Photovoltaics: between a bright outlook and uncertainty

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Abstract
There is “breakneck” growth in the global photovoltaics market, with the global market of photovoltaic cells growing by about 47% in 2009, 72% in 2010, and 74% in 2011. Global installed capacity in 2011 was three times more than 2009. Italy and Germany are leading with a 57% share of the global market. Costs are dropping rapidly and photovoltaic (PV) power generation is an attractive option for investors. Increasing support of European Union (EU) for renewable energy in general and PV aims to diversify sources of energy and reduce reliance on fossil fuels, on nuclear and on imported energy. Energy security is an important dimension for the EU. Almost all experts agree that there is no single technology that will provide a sustainable global supply of cleaner energy. However, the scale, the cost of the change needed and supporting policy and legislation are often subject to debate. High costs could be counterbalanced by economic yields from new businesses, the creation of new jobs, and economic growth from clean energy investments. The current situation in which Germany and Italy account for almost 2/3 of global PV market growth and, also, the strong reliance on supporting policies is unstable. If PV power generation is to continue growing, the balance of development will have to shift to new markets – both inside and outside of Europe. Fixed price policy is a game to be played with caution. This article highlights examples of Spain, Italy, and Germany that illustrate that without robust policy the system can be easily misbalanced. When – or even if – photovoltaic power does become cheap enough to compete without subsidies against more established energy sources, depends upon a number of uncertainties, including the continuing political will to provide financial support, and how readily developing nations such as China and India embrace renewable energies.

“Breakneck” Growth Trend of Global Market of Photovoltaics

The year 2012 was declared by the General Assembly of the United Nation the “The World Year of Sustainable Energy for All,” emphasizing the importance of investing in access to cleaner energy technology options to achieve a climate-resilient future for all and it also highlighted the need to improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources for sustainable development.

The European Union (EU) has binding sustainable energy and climate goals for the year 2020. The EU has recently presented a vision of a low-carbon Europe in 2050, which requires a reduction in carbon emissions by over 80%. This will require increased technology development and market deployment efforts in energy efficiency, renewable energy, and clean energy. Achieving these benefits will require greater integration of energy and climate and economic policy, which could form the basis of a green economy in Europe. The EU Commission has considered several decarbonization scenarios in this context, but in all cases, a few important common features are found: improving energy efficiency (reducing energy consumption by 41% by 2050 compared with 2005–2006), and increasing the share of renewable energy to at least 55% of final energy in 2050. In the case of electricity, the renewable energy source (RES) share varies from 64% to 97% in the different scenarios. Several studies both in Europe and elsewhere have shown that a high share of renewable energy could be...
feasible, but it may require improvements to the present infrastructure, for example, to the electricity grid [1, 2].

Solar power has no shortage of virtues. It is unlimited, nonpolluting, and extremely abundant. Yet to date our use of this vast resource has been marginal. It has been too expensive to become mainstream and currently provides just 0.2% of the roughly $2 \times 10^{16}$ kWh (kilowatt hour) of electricity consumed worldwide in 2009 [3, 4].

But with the global market in photovoltaic cells growing by about 47% a year in 2009, 72% in 2010, and 74% in 2011, and with total installed capacity standing at about 69.7 GW (gigawatt) in 2011, that looks set to change (Fig. 1). Some 13.4 GW of solar capacity was added in the EU in 2010, surpassing the continent’s newly installed wind capacity (about 9 GW) for the first time. More than 21 GW were added in EU in 2011(Fig. 2) [5]. The country that lead this growth in 2010 was Germany, which installed a capacity of 7 GW, equivalent of two thirds of the total capacity of nuclear energy produced in U.K. This rapid growth has been made possible by generous incentives, which other countries are now copying [6].

Solar photovoltaic (PV) electricity continued its remarkable growth trend in 2011, even in the midst of a financial and economic crisis and even as the PV industry was enduring a period of consolidation. As they have for the past decade, PV markets again grew faster than anyone had expected both in Europe and around the world. Solar photovoltaic markets saw “breakneck” growth in Europe last year led by Italy, according to the latest report from the European Photovoltaic Industry Association (EPIA). The report, Global Market Outlook for Photovoltaics Until 2016, assesses the European and global market conditions over the last year and makes predictions for the next five. According to this latest analysis, a total 29.7 GW of solar photovoltaics were connected to the grid in 2011, up from 16.8 GW the previous year. Of that, some 21.9 GW were connected to the grid in Europe up from 13.4 GW in 2010, giving Europe a 75% share of all new capacity in 2011. Italy came out top in Europe with 9.3 GW followed by Germany with 7.5 GW, meaning that just two nations accounted for 57% of the market growth last year. Other nations trail behind, with China installing 2.2 GW in 2011 and the United States 1.9 GW [5]. The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) says that incentives will help bring down the cost of solar to that of retail electricity in many countries by 2020–2030 [7]. In a “roadmap” on the future of photovoltaic technology published last year, the International Energy Agency (IEA) calculated that with government support some 3000 GW of solar cells could be installed by 2050, generating about 11% of the world’s expected electricity supply – revising its 6% prediction 2 years earlier [8, 9]. Each year, it becomes more likely that solar power will develop into one of the major energy sources of the future. Costs are dropping rapidly, but such a rapid growth rate cannot be expected to last forever. “The PV industry is now weathering a period of uncertainty in the short-term,” according to the EPIA President Winfried Hoffmann. “But over the medium- and long term the prospects for continued robust growth are good.” The next stage, says Hoffman, is for the photovoltaic industry to demonstrate its maturity. The results of 2011 show that under the right policy conditions PV can continue its progress toward competitiveness in key electricity markets and become a mainstream energy source. On a global scale, solar photovoltaics now have the third most installed renewable capacity after hydro and wind power [5]. Unfortunately, while simple in principle, photovoltaic cells are expensive to make in practice because of the high costs of purifying, crystallizing, and sawing the single silicon wafer. This increases the price of the electricity they

Figure 1. Evolution of World cumulative installed capacity of photovoltaics 2000–2012 MW [31].

Figure 2. Evolution of European new grid-connected PV capacities 2000–2012 (MW) [31].
produce, with 1 kWh in Germany costing about €0.22 from typical photovoltaic installations, while it costs about €0.10 from natural gas, €0.09 from onshore wind, and just €0.05 from nuclear [2, 6].

Why Renewable Energies? Why Photovoltaics?

Solar cells should be particularly attractive in countries with lots of sunshine, as more energy arriving at a cell results in the production of more electricity. However, it has been comparably less sunny Germany the country leading the way in cell development, rather than countries closer to the equator. Germany’s enthusiasm for solar stems from a desire to move away from “dirty” fossil fuels and the risks associated with nuclear power, while reducing its reliance on imported energy.

Energy policy has been dominated by three factors: energy security, economics, and the environment. Energy is perceived as a highly strategic resource on one hand, but on the other hand low energy costs are considered necessary for economic prosperity. An awareness of environmental aspects, in particular carbon dioxide (CO₂) emissions resulting from energy production, has increased tremendously over the last two decades, but has not yet been fully incorporated into the energy policies of the countries that are the greatest polluters. Energy security is an important dimension for the EU because 54% of all its energy is imported. Forty percent of the natural gas is imported and 25% of all gas used in the EU originates from Russia. The value of energy imports is around €500 billion a year. However, when related to the size of the EU economy, energy imports correspond to 3% of Gross Domestic Production (GDP) [10].

Both the scale and cost of the change needed are often subject to debate, but at the same time many of the co-benefits of mitigation strategies remain unnoticed. The high costs could be counterbalanced in particular by economic yields from new businesses, the creation of new jobs, and economic growth from clean energy investments. These so-called green energy economy gains could be substantial and important for boosting retarding economies such as the EU. On a world scale, the United Nations Environment Programme and the International Labor organization have estimated that the renewable energy sector could employ 20.4 million people by 2030 (2.3 million in 2006), once breakeven is achieved [11].

The most significant green energy economy initiative of any country comes from China. In its 12th 5-year plan, starting from March 2011, a more sustainable and innovative China with 40 million new skilled jobs is envisioned. Importantly, the Chinese government is prepared to invest over $1000 billion in clean energy and the environment ($570 billion in new energy industries and $520 billion in energy efficiency and the environment) [1, 12].

Europe was the global leader in PV market growth, with 75% of all newly connected capacity in 2011 and about 75% of global installed capacity. But non-European markets are showing signs that they may soon shift this balance in their favor. China, a production giant that has long had a relatively small market, is now becoming a source of increasing demand. The United States and Japan are also gaining momentum. Other countries have enormous potential for solar development that has only just begun to be tapped. This is significant, because if PV is to continue growing the balance of development will have to shift to new markets – both inside and outside of Europe. The current situation in which Germany and Italy account for nearly 57% of global market growth is unsustainable. While these markets will continue to be important, other countries will have to show more growth. In other words, the recent deployment rates can no longer be taken for granted. Keeping and increasing the momentum of PV development will require smart, measured policy support that moves beyond feed-in-tariffs (FiTs) and toward other incentives, such as removal of administrative barriers. The challenge may seem daunting. But the fact that the global market for PV has continued to grow even in times of economic crisis shows that there is a demand that can withstand a difficult period. With robust policy support, balanced market development, and continued industry innovation, the world’s most promising source of electricity can continue its remarkable growth rate over the short-, medium-, and long term.

Technological Developments

It is a well-known fact that innovations and new industries, frequently found in clean energy, are engines for economic growth and job creation in general: that “invention” leads to prosperity. That’s the theory of “innovation economics,” a relatively new doctrine that underlies today’s worldwide race to discover energy’s next game changer and is triggering some intriguing developments in renewable energy [13]. As well as stimulating the energy market, many developed countries also are investing heavily in R&D, creating some of the world’s leading solar research institutes. Japan, in particular, and the United States have also provided significant funding for solar, raising the world’s public R&D spending from $250 m in 2000 to about $500 m in 2007. The IEA, however, says that this is not nearly enough. It calculates that research spending should increase by a factor of between two and four if 11% of electricity is indeed to come from photovoltaics by 2050, a figure based on its target of reducing midcentury carbon dioxide emissions by 50% compared to 2005 levels [14].
Will one of these new technologies lead us out of our economic malaise? “Hurry up with your work.” That was the message delivered to energy innovators by Arun Majumdar, director of the U.S. government’s Advanced Research Projects Agency-Energy (ARPA-E). “Let there be no illusion that speed is of the essence right now.” Why the haste? The last 100 years brought us electricity, air travel, nuclear technology, fiber optics, wireless communication, and more. Now the world needs the equivalent breadth and depth of innovation from the energy sector, but this time we do not have a century to make the transformation. Depend on a single fuel for transportation, the United States is vulnerable from both a security and an economic perspective, particularly as it imports half of its oil – as does China. India also is an importer, as are Germany and Japan. “This is a global problem and people are looking for technological leadership in trying to solve it,” Majumdar said [13].

According to the IEA, research should be carried out across the full range of photovoltaic technologies, because all of them can be significantly improved. Crystalline silicon, which is used in around 90% of photovoltaic cells currently produced, could potentially be made cheaper through improvements to the manufacturing process. Researchers are also trying to increase the efficiencies of cells made from cheaper thin films of semiconductor – currently lab efficiency around 19.7%, as well as developing more advanced kinds of cell that equal or surpass the 20–25% efficiency of silicon while being as cheap to produce as thin-film cells [15]. This year, Researchers in the United States have built a new type of solar cell that emits light as well as absorbs it, making it the most efficient single-junction device ever developed. The efficiency of their prototype cell allows it to convert 28.6% of the sun’s energy into electricity. This is a considerable increase from the previously recorded highest efficiency of 26.4%, which was achieved in 2010 [16]. Table 1 shows lab-scale efficiencies of the most important types of photovoltaic cells and their evolution during last 5 years. Even though efficiency is in a steady increase, it is clear that this is not an easy job. More advanced “third-generation” cells will be needed if photovoltaics are really to take off.

Cells made from combinations of different semiconductor layers, each converting energy from a different portion of the solar spectrum, resulting in cell efficiencies of around 40%, are currently restricted to space missions because of their high cost. Manufacturers believe that photovoltaic solar cells can become a common source of energy without producing solar cells with high efficiency. All that is needed is to reduce the cost of existing technologies by improving the technological process. The photovoltaic industry follows the same curve as that described by Moor’s law. Every time the production of crystalline silicon cells doubles, the cost per unit comes down by about 20–25% [7]. Figure 3 shows a forecast for silicon module prices for two possible scenarios, low and high forecast to 2020. Forecast B Low scenario considers a linear silicon price decrease from 30 $/kg in 2011 to 20 $/kg in 2020, while Forecast B high scenario considers a linear silicon price increase from 30 $/kg in 2011 to 40 $/kg in 2020.

The IEA’s roadmap foresees that by 2020 homeowners will be able to generate electricity from solar cells on their rooftops as cheaply as they can buy it from the grid, while by 2030 large “farm” modules will be competitive with wholesale energy sources [4].

### Table 1. Development on efficiency of main technologies of photovoltaic cells.

| Technology                  | Efficiency% |
|-----------------------------|-------------|
| Si (crystalline)            | 25.0 ± 0.5  |
| Si (multicrystalline)       | 20.4 ± 0.5  |
| Si (thin film)              | 19.1 ± 0.4  |
| Amorphous/nanocrystalline Si| 10.1 ± 0.3  |
| Si (amorphous)              | 10.1 ± 0.2  |
| Si (nanocrystalline)        | 10.1 ± 0.2  |
| III-V cells                 |             |
| GaAs (crystalline)          | 26.4 ± 0.8  |
| GaAs (thin film)            | 28.3 ± 0.8  |
| GaAs (multicrystalline)     | 18.4 ± 0.5  |
| InP (crystalline)           | 22.1 ± 0.7  |
| Multijunction devices       |             |
| GaInP/GaInAs/Ge             | 34.1 ± 1.2  |
| a-Si/nc-Si/nc-Si (thin film)| 12.4 ± 0.3  |
| Thin film chalcopyride      |             |
| CIGS (cell) CuInGaSe2       | 19.6 ± 0.6  |
| CdTe (cell)                 | 16.7 ± 0.5  |

### Figure 3. Forecast until 2020 of silicon module price. Forecast B Low scenario considers a linear silicon price decrease from 30 $/kg in 2011 to 20 $/kg in 2020, while Forecast B High scenario considers a linear silicon price increase from 30 $/kg in 2011 to 40 $/kg in 2020.
While traditional solar markets have relied on distributed PV for most new capacity, these days it is the centralized large-scale projects that are gaining traction. In 2010 alone, eight centralized projects greater than 10 MW each were installed in US. The plant also serves as a real-life test bed as developers attempt to reduce the cost of solar power. Florida Power and Light (FPL) Group, the parent company of FPL, expects to cut costs by about 20% compared with a typical stand-alone concentrating solar power (CSP) facility [21]. Another big project, Desert Power 2050 (DP2050) examines the future energy challenges of Europe as well as the Middle East and North Africa (EUMENA). Desertec Industrial Initiative, which runs the project, plans to install a total of 125 GW solar power capacities. It shows that these challenges can at best be addressed by moving beyond the currently predominant view of the two regions as separate entities. The use of proven technologies will ensure the technical feasibility of a sustainable power system. The technologies that are the focus of this report are all widely used today – utility scale photovoltaic (Utility PV) and CSP technologies as well as on-shore and off-shore wind [22].

By this point governments should have more or less phased out incentives and also addressed a fundamental limitation of solar energy that will become increasingly relevant as its share of the electricity market increases—what happens when the sun does not shine? In addition to supporting the development and improvement of storage technologies, such as pumped hydropower, batteries, flywheels and compressed air or even hydrogen, new kinds of “smart” grids will need to be developed that manage the supply of energy to smooth out fluctuations in the output of solar cells and other renewable sources. The power-to-gas (P2G) pilot plant, the largest of its kind in the world, is one of example that demonstrates huge resources in field storage technologies. The research behind it could help to propel Germany to the front of the race for cleaner energy. Developers of the €3.5-million project say that the P2G technology is an ideal way to cope with the unreliable nature of solar and wind power. During sunny or breezy days, excess electricity can be used to make methane, which can be stored and then burned to generate power when the winds fail or the days turn dark. Another is extending and strengthening the electricity grid to wire up remote wind turbines and countless small photovoltaic installations. The research program also seeks to improve the efficiency of energy production from sunlight, wind and biomass, and to encourage people to reduce energy consumption. Germany currently stores excess electricity by using pumps to push water uphill into reservoirs. But there are limits to expanding this type of storage. With 30 pump facilities already in operation, Germany has few suitable sites left for building more; the country plans to increase pump-storage capacity by just 20% by 2020 [23].

Supporting Policies for Photovoltaics

For two decades, Germany has been a global leader in renewable energy, first creating FiT laws in 1991, then in 2000 via the Renewable Energy Sources Act (EEG) establishing different FiTs for different renewables. The so-called “feed-in-tariffs,” forcing users to buy electricity generated from renewable sources such as wind generators and solar panels with high prices compared with the market, are guaranteed for 20 years from the date of commencement of energy production. Since 2007 the nation has accounted for 30–50 percent of the planet’s annual solar PV capacity. Home photovoltaic generation has quadrupled in 4 years, with 1.3 million rooftop systems producing 28 TWh in 2012 – adding at least 1 GW more in 2012 than the government intended Germans pay a lot for their household electricity, about $0.34/kWh in 2012. The household tariff includes a “renewables surcharge,” expected to amount to roughly $249 per three-person household this year. Cumulative installed solar capacity is roughly 25 GW, an important part of the maximum power of 80 GW of total amount of electricity used in Germany during the summer, and the government is targeting 66 GW by 2030. The FiTs of electricity produced by facilities that start to produce in a later time are gradually being reduced because of reduced costs over time. This will help to rapidly promote the development of this new technology. German wholesale power prices have fallen about 30% just in the past 2 years to near 8-year lows, putting big utilities that underinvested in renewables under severe profit pressure. During 2012 wholesale electricity prices fell 10–15% [2].

Policy providing financial support is also in existence in several other countries, the most notable of which is Italy, whose fees are the largest in Europe, more than double those in Germany, 0.5 euros per kWh. With the sale price of electricity of photovoltaic power installed in Italy the figure is expected to grab 18 GW within the next year. The United Kingdom, on the other hand, has a lower production of electricity from solar energy, but in 2010 the British government decided to implement incentive for pricing fees and this is expected to be associated with a significant increase in photovoltaic installations [6].

Figure 4 shows the gross levelized cost of electricity for several case studies, under different risk circumstances. “Current” refers to the situation in 2009, with country and technology specific assumptions on costs and finance. “Best” refers to a situation where regulatory and market risks have been mitigated significantly. The figure reflects
the differences in the risk characteristics of the different support schemes. Furthermore, it shows significant cost reductions that can be attained, ranging from 3% to 25%. These reductions are a consequence of the lower risk profiles, which are reflected in reductions in the weighted average costs of capital ranging from 1% to 25% [24].

In Germany the system worked very well. The government had forecast an increase of installed power of 3.5 GW per year by 2010. However, in 2008, the growth of silicon resources and introduction of low cost products in the Chinese market overnight halved the cost of installation. Progressive reduction of the planned price was not able to reduce the demand for modules, which in turn was associated with rapid enrichment of the energy producers at the expense of consumers. Reduced fixed price sales that followed the earnings reduction caused fast reduction of domestic production, while Chinese companies expanded their market.

In 2009, in the United States, backed by ample stimulius funding and solid political support, federal clean technologies spending reached $44.3 billion. That spending has dropped steadily to an estimated $16 billion in 2010. By 2014, the federal government will spend $11 billion, or about a quarter of what it did 5 years earlier, on clean technologies. Also, the U.S. Government decided to follow more restrictive policies in spending stimulus fund, aiming to create market incentives that demand – and reward – technology performance and cost. The uncertain and short-term nature of current policy hinders investment as much as the cost considerations [25].

A more dramatic situation was observed in Spain, almost at the same time. The government believed that the photovoltaic industry had become too dependent on state charges of price, so decided to freeze benefits immediately. This caused the collapse of the industry. Photovoltaic production fell by nearly 3 GW in 2008 to 70 MW in 2009. In 2012 a similar situation was observed even in Germany. Five hundred and fifty billion-euro plan to replace nuclear reactors with renewable sources is stalling. Merkel’s 2011 plan to shut atomic plants and add sea-based wind farms remains bogged down amid wrangling over financial risk sharing and upgrading the transmission grid. The costs and scope of the project have moved energy to the center of the political agenda [26].

According to IEA experts fixed price policy “is a game to be played with caution,” keeping a balance between support for a new technology when its cost is high and the rate of reduction of support when it becomes established and costs reduce to limit unnecessary spending. This “game” became for the Italian government very difficult to “play.” Peak prices in Italy, although it is sometimes sitting facing the wrath of the owners of energy parks, are very high. Installed power of 8 GW provided to achieve in 2020 has already been achieved and exceeded by the end of 2011. “Dependence on fees” make many Italian manufacturer to state an earlier date from the real of commencement of production of energy. The result is much higher costs from the state budget and from customers in Italy than in Germany. Installing a solar energy park in Italy costs on average 4000 euros per kW, while in Germany it costs only 2500 euros per kW. This illustrates how difficult it is to enforce a policy incentive in a country where regulation is not robust enough [6].

To avoid “overheating” as seen in other European nations (Spain in 2008 and 2009 and Italy in 2010 and 2011), Germany has reigned in its FiT plans by nearly 40 percent. The EEG, which costs about €7 billion a year, is structured to degrees as installations climb, thus maintaining steady internal rates of return for projects, and generally keeping pace with plunging PV costs. In the first few weeks of 2012, German officials realized they had a big problem: preliminary estimates indicated new solar
PV installations in 2011 leaped to a record 7.5 GW in 2011, far outpacing the country’s 2.5–3.5 GW plans—with a whopping 3 GW in December 2011 alone, thanks to mild weather and desires to get installs done before the next scheduled FiT reductions in January. Continued half-year adjustment of the subsidies, now scheduled for a 15 percent degression to about 24 €-cents/kWh given the 2011 surge, would no longer be enough. New policies were immediately proposed: more frequent step-down degressions in the existing FiT and some kind of hard cap on annual installations, as low as 1 GW annually or even lower. Industry observers speculated on what would come out of negotiations, speculating on monthly or quarterly FiT reductions or a less-restrictive hard cap. The newly proposed subsidies cut the FiT levels by up to 30 percent, limit the payback on electricity produced, and eliminate a self-consumption bonus [27].

Most, if not all, industrialized and industrializing countries provide incentives to their key industries to help them improve and thrive in our global economy. Local governments also provide aid as inducements for industries to relocate. Almost all experts agree that there is no single technology that will provide the world with a sustainable supply of cleaner energy. It is the duty of government to look ahead and foster changes that strengthen the society and remove those that cause damage or harm. Our current energy paradigm is losing its viability and responsible governments must look ahead and foster new energy systems that provide sustainability and energy security with minimal environmental impact. Wind and solar are two such technologies. However, around the world recently the incentives for renewable energy technologies, such as wind or solar technologies, have decreased or been eliminated. In part, these developments are due to the impression that as applied to renewable energy technologies such incentives are subsidies, and subsidies are inherently bad. In actual fact, these incentives are subventions for fledgling industries that must thrive if the world is ever to solve its energy dilemma. While a subsidy is a direct monetary aid furnished by a government to a private industry, a subvention is a grant to stimulate scientific or industrial enterprises, especially those that are not fully developed. While a subsidy is an investment in the present, a subvention is an investment in the future. In difficult times, such as the world is now experiencing, investments in the future are critical to the maintenance of a sound and peaceful world society [28].

But in a green energy economy as demonstrated above, an integrated approach to the problems and solutions enables climate and economic challenges to be addressed simultaneously. One may always argue that the energy demand of developing countries is on the rise and will create new markets for energy anyway, irrespective of whether energy is green or gray. For example, in emerging economies such as China, energy and economic growth are still very strongly coupled. But the essence from a climate point of view is how the energy will be produced and how efficiently it will be used.

When—or even if—photovoltaics do become cheap enough to compete without subsidies against more established energy sources depends on a number of uncertainties. These include whether there will be the continuing political will to foot the bill, especially when the West’s financial future remains uncertain, and how readily developing nations such as China and India take up renewable energies. The Chinese market is set for enormous growth. The Chinese government has invested heavily in solar with the aim of producing 15% of its energy from renewable sources by 2020. China now manufactures more photovoltaic modules than any other country and, before long China could become the world’s number one consumer of solar energy [29, 30].

Conclusions

There is a “breakneck” growth in the global photovoltaic market. Global installed capacity in 2011 was three times more than 2009. Italy and Germany are leading with 57% of the global market. Each year, it becomes more likely that solar power will develop into one of the major energy sources of the future.

Costs are dropping rapidly increasing attractiveness to investors and accelerating the technology’s drive toward competitiveness with conventional electricity sources. The fact that the global market for PV has continued to grow even in times of economic crisis shows that there is a demand that can withstand a difficult period.

Increasing support of EU for renewable energy in general and PV aims to diversify sources of energy and reduce reliance on fossil fuels, on nuclear, and on imported energy. Energy security is an important dimension for the EU.

Many developed countries are investing heavily in R&D: Improvement of efficiency of PV, decrease of costs, development of smart grids, and storage technologies for the smooth integration of RESs. Research should be carried out across the full range of photovoltaic technologies, because all of them can be significantly improved. The increased complexity of the electricity system requires multidisciplinary consortia to share competencies and reduce risks.

Almost all experts agree that there is no single technology that will provide the world with a sustainable supply of cleaner energy. It is the duty of government to create market incentives that demand—and reward—technology performance and cost, to set policies that decline as
technologies improve in price and performance. Fixed price policy must keep the balance between the size of the technology support and the rate of reduction of support to limit unnecessary spending.

Both scale, cost of the change needed and supporting policies are often subject to critique. The high costs could be counterbalanced by economic yields from new businesses, new jobs created, and economic growth from clean energy investments.

The current situation in which Germany and Italy account for nearly 2/3 of global PV market growth and, also, the strong reliance on supporting policies is unstable. If PV power generation is to continue growing, the balance of development will have to shift to new markets – both inside and outside of Europe. Cases of Spain, Italy, and last year, Germany show that without a proper policy the system can be easily imbalanced.

When – or even if – photovoltaics do become cheap enough to compete without subsidies against more established energy sources depends on a number of uncertainties, the continuing political will to foot the bill or how readily developing nations such as China and India take up renewable energies.

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Conflict of Interest

None declared.

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