

## Solar

An aerial photograph of a large-scale solar energy project. The central focus is a Concentrating Solar Power (CSP) plant, featuring a tall, white, cylindrical receiver tower. Surrounding the tower are numerous rows of solar collectors, which appear as dark, rectangular panels arranged in a grid pattern. The solar farm is situated in a semi-arid landscape, with green agricultural fields visible on the left and right sides. In the background, there are some industrial buildings and a road. The overall scene depicts a modern, large-scale renewable energy installation.

Abengoa Solar develops and applies solar energy technologies in order to combat climate change and ensure sustainability through the use of its own Concentrating Solar Power (CSP) and photovoltaic technologies.

[www.abengoasolar.com](http://www.abengoasolar.com)



International Presence





## Our business

Abengoa is convinced that solar energy combines the characteristics needed to resolve, to a significant extent, our society's need for clean and efficient energy sources. Each year, the sun casts down on the earth an amount of energy that surpasses the energy needs of our planet many times over, and there are proven commercial technologies available today with the capability of harnessing this energy in an efficient way. Abengoa Solar's mission is to contribute to meeting an increasingly higher percentage of our society's energy needs through solar-based energy.

To this end, Abengoa Solar works with the two chief solar technologies in existence today. First, it employs Concentrating Solar Power (CSP) technology in capturing the direct radiation from the sun to generate steam and drive a conventional turbine or to use this energy directly in industrial processes, usually in major electrical power grid-connected plants. Secondly, Abengoa Solar works with photovoltaic technologies that employ the sun's energy for direct electrical power generation, thanks to the use of materials based on the so-called photovoltaic effect.

Abengoa Solar works with these technologies in four basic lines of activity. The first encompasses promotion, construction and operation of CSP plants, Abengoa Solar currently designs, builds and operates efficient and reliable central receiver systems (tower and heliostats) and storage or non-storage-equipped parabolic trough collectors, as well as customized industrial installations for producing heat and electricity. In each and every case, Abengoa Solar uses its own technology in both plant design and operation. This activity is currently being carried out in diverse geographical locations, including Spain, northern Africa, the Middle East and the United States of America.

The company also executes photovoltaic installations for industrial or commercial building roofs and other urban settings. Abengoa Solar's second line of business involves the promotion, construction and operation of photovoltaic plants and facilities. The company is currently developing installations using various technologies, including one and two-axis trackers and plants utilizing concentration systems.

Third among Abengoa Solar's lines of activity is marketing and manufacturing of the technologies it develops, which takes place together with third parties in some cases. The company currently designs and manufactures key elements such as heliostats, parabolic trough collectors, curved mirrors and high-concentration photovoltaic systems. It has also undertaken a joint venture for manufacturing mirrors.

Finally, Abengoa Solar is carrying out an ambitious R&D&i program to improve current technologies and develop new ones. To achieve this, the company has research centers in Madrid, Seville and Denver, in the United States. Abengoa Solar strongly believes that in a high-growth market like that of solar energy, R&D&i investment is crucial to ensure the enhancement of current technologies. Indeed, Abengoa Solar has an R&D&i team with over 25 years of experience in solar energy, which has proved its credentials by developing the company's own technology for the main business areas. This team also works in collaboration with the world's main research institutes, including Ciemat, DLR, Fraunhofer, ISE and NREL.

Abengoa Solar carries out these four activities in a market experiencing a high growth rate all over the world and promises to sustain that growth by making the most of the global need for clean energy solutions aimed at halting climate change, the need for numerous geographies to increase their energy independence, and the rising costs of fossil energies derived from the recognized costs of the CO<sub>2</sub> emissions they generate, as well as the volatility of oil and gas prices.

Abengoa Solar conducts its business in two main markets:

- Large-scale grid-connected CSP plants. There are currently around 500 MW connected to the power grid around the world (mainly in the United States) and approximately 700 MW under construction (principally in Spain). There are also approximately 8 GW in projects that are at varying stages of development, primarily in Spain, the U.S. and, to a lesser extent, in the Mediterranean area, northern Africa and the Middle East. Exponential growth is therefore anticipated for the coming years. In terms of its position in the market, Abengoa Solar is one of the world's five or six pioneers, and is one of the very few companies to boast its own technology, construction capability and expertise. Therefore, Abengoa Solar's competitive position stands it in excellent stead in a market characterized by genuine growth and significant entry barriers.
- Grid-connected and distributed photovoltaic installations. In 2008, this represents a 3.5 GW market, in which Germany, the U.S., Spain and Japan represent the main markets, and one where growth has been increasing at a rate of 30-40% per year. Until 2008, Abengoa Solar had been competing solely in Spain, a highly competitive market that is free from entry barriers as a result of an excessively liberal regulatory framework. Abengoa Solar did not have any competitive advantages in this market and have developed opportunistic projects, waiting for more suitable regulatory framework.





### 2008 in review

2008 was yet another key year in the evolution of Abengoa Solar's business. The company reinforced its foundations to support the high, sustained and global growth of its business. The following are among Abengoa Solar's 2008 highlights:

- Tremendously successful operation of PS10, the first CSP plant, with 11 MW of power, located at the Solúcar Platform in Sanlúcar la Mayor (Seville).
- Further development of the Solúcar Platform, which, with its 350 MW of installed power, will be the largest solar platform in the world.
  - The world's second commercial power tower technology-based plant, PS20, conducted the first round of performance testing and is on the way to commercial start-up at the beginning of 2009.
  - Progress was made on the construction of the first three parabolic trough plants, each with 50 MW, located at the Solúcar Platform, noteworthy among which is Solnova 1, where its mirror-equipped structures dominate the landscape.
  - Structure assembly began on the Solnova 3 plant, featuring the same characteristics as Solnova 1.
  - Earth-moving work began on Solnova 4, the third 50 MW plant.
- Consolidation of a project portfolio under promotion in Spain that will enable the company to meet its targets for building solar plants in the coming years. Within this portfolio, various projects have already obtained key permits, so construction is therefore expected to commence in the short term, including two 50 MW plants located in Écija (Seville).
- In photovoltaics, the first plant, Seville PV, completed its second year of production, proving the commercial viability of the low-concentration technology utilized. The Copero plant in Seville, with 1 MW of power, continues to operate with excellent performance levels.
- Noteworthy is the production start-up of three new photovoltaic plants in Sanlúcar la Mayor (Seville), Linares (Jaén) and Las Cabezas de San Juan (Seville), adding 9.5 MW of additional power to this activity.
- On the international stage, Abengoa Solar made progress, in collaboration with the industrial engineering and construction business unit, on the construction of the world's first two solar Integrated Solar Combined Cycle (ISCC) plants combining a natural gas combined-cycle with a parabolic trough field. These plants are located in Algeria and Morocco.



- In the United States, Abengoa Solar signed a contract with Arizona Public Service (APS) to sell solar power for a 25-year period. This endeavor requires the construction of a 280 MW parabolic trough technology-based plant, which will be the largest in the world.
- Continued construction of the installations that supply industrial steam to its customers, Abengoa Solar inaugurated its largest project to date for the Frito-Lay Company in California.
- As far as R&D&i is concerned, the Solúcar Platform became one of the world's main solar energy research centers in 2008. The platform currently has various groundbreaking research facilities either in operation or under construction, including a high-temperature power tower, a parabolic trough plant for direct steam generation and a Stirling dishes installation. Its photovoltaic laboratory was also consolidated to enable field assessment and validation of the simulation models for diverse photovoltaic technologies.
- Abengoa Solar brought two parabolic trough collector assembly plants into operation. They are currently supplying the Solnova 1 and 3 plants and are intended to supply the rest of the Solúcar Platform in the future.

**Our activities**

Promotion, construction and operation of CSP plants

The world's CSP promotion market experienced tremendous growth in 2008, indicating a prelude to the phase of implementation of this technology in different geographical areas. This growth is based on three fundamental factors:

- Recognition, by the societies in which Abengoa Solar operates, of the hidden costs of fossil energies due to the emissions they produce.
- The reduction in costs offered by solar energy and increased awareness of available options.
- Approval in various countries, as a result of these two factors, of regulatory frameworks favoring the introduction of CSP technologies and support of specific projects.

The Spanish market has plants in operation and under construction which, over the next two years, will exhaust the current regulatory framework, and therefore broader regulation is expected. However, significant initiatives have been undertaken in other geographies, enabling us to be optimistic about the future of large-scale CSP plants.

Within this context, Abengoa Solar upholds a solid commitment to the development of the CSP market, both in Spain and abroad, and currently has 11 MW in operation, 170 MW under construction in Spain and a few hundred more at the advanced promotional stage.

- PS10, the world's first commercial power tower plant in operation and the first grid-connected plant in Spain with the tariffs established under recent Royal Decree 661/2007. The year 2008 served to demonstrate the commercial viability of power tower technology and to situate Abengoa Solar as one of the world's pioneers in this technology with tremendous potential.
- PS20, the second power tower plant in the world, currently in the start-up phase, implemented a series of improvements over PS10 in certain key aspects.
- Solnova 1, 3 and 4, parabolic trough technology-based plants, each with 50 MW, located at the Solúcar Platform. Construction continued over the course of 2008 using the company's own technology and engineering.
- At a very advanced promotional stage, Abengoa Solar has various 50 MW plants, two of which are located in the municipality of Écija, as well as two 20 MW power tower plants, one at the Solúcar Platform and the other in Almadén (Ciudad Real).
- Beyond Spain, Abengoa Solar has teams that are heading up project promotion in various geographical locations, including the United States, northern Africa, southern Europe, and the Middle East. It is currently building hybrid plants in Algeria and Morocco using Integrated Solar Combined Cycle (ISCC) technology, and in the United States, in addition to the construction of industrial steam plants, a contract was signed with APS to build Solana, the largest solar power plant in the world with 280 MW of power.

### PS10 plant



Its solar field, with 624 heliostats of 120 m<sup>2</sup> each, is particularly eye-catching. It concentrates solar radiation onto the receiver that is located at the top of a 120 m high tower to produce steam and drive a turbine coupled to the electrical generator connected to the power grid.

This plant generates enough clean energy to meet the needs of 5,500 homes and provides a savings in CO<sub>2</sub> emissions of 6,700 t each year. The plant also features a storage system of almost an hour in duration which enables management of cloudy spells without having to shut down and then restart the plant. This is, in fact, the world's first solar power tower plant to feature a built-in storage system.

In June 2007, the plant excelled in the first series of operating tests in accordance with the contracts signed with the financing banks, and in 2008 it continued to show even better results. Since operation began, PS10 has



served as a tool at Abengoa Solar for both gaining knowledge and improving the next power tower technology-based plants.

**PS20 plant**

With its 20 MW of power, PS20 will be able to supply electricity to 10,000 homes; reducing CO<sub>2</sub> emissions into the atmosphere by 12,100 t per year. The plant is made up of 1,255 heliostats and a 160 m high tower.

This plant has profited from Abengoa Solar’s accumulated experience in the construction and operation of these types of plants, and features several enhancements in design that will enable this second generation of power plants to attain higher levels of efficiency than PS10.

**Solnova 1, Solnova 3 and Solnova 4 plants**

In 2008, Abengoa Solar made significant progress in the construction of its first two parabolic trough collector plants at the Solúcar Platform (Seville): Solnova 1 and Solnova 3.



The technology consists of concentrating solar radiation by means of high-precision curved mirrors onto a heat-absorbing pipe, inside which circulates a fluid that reaches high temperatures. This fluid enables the production of steam that is sent on to a turbo-generator, where it expands in order to produce energy.

Each plant is made up of 300,000 m<sup>2</sup> of collectors. A collector has an aperture of 6 m and almost 150 m<sup>2</sup> in surface area. The entire installation will take up an area of 120 ha and will enable the production of enough energy to supply 25,700 homes, reducing yearly CO<sub>2</sub> emissions by 31,400 t. Abengoa Solar also began

construction on Solnova 4, a plant with the same features as the previous two that will be located in the same place.

### Helioenergy 1 and 2 plants

These are CSP solar plants under development in the town of Écija (Seville), employing parabolic trough technology, each with 50 MW. They will enable the supply of electrical power to nearly 25,700 homes and the reduction of CO<sub>2</sub> emissions by 31,400 t per year.

### Almadén Solar plant

A power tower technology-based solar plant under development. It will be located in Almadén (Ciudad Real) and will have a nominal output capacity of 20 MW. Joint promoters are Abengoa Solar, Sepides and the IDAE. The plant will generate over 40 GWh of power, reducing CO<sub>2</sub> emissions into the atmosphere by more than 12,100 t each year.

### United States

In 2008, Abengoa Solar consolidated the Denver (Colorado) team. This team has the capability of delivering solar-based industrial steam solutions for customers currently using steam from fossil fuels. Abengoa Solar thus offers a wide range of options that fully cover industrial and commercial applications, including water heating, steam generation and climatization. Abengoa Solar installs these systems all over the world by means of the standard modifiable system designed by the company. Noteworthy among these projects is the plant for heating frying oil for Frito-Lay in Modesto, California.

This is the largest solar system for producing heat for industrial processes in the U.S. It is made up of 5,056 m<sup>2</sup> of parabolic trough collectors situated on a site lying adjacent to Frito-Lay's snack factory in Modesto, California.



The collectors will operate at temperatures of up to 250 °C to produce steam. This steam is then transferred to a plant where it is used to heat the oil for frying potato chips and other snacks.

The Abengoa Solar system enjoys the support of the California Energy Commission under a PIER (Public Interest Energy Research) program.

The highlight of the year in the United States was however the contract signed with APS in the face of stiff competition from the world's leading solar companies. The Agreement involves the supply of electrical power over a term of 25 years. To achieve this, Abengoa Solar will build a 280 MW parabolic trough technology plant. This plant, Solana, will be the biggest in the world.

### **International**

Outside Spain and the United States, Abengoa Solar has a team that is developing opportunities in other countries. It has the capacity to offer and design the best technical solution for each market and need. In 2008, work continued on the two major ISCC projects. These projects are the first in the world to combine solar energy and natural gas in the same electrical power production cycle. The combination of the two energy sources achieves a lower level of natural gas consumption, thereby curbing CO<sub>2</sub> emissions into the atmosphere.

The projects in Algeria and Morocco make Abengoa a pioneer in the design and engineering of combined-cycle hybrid solar fields.

### **The world's first Integrated Solar Combined Cycle (ISCC) plant in Algeria**

In 2008, construction continued on the parabolic trough plant in Hassi R'mel. Abengoa Solar is carrying out this project in conjunction with Abener, part of the Industrial Engineering and Construction Business Unit, and NEAL (New Energy Algeria).

The project involves the construction of a hybrid station that is made up of a solar field of parabolic trough





collectors with a power output capacity of 150 MW, 20 MW of which will come from a solar field with over 180,000 m<sup>2</sup> of useable reflecting surface area.

Also in 2008, Abengoa Solar strengthened its team involved in international development, which now has the capability to undertake projects in the world's main solar geographies.

### Promotion, construction and operation of photovoltaic installations

During 2008, the market for promoting photovoltaic technology continued to show very high growth in the main geographical locations, with an emphasis on Europe, and Spain, in particular, as the true driving forces behind this growth.

In the case of Spain, this growth was exorbitant and took place mainly through conventional and even "old" technologies. This has given rise to a genuine oversaturation of the sector, thereby resulting in the lowering of tariffs.

Within this context, Abengoa Solar has allocated to photovoltaics a small percentage of its investments, focusing efforts on developing and testing technologies that will enable the company to be competitive in the long term.

Throughout 2008, Abengoa Solar promoted and built grid-connected plants, utilizing the latest technologies, in both photovoltaic modules as well as sun-tracking systems to suitably position panels and obtain higher efficiency and profitability. It now has around 12 MW of power with the capacity to produce about 30% more than conventional systems located in even the best areas of Spain in terms of direct solar radiation.

### Seville PV plant

The world's first commercial plant to use low-concentration photovoltaic technology. With a power output capacity of 1.2 MW, it is located at the Solúcar Platform in Sanlúcar la Mayor.

The plant was started up in May, 2006, and since then operation and use have surpassed the estimated design figures.



Seville PV has 154 trackers and occupies an area of 12 ha.

The plant has the capacity to generate 2.1 GWh of clean energy per year, enough to supply around 650 homes, while eliminating the emission of over 1,800 t of CO<sub>2</sub> each year.

**Copero PV plant**

This is a series of ten photovoltaic installations totaling 1 MW built within Emasesa’s Wastewater Treatment Station (WTS) in the El Copero area of the town of Dos Hermanas (Seville). Ownership of the plants is split 50-50% between Emasesa and Abengoa Solar.

**Las Cabezas**

A 5.7 MW plant with one-axis trackers located in an area of high solar radiation in the province of Seville.

**Casaquemada**

A 1.9 MW plant employing two-axis tracking technology located within the Solúcar Platform. It includes a 100 kW high-concentration installation executed using the latest generation of Concentrix technology.

**Linares**

A 1.9 MW plant with two-axis trackers located in Jaén.

Supply of key components

Abengoa Solar develops its own technology, designs its plants and ensures the quality and reliable supply of the key elements in determining the cost and production of its installations. In order to fulfill this objective, in 2008 Abengoa Solar managed to guarantee the supply of most key components:

- For power tower CSP plants, Abengoa Solar designs its own heliostats and manufactures them at either its own or third-party facilities. As far as receivers are concerned, Abengoa Solar collaborates with specialized companies in order to make the designs required for each one of its plants a reality.
- For parabolic trough CSP plants, Abengoa Solar designs its own collectors, which are then manufactured by Eucomsa and Comemsa (Abengoa Solar investee companies), and assembled at the two assembly plants built at the Solúcar Platform. The parabolic trough mirrors are manufactured by Rioglass Solar, with which Abengoa Solar signed a commercial agreement enabling a guaranteed supply of this key component with a level of quality that far surpasses that of mirrors available on the market until now. This will translate into lower assembly costs and less breakage in the field. Finally, with respect to receiving pipes, in 2008 Abengoa Solar met its needs in Spain for the next two years.

