

Solar Tres

**First commercial molten salt central receiver plant
17 MW, 15 hrs storage, 6500 hrs/yr**

Fuentes de Andalucía (Sevilla) – SPAIN

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A long way

- Promoted initially by the Spanish company GHERSA, in association with NEXANT, and based in the Boeing receiver technology
- SENER joined the team in 2001
- For different reasons, Nexant and Boeing left the project.
- SENER assumed the promotion of the project and decided to launch a program to develop its own molten salt central receiver and to initiate the process of site location, permitting, etc.
- Funded with 5 M€ by the EU 5th Frame Program. Present partners in the EU development program: SENER, GHERSA, Siemens and Saint Gobain
- Mid 2005 SENER and CIEMAT reached an agreement to jointly develop a testing program at the PSA for the SENER prototype panel. The testing campaign started end 2006 and is presently in its first phase

Present status

- **The project is being developed by the special purpose company GEMASOLAR 2006 SA, 100% SENER**
- **GEMASOLAR has already secured the land rights and the electrical interconnection. Water and NG are available at the site. No permitting problems are expected**
- **Solar radiation data at the site have been recorded for more than one year. The site enjoys one of the highest radiation levels in Spain**
- **Testing of the molten salt panel at the PSA will validate the main receiver design parameters (flux, life, efficiency, etc.). The receiver system design will be finalized thereafter**
- **Basic design of the plant is under development by SENER**
- **Project construction is expected to start before the end of 2007.**
- **SENER will also be the EPC Contractor and provide receiver, molten salt thermal storage and heliostat technology.**

The site

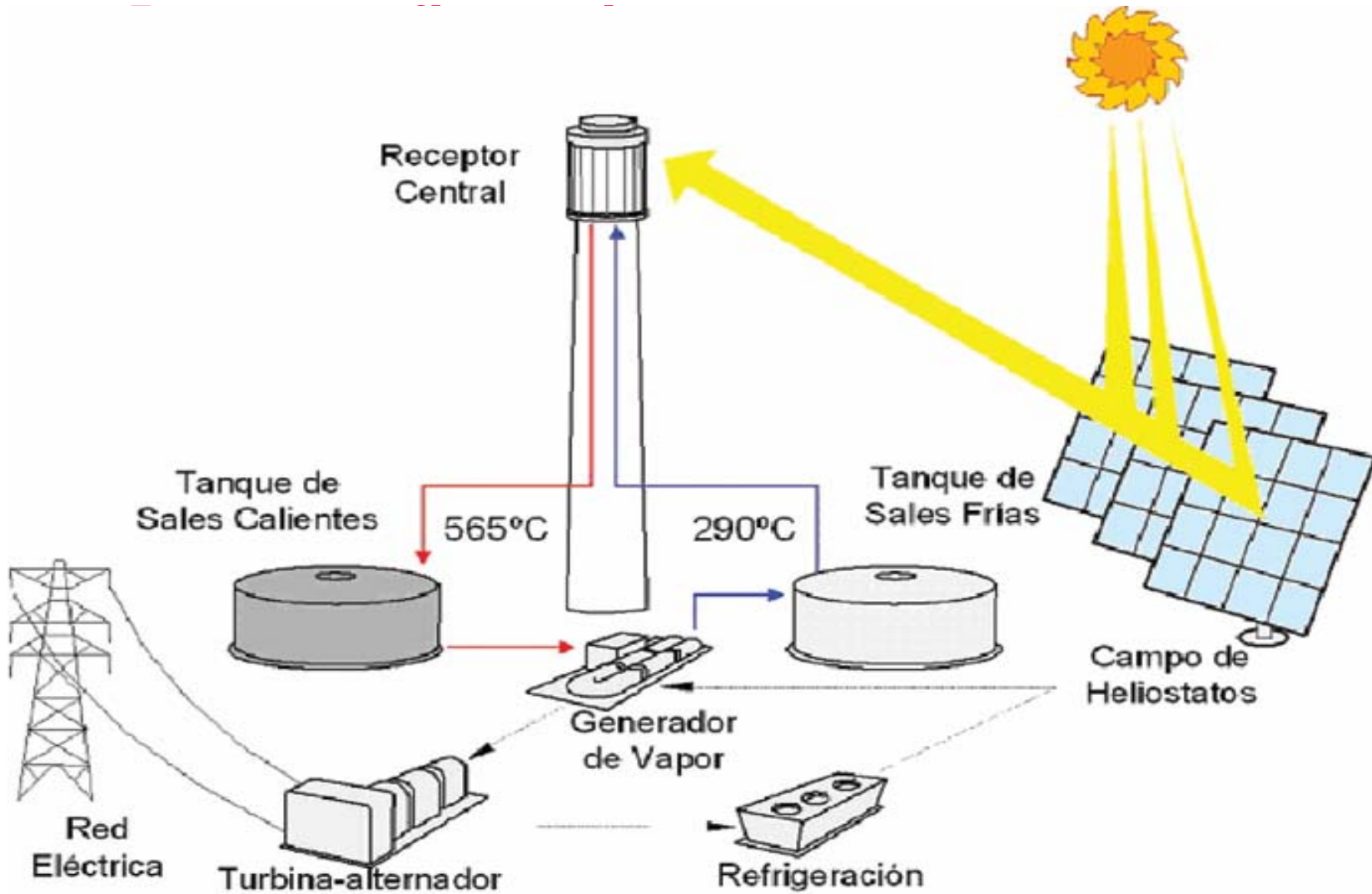


The site

- **Municipality** Fuentes de Andalucía (Sevilla)
- **Solar radiation** 2060 kWh/m²-yr
- **Altitude** 167 m above sea level
- **Electrical connection** Substation at Villanueva del Rey
- **Gas connection** Gas pipe-line Sevilla-Córdoba
at about 4 km
- **Underground water availability** Demonstrated trough extensive tests
- **Access** Close to the main highway system

The advantages of Solar Tres

- **Central receiver technology provides the possibility of operating with high steam conditions, leading to high thermal cycle efficiencies**
- **Molten salt as a working fluid allows for the collection, transport and storage of the thermal energy with also very high efficiencies through the high top and differential temperatures**
- **Compared with the storage system we have in Andasol, solar Tres will store three times more energy per kg of salt.**
- **Under this conditions, the large thermal storage capacity allows for very high utilization factors, above 70%**
- **The 12 to 15% hibridation with NG allowed by the Spanish regulations provides also an additional support to the reliability of the generation**



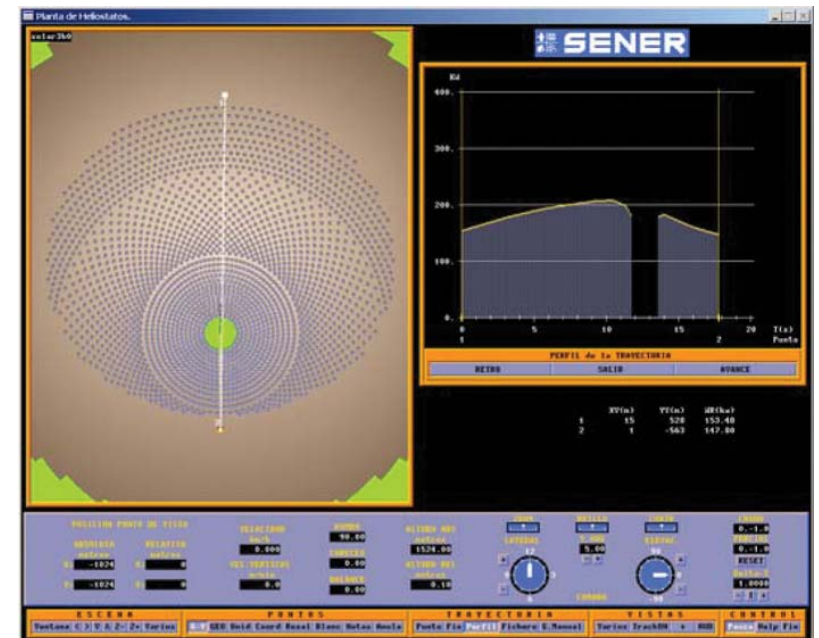
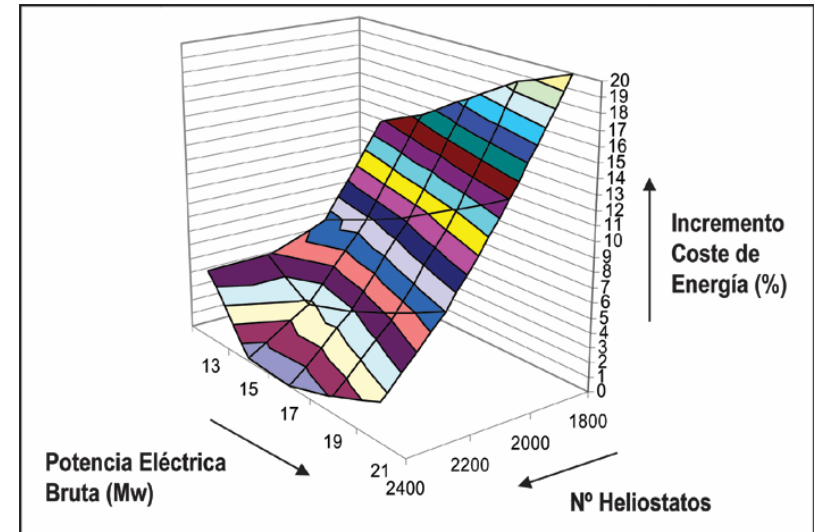
Main data

Technical data	
Total mirror surface	298 000 m ²
Number of heliostats	2590
Field surface area	142 Ha
Nominal receiver capacity	120 MWt
Tower height	130 m
Thermal storage capacity	15 hours
Turbine capacity	17 MWe
Annual normal direct radiation	2062 kWh/m ²

Operation	
Gross generated power	110 570 MWhe
NG hibridation	15%
Annual equivalent hours	6500 h/a
Capacity factor	74%

Plant optimization through SENSOL

- The plant configuration and the sizing of the different components and systems has been performed with SENSOL, a ray tracing based computer code developed by SENER.
- SENSOL is an extremely flexible and powerful tool to design and optimize solar plants, components and systems
- It allows the simulation of different plant operating strategies to maximize the plant output
- Its economical module analyzes the result of different plant configurations, looking for the minimum levelized energy cost, that is, maximizing the financial return
- It allows also for optimization of component parameters, like heliostat structure stiffness, mechanism pointing errors, etc



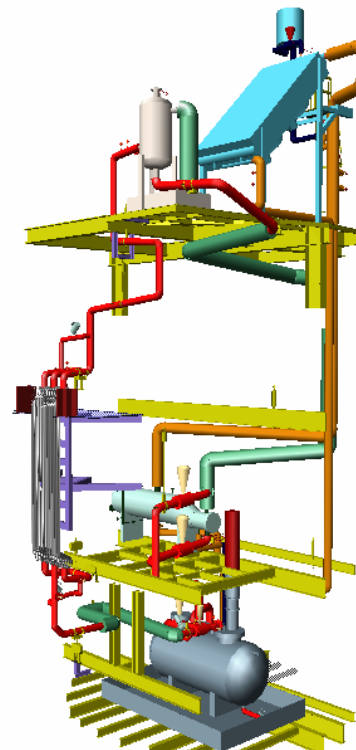
Receiver technology

- **Molten salt central receiver of high thermal efficiency, able to operate at high fluxes without compromising life (at least 25 years)**
- **Advanced features**
 - Receiver size optimized to minimize thermal losses in the plant
 - Small fluid cavities to maximize efficiency and minimize the costs of the receiver and the pumping power
 - Thin-walled conductions to improve efficiency
 - Design that minimizes pressure losses in the salt circuit
>> optimization of number of panels and molten salt circuit routing
 - Innovative integral header and advanced header-tube nozzle (SENER patents) to improve reliability and life
 - High nickel alloy material with excellent mechanical properties to low cycle fatigue (LCF) and stress corrosion cracking (SCC)
 - Definition of procedure and operation modes to assure the receiver life and to optimize the plant efficiency



Molten salt thermal storage

- Solar Tres will benefit from the experience SENER is gaining in the design and construction of the thermal storage for Andasol 1 and 2



- Molten salt system components (valves, heat tracing, ...) are also being evaluated in the loop used for panel testing at the PSA

Heliostat technology

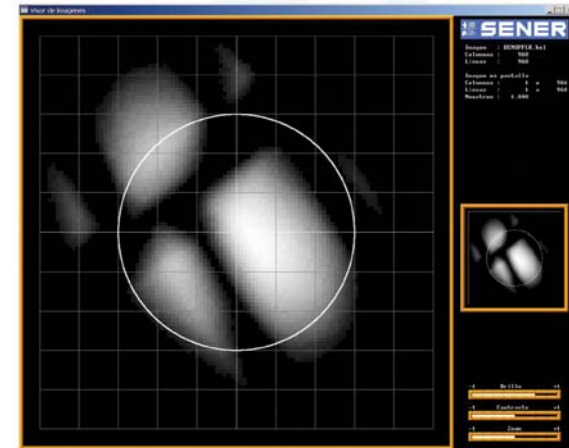
- SENER developed in the late 70's its first 36 m² heliostat, still working in the PSA
- For Solar Tres, a new, 120 m², optimized concept has been tested also at the PSA, including a SENER patented mechanism design
- The global heliostat design is the result of optimizing, for the combination of drive and structure, the balance stiffness/precision/cost



Other SENER projects and developments (1)

- **Andasol 1 & 2, 2x50 MW, parabolic trough, 7 hrs molten salt thermal storage**
 - Turn key Engineering, Procurement and Construction in Joint Venture with Cobra

- **Abu Dhabi 20 MWt beam-down system demo plant, sponsored by MASDAR/Cosmo Oil.**
 - Conceptual engineering phase for the JV Tokyo Tech (multi-ring technology) and Solar Hytech (Japan)



Other SENER projects and developments (2)

- **Direct Steam Generation demo plant, parabolic troughs, 3.5 MW, in JV with CIEMAT, IDAE, Abengoa and Iberdrola.**
- **Feasibility study for a 100 MW central receiver plant**
- **Other receiver types**
 - **saturated steam cavity receiver**
 - **flat molten salt receiver for beam-down systems**
- **Stamped arm, torque tube trough structure (SENER patent)**

