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Solar Photovoltaic Energy Policy in Europe: Losing Sight of What is Right

Current Developments and Lessons Learned for Policymakers and Industry

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Table of contents

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Introduction

Europe has set ambitious but drastic targets in order to fight climate change. The 20-20-20 objectives demonstrate this. By 2020, emissions are to be reduced by 20%, the share of renewable energy sources (RES) in energy consumption is targeted to rise to 20%, and energy efficiency is planned to increase by 20% in comparison to the 1990 levels in Europe. In order for Europe to reach these objectives, national targets for each Member State have been set. While not yet officially binding, the 2050 Roadmap of the Commission is focused on achieving even stronger reductions, namely a reduction of 80% in emissions compared to 1990 levels. The 2020 objectives account for less than half of these 2050 objectives.

Consequently, Member States are currently under pressure to formulate efforts seriously to comply with their national and European targets as part of the objective of sustainability. European countries have increased capacity of renewables: hydroelectric power, wind power, biomass and solar energy are increasingly produced. As part of the planned renewable electricity capacities for 2020, solar photovoltaic panels (PVs) are the third largest installed RES source, after hydroelectric capacity and wind capacity.

PV is an interesting renewable source for several reasons. First, PV uses an energy source which is available daily: the sun. Secondly, PV has shown positive cost and efficiency improvements over time, which makes it increasingly interesting from a business perspective. It is assumed that PV will provide electricity at competitive prices soon in some countries. Thirdly, PV is one of the few domestically usable applications for electricity generation. This might shift the position of consumers to being co-producers or so-called prosumers. These are a few of the reasons that explain the interest in analyzing efforts linked to PV.

From an industrial point of view, PV panels are produced in- and outside Europe. Looking from a European perspective, it is interesting to examine China and the United States in regard to PV manufacturing and installation capacity. China may be characterized by its high and early PV production, exporting almost 90% of its output. What will this and other developments mean for European PV industry and job creation?

At present, the deployment of PV is under much discussion in many countries, within and outside of Europe. Changes in Feed-in-Tariffs (FIT) are following each other closely and motivations behind deployment are presently frequently discussed in the political sphere. Still, there are important points to consider. What are the costs of PV?

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How are the costs expected to decrease and how effective are current policies concerning PV penetration? Are these policies also effective in eventually reaching the CO2 reduction targets? PV technologies are still developing and it is important to not be moved by assumptions on efficiencies or effectiveness of the technology.

The aim of this report is to provide recommendations for the debate concerning PV deployment in Europe and to provide suggestions for both policymakers and industry in- and outside of Europe. This is done by analyzing the main developments related to PV worldwide. The report will furthermore present technical developments of PV and will present a comparison in the international context with US and Asia.

In Section 2, the position of PV policy is given within the EU renewable projections for 2020. Before continuing with the support policies for PV in Section 4, the main developments in PV technologies with definitions are provided in Section 3. Afterwards, case studies of the five major European countries with the largest European installed capacities in PV are presented with their efforts and policies associated to PV in Section 5. In Section 6, an evaluation of the European Policy is presented, after which a brief review of the US and China and their PV industries is given with their policy incentives to increase PV installation in Section 7. Finally, this report ends with a conclusion in Section 5, providing the recommendations for policymakers and industries in a global context.

This study only focuses on Solar Photovoltaics, and not on Thermal Solar energy (which uses the heat to generate electricity). Additionally, the reader should be warned that FIT and PV connected regulation is constantly changing. Due to this, data given might not all be totally up to date when this report is published.

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European Renewables Projections for 2020

In 2007, the EU Member States endorsed an integrated approach to climate and energy policy that aims to combat climate change and increase the EU's energy security, while strengthening its competitiveness. EU members set a series of climate and energy targets to be met by 2020, known as the "20-20-20" targets. These objectives focus on EU greenhouse gas emissions reductions of at least 20% below 1990 levels, 20% of EU final energy consumption to come from renewable resources and a 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

For the implementation of these 20-20-20 targets, the renewable energy Directive (2009/28/EC) requires Member States to submit their National Renewable Energy Action Plans (NREAPs). These plans present national roadmaps to obtain the 20-20-20 levels within three different sectors: heating/cooling, electricity and transport. The EU-implemented, binding national targets differ in each country. The national targets range from a renewables share of 10% in Malta to 49% in Sweden. In 2007, 2008 and 2009, the share of renewables in the gross final energy consumption was respectively 9.9%, 10.5% and 11.7% (Eurostat data).

Individual Member States are able to set their own national plans that minimally reach what is given in the European national target. Some states have decided to aim for higher targets, for example Spain, which has a target that is 2.7% above the most ambitious plans in its NREAP, regarding the share of renewables in energy consumption. Second is Hungary with 1.7% and third is Germany which is 1.6% above its target, with 19.6% instead of 18% (ECN Policy Studies, 2011).

Due to the national character of the NREAP assignments, timing and decisions have been uncoordinated, though decisions by individual countries in fact have international consequences for prices, security of supply and interconnection transmission capacity in Europe. This, for example, is the case with Germany's decision on the phasing out of nuclear power, leading to a higher use of interconnection capacities and influencing electricity prices.

Besides the NREAP, the EU Commission provided an infrastructure package in 2010, to support the integration of the renewable energy sources in 2020. This gives a blueprint for the energy infrastructure. The blueprint recommends increasing the

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interconnection capacities throughout Europe. Lastly, the blueprint enhances the development of smart-grids and deplores the slow pace currently displayed. (For a review of the interconnection policies, please refer to research recently published by IFRI: Jaureguy-Naudin, 2012).

Projections of renewables in 2020 can be given based on the accumulated NREAP. In the graph in Annex 1, the accumulated NREAP of all countries are presented, showing how the contribution of RES in the total gross production is distributed across the three sectors. Heating and cooling will account for 46% of the planned contribution of RES, and electricity directly follows with 42% of renewables contribution.1 Renewable transport accounts for just 13% of the overall renewable energy contribution in 2020 (ECN Policy Studies, 2011).

Planned Renewable Capacities

According to the national plans, after hydro and wind power, PV will be third largest installed capacity for renewables within Europe's electricity sector. The installed capacity for wind power is calculated to be 213.4 GW, for hydro 135.6 GW, and for PV 84.8 GW in 2020 (see Table 1). The potential for hydro is highly dependent on location conditions, which limits installation capacity of hydro in some countries (for example in Malta, Cyprus, Luxembourg, Estonia, Denmark and the Netherlands). An estimated 2.2% of total energy consumption for electricity is projected to be produced by PV in 2020.

Table 1: Total renewable electricity capacity accumulated from the 27 individual NREAPs

European Installed Capacities (GW)	2005	2010	2015	2020
PV	2,2	25,5	54,4	84,8
Concentrated solar power	0	0,6	3,6	7
Hydro (without pumped storage)	115	118	125,6	135,6
Hydro pumped storage	18,7	23,4	27,3	34,8
Geothermal	0,7	0,8	1	1,6
Tidal, wave and ocean	0,2	0,2	0,4	2,1
Wind power	40,4	84,9	142,9	213,4
Biomass	15,7	22,6	32,2	43,3
Total RES capacity	174,2	252,6	360,1	487,8

[1] All information in this chapter is derived from the accumulated NREAP report, written by The Energy Research Center of The Netherlands (ECN) in assignment of the European Commission.

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If the installed capacities in 2009 of RES are compared with the targeted capacities in the NREAP's for 2010 (see Table 2), it is clear that Europe in 2009 had installed 92% of the planned total RES levels for 2010. From this installed RES, it is mainly hydro power that shows a large contribution: both installed hydro pumped storage and tidal energy were already above the EU 2010 target in 2009 (though tidal power had a very low target). In 2009, both installed solar PV and concentrated solar energy were largely below the 2010 target in 2009, but due to large increases in capacities for PV in 2010 the target for PV was reached: in that year 13 GW in extra capacity were installed in Europe, bringing the total capacity to 29 GW.[2]

Table 2: A comparison of planned and actual installed capacity, in 2009 and 2010*

Capacity in GW	EU installed RES 2009	EU planned RES in NREAP 2010	Percentage 2009 of 2010 target
PV	15.78	25.48	61.9%
Concentrated solar	0.28	0.60	47.2%
Hydro (without pumped storage)	92.94	107.83	86.2%
Hydro pumped storage	38.93	23.40	166.4%
Geothermal	0.73	0.80	91.0%
Tidal. wave and ocean	0.24	0.20	120.5%
Wind power	74.30	83.71	88.8%
Biomass	20.16	22.60	89.2%
Total RES capacity	243.36	264.63	92.0%

* Left out: Bulgaria, Cyprus, Latvia, Lithuania, Malta, Romania. Installed capacities taken from IEA data. In this table, 2009 data is taken from the IEA database, not the 2010 data for installed capacities because this was not yet available.

Even though the targets for Europe's Member States are of importance, the EU objectives are given as a motivating factor for the RES penetration and the accomplishment of the 2020 targets, which in themselves are set to reach emission reductions, competitive markets and security of supply (the achievement of the 3 pillars behind Europe's Energy policy). It is important to keep the three ultimate goals in mind and still leave flexibility, to consider the targets as a means to the underlying objectives. It is very questionable whether all efforts related to the Member States' national targets are effective and efficient in reaching these ultimate and competing goals.

[2] Information from Eurobserv'er 2011 Photovoltaic Barometer

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Planned Renewable Electricity Generation

Electricity production coming from the installed renewable capacity in Europe is expected to be distributed differently than the installed capacities since the different types of technologies produce differently. In 2020, it is expected that wind power will lead as a renewable generation source, with 495 TWh. Hydro power and biomass follow, with respectively a production of 370 and 232 TWh. PV is expected to take fourth place as a renewable source, with its production level of 83 TWh. The ratio for the four different renewable sources is then calculated to be: 26.5 % for wind power, 31.2% for hydro, 61.1% for biomass and just 11.2% for PV (see Table 3). (For and explanation of the ratio see Box 1.)

Table 3: Expected ratios for each RES in electricity production in 2020

	2020 (GW)	2020 (TWh)	Ratio[3]
PV	84.8	83.4	11.2%
Concentrated solar power	7.0	20.0	32.6%
Hydro (without pumped storage)	135.6	370.1	31.2%
Geothermal	1.6	10.9	77.8%
Tidal, wave and ocean	2.1	6.0	32.6%
Wind power	213.4	494.6	26.5%
Biomass	43.3	231.9	61.1%
Total RES capacity	487.8	1216.8	28.5%

Within the national plans, the Member States have presented their expectations on efficiency. Total final electricity consumption in 2020 for Europe is projected to be 3,826.3 TWh in the NREAP, but it is expected to be 3,535.5 TWh in the EU energy efficiency scenario in these NREAPs. The focus on energy efficiency with extra renewables is a key issue to reach planned CO_2 emission reductions. Only installing extra RES in parallel to back up capacity from combustibles will shift generation capacity upwards, supplying the increase in demand. Consequently, energy efficiency is an important measure to create effective efforts towards CO_2 reduction and not just supplying increased demand.

PV is one of the capacities that will be installed in order to reach the 2020 targets for RES. In 2020, the projected total solar capacity will be largest in Germany, with over 50 GW solar capacity in 2010. Second, the greatest increase is projected to be in Spain, with almost 15 GW. Thirdly, Italy is set to have around 8 GW capacity, and then France, with around 5 GW (see Table 4).

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[3] Calculated by dividing the installed capacity*number of hours in the year, by the expected production in that year. See box 1 for more detailed explanation.

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Table 4: Objectives for PV in Germany, Spain, Italy, the Czech Republic and France

	Germany	Spain	Italy	Czech Rep	France
PV installed capacity (MW)	51753	13445	8600	1695	5400
PV Gross electricity production (GWh)	43189	14316	9650	1726	5913
Ratio (%)	9.5%	12.2%	12.8%	11.6%	12.5%

Box 1: The ratio as an indicator for production efficiency

In order to provide an indicator regarding the respective efficiencies of different types of technologies for electricity production, the term ratio is used in this report. This ratio is calculated using the capacity given in TW, GW or MW and the gross generation given in TWh, GWh or MWh.

The expected generation if there is full production during the whole year, is the production in a year *n*, divided by installed capacity in the same year *n*, times the number of hours in the year (8760):

$$\frac{Prodution_{year\,n}}{Capacity_{year\,n} * 8760h}$$

The real capacity that is operating during a whole year is most of the time lower than the capacity found in databases. Some capacities might be installed later in a year and so these capacities are not operating during a full year. To capture this, the difference of the actual year is divided by the previous year on top of the actual year. The ratio for year *n* is thus:

$$\frac{Prodution_{year\,n}}{((Capacity_{year\,n} - Capacity_{year\,n-1})/2) + Capacity_{year\,n-1}) *}$$

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PV Technology

The sun offers a considerable amount of power, depositing 1,368 watts per square meter (W/m^2) when sunlight is perpendicular to the surface exposed. This measure is called the solar constant. However, since our planet is not a flat disk, the average amount of power over the year and over the surface area of the globe is one fourth of the solar constant: 342 W/m^2. Of these 342 W/m^2 a part is reflected back from the Earth's space by clouds, aerosols and the atmosphere, and the remaining 198 W/m^2 (about 57% of the total) reaches the Earth's surface on average (International Energy Agency, 2011). This makes the maximum possible electricity produced with a 100% efficient PV panel 1.7 MWh per year, per square meter (calculated as 198W/m^2 x 8,760 hours).

These promising statements seem appealing in perceiving the sun as an energy source for electricity production. Solar photovoltaic technology (PV) is a technology which converts "photons" (light) into voltage (electricity as DC electrical current). The PV industry is growing globally and installed capacities are expected to expand in order to fight climate change and so produce electricity sustainably. Even though this technology is still in development, in some places PV is at times competitive with conventional electricity. This demonstrates a clear business incentive to invest in PV. There are clear connections between the development of PV, the type of technology and the financial benefits for producing electricity from PV. Because of this, some of the basic characteristics of this technology are presented in this chapter.

The "p" value: Wp, kWp and MWp

In photovoltaics, the maximum possible output of a solar generator operating under standard conditions is defined as its peak output. The peak output is measured in watts or kilowatts and stated as either Wp (wattpeak) or kWp (kilowattpeak), where the *p* stands for the peak value of the production. The peak power is the power that the manufacturer declares that the PV array can produce under standard test conditions, which are a constant 1000 watt (W) of solar irradiation per square meter in the plane of the array, at an array temperature of 25°C. The peak output can be reached in early afternoon on a sunny summer day. The average output for a year is only about one tenth of the peak output due to night-time and less than optimal day-time sun conditions (Joint Research Center European Commission).

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Installation

PV systems can be installed in different ways. The most commonly used are rooftop PV, building integrated and freestanding PV systems (also called ground mounted). Rooftop PV systems are located on top of the roofs of buildings, either residential or industrial. Building integrated PV involves installation that replaces a part of the building, for example the roof or walls. Most of the time, FIT for PV that is building integrated is higher than FIT for ground mounted systems and rooftop systems. This is because of the higher associated costs of rooftop systems than for ground mounted systems.

Free standing or ground mounted systems are directly located on the ground, and are most of the time are used for large scale capacities, which cover a large area of land. FIT tariffs related to these systems are generally lower than for building integrated or rooftop systems.

Europe has long been the center of demand for fixed-tilt mounted structures. In 2010, Europe had installed 2.0 GW out of a total of 2.8 GW in fixed-tilt mounted structures worldwide.

PV Technology Performance

The performance of PV has large effects on the economic benefit that is gained out of the production. The performances (thus the electricity production) of PV panels depend on very different subsets: (1) the local temperature (higher temperature, lower performance); (2) the tracking possibility of the panel; (3) the mounting position; (4) the local solar irradiance; (5) the estimated system losses; and (6) the used module technology.

Temperature

With higher temperatures, the PV performance falls in the short and long term. In short term, higher temperatures decrease voltage output. In longer term, the high temperatures increase the degradation of the entire PV module. In some regions, PV panel temperatures might rise to 70° Celsius (for example in Cyprus) and this has a large effect on the performance of panels in the long term. Cooling systems might allow airflows to decrease panel temperatures. Very low temperature PV systems can produce high efficiencies with direct sunlight (for example at the North Pole).[4]

Tracking systems and tilt angles

The performance of a PV system is increased with the presence of a tracking system. Tracking systems increase the PV system energy harvest over a day, by allowing the panel to change direction following the sun, see Graph 3. Since most electricity is produced if sunlight is perpendicular to the panel, tracking systems try to increase the amount

[4] Website Energy Trend: http://www.energytrend.com/Cold_Weather_PV_20111130

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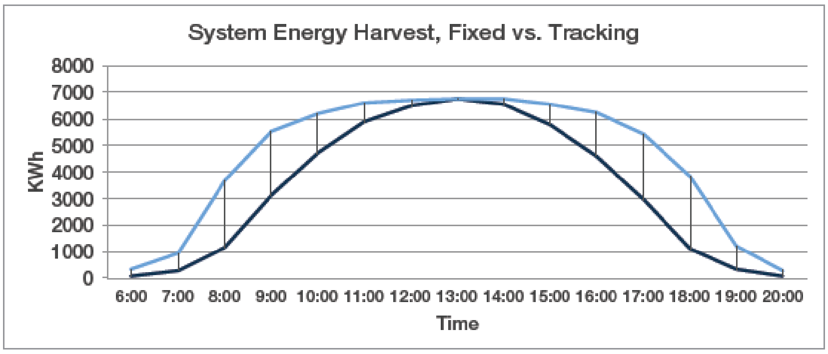
of sunlight entering the panel in this way. There are two different types of tracking systems: single axis tracking and dual axis tracking systems. Single axis tracking just involves panels turning in one axis, while dual axis tracking systems allow the panel to move both in a horizontal and a vertical direction. Tracking systems increase installation costs and maintenance needs. Collector tilt angles reduce geographical disparities in available solar energy source.

Graph 3: PV systems' energy harvest for fixed and tracking panels



The mounting position

PV performance depends also on the mounting position of the panel. The mounting position provides information on the way the panel is installed: free standing, on the ground, on a roof (rooftop) or building integrated. Ground mounted systems provide the highest efficiencies, followed by rooftop systems and building integrated systems. Most of the time, building integrated systems are partly shadowed and not optimally directed at the sun. Ground mounted systems are located in a free space and directed at the sun and are possibly cooled more easily due to the presence of open space behind the panels. Electricity from large utility scale PV is currently 27% less expensive than electricity from residential scale (rooftop) PV (International Energy Agency, 2011)

Solar irradiance

Solar irradiance is a major performance indicator for PV and very much depends on overall orientation. There are different types of irradiance affecting the performance of a panel: direct irradiance and diffuse irradiance. Direct irradiance is the radiation that directly comes from the sun reaching the Earth. Direct irradiance is fully received when a panel is held at an angle of 90 degrees to the sunrays entering it.

Diffuse irradiance however is solar radiation that does not arrive straight from the sun but is scattered due to the presence of particulates in the atmosphere. For example on a cloudy day, diffuse irradiation is high, while on a clear sunny day, the amount of direct radiation might be high.

The presence of high direct irradiance makes the use of concentrating devices interesting. Concentrating devices demand high direct irradiance for concentrating sunlight on the small area of a

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solar cell: for example, for Concentrated Photovoltaics technologies (CPV).

It is important to know that besides knowledge of locational direct and diffuse radiation, seasonal patterns and daytime temperatures also are of great importance in deciding on installing PV technologies and forecasting the performance of PV panels. Some specific areas might have very changing seasonal patterns in received sunlight radiation, which affects local PV performance.

Losses in the PV system

The conversion of DC current to AC current does not occur without losses. The performance of the PV panel therefore depends on the losses occurred due to the processes connected to the panel. For example, if the inverter, transformer, electrical protection, wiring, monitoring equipment is not working properly, high losses might be present and this decreases the performance of the PV module.

Module technology

The module technology used largely affects module efficiency and thus performance of the panel. Each technology has its own efficiency and price characteristics. It should be noted that PV cell technology is different from module efficiency. Its efficiency is usually lower due to the need for converting DC to AC current and losses in the system.

The main known technologies for PV cells are (see the graph in Annex 2):

- Crystalline silicon cells
  - Multi- or mono-crystalline
  - Efficiencies between 20-27%
- Thin film technologies produced from copper indium selenide (CIS) or copper indium gallium diselenide (CIGS) from Cadmium Telluride (CdTe) amorphous technologies (A-Si)
  - Efficiencies between 12-20%
- Multi-junction technology
  - Efficiencies between 25-42%
- Emerging PV: organic cells and dye sensitized
  - Efficiencies between 3-11%

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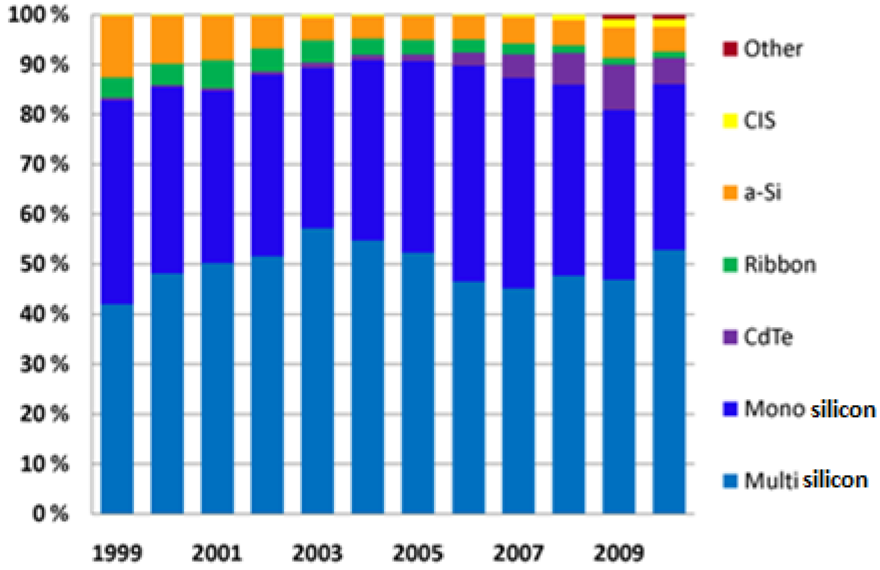
Graph 4: Market shares of different PV technologies[5]



Graph 4 shows the market share of the different photovoltaic technologies from 1999 until 2011. The light and dark blue are multi- and mono-crystalline silicon respectively; together they represented 87% of the market in 2010. CdTe and A-Si are both thin film technologies.

Crystalline silicon cells together with thin film technologies are most common in the PV markets. Multi-junction cells have mostly been used in satellites to provide electricity. Multi-junction yields the highest efficiencies among all technologies, due to use of different layers to capture a larger bandwidth of the light. Organic PV is the cheapest technology available; however lifetimes of these cells are still much shorter than average PV cells. In the following paragraphs a more complete description is given of the different PV solar cell technologies.

Crystalline silicon cells

Crystalline silicone cells accounted for nearly 90% sales of PV production in 2011. Solar cells based on silicon (Si) semiconductors account for nearly 90% of 2011 sales of photovoltaic (PV) products. Annual production of Si-based PV in 2011 reached more than 15 gigawatts—an order of magnitude higher than other PV technologies. Silicon in PV takes many forms, including the industry-dominant mono-crystalline (c-Si) which is the most efficient version, and multi-crystalline wafers sawn from ingots; melt-grown ribbons; thin hydrogenated amorphous silicon (a-Si:H); and micro-crystalline Si layers grown from gaseous precursors. Efficiencies of this type of cell run from 20-27%.

[5] Source: Cleanenergy (talk) 03:04, 12 June 2011 (UTC)

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Thin film technology

Thin film technologies are most commonly produced with Cadmium Telluride (CdTe). After crystalline silicon cells, thin film technology is the fastest growing product segment due to its competitive price and efficiency gains. This is especially so for CdTe-based thin-film solar cell modules, partly because of the simplicity of the two-component absorber layer (i.e., CdTe contains only cadmium and tellurium) and the ability of bulk cadmium telluride source material (in the form of high-purity powders) to be reconstructed into the CdTe thin films needed to produce PV modules. Current CdTe thin film efficiencies run between 12 -16%.

Furthermore, another technology within thin film is CIGS. CIGS-based thin-film solar cell modules currently represent the highest-efficiency alternative for large-scale, commercial thin-film solar cells. Several companies have confirmed module efficiencies exceeding 13%.

Additionally, amorphous silicon (a-Si) is a commonly used technology within thin film modules. Amorphous silicon is the non-crystalline allotropic form of silicon. Market shares for A-Si and CdTe are largest among thin film technologies. However, a-Si thin film PV efficiencies are lower than that of CdTe and CIGS: approximately 12%.

Multijunction technology

Multijunction cells are used both for space facilities like satellites and terrestrial power needs.[6] These cells have achieved the highest energy conversion efficiencies of all PV cells with the current record exceeding 40%. This high efficiency is due to the ability of capturing a larger wave-length of the light absorbed. In terrestrial applications, these solar cells are used in concentrated photovoltaics (CPV) with operating plants all over the world using sun-tracking systems, in order to concentrate the sunlight in the desired target. These cells need a high level of direct sunlight, making them usable only in a few places worldwide and this is significantly different from normal PV which also capture diffuse irradiance to produce electricity. The complexity of the manufacturing process and associated cost high indicate that they are mostly suitable for concentrated PV

However, this efficiency is gained at the cost of increased complexity and manufacturing price. To date, their higher price and lower price-to-performance ratio have limited their use to special roles, notably in aerospace where their high power-to-weight ratio is desirable. But there might be future possibilities of the use of quantum dots and nano particulates that could yield high efficiencies and low costs. This technology is currently still under development.

[6] Multi-junction, as the name suggests, consists of different layers or junctions that due to their own properties, are able to capture a separate part of the wavelength of light.

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Emerging PV technologies

Emerging technologies like organic and dye-sensitized solar cells are known for their low cost and quick return on investment. Generally these technologies have lower efficiencies. Dye-sensitized solar cells (DSSCs) are made of low-cost materials and do not need elaborate equipment to manufacture. In bulk, such technology should be significantly less expensive than older solid-state cell designs. DSSCs can be engineered into flexible sheets, though efficiency is less than with the best thin film cells (8-11%).

Organic solar cells are a relatively novel technology. But they hold the promise of a substantial price reduction (over thin-film silicon) and a faster return on investment. These cells can be processed from solutions, hence the possibility of a simple roll-to-roll printing process, leading to inexpensive, large scale production. Efficiencies are found to be between 4-8%.

Electricity production determents

As presented above, the impacts on electricity production of PV modules are very dependent on different (external) factors. Firstly, the highest impact comes from the local solar irradiance and module technology used. Both of these largely affect the electricity production of a panel. The tracking possibility of a panel and local temperature have secondary effects on electricity production. Tracking possibility raises the solar harvest and thus the electricity produced by the panel, while higher temperatures lower the performance in the short and long term. Furthermore, the mounting position (location of the panel) has effects on the efficiencies. The highest efficiencies come from ground mounted systems and lower efficiencies from roof-top and building integrated systems. However it has to be noted that, depending on the location and the technology used, the level of impacts might differ (thin film technologies are less sensitive to local temperatures than other technologies for example).[7]

The impact of PV on electricity grids

Traditionally, power flows move from high voltages to low voltages. But by adding PV in distribution networks in medium voltage (MV) and low voltage, a possible effect may lie in islanding problems. Households, which before were only consuming electricity, might become electricity producers. The impact on the grid caused by intermittent distributed electricity generation mostly affects electricity quality (harmonics, frequency and voltage drops). It would be unreasonable to incorporate distributed PV excessively, and so decrease the voltage quality of the entire system. Therefore, in order to cope with PV penetration, there is a need for network voltage regulation, frequency stability and power flow

[7] From the website www.pv technology.ucy.ac.cy

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control to manage uni-directional and bi-directional flows in lines (Domingo, 2010).[8]

The impact level of PV generation on grids depends on several aspects. Firstly, the size and place of the connection of PV to the grid. Generally, for large scale PV connected to high voltage (HV) transmission networks, the impacts are much higher than small scale PV installations connected to low voltage (LV) distribution networks. Large scale PV is mostly connected to the high voltage transmission network and requires monitoring devises to manage the PV connections remotely, with a protection relay to maintain the entire system's reliability. For example in Spain, the transmission grid manager is able to monitor and open or close connections of large scale PV capacities to the grid, in order to ensure the voltage quality of the entire system.

In LV networks, the impacts are modest when there is a low penetration of PV. Depending on the typography of the grid (the way the grid connects different dots), impacts might differ across networks. Generally, if PV capacity installed per household is lower than 1 kW, effects on the grid do not occur for voltages (Paatero & Lund, 2006). However, in Germany, the average size of a domestic PV system is already around 5 kWp (EPIA, 2010). This shows that it might create problems on the distribution level in the long term, if the penetration of PV increases, especially in countries where solar conditions are very positive, with high possibilities for PV electricity generation per household. In order to cope with this, a different type of network management is needed. Depending on locational factors (network quality, typology and current management of the system), it is important to assess the impact of distributed generation on the distribution business. Current networks are mostly built to be passive and this leads to important barriers for distributed generation integration. New ways entail innovation in how distribution networks are planned, operated and controlled, mitigating the effects of active and smarter grids. On a regulatory level, this entails new regulatory designs for the remuneration of operating distribution systems (who will pay for the control of the grid and how much?), distribution charges that reflect costs and adding real time pricing to promote efficiency of distributed generation operation and demand response. (Cossent, Gómez, & Olmos, 2011).[9]

The use of special inverters in PV systems could also be a way to control voltage levels in lower voltage grids.[10] Besides, energy storage might help to lower the change for over voltages in the low voltage grids with the use of one kWh storage capacity per kW of PV. This would result in at least a 36% reduction of local over-voltage and

[8] Domingo, C. M. (2010, October 6). *Structure of distribution grid and impact of solar electricity generation*, (PV Legal, Performer) Universidad Pontificia Comillas, Madrid.
[9] Cossent, R., Gómez, T., & Olmos, L. (2011). Large-scale integration of renewable and distributed generation of electricity in Spain: Current situation and future needs. *Energy Policy 39* , 8078–8087.
[10] http://www.greentechmedia.com/articles/read/PV-Inverters-Ambassadors-of-the-Grid-/

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up to a 0.6% reduction in voltage falls during the consumption peaks (Paatero J. , 2009). However, it should be noted that currently the penetration of PV is not high enough to create disturbances.

Registration models for PV electricity production: netmetering and tariffs

There are different ways in which PV electricity production can be registered and remunerated. Separate meters and Feed-In-Tariffs are most commonly used in Europe. This means that every kWh of electricity produced is paid a fixed tariff which is higher than the price of electricity. For electricity fed into the grid, a meter is needed to register exactly how much electricity has been produced. Sometimes there is also time of use metering (TOU), where the tariff changes are based on the time of the day. If for example the electricity has been fed into the grid in a peak period, there will be a higher remuneration for the electricity produced. This is attractive for PV, as in many places its production does peak when demand peaks during the day.

Another way of dealing with electricity flows and financial flows is netmetering. Unlike a Feed-in Tariff or time of use metering (TOU), net metering can be implemented solely as an accounting procedure, and requires no special metering, or even any prior arrangement or notification. With netmetering, the meter “runs backwards” when electricity is fed back into the grid. A household just pays the utility the difference of the electricity consumed and produced. Net metering for PV is currently used in the Netherlands and Denmark.

Components and cost reductions

The main and most expensive component of the PV system is the PV module, more generally known as the PV panel. The PV panel is built out of a set of PV cells. All necessary devices that are connected to the PV panels are brought together as the “Balance of System” (BOS). The BOS includes all components of a PV installation excluding the PV panels, so these are for example the inverter, transformer, electrical protection, wiring, monitoring equipment and sometimes also sun-tracking systems and fixed mounting frames. The inverter creates the DC to AC inversion. The transformer is used to increase or decrease the voltage output. Furthermore the sun-tracking system is a component that makes it possible for the solar panel to move with the direction of the sunlight. This increases the possible sunlight harvest of the panel.

Since each of these different components is still being improved, each has its own expected cost developments. In Graph 1, an expectation of the cost reduction is shown for each of these components. Major cost reductions are expected in the PV module.

Depending on the type of technology used, the price of silicon is important. Most obviously, silicon based cells (mono- and multi-silicon cells) depend much on the price of silicon. This is less important for other technologies, for example for thin film technology, which is produced from cadmium telluride. The major factors which drove cost reductions from 1980 to 2001 for PV are usually identified

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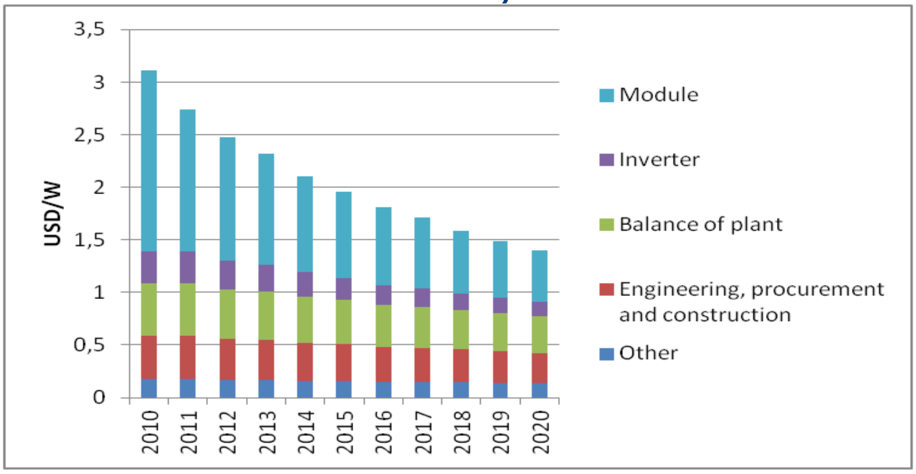
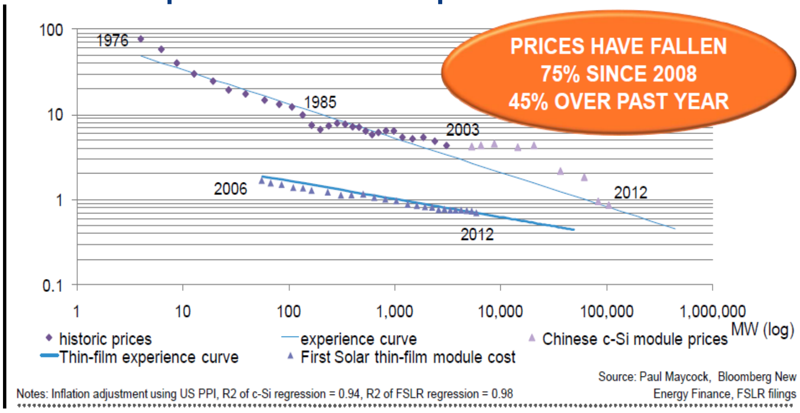
as not having been the learning curve itself, but rather manufacturing plant size, module efficiency and purified silicon cost (Nemet, 2006). However, some current PV factories in Asia seem already to have reached very large scales, so reductions in costs there will mostly come from module efficiency and the purified silicon cost.

Graph 1: Expected cost reductions for PV components in utility scale from 2010-2020 (in USD/W)



From: Bloomberg New Energy finance

Graph 2: PV module experience curve 1976 – 2012 ($/W)



Source:

From: Bloomberg Energy Summit 2012

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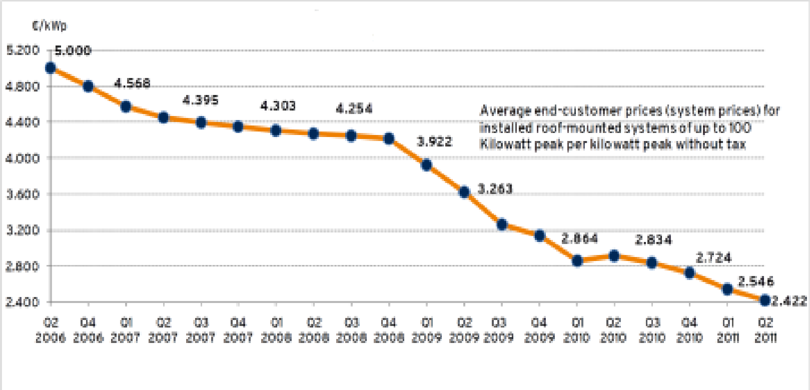
The costs and profitability of PV

Silicon prices were a key determinant of PV technology prices for a long time. However, some technologies have decreased or even totally diminished their dependency on silicon: for example, thin film technologies made with CdTe. The different technologies have their own cost characteristics and technical efficiencies and performance rates. Investing in PV only from a sustainable development point of view would be unreasonable if costs mean drastic losses compared to conventional electricity production. Costs are an important factor. Costs for PV have decreased rapidly in the last few years and are expected to decrease even more. This is due to the greater efficiency of PV panels, economies of scale in production and the evolution of silicon prices: see the PV system prices in Germany in Graph 3, for example. Prices have decreased from €5 to € 2.4 per kW.

Graph 3: PV system prices in Germany: an overall price reduction by 50% since Q2/2006



Source: BSW-Solar PV Price index 5/2011

Silicon prices

With the advent of solar power and its rapid growth, demand for silicon has increased greatly, leading to supply constraints as production capacity is not enough to meet current demand. These supply pressures have led to rising prices for solar equipment which in turn raises the price of solar power compared to other clean energy technologies such as wind power. In the period around 2005-2006, a shortage of polysilicon was reflected in higher prices for European PV modules (see Graph 4). Furthermore, higher silicon prices mean higher production costs for solar companies, and lower margins.

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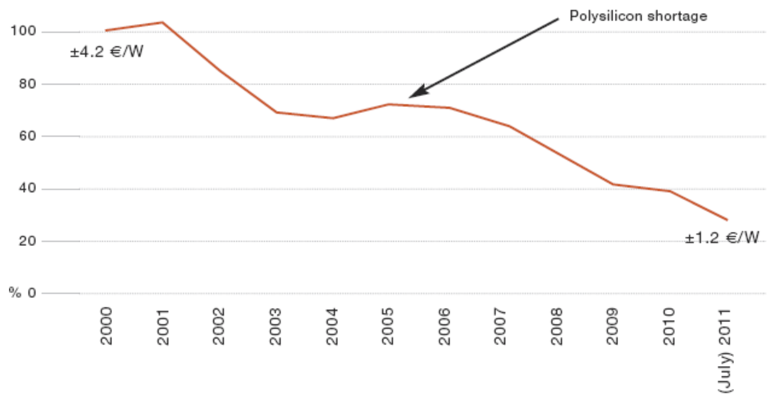
Graph 4: Europe PV module price



From : Paula Mints (Navigant Consulting)

Difficulties in calculating PV costs

Just as for hydro and wind energy, PV electricity production is variable and highly dependent on locational factors. In order to be able to state whether PV is a viable option in electricity production, it is important to focus on the costs of PV and the supposed remuneration coming from electricity production. One of the important aspects assessed by researchers at Queen's University is the emphasis on the fact that determining the Levelized Cost of Energy (LCOE) – the average cost of a PV installation over its lifetime – is a very "location specific" calculation. Taking all these factors together could spell good news for the PV supply-demand disparity, which is currently being experienced by the solar industry as a whole.[11]

Generally, electricity costs are simply calculated and specified as the levelized cost of electricity (LCOE, see Box 2). The LCOE for PV includes the cost of capital (including discount rates), the irradiance level and the performance ratio. This performance ratio takes into account the losses due to the inverter, the effect of less-than-optimal direction, the tilt of the modules and shadow effects. Reasonable estimates for average performance ratios are 75% for residential systems, 78% for commercial systems, and 82% for utility-scale systems. Electricity from large utility scale PV is currently 27% less expensive than electricity from residential scale PV (International Energy Agency, 2011) These different aspects are mostly based on assumptions, and in real time are variable, even for a given location and technology. For this reason, a recent study examined the lack of clarity in the assumptions and justifications which are used in some LCOE estimates, and which could lead to wrong outcomes and policy initiatives (Branker, Pathak, & Pearce, 2011).[12] Main uncertainties are found in the system cost, financing, panel lifetimes and loan finance. These depend much on the technology used and the location in

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[11] http://www.energytrend.com/Grid_Parity_20120117

[12] Branker, K., Pathak, M. J., & Pearce, J. M. (2011). A Review of Solar Photovoltaic Levelized Cost of Electricity. *Renewable & Sustainable Energy Reviews* , 4470-4482.

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which PV is installed. This report illustrates that the most important assumptions concern system costs, financing, lifetime and loan terms. A higher inclusivity of costs and reporting assumptions and justifications is recommended, even if this is merely based on the work of another source.

PV competitiveness and grid parity

Grid parity is said to be reached when production costs (taken as the levelized cost of electricity) of a certain electricity source are equal or lower than the electricity costs of electricity bought from the grid (electricity retail prices). It should be noted that distributed generation of PV competes with the distribution price, not the wholesale price (due to its location of production). Grid parity would mark an electricity source, for example PV or wind as competitive. It is important, that in terms of grid parity even distributed generation like PV should be assigned a distribution charge when comparing it to the retail electricity price. Since once a system is connected to a grid and the distribution net is needed for transmitting overproduction or to supply electricity for underproduction of the PV system, a charge needs to be paid in order to distribute the costs of the grid fairly.

Currently, PV is competitive when used in off grid situations, for example for street lightning or rural places where expensive fuel generators would provide for electricity generation. Grid parity is to be expected first on islands, because of their costly oil fired (diesel) plants. Madagascar, Cyprus and other Mediterranean islands, the Caribbean and the Seychelles are examples for this. Italy and California too are examples, mainly due to their sunny conditions. The cumulative support cost to get PV to a price of USD 1/w is calculated to be USD 1.3 trillion (International Energy Agency, 2011).

Residential and commercial PV produces electricity that is 27% more expensive than from utility scale, ground-based PV systems (International Energy Agency, 2011). Retail prices include distribution and transmission costs. Grid parity is reached when PV generation costs are roughly equal to electricity retail prices. In only a few years from now, grid parity is expected in most sunny places. PV will be competitive with utility scale electricity generation if oil prices rise to USD 80 per barrel, given the solar conditions of the Middle East (International Energy Agency, 2011).

An impediment for grid parity arises when prices do not always reflect costs. For example flattened prices, which are little higher than off-peak prices and lower than peak prices are present when grid power is subsidized. This will lengthen the time for residential PV to reach grid parity, even though residential and commercial PV are expected to compete with retail prices before 2020. But, the locational specific character of PV installations is important in defining grid parity (see the country studies for more on this topic). Italy is expected to reach grid parity first due to its higher electricity prices and positive location. In Denmark and the Netherlands, PV is deployed by the use of net metering (see

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paragraph 3.2.4). This reflects the competitiveness of PV with retail electricity prices already.

The subsidies that are available for the different electricity sources should also be taken into account. Highly subsidized prices for electricity do not provide a fair comparison, both for renewables and for conventional electricity.

Box 2: Levelized Cost of Electricity (LCOE)

LCOE represents the cost per kWh and covers all investment and operational costs of the system during its lifetime, including the fuel consumed and the replacement of equipment. Using LCOE makes it possible to compare a PV installation with any kind of power plant. For each system the LCOE calculation takes into account:

- The lifetime of the plant
- Investment costs (CAPEX)
- Operational and maintenance costs (OPEX)
- The discount factor (expressed as the Weighted Average Cost of Capital or WACC)
- The location of the plant, which it is essential to consider for PV

$$LCOE = \frac{CAPEX + NPV\ of\ total\ OPEX}{NPV\ of\ Total\ Electricity\ Production}$$

Source: IEA/OECD-NEA.

Maintenance

Compared to the investment costs of PV, maintenance accounts for a significantly smaller share of total costs. Normally PV is built on a “fit-and-forget” approach, meaning that after installation minimal maintenance is needed, especially for rooftop and building integrated systems. However PV systems with tracking devises do indeed need more maintenance than other systems. Besides, in places with high dust levels (GCC region for example), there is a need to clean the PV panels to maintain electricity production.

Benefits and challenges of PV from a technological perspective

Benefits of PV

PV provides different factors which make it interesting from a technological and business perspective. Currently, PV is already competitive in off-grid situations, being able to produce power in remote places. Electricity output follows a smooth production curve, and hence

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is easier to manage and predict than wind power. Besides, it can be installed domestically, so consumers are able to produce electricity and interact reactively with the grid. There are no real disturbances due to sound, excessive maintenance or other side effects coming from PV panels. PV can be used to create consumer awareness of energy consumption and is an essential part in the move to smart-consumption.

The production of PV in distribution levels, if evenly deployed in the distribution network, can significantly reduce network losses. Compared with large scale PV, distributed generation PV benefits from lower power losses, because generation is directly linked to loads. Besides, these capacities do not take up more space than those already used. Large scale PV (in rural areas connected PV usually has a larger scale) has higher efficiency rates most of the time, but is connected far from the loads. This means losses, and such PV requires specific network installations and power flows from distributed generation to the location of loads.

The challenges PV faces as a Renewable Energy Source

As shown in this chapter, the costs of PV modules are still decreasing. This decrease is partly caused by the invention of new technologies, decreases in silicon prices and economies of scale in production. The future cost for PV is expected to decrease but this is an unknown area. Also, the costs of disposal and removal, which have not been mentioned in this chapter, need to be taken into account.

Due to the intermittent character of sunlight, PV cannot produce electricity at all times. High penetration of this intermittent electricity source in low voltage networks demands a new approach in distribution networks from being “passive” to “active” and smart. This transition is needed both at the technological level and at the regulatory level (the right remuneration schemes for system operators on this level). Also, concerning the transmission level, there is a need for the right management of this interruptible electricity source.

Costs are extremely dependent on local subsidies, local irradiation, the technology used and mounting positions. To define grid parity there is thus also a need to define the assumptions on the above points.

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The Forces Driving Policy Instruments to Support PV Deployment

Currently, PV is already competitive when used in off-grid situations and remote areas where expensive fuel generators would otherwise provide electricity generation. However, in order for PV to compete with other (CO_2 emitting) electricity sources, further cost reductions are still needed. With believing that costs of PV will decrease in time, many governments have already started investing in this technology by supporting the deployment of PV in their national grids. Thus PV is expected to reach grid parity in some cases (islands with expensive oil-fired plants) before 2015, and in other markets by 2020 (International Energy Agency, 2011). Consequently, over the last years, the increase of global photovoltaic capacity has taken off rapidly. During 2010, Europe's PV sector installed more new capacity than any other renewable energy source for the first time. Global photovoltaic capacity doubled in 2010, rising from 7 GWp 2009 to 16 GWp in 2010 and eventually in 2011 an extra 27.7 GW is estimated to have been installed globally (EPIA, 2012). Different national strategies have been used to stimulate this massive growth of capacity. This chapter provides an overview of most common support policies for PV deployment.

The most known policy instruments for PV currently used within Europe are Feed-In-Tarrifs (FITs) and Feed-In-Premiums (FIPs), along with Green certificates, investment taxes, loan guarantees and emission trading schemes. Different policy instruments are suitable depending on the level at which technology is being developed: in the early stages of development for organic PV, or later stages of development like wind power, for example (see Image 1). All these instruments seek to decrease risks faced by investors in renewable energy sources. These risks might be:

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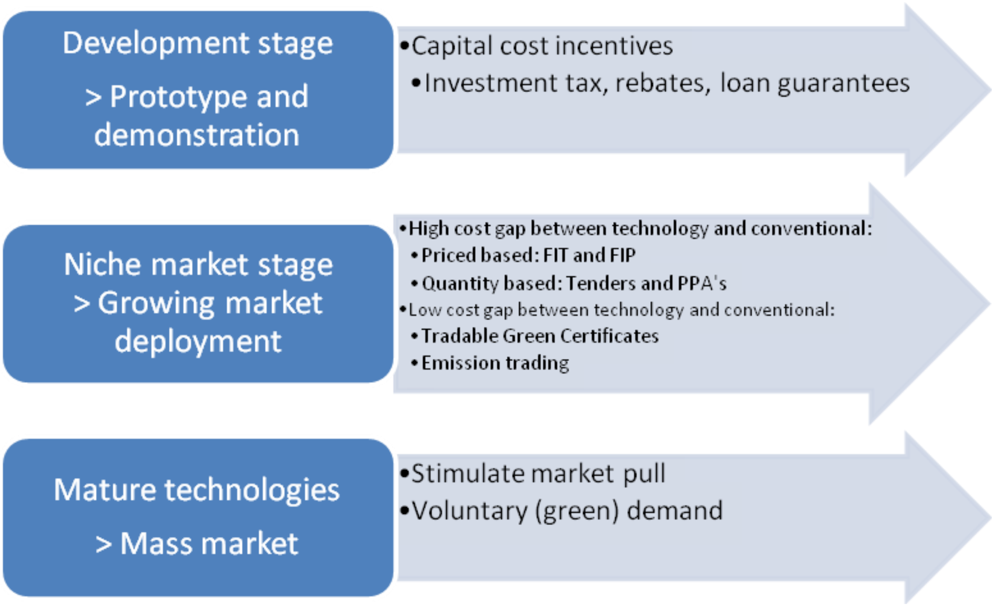
Image 1: Policy instruments for deploying renewables in different development stages [13]



Instruments for technologies in the development stage: tax incentives, credits and direct cash grants

Tax incentives, credits and direct cash grants are all reductions in investment costs and hence improve the returns for investors. It is a technology push strategy. For PV, this is mostly used in the US, for example a Renewable Energy Sources (RES) operator may receive tax reductions and afterwards can trade those reductions and deduct this amount from taxes. Direct cash grants provide a reduction in investment costs and to improve the returns for investors.

Technologies in the niche market stage for high cost gaps: Feed-in-Tariffs and Feed-in-Premiums, tenders and PPAs

In Europe FITs and FIPs are the dominant support policies for PV. Feed-in-tariffs guarantee the generator a certain price per kWh at which electricity is bought. This is set for a long period of time, commonly 20 years. Without retroactive measures by a regulator, tariff adjustments are only made for new plants. Feed-in-premiums however, are a premium given above market prices.

Tenders might be used to meet government set quotas for green energy. Tenders are used when a regulatory authority announces the installation of a certain amount of capacity of a

[13] IEA deploying renewables 2008

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technology. The company with the best price wins the tender. Usually this company then signs a long-term contract for producing electricity for the grid (Power Purchase Agreements, or PPAs). Brazil uses tenders for regulating RES deployment.

Power Purchase Agreements (PPAs)

PPAs are a commonly used system in US for renewable energy sources. Rates for electricity are agreed upon in the contract between both parties to provide an economic incentive for being a Power Purchase Agreement. Typically, the investor and the solar services provider create a special purpose entity that owns the solar equipment. The solar services provider finances, designs, installs, monitors, and maintains the project. As a result, solar installations are easier for customers to afford because they do not have to pay upfront costs for equipment and installation. Instead, customers pay only for the electricity the system generates. With the passage of the American Recovery and Reinvestment Act of 2009, the solar investment tax credit can be combined with tax exempt financing, significantly reducing the capital required to develop a solar project.

Technologies at the niche market stage for low cost gaps: portfolio standards and tradable green certificates

With tradable green certificates, the power is sold on the normal market, but in addition to that there is a market for green certificates. Generators of renewable energy sources can sell these certificates that represent a certain amount of renewable energy they generate. Entities under obligation are forced to buy a certain amount of green certificates, or have to pay a fine. Belgium used Tradable Green certificates in order to support PV deployment.

Most states with Renewable Portfolio Standards programs have associated renewable energy certificate trading programs. This portfolio standard places an obligation on electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. Certified renewable energy generators earn certificates for every unit of electricity they produce and can sell these along with their electricity to supply companies.

Consequences and recommendations for policy instruments

The different instruments have different effects on the way the market is installing PV. The high learning rate of PV with decreasing costs, combined with attractive tariffs (FITs) without a fixed cap might lead to unexpected installed capacities, raising policy costs in some countries to questionable levels. This has been an issue, especially in Spain, Germany and the Czech Republic. All of these countries used feed-in-tariffs (FITs) to support PV integration. To avoid situations like these, policy should be designed that adapts to changes in system costs. This is done by providing a clear schedule for regular review, linking

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diminishing rates to deployment volumes (setting caps: see *Deploying renewables*, IEA, 2011). Policy needs to take a dynamic approach, and needs to adjust its priorities as soon as critical barriers to the market change (price barriers or technological barriers).

Currently, the main markets for PV installation do not all benefit from good solar conditions. In some markets, PV may be deployed without particular financial support measures in an increasing number of regions and countries, for example islands (with their high priced electricity coming from oil fired power plants). The US is currently mostly known for its technology push strategy, it use development strategies such as cash grants and tax incentives to support PV deployment.

In order to a secure stable investment environment for new technologies, it is recommended that the pricing of support schemes for Renewables are reflected in electricity prices (and so do not lead to deficits), especially when a country has a track record of multiple changes in policy design (Jager & Rathmann, 2008).

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PV Deployment in Europe: Five Case Studies

In 2010, for the first time, Europe's PV sector installed more new capacity than any other renewable energy source. Global photovoltaic capacity doubled, rising from 7 GWp in 2009 to 16 GWp in 2010, while in 2011 an extra 27.7 GW was installed across the continent (EPIA, 2012).The production from this capacity was calculated to be 22.5 TWh in Europe at the end of 2010: i.e. 0.6% of the total electricity produced in 2010.[14]

In 2010, the three markets with highest installed capacities were Germany, Italy and the Czech Republic. In 2011, a shift occurred as Italy started to lead the ranks for new installed capacity, while Germany, China, the USA, France and Japan followed, each with over 1 GW of new capacity. The European share in the global PV arena remains predominant, accounting for more than 75% of all new capacity in 2011. The two largest markets for PV – Italy and Germany – provided nearly 60% of global market growth during 2011.

Table 1: EU Country CO_2 Emissions

	Emissions 2009* [15]	Total emissions 2009	Electricity Consumption 2009	Electricity Consumption 2009
	t CO_2/capita	Mt of CO_2	KWh/capita	TWh
Czech Rep	10.45	109.84	6103	109.84
Germany	9.16	750.19	6781	750.19
Italy	6.47	389.28	5271	317.25
Spain	6.17	283.37	6004	275.74
France	5.49	354.3	7494	354.3

*Emissions from fuel combustion only, not from the air travel industry

In Europe, the CO_2 emissions per capita differ largely between countries, partly explaining their different interests in investing in renewables. The Czech Republic and Germany rank among the high CO2emitting countries in Europe, while France is among the lowest

[14] Eurobserver: PV barometer 2011
[15] Data from table based on IEA 2011 Word Key Statistics

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emitting countries, due to the high penetration of nuclear power in its electricity generation mix (see Table 1).

This chapter gives an overview of the policies and installed capacities of the five Member States which are forerunners in the amount of installed PV capacity in Europe. They are Germany, Italy, Spain, the Czech Republic and France (see Table 2).

Table 2: Largest installed PV capacity capacities in Europe

	Acc. PV Capacity 2011 (in MWp)[16]
Germany	24700
Italy	12500
Spain	4200
France	2500
Czech Republic	2000*

* Estimation based on EPIA outlook report

Generally, Germany can be recognized by its high targets for renewables, reflected by the forceful penetration of wind and PV together, with its abrupt policy for phasing out nuclear power. In connection to PV, the Czech Republic installed large amounts of PV capacity in 2010, by providing very interesting FITs. Spain and Italy can be characterized by higher operational PV ratios due to good solar conditions.

PV in Germany

In 2009, Germany was the 7th largest electricity producer in the world with 586 TWh and 2.9% of the world total. It came after the US, China, Japan, Russia, India and Canada. It was among the 6 largest net exporting countries in the world with 12 TWh. In 2010, Germany's gross electricity production increased to 621,000 GWh.

Regarding consumption, Germany has one of the highest electricity consumptions in Europe, with 6,781 KWh/capita in 2009, and relatively high CO2 emissions of 9.16 tonnes CO_2/ capita. Coal, nuclear power and natural gas are the dominant fuels for electricity production in Germany (see Table 3 and Graph 6). Furthermore, Germany is the world's leading installer and producer of photovoltaic electricity. Photovoltaic electricity production in 2009 was 6.5 TWh, and in 2010 it was 12 TWh. The accumulated installed photovoltaic capacity in Germany in 2009 was almost 10 GWp and in 2010 Germany increased its capacity to 17 GWp, eventually growing to 25 GWp in 2011.

[16] Data from EPIA market Report 2011

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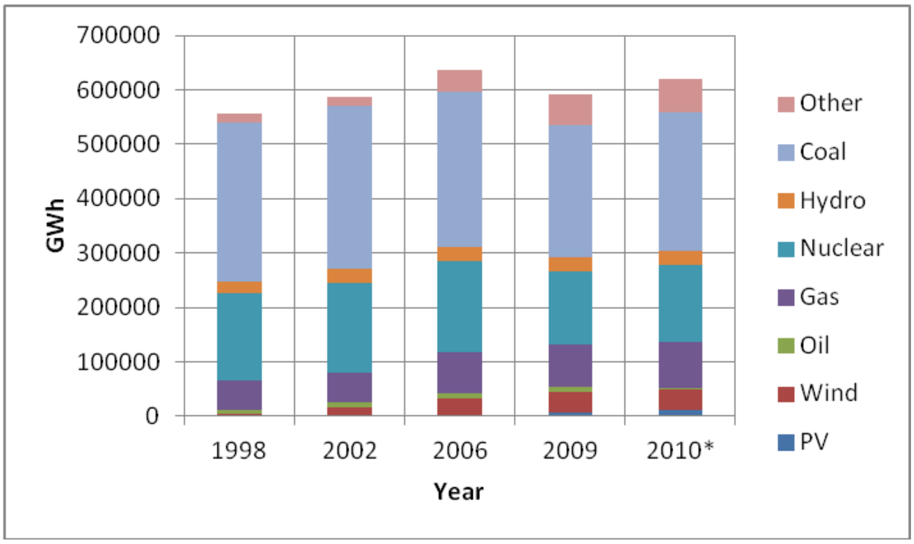
Table 3: Electricity generation mix in Germany (GWh)

(GWh)	1998	Share (%)	2002	Share (%)	2006	Share (%)	2009	Share (%)	2010	Share (%)
PV	35	0.0%	188	0.0%	2220	0.3%	6572	1.1%	12000	1.9%
Wind	4593	0.8%	15856	2.7%	30710	4.8%	38639	6.5%	36500	5.9%
Oil	6376	1.1%	8644	1.5%	8431	1.3%	8486	1.4%	3900	0.6%
Gas	53830	9.7%	54511	9.3%	76077	11.9%	78884	13.3%	84500	13.6%
Nuclear	161644	29.1%	164842	28.1%	167269	26.3%	134932	22.8%	140556	22.6%
Hydro	21234	3.8%	27864	4.7%	27304	4.3%	24710	4.2%	25927	4.2%
Coal	291929	52.5%	299318	51.0%	285357	44.8%	243226	41.1%	254396	41.0%
Other*	16752	3.0%	15471	2.6%	39393	6.2%	57015	9.6%	63221	10.2%
Total	556393		586694		636761		592464		621000	

* Pumped hydro, Waste, Bio fuels and other conventional fuels

Graph 6: Electricity generation mix in Germany (GWh)



Renewable energy projections according to the National Renewable Energy Action Plan for Germany

Concerning Germany's National Renewable Energy Action Plan (NREAP), the projected capacity for PV in 2020 is 51,753 MW, producing 41,389 GWh (see Table 4). In 2011 24,700 MWp was already installed, which is 48 % of the 2020 objective. Germany's production ratio in 2010 was 10.1%, while the projected ratio of production in 2020 as set out in the NREAP is 9.5%.

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For renewable electricity, the Renewable Energy Sources Act (*Erneuerbare Energien Gesetz*, EEG) came into force on April 1st, 2000.[17]

Germany's Energy Concept plan

In addition to the National Renewable Energy Action Plan, Germany released an Energy Concept document. This concept plan describes more ambitious targets concerning renewables in the German system. The main target in this plan is that by 2020 35% of Germany's power needs to be supplied by renewables: and an 80% by 2050. Additional goals are connected to offshore wind development, more onshore wind development (25 GW by 2030), promotion of residential rooftop solar panels in order to reduce reliance on the grid. The last goal is connected to more bioenergy plants to balance fluctuations between wind and solar supply.

Phasing out nuclear power

After the nuclear accident on March 2011 in Japan Fukushima, Germany announced on May 30th that it would shut down all of its nuclear power stations by 2022. Germany's 17 nuclear plants generated 140 TWh or 22.5% of its electricity in 2010. Seven nuclear plants that were shut after the Fukushima disaster — and another, shutdown since 2009 – will not re-open. To fill this electricity gap, in the short term, Germany has ramped up spare capacity at existing coal-fired plants, and has also increased imports for electricity from France and central Europe. In the longer term, the government wants to raise Germany's use of renewable sources from the current 17% of electricity generation, or 100 terawatt-hours, to 35% by 2020. As part of the same energy policy, adopted in October 2010, the government also wants electricity consumption to fall by 10%.

Yet, when putting the targets together, renewable energy sources will still not fill the gap created by the scrapping of nuclear power. This means that Germany will probably need to buy in electricity and build new gas or coal plants. The country already has enough gas and coal plants under construction to provide 10 gigawatts for 2015.

PV installation in Germany

Germany, the greatest world installer of PV capacity, has reached this position through private customers, who install small- and medium-sized installations (see Graph 7). Germany's newly installed PV capacity in 2011 reached 7.5 GWp. According to figures from the German Federal Network Agency (*Bundesnetzagentur* – BNetzA), new solar capacity amounted 490 MWp in September, 660 MW in October, and a

[17] Eurobserver – German Policy on PV (updated March 2011)

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record 3,000 MWp in December.[18] This newly installed PV capacity for 2011 will have exceeded even the 2010 record of 7,377,678 MWp, in order to profit still from higher FITs that were applicable for installations installed in 2011. The figure would also be more than twice as high as the government's 2.5 to 3.5 GWp PV target corridor.

Graph 7: German number of installation by size of installation (Oct. 2009- Oct. 2010)

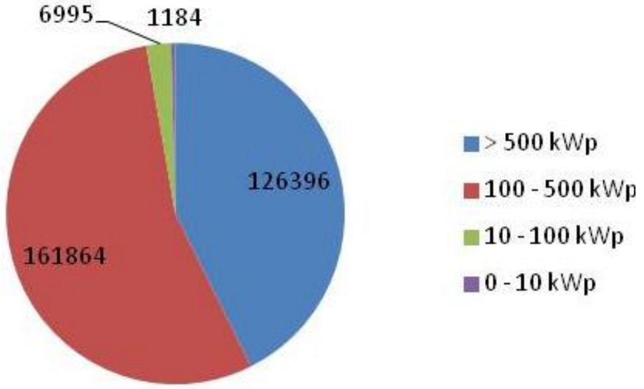

Table 4: Ratio of PV power output/PV power capacity 2001-2010[19]

Germany	2001	2003	2005	2007	2009	2010	2011
PV Capacity installed (MWp)	195	388	1508	3811	9800	17370	24700
PV Gross production (GWh)	116	333	1282	3075	6579	12000	
Ratio (%)		11.7%	13.2%	10.6%	9.9%	10.1%	
Share of gross electricity Production (%)	0.0%	0.1%	0.2%	0.5%	1.1%	1.9%	

Policy for PV in Germany

Germany could be characterized by its good regulatory conditions for installing solar PV. The German policy for photovoltaic is based on a dynamic Feed-in-Tariff (FIT) with an obligation for the grid operator to accept the renewable power. The FIT is guaranteed for 20 years for most technologies. The policy system is known for different parallel working supporting instruments (FIT and investment grants). There is no building permission needed for rooftop PV permits, only a notification to the federal network agency for statistical

[18] http://www.germanenergyblog.de/?p=8341
[19] Data from IEA database and the 2011 value from EPIA 2011 Market Report.

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purposes is required. Operators of photovoltaic installations have only been obliged to register their installed capacity with the Federal Network Agency since 2009. This decreases administrative burdens for installers. As a rule there is a 9% decreasing rate on the FIT, but this might be higher or lower depending on the size of the installed capacity of previous year. From 2010 to 2011, there was a decrease of 13%. The *Erneuerbare-Energien-Gesetz* (EEG) was the main support instrument for photovoltaic power in 2011 and beyond. Since Germany reached its goals for installed PV capacity early in 2011, in 2012 the decreasing rate for PV FITs has accelerated. See the Box 3 for the values of those FIT in 2012. In 2012, only 1.9 GW were installed in the first quarter in reaction to the announcement of a major reduction of the FIT in April 2012, together with a transitional period. In several market segments the new FIT in Germany is now below the retail price of electricity. This very low level should favor self-consumption, if the industry can remain profitable with the low support levels that are now in place. Demand side management tools such as controlled heat-pumps could gain some market share in the rooftop segment, in order to maximize the return on investment. In the ground mounted segment, the low FIT level will push for installations in the sunniest regions of the country.[20]

Regarding administrative procedures for PV installation, Germany seems not to be in to bad situation. 17% of the total project development cost excluding PV equipment is associated with administration procedures. For residential rooftop units this share is 11%. (PV Legal, 2012). This places Germany in a better position, in comparison to the Czech Republic, Spain and Italy. However administrative waiting time averages around 90 weeks for large ground mounted systems, but only 6 weeks for residential roof-top systems.

Currently, there are political discussions going on about the amount of decreases needed for PV FITs and the times per year these decreases should be adjusted.[21] Given that in 2011 the installation of new capacity was more than twice as high as the target range of 2.5-3.5 GWp per year of additional capacity, this meant high costs for German consumers in the RES charges.[22] Solar installations receive more than half of the renewables subsidies paid out in Germany, but produce only about one-fifth of the country's renewable electricity – or about 4% of the nation's total. However, in the meanwhile the decrease of FIT jeopardizes the local solar industry: already a couple of high-profile German solar companies – Solon, Solar Millennium and Q cells – have gone bankrupt. This moves job creation in the solar PV industry to Asia, where the PV industry is ever growing. Beside this, the increased electricity prices are affecting German households. Germany's electricity prices belong to the

[20] EPIA May 2012 Global Market Outlook
[21] http://www.renewableenergyfocus.com/view/23669/five-reasons-to-be-pessimistic-for-solar-pv/
[22] http://www.rechargenews.com/business_area/politics/article299046.ece

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second highest in Europe, just behind Denmark with 24.38 ct/kWh in second semester of 2010 (Cruciani, 2011).[23]

A recent study from the German Institute for Future Energy Systems showed that prices actually would have decreased due to the penetration of PV, but currently do not do so because the benefits are not passed on to consumers but are absorbed by retailers. This explains why a large section of energy-intensive industry, representing roughly 50 percent of total industrial power consumption, is exempt from the surcharge for renewable power. This shows that private households are covering a disproportionate share of the burden, and besides this that the way the surcharge for feed-in tariffs is designed in Germany signifies that the surcharge increases as prices on the power exchange drop. FITs are thus partly financed by revenues from the power exchange. If prices on the exchange drop, so does the revenue, consequently the amount reported as the surcharge increases. It is estimated that the retail rate would drop by around 0.15 cents per kilowatt-hour if these price reductions on the exchange were passed on and not kept by retailers and if the cost could be shared among all electricity consumers (IZES gGmbH, 2012).[24]

Box 3: German FIT Tariffs

For 2012, the decrease in the rate is 15%. The reduction will lead to the following solar feed-in tariffs as of 1 January 2012:

Roof-top	€ct/KWh
Up to 30 kW	24.43
Up to 100 kW	23.23
Up to 1 MW	21.98
Over 1 MW	18.33
Other free-standing installations	
On conversion/Sealed Areas	18.76
Other Qualified Areas	17.94

For electricity generated and consumed within the immediate vicinity of the building/facility by the operator or third parties for installations up to 500 kW, payment of feed-in tariffs for electricity consumed will be reduced by EUR 0.1638 for up to 30 percent of the generated power and by EUR 0.12 for the remaining power.

Source: http://www.pv-tech.org/tariff_watch/germany

[23] Cruciani, M. (2011). Évolution des prix de l'électricité. Paris: IFRI.
[24] From website: http://www.renewablesinternational.net/merit-order-effect-of-pv-in-germany/150/510/33011/

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Conclusion for Germany

Germany can be recognized as the global leader in installed capacity of PV. It has set the example for many countries and led the local industry in PV to have an optimistic future, creating “green jobs”. However this green future for PV in Germany currently seems to be moving in a different direction. Local solar conditions in Germany do not support the installed capacities’ efficiency, even though these installed PV capacities are high: they were still just below 2% of national generation in 2010. The penetration of this capacity is increasing without cost: the prices for electricity are rising and in order to stop this, FIT tariffs are decreasing. But this at the same time jeopardizes the local PV industry that has been built up in recent years. Germany might need to rethink the way RES charges are passed on to households alone, and it may need to find a way to make the positive effects of changes in the merit order benefit consumers.

Furthermore, the decision of the nuclear phase out might bring more pressure on the way security of supply and CO_2 emission reductions should take place. By looking at recent contributions of only PV to the national consumption, it is doubtful that this contribution will really become significant in the near future. Germany, is one of the highest CO_2 emitting countries per capita, and might need to focus on energy efficiency in the future and clear demand side management.

However, in 2012 the market of PV has still been growing even though FIT tariffs are decreasing and in some places reaching retail prices. It is expected that PV will continue to play an important role in the German renewables policy and the share of electricity production coming from PV might increase.

PV in Spain

Spain is among the countries with the highest electricity production coming from natural gas, after Italy. In 2009, 107 TWh were generated from natural gas. Spain was also in 9th place as a world net exporter, with 8 TWh. Consumption of electricity is among the lowest in Europe per capita: 6,004 KWh/capita emitting 6.17 t CO2/capita.

Spain’s electricity generation mix has changed in recent years. In 1983, the government decided to stop new investment in nuclear power, and increased the installed capacity of wind power. Spain still has a significant level of nuclear power and will probably keep it in the medium term. In order to cover the gaps from intermittent renewable power, many efficient Combined Cycle Gas Turbines (CCGTs) have been installed. Currently, Spain’s main generation of electricity comes from gas (30%), followed directly by nuclear, hydro and wind power. Installed capacity of PV is the third largest in Europe, after Germany and Italy. In 2009, the accumulated installed capacity in Spain was 3.4 GWp and in 2010 it was 3.8 GWp, growing a little more to 4.2 GWp in 2011. With an efficiency ratio of around 20%, the production from these installed panels was remarkably high: 6.0 TWh in 2009

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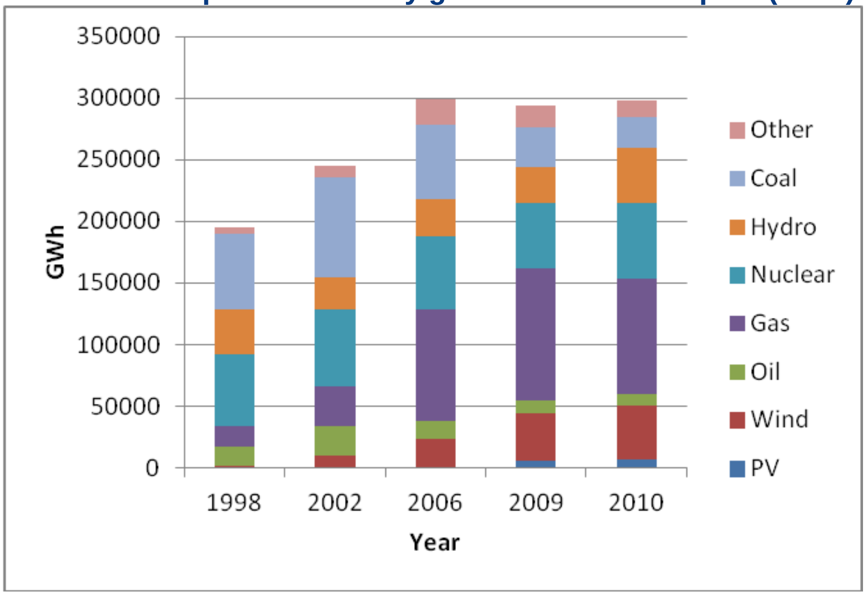
and 6.3 TWh in 2010. The share of low emitting technologies in 2010 amounted to 52.6% of the generation in that year.[25]

Table 5: The electricity generation mix in Spain (GWh)

(GWh)	1998	Share (%)	2002	Share (%)	2006	Share (%)	2009	Share (%)	2010	Share (%)
PV	15	0.0%	30	0.0%	119	0.0%	6018	2.0%	6302	2.1%
Wind	1352	0.7%	9342	3.8%	23297	7.8%	37773	12.9%	43708	14.6%
Oil	15787	8.1%	23961	9.8%	14195	4.7%	10428	3.5%	9595	3.2%
Gas	16212	8.3%	32386	13.2%	90570	30.2%	107445	36.6%	93378	31.3%
Nuclear	58993	30.2%	63016	25.7%	60126	20.1%	52761	18.0%	61788	20.7%
Hydro	35806	18.3%	26270	10.7%	29831	10.0%	29162	9.9%	45321	15.2%
Coal	61585	31.5%	81182	33.1%	60529	20.2%	32734	11.1%	24786	8.3%
Other	5459	2.8%	8776	3.6%	20787	6.9%	17526	6.0%	13527	4.5%
Total	195209		244963		299454		293847		298405	

Graph 8: Electricity generation mix in Spain (GWh)



[25] Hydro, PV, wind and nuclear are included.

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Renewable energy projections according to the National Renewable Energy Action Plan for Spain

The target according to Annex I of Directive 2009/28/EC is 20% for the year 2020 and the projected NREAP share in that year is 22.7%. According to the projection, the most important contribution in the year 2020 is expected from wind power (78.3 TWh, 31% of all renewable energy). The second most important contribution is expected from biomass (renewable heating and cooling) (49.50 TWh, equal to 22% of all renewable energy). The third largest contribution is from hydropower (39.6 TWh or 3,404 ktoe, 15% of all renewable energy). For solar photovoltaic energy, the contribution in 2020 is projected to be 8.4 GW (14.3 TWh).

For PV, installed capacity in 2011 was 4200 MW, 50% of the 2020 objective. The production ratio for PV in Spain is respectively high: almost 20% in 2010. However, in the NREAP the production ratio for 2020 capacity is only projected to be 12.2 %. This shows that, with current numbers of generation output, the 2020 projected capacity will very probably exceed the projected generation. However, there is a need to take into account the degradation of output of PV, second-best decisions for locations of PV installation and possible renewing of the old PV capacity (depending on its lifetime).

PV installation in Spain and repowering

Spain was one of the first countries which took steps to install PV. There was an installation peak in 2008, an additional 2.7GW installed, reaching a cumulative capacity of 3.3 GW (see Table 6). The price for polysilicon, spiked at about $400 a kilogram during the boom in the Spanish market in 2008 before collapsing and then edging up again last year to about $100, as the Italian and German markets heated up.[26] The high FITs for ground mounted systems supported this installation. Spain has not made particular progress since the halt in the market at the end of 2008 (EPIA, 2012), with a yearly increase that is capped at 400 MW, for all types of PV systems.

Most the installed PV (90%) is of large utility scale, and this was generally installed during the 2008 boom. Of all capacity installed in 2011, around 1% was for residential purposes, 9 % for commercial uses and 90% in ground mounted systems (EPIA, 2012).

The efficiency from this installed PV capacity is remarkably high: around 19% during the last 2 years, reflecting the good weather conditions in Spain for PV. But it also raises questions about fraud in connected PV capacity.[27] Old, degraded panels may have been

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[26] http://www.bloomberg.com/news/2011-06-16/solar-panel-raw-material-plunges-to-six-year-low-helping-trina.html

[27] http://www.energiadiario.com/publicacion/spip.php?article15173&var_recherche=repotenciaci%F3n

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renewed by new panels with higher efficiency, yet producers still receive the higher tariff for electricity output that was associated with the older panels. The CNE (Spanish regulator) has started investigating the age of the panels installed and found renewed panels in some areas.

Centro de Control de Régimen Especial (CECRE) is the Transmission System Operator for RES in Spain. All PV that is connected with a size of more than 1 MW has to be monitored by CECRE, and if its capacity exceeds 10 MW, the CECRE can decide on the opening or closing of the network connection, in order to secure system stability.

Table 6: Ratio of PV power output/PV power capacity 2001-2010[28]

Spain	2001	2003	2005	2007	2009	2010	2011
PV Capacity Installed (MWp)	16	27	60	734	3418	3808	4200
PV Gross production (GWh)	24	41	41	500	6018	6302	
Ratio (%)		19.9%	9.7%	12.6%	20.5%	19.9%	
Share of gross electricity Production (%)	0.0%	0.0%	0.0%	0.2%	2.0%	2.1%	

PV feasibility in Spain: PV policy and the economic environment

For PV the capacity limits for different system types are re-defined as part of the application procedure, in each quarter year. A cap of 400 MW per year is fixed for PV not to be over-installed. The FIT for PV in Spain decreased from 45 ct/kW in 2008 to 12 ct/kW in 2011 for all ground mounted systems, regardless of size.

Unlike Germany, which passed the cost of renewables directly onto the consumer, Spain deferred them by obliging utilities to hold these costs on their balance sheets as a state-backed debt known as the "tariff deficit". Through gradual increases in electricity bills the government promised that consumers would repay this debt. However, the deficit has been growing, and the current crisis is leading to difficulties in repaying these debts. Some retroactive measures have been applied in the past to lower the deficit by placing a limit on the maximum number of hours PV power installations are subsidized for. According to the Royal Decree (RD) 14/2010, of December 23rd, the number of hours depends on the solar irradiation and climatic zone the PV system is located in.[29]

[28] Data from IEA database and the 2011 value from EPIA 2011 Market Report

[29] http://www.pv-magazine.com/news/details/beitrag/spain-reduces-hours-of-subsidized-sunlight_100001877/

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For industrial ground mounted PV systems, 51% of the total project development cost excluding PV equipment is associated with administration procedures. Spain, together with Bulgaria and Italy, has among the highest costs for large scale PV administration. In the case of residential rooftop PV, administrative costs are 36% of the total. Moreover, waiting times are by far highest in Europe: almost 220 weeks for large systems, which may be largely due to conservative attitude of government towards large systems. However, even small systems have the longest waiting period in Spain: 68 weeks (PV Legal, 2012).

The current economic crisis, the tariff deficit and administrative barriers (see PV legal report on 13 countries) are all discouraging the installation of new PV capacities. In 2012, in reaction to the financial crisis, the new Spanish government approved a new law, under which the current system of remuneration for all renewable energies will be discontinued. As the Council of Ministers announced, the government will not give any economic incentive to fund new renewable installations, and the relevant administrative and funding systems will be suspended.[30] Spain has temporarily closed new applicants for FIT on PV and concentrated solar power.[31] The European Commission has criticized this renewable energy moratorium.[32]

It is hoped that the new net-metering scheme will allow rooftop installations to be developed, and in particular commercial ones, since consumption and production align quite well in Spain, thanks to the heavy use of air conditioning in peak hours of sunshine (EPIA, 2012).

Box 4: FITs for PV in Spain in 2011

Roof-Top	€ct/KWh
< 20 kW	26.6
>20kW	19.3
Building Integrated	€ct/KWh
< 20 kW	28.3
>20kW	19.3
Ground based	€ct/KWh
Any size	12.2

In 2012, Spain suspended FITs for connected PV.

Source: http://www.pv-tech.org/tariff_watch/spain

30 http://www.pv-magazine.com/news/details/beitrag/spain-suspends-fits_100005605/

31 See *http://www.solarserver.com/solar-magazine/solar-news/current/2012/kw05/spanish-government-halts-pv-csp-feed-in-tariffs.html*

32 http://www.pv-magazine.com/news/details/beitrag/eu-criticizes-spains-renewable-energy-moratorium_100005672/

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Conclusion for Spain

Spain is characterized by the early integration of PV into its electricity network. However, the high associated costs, which have not been charged to the consumer directly, have created a tariff deficit. This eventually led to (retroactive) measures by the government to decrease FITs and charges to pay to RES sources, ending in a current stop to all supporting mechanisms for RES deployment. Already, after the boom in 2008, the policy environment for PV was not optimal, and this seems to be continuing, due to efforts to address Spain's present economic difficulties. But, current electricity generation from PV capacity has the highest ratios in Europe, possibly due to the fact that planned generation from PV might even exceed the projected target for 2020.

The reason for these high ratios has also raised questions about fraud in connected PV.[33] Some old, degraded panels have been renewed with panels of higher efficiency, while producers continue to receive the higher tariff for electricity output that was associated with the older panels. This is an important lesson for monitoring and control in other countries where a decreasing FIT over time might motivate such behavior. The political situation has not been very supportive of high investment in PV in Spain. There might still be potential in the residential sector, as till now there has been very little investment in residential PV. However, since electricity prices do not reflect real costs (i.e. the tariff deficit), it is questionable when this will be profitable from a net-metering perspective.

PV in Italy

Italy is the world's largest net importer of electricity: in 2009 imports stood at 46 TWh, showing Italy's high dependency on imports and reflecting the national difficulty of attaining sufficient generation capacity. As the 2010 numbers show, national electricity generation comes from natural gas plants (52%) followed by hydroelectric power (18%) and coal (13%, see Table 7 and Graph 9). Concerning renewables, Italy has the largest geothermal capacity in Europe and 5th largest in the world. Furthermore 18% of the generation comes from hydro capacity, which presumably is already deployed as much as possible. In 2009, the electricity consumption was 5,271 KWh/capita, which places Italy's electricity consumption per capita below Spain. However Italy's CO_2 emissions per capita are higher than Spain's: 6.49 tCO_2/capita.

33 http://www.energiadiario.com/publicacion/spip.php?article15173&var_recherche=repotenciaci%F3n

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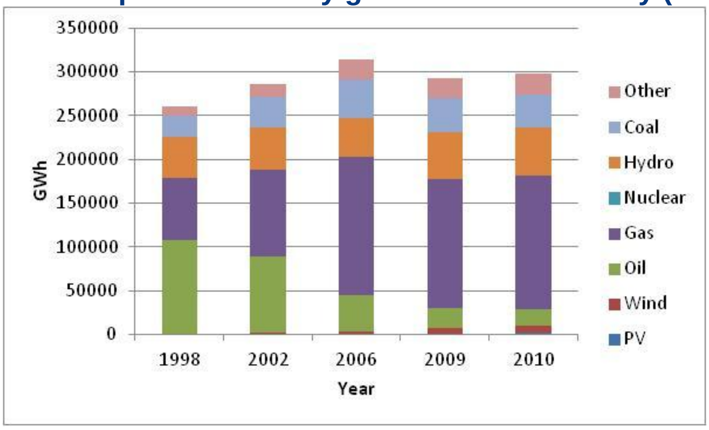
Table 7: Electricity generation mix in Italy (GWh)

(GWh)	1998	Share (%)	2002	Share (%)	2006	Share (%)	2009	Share (%)	2010	Share (%)
PV	16	0.0%	21	0.0%	35	0.0%	676	0.2%	1600	0.5%
Wind	231	0.1%	1404	0.5%	2971	0.9%	6543	2.2%	8449	2.8%
Oil	107305	41.3%	87764	30.8%	42121	13.4%	22561	7.7%	18143	6.1%
Gas	70883	27.3%	99414	34.8%	158079	50.3%	147269	50.3%	153800	51.6%
Nuclear	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hydro	47365	18.2%	47262	16.6%	43425	13.8%	53443	18.3%	53771	18.0%
Coal	23311	9.0%	35447	12.4%	44208	14.1%	39745	13.6%	37900	12.7%
Other*	10689	4.1%	13964	4.9%	23282	7.4%	22404	7.7%	24545	8.2%
Total	259800		285276		314121		292641		298208	

*Geothermal, (municipal) waste, other combustibles

Graph 9: Electricity generation mix in Italy (GWh)



Projections of the NREAP for Italy

The share of renewables in the NREAP for Italy is targeted at 17%, while in 2009 it was just 7.8%, up from 5.2 % in 2005. According to the 2020 projection for Italy, the most important contribution in RES is expected to come from biomass energy for renewable heating and cooling (25% of all renewable energy). The second most important contribution is expected from hydro power (16% of all renewable energy). The third largest contribution is projected to come from heat pumps (13% of all renewable energy). Wind power will contribute with 12.7 GW (20.0 TWh) in the year 2020 (onshore wind 12 GW/18 TWh, offshore 0.7 GW/2.0 TWh) and PV in 2020 is planned at 8,600 MW, producing 9,650 GWh. In 2011, 1,250 MW was already installed cumulatively; indicating that the target will be surpassed; the PV potential is higher than expected.

The share of RES in the gross final consumption of electricity production is expected to reach 26.4% in electricity generation in

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2020 compared with 18.7% in 2010. In 2010, about 5.8 GW of wind power capacity and 2.5 GW of photovoltaic capacity were installed. As part of the NREAP, Italian government ambitions are to increase onshore wind power capacity to 12 GW, plus 680 MW of offshore capacities.

PV installation in Italy

Italy's PV capacity boomed in 2011: from 5.8 GW in 2010 it increased to 12.5 GW in 2011. The capacities which were installed were already prepared in 2010 but connected later to the grid. This capacity currently indicates that the 2020 target for PV in Italy will be exceeded by 45% (EPIA, 2012). The authorities have been taking measures to decrease future PV capacity installation, by providing a cap and by lowering remuneration.

In Italy's NREAP with its PV target in 2020, Italy's efficiency ratio for PV is projected to be 12.8 % with the capacity of 8,600 MW which was targeted for 2020. This is a higher efficiency rate than is currently the case for PV in Italy: last year's efficiency was around 10% in 2010. Most probably, the efficiency rates will decrease in time, due to second best choices for locations when best choices are already taken.

Italy is expected to reach grid parity in a few years from now (International Energy Agency, 2011), due to the good local solar conditions and high electricity prices caused by electricity scarcity. In 2011, the cumulative installed capacity for residential systems amounted to around 15% of the total installed capacity, 60% for commercial electricity and 25% for ground mounted PV systems (EPIA, 2012).

Table 8: Ratio of PV power output/PV power capacity 2001-2010[34]

Italy	2001	2003	2004	2006	2007	2009	2010	2011
PV capacity Installed (MW)	20	26	31	45	87	1142	1600	12500
Gross PV electricity production (GWh)	19	24	29	35	38	676	3478,5	
Ratio (%)		10.5%	10.5%	9.9%	7.4%	7.5%	10.7%	
Share of gross electricity Production (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	1.2%	

Renewable Electricity Support for PV in Italy

Italy uses a combination of quota obligations (Tradable green certificates) with Feed-in-Tariffs and Feed-in-Premium systems to support renewables in its electricity system. There are sanctions, in case of non-compliance with the green certificate quotas. However,

[34] Data from IEA database and the 2011 value from EPIA 2011 Market Report.

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enforcement in practice is considered difficult because of ambiguities in the legislation.

The remuneration and regulation concerning PV changes frequently over time. Besides, there are many parallel, functioning regional support systems (like construction grants and tax reductions). In Italy, PV systems are normally promoted through a Feed-in-Premium (FIP, *Conto Energia per il Solare Fotovoltaico*). This is an extra amount (premium) of remuneration per kWh received on top of the market price for electricity. The FIP differs from a FIT, which is a fixed price per kWh, independently from market prices. Operators of photovoltaic systems receiving a premium tariff are not eligible for either green certificates or the normal Feed-in-Tariff. PV systems commissioned before 31st of December 2012, however, may be eligible for either selling their electricity on the free market, for selling electricity to the system operator for a fixed price, or if their capacity is below 200 kW, for net-metering ("scambio sul posto").[35] To manage the number of installations connected in 2012, a Budgetary CAP and Registry for "large" PV systems has been added. This support system applies to installations which enter operation between 1 June 2011 and 31 December 2016.

Special provisions apply to ground-mounted systems in agricultural areas. Tariffs are not applicable to systems that were supported by some types of construction grants, tax reductions and previous premium tariffs. Currently there are discussions going on about PV support in agricultural areas.[36] This might move installation from ground mounted to roof-top and building integrated systems, in the future. In markets like Germany also, small rooftop solar PV applications have been the foundation for strong growth in the past. As recent developments show, tendencies in markets such as Italy are pointing in the same direction and small as well as decentralized plants are gaining importance.

For the industrial ground mounted PV systems in Italy, 69% of the total project development cost excluding PV equipment is associated with administration procedures. For residential rooftop this share is 61% in Italy (PV Legal, 2012). This places Italy in second place for the highest administrative costs, after Bulgaria.

[35] http://www.res-legal.de
[36] http://www.renewableenergyfocus.com/view/23669/five-reasons-to-be-pessimistic-for-solar-pv/

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Box 5: Promotion of PV in Italy, first semester 2012

Roof-Top	
Capacity	€ct/kWh
1-3 kWp	27.4
3-20 kWp	24.7
20-200 kWp	23.3
200-1000 kWp	22.4
1-5 MWp	18.2
>5 MW	17.1
Free standing	
1-3 kWp	24.0
3-20 kWp	21.9
20-200 kWp	17.2
200-1000 kWp	18.9
1-5 MWp	15.6
>5 MW	14.8

Source: http://www.pv-tech.org/tariff_watch/italy

Conclusion for Italy

In 2011, the Italian PV capacity grew explosively and this has affected support costs for PV and the amount of measures needed to incorporate this PV capacity into the grid. In order to control the future support cost of PV, current policies are trying to control the amount installed, especially for large scale systems in agricultural areas. Current regulation regarding PV installation is detailed and complex. However, PV seems set to reach grid parity first in Italy, due to good solar conditions and high electricity prices. This might in the near future mean that support costs will eventually decrease and will soon not be required in order to promote PV installation. A 5th *Conto* is under discussion and will likely lead to a huge rush in demand before it enters into force, probably from July 2012, leading to potentially 6 GW in new connections in 2012. The outlook for the coming years is uncertain. Depending on the type of market control mechanism (a cap per type of system is under discussion), the market will be either constrained or will grow rapidly again (EPIA, 2012)

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PV in France

Nuclear power provides almost 75% of France's electricity (2010). It is followed by hydroelectric power and gas, with 11.9% and 4.6% in the generation mix respectively. Due to this large share of low-CO_2 emitting technologies in the French system, the CO_2 emissions per capita in France are among the lowest in Europe: 5.49 t CO_2/capita in 2009. In 2008, France was the world's 8th largest electricity producer with 537 TWh, or 2.7% of the world total. In 2009, consumption was 7494 kWh/capita.[37]

There has been a debate on nuclear energy in the wake of Fukushima, because of France's high dependency on nuclear power. Current policymakers hold diverging views on nuclear power, and its share in the generation mix might decrease over time, under public pressure. This opens the possibility for more renewables in the French generation mix, like PV and wind power.

France is generally known for its large electricity exports, but in the last years exports have decreased (3,059 GWh imports in 2000, and 1,995 GWh), and imports increased between 2000 and 2010. The imports are mostly to cover the peak periods of consumption for France, given that nuclear as a base load is not fitted for such peaks.

Table 9: Electricity generation mix in France (GWh)

(GWh)	1998	Share (%)	2002	Share (%)	2006	Share (%)	2009	Share (%)	2010	Share (%)
PV	2	0,0%	7	0,0%	13	0,0%	171	0,0%	653	0,1%
Wind	20	0,0%	266	0,0%	2182	0,4%	7891	1,5%	9643	1,7%
Oil	11651	2,3%	523	0,1%	561	0,1%	445	0,1%	457	0,1%
Gas	4975	1,0%	18369	3,3%	21760	3,8%	21013	3,9%	26203	4,6%
Nuclear	387990	75,9%	436760	78,1%	450191	78,3%	409737	75,6%	428585	74,8%
Hydro	66037	12,9%	65918	11,8%	61442	10,7%	61912	11,4%	68041	11,9%
Coal	33532	6,6%	23658	4,2%	22889	4,0%	25894	4,8%	23926	4,2%
Other	7072	1,4%	13693	2,4%	15571	2,7%	15121	2,8%	15376	2,7%
Total	511279		559194		574609		542184		572884	

[37] IEA key world statistics 2011

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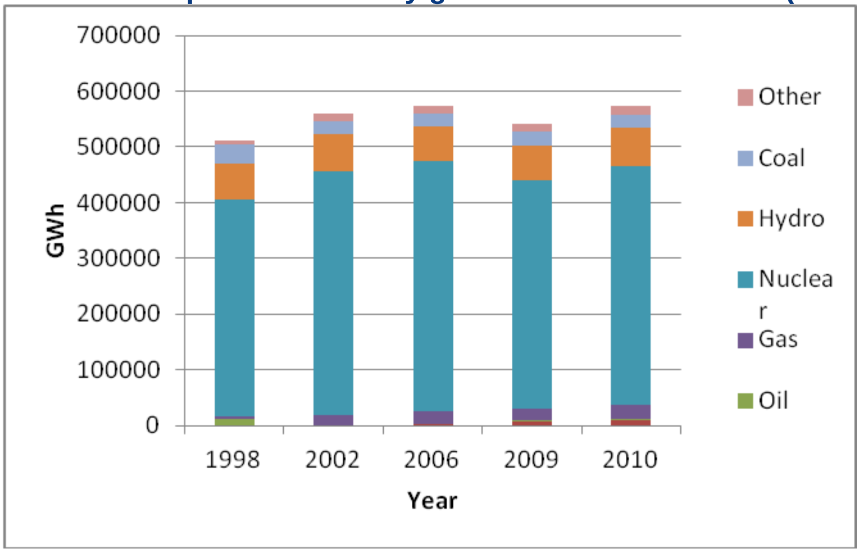
Graph 10: Electricity generation mix in France (GWh)



Projections of the NREAP for France

The share of RES in the gross final consumption of electricity production is expected to reach 27% in 2020, compared with 15.5% in 2010. Mid-2011, about 5.7 GW (900 wind turbines) of wind power capacity and 1.5 GW (200,000 installations) of photovoltaic capacity were connected to the distribution network. As part of the NREAP, the French authorities want to increase solar photovoltaic power to 5.4 GW. This will require developing networks, especially when the sites for future generation capacities will be further away from the existing grid. Already, numerous RES projects are ready to be connected but are waiting connection, probably due to insufficient network capacity.

France's NREAP states a PV capacity of 5,400 MW in 2020 with a generation of 5913 GWh. This presents a ratio of 12.5% in 2020, which is higher than it currently has been for PV generation (around 10% in recent years, see Table 10). This means that probably a higher capacity of PV would need to be installed in order to reach the 2020 objective. In 2011, the PV capacity installed was 2,500 MW, which is almost 46% of the 2020 target.

PV in France

The PV market in France has not shown instant, rapid growth: there has been no PV bubble, as was the case in Italy, Germany and Spain. Rather France shows slow but stable growth. Since 2008, capacity has doubled each year and this growth continued until 2011, when a cap was set for extra PV capacity, at 500 MW per year.

France's cumulative capacity of PV systems in 2011 was around 25% for residential PV, 40% for commercial/industrial PV and 30% for ground mounted systems (EPIA, 2012). This shows some untapped potential in the ground mounted and private roof-top sector.

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Table 10: Ratio of PV power output/PV power capacity 2001-2010[38]

France	2001	2003	2005	2007	2008	2009	2010	2011
Total capacity installed (MWp)	7	9	13	26	80	263	1054	2500
Gross production PV (GWh)	6	7	10	18	42	171	600	
Ratio (%)		9.4%	9.5%	10.0%	9.0%	11.4%	10.4%	
Share of gross electricity Production (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	

PV Policy in France

France uses a combination of tenders and FITs to both promote and control PV capacity installation. The tenders are published by the regulator (CRE) for the larger PV capacities. For any facility greater than 9 kW, a capital certificate has to be provided (issued by the statutory auditor of a bank), to guarantee the financial feasibility of the project. Different FITs depend on the type of facility to which the photovoltaic panels are connected. France recently introduced a new revised Feed-in-Tariff in 2011 after a three month moratorium, starting at the end of 2010. The new tariff limits bigger plants especially, through an applied tendering process and results in favoring rather small-sized installments up to 100kWp. The results of the complex tendering scheme will not be known until 2012, shifting the market development by six months to more than a year and the connection of systems even more. This means a large share of the systems which are expected to be connected to the grid in 2012 will correspond to projects dating from the end of 2010, and installed in 2011 and 2012. Because of this procedure, the grid connection process in France can take up to 18 months. The important FIT cuts and long grid connection lead times explain why new installations were at a poor level in 2011, whilst grid connections reached a record high of 1.5 GW in 2011. (EPIA, 2012)

The PV industry organization (Enerplan) currently disagreed with this tender procedure; project installation would be largely hampered due to this process.[39] The branch has demanded a freeze in feed-in-tariffs in 2012, as well as a change to a different tendering procedures for plants of more than 100 kW. Through the CSPE charge (*Contribution au service public de l'électricité*) consumers are charged for RES integration into the grid (for wind power and PV).

A recent investment report approves the strategy for smaller PV systems in France, as smaller installations would produce positive outcomes for investors in France (Karsten, Patrick, & Jens, 2011).

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[38] Data from IEA database and the 2011 value from EPIA 2011 Market Report

[39] See : http://www.pv-magazine.com/news/details/beitrag/france--fit-reductions-continue_100005582/

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The target will be reviewed in mid-2012 and revised up to 800 MW per year if needed. However, given current installed capacity and growth with the 500 MW cap per year, France could reach its NREAP PV target in 2017.

Politics in France

The national energy mix has been very much debated during this crucial electoral year for France. But in any case, the energy-related mindset in France might not lead to a fundamental change in the way RES are developing. For most politicians, nuclear power remains the preferred low-carbon technology. Because of this, there is potential for projects under Power Purchase Agreements (PPAs), in which a third-party developer owns and operates a PV system which falls outside of the FIT scheme. Another obligation that new buildings be self-sufficient in terms of energy consumption by 2020 also adds some hope for the future redevelopment of PV in France.

Box 6: Promotion of PV in France

Connected between May and August 2011
Roof-Top and Ground based

Capacity	€ct/KWh
0-12 MW	11.38
Building Integrated Residential	
	34.70
9-36 kWp	32.20
20-200 kWp	30.30
200-1000 kWp	30.90
1-5 MWp	28.90
<5 MW	27.50
Building Public Buildings	
0-9 kWp	34.70
9-36 kWp	32.20
20-200 kWp	30.30
200-1000 kWp	30.90
1-5 MWp	28.90
<5 MW	27.50

France is the only country that makes a distinction between types of building for the definition of FIT tariffs. Public buildings, Residential buildings and other buildings are defined. To find the tariffs for “other buildings” see the source.

Source: http://www.pv-tech.org/tariff_watch/france

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Conclusion for France

The French policy towards PV, when compared with the other countries, seems much more conservative. Current model of tenders and tariffs and a yearly cap control the cost and penetration of PV. However, they also slow down administration processes for PV projects in France. There might still be much unused potential for smaller systems of PV in France. But the related costs need to be known, in order to make the French grid ready to cope with larger shares of production on the demand side of the grid.

From a political point of view, nuclear power remains the preferred form of low-carbon technology. Because of this, there is potential for PV projects under Power Purchase Agreements (PPAs), whereby third-party developers own and operate PV systems which fall outside of the FIT scheme.

PV in the Czech Republic

In the Czech Republic, electricity generation is largely based on coal (55%) and nuclear power (33%), followed by a much lower production from hydro power (3.9%) and gas (1.2%) for peak purposes. Within the last ten years, the share of nuclear power has increased and the share of coal decreased in the generation mix (see Table 11). Combined heat and power (CHP) constitutes one-third of electricity generation and over 40% of overall heat production, making the Czech Republic the third-largest in CHP use after Denmark and Finland (IEA, 2010).

Due to high levels of electricity production from coal in 2009, the Czech Republic was among the highest CO_2 per capita emitting countries: 10.45 t CO_2/capita. In 2009, the Czech Republic with 14 TWh was the third-largest net exporter of electricity in the European Union, after France and Germany.

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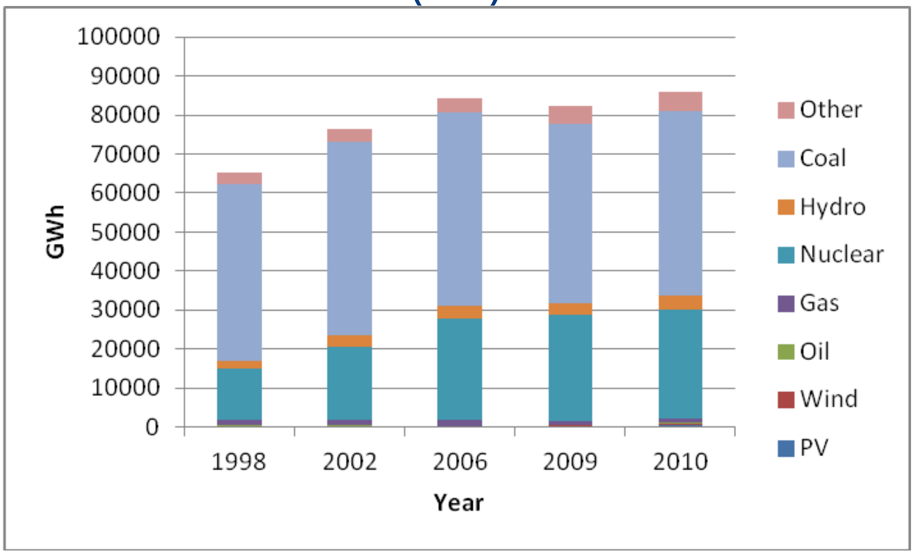
Table 11: Electricity generation mix in the Czech Republic (GWh) [40]

(GWh)	1998	Share (%)	2002	Share (%)	2006	Share (%)	2009	Share (%)	2010	Share (%)
PV	0	0.0%	0	0.0%	1	0.0%	89	0.1%	616	0.7%
Wind	0	0.0%	2	0.0%	49	0.1%	288	0.4%	336	0.4%
Oil	614	0.9%	384	0.5%	247	0.3%	154	0.2%	156	0.2%
Gas	1294	2.0%	1605	2.1%	1567	1.9%	975	1.2%	1073	1.2%
Nuclear	13178	20.2%	18738	24.5%	26046	30.9%	27208	33.1%	27998	32.6%
Hydro	1884	2.9%	2845	3.7%	3257	3.9%	2982	3.6%	3381	3.9%
Coal	45306	69.6%	49659	65.0%	49618	58.8%	45929	55.8%	47352	55.1%
Other	2836	4.4%	3115	4.1%	3576	4.2%	4625	5.6%	4998	5.8%
Total	65112		76348		84361		82250		85910	

Graph 11: Electricity generation mix in the Czech Republic (GWh)



Problems in the Czech Republic's electricity network

During 2011. the Czech Republic's transmission system encountered frequent near emergency situations in which the supply security of the system was jeopardized. One of the main reasons for the overload was excessive power output coming from wind farms in northern Germany. Other factors that put the network under stress were the big increase of installed PV capacity, the closure of eight nuclear power plants in Germany and intensive electricity trading on the spot market, as well as

[40] IEA database (consulted in 2011)

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increased electricity exports to the Balkans, due to a long-lasting dry spell.

The Czech Republic's Transmission System Operator (CEPS) has implemented several remedial measures and introduced new tools for identifying and predicting critical measures, but regional grid operators have been struggling to contain wind generation for some time. Grid operators say a grid limit would almost have been reached, and this resulted in a cap on additional PV and wind installations, without exception since February 2010 (EPIA, 2012).

Projections of the NREAP for the Czech Republic

Concerning the NREAP, mandatory targets for renewable sources (RES) indicate a 13% share of RES in the gross consumption of final energy and at least a 10% share of renewable energy in final consumption of energy in transport, by 2020.

The RES target according to the National Renewable Energy Action Plan (NREAP) of the Czech Republic is to achieve a 13.5% RES share of the final energy consumption (4,382 ktoe) in 2020. The contribution of PV power according to the NREAP projection is foreseen to be 1,695 MW or 2.1% of the gross final energy consumption in 2020. This capacity was already reached in 2010.

The goal in the Czech Republic NREAP for PV is set at 1,695 MW PV producing 1,726 GWh in 2020. In 2010, the installed capacity was 1,953, which surpassed the 2020 target. The ratio of PV in the Czech Republic is much lower than it is projected to be in 2020. In 2010, this production ratio was 5.8%, while in the NREAP this is projected to be significantly higher, namely 11.6%. It is not expected to reach a higher ratio in 2020 for installed capacity, given the current performance of PV. This is largely due to local weather conditions.

PV in the Czech Republic

In 2010, the Czech Republic has largely expanded its photovoltaic capacity, with capacity rising from 0.4 GWp in 2009 to 1.9 GWp in 2010. This made the Czech Republic's capacity the fourth largest in Europe. In contrast, the production of the Czech Republic's photovoltaic power plants in 2010 was only 0.6 TWh, presenting a ratio of just 5.8%. The goal for PV installation as projected in 2020 was already surpassed by then. In 2011, the increase of PV was not that high, showing a halt that has been implemented in the market of PV in the Czech Republic, due to grid difficulties and high costs. The EPIA states that this low growth results from strong opposition by major stakeholders in the Czech Republic (EPIA, 2012).

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Table 12: Ratio of PV power output/PV power capacity 2001-2010[42]

Czech Republic	2001	2003	2005	2007	2009	2010	2011
Total capacity installed (MWp)	0	0	0	4	465	1953	2000[41]
Gross production PV (GWh)	0	0	0	2	89	616	
Ratio (%)		0.0%	0.0%	9.1%	3.9%	5.8%	
Share of gross electricity Production (%)	0.0%	0.0%	0.0%	0.0%	0.1%	0.7%	

As described before, the high increase of PV capacity in the Czech Republic's grid brought problems in stability for the Transmission System Operator. The PV capacity rush has been so great that the state run company operating the Czech Republic's high voltage grid, ČEPS, announced to local electricity distribution companies not to authorize any new connections of solar or wind power to their grids. ČEPS feared that its grid could not withstand the surges in demand created by such fluctuating power production sources and that blackouts could follow.[43]

PV Policy for the Czech Republic

In 2005, a Renewable energy Scheme was introduced by the Act on Promotion of Electricity produced from Renewable Energy Sources. The Czech RES scheme promotes RES by a guaranteed Feed-In-Tariff or a premium (which is an amount paid on top of the market price), for all technologies used to generate renewable electricity.

In 2010, the PV sector unexpectedly developed at a fast level, and therefore a growth restriction was set for 2011. This was associated with a high risk of instability of the electricity grid.

After March 2011, an amendment entered into force to reduce the installed PV. After this, FIT Tariffs could be reduced with more than 5% and the FIT and green bonus for on-ground photovoltaic systems was abolished. Also, this FIT would only be applied to roof-top and integrated photovoltaic systems with a capacity up to 30 kW. Roof-top and integrated systems remain exempted from tax, while other photovoltaic systems are subjected to a 28% tax. These retroactive measures have affected the interest for investors in the Czech Republic's PV market.

In the Czech Republic, for industrial ground-mounted PV systems, the total project development cost excluding PV equipment which is associated with administrative procedures is 32%. For residential rooftop PV the share is 30% (PV Legal, 2012), following

[41] Estimation from EPIA.
[42] Data from IEA database and the 2011 value from EPIA 2011 Market Report.
[43] http://www.radio.cz/en/section/curraffrs/czech-electricity-grid-operator-seeks-to-brake-solar-power-boom

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Italy and Spain. Also waiting times are very low for large scale systems (61 weeks) and for residential roof-top systems (18 weeks).

Box 7: Promotion of PV in Czech Republic

Roof-top	€ct/kWh
<30 kWp	30.4
>30-100 kWp	24
>100 kWp	23

Source: http://www.pv-tech.org/tariff_watch/czech_republic

Conclusion for the Czech Republic

The Czech Republic is a country where good locational benefits for PV can obviously not be expected. However, its PV capacity grew strongly in 2010, due to the provision of a very good FIT and FIP policy. The sudden development of this PV capacity in the system, greatly affected the (already unstable) national transmission grid and system reliability. As a result, different (retroactive) measures affecting the support for PV were implemented in 2011, and consequently the PV market did not grow in the Czech Republic. Currently, the Czech Republic PV policy offers only promotion to smaller systems (roof-top and building integrated systems). PV does not look likely to receive a large place in public policy in the near future. But this might change when stakeholders change their opinions on PV for the Czech Republic and when supporting policies open up to larger systems. Up to this level, new projects are assessed on a case-by-case basis. Given the negative image today of PV among the Czech Republic's politicians, grid operators and a majority of citizens, the future of PV is very uncertain. The key to restarting the market lies in the residential and small rooftop segments, which are socially more "acceptable" for electricity consumers, and which can minimize transmission difficulties.

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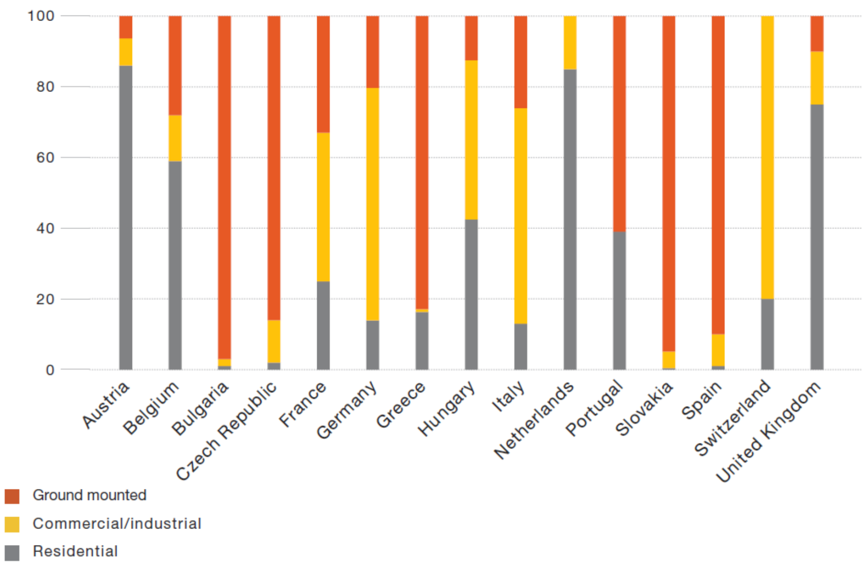
European countries have different approaches on PV deployment: see Annex IV for the deployment and ratios found for the five countries analyzed here. The countries with the highest capacity of PV (Italy and Germany) have both used stimulating FITs to encourage investment. In Germany, most investments have been in small scale systems and for industrial purposes (see Graph 12) while in Italy more investments concern larger-scale systems.

Graph 12: Cumulative European PV capacity, segmentation until 2011 (%)[44]



A certain trend is visible in most countries where a sudden PV bubble has taken place. Spain and the Czech Republic, for instance, clearly reacted on this sudden growth by taking retroactive measures to control PV costs (mostly Spain) and the impact on the reliability of the grid (mostly the Czech Republic). These measures, also called stop-go policies, might impede regional business confidence in PV technology. As the German example has shown, small and medium sized installations are driven by private customers for whom confidence in the technology is essential. The examples of Spain and

[44] Taken from EPIA Global Market Outlook May 2012

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the Czech Republic, both dominated by large players and ground-mounted installations, provide a contrast: the clear imbalance between segments has led to a lack of awareness among the population and policymakers (EPIA, 2010).

Small residential installations can be seen as a new possible market in countries where the market has collapsed. Spain and the Czech Republic could experience market rebirth, in this untapped segment. In France, the moratorium on PV imposed at the end of 2010 spared residential building-integrated photovoltaic (BIPV) systems. The future of small installations therefore remains bright, with the BIPV segment progressing well in both Italy and France (EPIA, 2010). This is so, even though the efficiencies of these smaller systems are lower than those of large scale systems. Also, other schemes, like for example power purchase agreements (PPAs), might become financially interesting, leaving aside the need for FITs.

Beside the case study countries described in this report, other countries are also increasingly installing PV capacity in Europe (EPIA, 2012). A list of new grid-connected PV in 2011, by region:

- The UK (700MW) surged thanks to a January 2011 "fast-track review" benefitting >50kW systems, and a rush to grid-connect systems ahead of a year-end FIT cut;
- Belgium (550MW), despite reduced support schemes;
- Slovakia (350MW), where PV connections slammed to a halt after a July pullback on PV support;
- Greece (350MW), with particular strength in the residential segment (60MW).

In general, within all countries there has been a visible stop in PV. Either countries had previously experienced strong growth (Spain, Italy, the Czech Republic and Germany), or just slow stable growth (France). Both groups of countries are presently showing a more conservative attitude towards PV deployment. In Spain, this is largely due to the financial issues, while in the Czech Republic system stability seems to be a problem. Only Italy still shows a positive future for PV and may soon reach grid parity.

PV as an industrial, green, job or environmental policy

Germany's green jobs seem to be transferring to Asia, as some major PV producers have gone into liquidation (for example Q-cells and Solar Millenium). Also, more cooperation is currently seen with Chinese manufacturers in order to cope with the very low prices for PV systems coming from Asia. It is expected that, because of cost advantages, future production of PV will move more to Asia and also to the US if it still has an advantage for thin film technology of First Solar. Eventually, low prices of PV are of major significance in liberalized markets, in which prices rule instead of green job objectives alone.

Germany has invested strongly in new PV capacity. However, the production coming from these systems covered just 2% of national demand in 2010. Due to the current financial costs and the current losses of green jobs, questions have started to be raised about the effectiveness of the German PV policy. Is it still worth the

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cost? Conversely others commentators claim that electricity prices have decreased due to PV. This raises the question of whether PV integration should remain a mere green-motivated policy or whether financial benefits actually govern decision-making in the short term.

The risk adversity of investors and governments

The PV policy development in different European countries can be analyzed and might provide examples for other countries. Both government (the regulator) and businesses that see a potential in PV are important actors for the penetration of PV. However, both actors are concerned with different interests and risks. Business is mostly concerned with the probabilities of returns on investment, and so bases its decisions on its perception of PV costs and returns. However, a regulator faces much more complex tasks, in which it balances long and short term objectives concerning competitiveness, the security of supply and sustainability (see Image 2).

In the Czech Republic for example, it was the case that when PV support was financially interesting, installation increased rapidly. This jeopardized competitiveness for the government and power system reliability, which in the end increased risk adversity for the government, leading to retroactive measures. A similar situation arose in Spain, where sudden increased capacity jeopardized the financial sustainability of the FITs. This has certainly been largely worsened by the financial crisis, and the tariff deficit in Spain. Political (retroactive) actions have resulted, which in the end have hampered PV capacity growth in this high sunshine location.

In Germany, it has mostly been the case that government has had a true vision of cost reductions, and has clearly transferred this to the market within the decreasing support rate. However, the motivation of perceived green jobs and sustainability has been put into question with current FIT investments, and retail price increases in electricity. Finally, in Italy, grid parity might soon be reached. This is a positive point for both investors and for the government. Local solar conditions and high electricity prices are positively influencing these trends.

This shows that government actions depend on a variety of factors, but these factors might be well managed by setting PV caps, securing the right PV locations and constantly looking at cost reductions for PV systems and PV performance.

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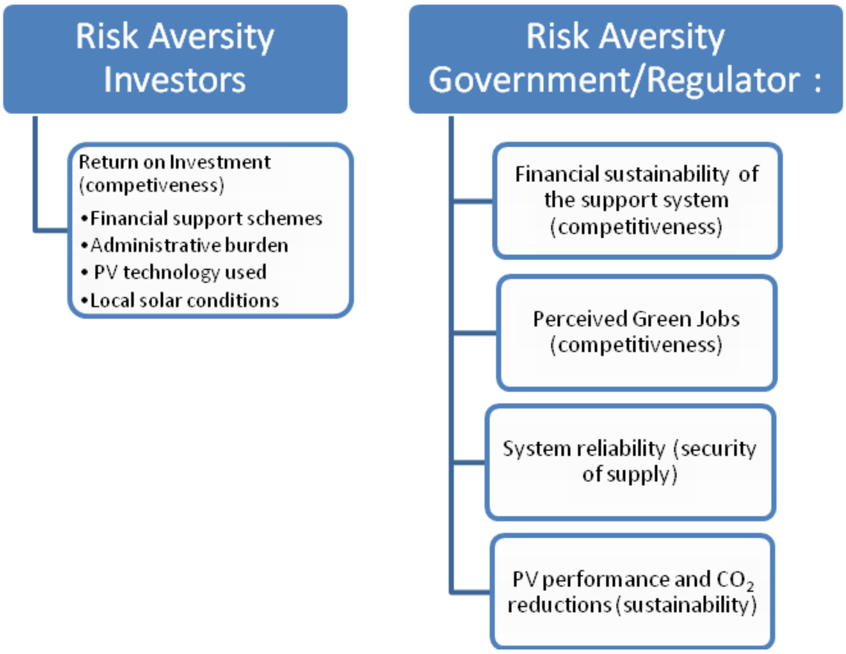
Image 2: Risk adversity of actors in PV secctor



Source: Author

The coordination of national and European RES policies

Ultimately, PV is not the only solution. PV is part of a larger pallet of renewables, and all of these different renewables have their benefits and difficulties, both in financial and practical terms. In the 20-20-20 objectives, nations established their targets, without having a clear vision of possible cost reductions and possible coordination within the EU. The consequence of looking at PV by itself as an isolated solution might disconnect the financial consequences and technological aspects that are closely related with PV. Finally, it is necessary to have an interconnection with renewables and conventional electricity sources, for the intermittence cannot provide total system security.

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PV in Asia and the US

Europe, with more than 75% of all new capacity in 2011, is the largest market for PV installation. However, Asia and the US also increasingly play an important role in this sector. This chapter provides a description of major developments concerning the rest of the world in the PV industry.

Table 13: The top 10 global PV cell manufacturers, ranked by capacity [45]

2006 — +46% per year — 2010

Company (2006)	Country	Capacity (MW)	Company (2010)	Country	Capacity (MW)
1. Sharp	Japan	500	1. JA Solar	China	1,900
2. Q-Cells	Germany	420	2. Suntech	China	1,620
3. Suntech	China	270	3. First Solar (TF)	US	1,502
4. Motech	Taiwan	240	4. Yingli	China	1,100
5. Solarworld	Germany	200	5. Trina Solar	China	1,000
6. China Sunergy	China	180	6. Q-Cells	Germany	1,000
7. Kyocera	Japan	180	7. Canadian Solar	China	800
8. Isofoton	Spain	130	8. Motech	Taiwan	600
9. Schott	Germany	121	9. Gintech	Taiwan	600
10. Sanyo Electric	Japan	115	10. JinkoSolar	China	600

Europe US China Other Asia

Asia clearly leads in PV manufacture. In 2010, the major two producers of PV cells were Chinese ground-based systems, while First Solar from the USA was in third place (see Table 13). First Solar is in a special position due to its focus on thin film modules. Traditional PV cells are made from expensive polysilicon, while First Solar uses cheaper cadmium telluride as a semiconducting material. This creates high efficiencies with lower costs, giving First Solar a competitive advantage. The German company Q-cells, which held 6th place in 2010, went into liquidation, probably due to FIT cuts in Germany and intense competition from foreign manufacturers. This is challenging for the German Green Job Policy, which was also one of the reasons for supporting PV in the German national grids (see Chapter 6).

Looking at the market shares of PV module production in 2010, shows that China alone produced 55% of the total, Japan 13%, Europe and Middle East 18%, and America 13%. This reveals the

[45] Bloomberg New Energy Finance April 2011, Summit Keynote Michael Liebreich.

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large share of Asia within the PV module production market. In 2011, the shares for Europe decreased, due to the liquidation of Q-cells and Solar Millennium in Germany. This trend might likely continue because of strong competition from Asia and the US. Currently, non-Asian PV manufacturers are looking for cooperation in order to decrease costs and stay ahead in the rapid changes of the PV sector. Different Chinese PV manufacturers have contracted with US- and European-based companies to supply local markets. For example, the Chinese PV manufacturer Yingli has been contracted to supply 180MW of multi-crystalline and mono-crystalline PV modules to Germany's IBC Solar throughout 2012.[46,47]

Outside Europe's intense growth in installation capacities, growth is expected to be strong in China and the US. China installed 2 GW of new PV in 2011, and the USA 1.6 GW. It is expected that these capacities will take off further. Other growing markets are: India with an 300 MW of extra installed PV in 2011, Australia with 700 MW, Canada (300 MW) and Israel (130 MW).

PV Support Policies outside of Europe

China is the world leader in the production of PV cells, although 90 percent of output is exported. Recent policies in both China and the USA appear to have influenced the growth in solar energy research, development, production and installation (these policies include in China the Renewable Energy Law of 2005; and in the USA the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and the American Recovery and Security Act of 2009).

For 2020, China has set a high target of 500 GW in renewable electricity: 300 GW coming from hydro power, 150 GW from wind, 30 GW from biomass and 20 GW from solar PV.[48] China has a portfolio approach in supporting its RES deployment, combining FIT policies with quota obligations and other instruments. China started to subsidize renewable projects under the Golden Sun program in 2009 in order to expand the use of green energy and reduce dependence on fossil fuels. Just as in Europe, the FITs in China have recently been undergoing cuts, due to perceived cost reductions of PV installations.[49] China now makes up almost half (48%) of Asia's entire solar demand, and its solar PV project pipeline has expanded to 20GW, though the Chinese central government could well step in with

46 www.solarplaza.com/news/yingli-wins-180mw-european-pv-order?utm_source=Solarplaza+SUN&utm_campaign=5978e7a2da-SUN&utm_medium=email

47 http://www.newenergyworldnetwork.com/investor-news/renewable-energy-news/yingli-wins-180mw-european-pv-order.html

48 Martinot, Eric and Li Junfeng (2010-07-21). "Renewable Energy Policy Update For China". RenewableEnergyWorld. Retrieved 2010-11-14.

49 http://www.pv-tech.org/news/china_cuts_solar_subsidies_by_22.3_for_pv_projects and http://www.bloomberg.com/news/2012-02-02/china-cuts-subsidies-for-pilot-solar-projects-on-declining-costs.html

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policy adjustments to control growth in 2012.[50] The incentives for demonstration sun-power projects have been reduced in 2012 in China by 21 percent, due significant cost cuts for panel components. The government has cut the feed-in tariffs to Yuan 5.5 (USD 0.87) a watt, down from the Yuan 7 set in February.[51] This is probably due to the decrease of polysilicon costs: according to Bloomberg New Energy Finance data, the average spot price of polysilicon decreased by a third since September 2011, with wafers down 35 percent and silicon based solar panels down by 25 percent. According to the Ministry of Finance in China, developers who applied for feed-in tariffs under the program of the previous year have been allowed to make amendments to or withdraw their projects in case of not obtaining “reasonable” returns.

In the USA, different support schemes are in use, mostly FITs and Treasury grants. Besides, there are different private schemes like Power Purchase Agreements (PPAs) and financial leasing arrangements for encouraging Solar PV integration. In California, TOD pricing (Time of Day or Time of Delivery) is used, meaning that in peak hours, the FITs are different than in base hours. These TOD factors differ between 1.25 and 1.30, meaning that PV projects receive an average of 25% to 30% above the base PPA price, as a result of peak generation.[52] Solar leasing is a financial method in the US, providing savings on customers’ electricity bills: users just pay their monthly electricity bill to the solar company and when electricity is saved this provides an extra bonus.

Recently, the US Congress decided not to extend the 1603 Treasury Program which was created under the American Recovery and Reinvestment Act of 2009.[53] The recent termination of the TGP has a negative effect in two ways. On the one hand, the cancellation of the TGP will significantly lower the attractiveness of solar PV investments. As the main focus of TGP funding was on solar PV systems with a size of over 50 kW, the number of larger systems will experience a decrease especially. On the other hand, due to the development of the world market on the supply and the demand side, in the manufacturing sector the competition is tightening in 2012. The expected downturn of Germany and Italy in 2012, which are important markets for the US, will affect the demand for solar PV products.

Asia's next-largest solar PV market, Japan, grew 30% year-on-year to 1.2 GW, but with only a slightly higher install rate in 4Q 2011, which was heavily slanted (70% share) to residential installations. A new FIT law which hopes to spur large-scale PV projects is imminent and spurs development activity, but the

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[50] http://www.electroiq.com/articles/pvw/2012/01/asian-solar-pv-installs-surging-china-blistering.html

[51] http://www.energymarketprice.com/SitePage.asp?Command=NewsLetter&ID=8672&trydf

[52] PV news July 2011; Greentech Media

[53] http://www.renewableenergyfocus.com/view/23669/five-reasons-to-be-pessimistic-for-solar-pv/

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legislation's lack of clarity has held back actual project implementation. Also, a "dramatic" influx of foreign module suppliers is shaping Japan's end market. Just as in the USA, Japan is starting to use solar leasing for the deployment of solar PV in the network. This private financing system allows less intervention from government but might need good locational conditions to work.[54]

[54] http://www.majiroxnews.com/2012/02/02/japanese-homeowners-may-see-the-profit-in-solar-energy-lease-option/

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Conclusion

The PV sector is evolving rapidly. Europe is a global leader with its installed PV capacities and is continuing to install PV, in order to reach the 20-20-20 goals set by the European Commission. This report has presented major developments in the PV sector in- and outside Europe, focusing mainly on five countries in Europe and some developments in Asia and USA.

Besides Germany, Italy, Spain, France and the Czech Republic, PV growth is expected in other European countries and in nations outside of Europe. Innovations within the PV industry, economies of scale in production and Asian penetration in the production market are decreasing costs of PV, so far that some European companies have gone into liquidation.

Germany, Italy and the Czech Republic have already exceeded their EU 2020 target for PV capacity installation. Even though Germany is the global leader in PV capacity installation, local solar conditions in Germany do not provide high performance ratios: only a little less than 2% of national electricity generation came from PV in 2011. This, together with the decreased possibility of local green jobs, has led to reconsiderations of local PV support in Germany. Spanish PV obtains the highest performance in Europe, however after the 2008 peak installation in PV with its increased RES cost for the government, PV support systems have undergone some (retroactive) measures in order to hamper installation. There might also be some fraud with the renewal of panels initially connected by newer, more efficient ones. Also, a PV-bubble took place for the Czech Republic, and after the peak in installations in 2010, policies have changed to limit PV costs, as well as help control the electricity system's reliability.

In 2011, installed Italian PV capacity grew explosively and this has affected the amount of technical measures needed to incorporate this capacity into the grid. In order to control the future support cost of PV, current policies are trying to control the amount of PV installed (by caps), especially for large scale systems in agricultural areas. Current regulation regarding PV installation is detailed and complex. However, PV seems to be reaching grid parity first in Italy. This might in the near future mean that support costs will eventually decrease and will no longer be required in order to support PV installation.

For France, the policy for PV seems still very conservative. Smaller PV systems apparently receive a higher priority, while larger-scale systems face high administrative burdens, partly because of presumed grid problems. In the political arena, nuclear power

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generally remains the preferred low-carbon technology. Because of this, there is potential for different schemes like projects under Power Purchase Agreements (PPAs).

The national 2020 targets do not appear to be absolute goals in themselves. They are part of a larger national and/or international strategy. The targets are changing, depending on perceptions of how more sustainable electricity generation could be integrated in a financially and technically reliable way. However, the means to these goals are constantly influenced due to cost reductions. Besides, Germany with its green job policy incentives provides another dimension to this target. The prominent role that Asia and the USA play within the competitive PV industry has led to reconsiderations of this green job policy. Early EU penetration has led to lowering global prices for PV; eventually the USA and other countries might benefit from these cost decreases.

Also, more cooperation is currently emerging with Chinese manufacturers, in order to cope with the strong competition in the PV business. Low prices of PV naturally have greater meaning in liberalized markets, in which prices prevail over green job objectives. Business is mostly concerned with the return on investment and its decisions are based on the perception of PV prices and returns, due to PV support schemes. However a regulator, which sets the PV support scheme, faces a much more complex task, involving balancing long and short term factors in competitiveness, security of supply and sustainability. These factors are constantly changing within the evolving PV sector.

This study implies different lessons for the actors associated with the PV sector. Therefore the recommendations given here are aimed at three different parties: first European policymakers, second non-European policymakers, and thirdly the PV industry. For the European and non-European policymakers the advice provided is partly similar, and they are recommended to read both parts.

Recommendations for European Policymakers

Analyze current FIT schemes for effectiveness: the need for efficiency and smart-grid focus

In Europe, FITs (Feed-in-Tariffs) are a commonly used incentive scheme for the deployment of PV capacity. It is recommended to keep in mind the reasons behind deployment of PV and to not mix the tools with objectives. Reasons behind the deployment of a not-yet-competitive electricity production source should be carefully considered. PV within the renewables mix is not the only option. The goal of emissions reductions can be reached even with measures that go beyond renewable deployment, for example by increasing energy efficiency. Besides, deploying renewables without decreasing electricity demand will just raise electricity consumption. Renewables will otherwise just supply the growth of demand, without creating a net reduction of CO2 emissions. Therefore energy efficiency measures should be successfully implemented together with a smart-grid focus. The latter makes it

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possible to create a demand response with active consumers who can react to lower prices, due to the availability of green electricity.

For countries like Germany, whose solar conditions are not as good as in Spain, a re-observation is needed for its renewables policy. PV deployment is just a means to achieve CO2 reduction, and is not a goal in itself. When PV does not produce sufficient electricity, there is no other use for integrating it massively in the grid. Other strategies would possibly be better to reduce CO2 emissions and cut the dependency on fossil fuels (for example, the deployment of biomass, wind, hydro power). Also, when PV is not expected to provide electricity at competitive prices in the near future, this will mean missing the target of decreasing CO2 emissions. FITs should involve being able to move soon towards net-metering or PPAs and other schemes which do need no additional financial support. Eventually, conservative support schemes that are used outside of Europe might become more interesting for places in Europe, where PV might shortly reach grid parity. This outcome is the financial goal for any renewable resource, reaching the point where the technology can compete in the electricity market. Policymakers should keep this in mind and stimulate investments in the right locations. However, it is important to not forget that even conventional electricity sources (gas, coal and nuclear) are subsidized in many countries; comparisons should take into account these subsidies together with a CO2 price.

No simple 'FIT' and forget attitude

Even though it is a proven way of incentivizing investment in PV, it is important to keep in mind that FIT tariffs do not necessarily encourage producers to reduce costs more than the tariff provided, because of guaranteed priority access to the market and guaranteed remuneration. Policymakers should take this into account and create incentives in another way to motivate those efficiencies if possible.

Secondly, if a FIT is used, this tariff should move along with the learning curve of PV and its cost reductions. Unexpected adjustments of the tariff result in uncertainty and thus reduce the attractiveness for investment. For this reason it is recommended that FIT reductions are transparent: they should follow a settled scheme and it should be clear when tariff cuts take place (for example, as in Germany). Furthermore, the costs for financing support schemes should be reflected in electricity prices (for example, like in Denmark and Germany) so that there are no deficits to the governmental budget that might eventually lead to highly impacting (retroactive) measures (for example, as in Spain).

Thirdly, as the case of Spain has shown, it is important to know that there might be a possibility of fraud when connected PV receives a lower tariff over time. In order to receive a higher remuneration, a temptation exists to renew older, inefficient solar cells with newer efficient cells in order to receive a higher remuneration per kWh while producing more electricity with more efficient panels. In order to prevent this, regulators and the TSOs should cooperate on

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the control and monitoring of the output generated by connected panels and define penalties for fraud.

Keeping in mind network limits and moves towards smart-grids

Integrating PV massively into the electricity grid might have large impacts on the system reliability of the entire grid. Just as the case of PV projects in the Czech Republic, where network problems started to arise after large PV integration, the technical characteristics of the network are important to analyze when a support scheme is designed for PV. Looking especially at distributed generation, electricity might flow in a direction in which the grid is not prepared to deal with. However, low amounts from residential users will not impact that much, but higher amounts of electricity flows might bring instabilities. This leads to the need for installing extra monitoring and reliability devices (capacitors etc.) to prepare grids to cope with new electricity flows.

As the move to more and more renewables production in the electricity mix is likely, the grid should be able to cope with this and consumers might do their part by actively participating. Such so-called smart-grids are an important link in creating the right settlement for high penetration of renewables, and also of PV. Advice for policymakers is to share efforts on both deployment but also on grid preparation for the electricity produced.

Grid parity should be well defined, incorporating a grid charge

Grid parity is most of the time defined as the situation where an alternative electricity source is able to produce electricity with a levelized cost that is equal or below the retail electricity price. However, it is also important to note that for distributed generation a grid-charge needs to be incorporated in the cost. The distribution net is needed for overproduction or for supplying underproduction of the PV system. Once connected to a grid, a charge needs to be paid in order to secure fair charge allocation.

Renewables need back up capacity: using fair remuneration schemes for other peak capacities

It is important to keep in mind that all renewables generate intermittent electricity; this requires back-up capacity. This back-up capacity needs to be paid for, including when it is used very little. Also, it is possible to study electricity storage options. Therefore, PV deployment should be analyzed within a mix in which it can provide part of demand, with other production sources. Policymakers should not forget to provide access to and financial support for back-up capacity units (storage and/or production units) in the entire electricity system.

Creating new frameworks to incentivize PV deployment

Europe has taken a more aggressive and centralized approach when compared to other continents in deploying PV. However, there are still many options left for motivating the deployment of PV beside FIT

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schemes. For example, power purchase agreements, solar leasing options and other bottom up initiatives might become more and more interesting and provide benefits for actors in some places in Europe already. Policymakers should investigate the effects of delegating efforts and targets to municipalities and businesses, as well as motivate new approaches.

Recommendations for non-European policymakers

Using FITs structured with long term plans

Europe can be recognized for the quick penetration of its PV capacities, due to strong financial incentive schemes. In comparison, non-European policies are a bit more conservative. Learning from the European efforts, it is good to use FITs only if they are flexible and capped, in order to avoid a sudden PV bubble as has been the case in countries within Europe. Also, the deployment should take place within a long term plan with a stable structure of decreasing FITs, which are clear for investors.

Creating regional policies and further developing bottom-up financing initiatives

Some locations outside of Europe might provide extremely good situations for PV electricity production (for example, with high direct irradiance levels). Policymakers could attract investments by providing low administrative burdens for the deployment of new PV and rewarding some efforts with tax benefits (as in the USA). However, the grid should be ready to cope with the flows coming from the PV system and efforts have also to be focused on updating the grid. Tendering procedures for new PV systems might bring some control for system operators and at the same time create opportunity to diversify the electricity mix. Furthermore, governments should focus and motivate bottom-up financing initiatives like solar leasing (see Chapter 7) and power purchase agreements.

Fair comparison with subsidized (conventional) electricity prices

Some countries are characterized with highly subsidized electricity prices (for example, some GCC countries). PV in these countries might be an expensive option if compared with existing electricity prices. The issue in this case is to compare PV with the non-subsidized costs of other electricity production and possibly also add a CO_2 tax to conventional production in order to distribute fairly the externalities created.

Keeping in mind particular needs on locations for PV: there is no simple "copy-paste" strategy from Europe

In some areas, problems might arise with the use of PV panels. For example, in some areas there might be high dust levels which decrease the electricity output of PV panels. When calculating PV costs in these areas, the increased maintenance costs of PV should be taken into account. Furthermore, tracking systems also demand extra maintenance

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compared with simple PV panels. There are special characteristics of particular PV technologies which will suit better certain locational conditions. Even within Europe there is a difference with the use of PV panels in northern Europe and southern Europe. This is also the case with technical characteristics of the network and electricity production, and thus financial remuneration. Therefore it is recommended to be careful when making comparisons with other locations.

Recommendations for the PV industry

Creating business models which can operate without FIT schemes

As business is focused on return on investment rates, it is obvious that the focus is mainly on incomes generated primarily by FITs. However, tariffs are currently decreasing rapidly and governments are probably moving more and more to a net metering model or other models that will not include FITs. Therefore, it is recommended to focus more on creating business models which are not dependent on FIT remuneration but are able to operate without it. These models will be able to stand long term changes and will possibly provide more stable incomes.

Creating business models for untapped markets and technologies

In Europe, there are different untapped markets in the residential, commercial and industrial sectors (see Chapter 6 and EPIA's 2012 Global Market Outlook of May 2012). It might be interesting to look at the possibilities in these sectors, focusing first on the countries providing interesting solar conditions (Italy, France and Spain). Also, outside of Europe, there are many untapped markets providing very interesting solar conditions. Furthermore, there are many locations across the world in which electricity is needed in rural areas that are detached from an electricity grid. In these locations, electricity is mostly generated with expensive fuel generators. PV panels would already be able to provide electricity at competitive prices in such places.

To do this, it is important to seek to detach incomes from FITs, as noted before. Focus should be on possible incomes directly for consumers or businesses. It should be borne in mind, that PV, after having been available for quite some time, is already installed by most "early adopters". Today, other potential clients are the ones primarily focused on financial gains and less on environmental and technical concerns.

Searching for cooperation with different and new actors: municipalities, private consumers, businesses and others

PV electricity is becoming more and more common. In order to find new solutions and provide the right business models, it is important to have good connections with different actors: potential clients and government authorities. This could create solutions for new projects which are built for example under Power Purchase Agreements (PPA's), in which a third-party developer owns and

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operates a PV system; without the need of any FIT to produce incomes. Also, solar leasing projects (a lease option for solar panels for private consumers) are an interesting development which is used in the United States. Government could motivate new building projects to integrate PV and private consumers to launch local PV projects. As an industry, it is important to try to be open to such initiatives.

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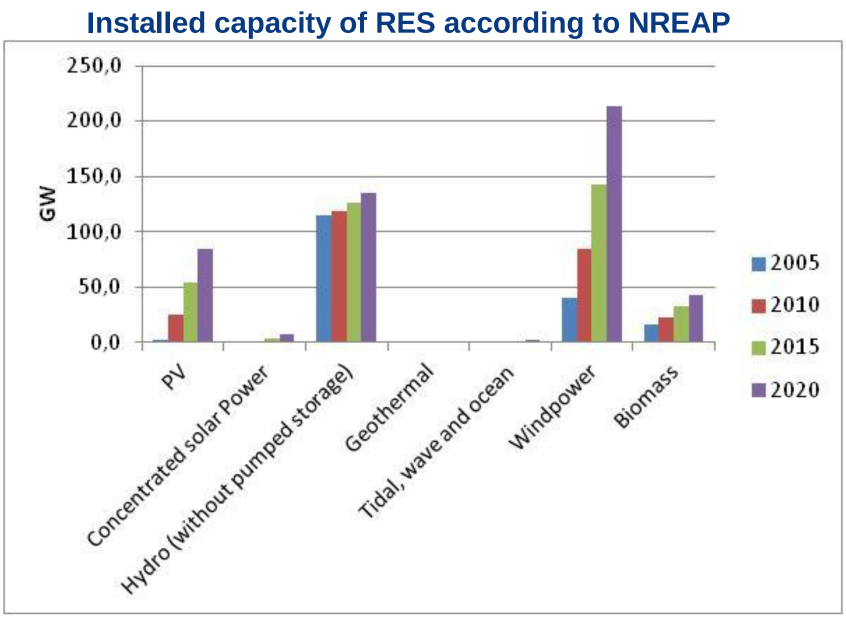
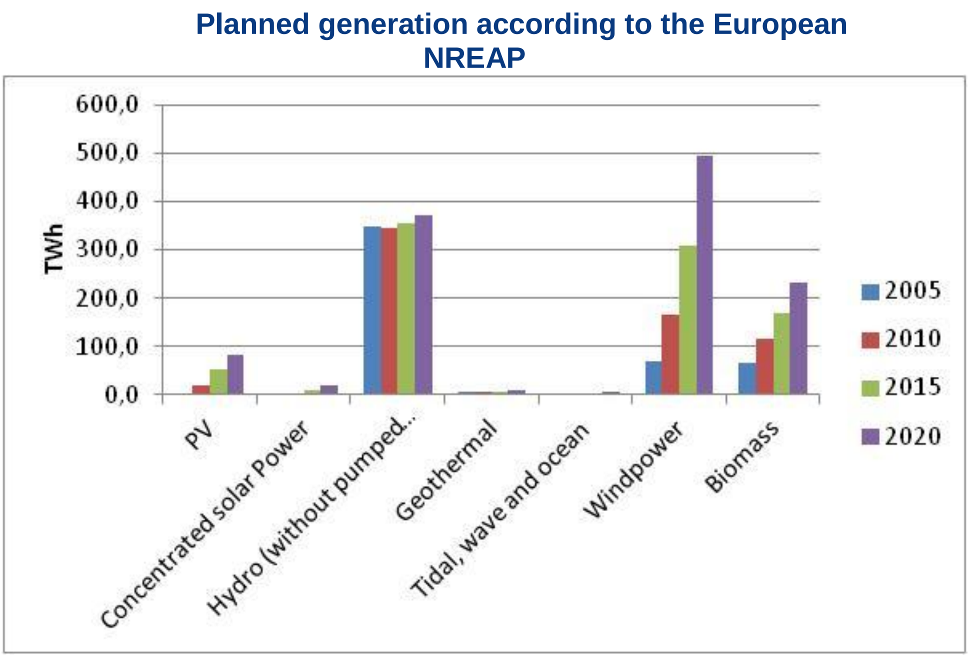
Annex I: 2020 European Targets





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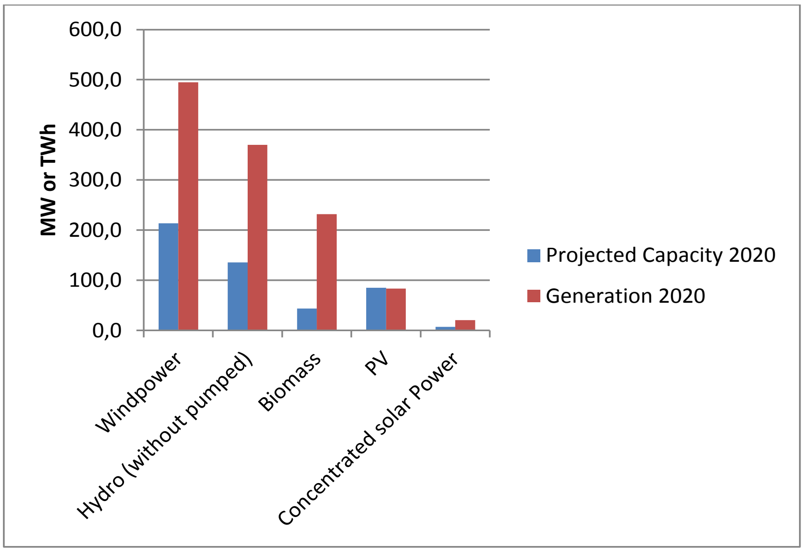
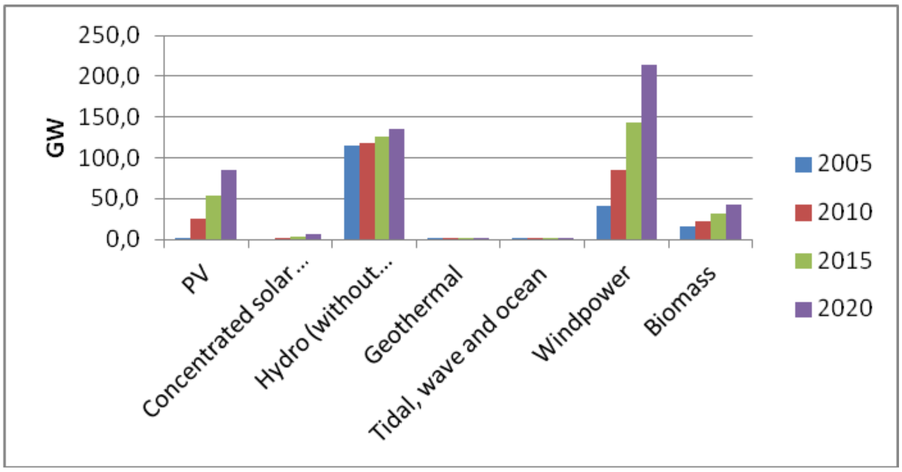


Total renewable electricity capacity accumulated from the 27 individual NREAP



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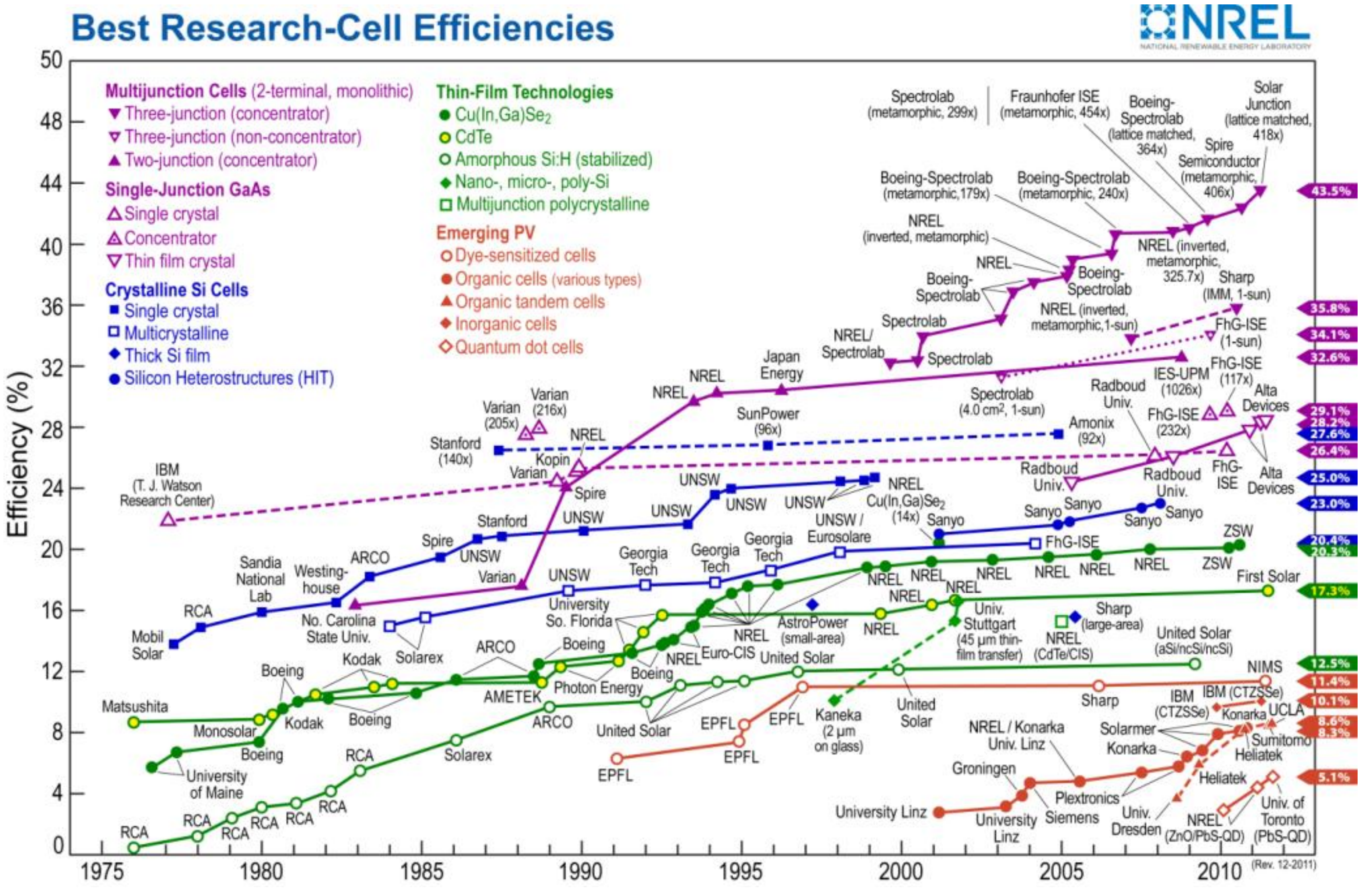
Annex II: PV Technologies and Efficiencies



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Annex III: *20-20-20* National Targets

	Renewable energy %*		
	2005	2009 (prov.)	2020 target
Austria	23.3	29.2	34
Belgium	2.2	3.8	13
Bulgaria	9.4	11.5	16
Cyprus	2.9	3.8	13
Czech Rep	6.1	8.5	13
Denmark	17	19.7	30
Estonia	18	22.7	25
Finland	28.5	29.8	38
France	10.3	12.4	23
Germany	5.8	9.7	18
Greece	6.9	7.9	18
Hungary	4.3	9.5	13
Ireland	3.1	5.1	16
Italy	5.2	7.8	17
Latvia	32.6	36.8	40
Lithuania	15	16.9	23
Luxembourg	0.9	2.8	11
Malta	0	0.7	10
Netherlands	2.4	4.2	14
Poland	7.2	9.4	15
Portugal	20.5	25.7	31
Romania	17.8	21.6	24
Slovak Rep	6.7	10	14
Slovenia	16	17.5	25
Spain	8.7	13	20
Sweden	39.8	50.2	49
UK	1.3	2.9	15
EU27	8.5	11.6	20

From the website of the EU Commission:
http://ec.europa.eu/energy/renewables/targets_en.htm

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Annex IV: Case Studies

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Czech Republic	Gross electricity production (GWh)	74647	76348	83227	84333	82578	84361	88198	83518	82250	85910
	PV gross production	0	0	0	0	0	1	2	13	89	616
	Share of PV in gross total production	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.7%
France	Gross electricity production (GWh)	549836	559194	566941	574269	576203	574609	569771	574055	542184	572884
	PV gross production	6	7	7	9	10	13	18	42	171	600
	Share of PV in gross total production	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Germany	Gross electricity production (GWh)	586406	586694	606719	615287	620574	636761	637100	637232	592464	621000
	PV gross production	116	188	333	557	1282	2220	3075	4420	6579	12000
	Share of PV in gross total production	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.7%	1.1%	1.9%
Italy	Gross electricity production (GWh)	279009	285276	293885	303347	303699	314121	313888	319130	292641	298208
	PV gross production	19	21	24	29	31	35	38	193	676	3478.5
	Share of PV in gross total production	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	1.2%
Spain	Gross electricity production (GWh)	236043	244963	260727	280007	294077	299454	305052	313758	293847	298405
	PV gross production	24	30	41	56	41	119	500	2562	6018	6302
	Share of PV in gross total production	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.8%	2.0%	2.1%

Data taken from IEA database

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Annex V: National imports and exports

Czech Republic electricity imports and exports (GWh)*

	2000	2002	2006	2009	2010
Total Imports	8725	9496	11463	8234	6682
Total Exports	18743	20892	24092	22232	21579

France electricity imports and exports (GWh)*

	2000	2002	2006	2009	2010
Total Imports	3059	3097	8079	19154	19950
Total Exports	71934	78863	69868	43281	48563

Spain electricity imports and exports (GWh)*

Spain	2000	2002	2006	2009	2010
Total Imports	12244	12408	9120	6784	5214
Total Exports	7446	6335	11859	14388	13117

Italy electricity imports and exports (GWh)

	2000	2002	2006	2009	2010
Total Imports	44932	51577	46525	46947	45899
Total Exports	476	917	1618	2099	1699

Germany electricity imports and exports (GWh)

	2000	2002	2006	2009	2010
Total Imports	44156	46217	48464	40564	42171
Total Exports	42598	45529	46140	54906	59878

Data is taken from Entsoe database.

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Annex V:Stock listed solar energy companies (by market capitalization)

	Company name	Outstanding shares (31/12/11)	Share value (31/12/11)	(in original currency)	Market capitalization (in millions)
1.	GCL-Poly Energy Holdings Ltd. (China)	15,470,000,000	$0.28	HDK 2.17	$4317
2.	First Solar Inc. (US)	86,420,000	$33.76		$2917
3.	SMA Solar Technology AG (France)	34,700,000	$55.78	EUR 43.17	$1935
4.	GT Solar International Inc. (US)	127,220,000	$7.24		$921
5.	SZ Topray Solar (China)	489,750,000	$1.67	CNY 10.51	$817
6.	Motech Industries Inc. (Taiwan)	437,400,000	$1.75	TWD 53.1	$764
7.	Conergy (Taiwan)	443,120,000	$1.53	TWD 46.6	$679
8.	SunPower Corp. (US)	100,490,000	$6.23		$626
9.	LDK Solar Co. Ltd.	144,960,000	$4.19		$607
10.	Yingli Green Energy Holding Co. Ltd. ADS (China)	157,640,000	$3.80		$599

Taken from www.SolarPlaza.com

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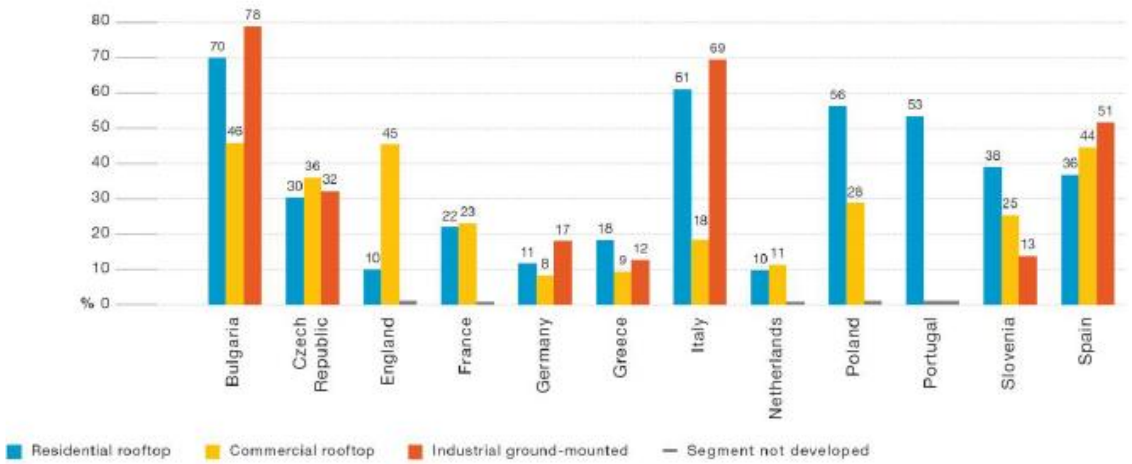
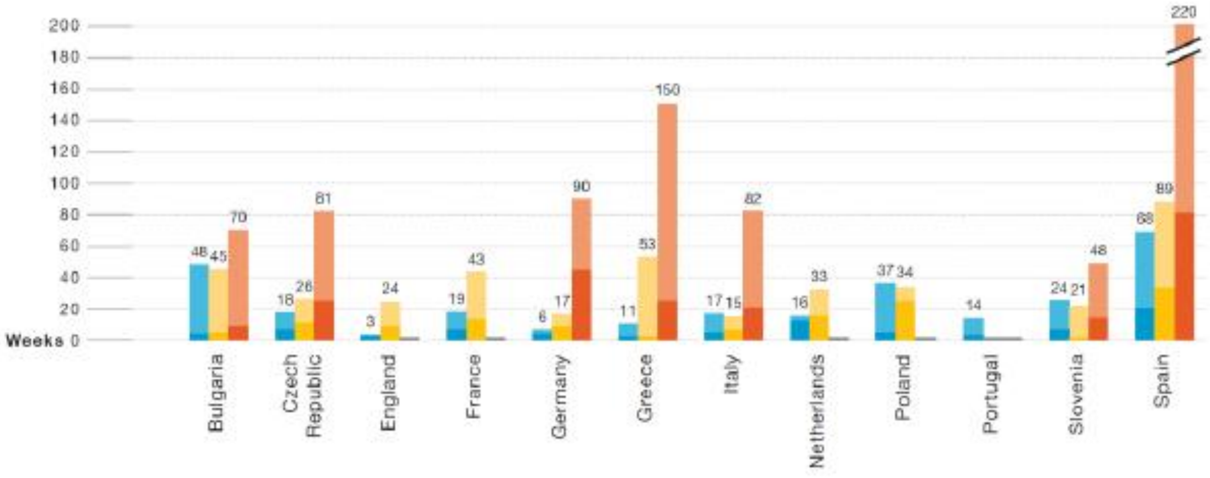
Annex VI: PV Legal procedure costs





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