Background information

# Solar industry
# Generating power from the sun

Light and heat from the sun is the most abundant energy source on earth. The solar energy that hits our planet's surface in one hour is about equal to the amount of energy consumed by all human activities in a year. What if we could find a way to efficiently transform sunlight into vast amounts of low-cost, usable electricity?

This scenario is no longer just a vision, and the rewards have never been higher: electricity generated by solar power is emissions free, and can help mitigate climate change as well as reduce our dependence on finite carbon-based energy sources.

The potential is greatest in the Earth's deserts, which span the globe north and south of the equator. More than 90 percent of the world's population lives within 3,000 km of a desert, which means these arid, virtually uninhabited sunbelts could potentially supply most of our electricity needs today, using existing technologies.[1]

This is the core vision of the Desertec Foundation,[2] which is relying on two essential technologies to achieve its goal of turning solar energy from the deserts of North Africa into vast amounts of sustainable, emissions-free electricity.

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These are:
- concentrating solar power plants, a technology ABB helped develop in the early 1990s, which enables solar power generation on a large scale

- high-voltage direct current (HVDC) power transmission, a technology pioneered by ABB in the 1950s which enables long-distance, low-loss electrical transmission

ABB is a technical advisor to the Desertec initiative, providing expertise in HVDC transmission technology, which limits electricity losses to about 3 percent per 1,000 km. The delivery system for a vast project like Desertec is already a reality - in China, ABB is delivering the full technical infrastructure for an "electricity superhighway," which will enable 6,400 megawatts (MW) of power from a hydropower plant to be transported, with minimal losses, over a distance of 2,000 km.

Meanwhile, R&D, government support and industry interest are steadily reducing the cost of solar power generation, and solar technologies today are much more commercially viable, as well as technically reliable.

**Most CSP plants will be built on sites with good or excellent sunshine – including deserts – close to significant consumption centers. The largest metropolitan areas likely to benefit from CSP electricity by 2020 are Ahmadabad, Alexandria, Algiers, Amman, Athens, Baghdad, Barcelona, Cairo, Casablanca, Houston, Istanbul, Jaipur, Johannesburg, Karachi, Las Vegas, Lima, Los Angeles, Madrid, Mexico City, Miami, Riyadh, San Diego, Santiago (Chile), Sydney, Tashkent, Tehran, Tripoli, Tunis and Urumqi.**
International Energy Agency, Energy Technology Perspectives 2010

The final hurdle to making large-scale solar power generation a reality is the political will to invest in such installations, and the momentum driving projects like Desertec is building.

ABB provides products, systems, services and expertise for both primary solar technologies:

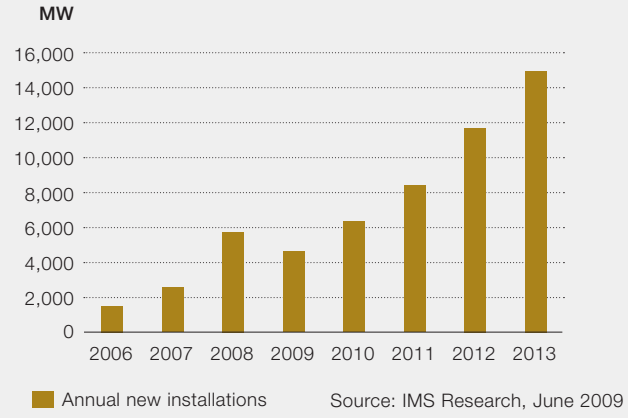
- Direct conversion of sunlight into electricity using photovoltaic (PV) cells

- Concentrating solar power (CSP), also known as solar thermal energy

### Photovoltaic (PV)
Solar PV power is a commercially available and reliable generation technology with significant growth potential in nearly all world regions, according to the International Energy Agency (IEA). PV panels can be used wherever the sun shines.

R&D and industry growth have produced a variety of PV technology options, in a range of costs and different levels of maturity. The global PV market has grown at an average annual rate of 40 percent for the last decade.[3]

**The world market for photovoltaics**




Germany, Spain, Japan and the United States account for 80 percent of global installed PV capacity, but the technology is also gaining momentum in countries like India, China, Australia and Italy as new policy and support schemes come into effect. Large-scale installations have gained considerable market share, and off-grid rooftop systems that once constituted the majority of PV installations are now less than 10 percent of the market.[4]

The IEA estimates that PV solar generation will provide about 5 percent of global electricity production by 2030 and 11 percent by 2050, at which time it will help avoid 2.3 gigatonnes (Gt) of $CO_2$ emissions each year.[5]

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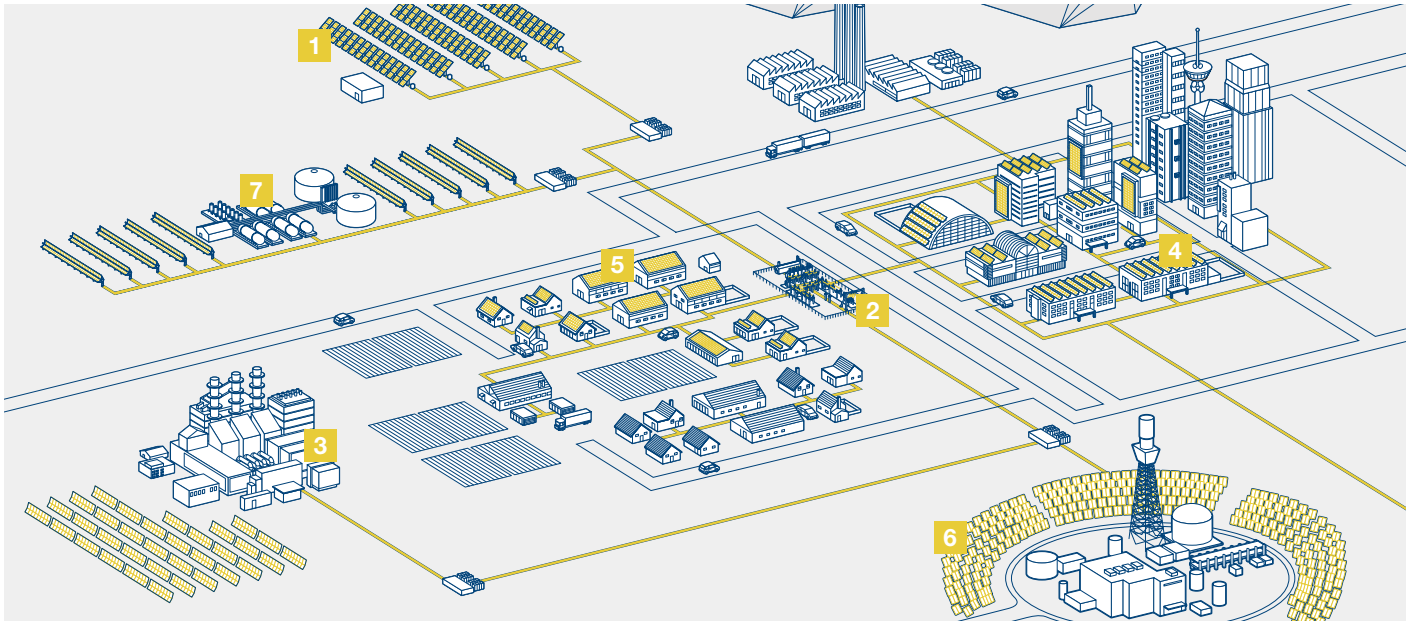


[1] Photovoltaic (PV) solar power
[2] Grid connections for solar power generation
[3] Integrated Solar Combined Cycle power plant (ISCC)
[4] Rooftop commercial/industrial PV solar power
[5] Rooftop residential PV solar power
[6] Concentrated Solar Power (CSP) field with power tower
[7] CSP field with parabolic trough collectors

The IEA also estimates 45 new thermosolar (CSP) plants and 115 million square meters of photovoltaic panels will be built every year from 2010 to 2015. China has announced it will develop a 2,000 MW photovoltaic farm in the Mongolian desert, to be completed in phases by 2019, which is expected to provide enough electricity to power three million Chinese homes.

The world's largest PV plant is a 60 megawatt (MW) installation in Olmedilla, Spain. There are currently more than 10 plants rated above 35 MW in Spain, Germany and Portugal.

### How it works

PV systems directly convert sunlight into electricity by using PV cells. A PV cell is a semiconductor device that converts solar energy into direct current (DC) electricity. About 90 percent of the PV market uses crystalline silicon for this conversion, with thin photosensitive films making up the balance.

Interconnected PV cells form a single PV module, typically ranging in power from 50-300 Watts (W). Pairing PV modules with other equipment such as inverters, batteries, electrical components and mounting systems creates a PV system. PV systems are modular, in the sense that they can be linked together to provide power in the range of tens of megawatts.

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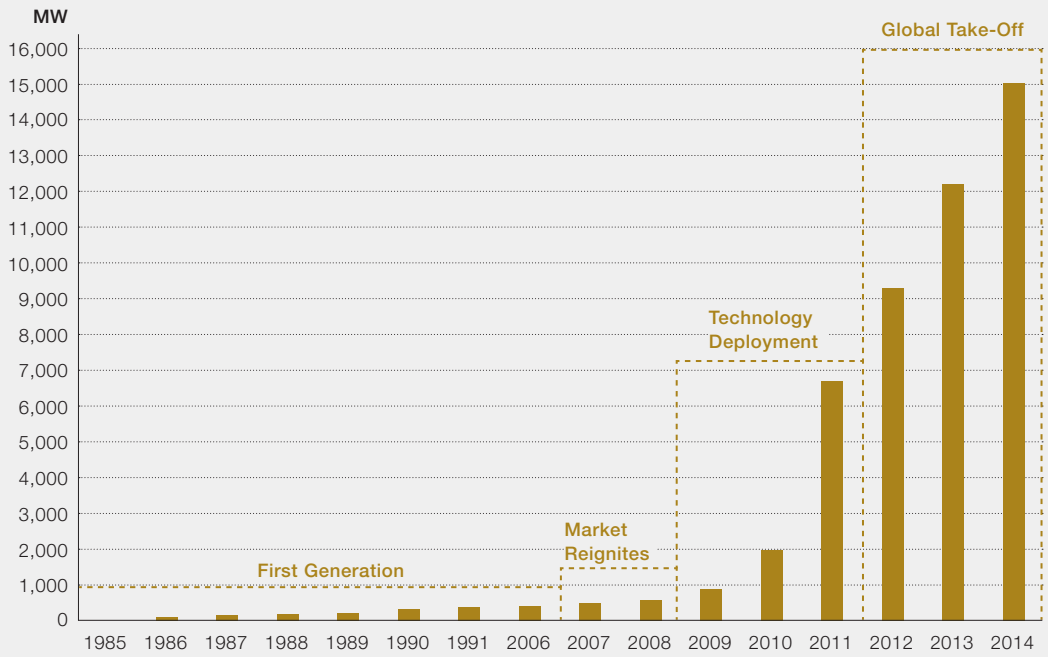
## Growth of CSP 1985-2014




Source: Emerging Energy Research, European Solar Power Advisory

### Concentrated Solar Power (CSP)

As of early 2010, the global stock of CSP plants was nearing 1 gigawatt (GW) of capacity. Projects in development or under construction in more than a dozen countries (including China, India, Morocco, Spain and the United States) are expected to bring the global installed capacity of CSP plants to 15 GW by 2014.

With appropriate support the IEA projects that by 2050, CSP could provide 11.3 percent of global electricity, with 9.6 percent from solar power and 1.7 percent from backup fuels (fossil fuels or biomass).

The flexibility of CSP plants enhances energy security. Unlike PV technologies that use batteries for electrical storage, CSP has an inherent capacity to store heat energy for short periods of time for later conversion into electricity.

With this thermal storage capacity, CSP plants can continue to produce electricity even when the sun is obscured by clouds or goes down, and can also be equipped with backup power from combustible fuels, such as natural gas.

After more than 20 years of successful operation, CSP technology is now entering a commercial ramp-up phase with large scale projects at or exceeding 50 MW around the world.[6] The main limitation to expanding CSP is not availability of suitable sites, but distance between the sites and consumption areas. When distances exceed a few hundred kilometers between generating source and final destination, HVDC technology can deliver electricity at distances exceeding 1,000 km, on land or under the sea, with low electrical losses.

### How it works

CSP generating systems concentrate energy from the sun's rays using a variety of technologies (parabolic troughs, dishes, reflectors, solar towers, etc), which heat a receiver to high temperatures. The heat in this receiver is then used to run steam turbines or other engines, which generate electricity. CSP is a simple, proven technology. Encouraged by government support, the first commercial plants began operating in California in the mid-1980s.

CSP works best in arid and semi-arid areas with reliably clear skies, a sunbelt that is typically found at latitudes from 15° to

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40° North or South. Although narrow, this band has enormous power generating potential. For example, if CSP were to be fully developed in the southwestern US, a few sates could meet the electricity needs of the entire country several times over.[7]

### What ABB provides

For PV and CSP plants, ABB has created efficient technologies to manage, transport and integrate solar generated electricity into our power systems, plants, offices and homes.

To start, ABB has developed special algorithm-based calculating tools that can determine the best PV design solution before work begins. It computes costs, revenues, return on investment and payback times so investors have a clear picture of their PV project from the very beginning.

For large-scale PV and CSP solar power plants, that can generate from one to hundreds of megawatts of electricity, ABB offers power and automation packages specifically designed to meet the market and technical requirements of both technologies.

ABB has extensive knowledge in the delivery of turnkey projects for PV plants. The company can meet the high performance demands of such installations with integrated, state-of-the-art power and automation technology, engineering support and execution expertise.

For the PV market, ABB has developed a unique 1 MW turnkey modular solution to capture maximum energy from the sun. The modules are easily connected to increase generating capacity, and come pre-assembled, factory-tested and containerized for rapid installation, anywhere in the world, ensuring a faster return on investment.

ABB solar technologies - several of which are patented - include a programmable logic controller (PLC), a small control device that increases the sun-tracking accuracy of solar panels, and an automatic switching system that lets a solar plant harness more energy for longer periods of time, even under poor light conditions such as dawn, dusk and cloudy weather.

Inverters are essential components in sustainable energy production. PV cells produce direct current, which an inverter transforms into alternating current that can be used at home, or fed into the AC grid.

ABB has decades of experience with this type of technology, and it forms the basis of new products for solar applications, available in power ranges from 3.3 to 500 kilowatts (kW). They include a central inverter (PVS800) designed to be used in industrial-scale PV power plants, as well as larger commercial or industrial rooftop PV installations. Also new is a small transformerless inverter (PVS300) that converts solar-generated DC to AC in homes, medium-sized commercial and industrial installations. A wireless control unit can monitor a PV installation from indoors.

ABB has also recently launched a turnkey solar connecting installation called the ABB megawatt station. This steel-framed container on a concrete pad houses all the electrical equipment needed to rapidly connect a PV plant to a medium-voltage grid. It is smaller and lighter than similar products on the market, making it less expensive to transport, and is designed for 25 years of operation in harsh environments.

For CSP, ABB provides complete power and automation solutions for entire installations, including automation control technology that enables each of thousands of parabolic troughs in a CSP solar field to collect maximum energy; instrumentation and control systems for the heat transfer tubes, thermal storage tanks and power plant; electrical balance of plant for the power block; and electrical equipment that feeds the power reliably into the power grid.

ABB also supplies a complete range of power and automation components for PV systems in building applications. The portfolio includes all the key components for operating the solar trackers, converting the direct current into alternating current, protecting the entire system from surges, and delivering power to the grid.

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### ABB references

– Examples of ABB solutions for CSP plants include the largest installations in Europe - Andasol 1&2, Extresol 1&2 and Manchasol 1&2 in Spain, generating 50 MW of electricity per unit. Other CSP examples include an automated control solution for eSolar in California (recently featured on the National Geographic TV channel), that helps harness sunlight at the 5 MW, 8 hectare (20 acre) site.

– ABB is supplying a complete electrical balance of plant solution, including integrated instrumentation, control and electrical systems, to the world's first Integrated Solar Combined Cycle (ISCC) project. The 150 MW Hassi R'Mel plant in Algeria is one of the first power plants in the world to integrate solar and combined cycle power generation in a single facility.
Combined cycle generation recovers high temperature exhaust from gas turbines to make high-pressure steam to operate steam turbines. In ISCC installations, additional thermal energy from solar collectors is injected into the heat recovery system to boost steam production and electrical output. ABB is involved in similar ISCC projects in Egypt (Kuraymat) and the US (Indiantown, Florida).

– ABB has delivered about 20 turnkey PV plants with capacities ranging from 1 to 24 MW. For the PV market ABB developed a unique 1 MW turnkey generating module designed for maximum energy recovery and rapid installation. First installed at Totana, Spain, in 2008, the turnkey module was equipped with innovative solar trackers and patented optimization technologies to maximize the plant's performance.

– ABB has recently won orders to deliver two turnkey photovoltaic power plants in Italy (a 13 MW plant in Lazio, and a 24 MW plant in Sicily), as well as a 13 MW photovoltaic power plant in northern Spain.

– ABB has installed a 181 kW solar power system on the roof of its own drives factory in Helsinki, Finland, to test the company's new solar inverters in cold weather, low light conditions.

Further reading: **www.abb.com/solar**

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1 Desertec Foundation, Red Paper, An Overview of the Desertec Concept
2 http://www.desertec.org/en/
3 Ibid, p.9
4 Ibid, p.10
5 Ibid, p.5
6 A.T. Kearney, Solar Thermal Electricity 2025, June 2010
7 According to the IEA, prime CSP locations include North Africa, southern Africa, the Middle East, northwestern India, southwestern United States, Mexico, Peru, Chile, western China and Australia. Other areas that may be suitable include the extreme south of Europe and Turkey, central Asia, and parts of Brazil and Argentina.