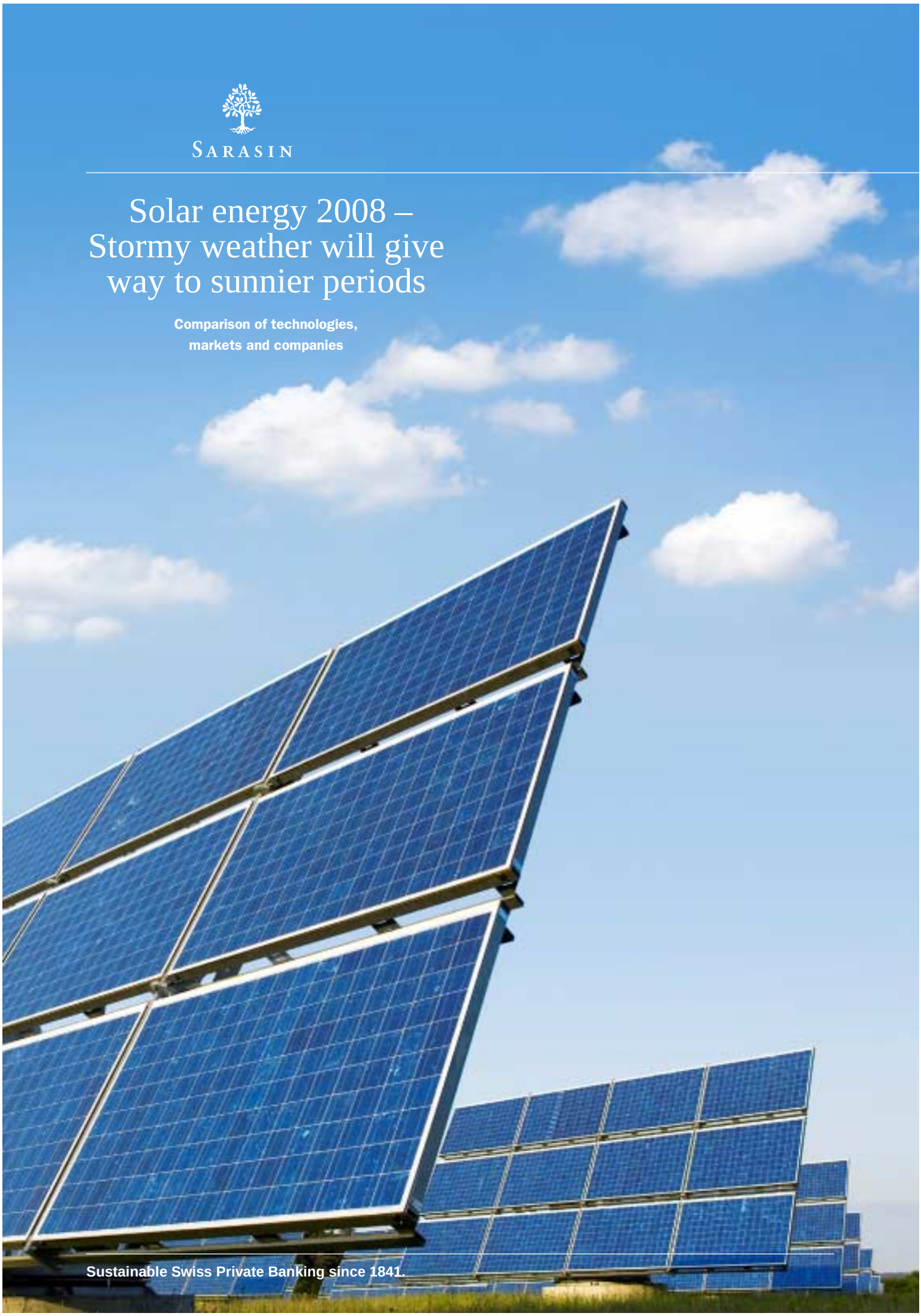
SARASIN

Solar energy 2008 – Stormy weather will give way to sunnier periods

Comparison of technologies, markets and companies



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Summary

The photovoltaics industry is in the process of transforming itself from a fledgling business into a mature industry. Global subsidy programmes have peaked in 2008, giving way to a transition period of lower subsidies which could last until grid parity is achieved in key markets. Companies need to slash their costs significantly to make sure that prices keep pace with falling feed-in tariffs. This is the only way of ensuring that demand weans itself off state support and continues to expand. Thin-film technologies in particular are maturing quickly and can expand their market share significantly, thanks to cost advantages. Large-scale systems based on photovoltaics and solar thermal power are becoming more popular, but also offer very diverse cost/benefit ratios. The global market for solar collectors is likely to remain extremely volatile for the time being, and would benefit from greater consistency.

Grid parity within reach

The solar industry now seems to be as close as it has ever been to achieving the overriding goal which all players are working towards: generating energy at competitive prices without any form of state subsidy. This would signal the achievement of grid parity and allow demand to grow to unprecedented levels. The steeper the fall in solar energy costs, the quicker this goal can be achieved. But the industry still needs to ride out some turbulent times before this point is reached.

Prices for solar modules start to tumble

Since the European Photovoltaics Conference in Valencia at the start of September there have been increasing signs of falling solar module prices. Bank Sarasin estimates the cost reduction potential at more than 10% p.a. over the next four years. The main drivers here will be cheaper thin-film technologies, falling raw material prices as a result of expanding polysilicon capacities, and tougher competition along the entire value chain.

Thin-film technologies are becoming more important

Solar companies have traditionally concentrated on crystalline silicon technologies, which still boast the highest level of efficiency at around 15 – 20%. However, thin-film technologies are set to gain significant market shares over the next four years. Although they currently have a comparatively low efficiency in the region of 7 – 11%, this is likely to be compensated by lower costs and a steeper learning curve. Over the next four years no clear winner is expected to emerge from the various thin-film technologies. Amorphous/micromorphous silicon technology (a-Si/µc-Si) will become more attractive than cadmium telluride technology (CdTe). The advantages of thin-film modules are most obvious in open-space or building-integrated PV installations. Crystalline silicon-based modules will continue to be the standard for roof-mounted systems of a predetermined size.

Comparison of leading thin-film companies

The thin-film industry now comprises more than 130 solar companies, which we have classed into three categories based on their level of experience: «Newcomer», «Learner» and «Professional». The most important companies for the future are *First Solar, Sharp, Calyxo (Q-Cells), United Solar Ovonics* and *Sunfilm*. They will be the biggest producers of thin-film modules in 2010 (in that order). So far, however, the two leading suppliers of turnkey production lines for a-Si/µc-Si technology, *Applied Materials* and *Oerlikon Solar,* have still not managed to come up with an installation offering proven functionality under normal operating conditions.

Attractive new markets emerging

As the PV industry continues to enjoy dynamic growth, new markets are starting to open up outside the traditional core markets of Germany, Japan, the USA and Spain. Sustainable growth is only possible if the solar industry market achieves wider geographical support. We have devised a new attractiveness index for 13 countries that makes it possible to estimate the future potential of individual markets. In 2009 Italy, the Czech Republic, Greece and France could develop into new attractive markets.

16.6 GW newly installed capacity in 2012…

In view of the turbulent state of the financial markets, clear signs of a slowdown in the growth of the real economy, and changing overall conditions for the PV industry (especially in Spain), Bank Sarasin predicts newly installed PV capacity of only 7 GW for 2010. This rate is expected to accelerate to 16.6 GW by 2012, so that average annual growth worldwide should be around 48% over the period 2007 – 2012. In Europe, however, average growth will only be 34% p.a. over the same period.

… and over 125 GW new PV capacity in 2020

By 2020 we expect the global market volume to rise to 125 GW newly installed PV systems. This is equivalent to an annual average growth rate of 28% (2012 – 2020). Here grid parity should soon become a reality in some sundrenched regions, and should be extended to more and more markets if prices continue to fall.

Company rating takes into account growth potential and financial leverage

In turbulent times, strong relationships with suppliers and customers, know-how and solid financing are all critical factors for PV companies. *Q-Cells, REC* and *First Solar* are the best positioned in this respect. By contrast, many Chinese companies display a disproportionately high level of debt.

Competition between PV and CSP for large-scale installations

Many large-scale solar energy systems will be constructed in the coming years in the Earth's sunbelt regions. Here strong competition exists between two technologies: photovoltaics (PV) and concentrating solar power (CSP). With both these technologies, research is currently being conducted into ways of improving reliability and the availability of electricity, as well as reducing the effective electricity generation costs.

Financing is becoming a critical factor

As the credit crunch drags on, the financing of ground-mounted solar installations is becoming increasingly important. Here a distinction needs to be made between small-scale projects and those implemented by financially strong electricity utilities. The European market tends to be dominated by many smaller project developers who are finding it increasingly difficult to raise the necessary finance. In the USA we are seeing a growing number of electricity utilities enter the market with large-scale solar projects. They are likely to benefit from the mounting trend towards infrastructure investments, and they also have access to cheaper financing thanks to their superior size and credit rating.

Solar collectors fighting for attractive subsidies and sustainable growth

In Europe especially, the market for solar thermal systems is becoming increasingly volatile. In 2007 growth rates fluctuated between -37% in Germany and +700% in Hungary. Newly installed solar collector capacity in Europe fell by 9% overall. Despite heated public debate about climate change and high energy costs, the pace of market growth has not picked up so far. The fact is, however, that a solar thermal system is able to compete on a cost basis once energy prices move upwards again. Attractive market growth of 20 – 25% is therefore anticipated in the long term.

Photovoltaics (PV)

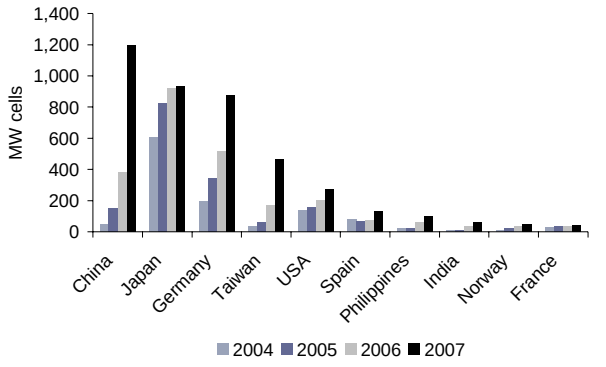
The solar industry is on the brink of a sea change: the shortage of solar-grade silicon is gradually coming to an end, sales of thin-film modules are growing and new, attractive sales markets are opening up. These are therefore challenging times for solar energy companies, which are already grappling with the worsening financial crisis and slowing economy. So what are the solar technologies of the future, and which companies are best equipped to master the new challenges? Against this backdrop of constantly changing industry conditions, Bank Sarasin assesses thin-film technologies and the key players in this industry. Our report also identifies new attractive markets. Finally, Sarasin presents its annual forecasts for the PV market and assesses the solar companies from a strategic viewpoint.

Solar cell production 2007

Global PV cell production rose by 68% in 2007 – up from 44% in 2006 – to reach a total of 4 GW_p[1]. After steadily increasing their production volumes and expanding their supply contracts, China and Taiwan captured the lead in the solar industry last year (Fig. 1). In 2007 these two countries produced around 28% and 11% respectively of the solar cells manufactured worldwide. China was therefore the world's biggest producer, ahead of Japan (22%) and Germany (21%). Taiwan now ranks as the fourth biggest producer, having overtaken the USA for the first time. The lion's share of growth in the USA came from thin-film modules. Around 160 MW of the total 270 MW PV production involved thin-film technologies (129 MW from *First Solar*, 28 MW from *United Solar Ovonics* and 4 MW from *Global Solar Energy*).

In 2008 there was once again a raft of announcements about the expansion of production capacities along the entire value chain, which holds out the prospect of a consistently dynamic pace of growth in the industry. The next section examines what is driving this constant expansion in supply and compares it with the trends in demand.

Fig. 1: Country analysis: the world's top ten solar cell producers



Source: Photon and Bank Sarasin, 2008

Key drivers of PV industry growth

Polysilicon bottleneck is easing

As far as the raw material polysilicon is concerned, there has been a constant stream of announcements about the construction of new production facilities and expansion of existing plants. Experts differ on their assessment of whether these expansion programmes will effectively be realised on time. Estimates for polysilicon production in the coming years therefore vary significantly. Forecasts for the amount of polysilicon available to the solar industry in 2012 range from 107,000 to 181,000 tonnes, which clearly highlights the lack of consensus regarding the future expansion of polysilicon production capacity. The

[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.

target range for the coming years can be seen in the table below:

Fig. 2: Production of solar-grade silicon and maximum production of c-Si cells

Polysilicon for solar industry	2006	2007	2008	2009	2010	2011	2012
Highest estimate (t)	23,166	30,070	46,084	71,019	111,187	156,611	181,278
Lowest estimate (t)	14,079	18,584	30,936	60,000	94,780	107,427	107,146
Sarasin-forecast (t)	**18,498**	**30,000**	**35,900**	**63,500**	**101,500**	**127,500**	**136,000**
Silicon need per MWp (t)	9,9	9,1	8,5	8,0	7,6	7,3	7,2
Potential c-Si cell prod.	**1,878**	**3,303**	**4,221**	**7,939**	**13,295**	**17,385**	**18,988**
c-Si cell prod. growth		76%	28%	88%	67%	31%	9%

Source: Bank Sarasin, Nov. 2008

Based on Sarasin's estimates for future polysilicon production, the potential output of c-Si solar cells amounts to around 4.2 GW in 2008, 13.3 GW in 2010 und 19 GW in 2012.

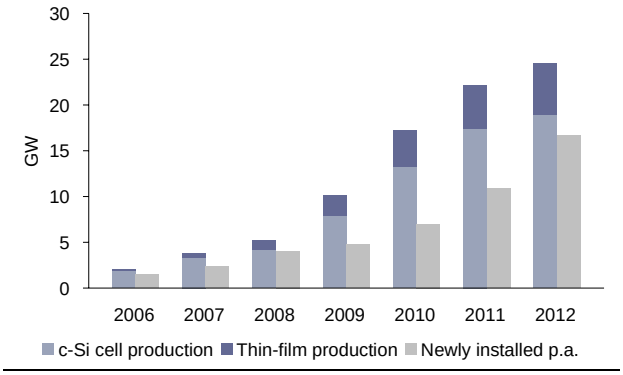
This is equivalent to an average annual growth rate of 50% between 2008 and 2012. The figures for future volume growth show that the additional polysilicon quantities are sufficient for the production of c-Si solar cells to grow steadily.

In future, however, conditions are likely to become more challenging for polysilicon producers. The trend towards thinner wafers, more efficient cells, tougher competition from innovative thin-film technologies and the potential substitution of polysilicon by upgraded metallurgical silicon (umg-Si) will make them a less indispensable link in the supply chain. These industry trends could well mean that polysilicon supply contracts may be renegotiated as of next year, with customers trying to squeeze selling prices. We therefore believe that both spot prices and prices for long-term polysilicon supply agreements have peaked in 2008, and that the gross margins of silicon and wafer producers will shrink as a result.

Gap between supply and demand set to widen right along the value chain

Not just silicon output, but production capacities along the rest of the value chain are set to rise. Attracted by the dynamic growth of the solar industry and low entry barriers created by a more plentiful supply of turnkey production lines, as well as the allure of low interest rates and high margins, both newcomers and established companies have announced massive capacity expansion programmes in recent months.

Fig. 3: Comparison of annual cell production and PV installation



Source: Photon, IEA-PVPS and Bank Sarasin (estimates), Nov. 2008

As a result, the excess cell production compared with the quantity of modules installed will rise sharply from 2009 onwards, even taking into account the delay between cell production and module installation (roughly 6 – 12 months). While the market for module installations is expected to grow around 48% p.a. on average up to 2012, cell production (including thin films) will rise by 66% p.a. up to 2010 (Fig. 3). Not until 2011 and 2012 will the two average growth rates level out at around 45 – 50%. This estimate already takes into account some deferral or possibly cancellation of specific capacity expansion projects.

How long will plant engineering companies continue to enjoy full order books?

The sharp increases in capacity have naturally benefited plant engineering companies, both in 2007 and in the current year. Order books are now full until 2009. But this positive situation is likely to change for plant engineering companies when the anticipated excess capacities come on stream from 2009 onwards. As the level of excess supply increases, we expect cell producers to scale back or postpone their capacity expansion.

A comparison of future production and installation volumes shows that it will become increasingly important for cell and module producers to achieve higher than average cost savings. This is the only way of absorbing the expected price cuts without suffering substantial erosion of margins.

Because there are so many independent cell producers, the pricing power of an individual company is very weak. Additional price pressure is created by the large number of newcomers to the market and the tougher competition coming from Asian companies.

Where will demand be concentrated in 2009?

In 2007 demand for solar modules was clearly driven by the vibrant Spanish market and the stable German market. Global demand remains strong in 2008 and is even being driven by certain pre-emptive effects.

In view of the changed subsidy programmes in the core markets of Germany, Spain and the USA, the effective demand for 2009 is relatively difficult to estimate. In Spain the government has now set a cap of 500 MW installed capacity on the subsidies it pays via feed-in tariffs, even though the amount of solar power capacity had already reached 1 GW in Spain in 2008. It is hard to predict what response this cut will trigger on the supply side.

The situation is so confused at the moment that solar park developers still want to secure their «requirements» without actually knowing exactly where they will eventually install the products. No one wants to experience a supply bottleneck should demand from up-and-coming markets remain unexpectedly high. This behaviour from module traders, project developers and installers also explains why module prices are still relatively stable at present. Even so, we expect prices to drop more than 10% p.a. in the coming years. Germany is an important benchmark here, with an 8 – 10% degression in the tariffs paid for renewable energy fed into the mains grid. The differences in module prices will remain high because they adapt in each case to the feed-in tariffs applicable to the country in question (see also the section on Country Attractiveness). In 2009 there will be clear signs of a shift from a seller's to a buyer's market. More details can be found in the section on Country attractiveness and PV market trends.

The appeal of thin-film technologies

Material-saving thin-film technologies, which have been continuously developed over the years to the point where they now consist of layers less than one micrometre thick, are gaining more importance alongside the dominant crystalline solar cell technology. Despite the improving situation on the silicon supply market, thin-film modules should be able to expand their market share to 23% by 2012.

Basic advantages of thin-film PV technology

Irrespective of the specific technology used, thin films offer certain advantages over crystalline silicon:

– Lower costs per watt, at module level
– Production processes in one casting
– Minimal (or even no) silicon required
– Higher temperature coefficient, i.e. the module's efficiency is not affected by high temperatures

On the other hand, thin films have certain drawbacks:

– Greater surface area requirements and higher system costs because their standard degree of efficiency is generally lower
– Comparatively immature technologies
– Availability of materials when using certain less common elements

– In some cases use of materials that are a potential health hazard

This report looks at the three most important thin-film technologies – silicon-based (a-Si & a-Si/µc-Si[2]), cadmium telluride (CdTe) and copper indium (gallium) diselenide (CIS, or CIGS) – and assesses their current (2007) and future (2012) attractiveness on the basis of four criteria. Third-generation technologies, such as dye-sensitized solar cells, have not yet been assessed this year.

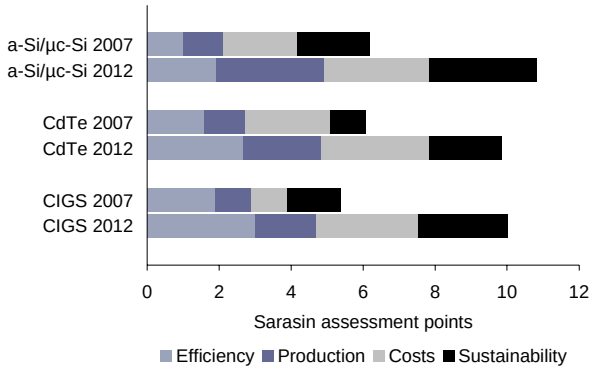
The results are mapped on a chart in Fig. 4. Each criterion was rated on a scale from 1 (weak) to 3 (strong). The four criteria are as follows:

– **Efficiency**: At present a-Si/µc-Si technology has an efficiency in the region of 6 – 8%, well behind Cd/Te (9 – 11%) and CIGS (8 – 12%). By 2012 a-Si/µc-Si technology should be able to just break through the 10% mark, while CdTe and CIGS should achieve an efficiency of around 11 – 12%.
– **Maturity**: The production volumes in 2007 and 2012 are used as a measure of that particular technology's maturity. Si/µc-Si technology will account for more than 50% of total thin-film production by 2012.
– **Costs**: At the module level, costs currently stand at around EUR 1.2 – 1.4/W for a-Si/µc-Si, EUR 0.9 – 1.1 /W for CdTe and EUR 1.5 – 1.8/W for CIGS. By 2012 all three technologies could achieve costs of less than EUR 0.8/W.
– **Sustainability**: This criterion includes factors such as energy payback time or use of hazardous substances. At the current point in time, CdTe technology has the worst rating due to the use of the hazardous heavy metal cadmium, which is banned in the electronics industry. All of the technologies will improve considerably thanks to more efficient production processes, reduced material consumption and systematic recycling concepts.

[2] a-Si: amorphous silicon; a-Si/µc-Si: amorphous/micromorphous silicon

According to our valuation criteria, the attractiveness of all three thin-film technologies will continue to improve over the next five years, and all three still seem to be potentially successful. It is impossible to pick a clear winner.

Fig. 4: Rating of the three most important thin-film technologies in 2007 and in 2012



Source: Bank Sarasin, Nov. 2008

Thin-film photovoltaics – an important growth driver for the future

Last year, thin-film modules with a total installed capacity of around 460 MW were manufactured, which is just over 12% of the entire production volume of PV modules. But this market share does not yet reflect the high level of activity at the level of R&D and in the construction of new production facilities. The big question at the moment seems to be when the era of thin-film technology will begin. At present some 130 companies worldwide are involved in thin-film technologies at many different stages, ranging from R&D to manufacturing on an industrial scale. The number of industry players has therefore once again risen sharply since our last report.

A steady stream of announcements on new production capacities has come from the two most important plant engineering companies, *Applied Materials* and *Oerlikon Solar*. These two technology groups offer something special to the solar industry: they save their clients the time- and capital-intensive work of developing and optimising production lines for amorphous/micromorphous

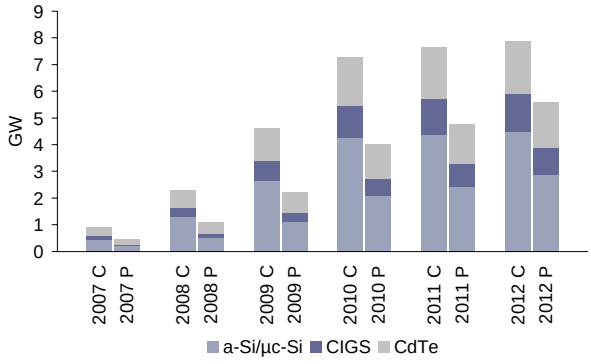
solar modules, by supplying them as a complete, turnkey solution. Around 60% of thin-film producers use a-Si/µc-Si, 30% CIS/CIGS and 10% CdTe technology. The two companies mentioned, along with *First Solar* (CdTe), are currently the most important players in a game which will ultimately be decided by costs alone. *First Solar* has already set the bar very high. The modules are manufactured at a cost of roughly EUR 0.90/W and have an efficiency of 9 – 10%. All competitors in this field will have to try and match this. Efficiency plays an important role, as it affects system costs. The smaller the module's surface area, the lower the requirement for substructures, cables, assembly time and land area. A system price of EUR 2/W requires module prices of no more than EUR 1.1/W, as long as the efficiency is at least 12% (EUR 1.05/W with an efficiency of 9%).

It is not yet clear which thin-film technology is most suited to achieving this cost level. Leading companies such as *Q-Cells* are therefore pursuing no less than five different processes through various equity participations and subsidiaries.

Thin-film technology growing faster than the overall market

The expansion plans for thin-film technologies are very ambitious. We expect production to expand to approximately 1 GW in 2008 and 5.6 GW in 2012 (Fig. 5). This is equivalent to an annual average growth rate of 65%. Within thin-film technologies, a-Si/µc-Si technology will account for around half the total production volume of 4 GW by 2010. In 2007, CdTe was still level with a-Si/µc-Si. We still think CIS/CIGS technology is interesting, but it is difficult to predict as well. From 2010 onwards, CIS/CIGS production will rise sharply (635 MW) and in 2011 some companies could manage to catch up with the market leader *First Solar* in terms of their expansion rate and cost structure. The flattening off of expansion after 2010 mainly reflects the poorer visibility of capacity expansion plans over the long term.

Fig. 5: Capacity (C) and production (P) expansion in the individual thin-film technologies up to 2012



Source: Syntegra Solar and Bank Sarasin, Nov. 2008

More widespread use of thin films in large solar parks

In recent months there has been a flurry of announcements about new solar park projects using thin-film modules. Cheaper CdTe modules from *First Solar* are particularly suitable for open-space PV installations. With their lower temperature coefficient, they are ideally suited to hot climates especially, because they can produce more electricity per installed unit of capacity than similar silicon-based solar modules. CIS/CIGS modules also operate very efficiently at temperatures up to 45° C.

Rapid expansion also presents certain risks

Considering the very ambitious expansion plans for thin-film technologies, it is important not to overlook certain risks which could significantly impede the rate of growth:

– It is uncertain whether all companies will be able to guarantee and secure their expansion plans through appropriate financing.
– Individual expansion plans could be delayed by the integration of additional technological advances (e.g. retooling or upgrade from a-Si to a-Si/µc-Si).
– The market entry of a dominant and low-cost player with a 1 gigawatt factory could put pressure on the business plans and cost structure of smaller competitors.

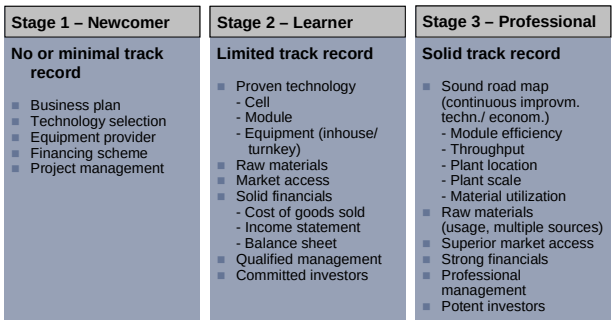
– The rapid and successful introduction of metallurgical polysilicon could undermine the competitiveness of thin-film technology versus crystalline technology.

Attractive thin-film PV companies

So what are the characteristics of companies that are the driving forces behind the dynamic expansion of supply in the thin-film segment – and which players are best equipped to overcome the risks facing this technology on the path towards grid parity? In view of the risks involved, Sarasin believes that the company's degree of technological and financial maturity is a decisive factor.

Thin-film companies can be divided into three categories: «Newcomer», «Learner» and «Professional». The criteria for rating companies along this learning curve are listed in Fig. 6.

Fig. 6: Criteria for rating thin-film companies into one of three categories



Source: Syntegra Solar, 2008

Professionals find it easier to raise finance

With confidence in the banking world at an all-time low, the financing of production facilities is likely to become a critical factor. «Professionals» certainly only have a slightly reduced, but still strong chance of securing project financing. The business plans of «Newcomers» will be carefully scrutinised and will need to be very well thought out in order to secure financing.

Based on this valuation matrix, the 15 biggest thin-film companies have been positioned along the learning curve for 2007 and 2008. An overview of the results, ordered by production capacities predicted for 2010, can be seen in Fig. 7.

Fig. 7: Future attractiveness of thin-film companies

Company	Production sites	Technology	Equipment	Classification 2007 (2008) Newcomer	Learner	Professional	Prod. 2010 (MW)
First Solar	US/DE/MY	CdTe	Inhouse			x (x)	1,150
Sharp	JP	a-Si/µc-Si	Inhouse		x	(x)	500
Calyxo (Q-Cells)	DE/(MX)	CdTe	Inhouse		x	(x)	250
Un. Solar Ovonic	US	triple junct. a-Si	Inhouse			x (x)	240
Sunfilm	DE	a-Si/µc-Si	AMAT*	x	(x)		200
Mitsubishi Heavy	JP	a-Si/µc-Si	Inhouse	x	(x)		160
Sontor (Q-Cells)	DE	a-Si/µc-Si	AMAT	x	(x)		140
Moser Baer	IN	a-Si	AMAT	x	(x)		110
Masdar PV	DE/(AE)	a-Si/µc-Si	AMAT	(x)			100
SunWell (CMC)	TW	a-Si/µc-Si	Oerlikon	x	(x)		100
Kaneka	JP	a-Si/µc-Si	Inhouse		x	(x)	80
Signet Solar	DE	a-Si	AMAT	x	(x)		75
Ersol/Bosch	DE	a-Si/µc-Si	Oerlikon		x (x)		70
Solibro (Q-Cells)	DE	CIGS	Inhouse	x	(x)		70
T-Solar Global	ES	a-Si	AMAT	x	(x)		65

Source: Syntegra Solar, 2008
* AMAT: Applied Materials

The five biggest companies have a number of success factors in common:

First Solar: This company focuses exclusively on 100% CdTe technology and in 2007 was already one of the top five cell and module producers (crystalline and thin-film). The business has seen a huge increase in its production capacity, from 60 MW in 2006 to 200 MW in 2007 and around 400 MW in 2008. The production target for 2010 is 1,150 MW. With this rapid growth, *First Solar* is pushing to retain its clear cost leadership (Q2-2008: USD 1.18/W) and achieve grid parity in certain regional markets as early as 2010. Its patented process technology has already passed the mass production stage and shown how quickly it can be copied and expanded. The modules have an efficiency of 11% on average. With production facilities in the USA, Germany and Malaysia, the company has an optimal geographic footprint, and since the start of the year also has its own US project

development department for open-space PV installations. *First Solar* clearly sets the benchmark for all thin-film companies when it comes to the expansion of production capacities, costs and life cycle management. *First Solar* also guarantees that it will collect for recycling all its CdTe modules at the end of their service life, to ensure they are disposed of correctly.

Sharp is a leading Japanese electronics company with a large solar energy business division. In crystalline PV technology, *Sharp* was the world's biggest cell producer up to 2006. In 2007 the company produced 363 MW of solar cells, slipping to second place behind *Q-Cells* with 390 MW. In addition, Sharp is the world's second biggest solar module producer, after Suntech. In the field of thin-film technologies, *Sharp* produces 80 MW of amorphous Tandem silicon (a-Si/µc-Si) modules, making it the world's fifth biggest thin-film producer. *Sharp* can also benefit here from the know-how it has acquired in producing flat-screen TVs/monitors. The average efficiency of its Tandem cells is 8.5%. A new production facility is being constructed in Sakai with an annual capacity of 1 GW. The first phase will have a production output of 480 MW p.a. and is due to come on stream in March 2010. There are plans for a fully integrated production facility with an upstream flat-glass factory. This 1 gigawatt factory also guarantees low production costs. The modules are expected to be increasingly used in large-scale solar parks. Like *First Solar, Sharp* has set up its own project management department. In addition, it announced a joint venture in May 2008 with Italy's *ENEL* to develop large-scale PV projects (160 MW by 2011).

Calyxo (Q-Cells): As a subsidiary company, the relatively young management team can benefit from the experience and know-how of its parent *Q-Cells* (93% stake). *Calyxo* is a mainstay of *Q-Cells'* strategy of ensuring an own presence in all the major thin-film technologies and keeping open the option of quickly expanding its global production capacities as and when necessary. *Calyxo's* CdTe technology and production processes come from the US company *Solar Fields (7% stake in Calyxo)*. The average efficiency of its modules is currently 8.5%. The cost structure is still open; in the mid-term there is a chance of bringing down costs to the region of *First Solar*. The first production line is about to come into service and an initial 15 MW will be produced by the end of 2008. The subsequent expansion drive is likely to be focused mainly on Mexico. A production of 250 MW CdTe modules is forecast for 2010.

United Solar Ovonics is a subsidiary of the US company *Energy Conversion Devices (ECD).* The production of its triple-junction a-Si cells is based on a roll-to-roll laminating process that produces flexible modules with a dimension of 5.4 m x 0.4 m and an efficiency of 6.5%. Thanks to close links with industrial roofing companies, *United Solar* has a profitable niche product for this application. Especially when the sun's rays are weak or in diffuse light, these modules are more efficient than in standard operating conditions (1 kW/m^2). In addition, the efficiency loss at higher module temperatures is only half as much as for crystalline modules. In 2007 *United Solar* produced around 48 MW a-Si modules. It is pushing ahead with production at two locations in the USA and one plant in Mexico and by 2010 will be able to produce approximately 240 MW thin-film modules. In terms of cost, the modules from *United Solar* are in the middle bracket and the selling prices obtainable on the market for the end product are comparatively high. However, the location of its production sites makes the company's export business very exposed to the US dollar exchange rate.

Sunfilm is the leading customer for the turnkey production lines of *Applied Materials (AMAT). Sunfilm* is led by an experienced management team and its strategic investors include *Good Energies* and *Norsun*. The first production line is about to come on stream, while a second one is already under construction. The first modules are due to be produced in the final quarter of 2008. The large tandem a-Si/µc-Si modules from the *AMAT* line have a surface area of 5.7 m^2 and an efficiency of 8%. Because of the size of the production plants and their location in low-wage countries, costs should be proportionately low, but presumably higher than for *First Solar*.

The ideal application for these large modules are ground-mounted PV systems or those integrated into the roofs of industrial buildings. *Sunfilm* is currently in the midst of a patent violation dispute with the Swiss technology company *OC Oerlikon*. This involves a patent for the micromorphous Tandem cell technology, an exclusive licence that *OC Oerlikon* purchased in 2003 from the IMT department of the Swiss University of Neuchâtel. In the market for thin-film production facilities, *Oerlikon* is competing directly with the bigger US manufacturer *Applied Materials*. This leads one to suspect that the dispute is possibly an indirect attack on the bigger rival.

Country attractiveness and PV market trends

Installed PV capacity in 2007

According to our estimates (incl. IEA-PVPS data)[3] around 2.3 GW new PV capacity was installed worldwide in 2007. This is equivalent to 56% growth on the previous year. The cumulative PV capacity at year-end 2007 stood around 8 GW. This means that 7.2 TWh of electricity was generated last year, which equates to around 0.05% of the total global electricity consumption of 18,000 TWh. This tiny percentage illustrates the enormous growth potential when starting from the current baseline.

Attractiveness of individual national markets

Recent years have clearly shown that prices on the PV market tend to move in sympathy with the subsidy programmes in individual countries. Up to September 2008 Spain had by far the most attractive conditions (high feed-in tariffs coupled with plenty of sunshine), but this is set to change in 2009.

Country attractiveness index

The attractiveness of the market, and subsequently the development of demand (MW installed PV systems) varies from one country to the next and is heavily dependent on national subsidy programmes.

From our forecast for the global PV market we have therefore produced ratings for the attractiveness of the major countries. This rating has been produced in close collaboration with Rabobank's «Food and Agribusiness Research and Advisory» (FAR) department in the Netherlands. The rating is based on the following four criteria:

– **Financial attractiveness**: We use the internal rate of return (IRR) on a standard 1 MW PV project as an indicator for a market's financial attractiveness based on the feed-in tariffs for solar energy, the local electricity tariffs, the amount of natural sunlight, etc. (rating scale 1 – 10).
– **Market maturity:** this criterion assesses to what extent suitable infrastructures and companies exist for installing PV systems. (rating scale 1 – 5).
– **Growth potential:** Here we assess certain legal upper limits or caps, or overriding political goals that have been set for photovoltaics. This allows us to determine the capacity potential that exists in the long run. The lowest cap means a rating of 1, and no cap at all results in a rating of 5 points. Countries with no political goals for photovoltaics are given a score of 1, while those with ambitious targets score 5.
– **Administrative effectiveness**: Here we assess the administrative and regulatory hurdles in each country. The average time frame for completing a project, which varies in practice between 12 and 24 months, is estimated here. A short time frame produces a score of 5, while a long one scores 1. This criterion reflects a mid-term perspective to a certain degree.

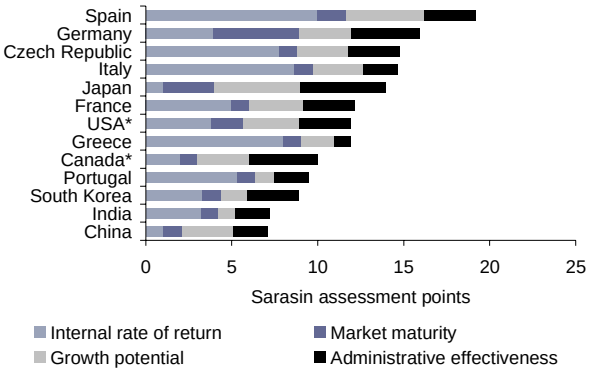
The purpose of the higher scale for scoring the financial attractiveness (1 – 10) compared with the other criteria, where the scale is just 1 – 5, is to deliberately give a greater weighting to the financial dimension.

The changes in the attractiveness of countries for large-scale PV systems between 2008 and 2009 (Fig.8 + 9) are based mainly on the latest developments in the subsidy programmes of Spain and Germany. Spain has cut its feed-in tariffs as of 2009 and has set a cap on the segment of open-space PV installations at 233 MW. Be-

[3] Trends in PV applications; Survey report of selected IEA countries between 1992 and 2007. IEA Photovoltaic Power Systems Programme – Task 1; September 2008. www.iea-pvps.org

cause of this, Spain has dropped from first to fourth place in the country rankings. The reason for Germany's fall down the rankings is the 6.5% cut in the feed-in tariffs offered for renewable energy from land-based PV installations in 2009. Although Germany only has an average IRR, we still expect attractive market growth thanks to its lean bureaucracy and the absence of any cap.

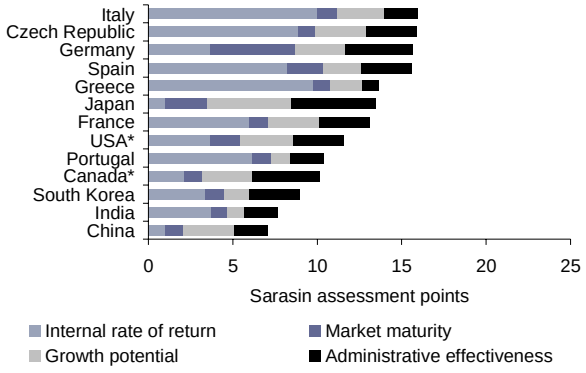
Fig. 8: Country attractiveness for open-space PV systems in 2008



Source: Rabobank FAR and Bank Sarasin, Nov. 2008
* California in the USA and Ontario in Canada

The most attractive markets in the coming years will be Italy and the Czech Republic. Unlike Italy, the Czech Republic has so far not imposed any cap on state subsidies and its administration is highly efficient, even though the market is less financially attractive due to low average levels of irradiation. In Greece, by contrast, it is the high administrative obstacles that make the market less appealing. Japan is not particularly attractive at the moment, because it offers no remuneration for solar electricity fed into the mains grid. Even so, we expect installation activity to pick up soon, as the government has hinted that it will once again offer support to private households in particular, in a bid to achieve its very ambitious political goals for photovoltaics.

Fig. 9: Country attractiveness for open-space PV systems in 2009



Source: Rabobank FAR and Bank Sarasin, Nov. 2008
* California in the USA and Ontario in Canada

The most attractive national markets in 2009

Based on the attractiveness rating for 2009 (Fig. 9), we now take a closer look at the most important national markets for large-scale installations (> 1MW):

Italy is a very promising market, offering remuneration based upon the price of mains electricity plus a bonus feed-in tariff of EUR 0.35/kWh in 2009. Another attractive feature is average sunshine of 1,725 kWh/m^2 p.a. and up to a maximum of 2,000 kWh/m^2 p.a. in the south of the country. The legislation on subsidies imposes a cap of 1,200 MW. At the moment we estimate that 900 MW are still available. The example of Spain shows, however, just how quickly a quota can be «used up» when conditions are attractive. Traditionally the sluggish administrative process in Italy has prevented a faster rate of growth in PV installations. It can take up to 19 months to receive the necessary permits and connect a solar park to the mains grid. Certain delays can however be seen as teething problems in a relatively young market, and should definitely improve as the market matures.

The **Czech Republic** is currently a dynamic PV market, but if growth gets out of hand the government could be forced to cut tariffs significantly. The feed-in tariff of EUR 0.57/kWh as a bonus on top of the price of grid electricity will be the most attractive rates per kWh offered by any country in 2009. This generous remuneration makes it attractive to operate a PV system even though the average sunshine is comparatively low (1,180 kWh/m^2 p.a.). In addition, there is no cap imposed by the law. According to PV project developers working in the Czech Republic, the administrative processes are far simpler and quicker than in Greece, for example. To complete a project from the drawing board to grid connection takes around 12 months on average. The annual review of remuneration payments is a relatively flexible procedure overseen by the Czech electricity authority, which is responsible for setting the tariffs for solar energy. In 2008 tariffs were only cut by 2.5% on the previous year. With the Czech market growing so quickly, entailing high costs for the subsidy programme, the annual reductions in the feed-in tariffs could soon turn out to be more substantial, however.

France's government gives support in particular to smaller building-integrated photovoltaic systems (BIPV) and large-scale installations in French overseas territories. The feed-in tariff for large installations is EUR 0.31/kWh, and EUR 0.57/kWh for BIPVs. The amount of sunshine is up to 1,600 kWh/m^2 p.a. Large-scale PV systems in the South of France and in overseas regions are therefore profitable, although less attractive than in the Czech Republic, Italy and Greece. France has not set a cap on its PV subsidy programme. Administrative procedures are relatively efficient, and it takes around 15 months to complete a PV project. One unusual feature of the French approach is the annual adjustment for inflation in both new and existing installations. Combined with the expected price cuts for PV modules, the French market will certainly become more attractive over the years. The government's PV targets are a total of 160 MW installed capacity in 2010 and 490 MW in 2015.

Greece, along with Italy, is the country with the most attractive financial conditions for PV projects. This is the result of a combination of relatively high feed-in tariffs (EUR 0.48/kWh on the mainland and EUR 0.53/kWh on the islands), with inflation-indexing and a medium to high amount of annual sunshine. The subsidy programme currently has a cap of 840 MW, which does not yet pose a constraint. Despite everything, market growth is rather sluggish because the administrative processes are complicated (up to 17 different permits) and convoluted (up to 40 different authorities involved). It can therefore take up to two years for a project to receive the go-ahead.

On 3 October 2008 the **USA** took an important step towards improving the conditions for solar energy by not only extending the investment tax credits (ITC) for solar installations for another eight years, but also substantially improving them. Now 30% of the investment sum can be reclaimed through tax credits. In addition, there is no longer any financial upper limit and electricity utilities can also take advantage of the ITC system. The USA is an interesting market for solar energy, with its generous amounts of sunshine and vast tracts of underpopulated countryside. So far, demand has been driven mainly by a variety of subsidy programmes at the level of the individual federal states. Here the incentives provided by the renewable portfolio standard (RPS) and the so-called «Net Metering» are the main drivers.

In **Germany** the feed-in tariffs have been steadily trimmed back in recent years. In 2009 they are still at EUR 0.32/kWh. Because of the relatively low level of annual sunshine, Germany PV projects are therefore not very attractive from a financial viewpoint. Extremely cheap solar modules are needed to ensure that such projects remain profitable. Furthermore, the future degression rates for feed-in tariffs are ambitious and the government could raise them by an additional 1% if it thinks market growth is excessive (>1.5 GW in 2009, >1.7 GW in 2010 or >1.9 GW in 2011). If module prices do not fall to the same extent, the rate of market growth in Germany will inevitably slow. On the other hand, Germany is a very mature market with rapid and smooth ap-

proval procedures combined with a high installation capacity and no legal cap. The German market will therefore remain important in future.

Spain has passed a new bill, Royal Decree 1578/2008, which imposes an annual cap on subsidies payable across the whole of Spain at 267 MW for roof-mounted systems and 133 MW for ground-mounted installations. For 2009 and 2010 a transitional arrangement has been agreed allowing an additional 100 MW and 60 MW respectively. The maximum capacity of roof-mounted PV systems will in future be limited to 2 MW, and 10 MW for land-based systems.
This new bill also proposes a feed-in tariff of EUR 0.34/kWh for roof-mounted systems below 20 kW and EUR 0.32/kWh for those between 20 kW and 2 MW. Open-space installations up to a capacity of 10 MW are entitled to a feed-in tariff of EUR 0.32/kWh. The bill explicitly states that the tariff will only be paid for another 25 years. In future, the feed-in tariffs will be raised or lowered in line with the development of the subsidies applied for. Despite the cut in tariffs, Spain is still a relatively attractive market from a financial viewpoint. However, the limiting factor is the restrictive cap of 500 MW and the upper limit of 10 MW for land-based PV systems. This means the size of the subsidised market for 2009 is only around 50% of the volume achieved in 2008.

Conclusion for the markets in 2009

For large-scale PV installations, the market focus will shift in 2009 away from Spain and Germany, and towards Italy and the Czech Republic. But there are still major size differences between the old and new favourite countries. By way of comparison: by the end of 2008 Germany will have installed PV systems with a total capacity of 5.5 GW and Spain around 1.7 GW. This contrasts with a much smaller capacity of 360 MW for the Italian market and 20 MW for the Czech Republic. There is therefore a risk that these two markets do not have sufficient experience and qualified personnel to actually install the potential PV capacities. The decline in the number of open-space PV systems installed in Germany and Spain from 2009 onwards will have a significant impact on global market growth. In 2007 these systems accounted for almost 40% of total global installed capacity and were concentrated mainly in Germany and Spain. In 2008 these two markets still play a relatively important role, before new markets take up the running from 2009 onwards.

Market trends up to 2012

To produce our market forecast we have processed the following key data:

– PV market data for the respective countries from industry associations, IEA-PVPS and Rabobank
– National targets for PV installations and production capacities
– Data on capacity expansion in thin-film technologies and information on reliability from the companies and from Syntegra Solar[4]

Country-specific trends up to 2012

Taking into account the ratings for country attractiveness, we expect market trends up to 2012 to follow the pattern shown in Fig. 10. On a global basis, our forecast puts average annual growth at 48% between 2007 and 2012. This results in 16.6 GW of newly installed PV capacity for 2012. However the respective growth rates vary significantly during this period. 2008 is expected to enjoy higher than average growth of more than 70%, which will then ease back to just 17% in 2009 before eventually settling down at around 45 – 50% in 2012.

Zero growth for Europe in 2009

In Europe itself, the decline between 2008 (growth of 79%) and 2009 (zero growth) is even more dramatic. This is mainly down to the capped Spanish market, which is being trimmed back from 1 GW PV installations in 2008 to 500 MW. This means that the 500 MW from Spain now has to be installed elsewhere. This is quite a challenge in the current environment, which is why we expect zero growth in 2009. After that, Europe can once

[4] www.syntegra-solar.de. Consulting specialists in the field of thin-film photovoltaics

again look forward to growth rates in the region of 30 – 40% through to 2012.

In the run-up to 2012 the strongest performers in Europe will be Italy (CAGR 07 – 12 of 91%), Greece (190%), France (82%) and Portugal (68%). The USA will grow by 88% on average over the same period, and will also become far more important in terms of volume (4.9 GW in 2012).

Fig. 10: Sarasin PV market forecast

	Newly installed PV-capacity [MW]						CAGR*
	2007	2008	2009	2010	2011	2012	07 – 12
Germany	1,135	1,703	1,873	2,247	2,921	3,652	26%
Italy	70	246	430	731	1,170	1,813	92%
Spain	512	1,050	500	460	575	891	12%
Greece	2	22	88	176	282	436	194%
France	31	94	150	255	409	633	82%
Portugal	15	29	46	79	126	196	68%
Rest of Europe	15	44	67	93	121	155	60%
Europe	**1,780**	**3,187**	**3,154**	**4,041**	**5,603**	**7,775**	**34%**
USA	**207**	**341**	**681**	**1,363**	**2,726**	**4,906**	**88%**
China	20	42	84	214	482	964	117%
India	10	20	40	90	180	342	103%
Japan	210	221	331	481	649	843	32%
South Korea	43	86	150	225	304	395	56%
Rest of Asia	31	65	124	216	303	394	66%
Asia	**314**	**434**	**729**	**1,226**	**1,918**	**2,938**	**56%**
Rest of World	**56**	**118**	**212**	**370**	**593**	**1,008**	**78%**
Total newly installed	**2,357**	**4,079**	**4,776**	**7,001**	**10,839**	**16,628**	**48%**
Annual growth rate	56%	73%	17%	47%	55%	53%	

Source: Bank Sarasin, Nov. 2008

* CAGR: compound annual growth rate

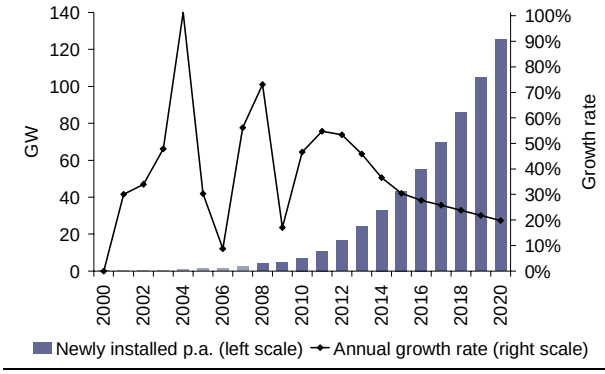
Market growth and subsidy programmes – a tricky balancing act

The overall conditions for photovoltaics have recently become more uncertain. This year, the PV industry has been influenced by two diametrically opposed macro-economic forces. On the one hand, the massive hikes in oil and gas prices have fuelled demand for renewable energies. On the other hand, the crisis in the financial sector has severely undermined investor sentiment and made it more difficult to finance capacity expansion programmes and PV projects. There were also a number of sector-specific doubts raised by the delay in renewing subsidy programmes in the key markets of Spain and the USA. In addition, an increasing number of politicians are critical of what they consider to be a poor cost/reward ratio for photovoltaics, i.e. high subsidy costs for only a few kilowatt hours of energy. This will continue to add an element of unpredictability to subsidy programmes in future.

Long-term forecasts are very positive

Something we already discovered last year is becoming even more obvious this year: the PV Industry needs to reach grid parity quickly if it is to sustain the existing market momentum. The previous assessment of the attractiveness of individual thin-film technologies and PV markets, as well as the subsequent strategic evaluation of PV companies, encourages us to take a positive long-term view, despite a certain amount of turbulence in 2009.

Fig. 11: Sarasin's long-term forecast for the global PV market



Source: Bank Sarasin, Nov. 2008

125 GW newly installed PV capacity in 2020 – long-term growth of 25 – 30% p.a. possible

With newly installed PV capacity of 125 GW in 2020, we anticipate average annual growth of 28% for the period 2012 – 2020. The solar industry will emerge stronger from the adverse conditions of 2009. If costs really can be cut by more than 10% p.a., the scenario described is perfectly viable. Achieving grid parity in the first key markets such as Italy, California and Japan would provide an enormous boost to the PV industry. The non-European markets will tend to grow even quicker up to 2020. Here

there are some very sunny regions that have enormous pent-up demand for solar energy.

EPIA forecasts for 2020 …

According to a new solar report published by the European Photovoltaics Industry Association (EPIA) and Greenpeace, solar energy can continue to look forward to double-digit growth rates in the years ahead[5]. The optimistic scenario predicts 56 GW of newly installed global PV capacity for 2020. The cumulative PV capacity of 280 GW will subsequently generate 360 TWh, which corresponds to 2.2% of the world's electricity demand (according to the IEA alternative scenario). Thereof the European share is 112 GW.

… significantly raised in response to the European SET Plan

The positioning of the solar industry within the European «Strategic Energy Technology» (SET) Plan[6] is extremely important. With this plan, the European Commission is trying to fast-track the strategic planning for Europe's entire energy industry. To this end it is contributing some of the money for research and development, but the lion's share is supposed to come from industry and from member states. By 2020, 40% of Europe's conventional power station capacity will need to be replaced. The SET Plan covers all 'clean' technologies with low carbon emissions. EPIA is aiming for better positioning by setting ambitious targets. Its forecast for the EU-27 member states are for a cumulative PV capacity of 175 – 350 GW by 2020. This is equivalent to an annual average growth rate of between 33% and 40%. This capacity would enable 210 – 420 TWh of electricity to be produced in 2020, equivalent to 6 – 12% of total EU electricity production.

Our forecast for Europe in 2020 is 200 GW of cumulative PV capacity. This puts us at the bottom end of the new EPIA target range.

Enormous potential for off-grid applications – Annual PV growth of 54% in the rest of the world

In addition to those countries listed in Fig. 9, we expect new fledgling markets to open up in a few years' time in developing and newly industrialised countries, particularly in the area of off-grid applications. This is reflected to some extent in the high annual growth rate of 54% for the «Rest of the World» region over the period 2007 – 2012. In these regions some two billion people have no access to mains electricity. Small decentralised solar home systems (SHS) or PV hybrid systems for supplying electricity to villages are often the quickest and cheapest way to substantially improve the living standards of predominantly rural populations. Not just PV cell and module manufacturers, but the entire business of solar systems technology stands to benefit from this huge sales market.

Strategic positioning of PV companies

The changes in the market described previously obviously have ramifications for the overall conditions affecting PV companies: price pressure caused by excess capacity, uncertainty about future subsidy programmes or the threat of reduced subsidies, as well as the financial crisis and credit crunch. The key question is therefore which companies are strong enough to weather the storm. For the third consecutive year, we have assessed PV companies on the basis of strategic criteria. This time our analysis included 27 listed PV companies, but only the «pure players» (excluding *BP Solar, Kyocera, Sanyo, Sharp* and *Wacker*). New candidates include *Canadian Solar, Energy Conversion Devices, Phoenix Solar, Schott Solar, Solarfun Power* and *Solargiga Energy*. The companies were assessed according to the following criteria, using a scoring system from 1 (weak or bad) to 10 (strong or good).

[5] www.epia.org; Solar Generation V - 2008

[6] www.ec.europa.eu/energy/res/setplan

– **Securing raw materials**: Although the bottlenecks in the silicon supply are likely to ease in the coming months, securing a reliable source of raw materials is a vital precondition for the unconstrained expansion of a company's in-house production volumes. Obviously this also applies by association to downstream companies and their intermediate products. The most important task here is to secure the intermediates at favourable conditions through long-term supply contracts.

– **Size of the company**: In industrial manufacturing, economies of scale play an important role in reducing costs. Only companies with lean cost structures will be able to achieve attractive margins. At the same time, suppliers of raw materials prefer to establish long-term partnerships with bigger and more stable companies. From the customer's viewpoint, the size of the company is also becoming increasingly important, particularly in the case of more long-term large projects. The scoring system took into account both sales figures provided in company accounts and the market capitalisation of the enterprise.

– **Technological know-how**: To be able to achieve significant cost savings, companies not only need to have a certain critical mass, but also technological know-how. On the one hand this helps smooth the path towards grid parity, and on the other it enables technological pioneers to set themselves apart from the competition by building a strong reputation. The essential factors here are not just the many years of experience accumulated in the past, but also leading-edge research and development.

– **Customer base**: Given that the future of subsidy programmes in some of the more «mature» solar markets looks less certain, while other countries are only just introducing subsidies, broad international diversification is crucial for companies. Whereas a certain amount of caution is advisable for the more mature markets, an early presence in new emerging markets is a prerequisite for success in the long run.

– **Growth**: In a rapidly growing market, higher sales volumes are critical for companies to maintain and continue to expand their market share. At the same time, however, it is important not to overlook profitability. Companies must also be sure they can finance their growth plans with sufficient equity and/or loan capital. When assessing this criterion, the first step was to look at the consensus estimates of financial analysts for future sales and EBIT growth. We then went on to evaluate companies' financial strength and access to the capital market using various ratios for leverage and cash flow.

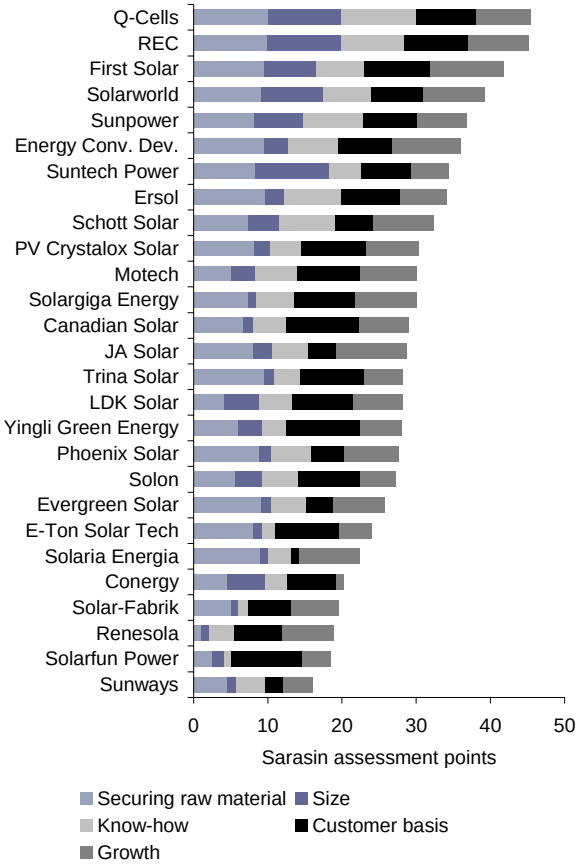
Q-Cells top of the table – First Solar in the top 3

This year Q-Cells gained our highest company rating, thanks to a consistently good score across all five criteria. The thin-film company *First Solar* was assessed for the first time this year and managed to leapfrog straight into third place in the list of established PV companies using c-Si based technology.

Chinese companies have disproportionately high levels of debt

The new criterion we introduced this year for healthy growth is designed specifically to assess the financial strength of individual companies, and to see how solid their financing is in the current critical period. *Conergy* is quite clearly in a difficult financial situation at the moment. Specific weaknesses as a result of overindebtedness can be seen in particular in the Chinese companies *Renesola, E-Ton Solar, Yingli Green Energy, LDK Solar, Trina Solar* and *Suntech Power*. Only *JA-Solar* managed to improve significantly, from 22nd to 14th place, thanks to its solid balance sheet and good cash flow. The assessment of financial strength and healthy growth showed last year's leading companies strengthening their position even further.

Fig. 12: Strategic positioning of PV companies



Source: Bank Sarasin, Nov. 2008

Conventional industry acquiring more of an appetite for photovoltaics

The recent takeover of *Ersol* by *Bosch* in Germany clearly illustrates the growing interest that traditional industrial conglomerates are starting to take in the solar business. *Conergy* has just entered into negotiations on a joint venture with the Korean company *LG Electronics* for its solar production in Frankfurt am Oder. This would be an important step for rationalising the company. Electricity utilities in particular will play an increasingly important role in the near future. Some conventional power stations across the globe have reached a critical age and a number of crucial investment decisions need to be taken about modernising them (especially in industrialised countries), and also expanding the electricity supply (in developing countries).

Concentrating solar power (CSP)

Concentrating solar power (CSP) systems are establishing themselves as a low-cost tech-nology for centralised electricity generation and thus provide an ideal entry opportunity for utility companies seeking to break into the solar energy market. Now CSP installations are coming under increasing competi-tive pressure from large-scale PV systems. This chapter provides a comparison of the benefits and draw-backs, as well as the associated electricity generation costs, in order to highlight the suitable areas of appli-cation for both technologies. Sarasin forecasts a cumulative CSP capacity of 5.5 GW by 2012.

Fresh momentum for CSP

With its original plans for an IPO (put on hold for the time being), *Schott Solar* has raised the public profile of concentrating solar power (CSP) technology in the world of finance as well. With its tube receivers, *Schott Solar* is the global market leader (>60% market share) in parabolic trough systems and stands to benefit from the dynamic growth rates in this industry. In the current list of worldwide CSP projects, parabolic troughs are the dominant technology, with a market share of more than 90%, ahead of Fresnel, Dish-Sterling and solar tower technology.

New CSP industry association, ESTELA, established in Brussels

In May 2008 the new European Solar Thermal Electricity Association (ESTELA)[7] was founded in Brussels to promote the development and refinement of this technology. ESTELA is also trying to get specific CSP targets included in national plans for renewable energies. The French have also worked up a «Plan Solaire Méditerranée». All these activities should raise the awareness of politicians and utility companies of this type of solar technology, and boost market growth in the process.

[7] www.estelasolar.eu

CSP still lags behind photovoltaics

A number of different PV-based and CSP-based technologies are now available for building solar power plants with an output of between 10 kW and 100 MW. In recent years it has been PV which has achieved the highest growth rate of all solar energy technologies and also attracted the most interest from investors. PV systems have been particularly popular in small (1 – 100 kW) to mid-sized (100 kW – 1 MW) installations mounted on the roofs of private houses or commercial buildings. By the end of 2007, approximately 7.8 GW cumulative PV capacity had been installed worldwide. Another 4 GW or so will be added in 2008. By contrast, only 1.3 GW cumulative capacity from CSP systems was in service up to the end of 2008.

Comparison of PV and CSP

Unlike PV systems, CSP systems use the sun's energy to generate heat first, and then convert this – with the help of a conventional steam turbine and generator – into electricity. This is also a major advantage because heat is easier and cheaper to store temporarily than electricity, allowing plants to continue to generate solar power up to seven hours after the sun sets. This means that CSP can also be reliably used to generate base-load electricity. One of the drawbacks of CSP installations is their high consumption of water for cooling and cleaning the mirrors. A 50 MW system has an annual water consumption of 600,000 – 700,000 m^3. This is roughly the same

amount of water needed to grow crops over an identical surface area. Air-cooled capacitors are slightly more expensive but are already used in locations where water is in short supply. Water-saving methods are also now in use for keeping the mirrors clean in CSP systems.

CSP power stations have an efficiency of 19% at peak-load capacity, which is slightly better than the c-Si modules (14%) and CdTe modules (10%) that are typically used in large-scale PV systems. The use of heat storage systems increases the annual average efficiency of a CSP system, because they allow the steam turbine to operate at optimum load capacity for longer periods. Fig. 13 shows the advantages and disadvantages of both technologies for use in a centralised solar power supply.

Fig. 13: Advantages and disadvantages of large-scale PV and CSP systems

Large-scale PV systems

Advantages	Disadvantages
Rapid project and construction phase	Higher electricity generation costs
Modular design allows it to be connected to the grid more quickly	Energy cannot (yet) be stored economically
No direct sunlight required	Large-scale PV projects (>50 MW) not (yet) economical
High cost reduction potential of 60% up to 2020	Low efficiency but higher space requirement

Concentrating solar power (CSP)

Advantages	Disadvantages
Energy can be stored	Direct sunlight required
Centralised generation of base-load electricity over 18 hours per day	Water consumption for cooling and cleaning
Many years experience of operating CSP plants in the USA	Not many locations meet the two criteria above.
High system efficiency of 19%	Lower cost reduction potential of 40% by 2020
Can be combined with conventional power stations	

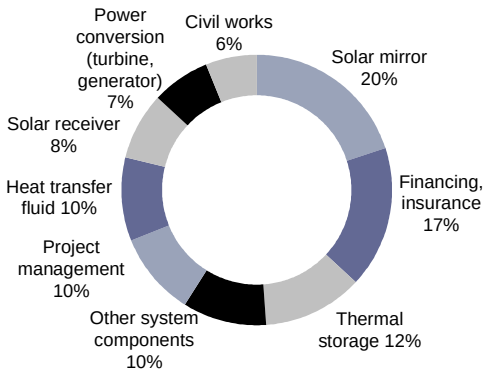
Source: Bank Sarasin, Nov. 2008

Cost reduction – the challenge for the future

Electricity costs and the availability of electricity generation are the two most critical factors that will ultimately dictate the future development of individual solar technologies. Both technologies still have significant cost reduction potential, with PV systems offering around 60% up to 2020 and CSP systems slightly less, at 40%[8]. With newer technologies such as linear Fresnel, solar tower and hybrid power stations, the cost savings could be even greater.

The example of the latest parabolic trough system Andasol 1 in Spain (with *Solar Millennium* and *ACS/Cobra* acting as project managers) in Fig. 14 gives an indicative breakdown of costs. The power station was connected to the grid in October 2008, it has an electrical capacity of 50 MW with an annual gross electricity production of around 180 GWh (net output approx. 140 GWh excluding the 12 – 15% for the gas burners) and cost around EUR 300m. The molten salt storage allows peak-load operation to continue up to seven hours after the sun goes down. This facility boosts the annual peak-load power from 2,000 to 3,600 hours.

Fig. 14: Indicative split of investments in a 50 MW parabolic trough power station



Source: Solar Millennium, 2008

[8] See Sarasin Solar Report 2007, Reducing CO_2 emissions through solar energy

The specific investments come to around EUR 6,000/kW, which is slightly higher than for a ground-mounted PV system tracking on a single axis, at roughly EUR 5,500/kW. Thanks to better capacity utilisation, the electricity generation costs for this parabolic trough system are around EUR 0.23/kWh, lower than for a PV system. By scaling up the technology, to 200 MW for example, the costs of generating electricity can be further reduced. In particular, the costs of the conventional parts of the power station (turbine, generator) do not rise in the same proportion.

Solnova 1, built by *Abengoa*, is an example of a parabolic trough system with no heat storage. With this CSP plant, the investment costs are just as high as for a non-tracking thin-film PV system (EUR 4,000/kW). The cost of power conversion is 1,800 kWh/kW, which lies somewhere between the figure for a thin-film system and Andasol 1. Electricity generation costs come to EUR 0.24/kWh.

The linear Fresnel CSP system is currently the cheapest form of CSP technology, with investment costs of EUR 3,500/kW. There is still no suitable storage facility available for linear Fresnel technology with direct steam production. Its electricity generation costs are roughly in line with other CSP systems.

New competition from thin-film technology

On the other hand the «booming» thin-film technologies could become serious competitors to CSP systems. *First Solar*, for example, is promoting open-space power stations with a system cost price currently around EUR 4,000/kW, which assuming solar radiation of 1,600 kWh/kW works out at an electricity price of EUR 0.26/kWh. Thin-film systems are particularly suited to regions with low levels of direct sunshine. However, this could even result in different market segments emerging for the two technologies.

Compared with the thin-film open-space system of *First Solar*, the large-scale PV system from *Sunpower* based on single-tracking monocrystalline modules is still a little more expensive, at EUR 0.30/kWh. Fig. 15 provides a comparison of the five different technologies for large-scale systems.

Conclusion: Different areas of application for PV and CSP

Fig. 16 provides an overview of the features of the individual solar systems, which can also offer different benefits for different customers. The individual technologies will therefore establish themselves for specific applications and specific sizes.

Centralised solar energy production – entry opportunity for electricity utilities

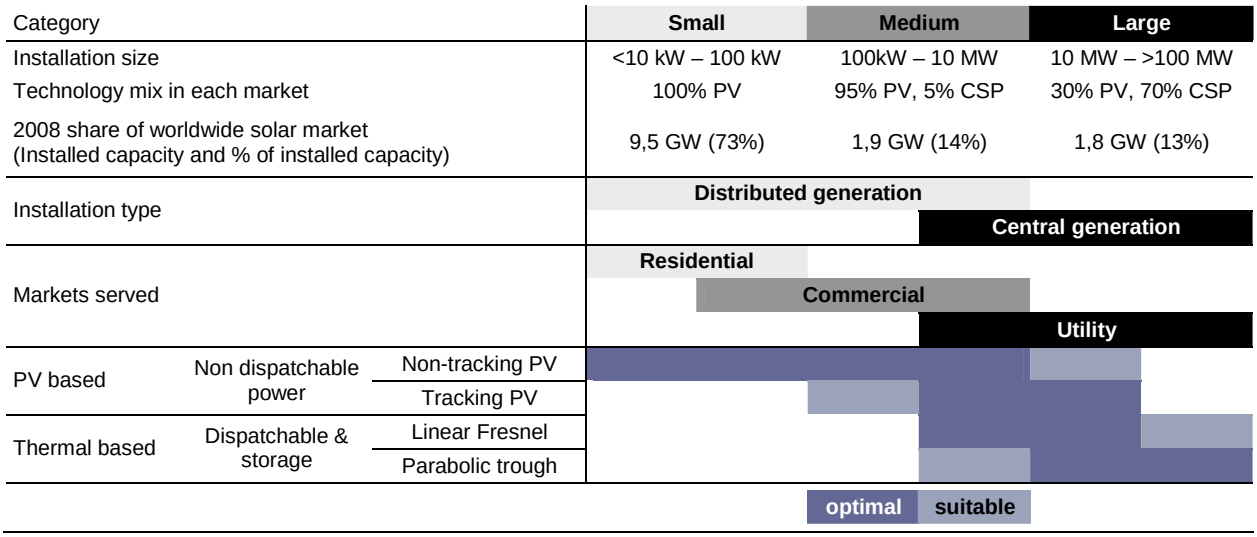
The ability to produce electricity with a high availability makes CSP very attractive for electricity supply companies looking to break into the solar energy market. Their attention is focused mainly on centralised production of solar power which is more scalable, predictable and easier to store. At this level, the ‘pure’ CSP applications or hybrid power stations, which can be combined with conventional heat or steam-powered plants, are becoming increasingly important. In the USA especially, more and more federal states now require electricity utilities to generate a portion of their electricity from renewable or solar energy, in accordance with the Renewable Portfolio Standard (RPS). One example of this is the CSP power station «Nevada Solar One» with a capacity of 64 MW, which was connected to the grid in the summer of 2007. The electricity generated by this plant is used by the two electricity utilities *Nevada Power Company* and *Sierra Pacific* under the terms of a 20-year Power Purchase Agreement (PPA). *Pacific Gas and Electric (PG&E)* is also planning similar CSP systems.

Fig. 15: Cost comparison for Si-PV, TF-PV, CPV and CSP land-based systems

	Photovoltaics		Concentrating solar power (CSP)		
	mc-Si-modules, single axis	CdTe-thin film	parabolic trough with storage	parabolic trough without storage	linear Fresnel without storage
	(Sunpower)	(First Solar)	Andasol 1 (Solar Millennium)	Solnova 1 (Abengoa)	DLR-study
Typical size (MW)	5 – 20	5 – 20	50 – 80	50 – 80	10 – 50
Contract costs (EUR/kW)	5,000	3,500	5,500	3,500	3,000
Financing costs (EUR/kW)	500	500	500	500	500
Total costs (EUR/kW)	**5,500**	**4,000**	**6,000**	**4,000**	**3,500**
Lifetime (years)	25	25	25	25	25
Power conversion, net; w/o gas (kWh/kW)	2,000	1,600	2,800	1,800	1,600
Efficiency, sun to grid power, gross	14%	10%	19%	19%	19%
Power production costs (EUR/kWh)	**0,30**	**0,26**	**0,23**	**0,24**	**0,24**
Discount rate (%)	7%	7%	7%	7%	7%
Annual costs (in % of total costs)	1,5%	1,0%	1,6%	1,9%	1,9%
Present value of annual costs (EUR/kW)	961	466	1,089	892	772
Lifetime costs (EUR/kW)	**6,461**	**4,466**	**7,089**	**4,892**	**4,272**
Annual degradation (%)	0,75%	0,75%	0,50%	0,50%	0,50%
Lifetime power production (kWh/kW)	21,867	17,494	31,265	20,099	17,866

Source: Companies; NEP-Solar; Bank Sarasin, Oct. 2008

Fig. 16: Markets and application areas for solar energy



Source: Prometheus Institute, Mar. 2008 and Bank Sarasin, Nov. 2008

The same is happening with large land-based or roof-mounted PV systems. Here the most suitable options include c-Si-based modules, thin-film modules or concentrating PV technology. *Southern California Edison (SCE)* plans to invest around USD 550m in solar energy systems over the next five years. Six million square metres of roof area is to be fitted with solar systems in America's biggest PV project. Week on week, *SCE* intends to install solar modules with a capacity of one megawatt.

We believe these large-scale applications offer enormous growth potential for the future. The idea of feeding solar energy from the Sahara through a high-voltage DC grid to Europe is once again being discussed as a viable option. The premiers of France and the UK, Sarkozy and Brown, seem to like this new plan[9]. It will ultimately also include offshore wind parks in the North Sea and Baltic Sea, as well as geothermal power produced in Iceland. The entire «supergrid» would cost around EUR 45 billion.

CSP systems competitive within five years

One of the biggest obstacles preventing solar thermal power stations from making a breakthrough is the high level of investments required compared with conventional power stations. Investments are currently in the region of EUR 3,500 – 6,000/kW compared with EUR 1,500/kW for a modern gas-fuelled power station. In the mid-term (approx. five years), however, capital costs for CSP systems could be cut to around EUR 2,500 – 4,000/kW, or roughly the same amount that would be required to construct a new nuclear power station. The technology's cost-efficiency therefore depends heavily on the financing opportunities and conditions, and on general interest rate trends, among others. *Solar Millennium*, for example, had to spend EUR 20 million on bringing the technology for its two Spanish power plants to market and developing the projects.

According to a study by Greenpeace[10] and ESTELA, more electricity could be generated worldwide by solar thermal power stations in 2040 than is currently generated by nuclear and hydroelectric power stations. By 2040 around five percent or 600 GW of electricity consumed worldwide could come from CSP plants – despite the fact that electricity consumption is expected to double by then.

The Middle East and North Africa could assume a pioneering role. Up to 100 million people living in the sunniest areas on earth could make use of this clean energy source. Another important driver here is the Masdar Initiative[11] from Abu Dhabi. In its commitment to sustainable development and renewable energies, explicit mention is made of the importance of solar energy, i.e. photovoltaics and CSP technology.

Market outlook for CSP systems

The project pipeline for CSP systems is still directly influenced by the subsidy programmes in Spain and the USA. Over 80% of solar power station projects in 2008 and 2009 are located in Spain and the USA. In the meantime other countries, such as France, Italy, Greece, Portugal and Israel have announced subsidy programmes for CSP systems, which means additional projects can be expected in these countries. Individual CSP systems are also being realised in North Africa, thanks to the law on feed-in tariffs for renewable energy in Algeria and GEF subsidies[12] in Morocco and Egypt.

The future development of CSP technology is heavily dependent on the experiences operating the first power stations which are connected to the grid in 2008 or at the start of 2009. This will allow the reliability of the latest generation of CSP systems to be rigorously tested under real operating conditions.

[9] www.ec.europa.eu

[10] Concentrated Solar Thermal Power – Now! Greenpeace, ESTELA, Solarpaces, Brussels, September 2005

[11] www.masdaruae.com

[12] GEF: Global Environment Facility. www.gefweb.org

Fig. 17 shows Sarasin's forecast for the expansion of CSP systems from 2007 to 2012. During this period, the cumulative capacity can be increased from 0.9 GW to 5.5 GW. This is equivalent to an annual average growth rate of 44%. We have significantly upgraded our forecast for 2020 from 16.5 GW to 32 GW of cumulative CSP capacity.

Fig. 17: Predicted expansion of CSP power stations up to 2012

MW	2007 in operation	Newly installed 2008	Newly installed 2009	Newly installed 2010	Newly installed 2011	Newly installed 2012	2012 in operation
Spain	50	150	320	450	550	650	2,170
USA	350	100	80	280	350	420	1,580
RoW	500	150	200	250	300	350	1,750
Total	**900**	**400**	**600**	**980**	**1,200**	**1,420**	**5,500**

Source: Bank Sarasin, Nov. 2008

Solar collectors

Solar collectors make by far the biggest energy contribution of all solar technologies. Global growth was 16% in 2007, and we expect average growth rates to be maintained around this level up to 2020. The Chinese market in particular is enjoying a boom, even without state subsidies. The most important European companies in the solar collector industry are investing heavily in new production capacities and want to make solar-heated buildings the actual standard by 2030.

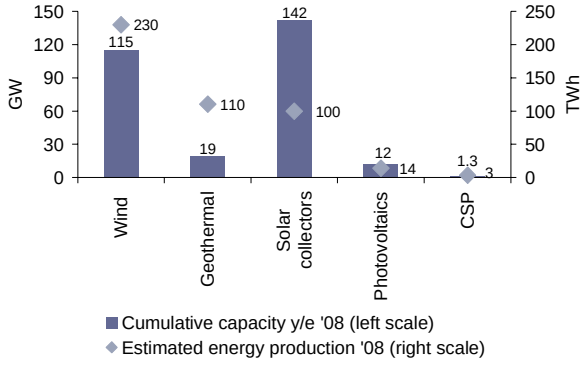
Decentralised heat generation using solar collectors for space heating buildings and hot water supply is the third area of application for solar energy.

When using solar thermal energy, the price of fossil fuels (mostly heating oil and natural gas) is still far more important than in the case of photovoltaics, since subsidy programmes play a much smaller role. The sudden price hikes in recent months have been a painful reminder of our dependence on oil and gas. This automatically makes solar thermal power more attractive, and an economic substitution mechanism kicks in that demonstrates measurable results. The heat generation costs for solar thermal systems will soon be able to compete with oil- and gas-fired forms of heating. The slightly more expensive acquisition cost is quickly offset by lower fuel costs.

Another supportive factor is that more and more governments are promoting solar heat through financial incentives or through new legislation. The new target set by the EU to increase renewable energies to 20% of total energy consumption by 2020 explicitly includes room heating and hot water supply.

Compared with other renewable energies (other than hydro power), solar collectors make a substantial contribution to global energy supply. Roof-mounted solar collector systems are already supplying 55 million households worldwide with hot water. This quota is the by far the biggest of any solar technology.

Fig. 18: Cumulative capacity (GW) at y/e 2008 and energy generated in 2008 (TWh)



Source: Bank Sarasin, Nov. 2008

Fig. 18 shows the projected cumulative electrical or thermal capacity ($GW_{el/th}$) at y/e 2008 for wind, solar collectors, geothermal power, photovoltaics and CSP, as well as the energy generated from it in 2008 ($TWh_{el/th}$)[13].

[13] 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 of 0.7 kW_{th}/m^2. For more details, visit www.iea-shc.org

Leading players in solar thermal power

The global solar collector industry is very fragmented and includes many smaller players. In the meantime, however, some bigger companies have floated on the stock exchange as well, with the industry attracting more attention from the world of finance in the process. As far as European companies are concerned, the big players are continuing to grow and still dominate the market. *GreenOneTec (GoT)* is hoping to ramp up its annual production of flat-panel collectors from 760,000 m^2 to 1 million m^2 , making it the global market leader. The large (traditional) boiler manufacturers such as *Bosch Thermotechnik*, *Viessmann* and *Vaillant* are still involved in the area of regenerative energy systems, which has since developed into an important line of business. These companies have clearly recognised the growing importance of the solar heating market.

With 500 employees worldwide and consolidated sales of EUR 235 million, ***Alanod*** is technology leader in the field of surface-treated aluminium and copper coils, and the biggest producer by a wide margin. The highly selective absorption layer systems produced by *Alanod-Solar* are used for solar thermal applications (flat-panel and tube collectors). The highly reflective, weather-resistant aluminium coils are used for solar thermal applications as well as in concentrating solar power (CSP) or concentrating photovoltaic (CPV) systems. *Alanod* is investing in a modern coil-to-coil coating plant and a fifth vacuum coating plant, both of which should be in operation by 2009.

On the occasion of InterSolar 2008, the German *MAGE Group* and the Italian *Almeco Group* announced the merger of their coating activities in the field of solar thermal energy. *TiNOX* has now changed its name to ***Almeco-TiNOX***. Following the acquisition, the joint venture now offers reflective surface coatings for CSP plants (like *Alanod*) on the one hand, and corresponding absorption coatings on copper and aluminium substrates for solar collectors.

BlueTec introduced an integrated management system on 3 March 2008 and has completed certification under ISO 9001:2000 and ISO 14001:2005. The highly selective absorber band «eta plus» is coated in a completely emission-free magnetron sputtering process.

Bosch Thermotechnik has increased its total annual production capacity in Germany and Portugal to more than 800,000 m^2 of collector surface area since August 2008. The actual production in 2007 was 240,000 m^2 and will be increased to nearly 500,000 m^2 by the end of 2008. *Bosch Thermotechnik* markets its flat-panel collectors through its international and regional brands, including *Buderus* and *Junkers*. In 2007, *Bosch-Thermotechnik* achieved sales of EUR 2.8 bn with 13,100 employees, of which 12% came from systems utilising renewable energies. By 2015 this percentage is set to rise to 30%. For the first time, the new Large Solar System (LSS) from *Junkers* provides an economical solution for large apartment blocks and multiple family dwellings. LSS ties the solar plant into the overall system, and can therefore now be used not only for providing hot water but also to support the heating system. Coupled with modernisation of the boiler, this can produce primary energy savings of up to 30%. *Bosch Thermotechnik* thereby clearly underlines its commitment to solar thermal energy and is seeking to expand its presence beyond EU markets to encompass all the major international markets.

Chromagen dominates the Israeli market for solar thermal energy, where over 85% of households have a solar water heating system. The company is increasingly concentrating its efforts on raising the quality and lifespan of its products. Its export component has risen slightly, primarily to Germany, but also to Europe as a whole, the Middle East and Africa.

Conergy has, in the course of its restructuring programme, pulled out of the solar heating business completely and is now concentrating solely on photovoltaics. In the second quarter of 2008 it split off completely from the thermal technology activities of its wholly owned subsidiary *SunTechnics*.

In July 2008 the new ***GreenOneTec (GoT)*** European logistics centre opened with a 140,000 m^2 collector surface area capacity. This means that even during the winter months the company's main products can be produced specifically for stock, with a constant headcount, in order to be able to maintain availability of supply even during seasonal peak months. Through the commissioning of an additional laser welding plant with an annual capacity of 500,000 m^2 absorber surface area, the total production capacity has been raised to its current level of 1.7 million m^2. This will potentially enable the production of around 1 million m^2 collector surface area in 2008. The export component is around 85%. A new type of collector has been specifically designed for use in southern Europe and North Africa. It is specially protected against corrosion from sea air, and from the ingress of dust or airborne sand. In addition, *GoT* has developed a large-surface collector of 5 m^2 or 10 m^2 for large-scale solar thermal plants. In addition to the Mediterranean region, the East European market is also a target for development.

KBB Kollektorbau GmbH has established itself as an innovative OEM manufacturer in the mass production of solar absorbers and flat-panel collectors within the sector and on the international market. In 2006 *KBB* moved to a new company location with considerable growth potential. The absorber surface area produced was 40% lower at 330,000 m^2 in 2007 than the peak achieved in 2006, due to the collapse of the market in Germany. The company's export component has doubled to over 40% since 2005, and will make *KBB* less reliant on its home market in future. Coupled with this international expansion drive, the company is seeking to concentrate more on its collector business.

The company ***Paradigma/Ritter Solar*** is the clear market leader in Germany and Europe for vacuum tube collectors. The production capacity at the Dettenhausen location has in the meantime been expanded to 300,000 m^2 p.a. For 2008, *Paradigma/Ritter* expects overall sales of 155,000 m^2 gross collector surface area. The «AquaSystem» product is to date the only solar heating system that operates entirely without antifreeze and which can be connected to an existing heating system without any additional conversion. *Paradigma/Ritter* is now seeking to offer this design more prominently in large-scale solar thermal plants. The world's largest vacuum tube collector plant, at 1,350 m^2, has been installed in Esslingen. Large-scale plants with a total surface area of 20,000 m^2 are in the pipeline. The successful joint venture *Linuo-Paradigma* is now among the top 3 in the Chinese domestic market. In 2008 *Linuo-Paradigma* is set to produce around 1 million m^2 of vacuum tube collectors.

Schott Solar suspended production following quality problems in its vacuum tube collectors (implosion of a number of tubes in 2007). Since then, *Schott Solar* has focused on photovoltaics and on its receiver tubes for parabolic trough power plants (CSPs), where it is the market leader. The stock exchange flotation planned for September 2008 has been postponed indefinitely due to the critical situation on the financial markets.

Schüco has become even stronger in its flat-panel collector OEM business, particularly in the key European market of France. There, *Schüco* is the market leader as the group *«Ortli, De Dietrich and Schüco»*, together with *Viessmann*. According to our estimates, sales will reach 350,000 m^2 collector surface area in 2008. A new departure for *Schüco* is the introduction of «standard collectors» from early 2009 with aluminium absorbers, with the bank of tubes attached on the rear side by means of aluminium strips.

Solahart is part of *Rheem* Australia, the world's largest company in the field of hot water systems, which in turn is part of the *Paloma Group*. This private holding company achieved around EUR 1.7 billion worth of sales in 2007 and employs about 15,000 people around the world. *Solahart's* market focus is on the southern hemisphere, and its products are now marketed in more than 70 countries. Its global production level reached around 240,000 m^2 collector surface area in 2007. In Europe,

Solahart is primarily concentrating on the southern European market.

Thanks to a new facility, ***Solvis*** is able to expand its capacity to 250,000 m^2 through a fully automated flat-panel collector manufacturing line. The capacity of the laser welding plant has been increased to 500,000 m^2 p.a. The focus has recently switched to large-scale plants for apartment blocks and industrial buildings. Extending its export operation to the entire EU is also planned. The company is set to grow by around 85% in the field of solar thermal energy in 2008.

Sun Master's sales volume for solar collectors will probably be around 165,000 m^2 in 2008. At the end of October the company moved into its new corporate premises. With 17,000 m^2 production area and 1,500 m^2 office space, the most modern «PassivHaus» industrial complex of its size has emerged. Total investment was EUR 17 m. This expansion will enable production capacity to be increased by 1 million m^2 p.a. In September 2008 a new collector line was introduced onto the market, which is suited mainly for sale in southern Europe.

At the end of August 2007 the listed Irish company ***Kingspan Group*** acquired the Northern Irish company ***Thermomax***. *Kingspan* is an internationally active manufacturer of products for the building industry, with a clear orientation towards energy-efficient integrated systems – particularly in the field of renewable energy. As the UK's largest manufacturer of vacuum tube collectors, *Thermomax* markets its products in more than 40 countries. Sales of collectors rose from 300,000 m^2 in 2007 to 430,000 m^2. Alongside its OEM business, the company is seeking to increase sales in future via the heating wholesale trade in Germany, and to increase the profile of the *Thermomax* brand.

Vaillant has been supplying the market with flat-panel collectors from its own production line since the spring/summer of 2007, with a production capacity of 150,000 m^2. Prior to that, *Vaillant* distributed flat-plate collectors by *Wagner Solar* (85,000 m^2 in 2007). As the most important supplier of *Schott* vacuum tubes, the company was particularly badly hit by the burst tube incidents and *Schott*'s withdrawal from production. *Vaillant* now procures its vacuum collectors from *Ritter Solar* and markets these as «auroTherm» under the *Vaillant* and *Saunier Duval* brands. The *Vaillant* group succeeded in increasing sales of products for utilising renewable energies by around 20% over the previous year to their current level of EUR 120 million, and is seeking to grow further in this area.

The ***Viessmann*** group of companies is one of the world's leading manufacturers of heating technology systems. Group sales are around EUR 1.4 bn and *Viessmann* employs around 8,500 people. With 16 plants in Germany, France, Canada, Poland, Hungary, Austria and China, with sales organisations in Germany and 35 other countries as well as 120 sales offices, *Viessmann* has a clear international orientation. 60% of its turnover is accounted for by exports (up 10 percentage points on last year). Its output of collectors will increase from 300,000 m^2 in 2007 to about 500,000 m^2 in 2008. *Viessmann* is the market leader in solar thermal energy in Spain and France, and is now the largest German manufacturer of solar collectors. The company also supplies PV systems based on flat-panel collector dimensions. The first production site for vacuum tube collectors is coming on stream according to plan, within the framework of a Chinese joint venture. These proprietary tube collectors are to be introduced before the end of this year, and will to a large extent replace the OEM collectors from *Thermomax*.

Wagner Solar commissioned a new collector factory in autumn 2008 for the EURO collector range. The total production capacity for the various collector lines has therefore been expanded to approximately 600,000 m^2 collector surface area p.a. An additional expansion of logistical capacity is on the agenda for 2009. Next year, *Wagner Solar* will celebrate 30 years of activity on the solar energy market. Building on a strong foundation in the German market, it now exports more than 50% of its

solar systems. The company has sales offices in Spain, France and, from 2009 onwards, in Italy too.

Wolf is a system provider in the fields of air conditioning and ventilation systems, solar thermal energy and biomass, as well as gas and oil heating systems. The company has been part of the listed ***Centrosolar Group*** since 2006. This led to the emergence of the first complete system provider for energy-saving systems for buildings. *Wolf* is represented in 45 countries. In 2008, over 100,000 m^2 of flat-panel collectors are expected to be sold for the first time. The goal is to focus primarily on expanding OEM production and exports of the company's own products.

Amongst others, ***VKR Holding*** owns the company *Velux* with its well-known brand of roof skylights. The solar energy business is contained within the company *SolarCAP* and represents the companies *Sonnenkraft, ProSolar, GREENoneTEC* (50% holding), *Heliodyne, EMMVEE, ARCON and Thermo-Sol.* These companies develop, produce and market solar thermal energy systems, mainly for the European market but increasingly also worldwide.

Chinese producers pushing ahead with enormous capacity expansion

Compared with a total production volume of some 2.8 million m^2 for European manufacturers, Chinese production of solar water heating systems is estimated at 22 million m^2 in 2007. Production capacities have increased by around 25% over the space of just two years. In stark contrast to photovoltaics, 90% of production is sold to China itself, and only 10% is destined for export. China's solar thermal industry now employs over 600,000 people and has more than 5,000 manufacturers and distributors of solar-powered water heating systems. Around 100 of these manufacturing companies are genuinely able to compete in the marketplace. The top seven firms have a combined market share of over 20%. More than 20 leading manufacturers have now been accredited under the Gold Star Labelling System. This system is designed to increase the quality and standardisation of the products. The new standards are closely aligned to the existing specifications and test standards of the ISO and the EU.

A typical solar thermal system with 4 m^2 tube collectors and a 180 l storage tank costs around EUR 200. A high-quality product from *Linuo-Paradigma*, a joint venture between the German company *Paradigma* and *Linuo*, sells at double the price. On the other hand there are also cheaper products available for around EUR 100, although their quality is obviously much poorer. A government survey showed that only about half of purchasers are happy with their solar products. The tough price war also seems to be one of the reasons why Chinese manufacturers are switching to more profitable markets in Europe and the US. It is unclear how well they will do in these markets, given their inferior quality.

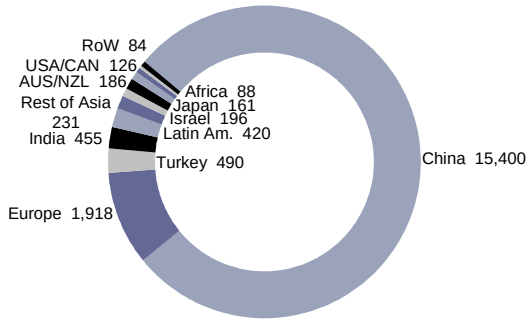
Global market trends

Global market growth of 16% in 2007

There are still huge differences between national markets in terms of newly installed collector area. China, easily the biggest market, is roughly eight times bigger than the European market. In contrast to Europe, it grew another 22% last year, once again making a vital contribution to the global growth rate of 16% in 2007. In 2007 the new globally installed capacity came to 19.7 GW_{th} (28.2 million m^2, see Fig. 19). Around 78% of this capacity was installed in China. Apart from China, other important markets include Germany, Greece and Austria in Europe, and also Turkey, Israel and Japan. The global solar thermal market in 2007 was worth EUR 4.4 bn[14].

[14] This is based on an assumption for China, Turkey and Latin America of a price of EUR 110 per square metre of collector area and a price of 600 EUR/m^2 in Europe, based on 28.2 million m^2 of newly installed collector area

Fig. 19: Global newly installed collector capacity in 2007 in MW_{th}. Total amounted to 19,700 MW_{th} (28.2 million m^2)

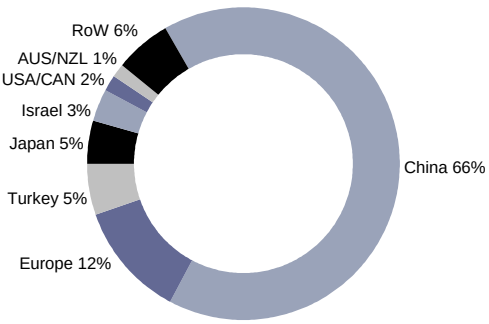


Source: W.B. Koldehoff (basic data), Oct. 2008

Big differences in national growth rates

Fig. 20 illustrates the total collector capacity currently in service in the individual countries and regions at the end of 2007. Compared with 2006, this capacity has increased by 18% worldwide to a total of 127 GW_{th} (182 million m^2). China has increased its quota from 64% to 66% and is still comfortably in the lead when it comes to the total solar collector capacity in service of 84 GW_{th}. Aside from this, growth rates were also higher than average in Australia/New Zealand (40%), India (18%) and Africa (14%). By contrast, growth was -9% in Europe, -12.5% in Israel and -6% in the rest of Asia. Turkey, Japan, the USA and Canada posted zero growth.

Fig. 20: Breakdown of total solar thermal systems in service up to 2007, with a capacity of 127 GW_{th} (182 million m^2)



Source: W.B. Koldehoff (basic data), Oct. 2008

USA on the starting block

The US market for solar heating and cooling seems to be on the brink of a dynamic growth phase. It's unclear yet, though, when the momentum will really start to pick up. In October the US government finally passed an Energy Tax Credit package (Solar ITC and Wind PTC) worth USD 18 bn. Two thirds of this tax rebate will go to renewable energies, and one third to subsidising fossil fuel sources. The ITC for both private and commercial solar power systems has been extended for 8 years, by one year for wind energy and by two years for the other renewables (geothermal, biomass, tidal power, etc.). Following these positive decisions, investments in the region of USD 230 bn could be triggered in all areas of renewables up to 2016.

A big plus in this new regime: in future energy providers can also benefit from the tax credits. The solar industry is a major beneficiary of the new rules. Here tax credits of 30% have been agreed for a full 8-year period. Information on additional subsidy programmes at the level of individual federal states is available on a database. [15]

Market trends in Europe

After posting strong growth of 45% in 2006, equating to newly installed capacity of 2,100 MW_{th}, the European solar thermal market[16] experienced a significant downturn in 2007 (Fig. 21). The total market for flat-panel and tube collectors shrank by 9% to 1,900 $MW_{th,}$ equivalent to a collector surface area of 2.7 million m^2. This was well short of our 2007 growth forecast of 18%. The forecast by the industry association ESTIF was as high as 29%. The sharp decline is mainly the result of the -37% slump in Europe's biggest market, Germany. But markets also stagnated or contracted slightly in Austria, the UK, Sweden and Denmark. By contrast, a number of other countries – in addition to France, Spain and Italy – recorded double-digit growth rates, including Switzerland

[15] www.dsireusa.org. Database of state incentives for renewables & efficiency

[16] ESTIF: European Solar Thermal Industry Federation, www.estif.org; Trends and Market Statistics 2007, June 2008; EU 27 + CH

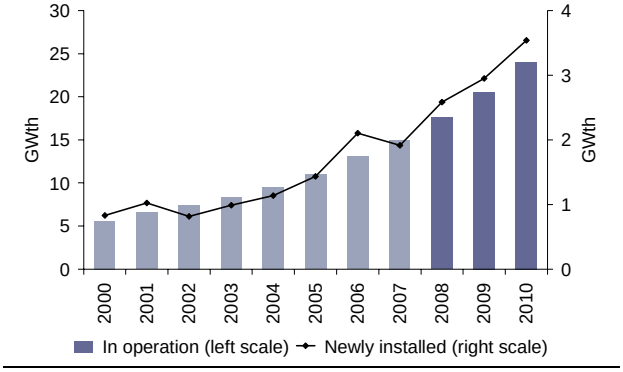
(26%), the Netherlands (36%), Slovenia (70%) and Poland (60%). For the first time ESTIF produced figures not only for the EU 15, but for the EU 27 (incl. Switzerland in each case). Poland is the first Eastern European country to work its way up to the top of the middle rankings for the solar thermal market. Switzerland is also up-and-coming, and Cyprus is traditionally a strong player in solar thermal technology.

Sales of solar collectors in Europe are now concentrated in six key markets: Germany, Greece, Austria, Italy, Spain and France. 83% of new capacity is installed in these nations.

Consumers reluctant to invest in energy-saving measures

Many people were taken by surprise by the negative market growth, particularly since climate change and soaring oil and gas prices were major public issues during the past year. But unfortunately their high media profile was barely reflected in sales of solar collectors. Consumers seem to be reluctant to invest in energy-saving measures. With persistently high energy prices, however, the market for solar collectors and energy-saving technologies in general is likely to grow in the longer term.

Fig. 21: Development of solar collectors in Europe (EU 27 + CH). Forecast for 2008 to 2010: 2.6, 3.0, 3.5 GW_{th}



Source: ESTIF, Jun. 2008; W.B. Koldehoff, Oct. 2008 and Bank Sarasin

Another encouraging development is that the EU is in the process of passing a Renewable Energy Directive which for the first time will cover the area of heating and cooling as well.

The solar industry itself has also formulated an ambitious vision: by 2030 a building heated entirely by solar power should not only be a viable option, but become the standard in Europe by 2030.

Growth rates should revert to 15 – 20% soon

This year we once again expect a dynamic growth rate of 35% to 2,585 MW_{th}, driven mainly by massive growth in Germany. In the next two years, 2009 and 2010, these rates will then sink back to a moderate 14% and 20% respectively. This growth should be supported above all by the subsidy programmes introduced for solar thermal energy in various countries. Spain even went one step further and following regional and municipal initiatives, and is now requiring the use of solar hot water systems in its national building regulations for newbuild and renovation projects.

Fig. 22: Solar heating market in Europe 2007: Overview ranked by market share in MW_{th}

Country	2007 in operation (MWth)	Europ. market share (%)	Market development 2006 – 2007			2008 Market estimate total	2009 Markt estimate total
			Installed 2006	Installed 2007	Growth rate		
Germany	6,296	41%	1,050	658	-37%	1,085	1,190
Greece	2,499	16%	168	198	18%	196	203
Austria	2,025	13%	205	197	-4%	210	221
Italy	770	5,0%	130	172	32%	238	294
Spain	675	4,4%	123	183	50%	245	301
France (EU)	609	4,0%	154	179	16%	217	280
Cyprus	438	2,8%	42	46	8%	48	49
Switzerland	356	2,3%	36	46	26%	53	60
Denmark	270	1,8%	18	16	-9%	18	20
Netherlands	237	1,5%	10	14	36%	16	18
UK	213	1,4%	38	38	0%	42	49
Sweden	184	1,2%	20	18	-11%	22	27
Poland	164	1,1%	29	47	62%	56	63
Portugal	144	0,9%	14	18	25%	21	25
Belgium	102	0,7%	25	29	18%	35	41
Rest of EU	387	2,5%	41	61	49%	84	112
Total	**15,370**	**100%**	**2,102**	**1,918**	**-9%**	**2,585**	**2,950**

Source: ESTIF, Jun. 2008; W.B. Koldehoff, Oct. 2008 and Bank Sarasin

German solar thermal market collapsed in 2007

The German market was 37% down on the previous year, with newly installed thermal capacity of just 658 MW_{th} in 2007. The decline was mainly the result of the slump in the overall heating market, which shrank by 30%. Investments in energy-saving heating systems dropped off dramatically, especially in the area of modernisation. This was in response to uncertainties in the market and poor communication between politics, industry and end consumers.

According to figures released by the German Solar Industry Association (BSW)[17] sales of solar heating systems once again increased by around 60,000 units in the first half of 2008. BSW puts this dynamic market growth of more than 50% down to soaring oil and gas prices and improved state subsidies. The government's market incentive programme provides subsidies up to 2012 of up to EUR 500m per year for installing heating systems using renewable energies. If householders exchange their old heating system with an efficient solar energy system with a collector area of 15 m^2 they are entitled to subsidies of up to EUR 3,400.

Austria: a high level of solar collector production, but installation is declining

Domestic production of solar collectors in 2007 rose to 1.16 million m^2 (2006: 1.13 million m^2). Of this, some 0.8 million m^2 was exported (68%). Three out of four collectors produced in Austria are now exported to more than 20 countries worldwide. Two thirds of the collectors go to Germany, almost 10% to Italy, less than 10% to France and Spain[18]. In 2007 a total of 0.281 million m^2 (197 MW_{th}) new flat and vacuum tube collectors were installed (2006: 0.292 million m^2), equivalent to a slight drop of 4% in new installations.

Turnover in solar systems in 2007 was estimated at EUR 385m, with a third of this figure coming from the installation business. The solar industry, including the maintenance and renovation of existing systems, currently provides around 6500 jobs in Austria.

Swiss solar collector market up 26%

Last year a total of 46 MW_{th} new capacity was installed in Switzerland[19], an increase of 26% on the previous year. The installation rate has therefore increased significantly for the fifth consecutive year. In 2007 flat-panel collectors had a market share of 96%. Total installed solar thermal capacity now stands at more than 321 MW_{th}. The prospects for continuing growth in the Swiss solar market are good. The introduction of a CO_2 tax on heating oil and gas as of 2008 provides property owners with an additional incentive to reduce their consumption of fossil fuels. The imposition of tougher energy consumption regulations for buildings agreed by the directors of the cantonal energy authorities are pointing in the same direction. In the longer run, solar thermal technology could account for 35% of Switzerland's heating requirement for residential properties.

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

In 2007 the world's newly installed collector capacity was 19.7 GW_{th}, roughly 16% higher than in 2006. For the current year 2008 we predict that newly installed collector capacity worldwide will reach around 23.4 GW_{th} (33.8 million m^2), which is 20% more than last year. This growth will come mainly from China and Europe and increasingly the USA, but also from new markets. For several years now China has shown itself to be a dynamic and self-sufficient market with annual growth rates and rising energy prices of over 20%. The Chinese government looks as though it will manage to achieve its ambitious targets for 2010 and 2020.

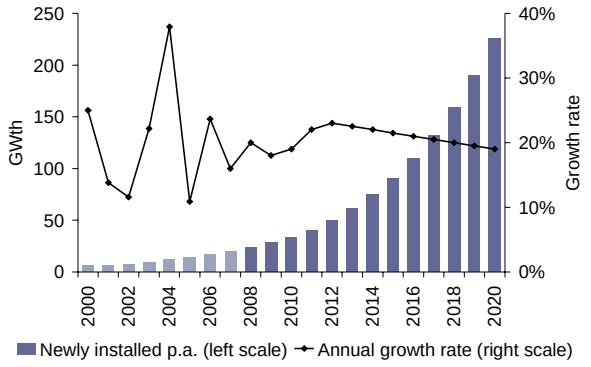
The annual global growth rate of the solar collector market should average roughly 25% up to 2010 (in terms of newly installed capacity). In 2010 we therefore expect a market volume of 42 GW_{th}. This is equivalent to a monetary value of around EUR 11 billion. This would ultimately result in total installed collector capacity of 214 GW_{th}

[17] www.bsw.solar.de
[18] www.solarwaerme.at
[19] Solar – Swiss Association of Solar Energy Professionals, Market Survey 2007; www.swissolar.ch

worldwide by the end of this decade. With the increasing absolute size of the market, we expect average growth will then ease back in the following decade (2011 – 2020) to newly installed capacity of around 18% p.a. The global market for newly installed solar collectors would therefore reach a volume of approximately 236 GW_{th} in 2020 (see Fig. 23). For the future we are confident that the global trend towards solar thermal power will remain intact in the coming decades.

In future we can expect to see other markets developing in sunbelt regions, such as Southern Europe, the US and Australia and other emerging markets such as India, Indonesia, Mexico and Brazil.

Fig. 23: Sarasin forecasts for the global solar heating market; newly installed collector capacity in GW_{th} p.a.



Source: W.B. Koldehoff and Bank Sarasin, Oct. 2008

Growth in the European market still relies heavily on Germany. Here the 1H 08 results are slightly more reassuring and the industry hopes that the installed capacity for the full year will once again revert to the level of 2006 (approx. 1,000 MW_{th}). The growth rate for the whole of Europe in 2008 is therefore expected to be in the region of 35%.

Europe's market share will shrink to 6.5% by 2020

In its recent White Book, the European Commission has set a 2010 target of 70 GW_{th} for installed solar collectors. At y/e 2007 the total installed capacity was 15.4 GW_{th}. Given the current growth rates, we estimate that the EU target will not be reached until 2015 at the earliest. In 2020 newly installed capacity will reach 14.8 GW_{th}, leading to 110 GW_{th} of capacity from solar collectors in service. Europe's share of the total figure will shrink from the current level of 10% to 6.5%.

Of the total primary energy consumption in the EU, 40% occurs in buildings, 32% in transport and 28% in industry. Room heating and hot water supply account for 85% of energy consumption in buildings. This magnitude is unfortunately totally out of proportion to the public and political attention devoted to heating energy. To provide stronger support to solar heating in the important energy segment of «heating and cooling», there need to be more effective public subsidy programmes or legal measures, such as the «Barcelona model» in Spain or the new «Regenerative Heat Act» in Germany. The European industry association ESTIF, together with the European Renewable Energy Council (EREC)[20] and other organisations, has published a declaration calling for an EU directive to ensure that renewable energies (solar thermal power, biomass and geothermal energy) will cover roughly 25% of heating and cooling energy by 2020.

[20] Joint Declaration for a European Directive to promote renewable heating and cooling; European Renewable Energy Council (EREC), Brussels, May 2008; www.erec-renewables.org

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