【Report】

Overview of the progress in photovoltaic sector in Europe

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Abstract

This paper aims to provide an overview of the progress of the photovoltaic sector in Europe. The European countries face different physical initial positions regarding the utilization of the suns direct energy, which leads to the question if these initial differences or political will is the more crucial driver for the development of a PV market. Whatsoever, PV is disputed for its cost and various side effects which result from a fostered market and therefore should be assessed in order to decide if and how subsidies should be carried out. PV roadmaps of various countries and institutions, outlooks and studies were examined to merge this information to a comprehensive picture, showing that the market leadership of Europe is based on the successful and strong policies of a few countries. Together with a glance at other important countries, an understanding of the state of PV usage, the reasons behind these developments and likely future developments in Europe are gained.

1. Introduction

Energy issues are of crucial importance. Energy is a fundamental factor for development, prosperity and in regard to actual environment, supply and social problems for sustainability. The biggest energy source for our planet is the sun. Solar radiation is available in a quantity several times the amount of energy we use currently, thus the potential of the utilization of solar power to produce a big share of our energy demand with photovoltaic is obvious. Europe is one of the world leaders regarding the usage of PV. Therefore the potentials and the policies in different countries should be examined, with the focus on the leading states within the European Union. As subsidies are of vital importance for the development of a technology as long as market competiveness is not reached, the costs and gains of the use of PV are compared to decide if subsidizing PV is the right thing to do. In the end, the approach with which this technology is supported paves the way for how fast PV will develop and hence how different countries in Europe and Europe among other regions in the world gain from the various beneficial side effects emerging from this technology.

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2. Physical potentials for PV

In general it can be said that there are just five different ultimate sources of energy to be found on earth. This is the sun, motion and gravitational potential, geothermal energy, human-induced nuclear reactions and chemical reactions from mineral sources (Twidell J., Weir T., 2006). All energy sources we use today are produced from these five, mostly from sun energy. This is also true for fossils, as they are just stored sun energy over a period of millions of years. The method of photovoltaic electricity production is that they are directly converting energy from the sun into electricity. Therefore solar radiation can be seen as the fuel of a photovoltaic cell in order to produce electricity. As the driver of almost all natural processes on earth, solar energy is available in a very high quantity around the planet.

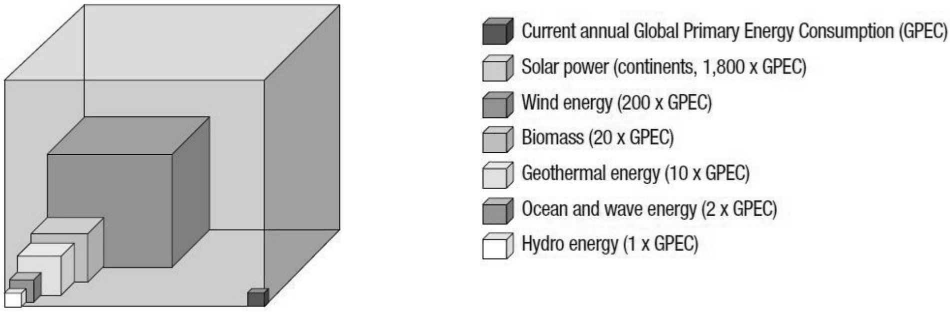

Figure 1. Global physical potential of renewable energies (EPIA, 2009)

In the figure above the current annual global primary energy consumption is compared with the available supply of renewable energy flow. The global primary energy consumption in 2004 was 463 EJ and is displayed in the figure as the red cube in the front right. It can be seen that solar power has the highest potential of all the renewable sources. The available solar radiation is 1800 times higher than the energy consumption in 2004. However, these values are not reflecting the real world potential of the use of renewables and in this case in particular solar power, as they are not taking into account the feasibility of the usage. Considering the technical potential with today's available technologies, the potential of accessible solar radiation is not 1800 but 3.7 times the global energy consumption (Nitsch J., 2007).

This is still a very high amount which shows that it is technically possible to produce a considerable share of the energy consumed by the use of solar power in the future. Nevertheless there are more obstacles on the way to make the usage of photovoltaic to a vital source of our energy consumption. One of them is the economic feasibility with which will be dealt in later chapters.

For a regional assessment of the potential of photovoltaic it is important to know how much irradiation is available on the earth's surface, rather than total radiation reaching the earth. The Photovoltaic Geographical Information System (PVGIS) of the Joint Research Centre's Institute for Energy within the European Commission provides therefore a very detailed dataset to deal with this issue.

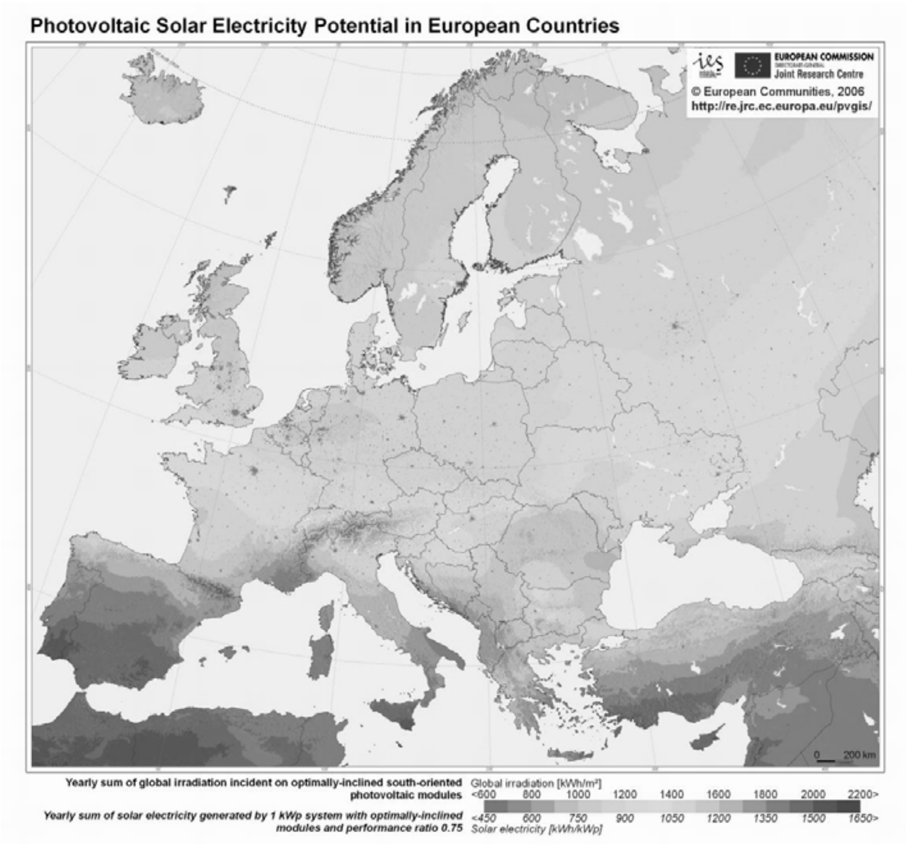

Figure 2. Photovoltaic potential map for Europe (Suri M. et al., 2007)

This figure illustrates the potential of solar irradiation for photovoltaic electricity production on a large scale for the whole of Europe. This map is designed for applied photovoltaics, as it shows the irradiation based on the assumption of an optimally inclined, south oriented photovoltaic module. Since the optimal inclining angle varies depending on mainly the latitude (but also other factors like altitude), it varies from one position to the other. The second information which can be derived from this figure is the yearly sum of electricity which can be generated on a particular spot per installed 1 KW. Again, the PV system is regarded to be optimally inclined with the assumption of a performance ratio[1] of 0.75.

Regional geographical differences aside, it is obvious that the potential of solar irradiation and hence the possible amount of generated electricity is increasing from north to south. Countries like Spain, Italy, Greece, Cyprus or Turkey as well as the south parts of France and many Balkan states have the best initial positions for the use of photovoltaic. Due to less irradiation in more northern countries the use of photovoltaic generates less output, which however does not necessarily mean that it is economically infeasible. The economic context of the use of photovoltaic will be discussed in a later chapter, together with policy backgrounds. In the next section it follows the view about the actual use of solar power to gain a comparison between the potentials and the utilization.

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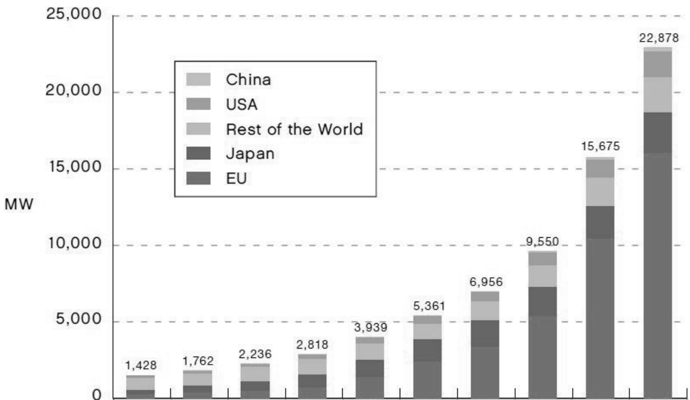
[1] The Performance Ratio is an important measurement in PV. It is the difference between the AC current which can be used in a grid and the DC current generated by the photovoltaic module itself.

3. Utilization of Solar Power for Photovoltaic Use

When it comes to the PV market, the European Union is the leading region in the world. The cumulative PV power installed in 2009 is almost 16 GW. In comparison, the total number of PV power installed worldwide in 2009 is a little less than 23 GW. This results in the fact that 70 percent of all PV power installed is installed in the EU. Japan follows the EU with 2.6 GW and the United States with 1.6 GW is third. This 23 GW of installed PV power produces 25 TWh of electricity in one year. This is a very small amount compared with total electricity consumption, but with the huge growth rates, photovoltaic is a potentially major technology for future power generation worldwide (EPIA, 2010).

These facts are illustrated in Figure 3 together with the historical evolution which shows the significant growth of PV over the years.

With almost 10 GW of cumulative installed PV power, Germany is EUs and also the world leader regarding the utilization of the suns energy. In 2009 alone, 3.8 GW of PV power was set up in Germany. The worldwide growth between 2008 and 2009 is represented by more than the half by the growth in Germany. The market in Germany is predicted to reach its peak in 2010 with a decline and stabilization in the years after. The second biggest market in the EU and also worldwide in 2009 was Italy. After 338 MW in 2008, Italy installed 711 MW last year and therefore outpaced Spain, which was the second biggest market still in 2008. Itis forecasted that Italy is becoming a GW market between 2010 and 2012. In cumulative numbers installed, Spain is still second in the EU and with its 3.3 GW installed in 2008 will remain on this position for some years. But the market completely collapsed in 2009 when just 69 MW of new installed power was added. It is projected that the market will not reach numbers like the one from 2008 in the coming years, but will stabilize at 2007 levels when new installed power amounted 560 MW .The third and fourth biggest markets in 2009 were the Czech Republic and Belgium, with 411 MW and 292 MW respectively. Especially for the Czech Republic this growth came too fast. In 2008 there were just 51 MW installed and after peaking in 2010 a breakdown of the market is forecasted. All together with a market for PV of 5.6 GW in 2009 the European Union represents 78 Percent of the global market (EPIA, 2010).



	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 3. Development of World cumulative PV power installed (Source: EPIA 2010)

What clearly can be seen from the numbers presented above, the potentials, examined in chapter 2, do not necessarily reflect the actual usage of solar power in terms of PV. The country with the highest installed PV power and the biggest market for PV of the last years is by far Germany, although the received irradiation is much lower than in many other European countries. Italy and Spain, two countries with a high natural potential follow Germany, but well exposed countries like Portugal, Greece or Cyprus stay behind. However, contrariwise shows the almost nonexistence of a PV market in the Scandinavian countries that to some point the natural potential sets a constrained to the use of solar power. The observation of the status of PV installations should now be investigated with a different approach.

For a better understanding of the rate of solar power utilization it is very interesting and straightforward to compare these absolute amounts with the population size of each country. For the further analysis the installation rate per capita is compared with the annual average solar radiation for each EU15 country.

Table 1. Radiation, PV capacity, Population and calculated PV capacity per capita

Location[2]	Annual average daily radiation[3] (kWh/m^2)	Total installed PV capacity 2008[4](09)[5](MWp)	Population[6] (Mil.)	PV capacity per capita 2008(09) (Wp)
Austria	3,03	32,4	8,4	3,9
Belgium	2,65	70,9 (363)	10,8	6,6(33,6)
Denmark	2,82	3,3	5,5	0,6
Finland	3,06	5,6	5,4	0,1
France	2,59	103,9 (272)	64,7	1,0
Germany	3,12	6019 (9785)	82,0	1,6(4,2)
Greece	2,81	18,5	11,3	73,4(119,3)
Ireland	4,31	0,4	4,5	1,6
Italy	4,18	458,3 (1167)	60,4	7,6(19,3)
Luxembourg	3,03	24,6	0,5	49,2
Netherlands	2,87	57,2	16,6	3,4
Portugal	4,72	68,0	10,6	6,4
Spain	4,36	33175 (3386)	46,1	72(73,4)
Sweden	2,83	7,9	9,3	0,8
United Kingdom	2,45	22,5	62	0,4
Luxembourg	3,03	24,6	0,5	49,2

The population in the EU15 countries is quite stable, for this reason the calculation of the 2008 and 2009 data was made with the 2010 population numbers. As the newest PV capacity data are not available for every European country, this calculation was done with the status of 2008. However, the 2009 capacity for the most important markets is known and was used in addition, displayed in brackets. This allows also a comparison of the total installed PV capacity of the most important PV countries in 2009 as well as a temporal analysis. The range in PV capacity per capita goes from 0.1 Wp for Ireland till 119.3 Wp for Germany. What already can be derived from the

[2] As the reference point for the available solar radiation the respective capital city was taken

[3] (Data source: Palz W., Greif J., 1996 in Celik A.N. et al., 2008)

[4] (Data source: EurObserv'ER, 2010)

[5] (Data source: EPIA, 2010)

[6] (Data source: Eurostat, 2010)

table is that in per capita terms the ranking within Europe looks slightly different than in absolute terms. Regarding the 2008 data the leader is Germany, closely followed by Spain. On the third place emerges Luxembourg, which with his small population reaches a very high per capita capacity. In the next places it follows Italy, Belgium, Portugal, Austria and the Netherlands. Within the top PV countries for 2009 in absolute terms, a worth mentioning point is the rise of Belgium which in this year constitutes an even bigger PV installation per capita than Italy.

In Figure 4, a division between higher and lower solar potential countries can be examined within the EU15. In particular it can be said that there are two groups, with Italy, Greece Spain and Portugal in the high and the rest in the low one. From this graph it can also be seen that, as stated before, the utilization does not necessarily reflect the actual potential. Although Italy, Spain and Portugal have considerable numbers of PV capacities per capita, many lower potential countries have similar or even higher rates of use. The regression line shows a slight increasing trend of installed capacity per capita in regard to the potential. However, the correlation is not high and a determination coefficient of R2=0.1087 shows that the line represents the countries places in the plot very poor. In temporal terms, as far as the 2009 data was available, it can be seen that France, Italy, Belgium and Germany increased their numbers significantly, especially Belgium. Spain on the other Hand remained constant.

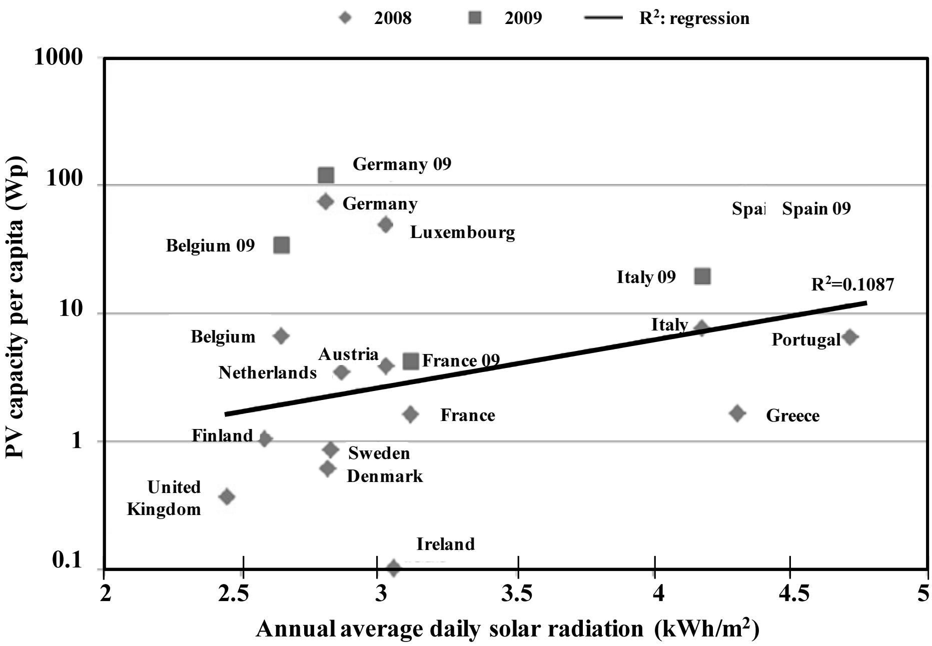


Figure 4. Installed PV capacity per capita as a function of annual average daily solar radiation in 2008 and 2009

Outside of Europe Japan is the biggest market for PV with 484 MW installed in 2009, cumulative 2.6 GW, closely followed by the United States with 477 MW, cumulative 1.7 GW. According to different forecast scenarios Japan is believed to become a GW market between 2010 and 2012, whereas for the United States this assumption is made for 2010 to 2011. China and India are well behind these numbers, although they are also growing fast. However, as they have significance for the topic as it is discussed in this paper, in particular for the PV industry in Europe, they will be again mentioned in a later chapter and should also be considered here (EPIA, 2010).

4. Renewable Energy Policies and Backgrounds in the Leading States

The actual use of renewables and in this case photovoltaic systems is very dependent on the energy policy set by governments. Due to the fact that nowadays the generation of electricity is still cheaper when produced in conventional, non-renewable ways, an incentive for the use of renewable energies has to be set in order to promote new technologies. To explain the observed use of PV mentioned in the last chapter, this section is intended to describe the energy policies which led to the present developments in certain countries of interest. Thereby the German model of renewable energy policy will be emphasized as it can be seen as best practice.

4.1 Germany

The German policy concerning renewable energy aims to make the energy sector one of the main contributors regarding climate and environmental protection. Thus, it aims to increase the share of renewables in the electricity production in order to make this sector more sustainable. The act regulates the purchase and compensation of electricity generated by renewable sources through the electricity network operator (BMU, 2009).

One of the most important parts, which made the act so successful, is the applied feed-in tariff, which guaranties the operator of a renewable energy facility a constant payment for the produced electricity. This constant payment is maintained for 20 years, in order to provide a calculable environment for investments in renewable energy. This incentive results in a sharing of the costs, as the expenses for installing the facility are passed from the producer to the network operator and then further to the end user. The compensation is staggered regarding the power of the facility leading to higher compensation for smaller facilities and vice versa. This is due to the fact that the installation of a bigger system is cheaper per installed power. To take into account the technological progress and hence the economic efficiency emerging from lower production costs, the feed-in tariffs are digressive, which means the compensation is decreasing from year to year. The tariff you get in the year of installation is valid for the whole 20 years though (BMU, 2005).

The stated goal set in the renewable energy act of the year 2004 aimed to reach 12.5 percent renewables within electricity production in the year 2010, with a further increase up to 20 percent in 2020. However, the first goal was already achieved in the year 2007 (BMU, 2007), with a further increase to a share of 15.2 percent in 2008 and 16.1 percent in 2009 (BMU, 2010). PV actually contributes about 9 percent of the total renewable energy production (BMU, 2007).

In the new act of 2009 there is a strong decrease of the feed in tariffs for new installed PV systems, due to the fact that the prices for modules dropped significantly and therefore solar generated electricity became cheaper. Also the yearly digression rate was raised. By reason of these adaptions, the market for PV in Germany is believed to slow down a bit in 2011. However, the growing trend in the following years will be maintained, with rates between 3 GW and 5 GW annually (EPIA, 2010).

The step of lowering the feed in tariffs was necessary, for the fact that the domestic industry loses competiveness in the world market if the technology is to much subsidized and hence the producers are not forced to raise efficiency. Furthermore, it intends to minimize the additional costs for the electricity consumers, as they are increasing from year to year.

The German Renewable Energy Act became a top export. In 2007 already 47 countries in the world used it as a model for their own policies as it is seen as a best practice for building a successful renewable energy framework. It is specially the progressive feed in tariff model, which proofed to work very well, which is adopted by many countries (Fallent G., 2007).

4.2 Spain

The Spanish energy system is highly dependent on energy imports. Therefore 80 percent of the consumed energy comes from imported non renewables. To foster development in order to produce more energy domestically and with the EUs goal of 12 percent renewables of total energy consumption in the back, the Spanish government approved a new Renewable Energy Plan in the year 2005. The objective of a 12 percent share of renewables from the EU was therefore also taken on. The support for the renewables is based on fixed feed in tariffs for generated electricity which are provided for 25 years. Different from the German way is the use of net metering, which allows a very detailed determination of when and how much electricity is produced and used during the day. For example, electricity is more expensive during daytime peak hours and therefore the feed tariff is adjusted to the actual daytime tariff. Thus, net metering is in support of PV, as PV produces electricity during these peak hours. To further stimulate the development of PV, the government made it compulsory to build PV systems on newly build “large buildings” like office buildings, government buildings or hospitals. As the potential for the use of solar power is very high in Spain, special incentives were also provided for the building of PV power plants (Salas V. Olias E., 2008). This policy worked very well and in the case of PV, the market took off in 2008 to newly installed 2.6 GW. In 2009 however, the market collapsed and just 69 MW were added. The reason therefore is that the administrative procedures for setting up PV systems grew significantly over time and in addition also adaptations to the existing policy were delayed. Together with the financial crisis which affected Spain quite seriously, causing financial problems for investors and lowering the energy demand, caused many developers to stop or postpone their in many cases already planned projects. In addition, the urgent need emerged in Spain to adopt the feed in tariffs to the new market prices already described with the German example. All this factors together it is forecasted that Spain’s PV market stabilizes at around 600 MW annually for the next years (EPIA, 2010).

4.3 Italy

Italy’s take off in terms of the use of photovoltaic occurred later than it did in Germany and Spain. In 2006 and 2007 the market still was quite small in comparison with Europe’s leader states. But in 2008 the market grew significantly to the current situation of Italy being the second biggest PV market in the world in 2009.

With the “Nuovo Conto Energia”, the Italian policy framework for renewable energies, the government also applied a very attractive feed in tariff scheme which supported renewables and especially PV. Besides the fixed tariffs, Italy also makes use of the concept of net metering for additional support of PV (EPIA, 2010).

Because of the fact that the market is growing in such a fast pace, fears arise regarding an overheating of the market. This effect, due to too favorable conditions for the installation ofPV systems, is demonstrated by the example of Spain in 2008, the Czech Republic in 2009 and also to a lesser extent by Germany in the same year (Kann S., 2010). For a market, a sustainable growth is very important. The former mentioned countries all adopted countermeasures after a too fast growth of the PV market which led to a slight decrease of the market in Germany and the collapse of the market in Spain and the Czech Republic. For Italy it is now important to learn the lesson provided by these countries and adjust their support mechanisms wisely.

The adjustment of the feed in tariff scheme is planned by the Italian government for 2011. In order to adjust to the new circumstances a cut is inevitable, but with the announcement of a too high cut as well as with a too long delay in announcing something at all, there is a risk that investors are bringing forward their planned projects to 2010 with the result of a takeoff in this year and a market decrease in 2011. In this context, the Italian government is facing a hard task in order to maintain a stable market for the next years (Kann S., 2010). The European Photovoltaic Industry Association however believes in just a small decrease of the market in 2011 due to the reasons mentioned above. A sustainable market with reaching the GW threshold between 2010 and 2012 is forecasted (EPIA, 2010).

5. Side Effects

The increase of the use of renewables in general and of photovoltaic in particular in Europe, together with the policies related to that growth, leads to several environmental and economic effects. Especially considering the fact that the growth of the use of PV is mainly a result of subsidies these effects are very important in the discussion of the pros and cons of maintaining the support schemes for this technology. Critics argue that the costs emerging from the support are too high and hence some renewables like PV are not effective. Proponents on the other hand refer to various side effects which have to be taken into account. In this context it is argued that especially the neglect of externalities resulting from conventional energy use have to be considered when speaking about prices. In the following considerations about the side effects, the focus will mainly be on Germany as the leading state of PV usage, with glances to other countries as well. In Germany a lot of investigation and research has already been done to describe these effects in monetary terms.

5.1 Electricity costs

Because of the feed in tariff which is granted for PV electricity, there are high costs for the network operators which are passed on to the energy users. In the case of Germany, where the installation of PV systems overshoot the government's earlier forecasts by far, it is calculated that the costs for the installed systems in 2009 were approximately 10 Billion Euros[7]. These costs arise and have to be stemmed over the period of 20 years. However, also in the following years several GWs of capacity will be installed in addition (VZBV, 2010). As a result the prices for electricity are rising.

On the other hand an effect called the "Merit-Order Effect" is pulling into the other direction. As renewable energies are already producing a certain amount of the electricity load, it is considered that a certain part of the conventional production is not needed any more. Therefore some power plants, normally the least economical ones, are shut down and the prices on the electricity market decrease. The German ministry of environment calculated that the Merit-Order Effect in the year 2006 led to savings of almost 5 Billion Euro. These calculations are disputed though, as there are many assumptions involved. One of the criticisms is that it is uncertain how the infrastructure of conventional power plants would have been altered without the rise of the renewables (Wissen R. Nicolosi M., 2007). It can be said that the effect is occurring, but to pin down an exact amount of savings is strictly speaking rather an assumption than an exactly calculable fact.

The influence of renewable energy policies on the prices of electricity for the costumers consist therefore of a visible part, which results from the feed in tariffs and a somewhat invisible part, the Merit-Order Effect, which outcome is calculated roughly but not seen directly by the electricity users on their bills.

In this context, the result of a survey, carried out in Germany in 2007, is very interesting. 77 percent of the German citizens want to use more electricity produced by renewables, also if this means that they have to pay more for it. This shows the significance of sustainable energy production for the citizens and the importance of so called voluntary mechanisms in addition to financial mechanisms (PDCD, 2007).

5.2 Greenhouse gas reduction goals

The German Government states that through the Renewable Energy Policy there was a reduction of CO2 emissions

[7] At time of writing: 1 Euro is equivalent for 112 Yen.

in 2006 of 44 Million tons. For 2005 the calculation resulted in 38 Million tons. Photovoltaic electricity production mainly substitutes gas and coal power plants and in the study a CO2 abatement factor of 1367 g per KWh produced electricity is calculated. In this context, the share of PV in CO2 abatement, considering the produced electricity, amounts to 2.3 percent, which is 1 million ton (BMU, 2007).

Germany is one of the countries for which it is projected that they are meeting their Kyoto targets. In the year 2007 they reached a GHG emission level which is 21 percent under the 1990 base year level (European Commission, 2009). It has to be mentioned that these high reductions resulted mainly due to the breakdown of many energy intensive production facilities in East Germany after the reunification. However, the fostering of renewable energies also contributed to this success and is appreciated by the European Union.

As the abatement of CO2 emissions per produced KWh of generated electricity is known, it is possible to calculate the abatement costs for the reduction. In 2000 the abatement cost for 1 ton of CO2 resulting from the use of PV was at about 900 Euros. For 2010 the costs drop to around 700 Euros and for 2020 450 Euros are forecasted (BMU, 2007). In the long run, because of lower costs of PV systems and higher efficiency factors, these costs are decreasing even more. Every form of abatement of CO2 or other Greenhouse gases results in costs for the national economy. The abatement cost from the increased use of PV is in this context still high, but should not be seen isolated from the costs which would arise with other forms of emission reduction.

A problem which is also worth mentioning is the impact of the fostering of renewables on other Kyoto measures, especially the emission trading scheme. In a emission trading scheme, a cap of allowed CO2 emissions is set and emission certificates are allocated. Certificates therefore can be traded by using a market price, emerging from supply and demand. Some criticize that the renewable energy acts counteract emission trading, because due to additionally abated CO2 emissions the certificate price decreases and not used certificates can be traded with other parties. This results in the fact that the abated CO2 emissions, due to the use of renewables, is considered to be emitted elsewhere (Diekmann J., Horn M., 2008). However, blaming the renewable energy policies for this circumstance is a too easy way to deal with this fact. Some even see this as a reason to argue the policies should be put on hold. What really would be necessary, as it is a problem which has to be dealt with, is that the policies regarding renewable energies must influence the decision making on emission trading caps. In this way the set cap would be lower, incorporating renewable energy growth forecasts, and the measures can work hand in hand instead of counteract.

Also in the other European countries the greenhouse gas reduction targets set within the Kyoto protocol are important points when it comes to the discussion of the support of renewable energies.

5.3 PV industry

In the beginning of the first decade of this century, the production of photovoltaic products has mainly taken place outside of Europe. To name one of the PV industries products, only 8.2 percent of the solar cell production in 2006 was done in Europe. But the market share changed rapidly due to the rise of the European markets especially Germanys (Sander K. et al., 2007). In 2009 17 percent of solar cells and 28 percent of PV modules were produced in Germany (EPIA, 2010). For an economic sector to grow solidly, it is favorable to have a strong domestic market on which economic development can rely (Fechner H. et al., 2006).

Emerging from the rise of the renewables, mainly induced by the strong renewable energy act, the German market regarding PV components grew to a leading market in the world. Many of the top producers of solar cells or PV modules are located in Germany, serving a strong domestic market and exporting all over the world. A growth of jobs in the PV sector goes hand in hand with this increased economic activity. In 2008 40.600 jobs in Germany could be associated with the PV sector. This is 60 percent more than in 2004 (BMU, 2007). In total, the PV industry has created more than 75.000 jobs in the EU, mainly in the last few years. Besides Germany as the market and industry leader, 27.000 jobs are associated to PV in Spain, which as mentioned is the country with the second largest installed PV capacity regardless of the market breakdown in 2009. It is estimated that the PV industry creates more than 200.000 jobs in the European Union till 2020 (EPIA, 2009). The statement that it is encouraging for a sector to have a strong domestic market is further supported by an example of another way of using solar power, solar thermal applications. Due to political incentives, Austria is the most successful country when it comes to installed solar thermal power per capita. With the development of a strong market for this technology a strong and successful industry emerged. In 2006 every third in Europe installed solar thermal collector was produced in Austria, a relatively small country within the EU (Fechner H. et al., 2007). In the nonexistence of a domestic market the industry is totally dependent on external market forces.

In Figure 5, the 2009 distribution of the production of four major PV products is shown. Europe has respectable shares in all shown categories, especially in module production. The United States and Japan were already mentioned as the biggest markets after Europe and due to their strong domestic markets they are also important in the worldwide production. As already mentioned in the chapter "Utilization of Solar Power for Photovoltaic use", other Asian countries and especially China have a special significance for the leading countries regarding PV. Albeit a till now small PV market they strongly contribute to the world's production. This is of course a result of lower production costs in the Asian countries like China, Taiwan and Malaysia and is a general phenomenon. Also India will soon become a very important producer for PV products, as many investors are planning projects there. In the last years, more and more PV modules for the European market are produced in China and other Asian countries. Thus, as argued when discussing the political incentives, the European countries governments have to adjust their subsidies wisely to equilibrate the fostering of domestic markets as well as forcing domestic companies to reach their most cost effective way of production.

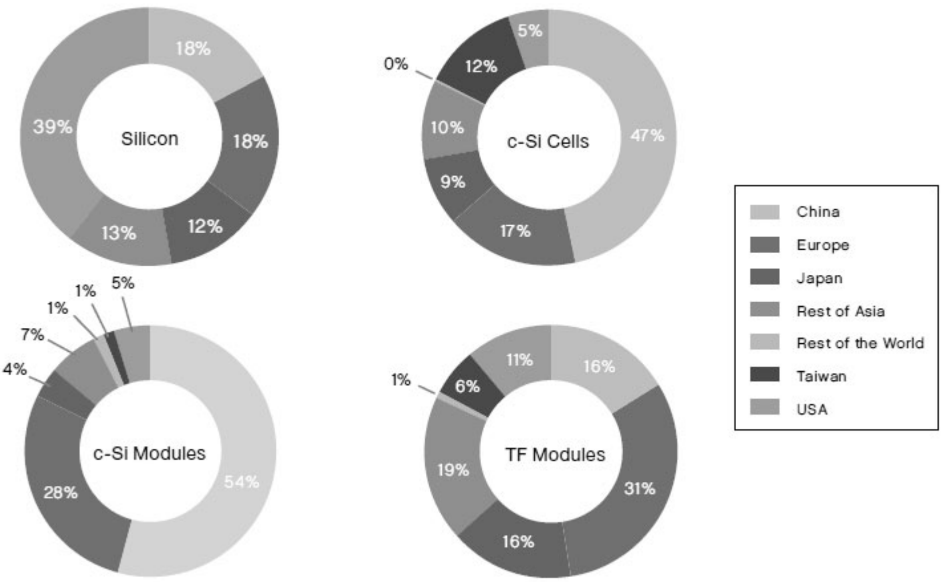


Figure 5. Regional distribution of production capacities of four major PV products (EPIA, 2010)

Positive employment effects aside, there are also negative consequences regarding the job market which should not be left out. When stressing the German example again, it is calculated that especially because of the costs arising for the electricity costumers due to the feed in tariffs and a resulting purchasing power loss, a decrease in employment takes place. It is important to mention that these numbers are well below the employment gains. There are no numbers for the case of PV alone, but as the jobs in the German renewable energy sector directly associated with the renewable energy act in total account for 134.000 jobs in 2006, the net employment gains are 67.000 to 78.000 jobs. In this calculation also other minor job cutting effects are considered (BMU, 2007).

5.4 Other side effects necessary to consider regarding renewables

This subchapter deals not so much with exact calculated numbers but gives a general picture of effects of the use of renewables. Often the argued effects below cannot easily be put into exact numbers or if so they are not separately available for PV. Regardless of this circumstance, the following points should also be mentioned and considered when talking about renewables like PV in Europe and elsewhere. This is especially true when making an overall assessment of the side effects as is done in this chapter.

A higher share of renewable energies leads to less consumption of conventional energy forms, mostly fossils. For this reason, fewer fossils have to be imported. For Germany it is calculated that the Renewable Energy Act saved imports of coal and gas, amounting to 0.9 billion Euros in 2006 (BMU, 2007). But it is not only the single fact that the cost of the substituted fossils is saved. Less use of non-renewable energy sources has also an effect on their prices. Less demand leads to reduced prices of fossil fuels on the market. In this sense the needed fossils can be purchased cheaper and in this way compensate the consumers additional spending for the renewables. It has been estimated that a decrease of natural gas demand in the United States of 1 percent can reduce the price of imported gas by 0.75 to 2.5 percent. There are also further complicated and not assessed effects connected with a decrease of fossil fuel use like the existence of risk premiums. To reduce the risks of price fluctuations countries sometimes pay premiums to have long term price contracts. Use of renewables also reduces the sums paid for these measures which can be relatively high (Wiser 1997 in Bhattacharya A., 2010).

Directly connected with the energy prices from fossils are market failures, ignoring externalities. The market failure regarding the use of fossil fuels is very important when considering the competiveness of PV and other renewables against conventional energy sources, since this market failure supports fossils by not reflecting their real cost for the society. In quantifying external costs regarding electricity production especially greenhouse gas emissions and air pollution are of importance. The first regards human induced climate change and the second concerns health defects, material damages and else. Many other effects, like for example effects on biodiversity, cannot be valued in monetary terms.

In a study to assess the avoided external costs due to the implementation of the Renewable Energy Act in Germany, it was calculated that in 2006 3.4 billion Euros of otherwise not accounted external costs were saved. Considering future predictions of the use of renewable energy, the avoided costs are increasing to 16 billion Euros per year in 2050 (Diekmann J. et al., 2008).

6. Subsidizing Renewable Energies

It is a fact that most renewables are not competitive on the market without energy subsidies. This is especially true in the case of photovoltaic and can be seen from the fact that PV needs the highest feed in tariffs. There are different ways of subsidizing renewable energies in Europe. These different schemes have their pros and cons, but it is not the aim of this paper to analyze these schemes in detail. However, until now the feed in tariff system as it is applied in Germany and adopted by many other countries has proven to be the most successful policy. It is argued by many that the costs related to subsidizing renewables are too high and should therefore not be carried out. However, as it was shown in the previous chapter on side effects, there are much more factors which have to be taken into account when referring to the costs of subsidy schemes.

Calculations show, especially when considering the external effects of the use of fossil fuels, that the mix of used renewables in Germany already delivers an economic balanced result of costs and benefits. For PV alone, this calculation is not yet positive, but this market has not yet matured and has still huge potential for development (Diekmann J. et al., 2008). The fact that European countries have to cut the feed in tariffs for PV drastically shows that this process is taking place.

Historically the costs of producing electricity with PV modules are decreasing at a pace of 20 percent for every doubling of production capacity. This is called the learning rate of a technology. By fostering technology through subsidies the speed at which the“learning” takes place is increased and the time until the technology is economically competitive gets shortened (Fechner H. et al., 2007).

Figure 6 shows when PV electricity production prices meet the actual market price and therefore PV achieves grid parity. The 1800 sun hours per year curve represent a Southern Europe case and the 900 sun hours per year curve represent a Central European case like it can be found in southern Germany. In Southern Europe, in particular in the southern part of Italy, grid parity is already reached for the case of peak load today. For the basic load case grid parity is forecasted to be achieved around 2020. In more northern parts of Europe, where the solar potential is not as high, grid parity can be achieved some years later. Thus, PV subsidies will have to be maintained till these points are reached.

Figure 7 illustrates the predicted moving up of the borderline of regions reaching grid parity in the peak load case from the south to the north, taking into account the electricity prices.

The actual market situation of PV and also of the other renewables in regard of being not competitive to fossil energy is a market barrier which has do be dealt with in order to make these technologies an important part of future energy supply. Coming back to the observed learning rate, the time which would be needed for renewables to reach competitiveness is too long, considering future energy demands, fossil supply and environmental issues. In this context, one fact stands out.

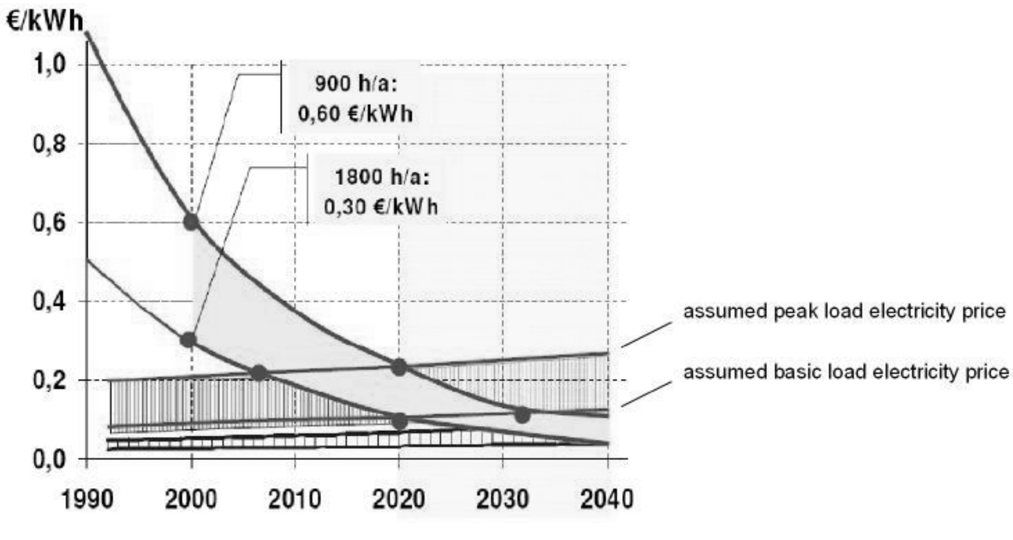


Figure 6. Comparison of predicted future costs for PV electricity with market electricity costs (Hoffmann W., 2009)

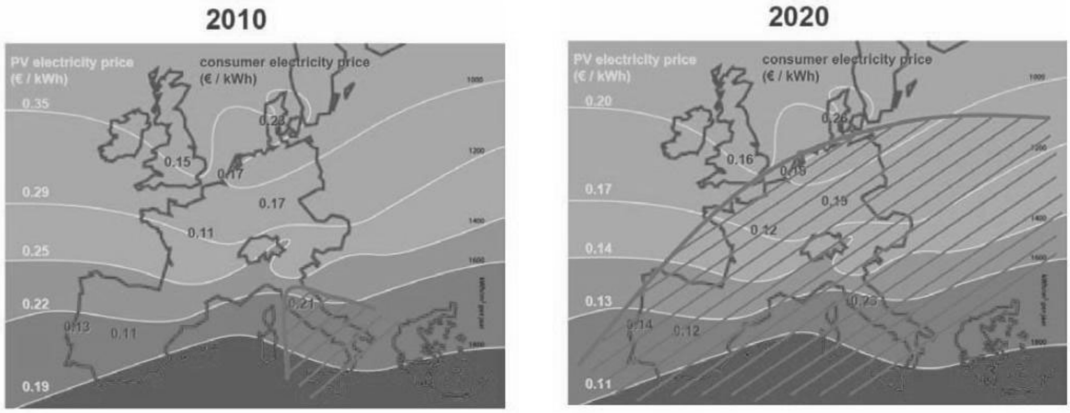


Figure 7. Comparison of predicted future costs for PV electricity with market electricity costs in peak load in 2010 and 2020 (EPIA in Fechner H., 2007)

Not many ofs today's energy technologies reached maturity without subsidization of the public sector. The nuclear power sector for example received very high financial support from governments in order to develop (UNEP, 2008). And also today this sector is still subsidized, directly and indirectly. Indirect due to the fact that nuclear power electricity prices, as well as electricity prices from fossil sources, are not reflecting the real cost for the society. One example: to insure for a maximum credible accident which can happen in a nuclear power plant, like it occurred in Chernobyl, is impossible for a power plant operator. The possible costs of such an accident are too high for an insurance company to bear. When it happens though, the government and therefore the society have to bear it. Such costs are not reflected in the market price.

In order to refer to the most stressed model in this paper also in this context, Germany, one example of still carried out subsidizing of fossils in Germany should be mentioned. Coal mining in Germany is financially supported by the government since more than fifty years. The subsidy was cut over the years, but the production declined in a faster pace. In 2007 every mining job of "Ruhrkohle AG", Germans biggest conveyor, was subsidized with 90.000 Euros per year (UNEP, 2008).

7. Other PV Roadmaps

The European Photovoltaic Industry Association has published a roadmap called set for 2020. Especially the EU goal of 20 percent renewables till 2020 is mentioned, which implies 35 percent of electricity consumption. A contribution of PV to the electricity consumption of 12 percent is argued as to be a "desirable objective". This means for 2020 40 GW of installed PV capacity. The price for 1 KWh generated with PV is demanded to fall to 10 € ct and 15 € ct for industrial size systems and residential systems respectively (EPIA, 2009).

In the photovoltaic roadmap of the United States fostering the use of PV is stated as a clear goal. The main reasons for the US to do this are to become more energy independent, therefore secure their supply and to promote the domestic PV industry. It is especially pointed out that the US PV industry lost their market leadership regarding development and commercialization to European countries and Japan and should therefore strengthen efforts to regain this position. For 2030 the US forecasts that 150.000 new PV related jobs will be created. In the US Roadmap it can also be found a link to state security, where it is noted that increased decentralized PV electricity production contributes to a safer supply regarding terror attacks. Further on, the forecast for 2020 sees 15 GW installed in the US and 88 GW worldwide. What is pointed out is the simultaneity of produced electricity and the peak electricity demand in the US. In 2030 10 percent of US peak load current should be provided by PV (USPI, 2003).

In the Japanese Roadmap of 2004 the fact that Japan is the world leader in PV production and installed capacity is pointed out[8]. It is referred to the European and the US Roadmap as they aim to compete with Japan regarding market leadership. Also the other Asian markets are mentioned in this context. In 2030 about 100 GW should be installed in Japan, producing 10 percent of the total electricity consumption, which is 50 percent of residential consumption. 2030 is the year in which PV should reach maturity, thus, research and the industry regarding PV should be transformed from policy to market driven. The price for electricity created from PV should therefore drop to 7 Yen per KWh (NEDO, 2004).

It has to be said here that the official roadmaps are several years old. In actual papers the forecasts for installed capacities in 2020 are already higher.

8. Conclusion

It has been shown that solar energy is available in a high amount and also in a sufficient intensity in many European countries. Therefore, a higher contribution to the electricity production in the coming years is possible. The utilization of solar power today is not so much determined by the irradiation available in each country, but by the political and hence economical insensitive set. Germany has by far the highest installed capacity of PV power followed by Spain and Italy and apart from Spain's market collapse in 2009 these countries also have the biggest markets. However, it was argued that for a better comparison between countries this numbers should be related to the actual population size. When it comes to the policies, the feed in tariff has proved to be the most successful way of promoting renewables and the German model of using this measure has become best practice. As the promotion of a not yet economical competitive energy form leads to costs for the society, the consideration of all side effects is of vital importance and should be a crucial factor of any overall assessment. Different positive externalities, like job creations, environmental gains and also altered energy prices stand against the more visible costs emerging from the usage of PV. It was argued that a balance of costs and benefits for the use of renewables is already achieved, whereas this is not yet the case for PV alone. Finally, the comparison with other non-European countries and their roadmaps gave a better understanding of the actual achievements and further plans of the European countries. With the emphasis set on 19 supporting renewables and therefore also PV, Europe is on a good way to stay a world leader in the PV market and in the PV industry sector.

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