Solar industry – Entering new dimensions

Comparison of technologies, markets and industries

November 2010

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Innovations add spark to the solar market

Dear Reader

I'm sure you must have noticed: for some time now - and with increasing frequency - the global media has been full of attention-grabbing headlines such as "Solar-powered aircraft successfully completes night flight", "Solar islands soon to appear on the world's oceans and in the Sahara" or "Solar-powered ship, the Superlative, embarks on round-the-world trip".

What may at first sight seem like a flood of sensational reports from the realms of science fiction is in fact concrete evidence of the exemplary innovation drive currently spanning the entire globe. It testifies to more than just the quantum leaps being made in the area of technology, but is symptomatic of an energy revolution that began back in 1954 with the visionary development of the first commercially viable solar cell and has now acquired a momentum that is propelling our society with full force towards a more sustainable future. This revolution is being driven by the strongest, most efficient and cleanest power source of all time, and moreover one that is practically inexhaustible: the sun.

Nowadays entire nations are actively encouraging the solar industry, and both small and large companies are investing not just in research & development, but also in production, as booming demand in the photovoltaics market holds the promise of dynamic growth in the coming years, following recent industry consolidation. In global terms, the solar industry has now reached the stage where it is capable of offering not only highly efficient but also very competitively priced products which are gradually closing the gap with grid parity. It's hardly surprising, therefore, to find that photovoltaics already accounts for 2% of total power generation in some regions of Germany, or that 30 million households in China are already being supplied with hot water produced by solar thermal systems, or that entire off-grid solar energy systems will soon be available worldwide at competitive terms. Last year alone, turnover in the global photovoltaics industry came to around 28 billion euros, and the innovation pipeline which provides the foundation for the next phase in the history of solar energy is bulging. Conviction, passion and perseverance will help to ensure that today's visions become tomorrow's reality.

So don't be surprised the next time you hear a piece of futuristic news emanating from the solar industry. Simply remember the words of Hermann Hesse: "To achieve the impossible, we must attempt the impossible again and again."

Kind regards

Burkhard P. Varnholt
Chief Investment Officer and
Member of the Executive Committee

Summary

Over the past two years the solar industry has shown itself to be incredibly resilient to the general economic crisis. Supported by cost-cutting and efficiency improvements, the photovoltaics (PV) industry has managed to achieve a growth rate of 87%, or 13.8 GW, of newly installed capacity in 2010. However, individual companies are feeling the strong price and margin pressure, and the intensifying competition. At least eight new PV markets with a potential annual capacity of 500 MW are expected to be added over the next two years. The PV industry will therefore acquire the stability and political autonomy it needs to be able to continue to grow unimpeded and to enter new dimensions. Concentrating solar power (CSP) and thin-film PV modules are jostling for the most cost-efficient technology for large-scale solar energy production. At the moment thin-film PV technology is just ahead. Nevertheless, CSP technology provides a number of important non-monetary advantages for utility companies. Solar collectors continue to play an important role worldwide for the supply of hot water to domestic and industrial consumers. They are likely to be more prominent in future.

PV industry holding up well

PV companies have had to contend with difficult economic conditions over the past two years in the wake of the global financial crisis, mounting overcapacity, intensifying competition and reductions in feed-in tariffs. Last year the turnover of the global PV industry reached almost EUR 28 billion, an increase of eight percent on 2008. Total installed solar energy capacity worldwide has now passed the 30 GW mark, which is enough to supply 10 million households with clean electricity.

Constant price and margin pressure affects all companies

Production capacities will continue to be expanded along the entire PV module value chain over the next few years. The risk of bottlenecks occurring is very small, in our opinion. After six consecutive quarters of falling prices, module prices began to recover slightly in the second quarter of 2010. Even so, prices are roughly 25% down on the previous year's level.

Sufficient quantities will also be available of other important components for PV systems, such as inverters, cables, mountings, etc. This buyer's market will keep price and margin pressure high. This pressure will no longer be restricted to module producers, but to an increasing extent to other components as well (BOS, Balance of System). Prices for a solar system will therefore continue to remain attractive and will be relatively flexible in accommodating the new feed-in tariffs.

Financial analysis: new valuation for the PV industry

The sharp fall in PV module prices has left its mark on the profit & loss account and the weak stock market performance of solar energy companies. The profitability of the PV industry has dropped off significantly in the past few years. The high profit margins of the young, but at the same time heavily subsided, PV firms are now a thing of the past and the industry is now steadily evolving into a mature industry with competitively priced mass production. This is reflected in the current stock market valuations of solar companies, which have fallen back from their highs in 2006/2007 to the same level as mature industries such as semiconductors and electronics.

New mood of confidence in thin-film PV technologies

Despite substantial price pressure from silicon-based modules, some thin-film PV (TFPV) companies seem to be doing well. There are certainly encouraging developments as far as production capacities, efficiency and cost base are concerned. Bankability continues to play a key role for

these new technologies, and some TFPV manufacturers appear to have convinced banks with their business plans. The market share of TFPV technologies as a proportion of total solar cell output rose by five percentage points in 2009 to 18%. Almost half of all TFPV modules were produced by *First Solar*. By 2012, TFPV modules will account for 30% of total PV cell production, comfortably outpacing the market as a whole. Within the TFPV technologies, copper-indium-gallium-diselenide (CIGS) technology is set to enjoy superior growth of around 100% p.a. over the same period.

Feed-in tariffs – uncertain times ahead

The rapid growth of the PV industry and the success story of "feed-in tariffs" both seem to be entering a critical phase. There is growing criticism from political circles and consumer pressure groups about the size and mounting costs of feed-in tariffs for solar power. Rising electricity prices and soaring public deficits are causing headaches for many governments in Europe, and solar energy is becoming a scapegoat. The crux of the matter is that these additional costs can be accurately calculated, while the associated savings (including lower spending on imported fuels such as gas, coal and oil, or downward pressure on the price of electricity traded on exchanges, or climate change prevention) are not quite as easy to quantify. By making steeper reductions in tariffs for ground mounted systems or providing additional incentives for building-integrated systems, policymakers are setting clear signals for PV systems installed on buildings. Above all investors would like conditions governing tariffs to be stable and predictable – an essential prerequisite for calculating and financing future projects.

New countries powering the PV industry forward

By introducing feed-in tariffs (a concept first developed by the German politician Hermann Scheer, who died in October 2010) Germany showed the way forward and played a pivotal role in making the enormous growth of the global PV industry possible. In the past, the German market has proven to be very elastic on the price front, making it the most important motor of the global PV industry even in difficult times. Other dynamic markets are now needed to provide effective support for Germany's PV market. It is definitely in the entire industry's interests to break into new geographical territory. By 2012, at least 8 new markets will drive the industry's expansion, with newly installed PV capacity exceeding 500 MW p.a. These include France, Italy, Spain, the USA, Canada, China, India and Japan. They will provide a diversified regional platform for stable growth in future.

PV market forecasts up to 2015

We expect newly installed PV capacity to reach 13.8 GW by the end of this year. This is equivalent to a growth rate of 87%. Looking ahead to 2011, we expect the PV market to have a particularly difficult first quarter. In many leading European PV markets, substantial cuts to solar energy subsidies are due in the new year. This could trigger a significant slump in demand for PV modules, although this should pick up again from the second quarter onwards. Overall we expect growth to reach 10% in 2011. Newly installed capacity worldwide is expected to expand by 33% p.a. on average over the period 2009 to 2015. Most of the growth will come from non-European markets, which should outperform. We expect China to achieve an annual growth rate of 77%, India with 76% and the USA with 70% will be close behind. Europe itself will continue to grow by roughly 16% p.a. By 2020 we expect the global market volume to rise to 116 GW newly installed capacity.

Grid parity within reach

Of all the renewables, photovoltaics has been most successful in driving down costs. Solar power is therefore rapidly becoming a competitive source of renewable energy. More and more markets are on the brink of achieving grid parity for private end consumers. For PV companies, this opens up exciting new opportunities for innovative system solutions, including electricity storage and management.

Environmental and social standards becoming increasingly important

As the PV industry continues to gain in maturity and size, the expectations of investors and the general public are also increasing. The emphasis is on transparent reporting and setting high targets for environmental and social standards. Here a renewable technology needs to present good credentials. Virtually emission-free electricity production cannot let itself down in the area of manufacturing of solar cells and modules as a result of pollution, health or safety concerns. *Bank Sarasin* therefore supports the "Sustainable Solar Initiative" launched by *Henderson Global Investors*.

CSP and large-scale PV plants: still in the race

In 2009 and 2010 around 1.4 GW of new capacity was installed for concentrating solar power (CSP) systems. This is an enormous growth spurt for this type of solar technology, but unfortunately it has not yet resulted in corresponding cost savings. Cadmium telluride thin-film PV systems can now produce electricity very economically. Furthermore, smaller PV projects from 2 to 20 MW can easily be completed within 18 to 24 months without a significant investor risk. By contrast, it may take up to 4 years to develop a CSP plant. Nevertheless, the CSP industry has the potential to cut its electricity production costs by 30 to 50% in the coming years. Furthermore, solar thermal electricity (STE) can provide a better quality of electricity for utilities because it is easier to store and dispatch, and is also suitable for use in hybrid power plants. Over the next 10 years the number of CSP plants will grow by 12% p.a. on average. This will bring cumulative CSP capacity to 32 GW by 2020.

Solar thermal power lacks stable growth

While the Chinese market for solar thermal power has been steadily growing for a number of years, the stable foundation for constant growth is missing in European and other solar thermal markets. After growing in 2008, both European and North American market shrank in 2009, by 10% and 15% respectively. We expect the European market to decline another 10% this year. Unfortunately the importance of solar thermal power has still not been fully recognised, which means it is not being consistently encouraged. Today more than 70 million households worldwide already obtain their hot water from a solar collector. As soon as energy prices start to climb again and the construction industry recovers, a solar thermal system will once more rapidly become attractive. Suitable building regulations should consistently require the use of solar thermal systems. We forecast global market growth in the region of 20% p.a. over the long term.

Solar energy – ideal to meet emerging markets' growing appetite for energy

At the current price level, and with costs being cut so rapidly, off-grid systems are starting to become more popular in emerging countries, whether to heat water or supply electricity. CSP systems also provide a sustainable solution to the enormous demand for energy in developing and newly industrialised countries. These solar technologies can already contribute to the social and economic good without any negative impact on the environment. For solar energy, these are important application areas for the future.

Photovoltaics (PV)

The reduction in feed-in tariffs across many different countries in Europe has been the dominant theme over the past 12 months. Despite these precarious overall conditions, the PV industry has managed to boost its production capacities and increase its sales. Continuous cost savings have allowed the necessary price adjustments to be made, thereby sustaining demand. For 2010 we therefore expect a dynamic growth rate of 87%. The outlook for thin-film technology is also more upbeat this year. Some of the key players are significantly ramping up their production lines. Our analysis of the attractiveness of individual countries highlights existing stars, as well as a number of interesting new PV markets. Despite the volatile environment, Bank Sarasin sets out to provide a forecast for the PV industry and tracks the steady progress towards grid parity.

Supply and cost trends

Slight market consolidation in 2009

After the difficult autumn of 2008 with the start of the financial crisis and the cap imposed on the Spanish PV market, expectations for 2009 were much more subdued. This new situation triggered a slump in demand and consequently an excess supply of modules. Many therefore feared there would be significant consolidation among the 250 or more manufacturers of solar wafers, cells and modules.

Looking back, we can see that these pessimistic predictions were never fully realised. Obviously almost every PV company had a challenging first half in 2009. Well-known companies such as *Q-Cells*, *REC*, *Solon*, *BP-Solar*, *United Solar*, *Suntech Power* and others were forced to restructure and shed jobs. A number of smaller firms were also bought up. *MEMC* purchased *SunEdison*, while *First Solar* acquired *Next Light* and *Optisolar*. There was also a series of mergers between producers of wafers, cells and modules. Only a few actually went out of business. *Sunfilm* and *Signet Solar*, key clients of *Applied Materials* (Sunfab production line for amorphous silicon modules) had to file for bankruptcy in April 2010. In addition, *BP Solar* and *General Electric (GE)* shut down their production facilities in Spain and in Delaware.

In fact the market consolidation process in 2009 was not as brutal as expected. Despite the challenging conditions, demand and installed PV capacity still rose by 24% in 2009. The bulk of this growth comes from the German market (+2.3 GW_p[1]) as well as from Italy (+0.4 GW) and the Czech Republic (+0.35 GW). The feed-in tariffs in these countries were still high enough for companies to be able to generate an attractive return from PV projects. Political announcements warning that feed-in tariffs would be cut more drastically in 2010 also generated a strong pre-emptive effect in the fourth quarter of 2009. Furthermore, project financing was easier to secure in the second half of the year. The unexpectedly strong demand for solar modules could not ultimately be entirely satisfied by low-cost module manufacturers such as *First Solar*, *Suntech Power*, *Yingli Solar* and *Trina Solar*. Because of this, the more expensive producers were also able to sell their modules. This situation continued up to the end of June 2010.

Polysilicon – continuous expansion

Global production capacities have been steadily rising over the past years. Our estimate for annual polysilicon production (for both the solar and semiconductor industry) is 145,000 t for 2010, around 180,000 t for 2011 and 200,000 t for 2012. The bulk of this expansion comes from new market entrants from China, such as *GCL Poly*, as well as from established polysilicon manu-

[1] GW_p: Gigawatt Peak: unit of measurement for the maximum potential output of PV modules. Measured under standard test conditions (STC). Throughout the rest of the report the 'p' is omitted.

facturers such as *Hemlock, MEMC, Mitsubishi Materials, REC, Sumitomo, Tokuyama* and *Wacker Chemie*. For the time being, however, Chinese polysilicon mainly seems to be used by Chinese wafer and cell manufacturers. In 2011 and 2012, established companies will operate around two thirds of production capacities. These key players are cost leaders who should be able to continue to produce profitably even if prices sink further. Based on their many years of experience, expansion plans still make sense for them. The top 10 manufacturers represent as much as 85% of total capacities. The projected supply of polysilicon offers a good market counterbalance to the expected demand for modules. In view of their painful experience of the volatility of the spot market price in 2008/09, most polysilicon manufacturers have allocated almost 100% of their production volumes via long-term supply contracts in the region of 50 - 65 USD/kg. This makes it difficult for any spike in demand to be met by the spot market at the moment. In any case, the long-term clients are first in the queue. As a result, spot prices have risen again from 53 (in March) to 60 USD/kg. Despite this temporary bottleneck, higher production capacities will mean that contract prices will fall back to around 40 to 50 USD/kg in 2011, and spot prices to 50 USD/kg.

Figure 1: Production of polysilicon and potential production of c-Si cells

	2008	2009	2010e	2011e	2012e
Polysilicon production (t)	55 000	105 000	145 000	180 000	200 000
Polysilicon for IC industry (t)		22 000	26 000	30 000	31 000
Polysilicon for solar industry (t)	55 000	83 000	119 000	150 000	169 000
Silicon demand (t per MWp)	8,6	8,2	7,8	7,6	7,5
Potential c-Si cell production	6 408	10 143	15 224	19 737	22 685
Max. growth of c-Si cell production	94%	58%	50%	30%	15%

Source: Bank Sarasin, Nov. 2010

Bottleneck in wafer production unlikely

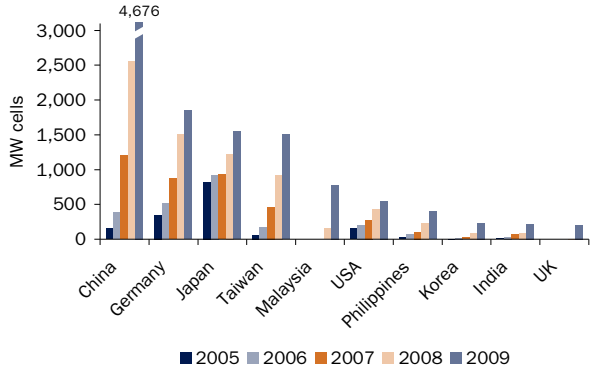
Global production capacities for crystalline silicon wafers rose 53% in 2009 to reach 12.7 GW (y/e 2008: 8.3 GW). The top 10 producers represent as much as 50% of all capacities. They plan to increase their capacities from 6 GW to 11 GW by the end of 2010, and eventually to 15 GW by the end of 2011. *Meyer Burger* estimates that total wafer capacities should reach 23 GW by y/e 2010. With this pace of expansion, there is only a minimal risk of bottlenecks occurring in wafer production in the years ahead.

Due to high demand and a temporary bottleneck over the summer months, the spot price for wafers rose from 0.85 USD/W in January by 20% to 1.06 USD/W in September 2010. By contrast, contract prices fell from 1.2 USD/W in September 2009 to the current level of 0.85 – 0.9 USD/W. The long-term contracts are now being adjusted to the spot price on a quarterly basis. Thanks to the strong expansion rates in wafer production capacities, we expect wafer prices to drop by around 20% in both 2011 and 2012 to reach 0.8 and 0.65 USD/W respectively.

Solar cell production in 2009

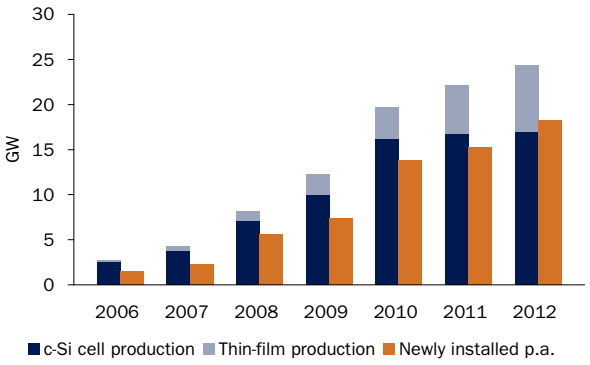
In 2009 global PV cell production reached a total of 12.3 GWp, an increase of 58% on last year's figure of 7.8 GW. China (+2.1 GW), Malaysia (+0.63 GW) and Taiwan (+0.58 GW) enjoyed the biggest yoy growth in absolute terms. The combined global market share of these three countries now stands at 66% (Fig. 2). Other up-and-coming production countries include the Philippines, South Korea and India. The off-shoring of solar cell production to Asia occurred mainly at the expense of the Europeans and Japanese. Germany still managed to increase its cell production by 22%. Although Japanese producers raised their cell output by 320 MW, their share of the global market shrank from 16% to 12.5%. By way of comparison: only five years ago, half of the world's entire solar cell production was concentrated in Japan.

Figure 2: Regional shift in solar cell production



Source: GTM Research, IEA-PVPS, Bank Sarasin, Nov. 2010

Figure 3: Comparison of annual cell production and PV installation



Source: IEA-PVPS and Bank Sarasin, Nov. 2010

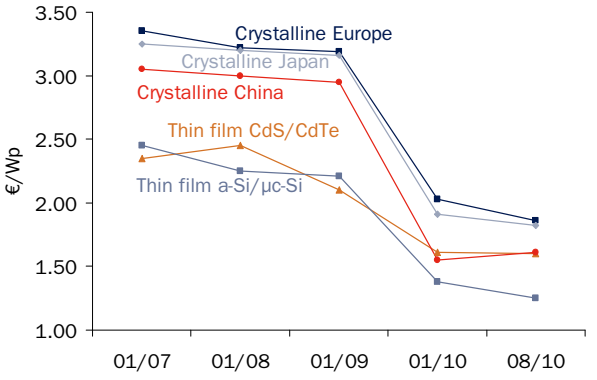
Global capacities for PV module production are still being continuously expanded and at the end of 2009 stood at 25 GW, with thin-film technologies accounting for around 4.2 GW.

In general, production capacities seem to have developed in a relatively synchronous fashion along the entire value chain. We therefore think the risk of a severe bottleneck occurring is relatively small. Furthermore, there is still some room for improvement in capacity utilisation for specific production lines. With module prices continuing to fall and a low utilisation level, there is still pressure to close down unprofitable production facilities or, where technically feasible, to upgrade them and to ensure that the most cost-efficient lines operate at full capacity.

Module prices stable in 2010 – but not for long

In 2009, solar module prices fell by 30-50%. In previous years the price fall only averaged around 5-10% (Fig. 4). This steep drop was caused on the one hand by the collapse of the Spanish PV market and on the other by the mounting glut of solar module supply. Rising demand in Germany in 1H 2010 was the result of pre-emptive activity ahead of further cuts to feed-in tariffs in July and October. This helped to stabilise module prices temporarily. Price pressure will rise again significantly for the first quarter of 2011 in response to the announcement of further reductions in feed-in tariffs. We therefore expect PV module prices to drop by between 10 and 20% p.a. over the next few years.

Figure 4: Module price trends* 2007 to 2010



Source: solarserver/pvXchange; Bank Sarasin, Nov. 2010

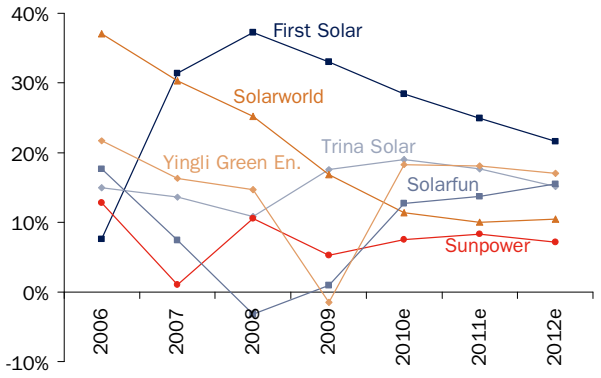
* ASP: Average Selling Price

Margin pressure still high

Falling prices have put pressure on companies' margins, but not to the same extent for all cell and module manufacturers. Fig. 5 shows the development of the EBIT margin of six leading solar players for the period 2006 to 2012. It is interesting to note that margins fell sharply in some cases in 2009. With the exception of *First Solar,* the EBIT margin for all companies has shrunk compared to 2006. The reasons for this development are to be found in the rapid increase in the number of providers and the associated expansion of production capacities. Competitive pressure has also intensified due to the market entry of Asian (especially Chinese) companies which benefit from specific cost advantages compared with their European counterparts. The overall effect of this has been that companies have had to reduce their prices more rapidly than their production costs in order to expand their market share.

With the sudden change of a market supported by generous subsidies in 2008 to more stunted growth in 2009, almost every company has been forced to improve its cost structure. This has allowed some PV companies to increase their margins again in 2010. Margins of well over 20% that were seen in the boom years are virtually inconceivable now. In the longer term, however, we think margins between 10 and 15% are perfectly realistic. They should be attainable for both Western and Asian producers. This is compatible with the normal development of a mature industry with competitive mass production.

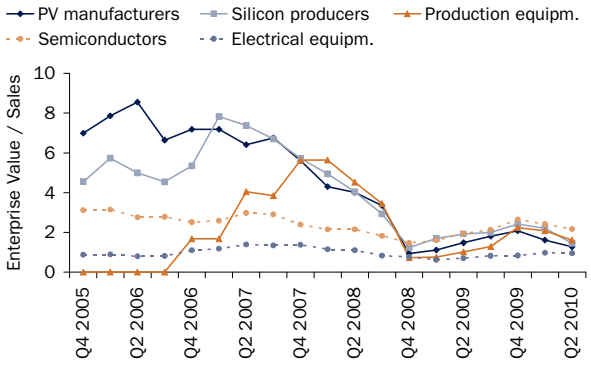
Figure 5: EBIT margin at six PV companies



Source: Datastream, Bank Sarasin, Nov. 2010

This trend can also be highlighted by analysing the stock market performance of the entire solar industry over a given time period. To this end, we examine the relationship between enterprise value and sales. Figure 6 shows the average valuation of selected silicon producers, PV manufacturers (wafer, cell and module producers) and manufacturers of production equipment on the one hand, and the valuation of selected semiconductor and electronics companies on the other. This clearly brings to light the high growth expectations placed in the solar industry during 2006 and 2007. These valuations were many times higher than comparable industries that were already mature. In the wake of the financial crisis, these expectations were reined in significantly, and within the space of a year the valuation of solar companies dropped back down to the same level as more mature companies and industries. Since then, silicon producers and PV manufacturers have moved more or less in parallel with the related semiconductor firms. At the same time, the manufacturers of production equipment seem to be shadowing electronics companies, which share similar characteristics. This is another reason for concluding that the former high-growth solar industry should in future be valued more along the lines of a mature, conventional industry.

Figure 6: Stock market valuation of the solar sector compared with the semiconductor and electronics industry



Source: Datastream, Bank Sarasin, Nov. 2010

PV industry: concentration and globalisation

As the size of the market increases and competition intensifies, the PV industry is increasingly turning into a mass market.[2] Solar cells and modules are already highly standardised products relatively speaking. Rivals are therefore competing increasingly on price. To remain competitive, cell and module producers primarily need to cut their costs. The industry's production structures are therefore developing in the direction of bigger units in order to exploit cost degression effects. The trend towards larger production units means that financially strong companies able to finance the rapid expansion of significant production capacities will succeed in the market over the longer term. At the moment we can see, for example, that a number of big players from the electronics industry, such as *Samsung* and *LG Electronics*, are investing in the construction of their own large production facilities. Big Japanese corporations such as *Sharp* and *Sanyo* are also keen to be involved in the mass production of solar modules. But the established, more specialised producers such as *First Solar* are also moving into new dimensions. This company, the largest module manufacturer, is now represented on the S&P 500 share index.

[2] Bank Sarasin, Aug. 2010, Renewable energies: Evolving from a niche to a mass market

We also expect the trend towards mass production to accelerate M&A activity in the sector. This mass production will mainly be built up in Asia, as shown in Fig. 2.

In a further trend in the offshoring and streamlining of production, the PV industry is following the lead of the electronics industry: outsourcing production to specialised contract manufacturers (OEM production). America's *SunPower*, for example, has entered a joint venture with Taiwan's *AU Optronics*, while Germany's *Q-Cells* is collaborating with *Flextronics*, one of the world's biggest contract manufacturers in the electronics industry.

However, certain political requirements imposed on local content have to be taken into consideration when choosing new production locations. There are stories coming out of China and India of conditions being imposed requiring up to 70% local content.

Focus on non-silicon-based costs

The significant shift in production quotas among regions reflects the cost trap that companies currently face. Established European producers suffered heavy losses in 2009 and could not keep pace with the aggressive pricing policy and cost structure of Chinese manufacturers. In the current competitive market environment, with a polysilicon price of around 50 USD/kg, non-silicon-based costs are becoming increasingly important.

In the case of polysilicon, procurement prices are now more or less the same for both European and Chinese cell and module producers. When it comes to non-silicon-based costs, however, the top company in China can produce a module at a cost of 0.90 USD/W compared with around 1.50 USD/W for European companies. This difference is split into 0.35 USD/W material and energy-related costs, and 0.25 USD/W labour costs.

In this context, however, the question arises as to whether the advantages enjoyed by Chinese manufacturers in non-silicon-based costs are of a permanent nature. If the generous subsidies from the Chinese government were to be taken away, it could significantly undermine these companies' cost advantages. Only the labour cost advantage of approximately 0.25 USD/W could persist in the longer term. With a premium brand strategy, however, European solar companies can achieve a higher price,

therefore making up for this disadvantage on the cost side.

Current foreign exchange rate movements have also helped to reduce the cost differential. The weakness of the euro puts European production locations in a more favourable position than China. At the end of June, the Chinese government officially removed the Yuan's pegging to the US dollar, even though for the time being it is making absolutely sure that its central bank closely monitors the exchange rate. The advantages China gains from other cost components could also decline in the near future. For example, there is now upward pressure on labour costs. Cheap labour is in short supply in some regions and there have recently been an increasing number of labour disputes, with workers demanding better working conditions and higher wages. After companies such as *Foxconn* and *Honda* were forced to raise the basic salaries of their employees, other manufacturers are coming under mounting pressure as well. The Chinese government's subsidy of energy prices has also come under increasing fire.

Marketing & services as key factors

In the current buyer's market, the expansion of marketing and distribution activities is becoming a vital success factor for PV cell and module producers. Additional services such as training, consulting and after-sales support are also very important to ensure that price is not the only assessment criteria. Furthermore, a number of companies such as *First Solar, Q-Cells, Suntech Power, Solarwatt* and *Solon* have entered the project business. The flipside of this forward integration is the potential danger of paper transactions with its own project company or competing with its own clients. Another strategy would be to focus on the higher-priced niche products or on the premium segment.

Due to growing domestic market demand, China certainly remains an attractive location for the solar industry. For an internationally active company, however, it will become increasingly important in future to have a local presence, in the form of a production facility, in all three of the world's biggest markets: North America, Europe and Asia. Producing modules in Europe still makes economic sense, particularly while oil prices and transport costs continue to rise.

Very few banks still offer project financing

Since the financial crisis in 2008 the conditions imposed by financial institutions for granting loans for PV projects have become much tougher, while the financing terms themselves have deteriorated. The number of banks offering finance, and the volume of credit available, have both fallen dramatically. Financing terms did improve slightly in 2009. Nevertheless, the stress test introduced in 2010 by the Committee of European Banking Supervisors (CEBS) obliges some of the banks active in the renewable energies sector to review their loan portfolio in order to bring their core capital quotas into line with the required limits. The following criteria are crucial for the bankability of a **large-scale PV project**:

- Financial strength and good track record of sponsors and investors
- Attractive, stable political and regulatory environment (e.g. subsidised feed-in tariff, tax advantages, etc.)
- Geographic and climatic conditions
- Track record and references of local installers
- High technical quality of the modules, the inverters and the overall system (balance of system, BOS),
- Transparent calculation of costs and returns. BOS costs are becoming increasingly important as module prices drop, i.e. greater focus on erection costs and inverter prices.

Thin-film technologies

Still a challenging environment

The rapid fall in the price of crystalline silicon modules over the last 18 months has been one of the major challenges facing thin-film photovoltaic (TFPV) technology companies. Even so, the market environment for thin-film technologies has turned slightly more positive recently for companies with the right cost and technology mix. To be successful nowadays, thin-film technology companies require a good combination of low cost structure, low investment capital requirement, low technology risk and solid balance sheet.

Compared with crystalline modules, TFPV modules are still attractive from a technical viewpoint as they offer efficient production processes and high-temperature coefficients, and require little or no silicon.

Bankability still an important aspect

Bankability is an issue that continues to play a key role for many newcomers among TFPV manufacturers. The volume of loan financing for renewable energy projects in the classic PV markets has been significantly scaled back during the banking crisis. Some banks have even withdrawn entirely from this segment. The rest have often trimmed their teams of experts in the face of growing cost pressure. Not much time is therefore left for the due diligence procedures required when granting a loan. Preference tends to be given to module producers who already have a track record (existing bankability). This makes it far more difficult for new TFPV companies to achieve bankability and to raise the finance for a new production line.

Success factors for thin-film technology companies

The following factors are essential in order to compete successfully in the current market environment with other TFPV technologies:

- **Low cost structure:** Nowadays the production costs of *First Solar*, at around 0.80 USD/W are accepted as the industry benchmark. New companies do not yet have the same economies of scale as international PV companies producing crystalline silicon modules. Their timetable for costs must therefore target the long-term goal of 0.50 USD/W in order to be able to achieve costs of less than 1 USD/W while they are building up capacity.
- **Low investment costs:** Investments for a turnkey TFPV production facility currently stand at around EUR 200 million for a 100 MW production line. The required cost level can only be achieved with low investment spending of well below EUR 100 million per 100 MW line in future.
- **Low system costs (BOS, balance of system):** With falling module costs and a low efficiency ratio, the relative weighting of other system costs steadily increases. Companies that offer attractive integrated solutions have a greater chance of success.
- **Low technology risk:** In order to meet the specified cost criteria, the company has to procure low-cost financing. The bankability of thin-film technology, as described in detail in Sarasin's last report[3] , thus continues to play an important role.
- **New application areas:** To avoid competition purely on the basis of cost, producers of thin-film technologies need to explore new areas of application for their products. This could include solutions for flexible PV modules or applications integrated into buildings to ensure compatibility in terms of colour and size.

Thin-film PV market trends up to 2012

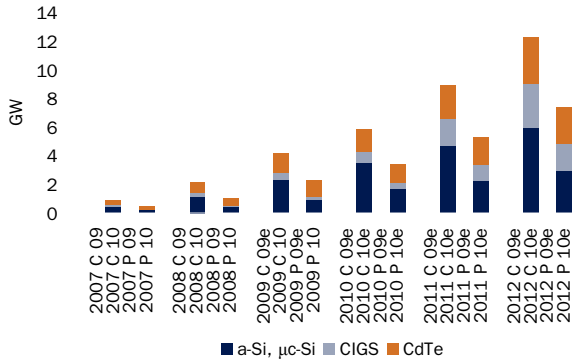
The market share of TFPV technologies as a proportion of total solar cell output rose by five percentage points in 2009 to 18% or 2,300 MW. This total volume for thin-film products was accurately forecast in our last report. By contrast, CIGS[4] and a-Si/µc-Si[5] produced 300 MW less than expected, while CdTe production[6] was 300 MW more than our original forecast. Around 47% of thin-film cells came from *First Solar* in 2009.

In 2010 we expect production volume to reach approximately 3,400 MW. Assuming a total cell production vol-

[3] Bank Sarasin, Solar industry 2009 – The first green shoots of recovery
[4] CIGS: Copper-Indium-Gallium-Diselenide
[5] a-Si: amorphous silicon; a-Si/µc-Si: amorphous/micromorphous silicon
[6] CdTe: Cadmium telluride

ume of 19.6 GW, the market share of thin-film technologies will have shrunk by one percentage point.

Figure 7: Capacity (C) and production (P) expansion in the individual thin-film technologies. Comparison of estimates for 2009 (cross-shading) and 2010 (solid)



Source: ACCELIOS Solar and Bank Sarasin, Nov. 2010

Compared with last year's figures, our latest estimates on capacity and production expansion in thin-film modules (Fig. 7) show a moderate increase of 11% in production in 2010 from 3,100 MW to 3,450 MW. The latest estimates for 2011 stand at 5,325 MW, 32% higher than last year. The compound annual growth rates (CAGR) for TFPV production between 2009 and 2012 are around 48%, which is still significantly higher than the CAGR for the solar market as a whole (37%). As far as the different technologies are concerned, we expect the strongest growth for this period (2009 to 2012) to come from CIGS technology, with a CAGR of 100%, followed by a-Si/µc-Si technology at 47% and finally CdTe with a CAGR of 31%.

Leading thin-film technology companies

Of the 150 or more companies active in thin-film technologies, a hard core of leading players is starting to emerge, while less competitive companies such as *Sunfilm* or *Signet* have been squeezed out of the market. More cut-throat competition and industry consolidation is likely as we move forward. The first example of this trend is the takeover of *Sunfilm* by *Schüco*, a market leader in aluminium, solar, steel and PVC systems for innovative building envelopes. The large-format modules of the two production lines are particularly well suited to integration in buildings. *Sunfilm*'s second production facility was acquired by the *Wilms Group*. This group already owns the solar system producer *Antec Solar Energy*, which also manufactures thin-film PV modules, although using CdTe technology.

This year's ranking of the top 10 TFPV companies is in turn based on the assessment of their performance in relation to production and distribution expertise. In contrast to last-year's assessment, the bankability of production facilities does not seem to be the sole critical factor this year. Thin-film technology companies need to score well with respect to all the success factors listed earlier.

The ten biggest TFPV technology companies were ranked according to the production volumes predicted for 2010 (Fig. 8). Nine of the top 10 companies have their own in-house developments in production facilities. Companies with standard equipment from *AMAT*[7], *Oerlikon, Centrotherm* or *Ulvac* only feature in the 10th-20th rankings. In this respect, the actual know-how still seems to be important.

[7] AMAT: Applied Materials

Figure 8: Top 10 thin-film PV companies

Company	Locations	Technology	Equipment supplier	Start of mass production	2009 production (MW)	2010e production (MW)	2010e capacity (MW)	2011/12e planned capacity (MW)
First Solar	US/MY/DE	CdTe	In-house	before 2006	1 100	1 250	1 416	2 742
Sharp	JP	a-Si/µc-Si	In-house	before 2006	110	250	320	640
Kaneka	JP	a-Si, a-Si/µc-Si	In-house	before 2006	40	110	150	150
Trony Solar	CN	a-Si	In-house	2009	70	110	145	205
Solar Frontier	JP	CIS	In-house	2007	60	80	100	1 000
United Solar Ovonic	US/MX	a-Si foil	In-house	before 2006	123	75	150	150
Solibro (Q-Cells)	DE	CIGS	In-house	2008	14	75	135	135
NexPower (UMC)	TW	a-Si, a-Si/µc-Si	ULVAC	2008	30	60	100	135
Solyndra	US	CIGS	In-house	2008	30	60	105	300
QS Solar	CN	a-Si	In-house	2008	20	50	165	165

Source: ACCELIOS Solar, Nov. 2010

All the companies in the top five have many years of production experience. Thanks to their advantageous cost structure and market access, they have been very successful in selling their modules. Out of the top 10 producers in 2010, there are three companies from Japan, three from the USA, two from China and one each from Germany and Taiwan. Nine of the top 10 rely on equipment developed in house, and only one uses *Ulvac's* a-Si/µc-Si production lines. The three biggest companies share a number of success factors:

***First Solar* – the industry leader grows and grows**

Based on its inhouse CdTe technology, *First Solar* is successfully defending its position as market leader among all cell and module producers, including silicon-based modules. This year production capacities have reached 1,400 MW and the target is to almost double production to 2,700 MW by 2012. The existing regional production footprint across the US, Germany and Malaysia will be expanded to France and Vietnam by 2012. First Solar is the clear benchmark for all thin-film PV companies when it comes to rapid capacity expansion, cost reduction, life cycle management and forward/backward integration. Compared with c-Si technology, a *First Solar* module can be finished in a few process steps on one site, within the space of two hours. *First Solar* has since increased the efficiency of its modules to 11.2%, and has managed to reduce production costs to 0.76 USD/W in the second quarter of 2010. Solar energy can therefore be produced at competitive terms in the Earth's sunnier regions.

All modules are covered by a prefunded module collection and recycling program. Despite all the company's efforts, a certain entrepreneurial risk exists due to repeated criticisms about the use of cadmium, a toxic heavy metal. It is impossible to rule out a legal ban being imposed in Europe or even in China on the use of cadmium in PV systems, as already introduced for electronic equipment.
By acquiring *Next Light*, *First Solar* has increased the pipeline of its large-scale free-standing PV systems by 2.2 GW. On the other hand, the 2GW systems contract in Inner Mongolia is endangered by the introduction of a 70% local content requirement by the Chinese government. The recent acquisition of *5N Plus*, the key supplier of tellurium, allows *First Solar* to secure raw material supplies for future business expansion.

***Sharp* – still in the top three**

The Japanese electronics group *Sharp* has a large solar business division that manufactures both crystalline and TFPV modules. Combined production totalled 595 MW in 2009. Based on its extensive in-house know-how, *Sharp* was the first company to manufacture a-Si/µc-Si modules back in 2004. Further innovations include semi-

transparent and triple-junction TFPV modules. Besides the existing a-Si/µc-Si production line in Katsuragi, a second line was added in March 2010 at the new production site in Sakai, increasing total TFPV capacity to 320 MW. Total TFPV production is estimated to reach 250 MW in 2010. Sharp wants to increase production capacities to 640 MW by 2012, starting in 2011 with a 160 MW line at *3Sun*, a joint venture between *Sharp*, *ENEL* and *STMicroelectronic*s located in Sicily. *STM* has a semiconductor factory there which has never been commissioned. Another 160 MW production line is due to come on stream in 2012 in Sakai. The efficiency of *Sharp's* a-Si/µc-Si modules is 9.5%. Actual production costs are not disclosed, but appear to be competitive due to the economies of scale and synergies at the Sakai factory complex. The same factory also houses a production line that makes flat glass for both solar modules and LCD screens. In September *Sharp* acquired the US project developer and independent electricity producer *Recurrent Energy*, adding 2 GW to its utility project pipeline in the US. This well-established brand enjoys good bankability and is supported by a strong multinational distribution network. There are projects ongoing in the US, Canada, Germany, France, Spain and Israel.

***Kaneka* – hard work pays off**

In 2010 ***Kaneka Solartech***, a division of the *Kaneka Corporation* in Japan, has risen to number three position among global TFPV manufacturers with an estimated production of 110 MW a-Si/µc-Si modules. This is mainly because last year's number two, *United Solar Ovonic*s, cut back its production due to internal problems and now only has capacity of approximately 75 MW (123 MW in 2009). Demand in the Japanese home market has also been strengthened by a new subsidy scheme. *Kaneka* launched a new solar roofing tile "Solitex PV", which has been very well received by the market. In June the company ramped up its production capacities to 150 MW.

Kaneka has a long track record in the research and development of a-Si technologies dating back to 1980. Under laboratory conditions, the company is able to produce a-Si/µc-Si modules with the world's highest efficiency of up to 12%. Kaneka's commercial a-Si/µc-Si modules reach an efficiency of 9%. *Kaneka* has slightly scaled back its bold expansion plans and will not reach a decision about further growth until 2012. Due to their long track record, these modules enjoy good bankability. In 2009 *Kaneka* only sold around 15% of its modules outside of Japan. Due to slow capacity expansion and the lack of an international distribution network, *Kaneka* is expected to drop in the rankings in the future.

Fast followers

All the companies classed as "fast followers" or TFPV technology leaders first need to put their planned business model to the test. The group of fast followers is led by the a-Si producer *Trony Solar* from China and by the CIGS producer *Solar Frontier (*formerly *Showa Shell Solar)*.

Established in 1993, *Trony Solar* is focused on the Chinese market and decided to go ahead with an IPO to finance its further expansion. The IPO was completed on the Hong Kong stock market at start of October. A listing on Nasdaq in New York has been postponed indefinitely.

The company will start operations in its 900 MW plant in Miyazaki in 2011, in addition to its two existing production facilities in Japan with a nominal capacity of 100 MW. Sales offices are also due to open in Germany and California. In October *Solar Frontier* announced that it could supply *General Electric (GE)* with TFPV modules. *GE*'s global marketing network can offer enormous support to *Solar Frontier* in selling its modules. At the start of November the company announced it had won a contract to supply 10 MW modules to the Arab oil company *Saudi Aramco Oil*. This installation will supply valuable information to the company on how CIS modules perform in desert conditions.

Ranked second last year, *United Solar Ovonic*s, a subsidiary of America's *Energy Conversion Devices (ECD),* certainly has a wealth of experience in triple junction technology. However, its lamination process appeals mainly to a niche market, which makes its cost structure higher and sales cycle slower. In the current fiercely competitive market climate, *United Solar* is losing market share. The company has experienced problems in the form of enormous price pressure coupled with capacity expansion.

Solyndra continues to expand production capacities of its tubular CIGS cells. These cylindrical modules can capture sunlight on a 360-degree photovoltaic surface and are therefore capable of converting both direct and diffuse sunlight into electricity. By the end of 2010, the second plant should be in full production mode, pushing the company's total capacity (incl. Fab 1 with 80 MW) to 300 MW.

Other very ambitious expansion plans have been published by industry newcomers. *Hanergy*, China's largest private operator of renewable energy systems has recently ordered turnkey a-Si production lines from Chinese equipment provider *Apollo Solar* with a capacity of 800 MW. In future this order is likely to be expanded to production lines totalling 3 GW worth USD 2.55 billion. At the same time *Hanergy* has acquired 52% of the share capital in *Apollo Solar* for USD 150 million.

Taiwan Semiconductor Manufacturing Company (TSMC) broke ground for its first 200 MW plant for the production of CIGS thin-film modules. For this it is utilising production equipment from the Californian company *Stion*. In a second phase the facility will be expanded to a CIGS production capacity of 700 MW. At the same time *TSMC* purchased a 21% shareholding in *Stion*. *TSMC* also owns 20% of *Motech*, a Taiwanese producer of c-Si cells.

Market trends 2011

Aside from the undisputed leader in TFPV technology, *First Solar*, a number of other companies will achieve a certain degree of maturity and stability over the coming years. Fig. 9 shows the most important trends, their drivers and the relevant implications for the TFPV market.

Figure 9: Thin-film PV market trends up to 2010

Performance	Driver/cause	Consequences
Mounting cost pressure	– Cheap polysilicon pricing – Excess capacities – First Solar sets benchmark for cost structure	– Relocation of production to low-cost countries predominantly in Asia – TFPV companies with poor efficiency and performance will be squeezed out of the market – Improvements in TFPV technology – Leading in-house technologies
Downstream integration	– Securing market access – Entry into utility-sized projects	– Acquisition of project developers or individual large-scale projects – Joint ventures with utilities
Upstream integration	– Limited access to raw materials	– Export restrictions on rare earths by Chinese government – Acquisition of raw materials suppliers
Market entry of multinational corporations	– Critical mass – Economies of scale – Internationalisation	– Established TFPV producers need to scale up or – Cooperate with large multinational corporations
Protectionism in some countries (China/India)	– Closing of technology gap – Generation of local jobs – Covering local energy demand	– Build up know-how for low-cost equipment and subsequent upgrade – Preferential financing conditions for local module capacity expansion and more exports – Introduction of minimum local content requirements

Source: ACCELIOS Solar, Bank Sarasin, Nov. 2010

Country attractiveness index (CAI)

Our annual global forecast for the photovoltaic (PV) market is derived from the systematic and comparative assessment of the attractiveness of the most important countries. This assessment has been developed in close collaboration with the Clean Tech Department of Rabobank's *Food and Agribusiness Research and Advisory (FAR)* in the Netherlands. The CAI for 2011 shows which countries are most likely to attract PV projects. The evaluation is based on the following four criteria:

– **Financial attractiveness:** We use the internal rate of return (IRR) on a standard 1 MW free-standing PV sys-

tem project and a small 4kW roof-mounted PV system as an indicator for a market's financial attractiveness. Our calculations are based partly on the feed-in tariffs, local electricity tariffs and natural incidence of sunlight, and are rated on a scale of 1 to 10. So that the financial attractiveness can be compared over time and countries, the PV system costs (BOS, installation) are set at EUR 2400/kW. It is assumed the company provides all its own financing.

– **Market maturity:** This criterion assesses to what extent the infrastructure and companies are available for the installation of PV systems. The scores are rated from 1 to 5. The largest PV market receives the highest score (5), while the smallest PV market receives the lowest (1).

– **Growth potential:** Here we assess certain legal upper limits or caps stipulated for feed-in tariffs or overriding political goals that have been set for photovoltaics, as these determine the capacity potential that can be exploited in the long term. Countries with no annual cap and with ambitious long-term targets score five points. The lowest cap, combined with the absence of any politically motivated targets on photovoltaics, produces a score of one.

– **Effective administrative processes:** Here, the administrative and regulatory hurdles within a country are assessed. To this end the latest information from the PV LEGAL project supported by the European Photovoltaic Industry Association has been incorporated as well.[8] In practice, the average length of time required for implementing a project varies between 12 and 24 months. A short time span scores 5 points, a long period of time 1 point. This criterion reflects a certain medium-term perspective. One new aspect is an assessment of the general stability or effectiveness of the state authorities, with reference to the Worldwide Governance Indicators (WGI). This criterion is not taken into account for small rooftop systems, as it is very hard to assess accurately with such a small size, and the necessary permits are usually relatively easy to obtain.

By employing the broader scale of 1 to 10 when assessing the financial attractiveness, a higher weighting is deliberately given to the financial aspect rather than the other criteria (rated on a scale of 1 to 5) in order to reflect the comparative importance of this criterion.

Feed-in tariffs: what are the current parameters, and how much longer will they apply?

At present seldom a week passes without a government somewhere announcing fresh cuts to feed-in tariffs. The aim is to bring back tariffs and prices to a reasonable level so as to prevent excessive returns. No politician wants to see an overheated solar energy market develop in his own country and be forced to defend rising electricity prices. Because of this, attractive remuneration is rapidly being adjusted to the relevant system prices. At the moment there is a vicious circle of intensifying cutbacks in individual countries.

With so much criticism about costs, the many positive aspects of solar energy seem to have been forgotten about. For example, this yarn industry provides a lot of jobs, wages and tax revenues at the communal level. Solar energy, along with other forms of renewable energy, also cuts the price of publicly traded energy due to the so-called "merit order" effect. Since most energy from renewable sources is fed into the grid, large quantities of wind and solar power reduce demand for conventional electricity. The most expensive conventional electricity offerings can no longer be sold on the exchange, so the price drops.

The most important changes from 2011 onwards

In the current year many governments have already made adjustments to the national PV subsidy programs and in some cases implemented them. Some have also announced further cuts for 2011. This affects important markets such as the Czech Republic, Germany, France, Italy and Spain. The decisive question for industry is how

[8] www.pvlegal.eu

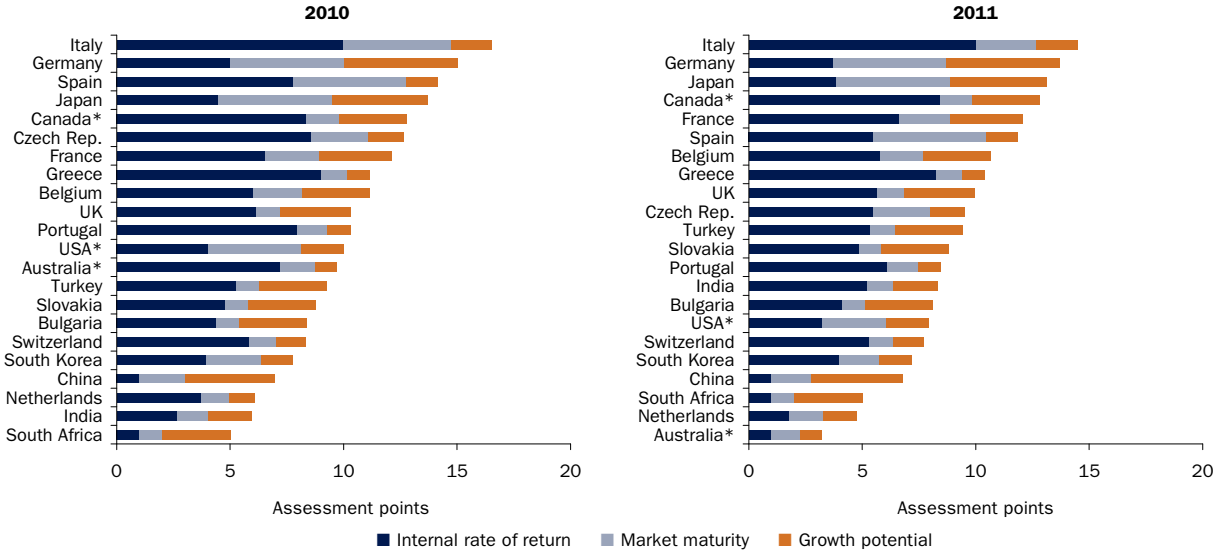
this affects the attractiveness of these markets. The most important changes are summarised in Fig. 10.

Figure 10: National PV subsidy programmes – most significant changes for 2011 vs. 2010

Country	Comments
Australia	New South Wales (NSW) is cutting tariffs for 2011 from 0.6 to 0.2 AUD/kWh, as the threshold of 50 MW of installed capacity has now been reached.
China	Feed-in tariffs for large-scale systems are being defined in a tendering process. Offerings lie between 0.73 and 0.99 CNY/kWh.
Germany	The newly introduced reduction rule, which is linked to the size of the market last year, results in a digression of 11 to 13% from 1 January onwards.
France	Sudden announcement of a 12% reduction in tariffs as of 1 September 2010. These rates will now apply until 2012. New rates are 0.37 EUR/kWh for compact rooftop systems and 0.28 EUR/kWh for free-standing systems in the south.
India	New legal target of 20 GW PV & CSP by 2022. Feed-in tariff of 17.91 INR/kWh (0.3 EUR/kWh) by 2013. For 2011 a cap of 150 MW and tender process will apply.
Netherlands	Not yet clear whether NL will offer remuneration for PV systems in 2011. We are using ECN proposals for our calculation. Large free-standing systems are unlikely in NL and were not taken into consideration.
Spain	High probability of a tariff cut. Unclear until the end of October. Assumption for the calculation: Free-standing -45%, commercial rooftop systems -25%, compact rooftop systems -5%.
Canada	Size categories of tariffs for rooftop systems have been adjusted. They now range from 10 to 250 kW (previously 100k W), from 250 to 500 kW and over 500 kW.
Czech Republic	After strong growth in 2010, remuneration is set to be cut by 50%.
South Africa	Feed-in tariff for large-scale systems (>1 MW)of ZAR 3.94 per kWh (EUR 0.35/kWh). Level of tariff to be reduced by tendering process for individual projects (-20%).
UK	In April 2010 feed-in tariff of 0.314 GBP/kWh (0.36 EUR/kWh) introduced for the first time for rooftop systems between 10 and 100 kW, and 0.93 GBP/kWh (0.34 EUR/kWh) for larger systems.
Switzerland	Financial cap for the cost-covering remuneration scheme (KEV) will be increased by 50% as of 2013. PV projects on the waiting list will start to come on stream. Tariffs to be cut by at least 8% compared with 2010.
Italy	In July 2010 tariffs were approved for the period 2011 to 2013. Now tariffs are to be reduced in stages, every four months.
Belgium	

Source: Rabobank, Bank Sarasin, Nov. 2010

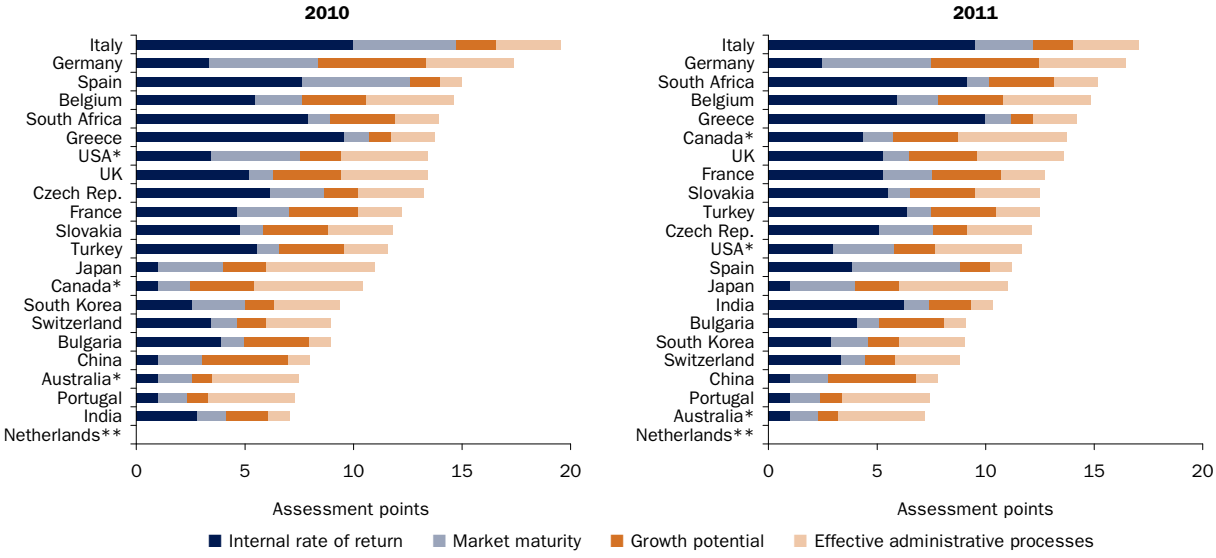
Figure 11: Country attractiveness scores for rooftop PV systems in 2010 and 2011



Source: Rabobank and Bank Sarasin, Nov. 2010

* New South Wales in Australia, Ontario in Canada and California in the USA

Figure 12: Country attractiveness scores for free-standing PV systems in 2010 and 2011



Source: Rabobank und Bank Sarasin, Nov. 2010

* New South Wales in Australia, Ontario in Canada and California in the USA

** The Netherlands does not offer feed-in tariffs for free-standing PV systems and is therefore not given a score.

Italy, Germany and Japan are attractive markets for small-scale systems

For small rooftop PV systems up to 3 kW, Italy Germany and Japan will be the most attractive markets in 2011. Canada, France and Spain follow in third, fourth and fifth place respectively. Although Germany and Japan no longer have the high rates of return, their high level of market maturity and ambitious political targets account for their high rankings. Furthermore, there is no cap on the remuneration programmes in these markets. In the case of the remaining countries, it is primarily the comparatively high rates of return that produce the top rankings.

Italy rose to become Europe's second largest PV market in 2009, with 723 MW of new capacity. The cumulative PV capacity at year-end 2009 stood at around 1.2 GW. Italy has developed into a very promising market, offering remuneration based upon the price of mains electricity plus a bonus feed-in tariff of EUR 0.31/kWh in 2011. Another attractive feature is average sunshine of 1725 kWh/m^2 p.a. in the north and up to a maximum of 2000 kWh/m^2 p.a. in the south of the country. With this combination, Italy has already achieved the highest yields for a free-standing PV system in 2010. Even with a planned reduction in 2011 of between 10 and 27.5%, the achievable returns remain very attractive depending on location and technology. The degression is set to take place in three stages, from 1 January, 1 May and 1 September. There will be substantial curtailments for free-standing systems with capacities greater than 5 MW. For this category of system, the reductions will total 27.5% by the end of the year. Small rooftop systems up to 3 kW will see total reductions of 10%, while systems up to 20 kW will receive 15% less. Similar to the situation in France, there is also to be a specific, more generous feed-in tariff for roof-integrated systems. There is also a 5% bonus for PV systems on industrial rooftops, landfill sites, contaminated sites and in disused quarries or mines. There is a 10% bonus for rooftop PV systems which replace an asbestos roof. A simplified licensing stage should eliminate the existing regional differences and speed up the approvals process. An annual reduction in the tariff of 6% p.a. is envisaged for 2012 and 2013. Over the coming three years, 3 GW "normal" solar plants, 300 MW building-integrated and innovative systems, together with 200 MW CSP systems will be promoted. On average this will produce around 1.3 GW of additional capacity per year.

Germany is experiencing another boom period this year. By the end of the year we could see newly installed PV capacity of around 7 GW. In 2009, new installations amounted to 3.8 GW. Because of this market growth and the associated cost reduction, the feed-in tariffs for new solar energy systems are being reduced by a further 13% with effect from 1 January 2011. As early as January, July and the start of October of this year, subsidies were reduced by a total of around 25% within the context of the Renewable Energies Act (EEG). Thus Germany already had a relatively low score for the IRR criterion in 2010 of 3 points out of a possible 10. Nevertheless, the German market will continue to grow strongly this year. Thanks to the broad base of solar energy companies and installers, coupled with the rapid implementation rate, the German market has proven itself to be highly elastic. The subsidy reductions are very high once again in 2011, so that Germany will lose a further point in the IRR criterion. The latest amendments to the EEG will mean that subsidies per kilowatt of solar energy will reduce by 50% between 2009 and 2012. However, in the case of the other criteria, Germany achieves the maximum score in both years and both categories (rooftop and free-standing systems). Thus the country can compensate for its low investment return score and defend its second-place position in 2011. We anticipate a shrinking market in 2011, although when viewed in absolute terms it will still see the largest quantity of modules installed. Nothing will change in this respect before 2012. Not until 2013 will additional markets emerge with orders of magnitude of four to five Gigawatts.

Thanks to the subsidy programme for private rooftop systems introduced in **Japan** in 2009, newly installed PV capacity rose to 483 MW. This is more than twice as much as was installed in 2008. Almost 99% of the installations were rooftop systems. This programme continues to run

in 2010. For small domestic rooftop systems up to 10 kW, a tariff of JPY 48/kWh applies, which is twice as high as the household electricity tariff. For larger commercial plants a tariff of JPY 24/kWh applies. Combined with the maturity of the PV market, the high growth potential and a fast-moving bureaucracy, Japan remains among the top three most attractive countries for private and commercial rooftop systems. The Japanese finance ministry has announced a revision of feed-in remuneration for 2012.

In **Greece**, around 35 MW of grid-connected systems were installed in 2009. In fact, the country has boasted a very attractive feed-in tariff system since 2006, which is also reflected in its high IRR scores. However, up to now administrative hurdles have prevented more rapid growth in the PV market. Since 2010, a new programme for small rooftop systems up to 10 kW has been in force. The corresponding feed-in tariff is 0.55 EUR/kWh, is applicable for 25 years, and is even linked to inflation (25% of the previous year's consumer price index each year). The degression for new installations is 5% p.a. up until 2012. At the present time it is not clear how the financial squeeze on the Greek government will impact on the PV market. As in Germany, the feed-in tariff is financed through a levy on the general electricity price, and is therefore not affected by the budget deficit.[9] However, the government appears to want to profit from the booming solar industry by introducing new, unforeseen taxes and fees for solar projects. For this reason, as an investor one must make very conservative calculations in relation to any Greek project. A further inhibiting factor is the high level of interest on borrowed capital. For these reasons, Greece receives the lowest score for market maturity and market potential. Overall, this market achieves 5th place for rooftop systems and 9th place for free-standing systems.

India installed around 30 MW of PV capacity in 2009. India passed a solar energy law at the start of the year. The combined goal of this Jawaharlal Nehru National Solar Mission (NSM for short) is the installation of 20 GW of PV and CSP capacity by 2022. During an initial phase running until 2013, a feed-in tariff of INR 17.91/kWh will apply. The maximum installation level for 2011 is set at 150 MW, and at 350 MW from 2012 to 2013. Project size is limited to 5 MW. If the maximum capacity is exceeded, those projects which offer the greatest rebate on the feed-in tariff are selected by means of a reverse bidding process. Applications for three times the capacity have already been received by the government for 2010. For this reason we are only applying 85% of the feed-in tariff for the purposes of our LAI computation. The Indian authorities must now demonstrate that they can organise the various administrative processes in a rapid and trouble-free manner.

Around 250 MW of new PV capacity was installed in **France** in 2009. The remuneration structure continues to support building-integrated PV (BIPV) systems with a special remuneration rate. As a result of this, around 40% of total new capacity has emerged as large-scale rooftop systems. So as not to impair comparability between countries, only the simple tariff for rooftop systems has been used in the IRR evaluation. Even so, France is in 4th place in terms of rooftop systems. This autumn, the rapidly falling costs for solar systems have led the French government to reduce the feed-in tariffs for large-scale plants by 12% with effect from 1 September 2010. Very little notice was given of this change – only a few days – and it contradicts the statement from last year that the tariffs would remain unaltered until 2012. The reduction is modest compared with other countries and France therefore remains an attractive market. PV capacity is set to rise to 5.4 GW by 2020, with the proportion of renewable energies as a percentage of total electricity production reaching 23%.

On 1 April 2010 the long anticipated feed-in remuneration system began in the **UK**. The specified tariffs should yield returns for investors of between 5 and 8%. A total of 25 MW was installed between April and September, around 10,000 private systems and 41 commercial PV systems. According to recent statements by the new coalition gov-

[9] www.helapco.gr

ernment, the feed-in tariffs will be reviewed as planned in 2013.

Newly installed PV capacity in **Switzerland** reached 25.7 MW in 2009. This represents an increase of 120% compared with 2008. However, per inhabitant this is still 15 times lower than in Germany. The cumulative solar energy capacity was 73.6 MW at the end of last year. Cost-covering feed-in remuneration (CRF) for electricity from renewable sources came into effect on 1 January 2009. The remuneration is financed through a surcharge of CHF 0.006 on every conventional kilowatt hour of electricity (CHF 0.009 from 2013), corresponding to around CHF 500 million annually. According to the Energy Act, at the present time only 5% of the total CRF funds are available to photovoltaics, a proportion that is set to increase gradually in the future as production costs for solar electricity fall. At the moment these costs are falling continually and markedly, such that it should be possible to make 10% of CRF funds available to photovoltaics from 2011 onwards (CHF 34 million per year). Thanks to the 10% level, from 2011 around one third of the 5,200 PV projects with over 150 MW capacity can be taken off the waiting list. With the IRR score achievable with a small rooftop system (5 out of a possible 10 points), Switzerland does not fare too badly. On the other hand the de-facto cap created by the CRF's existing cost ceiling acts as a drag on the development of the solar energy market.

The new decree DL 363, introduced in **Portugal** at the end of November 2007, offers an attractive feed-in tariff (currently EUR 0.6175/kWh) for small rooftop systems up to 3.68 kW. The annual cap is 14.4 MW and is increased by 20% each year. As soon as this is reached, the tariff is reduced by 5%. The level of the tariff and the annual adjustment lead to a payback period of around six years. Around 1 GW of PV systems could be installed by 2023 on the basis of this programme. Admittedly, the introductory phase ran very successfully, although the restriction of feed-in remuneration to small systems is not producing large installation capacities. The law also requires the construction of a solar thermal system of at least two square metres. The time required for project development is set to be reduced to six months through a simplified and web-based registration process.

Large-scale PV systems: Italy, Germany and South Africa

Italy, Germany and South Africa appear to us to be the most attractive markets for large-scale PV systems in 2011. Annual degression is less sharp in Italy and South Africa compared with other principal markets, so they are able to maintain their strong rankings.

Last year, **South Africa** was the most interesting newcomer to the LAI. The combination of high levels of sunlight and the feed-in tariff for PV of EUR 0.35/kWh announced in November 2009 as part of the national "Refit" (renewable energy feed-in tariff) plan, appeared very attractive. However, the actual implementation of the Refit plan by the authorities was very sluggish. The National Energy Regulator of South Africa (NERSA) has limited resources in terms of both money and personnel, and must fulfil the lofty expectation that the feed-in tariff will create as many jobs as possible across the country. 1,025 MW of renewable energy capacity is to be produced by independent power producers (IPPs) by 2013. The government has put a bidding process in place for this purpose,[10] whereby the feed-in tariff is to be set according to the proposals received. This process is unpleasant for project developers and investors, as they cannot use a "real" feed-in tariff to base their calculations upon. For this reason we have reduced the published tariff by 20%, from EUR 0.35 to EUR 0.28/kWh. Even so, the South African PV market is in 3rd place in our LAI index for large-scale PV systems in 2011. By March of next year the energy ministry will select the winners from the bidding process. After that we will know more about the feed-in tariffs actually issued. Although the market is very young, it possesses immense potential once the administrative processes are up and running.

Thanks to lucrative subsidies, new PV installations of 411 MW were created in the **Czech Republic** in 2009.

[10] www.energy.gov.za/files/media/pr/REFIT_programme.pdf

High feed-in tariffs in the Czech Republic had led to the country's ascent to become the third largest market for photovoltaics in Europe, after Germany and Italy. This rapid growth has caused not just the government but also the national grid operator CEZ to alter the framework conditions. CEZ estimates that this year around 1,110 to 1,200 MW of new capacity will be installed, sending electricity prices sky high. The feed-in tariff for photovoltaics will be halved in 2011, to EUR 0.26/kWh. In addition, a legal obligation to recycle old solar modules is to be introduced. The change to the law is to come into force on 1 March 2010 and is construed in such a way as to once again make the payback period for a solar investment 15 years, as originally intended. An additional specific tax and levy is planned for free-standing systems on agricultural land. Recent proposals being considered by the Czech government envisage taxing the electricity produced by large-scale plants over 30 kW constructed during the boom years of 2009 and 2010 at 26%. This would have the same practical effect as a retrospective reduction of the feed-in tariff.

In 2009 the PV market in **Spain** collapsed from 2,700 MW of installed capacity in 2008 to just 60 MW. The statutory cap would allow annual installation of 500 MW (160 MW rooftop and 340 MW free-standing systems). Pressure on the solar industry is high, as it receives more than half of the five billion euros in subsidies for renewable energy, but produces only 11% of the electricity. A commission is seeking to review the details of over 9,000 solar parks with capacities of 955 MW which are still to be built before the 28% cut in September 2008. If a system should fail to fulfil the conditions for the high level of remuneration, it will lose the right to any remuneration. The systems can at least claim the lower tariff after 2008 if they make a self-declaration. The government is hoping to save around EUR 800 million by these means. The retrospective reduction in the feed-in tariff for existing PV systems which was also discussed by the government has led to a marked degree of insecurity among project developers and investors. Although, with a view to Spanish financial institutions and the EU, the government will not in fact be implementing this measure, the debate has halted or delayed a large number of projects. As at the end of October, there was still no clarity on the precise conditions for 2011 in relation to the feed-in tariff. At the present time a joint proposal from the solar energy association and the Ministry is on the table. It aims to limit the electricity production of a PV system to 2,350 and 2,430 operating hours and reduce the feed-in tariffs as follows: Free-standing: -45%, commercial rooftop systems: -25%, small rooftop systems: -5%. For these reasons, Spain has dropped a few places in the LAI ranking for 2011.

Around 80 MW of new PV capacity was installed in **Australia** in 2009, raising the cumulative capacity to 184 MW. Growth was driven primarily by the nationwide rebate programme of 8 AUD/W (5.6 EUR/W) with an upper limit of AUD 8,000. This rendered the construction of a 1-2 kW system very cost effective. In the meantime the programme has been suspended and all approved systems installed during the first half of 2010. Since the start of the year, incentives in Australia have been based purely upon feed-in remuneration in eight out of eleven federal states. For our CAI calculation we selected the program in place in the populous state of New South Wales (NSW).[11] This programme led to new installations of 50 MW in the first eight months. Around 180 MW was installed across the entire continent this year. The IRR score, attractive in itself, is regrettably forced lower by insufficient market maturity and a lack of long-term political goals. At the end of October the government of New South Wales announced the reduction of the feed-in tariff from AUD 0.6 to AUD 0.2/KwH. An adjustment was necessary, it said, because the upper limit of 50 MW had already been reached.

473 MW of new PV capacity was installed in the **USA** last year, corresponding to a growth level of 40%. Total capacity therefore reached 1,642 MW at the end of 2009. In 2009, 49% of all American PV systems were installed in California – in 2008 it was 64%. Newly emerging states are New Jersey (57 MW), Florida (36 MW), Colorado (23

[11] www.industry.nsw.gov.au/energy/sustainable/renewable/solar

MW) and Arizona (21 MW). Last year, 40 new solar incentive programmes were introduced in 19 US states. Thus there are now renewable portfolio standards (RPS) in 29 US states. This is also reflected in the plethora of large-scale solar projects undertaken by American energy utilities. They have a project pipeline of around 7.7 GW of large-scale PV (2.1 GW) and CSP (5.6 GW) for the near future.
Because no feed-in tariff has yet been introduced at the Federal level in the USA, the LAI is based on the Californian system. Here, the combination of feed-in tariff and investment tax credit (ITC) is particularly attractive. The US market will achieve a good gigawatt of new installations this year, and the market could double again in 2011, too. The dynamic market segments are commercial rooftop systems in the 100 kW range, and large-scale plants in the MW range operated by energy utilities.

We estimate new PV installations in **China** at around 165 MW for 2009, raising the cumulative capacity to 285 MW. Up until now, around 200 building-integrated systems and ten free-standing systems have been installed under the Golden Sun programme. The largest system has a capacity of 20 MW. China's efforts to promote photovoltaics operate at both the central government and individual province level. China sets its feed-in tariffs for large-scale plants by means of a tender process. In June 2009 the tariff for two 10 MW projects was set at CNY 1.09/kWh. The latest concession allocation for 13 PV projects with a total capacity of 280 MW is currently underway. Bids have been submitted of between 0.73 and 0.99 CNY/kWh. In a global comparison this produces a low IRR score for large-scale systems. Therefore only those proposals with the lowest price per module stand any chance. The various investment subsidies for building-integrated and off-grid systems are not considered here.

Other countries in the starting blocks
Alongside the markets referred to above, there are other promising PV markets such as Brazil, Indonesia, Thailand, Turkey and other developing and emerging economies which offer enormous potential for solar power. These countries have a high demand for low-cost compact systems for generating electricity and light. These off-grid PV systems (solar home systems, or SHS) will soon become affordable for the rural population. With attractive pre-financing terms with an interest and maintenance payment, which would be below the level of expenditure for kerosene and candles, there is no doubt that people could be won over to this technology. At the moment this remains a market which is wantonly neglected by the major solar energy companies. Great potential is being wasted.

PV Market trends

Installed PV capacity in 2009
Around 7.5 GW of new photovoltaic capacity was installed **worldwide** in 2009 (according to IEA-PVPS)[12]. This corresponds to an impressive growth rate of 24% compared with the previous year. Admittedly, this is very much lower than the growth rate of 150% achieved in 2008. However, many people expected a growth rate as low as zero. The cumulative PV capacity at year-end 2009 therefore stood at around 21 GW. This equates to around 7% of total global installed electricity capacity from renewable sources of 305 GW[13], generating around 31.5 TWh of electricity per year.
For the **European** solar energy market the decline in market growth from 170% in 2008 to 18% in 2009 was, admittedly, drastic. However, it was not as severe as originally feared. The booming market in Germany (+155%) and above-average growth in Belgium (+500%), France (+139%), Italy (+144%) and the Czech Republic (+560%) were able to compensate for the collapse in the Spanish market.

2010: Growth despite lower remuneration rates.
This year, too, the number of new installations in many markets came as a positive surprise. Despite the lowering of remuneration rates in double figures in percentage

[12] Trends in PV applications; Survey report of selected IEA countries between 1992 and 2009. IEA Photovoltaic Power Systems Programme – Task 1; September 2010. www.iea-pvps.org
[13] REN 21, June 2010. Renewables Global Status Report: 2010 Update

terms (see LAI), we anticipate a growth rate of 87% or 13.8 GW worldwide. Europe will see growth of 86% or 10.6 GW in 2010. Germany's huge market will again grow by 79% or 6.9 GW this year.

Global market trends to 2015

We have analysed the following core data for our market forecast:

- PV market data for each country, from trade associations and IEA-PVPS
- National targets for PV installations and production capacities
- Data on capacity expansion in thin-film technologies and information from companies on their reliability

Taking into account the attractiveness rating for each country, we anticipate the market trends shown in Fig. 13 for the period to 2015. Globally, our forecast for the period 2009 to 2015 produces annual average growth of 33%. This results in newly installed PV capacity of 13.8 GW for 2010, 15.2 GW for 2011 and 18.3 GW for 2012. The growth rates for the individual countries and years vary enormously, however. Following 87% growth in 2010, we anticipate global growth of just 10% in 2011, rising to 20% in 2012.

In Europe, the strongest growth countries for the period to 2015 are primarily Spain (CAGR 2009 to 2015 of 69%), France (55%), Greece (51%) and Portugal (42%). The USA will grow by on average 70% per year over the same period, and will also gain massively in importance in terms of volume (an additional 11.3 GW in 2015). Other important growth markets are China (CAGR 2009 to 2015 of 77%), India (76%), Japan (30%), the rest of Asia (35%) and other countries (64%).

Figure 13: Sarasin PV market forecast to 2015

	Newly installed PV capacity (MW)							CAGR*
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**09-15**
Germany	3 845	6 900	5 500	4 300	4 515	4 650	4 697	3%
Italy	723	1 350	2 025	2 228	2 339	2 503	2 878	26%
Spain	60	250	535	660	900	1 100	1 375	69%
Greece	36	100	150	218	294	352	430	51%
France	250	630	1 008	1 512	2 117	2 710	3 455	55%
Portugal	34	55	85	128	176	222	283	42%
Czech Rep.	411	1 130	230	120	140	176	225	-10%
Belgium	292	100	120	130	135	170	217	-5%
Switzerland	26	30	60	70	80	90	100	25%
Rest of Europe	43	75	120	160	255	400	618	56%
Europe	**5 720**	**10 620**	**9 833**	**9 525**	**10 951**	**12 374**	**14 278**	**16%**
USA	**473**	**1 000**	**2 000**	**3 600**	**5 760**	**8 352**	**11 275**	**70%**
China	165	377	778	1 458	2 500	3 685	5 159	77%
India	30	80	152	274	443	629	887	76%
Japan	483	800	1 040	1 300	1 599	1 951	2 360	30%
South Korea	84	130	160	204	256	319	394	29%
Rest of Asia	186	300	420	546	699	888	1 118	35%
Asia	**948**	**1 687**	**2 550**	**3 782**	**5 497**	**7 472**	**9 919**	**48%**
Rest of the World	261	500	800	1 360	2 244	3 590	5 027	64%

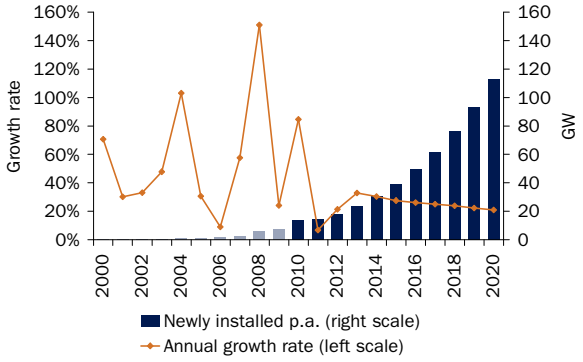
Total newly installed	**7 402**	**13 807**	**15 183**	**18 266**	**24 452**	**31 788**	**40 499**	**33%**
Annual growth rate	24%	87%	10%	20%	34%	30%	27%	

Source: Bank Sarasin, Nov. 2010; *CAGR: compound annual growth rate

116 GW of newly installed PV capacity in 2020

An important trend which we mentioned last year can now be confirmed in fact. Several markets will achieve an annual volume of over 500 MW of newly installed PV capacity this year or over the coming two years. This is a decisive factor, because it will mean that the PV industry is less susceptible to changes to the general operating conditions in individual key markets. A globally based PV industry of this kind will therefore grow in a more stable manner. We anticipate average annual growth of 28% for the period 2009 to 2020. This will produce newly installed PV capacity of 108 GW in 2020. The tendency will be for sunny, non-European markets to grow more rapidly in the period to 2020, as they still have a great deal of catching up to do in terms of solar power generation. Over the past two years the solar industry has demonstrated that it can survive and continue to grow even in a challenging economic and political environment. We are convinced that costs can also be reduced by on average 10% per year over the coming years, and that our scenario can therefore be realised in practice.

Figure 14: Sarasin's long-term forecast for the global PV market



Source: Bank Sarasin, Nov. 2010

Further cutbacks, stiffer competition, and huge market potential

For the coming year and beyond, the industry has prepared itself for further cutbacks in subsidies for solar power. There will be a significant reduction in tariffs in Italy, Germany and also in the Czech Republic. The politicians responsible fear, amongst other things, a rise in energy prices and instability in their power distribution grids. This will intensify competition among module manufacturers across Europe.

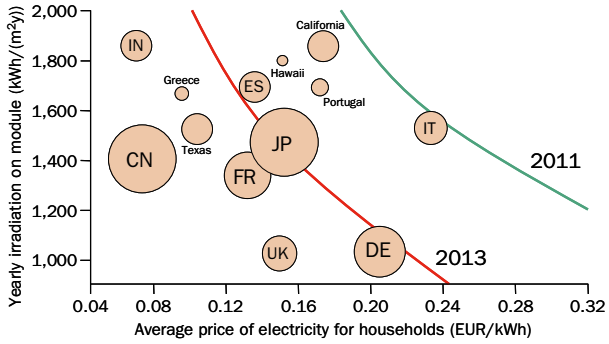
Grid parity arriving sooner than expected

The solar industry has already achieved incredible things. Since as recently as 2006, prices for solar electricity have fallen by 40% and, over the coming years, it will converge with the price level of consumer electricity tariffs. The key goal at present is to ensure an efficient and sustainable broadening of the photovoltaic market and to secure both the investments already made and those still required by this forward-looking industry. It will only take a few more years before the solar industry can survive without subsidy programmes in many key markets. Even in Germany, the electricity produced by solar panels on one's own roof will match the price charged for electricity by conventional energy suppliers or regional public utilities from 2013 onwards. This will mark an important milestone on the road to commercial competitiveness. For this reason, the industry is currently developing a road map towards further successful development of the photovoltaic market, and in the course of this process will demonstrate ways in which this commercial competitiveness may be achieved in a speedy manner. In addition, the solar industry is making efforts to underscore its positive economic and commercial achievements, and is increasingly bringing hard facts and figures to bear to counter one-sided arguments centred around cost.

Grid parity will be an important driver for demand in future. Compared with feed-in tariffs which are being continually reduced, thereby forcing house owners and investors into rash decisions, where grid parity applies the returns become better the longer one waits. A market with grid parity will therefore tend to see more gradual progress, and will not create a "gold digger" mentality as is the case in subsidised markets.

In sunny regions of the world such as Italy, California, Hawaii and Spain we expect this household grid parity to be achieved as early as 2010-2012. In Japan, too, with the highest electricity prices in the world, PV systems on the roof of a private home will soon become the norm, simply because it makes economic sense. From 2013 onwards, solar electricity will be as cost-effective as conventional grid power even in the countries of central Europe.

Figure 15: Trend toward grid parity for private customers



Source: EPIA, REC, Bank Sarasin, Nov. 2010

Sarasin forecast above the EPIA target for 2014

According to the new solar energy report from the European Photovoltaic Industry Association (EPIA), solar electricity will also see double-digit percentage growth over the coming years.[14] Compared with the 30.3 GW forecast by us, the moderate EPIA scenario anticipates global newly installed PV capacity of 13.8 GW for 2014. The additional policy-driven scenario anticipates 30 GW of new PV capacity. Our forecast is higher for 2010, and from 2014 onwards, while for 2011, 2012 and 2013 we are lower. This is certainly not out of any hope for greater support from policymakers, but because of the growing economic arguments for photovoltaics.

Sustainability rating of solar energy companies

From the start, Bank Sarasin has always tried to assess PV companies according to extensive sustainability criteria. For Sarasin it was never simply enough that the companies produced products for "green electricity". To begin with it was very difficult to get hold of the necessary information. In the meantime there are now a few PV companies which undertake comprehensive corporate social responsibility (CSR) reporting. For a long time now, SolarWorld AG has been a shining example. In order to raise the transparency and depth of the information provided by other solar energy companies too, Bank Sarasin supports the Sustainable Solar Initiative from Henderson Global Investors. With invested assets of USD 1,500 billion, this initiative has huge investor power behind it, enabling it to exert sufficient pressure on the companies concerned.

Sustainable Solar Initiative

Photovoltaics allow energy to be produced without harmful emissions, but the manufacture of solar modules is far from emissions-free. There are strong indications that some manufacturers in the PV industry employ environmentally critical production processes. For this reason, concerns are being raised among investors – not only because of the damage done to people and the environment, but also because of the possible consequences for the finances and share prices of the companies involved. If solar energy is intended primarily to serve the environment and the climate, it seems only reasonable that environmental impacts should be taken into account during their manufacture!

In 2009 the Silicon Valley Toxics Coalition (SVTC), an American environmental organisation, produced a questionnaire in collaboration with Henderson Global Investors (HGI) which was presented to the leading PV companies in order to determine how seriously they took important topics such as the avoidance of toxic chemicals, the health and safety of employees and people living nearby, and the recycling of discarded modules. The initial results of the questionnaire were published this year and show that while a number of companies including SolarWorld, Q-Cells and Yingli Solar demonstrably possess effective management processes in relation to these topics, many other companies do not.

Only 30% of the industry (measured in volume terms) addressed the questions presented to them at all.
In order to strengthen the incentive to respond, HGI has in the meantime taken steps to involve further investors with an interest in photovoltaic technology, to encourage the PV companies to strengthen their level of engagement concerning the social and environmental impacts of their business activities. The circle of investors comes from Italy, France, Switzerland, the USA, the United Kingdom and the Netherlands. It includes both "conventional" asset managers as well as specialists in clean energy and sustainable and socially responsible investing such as Bank Sarasin. Together they represent investments valued at more than USD 1,500 billion.
A second round of questionnaires will be launched in October 2010. At present it is not possible to foresee whether the response rate will improve. The final report will be available in the spring of 2011. A number of solar energy companies who previously rejected the survey have already indicated that they will participate this time round.
For further information visit
www.svtc.org or www.solarscorecard.com

Dummy-Fussnote[14] (**Am Schluss weiss machen!**)

[14] www.epia.org; Global Market Outlook for PV until 2014, April 2010

Concentrating solar power (CSP)

During the two years of 2009-2010, concentrating solar power plants (CSP) achieved an expansion of 1.35 GW in new, centralised electricity generation. In the battle for lowest cost of electricity generation CSP systems were temporarily overtaken by photovoltaics (PV) – foremost by cadmium telluride thin-film technology. The CSP sector nonetheless has considerable cost reduction potential as well as other substantial non-monetary advantages which keep the sector competitive. The latest Sarasin prognosis forecasts a cumulative CSP power station capacity of 32 GW by 2020.

CSP plants ready for market

Solar thermal electricity (STE) has been in a critical stage of commercial development during the past two years. Efforts in the areas of innovation and cost reduction are leading to a proven and attractive form of electricity generation based on solar energy. Furthermore, the industry has improved its organization. The leading European industry association ESTELA (European Solar Thermal Electricity Association) has grown increasingly active. Current reports indicate possible developments among CSP regarding cost reduction and power station construction.[15] As a result STE has gained stronger perception among the media and in the broader population.

CSP with huge project pipeline

Last year roughly eight power stations with a sum capacity of 350 MW were brought on line. One plant each was erected in Algeria, Italy and Mexico, while remaining construction occurred in Spain. This year some 18 power stations with a capacity of 1,000 MW are due for completion.

The current global pipeline for STE projects amounts to around 3,500 MW, with some large-scale power stations having a capacity of more than 50 MW. The focus of activity continues to lie in Spain and the USA. Additional CSP plants are either under construction or in planning in Sudan, South Africa, the Middle East, India and Australia.

CSP technology has gained further momentum especially in the sunny American Southwest, where it is the preferred form of renewable energy. The world's largest parabolic trough system, a power station with a capacity of 1 gigawatt, is slated for construction by *Solar Millennium* and *Chevron Energy Solutions* in Blythe, California. The USD 6 billion project consists of four power stations, each with a capacity of 250 MW, and is due on line in 2013. Blythe Solar services an area of 28.5 km^2 some 350 km east of Los Angeles.

In October U.S. Secretary of the Interior Salazar approved additional CSP projects in California and Nevada having a total generation capacity of 1.8 GW. By matter of comparison, one megawatt of CSP capacity (2,700 MWh/a) meets the electricity consumption needs of 400 average American households.

In the summer of this year construction also began on the Shams 1 CSP plant in Abu Dhabi. Chosen for the 100 MW CSP plant was the joint venture of *Masdar* with *Abengoa Solar* and *Total* from the bidding consortium. The plant is due on line in 2012. Onsite experts have discovered in the meantime that direct solar radiation is considerably reduced due to airborne sand particles, impairing the performance of the parabolic troughs. The array of mirrors will therefore be enlarged.

In the current list of CSP projects worldwide of 900 MW in operation, parabolic trough technology dominates with a 93% share of the market, followed by solar tower at 5%, Fresnel at 1% and Dish-Sterling at less than 1%. For CSP plants currently under construction this distribution will not change markedly. Only with those power stations

[15] ESTELA & A.T.Kearny: Marketability of solar thermal electricity (STE), June 2010

scheduled for 2015 will solar towers, Fresnel and parabolic mirrors emerge more strongly.

Attractive feed-in tariffs for CSP

The feed-in tariffs for CSP plants are only marginally affected by the current discussion regarding compensation rates for photovoltaics. Various countries have established subsidy programmes for CSP technology. Spain launched a feed-in tariff for solar thermal electricity as early as 2002. In the meantime such tariffs are also provided in Greece, Portugal, Italy, France, Israel, Algeria, India and Turkey, as well as in South Africa since March 2009. Alongside this in the USA subsidies are granted in the form of tax reductions of up to 30% (investment tax credits, ITC).

Consolidation in the CSP industry

Solar thermal power plants are huge capital investment projects, the supply chain for which also requires expensive infrastructure. In contrast to the PV industry, in which more than 400 companies are still active, there are in the CSP industry only a few vertically integrated major enterprises. In view of banks' continued rather conservative lending activities and the high capital requirements for a CSP project, the key financial data must meet very high criteria. As a result financially strong companies such as *Chevron*, *Alstom*, *Areva* and *Siemens* are increasingly entering the fray. *Alstom* announced an investment of USD 55 million in a partnership with *BrightSource Energy (BSE)* in May. Thereby *Alstom's* experience in turbine construction is to be combined with *BSE's* know-how in CSP technology. Together the duo will build power stations in the Mediterranean Region, in Africa and the USA. *BSE* has a project pipeline in the USA amounting to 4.0 GW.

Energy utilities' engagement also continues, helping to develop CSP to an established technology for renewable energy. Particularly the possibilities of energy storage or the combined use with a fossil fuel (hybrid operation) make CSP plants suitable for peak as well as for base load electricity production.

***First Solar* with large-scale ambitions**

First Solar has substantially strengthened its engagement in project business in recent years. The company has acquired one engineering and project planning company after another. The most recent was *NextLight Renewable Power* with a project pipeline of 1.1 GW. This yields an important sales channel for the company's thin-film modules. With new projects, also including some with capacities exceeding 500 MW, *First Solar* is clearly playing in the big leagues among CSP plants.

PV and CSP – the battle of lower costs

Due to the significant price reduction among PV modules (c-Si-based and thin-film) during the past twelve months, electricity generation costs per generated kilowatt hour by large-scale PV plants have also dropped substantially. A CdTe thin-film installation has surpassed a parabolic trough system using a storage medium in the interim on a cost basis. The former achieve electricity generation costs of 0.14 EUR/kWh. Newly installed CSP plants, though they appear to have contributed experience to the industry, have not been able to reduce generation costs per kWh in the same measure. The two solar technologies were presented in detail within the scope of the Sarasin Solar Energy Study 2008.[16]

CSP with cost reduction plans

CSP plants can nevertheless achieve further advancements in the future to regain the cost leadership position. According to industry representatives[17] electrical power production could become 30 – 50% cheaper by 2015. Thus electricity generation costs of 0.08 – 0.10 EUR/kWh would be achieved.

This should be reached foremost due to steam temperatures of up to 580°C. In comparison with current temperatures of 380°C, the higher level can increase the efficiency of the steam cycle by 20%. An initial pilot power plant with a capacity of 5 megawatts using molten salt not only for heat storage but also as a transfer medium was started up in Sicily during the summer. With it a

[16] Solar energy 2008 – Stormy weather will give way to sunnier periods, Bank Sarasin, Nov. 2008

[17] Abengoa Solar, Michael Geyer, Director of Internatl. Development

steam temperature of 500°C should be achievable. In addition, it enables a simplified design of the power plant which eliminates oil-to-molten salt heat exchangers, resulting in fewer safety and environmental concerns within the context of synthetic oil use. The pilot project described has a current high price of EUR 60 million for 5.0 MW. Despite the previously low net efficiency of 13%, the technology could gain footing in the market. The mentioned heat storage and the option of constructing a hybrid power station remain additional benefits of CSP technology. Cost reduction potential consists primarily in the leverage of scale. The investment per kilowatt of electrical capacity drops upon doubling the size of the power plant by roughly 15%. Until now the standard size for such CSP plants stood at 50 MW. New projects in the USA now often range above 200 MW. In Spain funding for CSP would need to be adjusted accordingly, as it has previously promoted power plants of 50 MW.

Current cost comparison

Beginning two years ago we have compared the various technologies for large-scale solar power plants with each other. Fig. 16 illustrates an updated cost comparison of two PV installations, one with polycrystalline Si-modules and the other with CdTe thin-film modules, as well as two CSP plants, one with a parabolic trough solar array and the other with linear Fresnel technology.

Since the last solar energy study the specific total investment for CdTe thin-film has fallen by some 25%, and that for a c-Si-module installation by roughly 14%. For parabolic trough systems we assume a reduction of about 3%. Data for the linear Fresnel CSP plant continue to be based on last year's project; costs have incurred only slight reduction due to moderately improved financing conditions. Thus a CdTe thin-film installation with electricity generation costs of 0.14 EUR/kWh lies clearly ahead of the polycrystalline PV installation at 0.16 EUR/kWh, and of the parabolic trough system with generation costs of 0.17 EUR/kWh. The Fresnel technology with 0.21 EUR/kWh has the highest electricity generation costs. In point of comparison electrical power from a coal-fired plant costs roughly 0.042 EUR/kWh. The peak efficiency of CSP plants at 25% is higher than that of photovoltaics. The average efficiency of polycrystalline Si-modules lies at some 15%, and that of CdTe modules at 11%.

At the moment CSP project developers in California are battling increasing risks simultaneously with decreasing electricity tariffs. Twenty-two of twenty-nine total CSP projects in California with power purchase agreements (PPAs) are under negotiation with only two energy utilities. These are *Pacific Gas & Electric (PG&E)* and *Southern California Edison (SCE)*. The two energy utilities have the much better negotiating position and shift additional costs to the project developers, for example for power transmission.

Speedier implementation of mid-sized PV projects

From an investor's standpoint the swift realisation of a project is also significant. In this instance mid-sized PV installations of 2 – 20 MW have the lead. They can be built very rapidly in 18 – 24 months without major environmental impact studies. This occurs preferably in the vicinity of an existing network (medium voltage) in the sense of a decentralised electricity generation and without excessive burden to power transmission capacities. Such an installation size has become the specialty—among others—of the American *Recurrent Energy*. The company has been acquired just recently by *Sharp*. CSP projects require up to five years' development time, since they must fulfil a greater number of environmental regulations and because a link to the electrical power network might need to be built. The environmental approval process for the 400 MW CSP Ivanpah project from *BrightSource Energy* in California took for example two and a half years.

Figure 16: Pros, cons and cost comparison of large-scale Si-PV, thin-film PV and CSP installations 2010

	Photovoltaics (PV)		Concentrating solar power (CSP)	
Pros/cons of individual technologies	**Multi-crystalline silicon module**	**CdTe thin-film module**	**Parabolic trough solar field**	**Linear Fresnel technology**
Typical size (MW)	2 - 50	2 - 50	50 - 200	1 - 30
Project phase	short; systems are scalable		lengthy planning and construction times	
Surface area required per kW	medium	large	medium, but even surface	
Irradiation	direct irradiation	diffused light	direct irradiation required	
Storage	not usual, expensive at present		simple to implement	possible
Steam cooling	-	-	water or air	
Suitable for hybrid operation	-	-	hybrid operation with gas possible	
Adjustability of power	no	no	yes	yes
Service life (years)	25	25	25	25
Cost comparison				
Gen. contractor, contr. costs (EUR/kW)	2 800	2 200	3 900	3 600
Financing (EUR/kW)	280	242	429	396
Total investments (EUR/kW)	**3 080**	**2 442**	**4 329**	**3 996**
Electricity conversion (kWh/kW)	2 000	1 800	2 700	2 000
Peak efficiency	15%	11%	25%	19%
Maintenance p.a. (% of total investm.)	1,3%	1,4%	2,1%	1,3%
Electr. generation costs (EUR/kWh)	**0,16**	**0,14**	**0,18**	**0,21**

Location of solar energy installations: southern Spain receives annual solar radiation of 2,000 kWh/m^2

Source: company, Bank Sarasin, Nov. 2010

New CSP technologies

The development of new technologies is exposed to very high financial and political risks. Banks are currently refraining from financing power plants based on sparsely proven technologies. The guarantee of a public authority or of a major energy utility is thus nearly imperative. In the following are two technologies that may possibly achieve a breakthrough:

Stirling Energy Systems (SES) is attempting a less conventional technology based on parabolic mirrors in combination with a Stirling engine. This is driven by the heat of concentrated solar radiation, and through a generator delivers 25 kW. According to information from *SES* such installations achieve an efficiency of 31%. Recently in Arizona a 1.5 MW park with 60 parabolic disks was dedicated. Far larger power plants are being planned by *SES* to 2012. A 250 MW power plant is slated for Phoenix at a cost of EUR 525 – 700 million. Two further projects of 750 MW and 850 MW are now in planning in California. Apparently a power purchase price as low as 0.07 – 0.09 EUR/kW has been agreed upon.

Fresnel technology has also made decisive progress. Particularly the CLFR technology (Compact Linear Fresnel Reflector) received a powerful boost due to acquisition of CLFR expert *Ausra* by *Areva Solar*. This CSP technology should derive 1.5 – 3 times as much electricity from one square kilometre of desert as parabolic trough arrays, a solar tower or a thin-film PV installation, due foremost to the sophisticated design of the mirror and the receiver.

The innovative Swiss company *Airlight Energy (ALE)*[18] with its novel, cost-effective solar collector was presented last year in detail. The system is based on pneumatic mirrors and uses air as a heat transfer medium. At the beginning

[18] www.airlightenergy.com

of November detailed, independent university and industry certifications were successfully concluded. Following the completion of this prototype test phase, the construction of a pilot plant is being expedited. The new dual-axle receiver promises especially high power station efficiency, nota bene significantly higher than current parabolic trough systems. The now tested gravel bed heat accumulator enables low-cost electricity production, suitable for the market. The integrated rain water collection system employing air-cooled condensors to cool steam induces a positive hydrological balance.

Solar hybrid power stations as a great chance…

With an increasing proportion of solar-derived electricity in the network, a disadvantage of solar energy becomes apparent, namely intermittency, the swiftly altering quantity of electricity that can be generated from sunlight.

CSP has bridged this difficulty with the storage of heat, which can also drive a turbine after sundown. Lately some developers are working on hybrid power stations in which solar energy is applied along with gas, coal or diesel fuel. CSP technology is highly suited for this, since it also operates with steam turbines and generators, which can be actuated by both energy sources, depending upon the availability of solar radiation. At the moment, such hybrid power stations based on CSP are being developed in a number of countries in the Middle East (Israel, United Arab Emirates) and North Africa (Egypt, Algeria, Morocco). These countries can thus gain initial, low-risk experience with solar technology. Solar hybrid systems do offer persuasive arguments, since they generate fewer emissions and require less fossil fuel, at the same time facilitating the integration of solar electricity into the network.

In appropriate locations such CSP technologies can be retrofitted for existing power stations comparatively easily and inexpensively. They could in future become acknowledged competition to planned carbon capture and storage (CCS) power stations. In contrast to CCS technology, the efficiency of the fossil-fueled portion of the power station is markedly less reduced by the solar portion.

The mentioned CSP pilot plant employing molten salt as heat transfer medium and higher steam temperatures will further simplify linkage with an existing power station. With the higher temperatures it is possible to employ a steam turbine with standard pressure and temperature parameters that is already in use in conventional power stations today. In combination with a heat storage unit a competitive, efficient power station generating dispatchable power can be created.

Market outlook for CSP systems

The project pipeline for CSP installations in the coming years will be strongly dependent on development programmes in the aforementioned countries and on individual innovative energy utilities. More than 70% of installations planned in 2010 and 2011 are located in Spain and the USA. Other countries in the Middle East and North Africa (MENA Region) as well as in southern Europe will realise various projects including hybrid power stations with a sum capacity of over 700 MW. Experience gained thus far with new installations is encouraging and critical for a broader deployment of CSP technology. Our forecast projects a cumulative CSP capacity of 32 GW by 2020 (Fig. 17). For the period from 2010 – 2020 this corresponds to an average annual growth rate in newly installed capacity of 12%. This forecast is of a similar order of magnitude as the report by A.T. Kearny, prepared for ESTRELA in June 2010. This assumes capacity of 30 GW by 2020 and 60 – 100 GW by 2025.

Figure 17: Predicted expansion of CSP systems

New capacity in MW	Cumulative 2009	Annual additional capacity 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Cumulative 2020
Spain	345	455	600	700	900	700	500	450	450	400	500	500	6 500
USA	435	265	600	1 300	2 300	1 600	1 200	1 200	1 200	1 100	1 000	1 100	13 300
MENA	80	170	250	350	460	1 200	700	850	950	1 200	1 200	1 250	8 660

CSP Systems

RoW	30	120	150	200	290	350	450	400	400	400	400	350	3 540
Total	**890**	**1 010**	**1 600**	**2 550**	**3 950**	**3 850**	**2 850**	**2 900**	**3 000**	**3 100**	**3 100**	**3 200**	**32 000**

Source: ESTELA, Bank Sarasin, Nov. 2010

Solar collectors

Solar heat is an important form of renewable energy that does not bathe in the spotlight as photovoltaics or solar thermal power stations do. Worldwide today already 70 million households supply their own hot water using solar collectors installed on the roof. Annual expansion in individual countries fluctuates heavily and is strongly dependent on the economic cycle, building and construction and energy prices. We anticipate average annual growth of 20% through 2020.

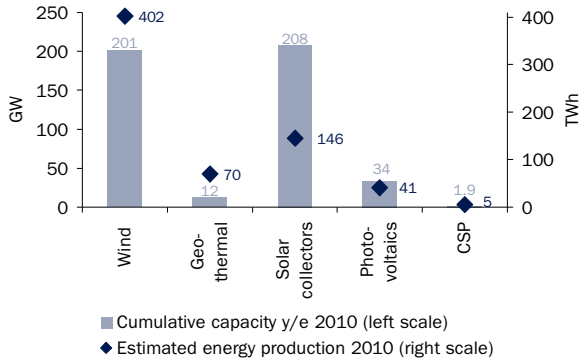
Decentralised heat generation using solar collectors for hot water and space heating represents the third application area of solar energy.

The prices of fossil fuels (normally heating oil or natural gas) are more significant for solar thermal energy than for photovoltaics, since development programmes play a smaller role. As a result of the economic crisis oil prices are now far below their high of USD 150 a barrel of 2008 and are not stimulating additional use of solar thermal energy.

Nevertheless solar thermal energy is being supported by many governments through financial incentives and legislation. The EU target to increase its proportion of energy supply from renewable sources to 20% by 2020 includes space heating and warm water. The International Energy Agency (IEA) estimates that solar hot water and space heating systems could replace 60 – 70% of gas and electricity consumption for this purpose.

In comparison with other renewable energies (excluding hydropower) solar collectors deliver a substantial portion of energy supply. Already 70 million households in the meantime supply themselves with hot water using solar rooftop installations. This portion is the largest energy contribution among all solar technologies. Fig. 18 shows the projected cumulative electrical or thermal capacity ($GW_{el/th}$) at y/e 2010 for wind, solar collectors, geothermal power, photovoltaics and CSP, as well as the energy generated from it in 2010 ($TWh_{el/th}$).[19]

Figure 18: Renewable cumulative capacity (GW) at y/e 2010 and energy generated in 2010 (TWh)



Source: Bank Sarasin, Nov. 2010

[19] In this report the installed solar collector capacity is not expressed in square metres, but in kilowatts of thermal energy based on the conversion factor 0.7 kW_{th}/m^2. For more details visit www.iea-shc.org

Leading players in solar thermal power

The following describes the most important news as well as changes within individual companies.

Alanod is one of the worldwide leading manufacturers of surface-treated aluminium and copper coils. Beginning in 2010 fabrication was consolidated at the headquarters in Ennepetal, with capacity of the enamelling line being expanded to more than 3 million m^2/a for EUR 20 million. To protect reflective surfaces for outdoor applications *Alanod* secured patents from *Bayer MaterialScience* for a specialised coating. The finished aluminium band material will be used among other places in parabolic trough systems in CSP plants.

The joint venture ***Almeco-TiNOX*** merges the coatings know-how of two companies which have been influencing markets for years with their innovations. *Almeco-TiNOX* provides absorber coatings on copper and aluminium substrates for solar collectors as well as reflective surface coatings for CSP installations. At the company's Bernburg location in addition to a modern coating plant a new cutting centre has also been installed. In 2009 *Almeco-TiNOX*, with 23 employees and production encompassing 710,000 m^2, registered sales of EUR 11 million with absorbers for solar thermal energy.

Ariston Thermo Group is a worldwide active company headquartered in Italy. Group sales in 2009 amounted to EUR 1.1 billion, 89% deriving from the area of *Thermic Comfort*, in which solar thermal energy is classified. The company registered 6,500 employees. In 2009 a total of 75,000 m^2 flat-panel collectors (42,000 m^2 of which in Italy) and 18,000 m^2 vacuum tube collectors were produced. The company exported 85% of its output.

Citrin Solar achieved sales of EUR 34 million in 2009 and had 75 employees. Production of flat-panel collectors amounted to 60,000 m^2, with 15% exports, a growing trend. The company has recently entered markets in Eastern Europe, Turkey and India (solar water treatment). In addition a new production hall (3,000 m^2) for solar collectors (annual production capacity 250,000 m^2) has been built, and a second fabrication line as well as an extension of storage tank fabrication for large tanks are under construction.

DeDietrich Remeha Gruppe and ***Baxi Gruppe*** founded ***BDR Thermea*** in November 2009 as a joint European heating appliances and systems company. Business activity in 2009 recorded sales of roughly EUR 1.7 billion and a staff of more than 6,400 employees. The company remains active across Europe with the well known brands *De Dietrich, Baxi, Remeha, Heatrae Sadia, Brötje, Potterton, Chappée, BaxiRoca* and *Baymak.*

BlueTec in Eberschuetz, Germany moved into a new factory for production of reflective aluminium band (indoor lighting) along with a new administration building (approx. 900 m^2). Production of solar absorbers remains at the former location in Karlshafen. The entire coating capacity now amounts to roughly 10 million m^2 (3 shift operation). The proportion of exports of solar absorbers surpasses 60%, increased especially due to the high level of deliveries to China. Sales – despite poor market conditions in Germany and in certain parts of the EU – remained at the previous year level. Production output registered slight growth in 2009 (BY 2008 roughly 1.3 million m^2) and follows this trend in 2010.

Bosch Thermotechnik has annual production capacity in Germany and Portugal of more than 1.0 million m^2. In 2009 with some 13,000 employees *Bosch Thermotechnik* achieved sales of EUR 2.87 billion, of which 15% came from systems for use of renewable energies. By 2020 this proportion should grow to 30%. In 2009 and 2010 *Bosch Thermotechnik* launched a new collector series for warm climate zones and expanded its solar products and systems distribution to Latin America and Australia. As a system supplier *Bosch Thermotechnik* also expanded its offerings for solar large-scale installations.

Chromagen reached 2009 turnover of USD 50 million, has two production factories in Israel and distributes its products in 35 countries. Since spring of 2010 *Chroma-*

gen has been in close strategic cooperation with the American *A.O. Smith Corporation*. With turnover of USD 2.0 billion, this company is the leading manufacturer of water heaters in North America. *A.O. Smith* secured exclusive marketing and distribution rights for *Chromagen* solar collector products for privately owned homes and for the commercial sector.

GreenOneTec (GoT) had annual production of flat-panel collectors of 830,000 m^2 in 2009. Currently the annual production capacity amounts to 1.6 million m^2. Long term expansion of the factory in St. Veit is however already designed for a capacity of 3 million m^2 of collector surface area. *GoT* has an export quotient of over 85% to more than 40 countries worldwide, and in 2009 had a market share of 25% in Europe.

Ritter Gruppe is the clear market leader in vacuum tube collectors in Germany and Europe. In 2009 the company produced some 136,000 m^2 of gross collector surface area with roughly 100 employees. Billed sales amounted to EUR 102.5 million, the rate of export registered at 30%. The most important markets were Germany, Italy and Poland. *Linuo-Paradigma*, a successful joint venture, is meanwhile perched among the top 3 in China's home market. *Linuo-Paradigma* manufactured roughly 1.14 million m^2 of vacuum tube collectors there in 2009, of which 7.5% were exported. Sales amounted to EUR 99.6 million. 1,020 people were employed.

Schüco introduced a new heat-conducting technology in its production lines which enables a 360-degree welding joint of the absorber tube, yielding a substantially enlarged heat exchange surface for the meander tube. With its combi-installation hybrid heat pump, *Schücho* has strengthened its profile as a systems supplier. Total production of flat-panel collectors in 2009 amounted to 240,000 m^2. The company reached turnover of EUR 2 billion, of which EUR 660 million derived from the Solar Division, with an overall staff of 4,850 employees. *Schüco* has also entered the area of thin-film PV (see chapter Thin-film Technologies).

Solvis has an annual production capacity for absorbers (Al) of 400,000 m^2, and in 2009 produced some 75,000 m^2 of flat-plate collectors. New markets and its own subsidiary in Spain have raised exports to 10%. A focus lies on large-scale installations for multi-family homes and industrial buildings. Sales in 2009 declined to EUR 66 million following EUR 72 in the previous year.

Austrian ***Sun Master*** (belongs to *Xolar Gruppe* with roughly 200 employees) sales volume of solar collectors in 2009 reached roughly 120,000 m^2, amounting to EUR 15 million. The company has 70 employees. Annual production capacity encompasses 300,000 m^2 of solar collectors. Following new construction and plant expansion this should increase to 1 million m^2 annually. The company is occupied with the development of a long-term storage system and a thin-film solar collector.

Thermosolar achieved sales of EUR 20-25 million in 2009 on 230,000 m^2 of collector surface with roughly 180 employees. Planned by 2010 is a capacity expansion up to approximately 1 million m^2 per year. The proportion of exports amounts to over 80%. Business with solar-supported heat pumps shows a clear upward trend. The company's good market share in the UK should be expanded, among other ways through a controlling participation in *Genersys*. Additional export markets will increasingly be South and Central America. *Genersys* distributes its products for solar thermal energy and swimming pools in more than 65 countries.

TiSun with some 135 employees achieved sales of EUR 29 million in 2009 on production of roughly 89,000 m^2 of solar collectors. The company's export quotient of 85% is reached in 42 countries. Besides long-term cooperation with the U.S. company *Lochinvar Corporation* of Nashville, a strategic partnership has been established in Australia.

The solar business of ***Kingspan Renewables*** encompasses activities in solar thermal energy. Belonging among these is the *Thermomax* brand, a worldwide represented vacuum tube collector. These are manufactured in a new, fully-automated factory in Portadown, Ireland

(headquarters of *Kingspan Ltd*). Sales of the *Environmental & Renewables* division amounted to EUR 169 million, thereby responsible for 15% of total sales. Nearly 75% of demand stems from the UK and Ireland, though for vacuum tube collectors the export quotient amounted to 70% of production of some 75,000 m^2 in 2009. In focus for the coming years are the markets of Middle East, Asia and the USA. Overall *Kingspan* employs more than 4,700 people, approximately 5% in the area of solar thermal energy.

Vaillant produced flat-plate collectors with a total surface area in 2009 of 165,000 m^2, and the proportion of exports could be increased above 50%. Since September 2009 collectors are also fabricated in Nantes (FR). *Vaillant* total capacity now amounts to roughly 700,000 m^2. At the beginning of this year a third collector fabrication was started in Turkey under the *"Demir Döküm"* brand. Thermosiphon systems are built here for Turkey and bordering countries.

Viessmann enterprise group is one of the internationally leading manufacturers of heating technology systems. In 2009 the company generated group turnover of EUR 1.6 billion and employed some 8,600 people. Flat-plate collector output amounted to roughly 360,000 m^2, that of vacuum tube collectors to roughly 80,000 m^2. The export quotient lies at some 55%. Activities in the area of solar thermal energy and reservoirs are consolidated in a competence centre in Faulquemont, France. Vacuum tube production in Dachang, China has been expanded.

Wagner Solar currently has a total capacity for production of various collectors of some 600,000 m^2 per year. In 2009, 150,000 m^2 of flat-plate collectors were produced. With its two divisions of solar thermal energy and photovoltaics the company achieved sales of roughly EUR 240 million. With a strong basis in the German market, in the meantime something more than 50% of solar thermal systems are being exported. Existing distribution subsidiaries in Spain, France and Italy were joined in 2010 by *Wagner Solar Inc.*, located in the USA.

Wolf is a systems provider in the areas of climate and ventilation systems, solar thermal energy and biomass as well as gas and oil heating. The company has belonged to the exchange-listed *Centrosolar Group* since 2006. In 2009 *Wolf* achieved turnover of some EUR 260 million, of which approximately EUR 40 million came from *"New Energies."* The company has some 1,400 employees. Exports as a proportion of turnover amounted to around 30%. Production of flat-plate collectors totalled 135,000 m^2.

Chinese solar thermal industry

China has the largest solar thermal industry in the world. This also includes the corresponding suppliers of borosilicate glass, vacuum tube manufacturers and assembly firms. In 2009 the entire production of borosilicate glass amounted to 748,000 tons. More than 1,500 production lines for coating vacuum tubes were in operation and manufactured 350 million units.[20] Particularly the vacuum tubes have a convincing price-performance ratio as well as the required certificates, so that they are now an important export good. Last year these exports reached sales of USD 200 million. There is nevertheless a clear drawback with building-integrated solar thermal energy installations. In China a major portion of installed systems consist of a conventional thermosiphon system on the rooftop. Chinese production of solar warm water systems in 2009 lay at roughly 40 million m^2 and has grown on average over the last ten years by 25% per year. In the interim the 15 largest companies in the Chinese solar thermal energy market account for 72% of the market.

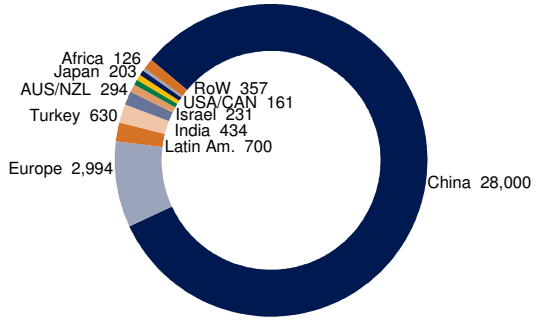
[20] Sun & wind energy, 7/2010, Seiten 88 ff

Global market trends

Global growth of 23% in 2009

Across the world, regional differences regarding newly installed collector surface area remained large. Global newly installed capacity in 2009 registered 34.1 GW_{th} (48.8 million m^2, Fig. 19). Around 82% were installed in China, which corresponds to a surface area roughly ten times larger than that installed in Europe. Last year the Chinese market again recorded growth of 29%. Demand in China is mainly driven by the central government programme "Household appliances for the rural population." This was responsible for some 58% of installations. The European market shrank in contrast by 10%. Besides the Chinese home market there are other major markets in Europe (Germany, Austria and Greece) as well as in Latin America, in Turkey, India, and Australia/New Zealand.

Figure 19: Global newly installed collector capacity. Total amounted to 34,000 MW_{th} (48.6 million m^2)



Source: W.B. Koldehoff (Underlying data), Nov. 2010

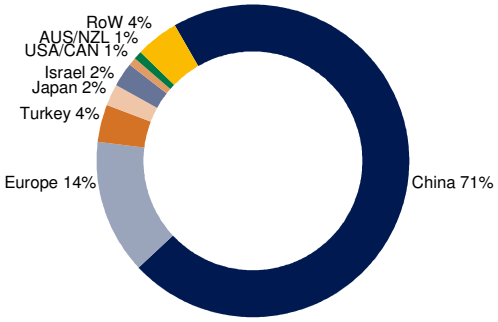
National growth rates fluctuate

Markets for solar collectors in individual countries are not very stable, and fluctuate from year to year. Growth rates in 2009 in Australia/New Zealand (50%), Africa (43%) and China (29%) were all above the global rate of 23%. In Latin America (13%), Japan (12%), Israel (14%) and India (13%) there was positive growth below the global average, Turkey recorded zero growth, whereas markets in Europe (-10%) and USA/Canada (-15%) showed negative growth.

In 2008 growth rates looked completely different: Australia/New Zealand (6%), India (-15%), Africa (-1%), Europe (60%), Israel (4%), Turkey (29%), Japan (13%), and USA/Canada (50%).

Fig. 20 shows the cumulative collector capacity in operation in individual countries and regions through the end of 2009. In comparison with 2008 this capacity has grown worldwide by 11% to a total of 158 GW_{th} (226 million m^2). China has increased its share further from 68% to 71% and is clearly the largest market with an operational solar collector capacity of 112 GW_{th}. The percentage shares of total collector surface area are regionally very stable despite fluctuating annual growth rates.

Figure 20: Global total operational solar thermal energy installations to 2009 of 158 GW_{th} (226 Mio. m^2)



Source: W.B. Koldehoff (Underlying data), Nov. 2010

Market trends in Europe

After the European solar thermal energy market experienced extraordinary growth of 60% in 2008, newly installed solar collector capacity dropped by 10% in 2009.[21] Sales declined in five of the six top markets. Besides the financial crisis, the solar thermal energy market was also affected by the turbulence in the building and construction sector as well as in the real estate market.

[21] ESTIF: European Solar Thermal Industry Federation, www.estif.org; Trends and Market Statistics 2009, June 2009; EU 27 + CH

A clear correlation exists between the solar thermal energy market, energy costs and the general economic situation. Despite this the installed surface area in 2009 amounted for the second time to more than four million square metres. Furthermore, the European market has diversified and is now less dependent on developments in Germany. In 2009 Italy, Spain, Austria, France and Greece together achieved a market share of newly installed collector surface area of 39%, for the first time more than Germany with 38%. Markets did not grow in those countries, however, but merely shrank less severely than in Germany (-23%). Due to tax credits in Italy, sales fell by only 5% in comparison with the previous year. With the collapse of the building boom in Spain the solar thermal energy market also succumbed, since building codes are its central pillar. There was a similar plunge in Greece of nearly one third in comparison with the prior year. The market in France declined 15% year-on-year. Only in Austria as a result of environtmentally conscious private home owners was there a sliver of growth at 3%.
There is nevertheless positive news to report from smaller markets. An above average quantity of solar collector surface area was installed in Romania (150%), Hungary (127%), Portugal (103%), the Netherlands (76%), Denmark (65%), Switzerland (48%) and Slovenia (38%).

Figure 21: Solar thermal energy market in Europe 2009; overview ranked by market share in MW_{th}

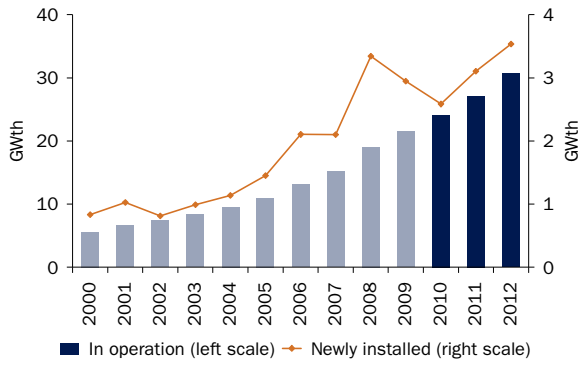
Country	2009 in service (MW_{th})	European market share (%)	Market trend 2008-2009 Installed 2008	Installed 2009	Market-growth	2010 market forecast total	2011 market forecast total
Germany	8 896	40%	1 512	1 131	-25%	840	940
Greece	2 852	13%	209	144	-31%	126	140
Austria	2 518	11%	244	250	2%	217	230
Italy	1 404	6%	295	280	-5%	252	260
France (EU)	1 322	6%	224	186	-17%	189	210
Spain	1 262	6%	304	274	-10%	210	210
Cyprus	524	2%	48	39	-19%	42	45
Switzerland	462	2%	57	84	48%	110	120
Poland	357	2%	90	101	12%	140	160
Portugal	345	2%	60	122	103%	70	75
UK	332	2%	57	62	10%	56	70
Denmark	331	1%	23	38	65%	28	40
Netherlands	285	1%	18	31	76%	30	35
Belgium	224	1%	64	36	-44%	40	45
Sweden	217	1%	19	15	-20%	21	25
Slovakia	105	0,5%	9	9	0%	11	13
Ireland	76	0,3%	30	23	-22%	21	22
EU Rest	558	2,5%	77	103	33%	150	175
Total	**22 127**	**100%**	**3 341**	**2 945**	**-12%**	**2 525**	**2 815**

Source: ESTIF, June 2010; W.B. Koldehoff, Bank Sarasin, Nov. 2010

Prospects for Europe

Last year we had predicted the collapse of the European solar thermal energy market in 2009 with -20% more strongly than the
-12% which eventually occurred. For 2010 we anticipate another market decline of 12%. Once again the major markets will shrink. In contrast the Eastern European countries exhibit stable growth, as do Switzerland, Belgium and Sweden. The French solar market could gain slightly.
In 2011 Germany can once more reckon with 15% growth, provided that market parameters there align. In the rest of Europe the Eastern European countries will continue to advance. Portugal could achieve slight growth in conjunction with its current subsidizing policy (coupling with PV feed-in tariff and large-scale systems). Growth of some 5% is also possible in France. Sizable uncertainty exists in Spain and Italy. For the entire European solar energy market (EU-27 + CH) we predict moderate growth of roughly 10% for 2011.

Figure 22: European solar thermal energy market (EU-27 + CH). Estimate for 2010 – 2012: 2.5; 2.8; 3.2 GW_{th}



Source: ESTIF, June 2010; W.B. Koldehoff, Bank Sarasin, Nov. 2010

German solar thermal market ups and downs

After the record year 2008 when more than 1,500 MW_{th} of solar thermal capacity was installed in Germany, new installation dropped by 25% in 2009 to 1,131 MW_{th}. Nonetheless since 2004 a doubling of installed capacity from 525 MW_{th} to 1,131 MW_{th} has been recorded. In 2009 low oil and gas prices as well as curtailed investments by end customers had a negative effect. Especially in Germany, many solar thermal energy companies view photovoltaics as serious competition.
In July 2010 the budget committee of the German Bundestag lifted the budget freeze for the market stimulus programme. Thus funds frozen till then amounting to EUR 115 million can be used this year to subsidize renewable energies in the heating market further. Consequently there is a total of EUR 380 million available this year for subsidies in the market stimulus programme. Despite this we again predict a market decline of 26% for 2010.
2011 will be another difficult year for the German solar thermal energy market. Depending on oil price developments, the final ruling regarding thermal insulation of building stock to 2050 as well as the general economic situation, the solar thermal market will catch more or less tailwind. The market's reaction to farther reduction by 13% of the feed-in tariff for photovoltaics as of 2011 will also be decisive. We consider moderate growth of 15% possible for solar thermal energy.

Austria – growth in production, exports and domestic installation

In 2009, 0.356 million m^2 of thermal solar collectors were installed in Austria, corresponding to an installed capacity of 250 MW_{th}. After strong market growth of 24% in 2008, 2009 yielded growth of only 2% for newly installed collector surface area. Average annual market growth from 2000 to 2009 amounted to 9%. During this period the yearly installed capacity more than doubled from 117 MW_{th} to 250 MW_{th}. For 2010 a decline of some 12% is anticipated, while for 2011 we once more prognosticate moderate growth.
Between 2002 and 2009 annual production of solar collectors in Austria nearly quadrupled, from 0.33 million m^2 (2002) to 1.40 million m^2 (2009). Of this output, 1.0 million m^2 were exported last year (2008: 1.3 million m^2), corresponding to 76% of domestic production. Two-thirds of collectors proceed to Germany, some 10% apiece to Italy, France and Spain respectively. The remainder is sold throughout the world, reaching Mexico, Brazil and

China. Solar installations generated sales of EUR 500 million in 2009, a third of this in the installation trade. The Austrian solar energy sector accounts for roughly 6,200 jobs.[22]

Swiss solar collector market grew 48%

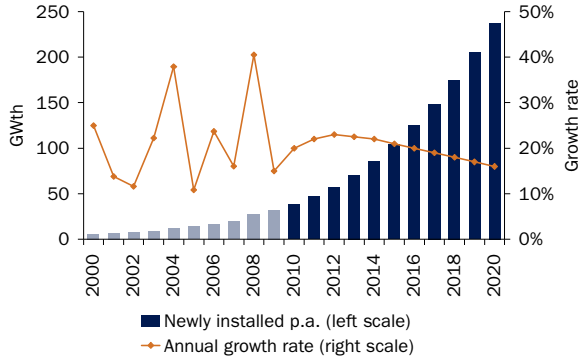
Switzerland counted among the few solar thermal energy growth markets in Europe in 2009. Last year a total capacity of 84 MW_{th}, or 120,000 m^2, were newly installed in Switzerland. This corresponds to growth of 48% in comparison with the expansion of the previous year. The rate of expansion has risen continuously now for the sixth year in a row. In 2009 flat-plate collectors had a market share of 94%. Total installed solar thermal capacity accrues to 462 MW_{th}, or 660,000 m^2. The signs for a continually growing Swiss solar market are auspicious. The introduction of a CO_2-tax on heating oil and gas in 2008 gave additional incentive to real estate owners to lower consumption of fossil fuels. The proportion of imports increased markedly. While in 2008 just 35% of collectors stemmed from abroad, in 2009 this figure reached 45%. Water heating installations for single-family homes are the most common of new installations, accounting for two-thirds. Aside this some 2,200 installations were made in multi-family homes. In the current year 2010 it appears that targeted growth of greater than 20% will not be reached, while for 2011 a more moderate increase is anticipated.

The current survey in the cantons regarding subsidies for solar collectors lends a positive image overall. For the first time in 2010 all cantons paid subsidies for solar collectors. The Swiss industry association Swissolar raised the level of the cantonal contributions based on a reference installation. This has a surface area of 5 m^2 and costs CHF 15,000. Such a compact installation covers 70% of annual warm water needs for four persons. The subsidies range from CHF 6,750 in Basel to CHF 1,200 in Grisons.

Global forecast up to 2020: growth of 20% p.a.

At 34.1 GW_{th} (48.8 million m^2), global newly installed collector capacity in 2009 was some 23% higher than in 2008. For 2010 we assume a global newly installed capacity of 41 GW_{th} (58 million m^2), or an increase of around 20%. This growth continues to be carried by China, but is now also boosted by Africa, Oceania, Japan and India. This year in Europe and the USA we again anticipate a decline in installations. For a number of years China has demonstrated itself to be the stablest, most dynamic market, with annual growth rates exceeding 20%. With this growth, the Chinese government can presumably achieve its own objectives in the area of solar thermal energy for 2020.

Figure 23: Sarasin forecast solar collector market. Newly installed collector capacity in GW_{th} per year.



Source: W.B. Koldehoff and Bank Sarasin, Nov. 2010

In 2011 the global growth rate of the solar collector market (newly installed capacity of 50 GW_{th}) should again approach 22%. In 2012 we anticipate market volume of 61 GW_{th}. This corresponds to a monetary volume of roughly EUR 16 billion. Thus by the end of 2012, 320 GW_{th} of cumulative collector capacity would be in operation globally. For the entire period from 2010 to 2020 we continue to prognosticate an average annual growth rate for newly installed capacity of approximately 20%. The global market for newly installed solar collectors would have in consequence a volume of roughly 254 GW_{th} by 2020 (Fig. 23). We are convinced that the trend toward solar thermal energy worldwide will also continue in the coming

[22] www.solarwaerme.at

years. It can be anticipated that in future the dynamics of markets in sun-drenched countries will increase considerably, for instance in southern European countries, the USA, South America, Australia as well as other emerging countries such as India, Indonesia, Mexico, Brazil, South Africa and the countries of North Africa. This prognosis rests – besides the high growth possibilities among current primary applications – in particular on the enormous potential of new applications such as solar cooling, solar water treatment/desalination and the broad field of industrial process heat.

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