# Glass processing opportunities for solar industry

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## Keywords

1 = wafers 2 = photovoltaics 3= thinfilm 4=concentrators

## Abstract

The recent revival of solar energy applications and the growth prospects offered include major opportunities for glass processors looking to grow with the trend. Glass is a key element in solutions based on i.e. photovoltaics and concentrated solar power technologies and glass processors naturally think seriously about what this development entails for their part.

Modern high-efficiency glass processing is usually run in continuous processes designed for better, constant optical quality, optimized process balancing and effective cost control to produce the lowest feasible manufacturing cost per glass area produced. This generally means that processes need to be geared for optimum runs, full utilization of line width and minimum spacing of glass.

The special case of solar products poses additional challenges such as the capability to process thin glass and handle advanced coatings for better light transmission. The requirements for heat treatment increase and the interaction of quality, efficiency and cost is pronounced. For glass processors all this spells a clear message: increased processing efficiency and timely up-grading of machine capability. Glass enjoys a unique position as a component in solar elements due to its physical characteristics: As a material it is really the only viable option for making solar power panels thanks to its great durability and stability.

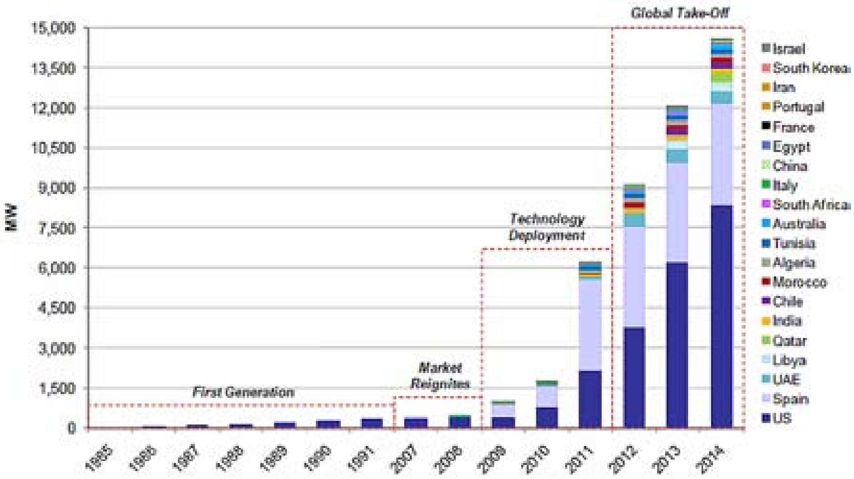
## Introduction

The world's energy and climate challenges have grown markedly over the past few years. The concern of how to provide the required energy supply for continuous growth while at the same time caring for the climate have brought on a revival of the solar energy issues that first surface a couple of decades ago. The World Energy Council has estimated that on average 7,500 more times solar energy reaches the Earth in the form of sunshine than is needed for the world's primary energy consumption./1/

| Capacity MW | Technology | Name | Country | Location |
|---|---|---|---|---|
| 354 | Parabolic Trough | SEGS | USA | Mojave Desert |
| 64 | Parabolic Trough | Nevada Solar One | USA | Las Vegas Nevada |
| 50 | Parabolic Trough | Andasol 1 | Spain | Granada |
| 11 | Tower receiver | PS10 | Spain | Seville |
| 5 | Fresnel reflector | Kimberlina | USA | Bakersfield California |
| 0,36 | Fresnel reflector | Liddell Power Station | Australia | New South Wales |

*Table 1.*

*Operational CSP Facilities end 2008*




Source: Emerging Energy Research

*Figure 1.*

*Announced CSP Projects by country*

## Concentrated Solar Power CSP

The world's largest solar energy facility was built in the Mojave desert in the US in the period 1985-1990 to produce the as such imposing power of 354 MW using parabolic through technology. At the end of 2008 the operational CSP facilities in the world generated a total of 484 MW as shown in table 1.

Most of these facilities have been built in recent years which indicates a pause in full scale utilization of solar energy for about two decades. The reason was not technological but rather economical. Other energy sources and production technologies represented more advantageous economy and the constraints caused by growing negative environmental effects from i.e. the burning of fossil fuels were prohibitive.

The situation has turned around and the prospects for increased concentrated solar power investments indicate imposing growth rates as shown in figure 1.

Like the illustration shows, the first generation stage is left behind, the market has reignited and technology development may pioneer a global take-off in the next decade./2/ For glass processors this paints an inspiring picture of a strongly growing market. In today's difficult economic environment the prospects of new growth cannot of course be overlooked.

The relative share of different types of CSP installation technologies and an estimate of cumulative CSP in GW is shown in figure 2 and 3.

These illustrations display exponential growth. For a glass processor to be able to capitalize on this development a number of new factors enter into the traditional processing picture. The two main technologies for producing solar collector glass today are based alternatively on annealed or tempered glass. Both have their spokesmen. Whichever the mode of production the requirements on the production lines become much tougher.

## Photovoltaics PV

The raw glass used for advanced solar applications is more transparent than traditional glass with a reduced iron oxide content in the glass and a solar transmission improved from some 88 % to 91 %. This as it appears small increase already has a significant effect on the end quality of the product. Energy generation in case of PV module may increase by some 6 %, which is a lot.

The previous facts about CSP include amazing growth as such but that growth is clearly overshadowed by the projected market development of the newer technology based on photovoltaics as shown in figure 4.

While the share of glass in thin film photovoltaic elements at some 14 % is smaller than in CSP-elements, at some 20 %, the sheer volume of the market makes total glass use manifold. The different growth trends for the PV technology depend mainly on to what extent special support mechanisms will be introduced by national authorities faced with energy and environmental concerns. The so called Feed in Tariff idea is based on establishing a set and favourable price for energy generated based on PV-solar technology in which case demand is expected to receive a strong boost. The same holds for producers of solar collectors and their components as the case in some countries clearly shows. Potential growth rates in different regions are shown in figure 5.

As shown here the annual PV market growth rate has been some 40 % in the past years and it is expected to continue for the next five years at a pace of some 20 -30 %. For glass processors struggling on today's tough markets seeking growth where it can be found the consequences of the PV-boom are obvious. What is needed is now a solid estimate of sustainable growth. A quick boost of some two years at the time is not enough to warrant long-term industrial investments. There are some positive signs of the introduction of more long-range thinking in many regions now, including the important US market where developments are said to be reasonably accurate for the next eight years. That perspective is already one for industry to react on.

*Figure 2.*

*Cumulative CSP Capacities as predicted by Bank Sarasin and Greenpeace/ ESTIA. /3, 4/*

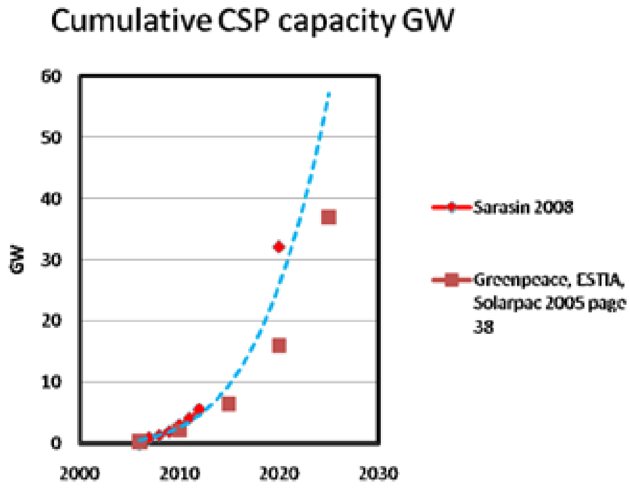
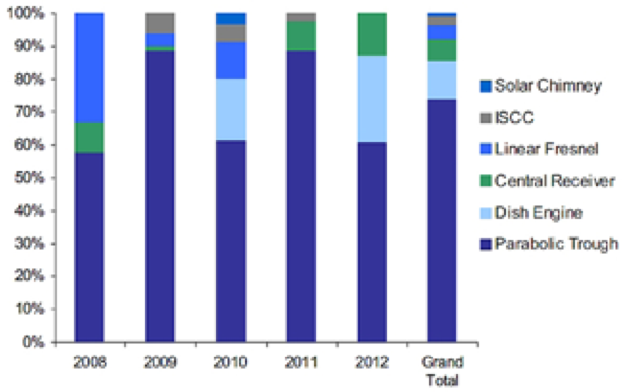



*Figure 3.*

*CSP Capacities by technology /2/*



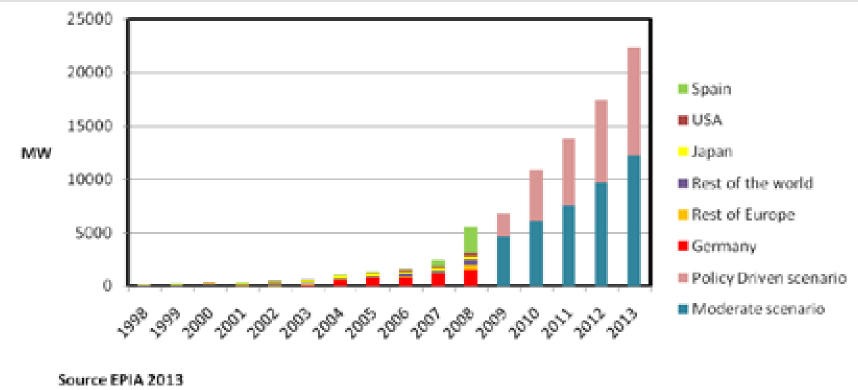




*Figure 4.*

*Global Annual PV Market Outlook until 2013. /5/*

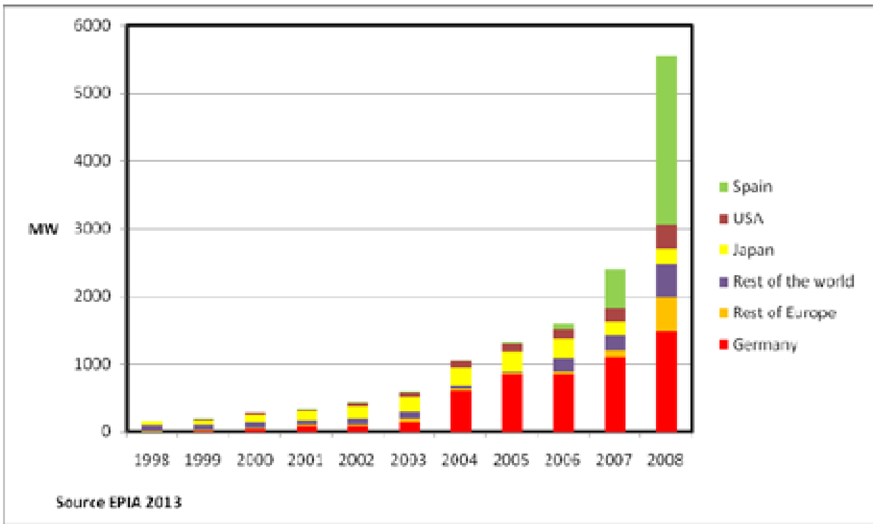



*Figure. 5*

*Global Annual PV Market by region /5/*

The PV industry is currently using some 1 % of the total volume of raw flat glass produced in the world. The more than ten times faster growth of the PV industry as compared with other glass consuming industries will hoist its share of raw glass production to some 5 % within a few years (figure 6). This solar glass market need must be met by the world's glass processors operating production lines that are sometimes highly efficient and sometimes not so. Looking commercially at what type of technology is deployed in the solar industry by the year 2020 it is easy to see that thin film and silicon wafer technology are the dominant two (figure 7). /3/

It is also interesting to note what the build-up of PV production capacity might look like in the next few years. China has become the biggest PV producer in the world, as shown in figure 8.

At the same time it is also clear that solar energy facilities will be concentrated to some of the sunniest regions of the world. A look at the map in figure 9 gives an interesting indication of where the solar facilities using the solar elements are likely to be located. Growth in demand and technological development has a powerful impact on the solar industry and it is easy to determine that a viability development where the fittest will survive is now in progress. Companies need to build up reputation, track records and the required financial resources to successfully take part in this development.

## Challenges for the glass industry

Looking at the main competitive factors of competitive solar glass production again puts the focus on us glass processors and our supply chain that needs to measure up to even more stringent quality, efficiency and cost advantages. The biggest solar industry presently, c-Si is calling for good quality heat treated patterned glass with general bow sometimes less than 0,1%.

The glass industry needs to pay special attention to gearing up for the solar challenge especially for evolving thin film applications where the quality requirements are even higher than in c-Si. Primary glass processors are faced i.e. with the issues such as new antireflective (AR) and TCO coatings, better edge finishing and need for automated quality control systems. ( TCO, Transparent Conductive Oxide). The need to deploy more transparent solar glass is a quality issue above all. Naturally this also has cost implications but end-product competition focuses on quality. Antireflective coatings and Transparent Contactive Oxide will play a growing role in future PV-elements and thus influence the processing of the basic glass elements as well.

In total these very special products of very special quality bring added

*Figure 6.*

*PV Solar glass share of world total glass production. /6/*

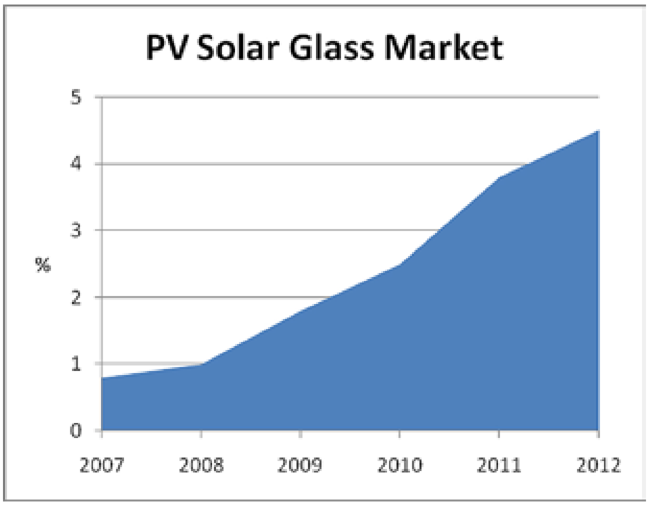



*Figure 7.*

*Segmentation of PV Market by Technology*

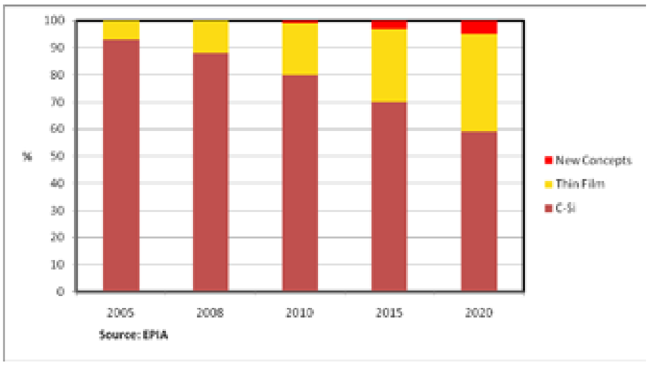
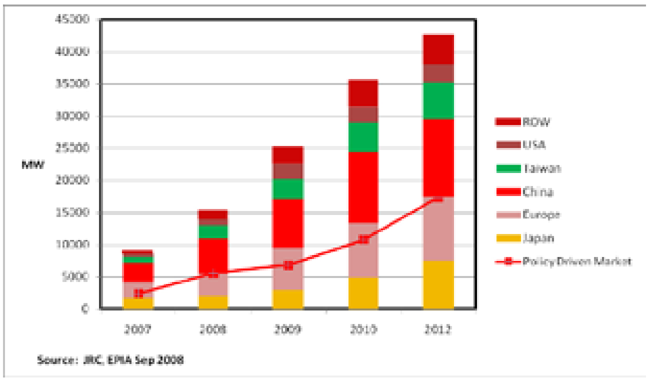



*Figure 8.*

*Planned PV production Capacity*



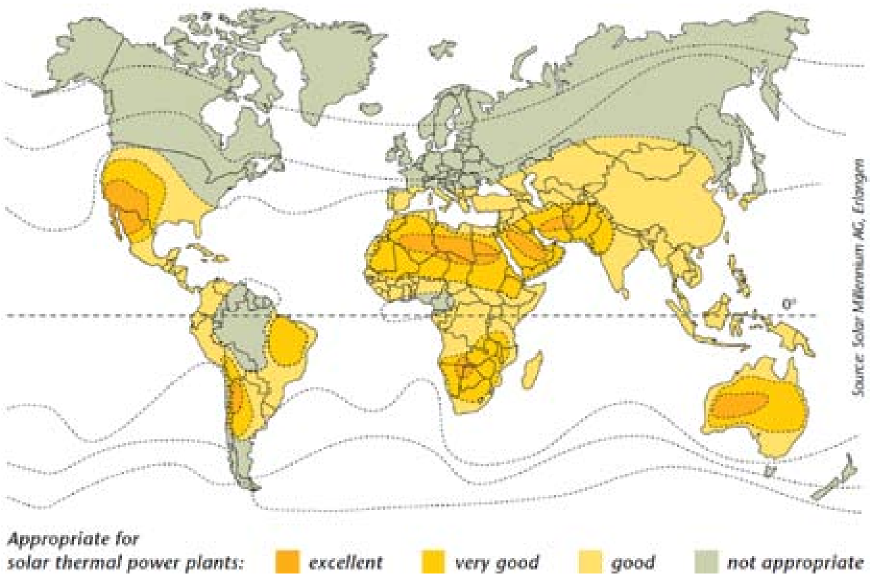




*Figure 9.*

*Suitability of different locations for solar thermal power installations* challenges to heat treatment and laminating. Although it may seem like a detail in this total picture but one special issue of roller wave distortion measurement in glass processing quality control needs to be addressed. There is a difference in the measuring of roller wave distortions from peak to peak - or peak to valley and millidiopter measurement as practised especially in some regions. I will bring the argument further in some more illustrations because there are many enough who hold the opinion that a set millidiopter reading also determines the quality of the glass required.

Figure 10 illustrates the roller wave phenomenon, well known to glass processors and this is commonly expressed as millidiopter value (table 2). The processing line may be equipped with large rollers or small rollers.

Figure 11 provides a result of roller wave measurements that end up giving the same millidiopter reading for the curvature of glass shown at the top of the figure as for the one at the bottom.

Yet the peak to valley distances are very different. The mdpt readings in the table may give food for the thought that the problem is easily solved by changing the roller size only. But that falls well short of fixing the problem. The larger peak to valley amplitude below remains and may cause real problems in laminating. It will also consume more pv-film than is anticipated. Cost and quality problems follow.

Correct measurement of the roller wave characteristics of the glass for solar glass applications will eliminate misunderstandings in quality control and also accidental use of inferior quality glass on the processing line when changes and mistakes are costly. Naturally glass processors have a number of issues to consider in gearing up for the extreme quality requirements typical of the solar element applications.

When it comes to glass use in CSP technologies the factors influencing the precise targeting of radiation reflections raise their own demands (Figure 12).

Local glass processors have always had the challenge of operating under extreme production efficiency. The cost of process machinery, energy, materials and labor has eliminated less efficient producers unable to meet the objectives of quality with the precise delivery times and cost constraints of the market. Loss of production has meant a loss of orders. The markets remind glass processor that nothing is ever so good that it cannot be improved. And that is precisely what competitors do all the time. In addition, changes to the traditional game are being introduced thanks to the influence of the developing and growing solar industry.  This is actually something to be grateful for – growth stimulus is always welcome.

*Figure 10.*
*Roller wave distortion*

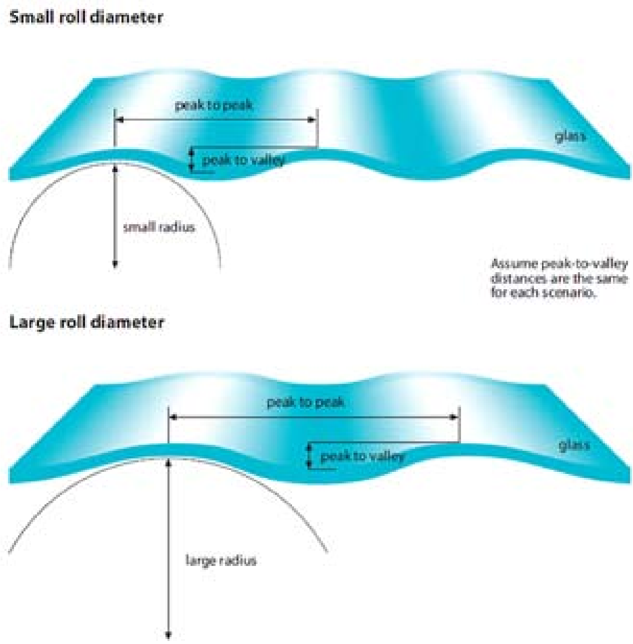



*Table 2.*
*Millidiopter reading*

**Distortion, D (mdpt)**

| Peak to valley Depth, W | | Roll diameter | | | |
|---|---|---|---|---|---|
| | in | 1.59 | 2.23 | 2.87 | 3.51 |
| | mm | 40.4 | 56.6 | 72.9 | 89.2 |
| | | Wavelength, L | | | |
| in | | 5.0 | 7.0 | 9.0 | 11.0 |
| | mm | 127 | 178 | 229 | 279 |
| 0.0005 | 0.01 | 31 | 16 | 10 | 6 |
| 0.0010 | 0.03 | 62 | 32 | 19 | 13 |
| 0.0020 | 0.05 | 124 | 63 | 38 | 26 |
| 0.0040 | 0.10 | 249 | 127 | 76 | 52 |
| 0.0060 | 0.15 | 373 | 190 | 115 | 77 |
| 0.0080 | 0.20 | 497 | 253 | 153 | 103 |
| 0.0100 | 0.25 | 622 | 316 | 191 | 129 |

Acceptable
Not Acceptable

$$W = \frac{DL^2}{4\pi^2 10^6}$$

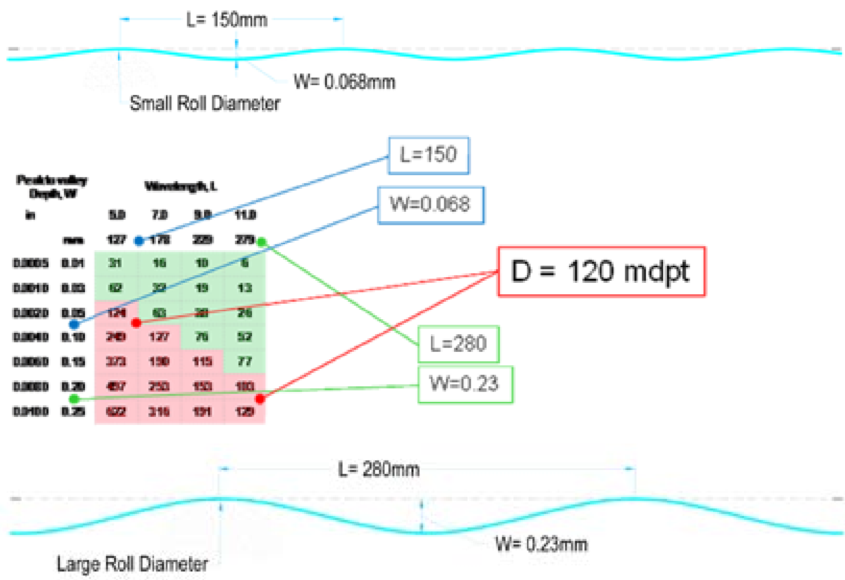



*Figure 11.*
*Roller wave distortion as measured by mdpt reading and peak to valley measurement*

## Conclusions and Summary

This presentation is about knowing the solar glass market, its characteristics, trends and special challenges. Producers of solar energy collectors look to glass processors to find sources of steady, quality and long-range supply with growth potential. Glass processors look to solar specialists with the special eye on how to upgrade their production lines so that the demands of this challenging growth sector can be met.

Solar industry and Glass industry are just starting to understand each other and the role of glass in solar applications. So far the market has been fragmented, using generic products and equipment that have been currently available. Solar industry is looking for specific materials (including special glass) and special equipment designed to process solar glass in search for more durable and efficient system. Often solar collector warranty has to cover for 25 years. Glass as a structural part of the collector has a major influence on the life of the unit.

For glass processors it is also evident that traditional production lines and traditional operating procedures may not be enough to measure up to a whole new set of quality parameters. The requirements on the performance of the end products and the accuracy to which they need to capture the endless energy flows from the sun for efficient use trigger a whole new game. Here, too, the fittest will survive a wave of industrial structural change. The good news for us is that we are all in the same boat and fully capable and willing of navigating together.

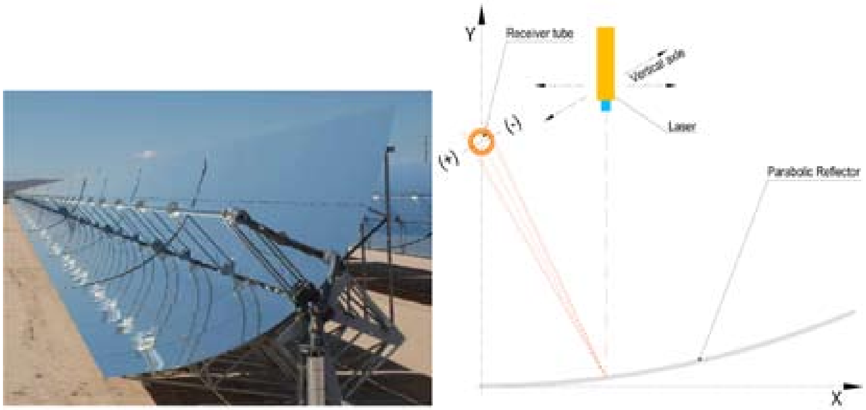



*Figure 12.*
*Glass quality requirements for parabolic trough CSP collectors*

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