainable Energy Competence (SENCE)
	University of Applied Sciences - Munich	Bachelor of Science in Engineering
	University of Applied Sciences - Munich	Master of Science in Electrical Engineering and Renewable Energy Technologies
	International Solar Energy Society, German section	Professional trainings (solar thermal energy, PV, biomass)
	Target GmbH	Professional trainings (solar thermal energy, PV)
	University of Flensburg	Master of Engineering (Industrial Engineering) in Energy and Environmental Management, with specialisation in Sustainable Energy Systems and Management in Developing Countries (SESAM)
	Solar Energie Zentrum (SEZ)	Professional trainings (solar technology and vocational trainings)
	Solarzentrum der Gewerbe-Akademie Konstanz	Professional trainings (solar thermal energy, PV and vocational trainings)
	Richard-Fehrenbach-Gewerbeschule	Professional trainings (Master tradesman school for installation, heating and solar technology; full-time)
	Solarbildungszentrum Euregio Freiburg	Professional trainings (solar thermal energy, PV, Renewable Energy Sources)
	Sanitär-Heizung-Klima (SHK) - Innung Freiburg Breisgau/Hochschwarzwald	Professional trainings (solar energy)
	Mp-Tec GmbH & Co.KG	Professional trainings (solar energy)
	Städtisches Bildungszentrum für Solartechnik	Professional trainings (advanced trainings in solar technology)
	Akademie für Technologien, Handwerkskammer für München und Oberbayern	Professional trainings (advanced vocational trainings in solar energy)
	renergie Allgäu e.V.	Professional trainings (energy consultant courses, vocational trainings)
Japan	Naresuan University	Master of Science in Renewable Energy, MSc
	Naresuan University	Doctor of Philosophy in Renewable Energy, PhD
	Tokio University	Solar courses
Spain	Instituto de Energia Solar (IES)	Master Course in photovoltaic Solar Energy
	Centro de Investigaciones Energéticas, MedioAmbientales y Tecnológicas (CIEMAT)	Course on photovoltaics
	Solar Energy Training Centre (CENSOLAR)	Training Course on photovoltaics

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