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Leipzig Graduate School of Management

Chair of Strategic Management and Organization

Future Scenarios for the German Photovoltaic Industry

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Future Scenarios for the German Photovoltaic Industry

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Working Paper Chair of Strategic Management and Organization

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EXECUTIVE SUMMARY

The photovoltaic industry is an example of a sector that is presently influenced by a large number of uncertainties that make future developments hard to predict. As a matter of fact, the photovoltaic industry in Germany is currently undergoing a phase of tremendous transformation triggered by changes in the political, economic and competitive landscape.

Events like the United Nation's climate conference in Copenhagen in December 2009, which largely focused on CO_2 reduction targets, make it clear that the renewable energy sector in general and the German photovoltaic industry in particular possess tremendous growth opportunities. Experts believe that due to the increasing global awareness for climate change on the one hand and decreasing prices for solar modules on the other, the photovoltaic industry will grow at an annual rate of 11 percent until 2020[1].

However, the industry also faces important challenges. New technologies like thin-film cells and new developments in solar thermal power plants are evolving and impose substitution threats to existing technology. Furthermore, the future of the Global and German regulatory environment is very uncertain. The German Federal Government is currently debating a revision of the Renewable Energy Sources Act (EEG), which determines the amount of subsidies paid for photovoltaic technology in Germany. This raises doubts whether subsidies will continue to be paid and to what amount. In addition, competition in the photovoltaic sector has intensified as Asian companies can produce their modules at up to 30 percent lower costs[2] compared to German manufacturers and increasingly push into the world market.

To overcome these challenges and help managers in the industry to plan for the future, we created the current study using our new and innovative approach to scenario-based strategic

planning that was jointly developed by HHL and Roland Berger Strategy Consultants. Our scenarios are based on extensive research, expert workshops and a survey that combines insights from companies which together make up for 40 percent of the total revenue of the photovoltaic industry in Germany. This insures a holistic picture of the relevant trends and influence factors and safeguards the quality of the scenarios.

The four scenarios, which we created, center around two key uncertainties, which we identified in our survey with industry experts and a subsequent scenario workshop. These two critical uncertainties are:

- ***The further development of the regulatory environment***
- ***The development of substitute technologies***

Based on these uncertainties as well as additional trends and influence factors four plausible scenarios emerge on how the German photovoltaic industry might evolve between now and the year 2015. These four scenarios are the following:

- **Phoenix** describes a world that is dominated by German photovoltaic producers. 80 percent of the photovoltaic systems produced are thin-film modules, in which European companies have a strong advantage compared to their Asian competitors due to their leading position in research and development. Global trade is free of barriers and the emerging markets for photovoltaic can be openly accessed.
- **Survival of the Fittest** describes a highly competitive world in which German subsidies for the industry have been cut significantly. Asian manufacturers account for

three quarters of the extremely price driven world market that is characterized by protectionism by the Chinese and United States' Governments.

- **Icarus** describes a world in which all German photovoltaic companies have disappeared from the world market. While both China and the United States build on "buy domestic" clauses to protect their industry, the EU has not followed leaving the European market open to competition from overseas. Alternative sources of energy generation like solar thermal energy are expected to be the main energy provider for future years.

- **Go Green** is a world in which European producers cannot meet the production costs and prices of their Asian competitors. Additional pressure is caused by cuts in the subsidies for the photovoltaic industry and the fear of a technological paradigm shift towards alternative sources like solar thermal power plants that promise a safe, reliable and cheap energy supply for Europe and the world. Formerly existing trade barriers to the emerging major markets in China and in the United States, however, have disappeared.

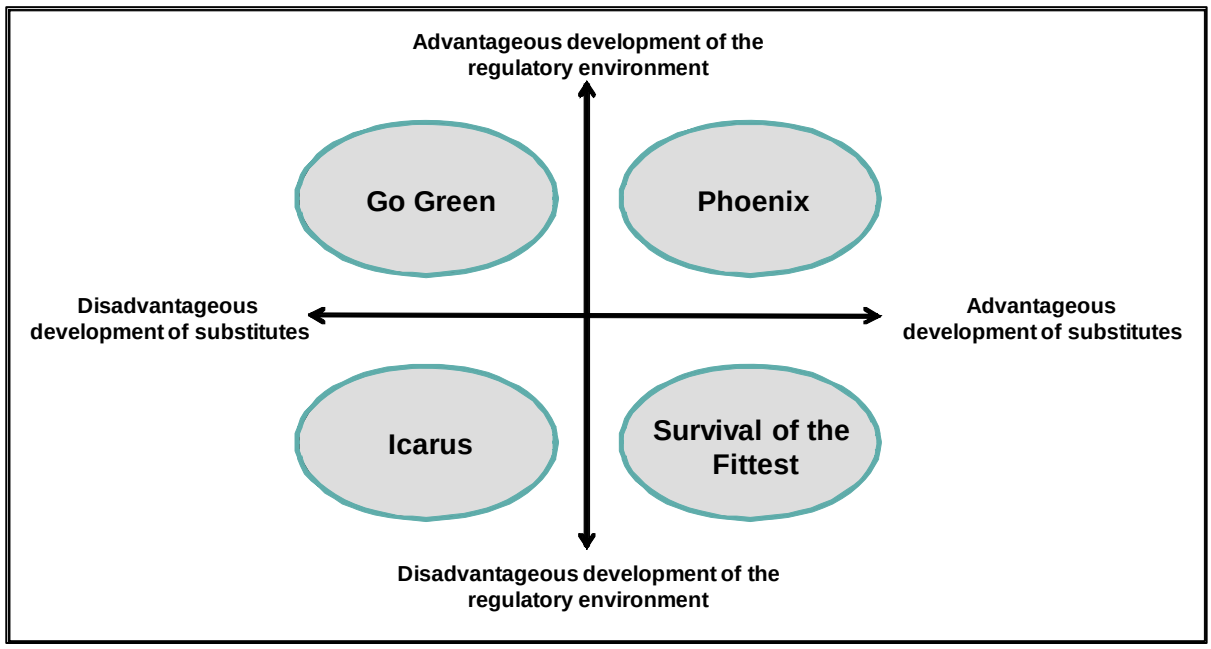


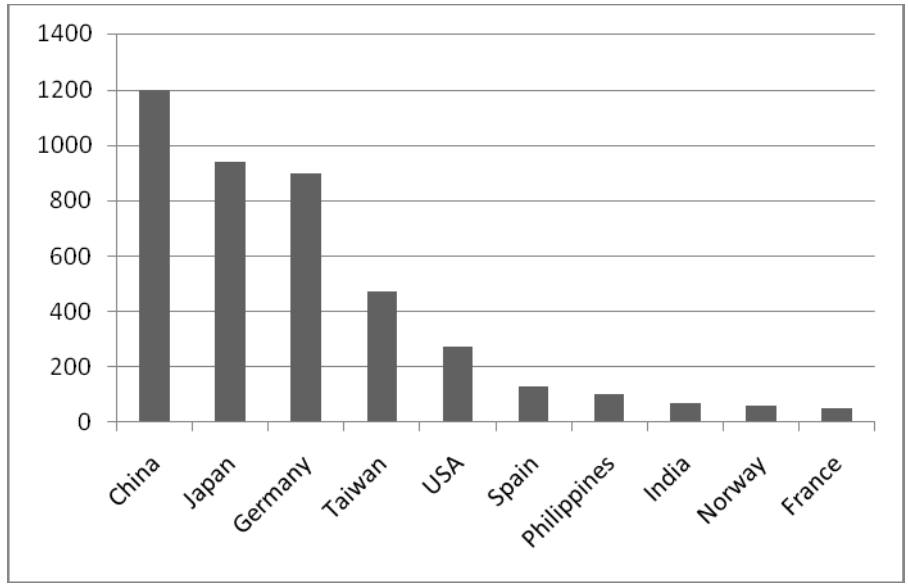
Figure 1: Future scenarios for the German photovoltaic industry

Each of these scenarios describes different possible developments of the industry in the next six years. They are not intended to predict the future. Rather, they aim at inspiring ideas and expanding the field of vision of industry leaders and at helping them to prepare for the opportunities and challenges ahead. The scenarios can serve as a foundation to develop company specific strategies and action plans that allow German players to remain competitive in this highly dynamic environment.

THE GERMAN PHOTOVOLTAIC INDUSTRY

Industry Overview

The German photovoltaic industry holds a number three position on the world market for solar cell manufacturing behind China and Japan. Taiwanese and U.S. companies also play an important role, whereas players in other countries are rather negligible (Figure 2).



Source: Bank Sarasin & Cie AG (2008)

Figure 2: The ten largest solar cell manufacturing countries in 2007 [MW/year]

The photovoltaic industry is characterised by a strong technological focus. At the moment, the market is dominated by silicon-based modules with a combined market share of almost 90 percent. Thin-film technology accounts for the remaining 10 percent. However, thin-film systems, as well as the third technological generation of modules, that will mainly be based on organic materials, are expected to grow significantly in the future and capture a large share of the market[3].

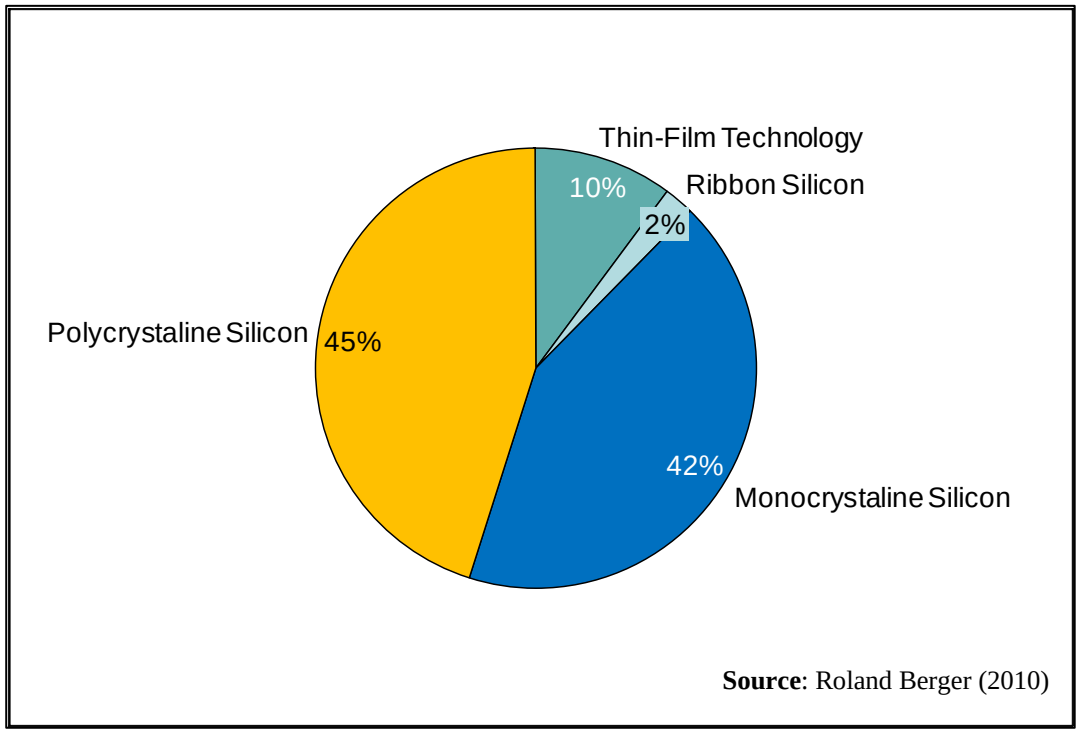


Figure 3: Market share with regard to technology [in percent]

Technological advances as well as decreasing production costs due to economies of scale have led to a continuous decline of the cost of energy generation from photovoltaic technology. Nevertheless, compared to energy production from fossil fuels or wind it is relatively expensive (Figure 4). Net parity, i.e. the point at which photovoltaic energy is as expensive as traditional energy, is yet to be reached.

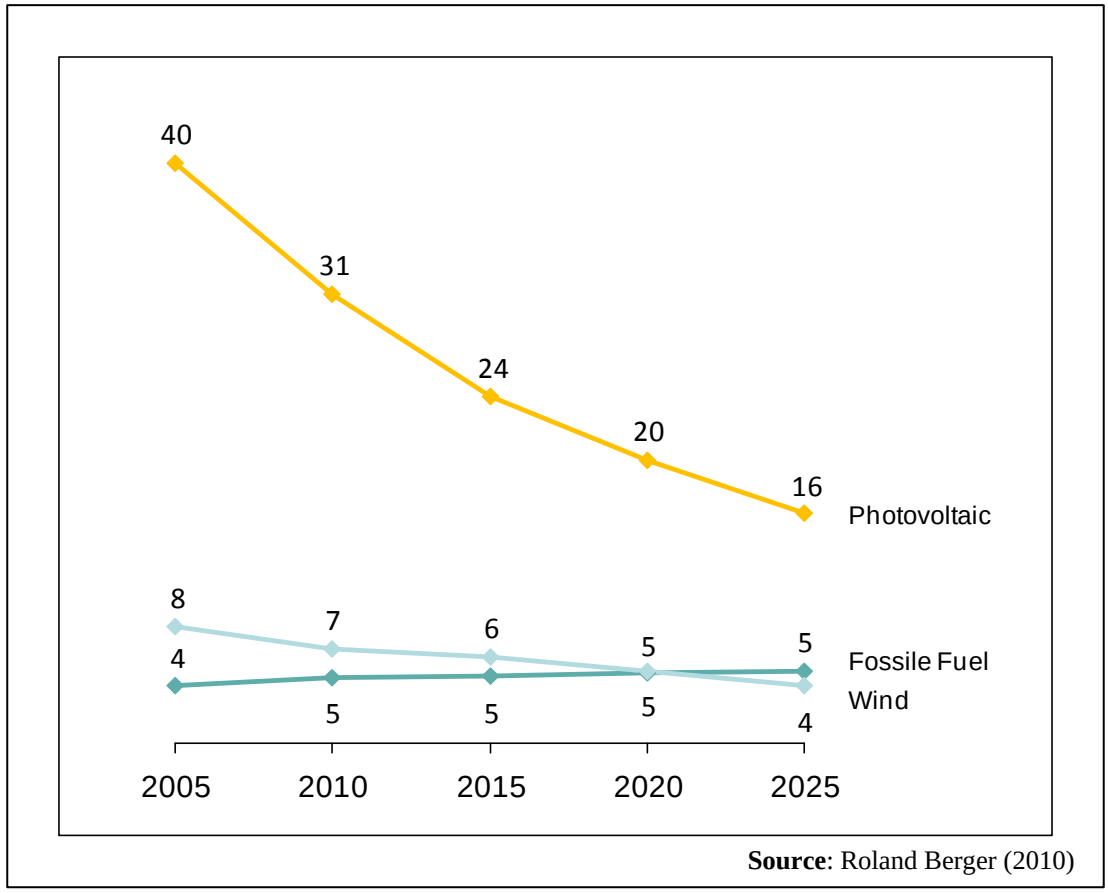


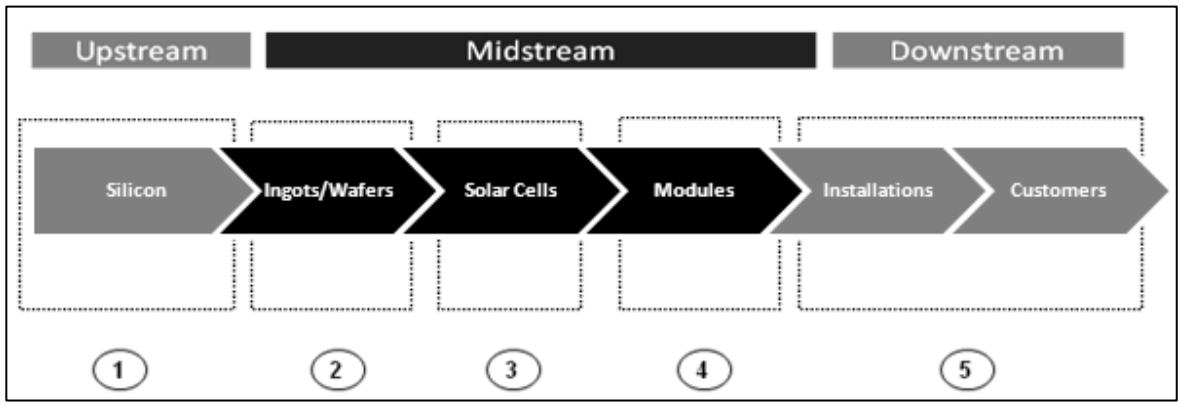
Figure 4: Development of energy generation costs in Germany [in Euro Cent /kWh]

The value chain of the photovoltaic industry comprises five major steps (Figure 5). In the first phase of the industry value chain, which comprises the extraction and refinement of raw silicon, WackerChemie AG has a dominant position. Wacker is the largest German silicon-producing company and number two in this sector worldwide[4]. In 2008 WackerChemie AG achieved a turnover of € 828.1 mill. with polysilicon (p-Si) - an increase of 81.2 percent compared to 2007. Simultaneously, the company reached an EBITDA-margin of 51 percent in the polysilicon segment[5].

The midstream part of the industry value chain comprises steps two to four. Here, the refined silicon is further prepared. At first the silicon is refined into bricks called ‘ingots’, that are

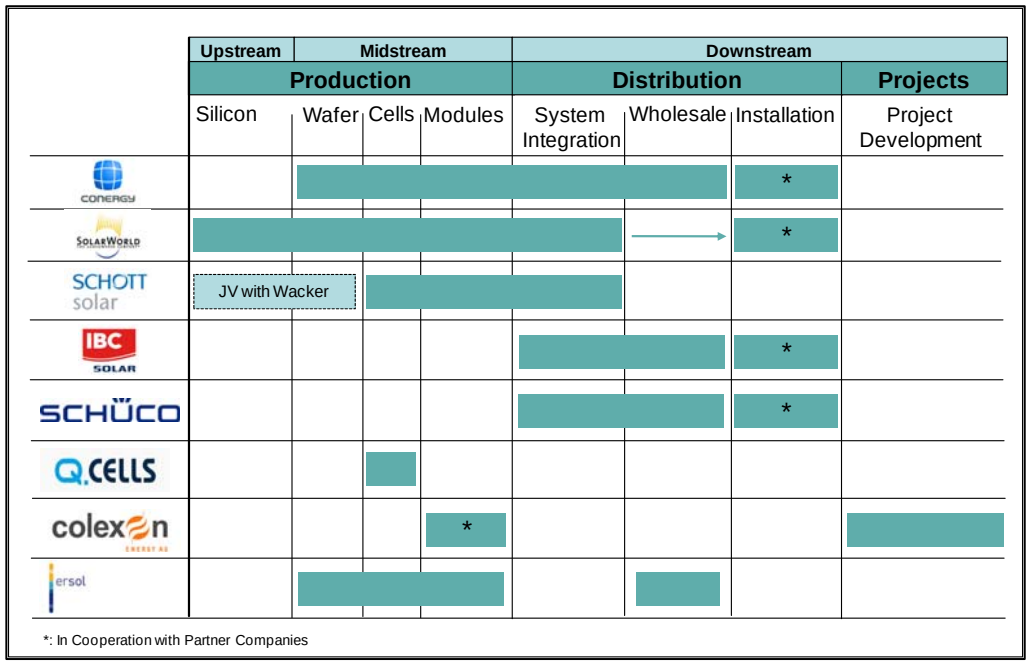
then cut into smaller slices, called ‘wafers’. Based on these ‘silicon slices’ solar cells with a photoactive layer are produced. In the fourth step of the value chain, the specific solar modules are put together e.g. to form a roof installation.

In the fifth step of the industry value chain multiple modules are connected together to form e.g. a power plant. This last step of the industry value chain also comprises customer service and the maintenance of the installation. Our scenario study focuses on the midstream part of the industry value chain, i.e. on companies that manufacture solar cells and modules as well as wafers and ingots. Figure 6 shows the activity areas of selected German photovoltaic companies. Figure 7 displays the major German companies and their sales revenues in the midstream part of the industry value chain.



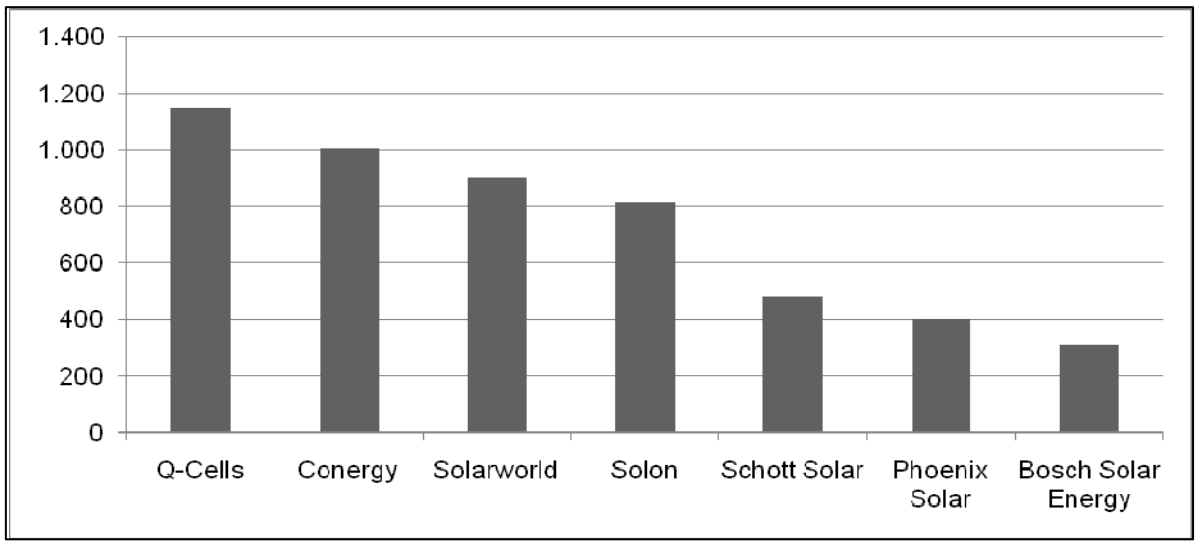
Source: Own compilation/adapted from Ernst &Young (2006)[6]

Figure 5: The silicon-based value chain in the photovoltaic industry



Source: Roland Berger (2010)

Figure 6: Value chain of selected German companies



Source: Own compilation/Annual reports 2008

Figure 7: Sales revenues distribution of the largest German companies, active in the solar cell manufacturing sector in 2008 [€ mill./year]

Important Regulatory Schemes

The German Renewable Energy Sources Act (EEG)

The aim of the Renewable Energy Sources Act – the 'Erneuerbare-Energien-Gesetz' (EEG) – is to increase the share of renewable energy in Germany, with the goal of reaching a share of 30 percent of the overall electricity supply by 2020[7].

According to the EEG in the version of the October 25th, 2008, every kilowatt hour (kWh) generated out of renewable energy sources is subsidised for twenty calendar years[8]. The extent to which a plant is subsidised depends on the capacity of the plant, the technology used, partially on its location and the point in time when it was connected to the electricity grid[9]. The carrier of the respective electricity grid has to feed the produced electricity into the grid[10]. The level of subsidies is based on a degressive function and decreases every year for newly installed plants[11]. This system is meant to put pressure on the companies that benefit from the subsidies to remain innovative and to lower their costs[12].

Technically, the EEG is not a governmental subsidy program but rather foresees an increase of the prices which end customers have to pay. Every electricity consumer pays 0.07 €/kWh for this so called EEG-apportionment[13]. Figure 8 displays the ranges of the feed-in tariff that the carrier of the respective plant is guaranteed to receive for the next twenty calendar years.

Form of energy generation	**Feed-in tariff range [€ ct/kWh] for the respective capacity of the plant**
Water-power	12.67 for < 500 kW; 8.65 for > 500 kW; 7.65 for > 2MW, <5MW
Bio mass	11.67 for < 150 kW; 9.18 < for 500 kW;8.25 for < 5 MW; 7.79 for < 20 MW
Geo thermal	16.00 for < 10 MW; 10.50 for > 10 MW
Wind energy onshore	9.20 starting subsidy for the first five years; 5.02 base subsidy.
Wind energy offshore	13.00 starting subsidy for the first five years; 3,50 base subsidy
Photovoltaic roof-installation	*43.01 for < 30kW, 40.91 for < 100kW, 39.58 for < 1000 kW, 33.00 for > 1000kW*
Photovoltaic open space installation	*31.94*

Source: Own compilation/ adapted from BMU (2009)

Figure 8: Feed-in tariffs under the German Renewable Energy Sources Act as of the 25th October 2008 for different forms of renewable energy generation.

The German government plans to reduce the EEG-subsidies in April 2010 by 15 percent and even more drastically in 2011[14]. This development, justified with decreasing market prices of modules, poses a significant threat to the German photovoltaic industry.

Figure 8 shows that photovoltaic installations are, no matter whether one refers to roof installations or open-space installations, compared to other forms of renewable energy generation the heaviest subsidized. The feed-in tariff for photovoltaic is at this stage five to seven times higher than the prices for conventional electricity at energy exchange markets[15]. The subsidies for photovoltaic electricity are estimated to sum up to € 77 bn. until 2013[16].

Over the coming years, however, the market for solar cell modules is likely to develop from a sellers' to a buyers' market[17]. A main reason for this is that the demand for modules in Spain will decrease, as the Spanish Royal decree 1578/2008, the Spanish equivalent to the EEG, contains a substantial reduction in the feed-in tariff of about 30 percent to 34 € ct/kWh and the introduction of a cap of in total 400 MW of newly installed capacity in 2009[18]. This equals a reduction of 50 percent in the subsidized market volume in 2009 compared to 2008.[19] In 2008, Spain was the largest market for photovoltaic systems in Europe and thus highly important for German solar cell manufactures that possess an export ratio of about 89 percent[20]. Combined with the financing problems of potential investors, caused by the financial crisis, this subsidy-reduction in Spain started the shift in the market equilibrium from a sellers' to a buyers' market.

The European Emission Trading System (ETS)

The European Emission Trading System (ETS) is a political instrument of the European Union to reach the climate objectives of a greenhouse gas emission reduction in order to slow down global warming, as set out in the Kyoto Protocol[21]. The ETS is applicable to electric power generation as well as to some other industry sectors like cement manufacturing or the steel industry in thirty European countries. These countries jointly account for about half of the European CO_2-emissions. The emission allowance trading system went into effect on January 1st, 2005 and is regarded as the pioneer for a future worldwide emission allowance trading system. The reduction ratified in 2002 by the EU member states foresees an 8 percent reduction of CO_2 -emissions in the EU and a 21 percent reduction in Germany from the base year 1990 until 2012. The basis of the ETS is a determination of national volume-contingents as well as rules for their allocation to companies or plant operators.

The ETS is for multiple reasons essential for the development of renewable energies in general and the German photovoltaic industry specifically. First, the costs of the CO_2-emission-allowances are a substantive factor in the operating cost structure of competing fossil power plants. They initiate eventually higher electricity prices. The introduction of the ETS has hence fostered the relative attractiveness of renewable energies.

Second, the development of the CO_2-emission prices has a significant influence on the point in time when forms of renewable energy generation such as photovoltaic reach parity with conventional forms of power generation. The higher the prices for CO_2-emissions are, the earlier renewable energy reaches parity.

The effectiveness and efficiency of the EEG in the light of the ETS is highly controversial. On the one hand the German Federal Ministry of Environment states that the EEG is a success story that has been copied by numerous other countries[22]. On the other hand various economists argue that the EEG has not led to any additional CO_2-emission reduction and is one of the most expensive forms of greenhouse gas abatement options. To make things worse, it has distorted competition in the energy market with significant long term effects on the German photovoltaic industry[23].

A definite decision has not yet been taken by the responsible actors as to what will happen to these two regulatory instruments and it is likely that multiple adjustments will take place over time. Regarding the ETS however, a trend towards even stricter emission conditions can be expected[24].

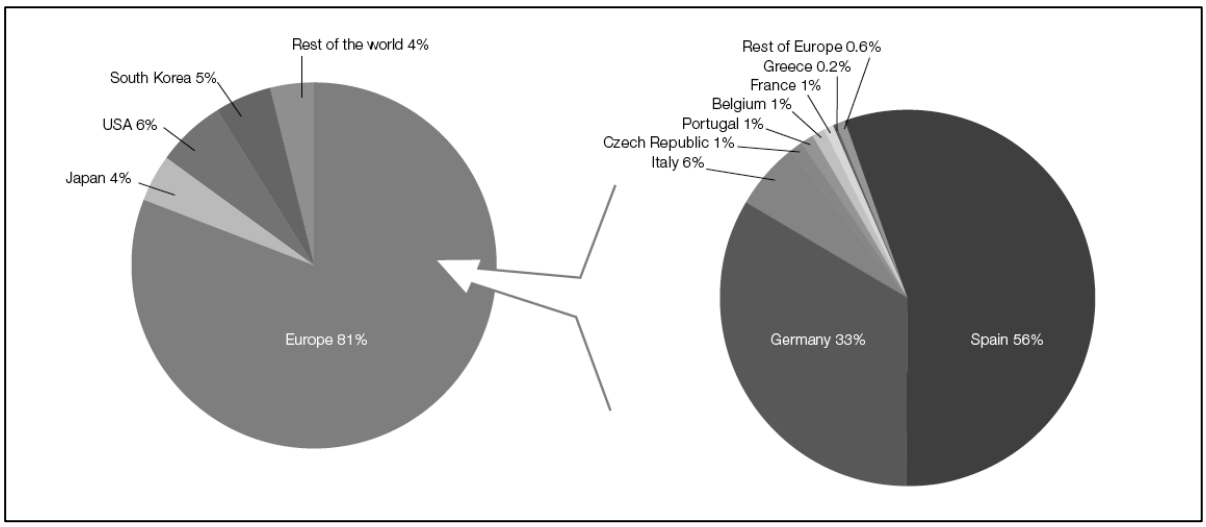
Global Opportunities

Market Opportunities

Especially in Europe, the markets for photovoltaic modules in terms of installed capacity have in the last few years been extremely dynamic. However, whereas in 2008 the growth rate was 164 percent, a decrease of 20 percent could be seen in 2009[25]. Only the German market with a growth rate of about 54 percent prevented an even sharper decline. In 2009, 40 percent of the total globally installed capacity was located in Germany. The lion's share of these installations were private household roof-installations. Large-scale power plant installations represent a potential major market opportunity. In this area particularly the USA could become an interesting market. The combination of a high solar radiation and a rela-

tively generous feed-in tariff of 0.35 €/kWh could also make South Africa an attractive market. As the market is still relatively young, however, the administrative procedures yet need to prove reliable.

Other markets such as Australia, Brazil, China, India and Turkey also carry a large potential. In these countries the potential lies in turnkey installations for electricity and light – so called self-sufficient solar home systems (SHS) – rather than in high feed-in tariffs. If these SHS become affordable for the population, the favorable solar radiation and the available space provide these countries with an enormous potential for photovoltaic installations. In the years to come, further market shifts not only in Europe but also worldwide are expected. Figure 9 shows the distribution of the installed photovoltaic capacity in 2008.



Source: EPIA (2009)

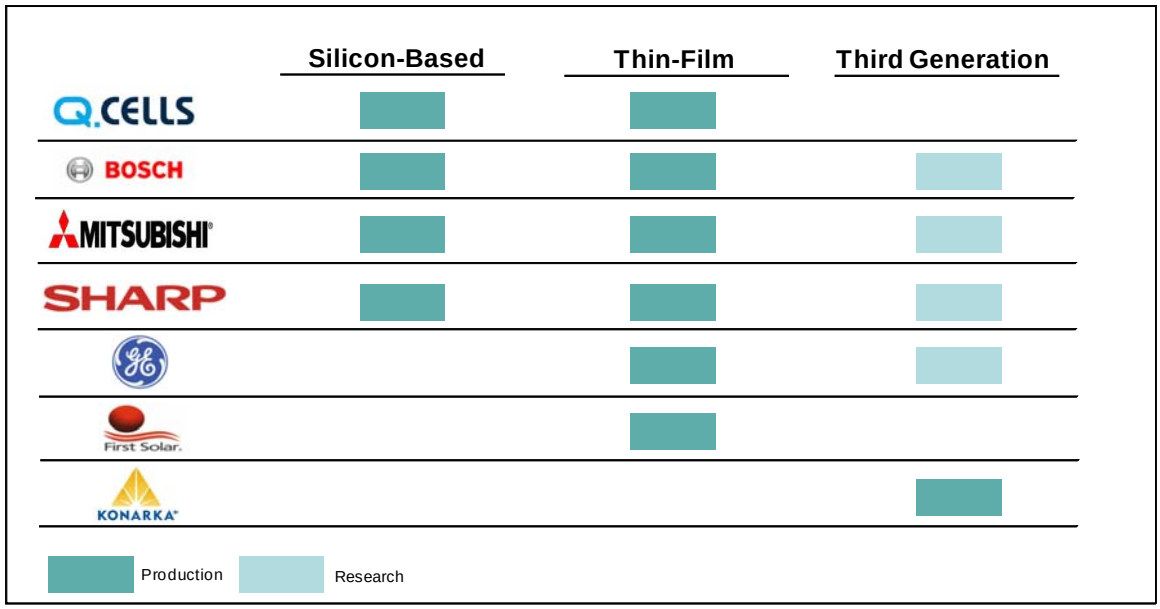
Figure 9: Regional distribution of the global and European photovoltaic markets [2008]

General Opportunities

The spot prices on the polysilicon market have dropped from about 350 USD/kg to 70 USD/kg[26]in recent years. A further decrease to around 35USD/kg until 2012 is not unrealistic. This takes away a large part of the cost advantage that the thin-film technology possesses over conventional photovoltaic installations. Thus, those companies that lag behind in manufacturing thin-film modules are granted more time to reposition themselves and to decide which extent of resources to invest into the thin-film technology.

This cost reduction also accelerates the possibility for the photovoltaic technology to reach grid-parity in some countries. Grid-parity in this context refers to the price a household has to pay for a kWh. For private households it is a significant incentive to obtain electricity cheaper from their rooftop photovoltaic installation than from a large supplier.

In the main technology areas of photovoltaic installations, the traditional silicon based solar cells and thin-film modules, major, but not all, German, Asian and U.S. companies are already in the production stage. Here, the R&D-focus is mainly on optimizing the coefficient of performance (C.O.P.), i.e. the solar cell-efficiency. Third-generation modules that are mainly based on organic materials are still being developed and only a few companies already produce solar cells using this technology (Figure 10).



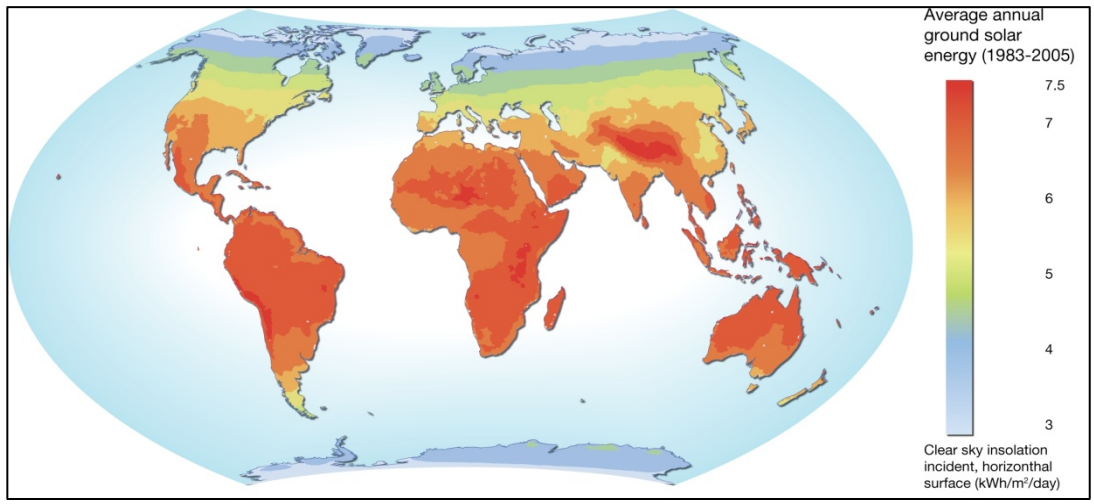
Source: Roland Berger (2010)

Figure 10: Technological focus: exemplary companies

Global Challenges

Market challenges

General upcoming challenges for the German photovoltaic industry are the market shifts that are expected to take place in the near future. The market shift to countries like Italy, Greece, France and the U.S.A.[27] implies that new administrative procedures in the respective countries need to be understood and handled. Figure 11 shows that also in countries like China or even large parts of Russia solar radiation is more favorable than in Germany.



Source: NASA (2008)[28]

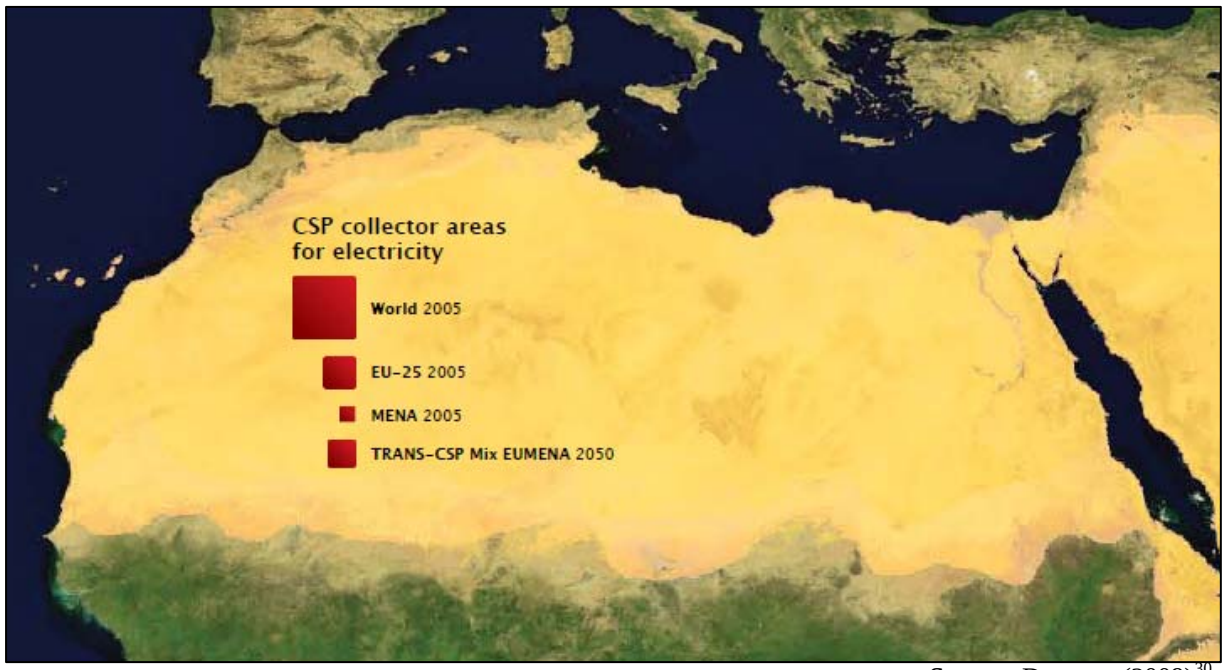
Figure 11: Solar radiation in different world regions

Technological Challenges

Amongst the several other forms of renewable energy generation like energy generation from water, wind, geothermic heat and bio mass, the outcome of our study has shown that the biggest competition in terms of a substitution threat to the photovoltaic technology originates from energy generation using solar thermal technology. This is particularly true for large-scale photovoltaic power plants. Therefore, in our scenarios, we will mainly refer to solar thermal power to exemplify substitutive threats to photovoltaic systems. These threats could, however, also come from other technologies.

Solar thermal power plants (CSP - Concentrating Solar Power) form a technological threat not only for the German photovoltaic industry but for the technology itself. The largest advantage of solar thermal technology lies in its capability to store energy which is not possible on the basis of photovoltaic technology[29]. Thus, the technology is also usable for base load

electricity generation. Due to falling polysilicon prices, however, photovoltaic technology is expected to be competitive from a cost perspective with solar thermal technology. Figure 12 shows the size of the areas that need to be covered by solar thermal power plants in order to cover the energy needs of different parts of the world.



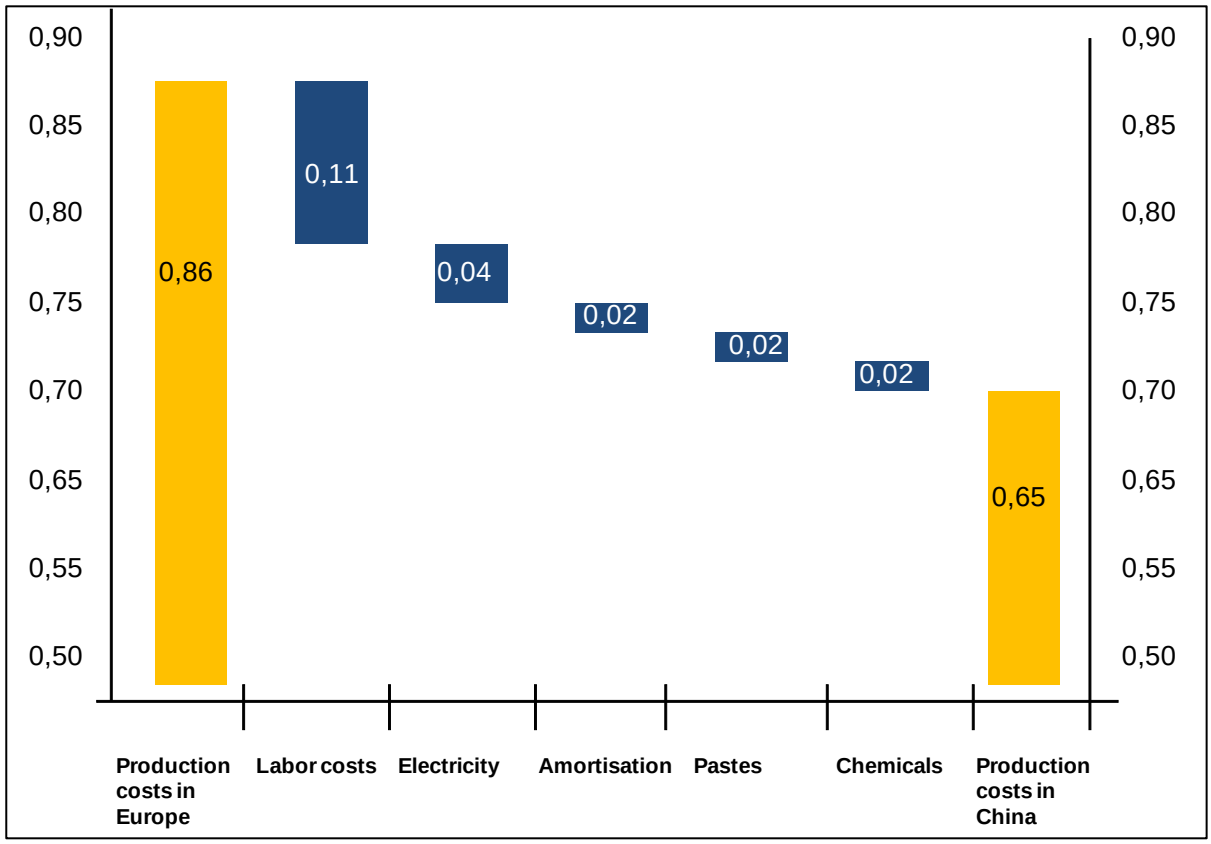
Source: Desertec (2009)[30]

Figure 12: Respective area to cover the energy needs of different parts of the world

The Desertec project is the bright vision for solar thermal power generation. Until this project is realized, investments of about € 400 bn. will have been made. Such investments are likely to give solar thermal power generation a technology boost and thereby also a significant head start compared to the photovoltaic technology.

Competitive Challenges

The biggest competitive challenge for companies in the German photovoltaic industry lies in making up for the cost advantage which Asian solar cell manufacturers enjoy at the moment. Asian competitors are presently producing modules at up to 30 percent lower costs[31]. Figure 13 shows a break-down of the cost advantages of Chinese producers.



Source: LBBW (2009)

Figure 13: Estimated production costs for 2009 in €/W

As modules of Asian and particularly of Chinese competitors are not of lower quality, German manufacturers will need to think about a strategy to counter this disadvantage. To make things worse, German manufacturers are partly bound to somewhat disadvantageous long-term polysilicon supply contracts.

Besides having to tackle cost advantages of Asian players German solar cell manufacturers also need to adapt to new market conditions and administrative procedures in diverse countries. Additionally, the development of rival technologies like solar thermal power poses a considerable challenge not only for German solar cell manufacturers but rather for the entire industry.

SCENARIOS FOR THE GERMAN PHOTOVOLTAIC INDUSTRY IN 2015

Based on the starting conditions in 2009 as well as the general outlook for the photovoltaic industry described above, we have created four scenarios which describe possible future states of the industry in Germany in 2015. These scenarios depend in particular upon the future development of two key uncertainties – the development of the regulatory environment as well as the development of substitute technologies. We have named these four scenarios “Phoenix”, “Survival of the Fittest”, “Icarus” and “Go Green”. They are described in the following, first in brief and then in more detail.

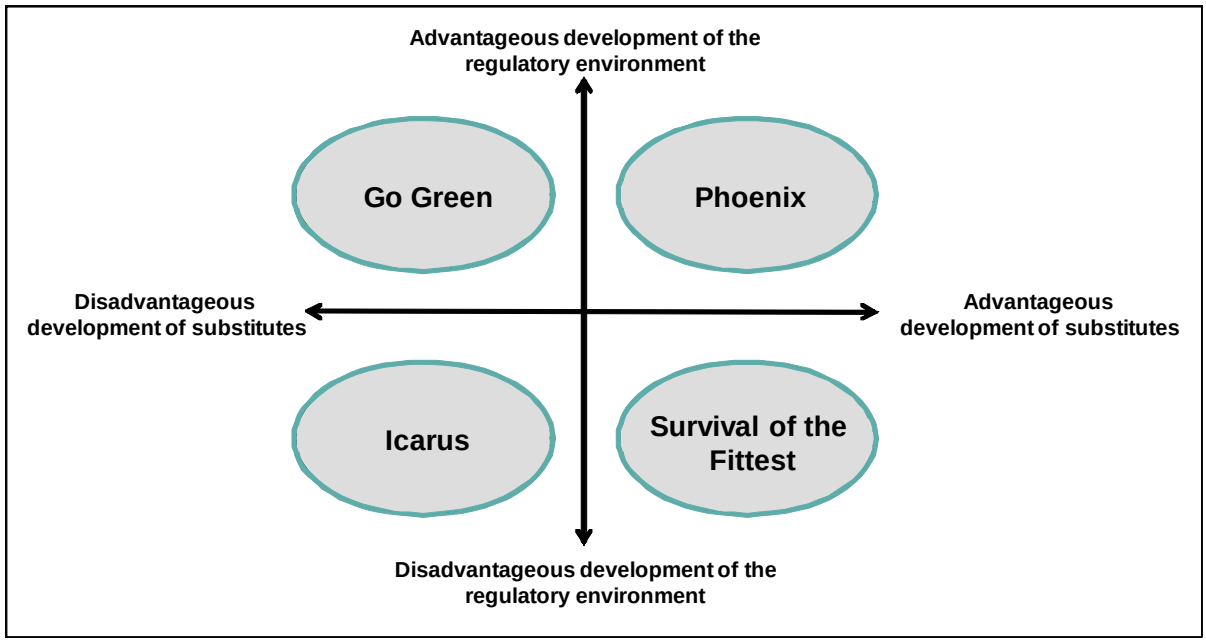


Figure 14: Future scenarios for the German photovoltaic industry

Overview

Phoenix describes a world that is dominated by German photovoltaic companies with a world market share of 30 percent. China’s share of the world market falls back to 25 percent, Japan’s to 17 percent and Taiwan’s stays at approximately 11 percent. 80 percent of photo-

voltaic systems produced are thin-film modules, in which European companies have a strong advantage compared to their Asian competitors due to their leading position in research and development. Global trade is free of barriers and the emerging markets for photovoltaic technology are openly accessible. Simultaneously, alternative technologies and projects like Desertec suffer from enormous problems. The integrative transmission grid within the European Union, a vital prerequisite for the realization of the Desertec project, lags tremendously behind schedule.

Survival of the Fittest describes a highly competitive world in which German subsidies for the industry have been cut significantly. The dominance of Asian solar cell manufacturers is as evident as never before. They account for three quarters of the world market. To be precise, China, Taiwan and Japan hold 35, 14 and 25 percent respectively of the world market. German solar cell manufacturers seem to be the clear losers of this process. The extremely price driven photovoltaic market is characterized by protectionism by the Chinese and United States' governments. The 'buy-domestic' clauses that both countries had included in their corresponding subsidy programs, the American Recovery and Reinvestment Act of 2009 and the Chinese 'Golden Sun' project, have been enforced. These clauses had the effect of trade barriers and excluded the European competition from the respective markets. In 2015 only 10 of the formerly 60 German solar cell manufacturers are still active in the market for solar cell production.

Icarus is a world in which all German photovoltaic companies have disappeared from the world market. In the course of an unseen wave of bankruptcies of German solar cell manufacturers, Asian solar cell manufacturers have gained a market share of over 95 percent. While both China and the United States build on 'buy domestic' clauses to protect their in-

dustry, the EU did not follow, leaving the European market open to competition from overseas. Yet another attack against the German photovoltaic industry comes from a side that no one had expected and assessed as a realistic threat. An alternative technology, the Desertec project, which in 2009 had by most experts been classified as a daydream of the large power suppliers, advances much faster than initially expected. Solar thermal energy is expected to be the main global energy provider for future years.

Go Green is a world in which European producers cannot meet the production costs and prices of their Asian competitors. Although production costs for solar cells in Germany have been sinking, their Asian competitors have managed to keep on selling their systems at significantly lower prices. Additional pressure is caused by cuts in German photovoltaic subsidies, which came along with the new version of the EEG. Although the German producers are unlikely to further lose out on their present market share, the substitution threat of alternative technologies like solar thermal power plants is hanging above the industry like a sword of Damocles. Once projects like Desertec are running and the advantages of solar thermal power plants become evident in large-scale practical usage, the subsidies for photovoltaic installations are likely to be cut drastically and reallocated to other forms of renewable energy generation.

Detailed Description

Phoenix

The phoenix is a mythical sacred firebird, which originated in ancient mythologies[32]*. It roots in the Phoenician, Egyptian and later also the Greek mythology. At the end of its life-cycle both the bird and its nest burn and fall to ashes. From this a new phoenix arises, reborn. Sometimes the bird is considered to be an emanation of the sunlight.*

30.06.2015 - Like a phoenix from the ashes, the German solar cell manufacturers shine in new splendor.

Germany is likely to take the lead from China as the largest solar cell producing country at the end of this year, having overtaken Japan in 2012. Forecasts predict that 30 percent of the globally produced solar cells will be manufactured in Germany. China's share of the world market is expected to fall back to 25 percent, Japan's to 17 percent and Taiwan's to stay at approximately 11 percent. Also the U.S. makes a leap forward, producing 11 percent. 80 percent of the photovoltaic systems produced are thin-film modules.

Following a prediction in 2009/2010 that the German solar cell industry would in the mid-term not be able to survive the competition – especially with its Asian rivals[33] – an astonishing process was triggered. The pressure that was put on the domestic solar cell manufacturers mainly by its Asian competitors that produced modules of similar quality at up to 30 percent lower prices[34], led to a healthy renewal process within the industry. Many companies went through a restructuring process and gained a technological advantage in building thin-film modules based on a disruptive technological innovation. This relatively new technology substantially over-exceeded the expectations in terms of efficiency. A R&D joint venture of so-

lar cell manufacturers and research institutions led to a quantum leap in terms of efficiency and economic viability of thin-film technology that gave the participating German companies the lead over their competitors by 2012. Especially, relatively young companies used this new technology to reach a sufficient degree of economies of scale and to become competitive earlier than expected. The efficiency of traditional solar cells that many of the foreign competitors had relied upon could not match this progress in thin-film technology. This success was and still is one of the bright examples of how a technological breakthrough invention made in Germany can be brought to market and converted into a competitive advantage by German companies. The combination of restructuring efforts and the advantage through technology also brought the production costs in Germany down to a competitive level.

Simultaneously, the Desertec project, which for a long time had been considered to push a rival technology – solar thermal power plants – to an efficiency and economic viability level which would condemn the photovoltaic technology to a niche existence was suffering from enormous problems. The integrative transmission grid within the European Union, a vital prerequisite for the realization of the project, was lagging tremendously behind time schedule. Without further progress in this aspect, however, none of the participants in the project consortium were willing to commit the large resources necessary for the realization of the project. Other forms of renewable energy generation faced similar problems.

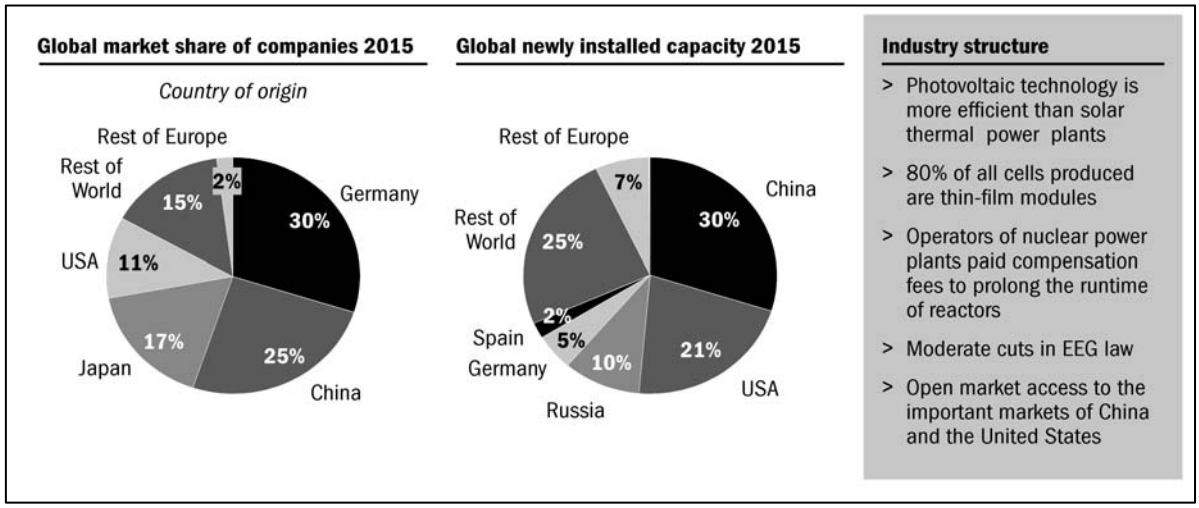
Another topic that troubled the industry in 2009 was the question of a delay of the nuclear exit in Germany. The concerns that the new government, a conservative-liberal alliance, would delay the nuclear phase-out and use nuclear power as the preferred instrument to reach the goals of greenhouse gas emission reductions, did only partly come true. The runtime of

some nuclear power plants was extended; the operators, however, had to pay a compensation fee, from which indirectly the photovoltaic industry benefited, as the earnings from this fee went directly to German research institutions with focus on photovoltaic technology. This regulation was a compromise with which the general public was satisfied, as the population was becoming more and more aware of the consequences of the climate change and the necessity to reduce the emission of greenhouse gases. The cuts in the EEG that the new government brought forward in 2010 were moderate and did not come unexpected. The developments of the subsidy programs in other European countries went into a similar direction with moderate reductions. Hopes were raised that from 2015 onwards these subsidy programs could start to be upgraded again. Politicians in Brussels stated in 2013, that they saw the fact that photovoltaic systems were on the edge of reaching parity with electricity generated by conventional power plants, as an opportunity to further deregulate the electricity market in Europe and put more competitive pressure on the large power suppliers. The vision that by 2030, 50 percent of the domestically consumed electricity would come from self-sufficient photovoltaic household installations did not seem completely utopian anymore.

China appreciated that the building of trade barriers was becoming more and more a problem for itself, as the EU was answering such attempts tit for tat and was thereby painfully affecting the growing Chinese economy. „Buy Chinese" clauses that were formerly included in the Chinese „Golden Sun"[35] project were abandoned in newer editions of the Chinese subsidy program. This paradigm change in Chinese politics granted German solar cell manufacturers access to the growing Chinese photovoltaic market. As China dropped its „buy domestic" clause, the United States' government followed and opened up the U.S. market to German

solar cell manufacturers. This combination of an advantage through technology and favorable external circumstances let the German solar cell manufacturing industry make a comeback that the least had expected in 2009.

Fact Sheet: Phoenix



Survival of the Fittest

The expression „survival of the fittest" was first formulated by the British scientist Herbert Spencer, after he had read Charles Darwin's book „on the origin of species"[86]. Originally the expression was used as an analogy to the process of natural selection. Today, this phrase is sometimes taken as an analogy for unrestricted competition.

30.06.2015 – Dark clouds in the sky above the German photovoltaic industry.

German solar cell manufacturers struggle for survival as they do not get fed by subsidies anymore. By the end of the year 2015 the dominance of Asian solar cell manufacturers is as evident as never before. China, Taiwan and Japan with 35 percent, 14 percent and 25 percent

respectively, account for almost three quarters of the worldwide solar cell production. German solar cell manufacturers seem to be the clear losers of this process. In 2007 still accounting for 21 percent of the worldwide solar cell production[37], Germany contributes only 10 percent to global solar cell manufacturing in 2015.Experts see the substantial cuts in subsidies that gradually took place, starting in 2009, as one of the major reasons for this development. The cuts in the EEG that started after the German parliamentary elections in September 2009 did not come as a surprise to the industry. Also, the nearly complete abolishment of regional subsidy programs that some federal states in Germany used to run, did not shock the industry.

What caused an unpleasant astonishment to German solar cell manufacturers, however, was the signaling effect that this adjustment had. Following the formerly largest photovoltaic market in terms of newly installed capacity[38], the other major countries which used the technology in Europe, like Spain, Italy or France, cut their corresponding subsidy programs drastically. These cuts reduced the total newly installed capacity in Europe enormously. In 2008 the newly installed capacity in Europe was 4,500 MW, accounting for approximately 81 percent[39] of the worldwide newly installed capacity. In 2012 however, only 1,000 MW were newly installed in Europe, accounting for 12 percent of the world wide newly installed capacity. This reduction increased competitive pressures significantly. German companies that in 2008 were already producing at significantly higher production costs compared to their Asian rivals[40], were struck the hardest by this development. Thus, also R&D investments had to be delayed and most German manufacturers continued to rely on traditional solar cells.

Yet, not only the European countries, but also the U.S. and the Chinese governments reacted in an unforeseen manner to the changes in European Renewable Energy Laws. The „buy-domestic" clauses that both China and the USA had included in their corresponding subsidy programs, the American Recovery and Reinvestment Act of 2009[41] and the Chinese „Golden Sun" project[42], were aggravated. These clauses had the character of trade barriers[43] and kept the German solar cell manufacturers from entering the growing Chinese market. This contraction of markets in Europe and the U.S. forced a large number of German manufacturers to file bankruptcy. Especially relatively young companies, that were too small to realize a sufficient degree of economies of scale, were affected.

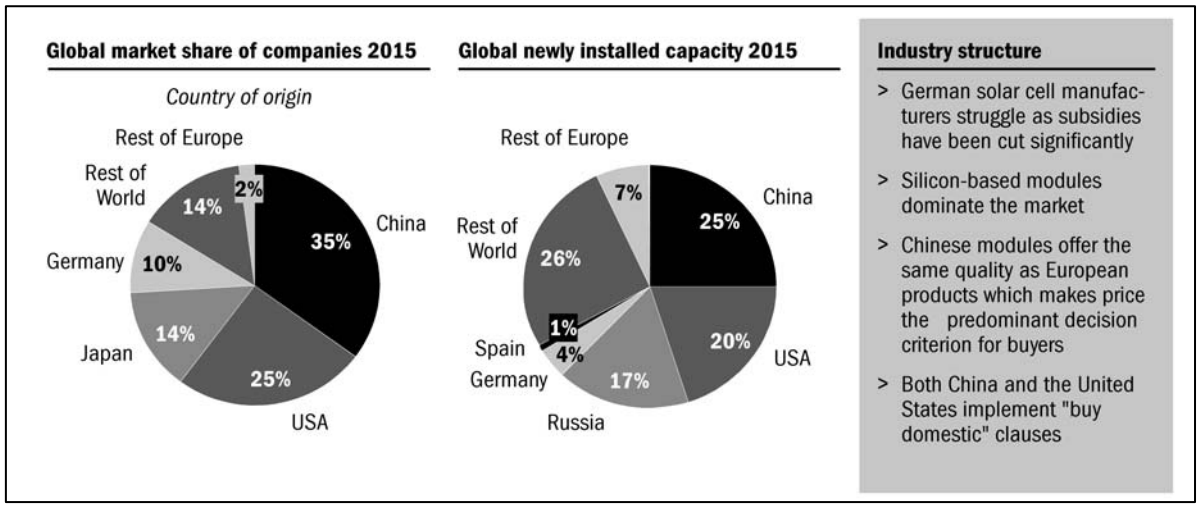
From a technological perspective, however, the situation of German manufacturers is not as difficult as many experts had expected in 2010. The learning curve effects that were predicted to bring the thin-film technology from a coefficient of performance (C.O.P.) of approximately 7 to 11 percent in 2008[44] into the efficiency range of silicon-based modules were not realized. By the end of 2014 thin-film-based solar modules reached efficiency levels of about 16 to 21 percent, whereas silicon-based modules were able to reach 25 to 30 percent. This gave the German industry a significant advantage compared to global competitors due to their strong position in this segment.

Other issues that had worried the industry in 2009/2010 neither materialized. The newly elected conservative-liberal coalition government did not extend the runtime of nuclear power plants, but instead chose to back renewable energies as the major instrument to reduce greenhouse gas emissions. Also the trend towards an ecological consciousness of the population continued. Surveys, however, showed that people did not care whether the photovoltaic-

installations on their roof were made in China or in Germany. As several tests had shown that Chinese systems or those of other Asian producers were of a similar quality as German systems, the system price was the predominant basis for the buying decision of the customer. Also, a different threat to the industry, the Desertec project, - like many other forms of alternative energy generation – made much slower progress than expected. Concerns about the feasibility of transmitting electricity from the Sahara to Europe were raised. Not only the technological challenges regarding the transmission from Africa to Europe, but also a possible strategic dependence were issues that concerned the European governments. The leap in efficiency and economic viability of solar thermal power plants – the technology used for the project – was thus delayed. Consequently the technology still does not pose the substitution threat to the photovoltaic technology, which some experts had projected[45].

In 2015 only 10 of the formerly 60[46] German solar cell manufacturers are still active in the market for solar cell production. These are, with a few exceptions, those companies that already in 2009/2010 had the size to absorb shocks and to adapt rapidly to the new, more hostile environment that they were facing due to the cuts in subsidies. Q-cells for example, formerly the world market leader and largest German solar cell manufacturer, acquired on its own 17 of the smaller companies that sprang up in the early 2000s under the subsidy shelter that existed at that time.

Fact Sheet: Survival of the Fittest



Icarus

Icarus is a character in Greek mythology[47]. Together with his father Daedalus, he was kept as a prisoner by King Minos in Crete. His father, a talented craftsman, built two pairs of wings out of wax and feathers for himself and Icarus to escape from Crete. Young Icarus, overwhelmed by the giddiness flying lent him, soared through the sky incautiously. Flying too high, he came too close to the sun so that the wax in his wings melted. And so, Icarus fell into the sea and died

30.06.2015 - The last German solar cell manufacturer has filed bankruptcy.

In the course of an unseen wave of bankruptcies of German solar cell manufacturers, Asian competitors have gained a market share of over 95 percent. This process was accompanied by a major technological shift: 85 percent of solar modules use thin-film technology. As an enormous surprise experts predict that already in 2020 42 percent of the total electricity con-

sumption in Europe will be generated by rival sources of energy generation, particularly the Desertec farms.

How could all this happen and how could a formerly showpiece-industry in Germany die? – Let's start from the beginning.

After the parliamentary elections in September 2009 in Germany, which saw the conservative-liberal coalition emerge as a winner, a lot changed. The German photovoltaic industry which already was under high competitive pressure from Asian solar cell manufacturers that were selling their modules at as much as 30 percent lower prices[48] was also attacked at several other frontlines. The first attack did not come completely unexpected.

The new government, constrained by the enormous amount of debt that the state had built up during the financial crisis[49], decided to drop its support for the German photovoltaic industry at once. Everyone had expected cuts in the EEG. What came as a real shock to German solar cell manufacturers, however, was that the government did not opt for a „buy European/German" clause in Brussels. The industry had hoped for this clause to be included into the new edition of the EEG and the corresponding legislation in the other European countries. This hope was not completely unjustified.

The U.S. and China had included similar clauses in their economic stimulus packages. The American Recovery and Reinvestment Act of 2009 contained a clause stating that all funds made available by this act were solely available if all manufactured goods used in a project were produced in the United States[50]. The Chinese „Golden Sun" project that guaranteed fiscal subsidies for the installation of up to 500 MW in China within the time period between

2009 and 2011[51], contained a similar clause[52]. While the Asian manufacturers quickly found a way around the American clause, by simply producing the module components in China and assembling them in the United States, none of the leading European politicians was willing to take similar steps.

Spain introduced a cap of 100 MW for newly installed capacity in its new edition of the Spanish Royal decree 1578/2010 and cut its subsidies drastically; similar adjustments to the corresponding programs could be seen in most other European countries. This caused the European photovoltaic market, formerly the world's largest[53], to shrink tremendously. The newly installed capacity in Europe decreased from some 4,500 MW in 2008[54] to some 500 MW in 2011. As a consequence of these cuts in the governmental subsidy programs, smaller regional subsidy programs[55] were completely abolished. The growing Chinese market was on the other side firmly within the hand of Chinese cell manufacturers. Officially, everyone had access to the market, but in reality Chinese politics made sure that most of the large orders and projects went to Chinese companies. The resulting competitive pressure was too high for many. From the about 60[56] solar cell manufacturing firms in 2008 only 5 were left in Germany by 2012.

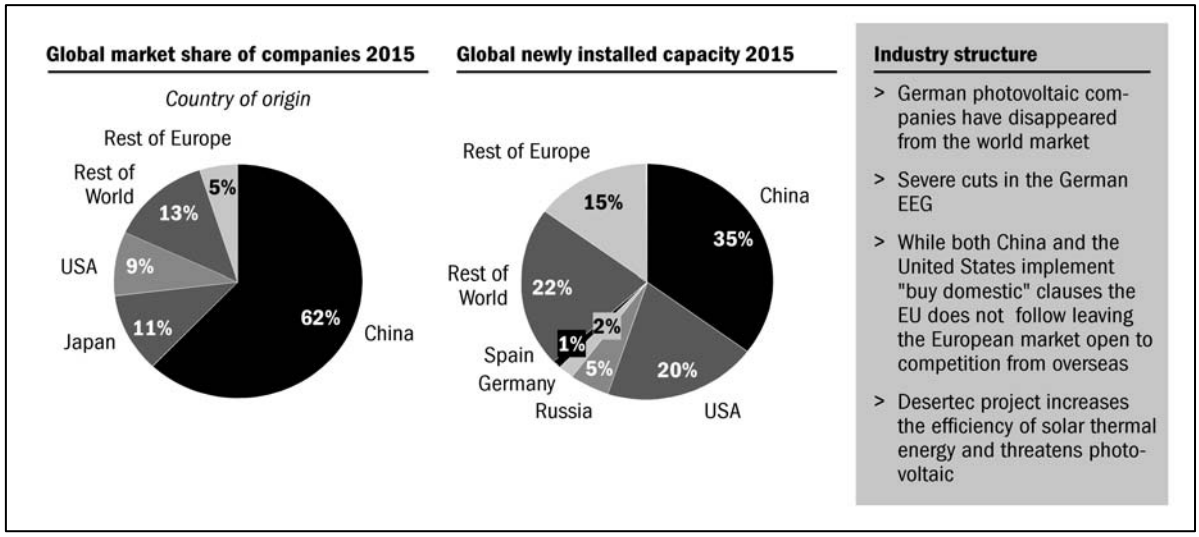
Especially young manufacturing companies that had not reached a critical size to realize a sufficient degree of economies of scale were crushed by this pressure early on. The fact that most of the German solar cell manufacturers had realized the cost-saving potential of the relatively new thin-film technology too late, additionally accounted for their inability to compete with foreign manufacturers. The German Minister of Economic Affairs stated: "There is no justification at all to subsidize an industry such as the German photovoltaic industry to the extent it used to be the case. There is no way to tell our citizens, especially in

times of a worldwide economic and financial crisis, that they have to pay more for electricity than they normally would have to pay without the subsidy[57]. We have already seen where this kind of politics leads us to. Opel, in 2009 still heavily subsidized, is now – in 2012 – bankrupt." This statement was an expression of the new economic rationale that increasingly became the underlying theme of the new government. People were still concerned by the effects of climate change. They understood and supported, however, the delay of nuclear exit in Germany[58] – in a first step until 2030 –, as a measure to reach the goals set for the greenhouse gas emission reductions. Thus, nuclear power at least partly became a substitute for photovoltaic systems as a means of reaching the CO_2 avoidance goals.

Yet another attack against the German photovoltaic industry came from a side that no one had expected and assessed as a realistic threat. Alternative forms of energy generation, particularly the Desertec project, that in 2009 had been classified as a daydream of the large power suppliers by most experts[59], advanced much faster than expected. The consortium of German companies, which started the Desertec project, was complemented by British, French, Italian and Spanish power-suppliers in a way that the project developed from a German to a European project[60]. No one had foreseen the political support and pressure to realize an integrated European transmission grid. For the project a large number of solar thermal power plants were built in the Sahara. Due to the enormous investments[61], the technology used for solar thermal power received a tremendous boost. The efficiency degree, economic viability and practical advantages over the relatively expensive German photovoltaic modules became very clear. In fact, these advantages were so evident that experts predicted already in 2012 that within 10 to 15 years even Asian manufactures would struggle to compete against this technology.

And so, by 2015 the last German solar cell manufacturer had to file bankruptcy. In the end the industry did not stand a chance against the drastic change in the regulatory environment in combination with the unexpected positive development of rival technologies.

Fact Sheet: Icarus



Go Green

The notion „go green", is meant to express the call for reducing greenhouse gas emissions, no matter how this is achieved. In this context „green" does not imply that only forms of renewable energy generation are addressed. Rather the whole range of instruments available to reduce greenhouse gas emissions is taken into consideration. Therefore, also electricity generation using nuclear power is included as a possible measure.

30.06.2015 – What will be the role of German photovoltaic systems in the quest to reduce CO_2 emissions?

The EU formulates new goals for reducing greenhouse gas emissions and aims at generating 32 percent of the total electricity consumption within the EU from renewable energy sources by 2025. This goal does not seem completely out of range, as alternative forms of energy generation like the Desertec project that began in 2010 have made tremendous progress. The German photovoltaic industry is despite the formulation of new climate protection goals in a troubled position. Asian solar cell manufacturers, especially the Chinese, have in recent years managed to further establish their position as the world's production line for photovoltaic systems.

The dominance of Asian solar cell manufacturers was to a great extent precipitated by the inability of German manufacturers to reach Asian production cost levels. Although production costs for solar cells in Germany were sinking, their Asian competitors managed to keep on selling their systems at significantly lower prices. This impeded many German solar cell manufacturers from reaching a size to realize the necessary economies of scale to lower production costs. The claim that Asian manufacturers were selling their products below original costs that was raised in 2009 by the German photovoltaic industry[62] proved to be false.

The process that triggered the distribution of market shares described above was strongly influenced by the developments that took place after the parliamentary elections in Germany in 2009. The new government reduced the subsidies for photovoltaic systems moderately in the new edition of the EEG. These adjustments did not come unexpected to the industry. Regional subsidy programs in fact were extended; even though they continued to play a minor role for the industry, these adjustments showed that politicians were aware of the rising ecological consciousness in the population. The subsidy program for photovoltaic installations in Spain followed a similar path as the EEG and kept the subsidies and the cap for

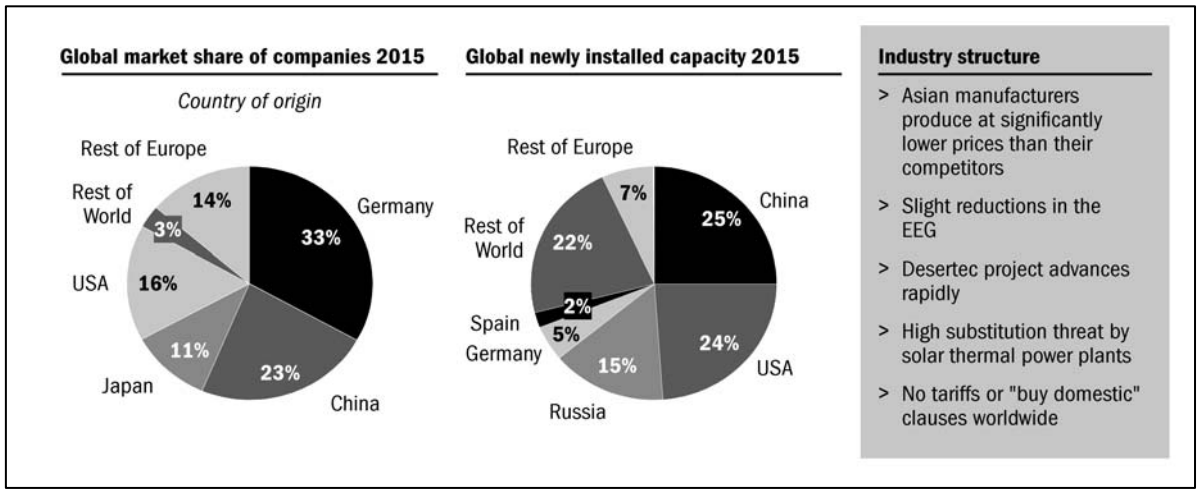
newly installed capacity relatively constant at the level of the Spanish Royal decree 1578/2008. Other European governments even extended their subsidies. Due to the abolishment of a cap in Italy and the retention of the inflation adjustment clause[63] in the French subsidy program for photovoltaic systems, France and Italy developed into highly attractive markets. The newly installed capacity in these two markets reached 800 and 650 MWp respectively by 2012. These developments in the European subsidy programs caused the U.S. and China to cut by 2012 the „buy-domestic" clauses that had been included in the 2009 editions of their respective subsidy programs, as they wanted to avoid the build-up of equivalent European trade barriers. This granted European manufacturers at least a limited access to the growing U.S. market. The expanding Chinese market, however, continued to be very difficult for German solar cell manufacturers.

The delay of the nuclear exit in Germany on which the new government decided after the elections in 2009 was on the other hand a rather unfavorable development for the German photovoltaic industry. The delay made nuclear energy a more and more accepted instrument to reach the targeted climate goals. The unforeseen rapid advances of alternative forms of energy generation like the Desertec project posed an even more serious threat to the photovoltaic industry in Germany. Because of the enormous investments in the project, solar thermal power plants reached efficiency levels that rival large-scale photovoltaic installations were still far from achieving. In 2014, experts predicted that once the remaining obstacles which the Desertec project was facing were overcome the advantages of solar thermal power plants would become so evident that the photovoltaic technology would be pushed back into a niche-existence. The fact that most German solar cell manufacturers did not possess a technology advantage in thin-film modules added to their difficult situation. Thin-film-based

photovoltaic-systems had in the past years reached similar C.O.P.s (coefficient of performance) as silicon-based systems, after learning curve effects had been realized as predicted by experts[64]. German companies could, however, not take advantage of this development and the resulting lower production costs which these modules had compared to silicon-based systems.

The above described development led in sum to a dangerous situation for those German solar cell manufacturers that still existed in 2015. The volume of the European photovoltaic market was kept artificially high by the subsidies of the governments. Although the German producers were unlikely to further lose out on their present market share, the substitution threat of other forms of renewable energy generation, particularly solar thermal power plants, was hanging above the industry like the sword of Damocles. Once the Desertec project would be running and the advantages of solar thermal power plants became evident in large-scale practical application, the subsidies for photovoltaic installations were likely to be cut drastically. Such a development is by many experts seen as the trigger of a potential complete doom of German solar cell manufacturing.

Fact Sheet: Go Green



IMPLICATIONS FOR PHOTOVOLTAIC COMPANIES

The four scenarios described above are not meant as predictions of the future development of the photovoltaic industry. Nevertheless, they describe realistic alternative pictures of the state of the industry in Germany in 2015. Therefore, it is essential for German solar cell manufacturers to start to prepare for all of these possible futures today. In this chapter we thus highlight a few strategy implications for German photovoltaic companies. Detailed strategy recommendations, however, can always only be derived in the light of the specific situation of the company at hand.

When assessing and comparing the strategy implications for the four scenarios, one can identify those recommendations that are common for all four scenarios as well as those that are specific for just one or a few of these scenarios. The common strategy recommendations form the basis of a core strategy which German solar cell manufacturers can start pursuing today independent of the exact future development of the industry. This core strategy is complemented by scenario-specific strategic options, which are realized if specific developments of the environmental conditions come true.

The core strategy for the German photovoltaic industry focuses on research and development. As a matter of fact, it is beneficial in all four scenarios to invest in making the photovoltaic technology more efficient and thus more affordable for its customers. By offering a technologically advanced product that generates higher output in terms of power generation, the company not only protects itself against potential substitutes but also against low price competition. As a matter of fact, we have shown in our scenarios that achieving a technological breakthrough is one of the major preconditions for the survival of the German photovoltaic industry.

R&D efforts need to be accompanied by lobbying efforts in order to safeguard the important German subsidies as well as to prevent trade barriers from being established. If trade barriers or “buy domestic” clauses are created or enforced in important markets, individual companies do not possess the power to go against these by themselves. Rather a joint effort by all German or even European companies is necessary. The German Association of Photovoltaic Companies (BSW) thus plays a crucial role in ensuring a positive competitive landscape for the photovoltaic industry in Germany and beyond.

This core strategy has to be complemented by scenario-specific strategic options which are briefly exemplified for the scenario ‘Go Green’. In this scenario subsidies in Germany have been reduced and competitive pressure by low-cost Asian manufacturers is high. For these circumstances two strategic options promise positive results. The first option is to build up production capacities on a large scale in Asia in order to meet or even undercut the cost base of rivals. The second strategy option consists in establishing joint venture agreements with technology leaders in alternative areas of renewable energy generation like solar thermal energy. On this basis solar cell manufacturers would be able to quickly restructure their product portfolio in case of a technological shift towards alternative technologies. Already today, companies can prepare for this option by taking first steps towards investing in Asia and towards establishing joint ventures.

The details of each scenario-specific strategy option certainly differ for each company, depending on their specific core competencies and positioning. These options thus have to be defined for each company individually. The robust core strategy, however, is applicable for all midstream companies in the German photovoltaic industry and only needs slight company-specific modifications in terms of the individual R&D focus. As German manufacturers

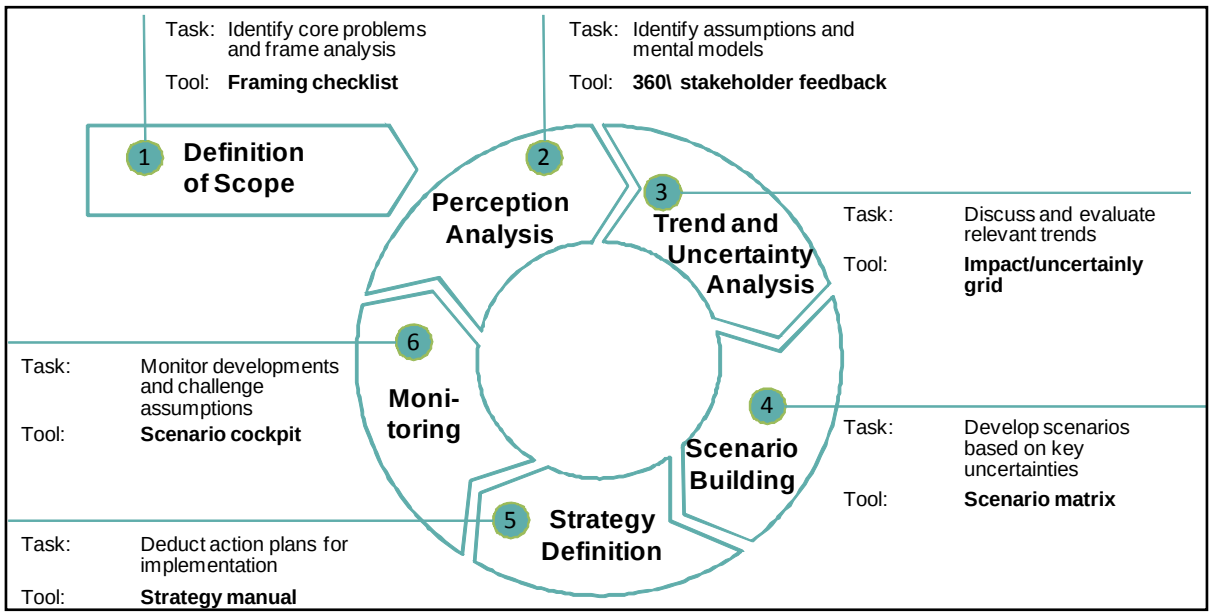
will be jointly affected by the negative or positive implications of tariffs and subsidies, joint steps need to be taken to ensure favorable competitive conditions for the industry in Germany also in the future.

METHODOLOGY

HHL-Roland Berger Approach to Scenario-Based Strategic Planning

Our scenario study is based upon the approach to scenario-based strategic planning that was jointly developed by HHL and Roland Berger Strategy Consultants. The approach does not only allow creating scenarios but also enables companies to integrate scenarios into their strategic planning processes.

Our approach consists of six process steps for each of which we have created a specific tool that eases business planning with scenarios in practice. The approach thus enables managers to on the one hand plan for multiple options. On the other hand it allows integrating and aligning external and internal perspectives to challenge existing assumptions and mindsets.[65]



Source: Wulf, Meissner, Stubner (2010)

Figure 15: HHL-Roland Berger Approach to Scenario Based Strategic Planning

Application for Industry Scenarios

The HHL-Roland Berger approach, though originally developed as a strategic planning tool for individual companies, can also be applied for the purpose of creating scenarios for the future development of different industries or countries. For this, only the first five steps of the approach are followed. Phase six, in which company specific strategies and environmental developments are constantly monitored, can in this case be omitted.

Description of Process Steps

Definition of Scope

In step 1 of our scenario development process, we define the project scope. Experts of our Center for Scenario Planning and project partners meet to agree upon the core goal of the project. This includes identifying core problems and framing the analysis. Our Framing Checklist tool makes sure that every important aspect is covered and that all project partners share a common understanding of the steps ahead.

In order to create the four scenarios for the German photovoltaic industry we applied this Framing Checklist. We defined the goal of the analysis to be the development of industry scenarios for the German photovoltaic industry until 2015. The industry itself is very diverse and companies vary significantly with regard to their level of integration. Therefore, this study specifically focuses on the midstream part of the value chain, which includes companies active in the ingot/wafer manufacturing, the solar cell manufacturing and the module construction.

Perception Analysis

In step 2 of our scenario development process, we apply our 360° Stakeholder Feedback tool in order to examine the assumptions and underlying mental models of different players in the industry as well as of external stakeholders. This reveals possible blind spots and weak signals.

In order to analyze the important influence factors of the German photovoltaic industry, we used the 360° stakeholder feedback tool and sent out a questionnaire to major solar cell manufacturers in Germany as well as to research institutions in order to get an overview on their assumptions as well as the trends and factors they considered important for the future of the industry. The internal view on the industry was represented by several major German solar cell manufactures which in 2008 had cumulative sales revenues of € 2,912 mill., equal to about 40 percent of the total sales revenues of the German photovoltaic industry. The external view on the development of the industry is represented by prestigious German research facilities with a focus on the photovoltaic industry.

The questionnaire was designed to get a holistic picture of the relevant political, economical, environmental, social and technological influence factors in the German photovoltaic industry. In each of these five categories several driving forces and factors that could potentially be important for the future development of the photovoltaic industry in Germany were included. Additionally, every category included three blank spaces to give the study participants the opportunity to name factors that originally had not been listed in the questionnaire.

Trend and Uncertainty Analysis

In step 3 of our scenario development process, we determine and analyze trends that are likely to impact the project partner in the future. With the help of our Impact/Uncertainty Grid tool, we cluster the trends according to their degree of impact and their level of uncertainty. Factors which score high on both dimensions are then transformed into 'key uncertainties', the basis of the next step in our scenario development process.

For the scenario generation in the German photovoltaic industry a workshop with specialists from the HHL Center for Scenario Planning was conducted. In this workshop, different influence factors that were gathered and rated by the experts in the previous process step were transferred into the Impact/Uncertainty Grid and clustered into critical uncertainties, trends and secondary elements (Figure 16).

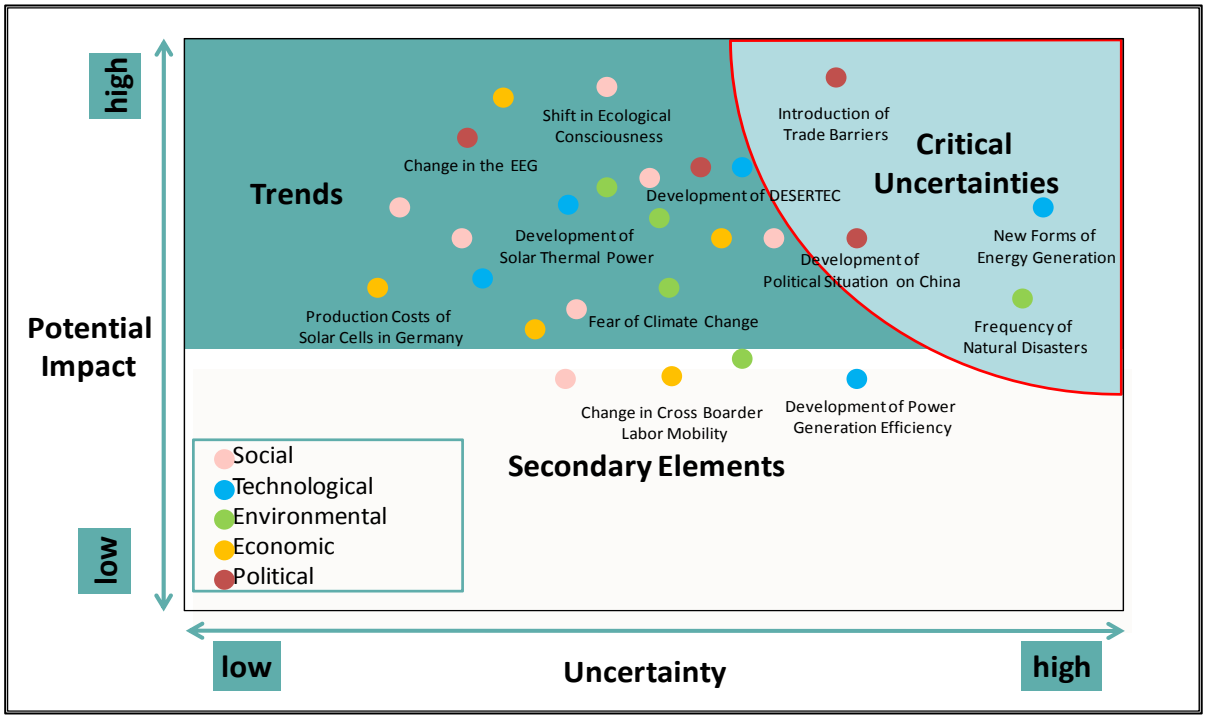


Figure 16: Impact/Uncertainty Grid for the German Photovoltaic Industry

An important task of this workshop was the identification of two key uncertainties which built the basis for the scenario development in the next process step. For this we clustered four and three related factors respectively into two meta-categories, which we call key uncertainties or scenario dimensions. The first scenario dimension is a cluster consisting of four critical uncertainties. These are:

- The development of subsidy programs such as the EEG in other European countries;
- The development of regional subsidy programs/politics;
- The introduction of trade barriers; and
- The development of the political situation in China.

Changes in each of these factors have a significant impact on the regulatory environment of the photovoltaic industry in Germany. Thus, together they form the scenario dimension **„Development of the regulatory environment"**.

The second scenario dimension, **„Development of substitute technologies"**, is a cluster consisting of three distinct critical uncertainties. These uncertainties are:

- The development of new forms of energy generation;
- The impact of the Desertec project; and
- A delayed exit of nuclear power generation in Germany.

These three factors not only significantly influence the relative competitive situation of the photovoltaic industry in Germany but the relative competitiveness of the photovoltaic technology as a whole.

Scenario Building

In step 4 of our scenario development process, the scenarios themselves are created. Using the Scenario Dimensions determined in the previous step, we derive possible futures and describe them in detail. Typically, four plausible and distinct scenarios are developed. Our Scenario Matrix tool guides this process step. To speed up the process and to make the scenarios as accurate as possible, we also use the know-how of global scenario experts assembled in our Scenario Network for this step.

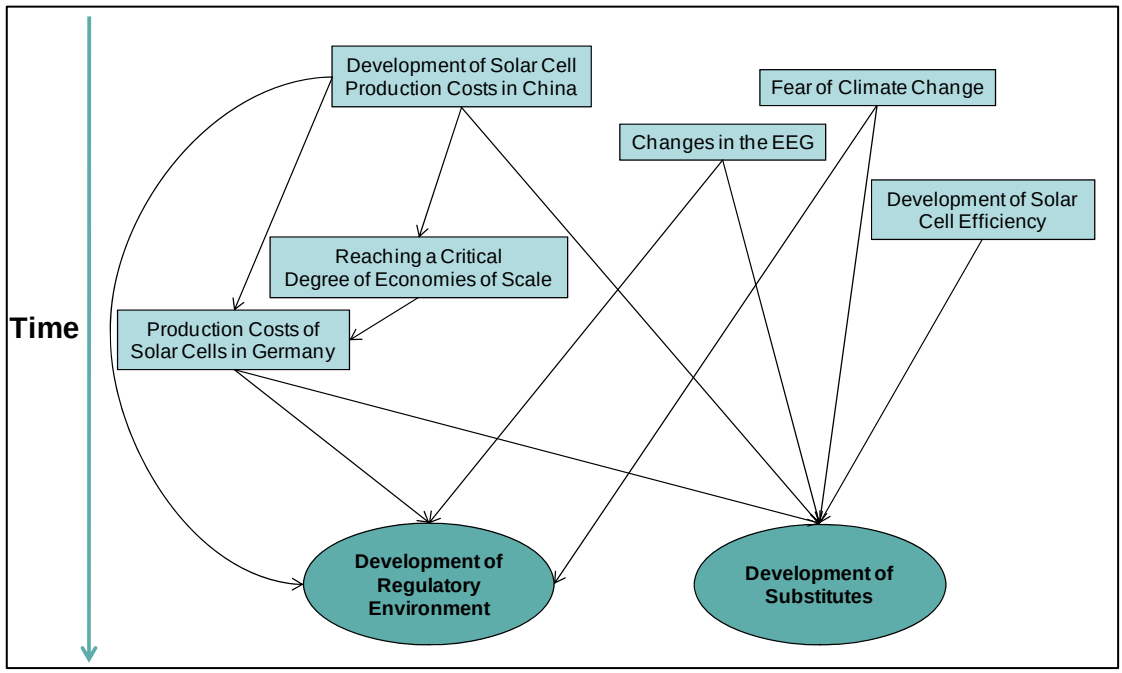


Figure 17: Simplified Influence Diagram for the German Photovoltaic Industry

In the present scenario project, the creation of the scenario matrix resulted in four scenarios for the German photovoltaic industry as described above. We named these scenarios “Phoenix”, “Survival of the Fittest”, “Icarus” and “Go Green”. In order to describe these scenarios in more detail, we created an influence diagram. This diagram displays the chain of causes and effects which lead to specific states of the two scenario dimensions. These influence diagrams formed the basis for the detailed description of the four scenarios presented above (Figure 17).

Strategy Definition

In step 5 of our scenario development process, we transform scenarios into action plans for implementation. With the help of our Strategy Manual tool, we derive detailed strategy implications for each scenario.

For the German photovoltaic industry we first assessed environmental and strategy implications individually for the four single scenarios. In a second step, we compared these recommendations in order to derive a core strategy. This core strategy was then complemented by scenario-specific strategic options. The details of each scenario-specific strategy option certainly differ between companies. They thus have to be defined individually for each company. The robust core strategy, however, is applicable for all midstream companies in the German photovoltaic industry and only needs slight company-specific modifications.

Monitoring

In step 6 of our scenario development process, we monitor scenario paths and adjust strategies if necessary. For this process step, we have created a tool called Scenario Cockpit. In the present analysis, however, this process step was omitted.

HHL CENTER FOR SCENARIO PLANNING

The HHL Center for Scenario Planning is jointly run by HHL – Leipzig Graduate School of Management and Roland Berger Strategy Consultants. It brings together internationally renowned experts in the fields of strategic management and scenario planning from both academia and practice. The Center's activities focus on four areas:

1. Research: We advance scenario knowledge by developing new methods and tools for strategic planning, researching the cognitive and behavioral effects of using scenarios in strategic decisions and developing new scenarios in a broad range of areas.

2. Teaching: We teach scenario planning to corporate managers and strategic planners in executive education seminars and workshops, PhD candidates in summer seminars and MBA and MSc students at HHL studying strategic management.

3. Consulting: We advise corporate, public and civil organizations on how to set up scenario planning structures and processes, review and adapt existing planning processes and communicate effectively to all stakeholders in times of uncertainty.

4. Networking: We provide a platform and act as a facilitator to bring together scenario experts from all over the world, bridge the gap between theory and practice and share ideas on what the future will look like.

Further information on the Center is available at www.scenariomanagement.de.

REFERENCES

[1] **Federal Ministry for Environment, Nature Conservation and Nuclear Safety** (2009): *Green Tech Made in Germany 2.0.* Munich.

[2] **Landesbank Baden-Württemberg** (2009): *Solardarwinismus – die Besten bleiben…* Branchenanalyse Photovoltaik 2009.

[3] **Roland Berger** (2010): *Roland Berger Strategy Consultants*, Munich.

[4] **Wacker Chemie AG** (2009): *Geschäftsbericht 2008: Wege zur Globalität*, http://reports.wacker.com/2008/gb/serviceseiten/downloads/files/gesamt_wacker_gb08.pdf

[5] **Ibid.**

[6] **Ernst & Young** (2006): *Photovoltaik in Deutschland: Marktstudie 2005 – Entwicklung und Trends.*

[7] **Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit** (2009): *Gesetz für den Vorrang erneuerbarer Energien (Erneuerbare-Energien-Gesetz)*, http://www.erneuerbare-energien.de/inhalt/40508.

[8] **Ibid.**

[9] **Agentur für Erneuerbare Energien** (2008): *Einspeisevergütung und Quotenmodell mit Zertifikatehandel auf dem Prüfstand*, http://www.unendlich-viel-energie.de/de/politik/detailansicht/article/153/einspeiseverguetung-und-quotenmodell-auf-dem-pruefstand.html.

[10] **Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit** (2009): *Gesetz für den Vorrang erneuerbarer Energien (Erneuerbare-Energien-Gesetz)*, http://www.erneuerbare-energien.de/inhalt/40508.

[11] **Ibid.**

[12] **Agentur für Erneuerbare Energien** (2008): *Einspeisevergütung und Quotenmodell mit Zertifikatehandel auf dem Prüfstand*, http://www.unendlich-viel-energie.de/de/politik/detailansicht/article/153/einspeiseverguetung-und-quotenmodell-auf-dem-pruefstand.html.

[13] **Ibid.**

[14] **Spiegel** (2010): *Regierung will Solarförderung schon ab April drastisch kürzen,* http://www.spiegel.de/wirtschaft/unternehmen/0,1518,672035,00.html.

[15] **Financial Times Deutschland** (2009): *Solarkonzern will auf Entzug: Solarworld-Chef Asbeck für Senkungen der Subventionen,* http://www.ftd.de/unternehmen/industrie/:gefallene-weltmarktpreise-solarkonzern-will-auf-entzug/50012772.html.

[16] **Ibid.**

[17] **Phoenix Solar AG** (2009): *Geschäftsbericht 2008,* http://www.phoenixsolar.de/InvestorRelations/Finanzberichte/2008/.

[18] **Rödl & Partner** (2008): *Pressemitteilung: Spanien bremst Wachstum der Solarindustrie-Einspeisevergütung wird reduziert,* http://www.roedl.de/upload/PM_080930_Solarindustrie_Spanien_end_5622.pdf.

[19] **Bank Sarasin & Cie AG** (2008): *Solarenergie 2008 – Stürmische Zeiten vor dem nächsten Hoch Technologien, Märkte und Unternehmen im Vergleich.*

[20] **Research and Markets** (2009): *The German Solar Photovoltaic Market: A New Era of Competition Daws,* http://www.researchandmarkets.com/reports/944699/the_german_solar_photovoltaic_market_a_new.htm and Ibid.

[21] **Landesbank Baden-Württemberg** (2009): *Solardarwinismus – die Besten bleiben… Branchenanalyse Photovoltaik 2009.*

[22] **Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit** (2009a): *Das Erneuerbare-Energien-Gesetz – eine Erfolgsgeschichte*, http://www.unendlich-viel-energie.de/uploads/media/Das_EEG_-_Eine_Erfolgsgeschichte.pdf.

[23] **Weimann, J.** (2008): *Die Klimapolitik-Katastrophe Deutschland im Dunkel der Energiesparlampe*. Marburg: Metropolis and **Sinn, H. - W.** (2008): *Das grüne Paradoxon, Plädoyer für eine illusionsfreie Klimapolitik*, Berlin: Econ.

[24] **Landesbank Baden-Württemberg** (2009): *Solardarwinismus – die Besten bleiben… Branchenanalyse Photovoltaik 2009.*

[25] **Bank Sarasin & Cie AG** (2009): *Solarenergie – grüne Erholung in Sicht.*

[26] **Ibid.**

[27] **Ibid.**

[28] **NASA** (2008): http://www.parario.com/resources/economy/articles/1/article.html.

[29] **Bank Sarasin & Cie AG** (2009): *Solarenergie – grüne Erholung in Sicht.*

[30] **Desertec** (2009): *Clean Power from Deserts, the DESERTEC Concept for Energy, Water and Climate Security.* White Book.

[31] **Landesbank Baden-Württemberg** (2009): *Solardarwinismus – die Besten bleiben… Branchenanalyse Photovoltaik 2009.*

[32] **Gebhard, H., and Ludwig, M.** (2005): *Von Drachen, Yetis und Vampiren – Fabelwesen auf der Spur*. München: BLV.

[33] **Financial Times Deutschland** (2009): *Suntech attackiert deutsche Solarkonkurrenz*, http://www.ftd.de/unternehmen/handel-dienstleister/:interview-mit-shi-zhengrong-suntech-attackiert-deutsche-solarkonkurrenz/50014372.html.

[34] **Ibid.**

[35] **Solarglobalgreen** (2009): *China Global Sun Project Aims to Speed Construction of Solar farms,* http://solarglobalgreen.com/pg/blog/justin/read/1278/china-golden-sun-project-aims-to-speed-construction-of-solar-farms.

[36] **Holmes, B.** (1994): Herbert Spencer. In: *Prospects*, 24, 533-554.

[37] **Bank Sarasin & Cie AG** (2008): *Solarenergie 2008 – Stürmische Zeiten vor dem nächsten Hoch Technologien, Märkte und Unternehmen im Vergleich.*

[38] **EPIA** (2009): *Global market outlook for photovoltaics until 2013*, http://www.epia.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/EPIA_docs/publica-

tions/epia/Global_Market_Outlook_Until_2013.pdf&t=1256640375&hash=bf5c703110825eaadefc5ddffad12cf5.

[39] **Ibid.**

[40] **Financial Times Deutschland** (2009): *Suntech attackiert deutsche Solarkonkurrenz*, http://www.ftd.de/unternehmen/handel-dienstleister/:interview-mit-shi-zhengrong-suntech-attackiert-deutsche-solarkonkurrenz/50014372.html.

[41] **Greentechsolar** (2009): *Of PV and buy American, excerpt GTM research report*, http://www.greentechmedia.com/articles/read/of-pv-and-buy-american/.

[42] **Solarglobalgreen** (2009): *China Global Sun Project Aims to Speed Construction of Solar farms*, http://solarglobalgreen.com/pg/blog/justin/read/1278/china-golden-sun-project-aims-to-speed-construction-of-solar-farms.

[43] **Samuelson, P. A., and Nordhaus, W. D.** (2007): *Volkwirtschaftslehre. Das internationale Standardwerk der Makro- und Mikroökonomie.* Italy: mi-Fachverlag, Redline GmbH.

[44] **Bank Sarasin & Cie AG** (2008): *Solarenergie 2008 – Stürmische Zeiten vor dem nächsten Hoch Technologien, Märkte und Unternehmen im Vergleich.*

[45] **Ibid.**

[46] **Germany Trade & Invest Gesellschaft für Außenwirtschaft und Standortmarketing mbH** (2009): *The Photovoltaic Industry in Germany – The World's Stongest PV Cluster - Industry Overview*, http://www.gtai.com/uploads/media/IndustryOverview_Photovoltaics_GTAI_01.pdf.

[47] **Schwab, G.** (1982): *Sagen des klassischen Altertums.* Frankfurt am Main: Insel Verlag.

[48] **Financial Times Deutschland** (2009): *Suntech attackiert deutsche Solarkonkurrenz*, http://www.ftd.de/unternehmen/handel-dienstleister/:interview-mit-shi-zhengrong-suntech-attackiert-deutsche-solarkonkurrenz/50014372.html.

[49] **Handelsblatt** (2009): *Das Konjunkturpaket II kommt*, http://www.handelsblatt.com/politik/deutschland/das-konjunkturpaket-ii-kommt;216470.

[50] **Greentechsolar** (2009): *Of PV and buy American, excerpt GTM research report*, http://www.greentechmedia.com/articles/read/of-pv-and-buy-american/.

[51] **Solarglobalgreen** (2009): *China Global Sun Project Aims to Speed Construction of Solar farms*, http://solarglobalgreen.com/pg/blog/justin/read/1278/china-golden-sun-project-aims-to-speed-construction-of-solar-farms.

[52] **Handelsblatt** (2009): *Solarbranche verlangt Schutzzölle*, http://www.handelsblatt.com/unternehmen/industrie/solarbranche-verlangt-schutzzoelle;2447470.

[53] **EPIA** (2009): *Global market outlook for photovoltaics until 2013*, http://www.epia.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/EPIA_docs/publications/epia/Global_Market_Outlook_Until_2013.pdf&t=1256640375&hash=bf5c703110825eaadefc5ddffad12cf5.

[54] **EPIA** (2009): *Global market outlook for photovoltaics until 2013*, http://www.epia.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/EPIA_docs/publications/epia/Global_Market_Outlook_Until_2013.pdf&t=1256640375&hash=bf5c703110825eaadefc5ddffad12cf5.

[55] **Solaranlagen.org** (2009): *Photovoltaik Förderung Fördermittel für Photovoltaikanlagen durch Bund und Länder*, http://solaranlagen.org/finanzierung/foerderung-photovoltaik.

[56] **Germany Trade & Invest Gesellschaft für Außenwirtschaft und Standortmarketing mbH** (2009): *The Photovoltaic Industry in Germany – The World's Stongest PV Cluster - Industry Overview*, http://www.gtai.com/uploads/media/IndustryOverview_Photovoltaics_GTAI_01.pdf.

[57] **Agentur für Erneuerbare Energien** (2008): *Einspeisevergütung und Quotenmodell mit Zertifikatehandel auf dem Prüfstand*, http://www.unendlich-viel-energie.de/de/politik/detailansicht/article/153/einspeiseverguetung-und-quotenmodell-auf-dem-pruefstand.html.

[58] **Financial Times Deutschland** (2009a): *Geld her oder schließen,* http://www.ftd.de/politik/deutschland/:atomausstieg-geld-her-oder-schliessen/50018076.html.

[59] **Manager Magazin** (2009): *Die Kalkulation von Desertec ist absurd,* http://www.manager-magazin.de/unternehmen/energie/0,2828,635955,00.html.

[60] **Bank Sarasin & Cie AG** (2008): *Solarenergie 2008 – Stürmische Zeiten vor dem nächsten Hoch Technologien, Märkte und Unternehmen im Vergleich.*

[61] **Financial Times Deutschland** (2009): *Zwischen Fata Morgana und Vision Wüstenstrom,* http://www.ftd.de/unternehmen/:wuestenstrom-zwischen-fata-morgana-und-vision/539623.html.

[62] **Financial Times Deutschland** (2009e): *Suntech attackiert deutsche Solarkonkurrenz,* http://www.ftd.de/unternehmen/handel-dienstleister/:interview-mit-shi-zhengrong-suntech-attackiert-deutsche-solarkonkurrenz/50014372.html.

[63] **Bank Sarasin & Cie AG** (2008): *Solarenergie 2008 – Stürmische Zeiten vor dem nächsten Hoch Technologien, Märkte und Unternehmen im Vergleich.*

[64] **Ibid.**

[65] **Wulf, T., Meissner, P., and Stubner, S.** (2010): *A scenario-based approach to strategic planning – integrating planning and process perspective of strategy, in press.*

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