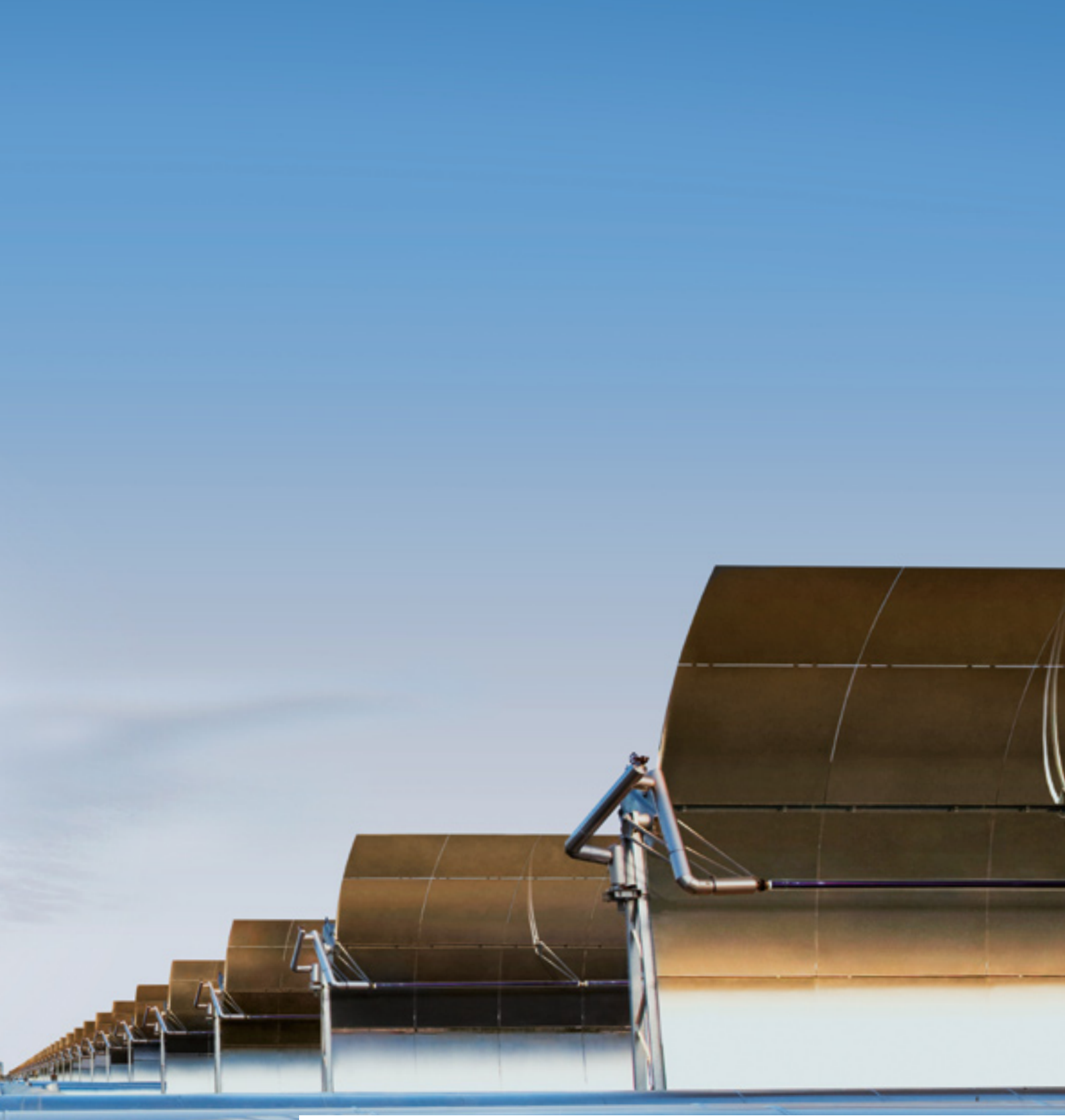
Securing the future with the power of the sun

Concentrated solar power technology for sustainable power generation

Answers for energy.

SIEMENS

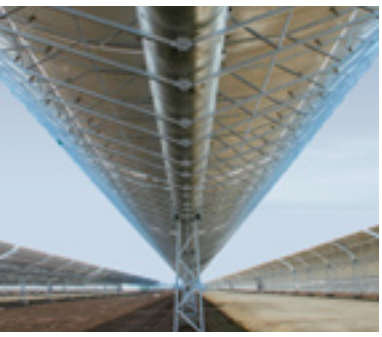
Why can’t all sources of energy be this efficient and environmentally friendly?



Facing ever-increasing worldwide energy demand, the reliable and environmentally friendly use of natural energy sources is one of the biggest challenges of our time. Alongside wind and water, the sun – clean, CO_2-neutral, and limitless – is our most valuable resource. With its comprehensive range of products, solutions, and services, Siemens is the leading partner worldwide for producing solar energy.

Optimizing solar energy for utility-scale mainstream viability

Siemens is committed to making concentrated solar power a utility-scale mainstream solution. With the concentrated solar power market set to grow by double digits over the coming decade, the company has created integrated technology solutions leading to lower investment costs, lower project risk, and improved project viability. With precise engineering and unmatched solar and power generation experience, Siemens enables its customers to optimally utilize the available solar resource. Offering the world's broadest concentrated solar power portfolio, from solar field components to turnkey power plants, Siemens provides tailor-made solutions for all customer requirements – sun-to-heat, sun-to-steam, and sun-to-energy.



Decades of experience

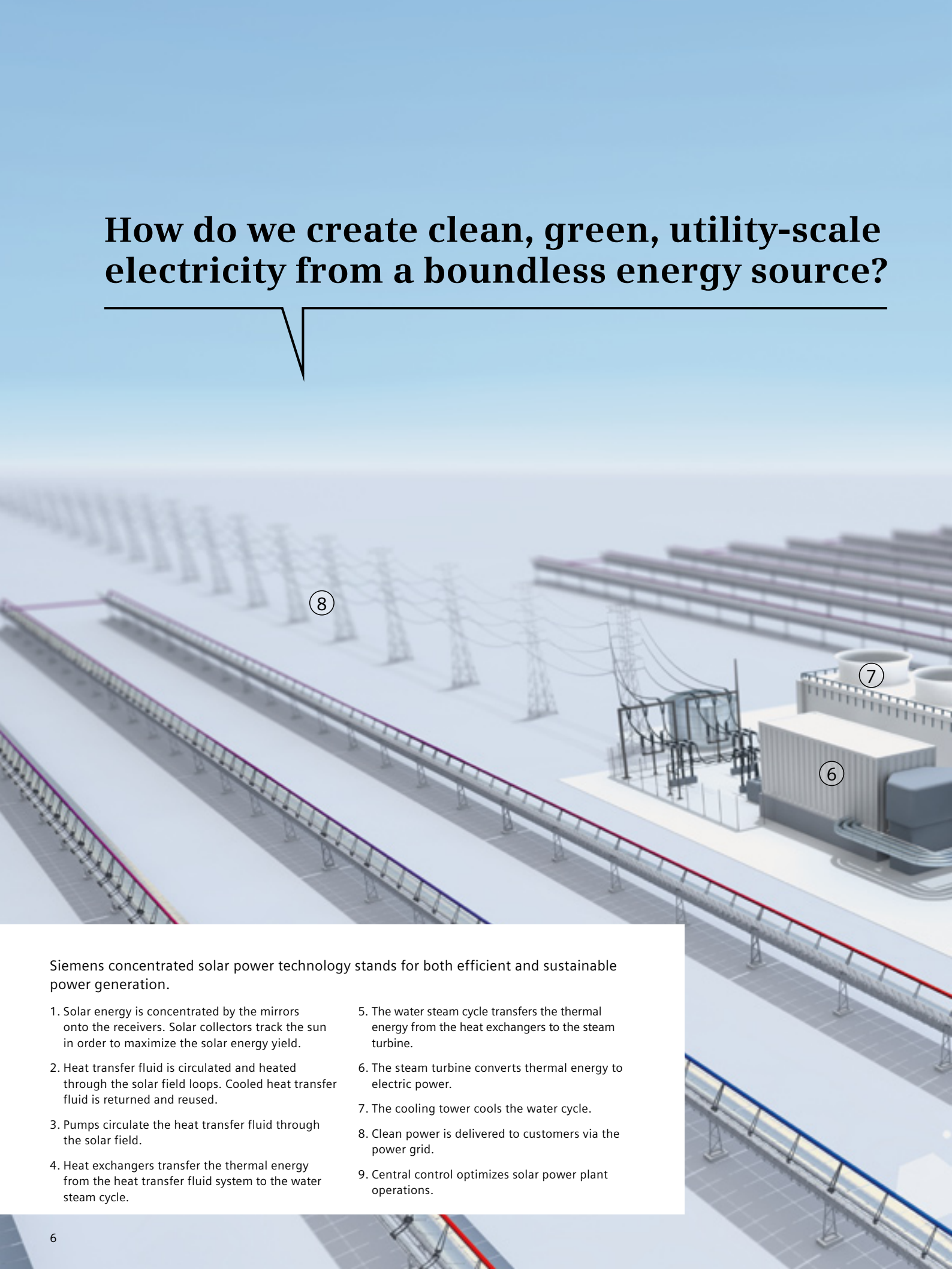
Today, over 200,000 California homes are supplied with clean, environment-friendly electricity using Siemens concentrated solar power technology. Over recent years, Siemens has steadily evolved the technology and has reached new heights of efficiency. The result is utility-scale green electricity, based on proven, predictable, and reliable technology.

Siemens is the only company that can provide solar power generation to transmission and distribution solutions and products, in all its multifaceted complexity. Upon customer request, Siemens can provide full engineering, procurement and construction solutions. This unique expertise is founded upon several decades of experience gained in solar power production, on profound knowledge of company-wide leading technologies, and expertise spanning the entire energy conversion chain throughout the whole life cycle of a solar power plant.

Commitment to the future

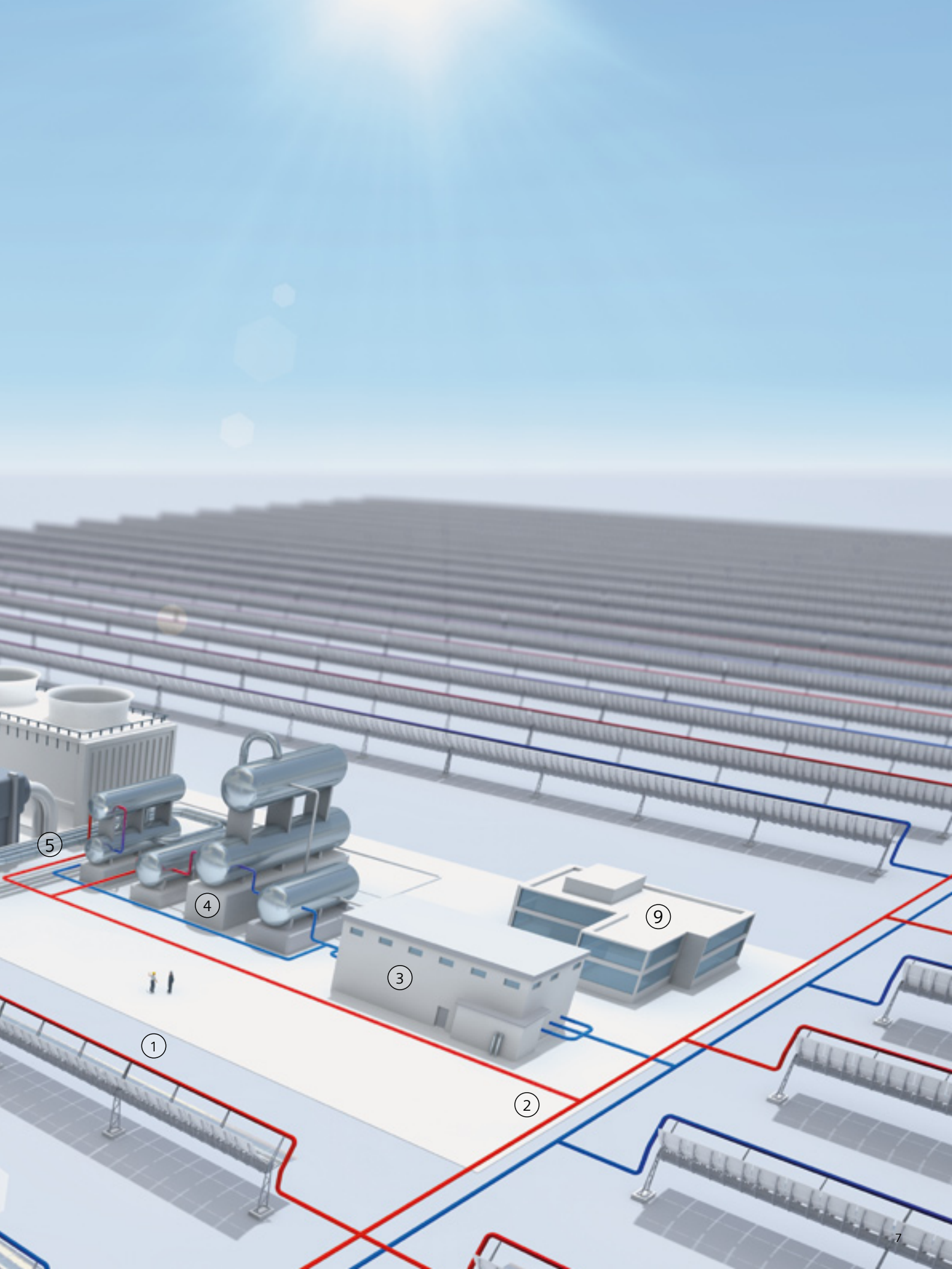
With the promise of "sun-to-energy – with a guarantee for the future," Siemens is committed to the future of solar energy. Behind this commitment stands Siemens' mission to establish concentrated solar power technology as a mainstream solution for solar power plants worldwide, and to provide the utmost in solar thermal reliability, cost-effectiveness, and convenience. Needless to say, with Siemens' ongoing commitment to investment and innovation, the future looks bright.

How do we create clean, green, utility-scale electricity from a boundless energy source?



Siemens concentrated solar power technology stands for both efficient and sustainable power generation.

1. Solar energy is concentrated by the mirrors onto the receivers. Solar collectors track the sun in order to maximize the solar energy yield.
2. Heat transfer fluid is circulated and heated through the solar field loops. Cooled heat transfer fluid is returned and reused.
3. Pumps circulate the heat transfer fluid through the solar field.
4. Heat exchangers transfer the thermal energy from the heat transfer fluid system to the water steam cycle.
5. The water steam cycle transfers the thermal energy from the heat exchangers to the steam turbine.
6. The steam turbine converts thermal energy to electric power.
7. The cooling tower cools the water cycle.
8. Clean power is delivered to customers via the power grid.
9. Central control optimizes solar power plant operations.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Sun-to-heat: precise solar fields

Based on precise solar engineering, Siemens SunField LP optimizes the energy yield of the solar field. The SunField LP is a vertically integrated turnkey concept in which all critical heat-generating components are designed and manufactured to work harmoniously and are delivered as a package.

By assuming the entire responsibility for project planning, critical components, and solar field erection, Siemens provides significant financial and technical advantages, including relevant guarantees, and reduces potential risks to the plant developer and operator. As such, the SunField LP can suit the operational and financial models of investors as well as EPC (engineering, procurement, and construction), and promote bankability.

The SunField LP takes advantage of Siemens' decades of research and development in solar power, as well as its significant experience in testing, calibrating, and optimizing parabolic trough performance. The result is a reliable and highly efficient solar field solution based on commercially proven technology.

The SunField LP package also includes solar field design and integration as well as operations and maintenance services that help maximize the operational integrity of the SunField LP.

Collectors

The basic component of the SunField LP solar field is the solar collector assembly, a metal parabolic framework designed to keep the receiver and reflector panels perfectly aligned. Engineered and assembled in-house, the Siemens solar collector assembly offers complete component synchronization and compatibility.

The Siemens solar collector assembly includes state-of-the-art advances in high torsion stiffness, vibration damping, and corrosion resistance. Its torque-tube-based frame is considered the industry standard for long-lasting stability, providing tenth-of-a-millimeter precision and consistent optical efficiency.

Siemens' own collector azimuth tracking platform – the only such facility in the world – enables testing from all solar incident angles. A dual tracking mechanism enables the solar collector assembly to precisely track the sun.

Receivers

The solar receiver is the heart of a parabolic trough solar field. It absorbs the sun's energy and converts it into heat, which is then converted into electricity. No single component has more influence on the commercial success of a solar field. The high efficiency of Siemens' UVAC 2010 can lead to more productive and cost-competitive solar fields.

The UVAC 2010 is designed for high transmission of sunlight, outstanding heat creation and extremely low heat loss. Its overall optical and thermal properties, including its vacuum maintenance system, increase the electrical output of a solar power plant, and can translate into significantly increased power plant revenues.

Parabolic reflectors

Siemens parabolic reflectors/mirrors precisely concentrate the sun's rays onto the narrow linear solar receiver. With their extreme accuracy and reflectivity, the sun's energy is efficiently converted into heat and ultimately into electricity.

Siemens mirrors are hot-formed, mirrored glass panels supported by a truss system that gives the solar collector assembly its structural strength. To increase their transmissivity, the mirrors include a silver-based mirror coating made of glass with a particularly low iron content. Because even the slightest degradation can impair overall efficiency, Siemens mirrors are built to maintain their geometrical accuracy over many years.

Solar field construction

Siemens' solar field installation system is an industry benchmark. Using industrialized flow manufacturing in on-site parabola assembly buildings, Siemens achieves fast and simple assembly with a relatively low skilled labor requirement. The result is optical precision and efficiency, as well as reduced risk of mirror and structural damage.

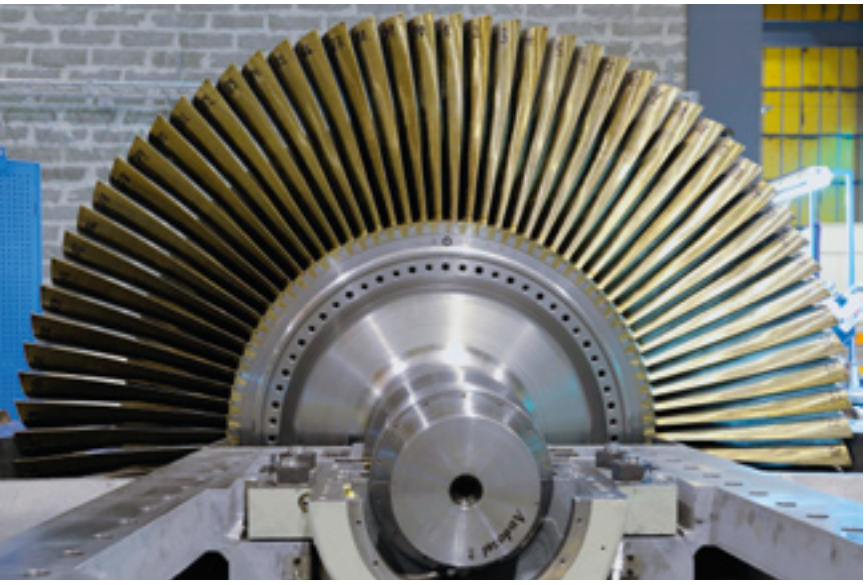
This line-based production, as opposed to the project-based approach, enables the Siemens installation system to be completely transferable. Project management is localized, focusing primarily on site setup. Installation know-how is documented and easily applied to concurrent solar field projects.

Sun-to-steam: integrated heat transfer fluid system

The solar power plant's heat transfer fluid system collects the heat generated in the loops and pumps the hot fluid to the power block. It must absorb maximum energy while feeding the steam generator with stable thermal energy to prevent turbine shocks resulting from uneven temperature flows.

The Siemens sun-to-steam concept is unique: through the integrated design of the solar field together with the heat transfer fluid system, Siemens ensures a seamless interface between the two systems and provides the associated guarantees.

One control system manages both the solar field and the heat transfer fluid, and integration risk is eliminated. Consistent heat balance and pressure are maintained, and stress to the power block is reduced. As a result, overall plant production and efficiency are increased.



Sun-to-energy: flexible power block design

With a portfolio geared toward customers worldwide, Siemens offers the complete power plant as an engineering, procurement and construction solution, together with a comprehensive performance guarantee. The key system to complement a concentrated solar power plant's functionality is the power block. In addition to the steam turbine generator set, the power block includes the entire range of auxiliary and ancillary system components, including condensing system preheaters, steam generators, and cooling systems. It also includes all electrical equipment, plant control systems, and instrumentation.

All these components bear the hallmarks of the company's renowned tradition of engineering excellence. The combination of long-standing experience and excellent capabilities in the conventional part with highly reputable solar products and systems results in an integrated, well-aligned solution. Having a partner that offers all main components from a single source is a double advantage – maximum flexibility during configuration and proven performance during operation.

The steam turbine – a paragon of efficiency

Siemens is the world market leader in steam turbines for CSP plants and commands a comprehensive steam turbine portfolio for solar thermal applications, covering the full range from 1.5 MW to more than 250 MW. The turbine technology fits all CSP technologies and is suitable for air- and water-cooled plants. The steam turbines are available in non-reheat, reheat and double-reheat solutions and provide excellent flexibility for all cycling conditions.

The Siemens SST-700, for example, is a dual-casing reheat turbine specially optimized for solar power plants and capable of generating up to 175 MW of power. Its compact design is also ideally suited to smaller solar fields and offers significant advantages in terms of economy and maintenance costs. The SST-700's high degree of efficiency enables heat storage, and its reheat function enhances productivity and protects the system from erosion and corrosion.

Optimized output through solar modeling

Siemens has designed complex models for predicting and optimizing solar field output. These tools simulate the operating modes of the solar field, using meteorological data to perform a heat-balance calculation at every interval of time throughout the year. By closely matching production to ambient conditions and by optimizing the solar field / power block interface, the models promote electricity generation stability and reliability. Together with well-proven Siemens design tools for the power block, specifically optimized plant-wide solutions are derived.

Siemens' operational models have been calibrated and verified through many years of observation and field testing. By balancing flow rates of the heat transfer fluid and the water steam cycle, managing and optimizing pressure, steam quality, and other factors, overall plant performance is enhanced. Artificial intelligence is employed to continuously improve performance over time.

Breakthrough innovations

Through creativity and innovation, Siemens is committed to reducing the cost of solar thermal power to parity levels with fossil fuels. While some of these advances are Siemens enhancements to solar field components, other innovations, such as proprietary storage with advantages over currently available systems, will enable Siemens to make a major reduction in the levelized cost of electricity.

Perhaps the most significant Siemens advances are innovative ways of applying existing technology. One example is a design that combines a solar thermal power station with a conventional plant, which can create significantly enhanced utilization of the energy resources.

Cloud Prediction and Management System

Siemens has developed the Cloud Prediction and Management System, a module within the Siemens power plant operations platform, to analyze meteorological conditions and create operational instructions at the resolution of a solar field collector loop. Using the existing communications interface and Siemens' patented sun sensors, predictive Cloud Prediction and Management System algorithms provide for a smooth and maximized heat transfer from individual loops. As a result, transient operational periods are reduced or eliminated, heat levels are maintained, and power block maintenance costs are reduced by avoiding unnecessary shutdowns.

Selected references and projects

Lebrija, Spain

- 50 MW parabolic trough plant
- Thermal oil as heat transfer fluid
- Industrialized solar field construction process
- SunField LP products – collectors, mirrors, and solar receivers
- Siemens SST-700 DRH (dual-casing reheat) steam turbine with air-cooled generator
- Commercial operation in 2011

The first concentrated solar power plant to be built primarily with Siemens components has been constructed in Lebrija, an Andalusian village located approximately 60 kilometers south of Seville, Spain. Built on sun-drenched land formerly used for growing cotton, the Lebrija power plant is to supply approximately 50,000 homes in the region with environmentally friendly solar power.

The solar field includes nearly 6,000 parabolic collectors, approximately 18,000 solar receivers, and more than 150,000 parabolic reflectors. The power block uses the Siemens SST-700 steam turbine.

Although the plant was built during one of the wettest winters the region has ever known, the construction was completed smoothly and on time, using prefabricated parts assembled in Siemens' on-site assembly structure, the Parabola Assembly Building.

Nevada Solar One, USA

- Parabolic trough plant with 64 MW capacity
- Powered with UVAC solar receivers
- Equipped with a Siemens SST-700 steam turbine generator set and reheating
- Producing energy since 2007

The 64 MW Nevada Solar One plant became the first utility-scale concentrated solar power plant to be built in the USA after the California SEGS plants, which were built in the late 1980s and early 1990s using Siemens technology.

Located near Las Vegas, Nevada, Solar One supplies 15,000 local homes with green power. Nevada Solar One can be extended to produce up to 200 MW of power.

Andasol I and II, Spain

- Parabolic trough plants, each with 50 MW capacity
- Powered with UVAC solar receivers
- Equipped with two Siemens SST-700 steam turbines with turbo system and reheating
- Producing energy since 2009

With a collector surface of 1.1 million square meters, and employing molten-salt-based storage, Andasol I and II are two of the largest solar power plants in the world.

Andasol I and II are located on the Guadix plateau in the Andalusian province of Granada. Each year, the two solar power plants can feed over 157 GWh of solar power into the Spanish power grid, supplying energy to approximately 50,000 homes.

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