



# Steam turbines for solar thermal power plants

Industrial steam turbines

Answers for energy.

**SIEMENS**

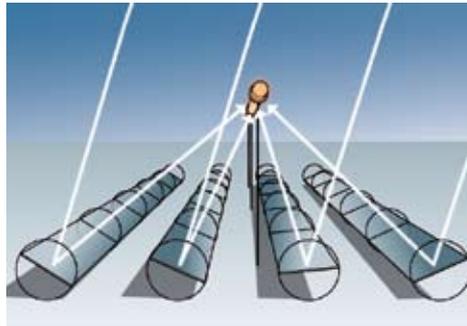


# Power without carbon dioxide

The advantage of solar energy is that the fuel is free, abundant and inexhaustible. In the face of global warming, with energy policies calling for wide-scale use of renewable and sustainable technologies, solar projects are proving increasingly valuable in the reduction of energy use and costs.



Parabolic trough collectors



Linear Fresnel collector panels



Solar tower plant

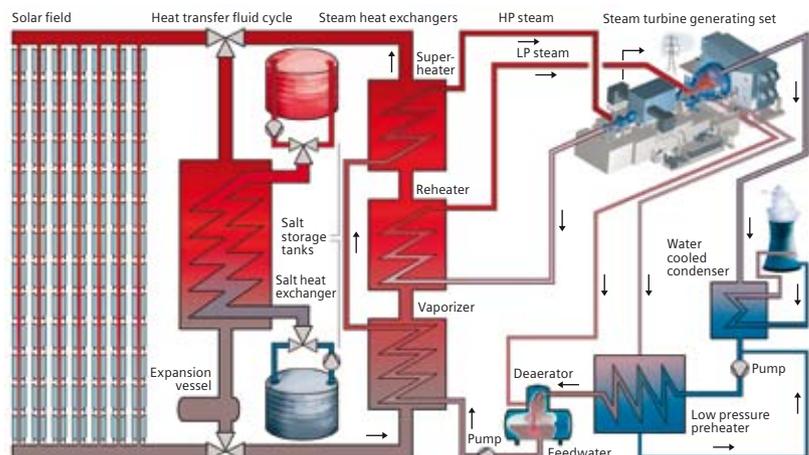
## Solar power technologies

Since the solar boom of the eighties in USA, solar thermal energy is considered to be proven technology. The most common type of plant until now is the parabolic trough collectors, but other technologies are rapidly coming to the fore, such as linear Fresnel collector plants with flat mirrors and central tower plants with slightly curved mirrors or heliostats.

The basic principle is the same for all plants, only the details vary. In central tower plants, mirrors are used to focus the sun's rays on to the tower, where the heat is transferred into a steam cycle or other kind of heat-receiving medium, such as liquid sodium. The linear Fresnel concept uses flat mirrors close to the ground to reflect and concentrate sunlight on water-filled pipes that hang over the mirrors.

In a parabolic trough plant, sunlight is focussed onto a receiver tube filled with thermal oil in the center of the parabolic mirror collectors, the heat being transferred via heat exchangers to the steam turbine, which generates electrical power. In all cycles, surplus heat can be stored in large storage tanks and used to extend the running hours of the steam turbine during times without sun radiation.

Siemens turbine technology can fit all of these concentrated solar power (CSP) concepts.



# Siemens CSP solution: SST-700 DRH

## Efficiency from the word go

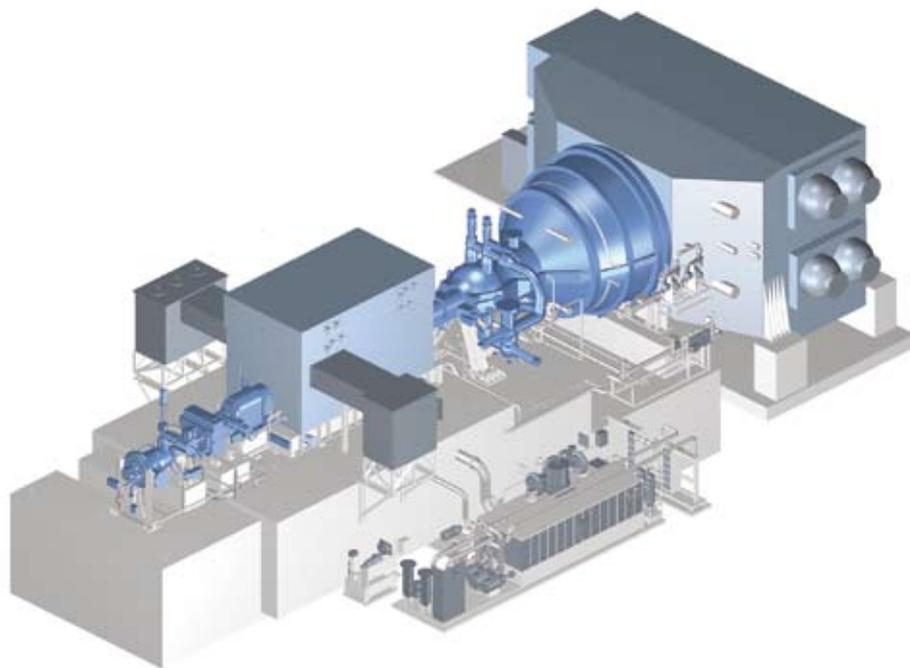
In order to justify the high investment cost for a CSP plant, which will not be run twenty-four hours per day, high demands for efficiency and increasing economic returns are imposed on the steam turbine used in the process. Siemens has cooperated closely with leading solar thermal EPC companies to develop and finetune the SST-700 DRH (dual-casing reheat) steam turbine, now optimized for solar steam cycles and capable of generating up to 175 MW in CSP applications. This highly efficient turbine with its high-speed, high-pressure module enables a smaller solar mirror collector field with associated reduction in investment cost for generation of the required electrical power output. Alternatively, the surplus heat can be put into thermal storage to extend the production time for the plant.

**The reheat** solution improves efficiency and reduces problems with erosion / corrosion and moisture in the LP turbine.

## Excellent daily-cycling capacity

When focusing on annual power production, the short start-up times the turbine can provide are of great benefit to the CSP plant owner. Daily cycling and temperature variations require special attention. The SST-700 DRH, with its low-mass rotors and casings, is ideal for daily cycling and has a low minimum load, enabling maximum running hours per day for plants without heat storage. The cycle has also been optimized for stand-still at night and rapid restart in the mornings. The SST-700 DRH uses high quality materials specially chosen for long and trouble-free operation in a solar plant, bearing in mind the potential wear and tear of the special cycle conditions.

In Southern Spain, due largely to government-granted price surplus for solar-produced power from units under 50 MW, the 50-MW size has proved to have the optimal fit and flexibility for single or multiple units.



*3-D schematic of the SST-700DRH (dual casing reheat) solution for solar thermal applications*

### Features of the solution

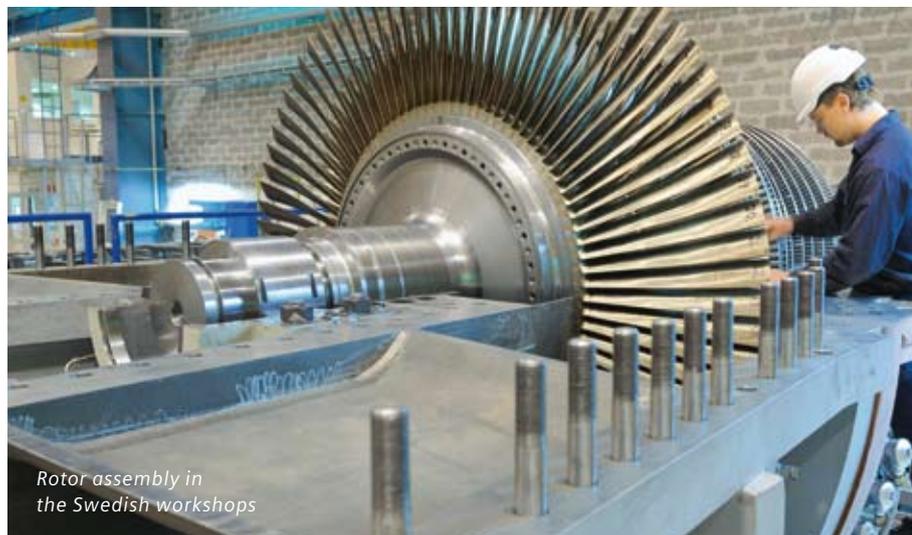
- Modular design
- High quality
- Low-profile foundation
- Geared HP-turbine with optimal speed
- Proven design

### Advantages of the solution

- Flexible solutions, customization
- Long lifetime, high availability
- Short start-up time
- Fast and easy assembly, lower installation cost
- High efficiency, savings on the solar field
- High reliability, easier to finance

The high technical efficiency is a prerequisite for operational cost-efficiency. Siemens' solar thermal experience is best-in-class and the solidity and reach of the Siemens global network is an advantage in terms of security of investment, supply and aftersales service.

*Installing the low-pressure steam turbine on the Boulder City site, Nevada, USA*



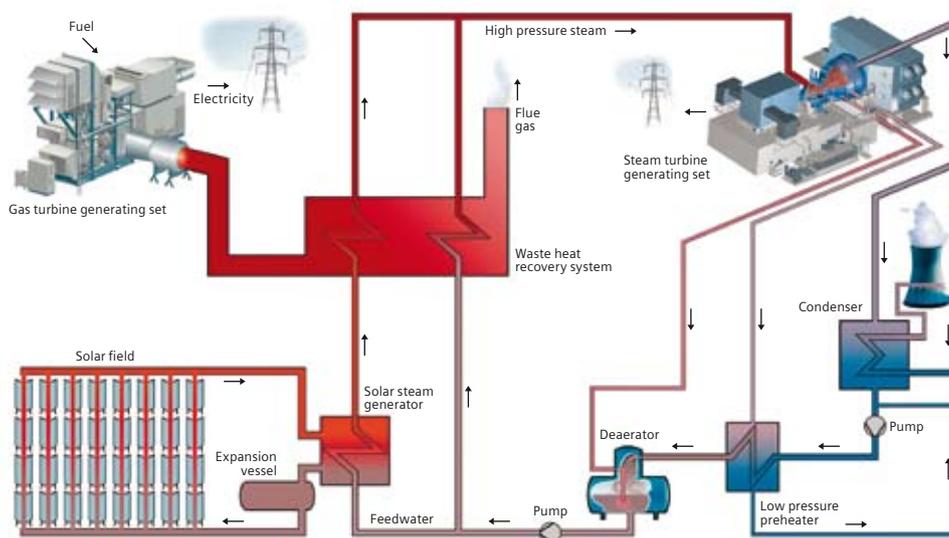
*Rotor assembly in the Swedish workshops*



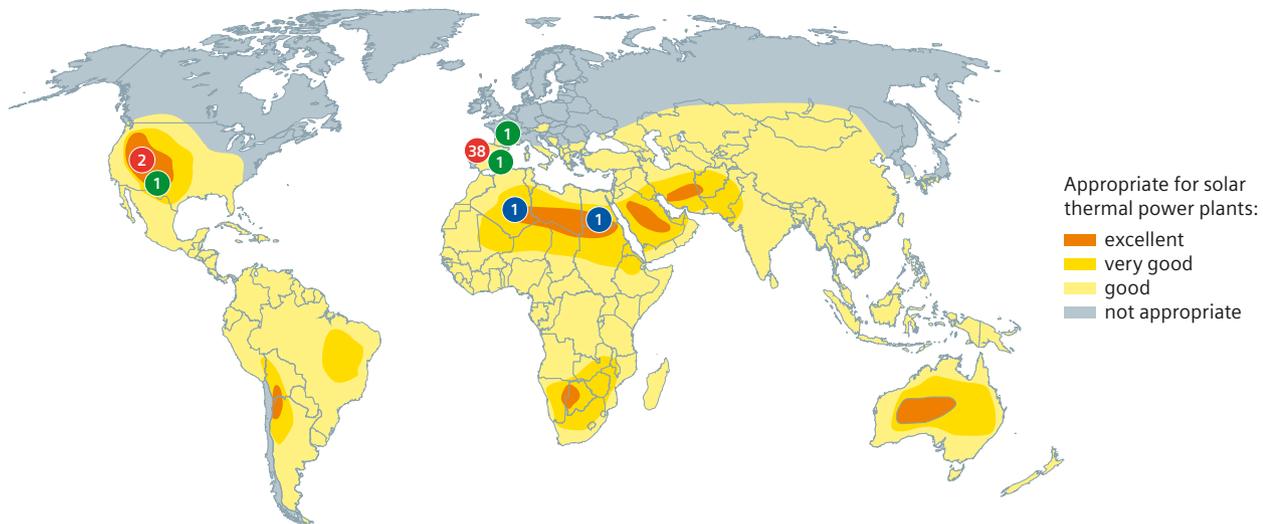
### ISCCS – Integrated Solar Combined-Cycle System

For excellent performance and attractive emissions reductions, parabolic troughs can be effectively integrated with a conventional combined-cycle plant, as well as a steam-cycle plant. The Siemens ISCCS (integrated solar combined-cycle system) is a single-casing high-pressure non-reheat unit, suited to demands of the combined cycle. This SST-900 can be used with any gas turbine, or in combination with one or more Siemens 47-MW SGT-800 gas turbines, as in a pioneering ISCCS in Morocco.

This configuration is doubly effective. It not only minimizes the investment associated with the solar field by sharing components with the combined cycle, it also reduces the CO<sub>2</sub> emissions associated with a conventional plant. The integration maximizes operation efficiency even though solar energy intensity varies according to the weather and time of day. Peak thermal-to-electric efficiency can exceed 70% for an ISCCS plant compared to 50–55% for a conventional gas-fired combined cycle plant.



# Siemens experience



## Siemens turbines power solar plants all over the world

As per September 2008, Siemens has secured orders for 45 steam turbines for solar thermal power plants:

- **CSP trough technology:** 40 steam turbines for CSP trough technology
- **CSP solar tower technology:** 3 steam turbines for solar tower
- **ISCCS trough technology:** 2 steam turbines for ISCCS power plants

### Alternative Siemens solutions

The SST-700 DRH turbine configuration is the most used on the market, but all Siemens steam turbines have the potential for solar applications. Demonstration tests are currently underway with leading institutions in Spain and Germany to test both the lower end of the industrial turbine range – around 1.5 MW – and also the mid-range – around 20 MW – in solar tower applications. One commercial order has been placed for an 19MW SST-600 steam turbine for the solar tower project Solar Tres in southern Spain.

### Future prospects

Market trends indicate that solar power will increase up to twenty-fold in the mid-term future. The benefits of solar power are compelling: environmental protection, economic growth, job creation, diversity of fuel supply and rapid deployment, technology transfer and innovation.

Solar thermal technology undoubtedly has a large global potential. Where there is sun there is heat, where there is heat, there is power – clean and renewable power. Development is rapid, and a number of different solutions are coming to the fore. The proven high quality, reliability and flexibility of the Siemens industrial turbine range, as well as the early experience gained in the field, contributing to financeability, ensure that customer confidence is not misplaced.

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