

CSP PROJECTS FROM THE SPANISH INDUSTRY

Gonzalo Barrantes Director Energy Cluster of Extremadura



















WHAT IS ENERGY CLUSTER OF EXTREMADURA?

- ♦ Non-profit bussiness association.
- Mission: To boost cooperation, comercial and technologial.
- Development of the energy sector in Extremadura region..
- We pursue competitiveness increase, new business opportunities in strategic markets and launching of innovative R&D projects.





WIDE GEOGRAPHIC AREA FOR INVESTMENT IN ENERGY

♦ LARGE HYDRAULIC CAPACITY

HIGH LEVEL OF SOLAR RADIATION



NUCLEAR POWER: 16,089 GW / H = 25% NUCLEAR ENERGY IN SPAIN

HYDRAULICS: 2210 MW INSTALLED CAPACITY

CSP: 19 PROJECTS AND 950 MW RATED CAPACITY

PHOTOVOLTAIC: 300 MW INSTALLED AND 320 PROJECTS

WIND: 23 PROJECTS OF WIND FARMS AND 501 MW RATED CAPACITY

BIOMASS: 11 PROJECTS AND 150 MW RATED CAPACITY

BIOFUEL: 7 PROJECTS: 605,000 TONNES OF BIODIESEL AND 250,000 TONNES OF BIOETHANOL



Solar Thermal Electric Technology in Spain: A success story of public support to R&TD

ELEMENTS:

- □ Continuous support to R&TD since late 70's
- Specialized and highly qualified education in several Spanish Universities
- □ Active role of Research Centers
- International collaboration
- □ Feed in tariff system
- Dynamism of the companies

RESULT: INTERNACIONAL LEADERSHIP



Types of STE Technologies



Parabolic trough



- Uses parabolic mirrors to concentrate solar radiation on linear tube receiver.
- Provides heat storage capabilities
- Is a long-term, commercially proven technology.
- Has high maturity level, operational experience, modularity and large number of providers.

Solar tower



 Concentrates solar radiation on a point receiver at the top of a tower.

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- Enables operation at high temperature level and provides heat storage capabilities.
- Has high net solar to electrical efficiency and is a commercially proven technology

Dish Stirling

- Uses parabolic dish to concentrate solar radiation on a Stirling engine
 - Has high net solar to electrical efficiency with low water consumption

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Is highly modular and suitable for both small standalone, decentralized off-grid power systems and large gridconnected power systems.

Linear Fresnel



Uses flat mirror desíng to concentrate sun, enabling simpler production and installation

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- Enables other industrial uses such as steam processing.
- Has high land-toelectricity ratio due to linear desing and the usability of space below support structure
- Provides heat storage capabilities.





Nombre	Localidad	Potencia MW	Faso	Provincia	Tecnología
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C. TERMOSOLAR "LA AFRICANA" PL, TERMOELECTRICA DE CONSOL ORELLANA	Fuerte Pelmera Oreiena	50 50	Fase 1 Fase 1	Córdobe Bedejoz	Canales parabólicos Canales parabólicos
C, TERMOSOLAR "LA AFRICANA" PL, TERMOELECTRICA DE CONSOL ORELLANA HELIOS I	Fuerte Palmera Orojana Puerte Lácico	50 50 50	Fase 1 Fase 1 Fase 1	Córdobe Bedejoz Ciudad Reel	Canales perabolicos Canales perabolicos Canales perabolicos
C. TERMOSOLAR, "LAAFRICANA" PL, TERMOELÉCTRICA DE CONSOL ORELLANA HELIOS	Fuerte Pelmana Organa Puerto Lápice Puerto Lápice	50 50 50 50	Fase 1 Fase 1 Fase 1 Fase 1	Córdobe Bedejoz Ciudad Reel	Canales persolícicos Canales persolícicos Canales persolícicos Canales persolícicos
C. TERMOSOLAR "LAAFRICANA" PL. TERMOELÉCTRICA DE CONSOL ORELLANA HELIOS HELIOS C. SOLAR TERMOELÉCTRICA "ASTE-1A"	Fuerte Pelmera Orderra Puerte Lácice Puerte Lácice Alpázar de San Juan	50 50 50 50 50	Fase 1 Fase 1 Fase 1 Fase 1 Fase 2	Córdobe Bedejox Ciuded Reel Ciuded Reel Ciuded Reel	Caneles perebólicos Caneles perebólicos Caneles perebólicos Caneles perebólicos Caneles perebólicos
G, TERMOBOLAR, "LAAFRICANA" PL, TERMOELÉCTRICA DE CONSOL ORELLANA HELIOS I C, SOLAR TERMOELÉCTRICA "ASTE-1A" C, SOLAR TERMOELÉCTRICA "ASTE-18"	Fuerte Polmera Orogena Puerte Lápice Apotar de San Juan Alotar de San Juan	50 50 50 50 50 50 50	Fase 1 Fase 1 Fase 1 Fase 1 Fase 2 Fase 2	Córdoba Badajox Ciudad Real Ciudad Real Ciudad Real Ciudad Real	Caneles perubólicos Caneles perubólicos Caneles perubólicos Caneles perubólicos Caneles perubólicos Caneles perubólicos
C, TERMOREAR, "LAARRICANA" RI, TERMORECTREA DE CONSOL GRELLANA HELIOSI HELIOSI C, SOLAR TERMOREÉCTRICA "ASTE-IA" C, SOLAR TERMOREÉCTRICA "ASTE-IS" SOLACORT	Fuerie Polmena Orolpena Puerto Lásico Puerto Lásico Alpázer de San Juan Alpázer de San Juan El Carolo	50 50 50 50 50 50 50 50	Fase 1 Fase 1 Fase 1 Fase 1 Fase 2 Fase 2 Fase 2 Fase 2	Córdoba Badajox Ciudad Real Ciudad Real Ciudad Real Ciudad Real	Caneles perabólicos Caneles perabólicos Caneles perabólicos Caneles perabólicos Caneles perabólicos Caneles perabólicos Caneles perabólicos
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C, TERNOBILAR, "LAKRICANA" PH, TERNOBLÉCTIREA DE CONSOL ORELLANA HELIOS I HELIOS I C, SOLAR TERNOBLÉCTIREA "ASTE-IA" C, SOLAR TERNOBLÉCTIREA "ASTE-IB" SOLACORT	Fuerie Polmena Orolpena Puerto Lásico Puerto Lásico Alpázer de San Juan Alpázer de San Juan El Carolo	50 50 50 50 50 50 50 50 50 50	Fase 1 Fase 1 Fase 1 Fase 1 Fase 2 Fase 2 Fase 2 Fase 2	Córdoba Bedajox Ciudad Reel Ciudad Reel	Ganales perabolisce Canales perabolisce Canales perabolisce Ganales perabolisce Canales perabolisce Canales perabolisce Canales perabolisce Canales perabolisce Canales perabolisce Canales perabolisce
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Morón de la Frontera

Sevila

Canalee parab

Fase 4



Total de Plantas 60

ARENALES

Operativas
 Oconstrucción avanzada

ada 🔹 🛛 🛛 🔴 Preasignadas



SOLNOVA 1, 3 and 4 & PS 10 and PS 20









EXTRESOL 1



CTS Puertollano



LA RISCA, Alvarado



LA FLORIDA, Alvarado



PUERTO ERRADO 1



Villarrobledo

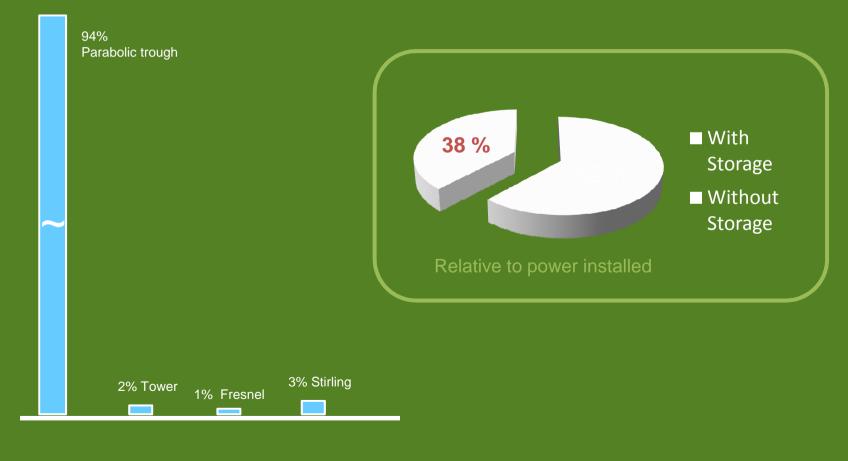


GEMASOLAR, Fuentes de Andalucía

Breakdown of the operative, under construction and registered plants in Spain



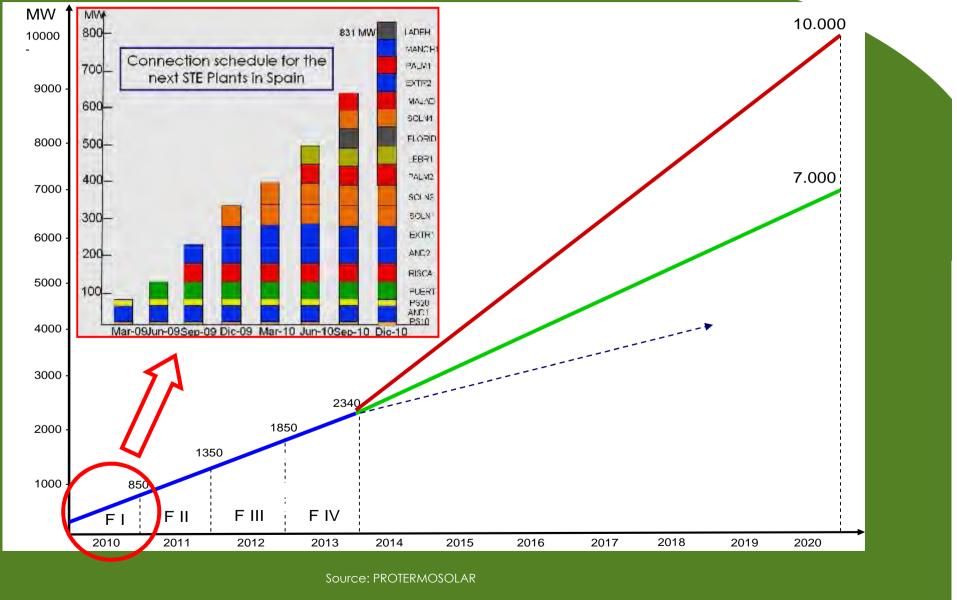
Total: 2423 MW (In operation by the end of 2013)



Source: PROTERMOSOLAR

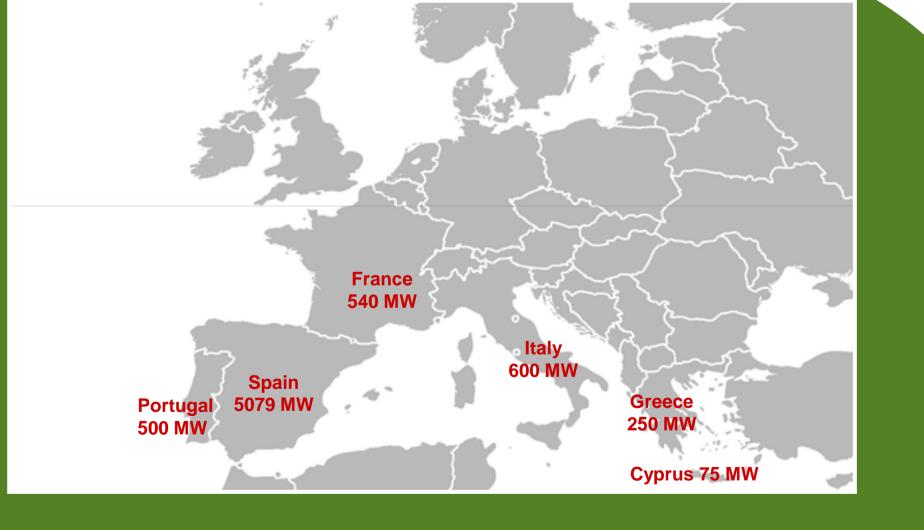


Forecast for STE plants in Spain

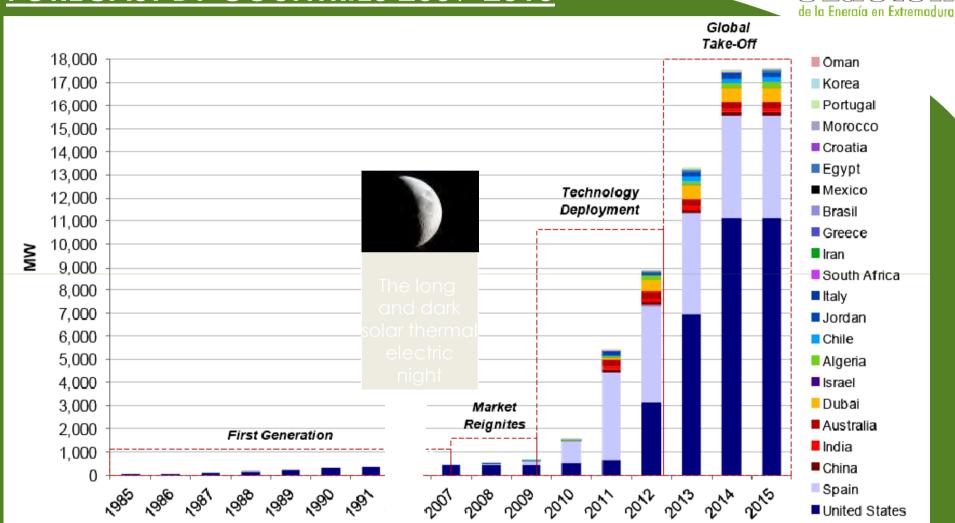




Forecast in European countries by 2020 (NAP's)



Source: PROTERMOSOLAR



Π

FORECAST BY COUNTRIES 2009-2015

Source: PROTERMOSOLAR

Economic sectors



1. Promotion (22-36 months ,3-5 mill / €)

1.1. Land and Administrative treatment

- » Resource study, measurements. (2-3 years)
- » Agriculture (Sale or rental of land ,200-300 Ha / project)
- » Environmental studies and reports.
- » Engineering (water supply, access, stream diversions, discharges, discharge lines, plant setup ...)
- » Archaeological studies.
- » Environmental Impact Study (countervailing measures).
- » Attorneys (agreements, contracts, agreements ...) and Notaries
- » Electric Company

1.2. Municipalities (Finance, Tax)

1.3. Conventions (I + D + i)

- » University.
- » Research Centers.
- » Municipality and autonomous region

CLUSTER de la Energía en Extremadura

Economic sectors

2. Financing

- » Banks
- » Investors (investment funds, institutional investors ...)
- » Legal advisor
- » Technical Advisor
- » Insurance Consultant
- » Insurance Companies



Economic sectors

3. Construction (24-30 months, 70-450 workers)

3.1. Directly on the ground .

- » Earthmoving.
- » Civil works.
- » Assembly of the metal structures.
- » Engineering.
- » Machinery (exchangers, boilers, turbines, pipe receivers ...)
- » Water, salt and hot oil.
- » Electrical (lines, substations ...)
- » Isolates.
- » Transportation.
- » Insurance.

3.2. Indirectly on the ground

- » Services (cleaning, catering, hotel ...)
- » Transportation.
- » Surveillance.









Economic sectors



4. Exploitation (40-50 workers, 20-30 indirect)

4.1. Directly on the ground

- » Operation & maintenance.
- » Forecasting resource.
- » R + D + i.
- » Supply.
- » Parts.
- » Partial maintenance contracts.
- » Office and administration.
- » Relationship institutions.
- » Energy marketing agent
- » Network Operator
- » Electric Company

Investment and electricity generation

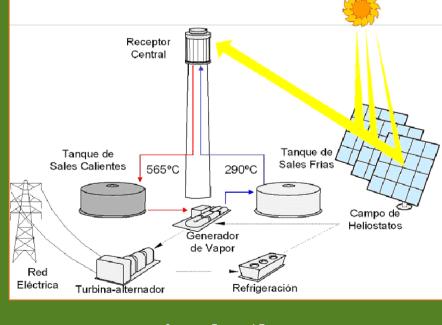


(The investment required depends on site characteristics and technology.)

The investment for a plant tower receiver system with molten salt storage:

- Annual insolation (RDN): 2,700 kWh / m² 2,000 kWh / m²
- ✤ Power: 50 60 Mwe
- Storage: 10 18 hours
- ✤ Net Production: 180 to 220 GWh / year
- INVESTMENT: 300 350 M €

solar field 45% Receiving system 15% Storage System 9% Steam generation system 7% Power generation system 24%

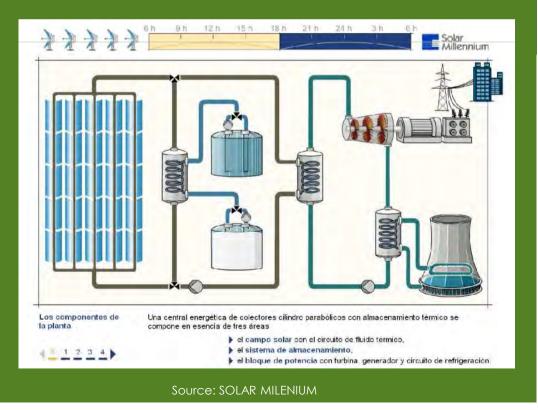


Source: Torresol Energy

Investment and electricity generation for parabolic

trough collectors system with molten salt storage:

- Annual insolation (RDN): 2,700 kWh / m² 2,000 kWh / m²
- Power: 49,9 Mwe
- Storage: 7 8 hours (1.000MWh)
- ✤ Net Production: 160 GWh / year
- INVESTMENT: 300 M €
- ✤ CONSTRUCTION 2 YEARS





✤ Solar field : 30%



- 220 ha, 230.000 mirrors(550.000m2), corresponds to nominal thermal output
 300MWt.
- ✤ 25.000 absorber tubes (100 km), 2.8 million litres of thermal fluid (298°C-393°C).
- 2 expansion tanks and an overflow tank of thermal fluid , 3 pumps (2+1 back-up)
 70.500 l/min.
- ✤ 3 natural gas auxiliary boilers 15 MW, solar fiel instrumentation and control.

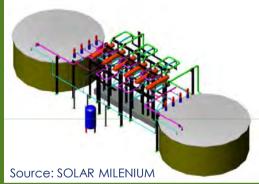
Power block: 30%

- Steam generation system and feedwater preheater (2 lines 60,4 kg/s of steam at 380°C, 105bar)
- The Rankine cycle steam turbine 50MW (3 phases, 15 kV, 50Hz)
- Condenser cooled by water fron the cooling tower in an open circuit (84.000KW, 140 t/h)

Storage System : 20%

- ✤ 2 steel tanks of 38,5 m in diameter and 14 m in height.
- ✤ 30.000 t of salt provide a storage capacity of 1.000 MWh of thermal energy.
- Each tank 3 vertical pumps for the transfer of salt (550 m3/h), 3 heat exchangers(292°-386°)

✤ Auxiliary Facilities: 20%



- Water treatment system of providing water for all the systems at the plant(325m3/h)
- Auxiliary steam system (1.000kg/h, 10 bar, 255°C)
- Electrical Equipment to transmision of electrical energy from the generator to the main transformer (current 3.500^a, isolation voltage of 17,5 kV)
- Control system (Solar field, Steam turbine and the elements that make up the Power block).





Economical development through job creation

	Local conten	Foreign share	Local manpower demand	
Project development	0-10%	90-100%	6-20 MY	
Engineerring planning	30-50%	50-70%	75-95 MY	(2 years)
Technology (procurement)	30-60%	40-70%	145-220 MY	(2 y
Construction and site improvement	100%	0%	320 MY	
Operations and maintenance	90-100%	0-10%	40-45 FTE	Permanet jobs

Notes: 1 MY(man year) equals 1760 man hours; FTE estándar for full-time equivalent, the reference a 100-MW plant instalation.



MODULAR CSP PLANT 100Kwe, 170 Kwt

<u>Modular operation</u> in 100kW units. <u>It does not need water (except the one necessary for cleaning)</u>. <u>Hybrid working</u> : biogas, biomass, fuel, etc. <u>Usage of the surplus thermal power</u> in a variety processes.



Source: <u>www.aorasolar.es</u>

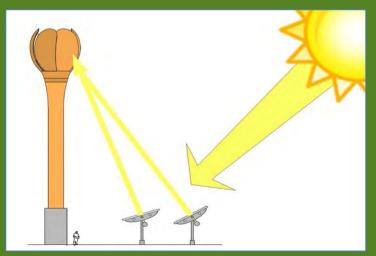


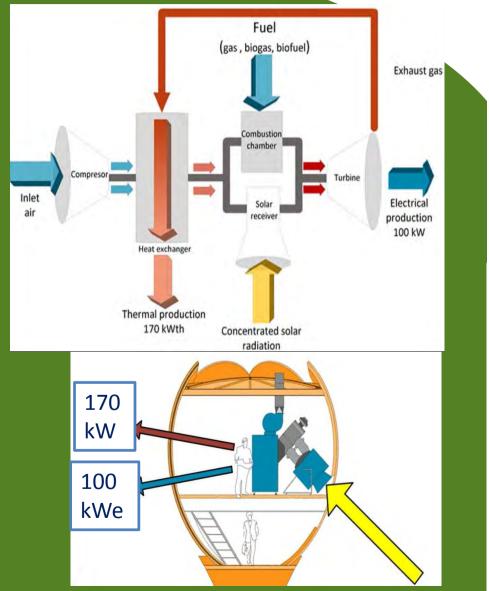
<u>The turbine's inner process is the</u> <u>following:</u>

• The air is compressed and partially heated in the turbine. Then, the pre-heated compressed air is circulated through the solar receiver where is reheated to very high temperatures thanks to the concentrated solar radiation from the heliostats field.

• The air is finally used by the hybrid turbine to produce electrical energy (100 kW) and thermal energy (170 kW).

• When there is not enough sun radiation, the turbine will work with any fuel such as gas, biogas, biodiesel and ordinary fuel.





Investment



100 kW MODULAR UNIT COST

SINGLE UNIT'S COMPONENTS

Solar Field

Tower

Solar Receiver

Hybrid Solar-fuel Turbine

Solar Field

Construction: Two month

COST

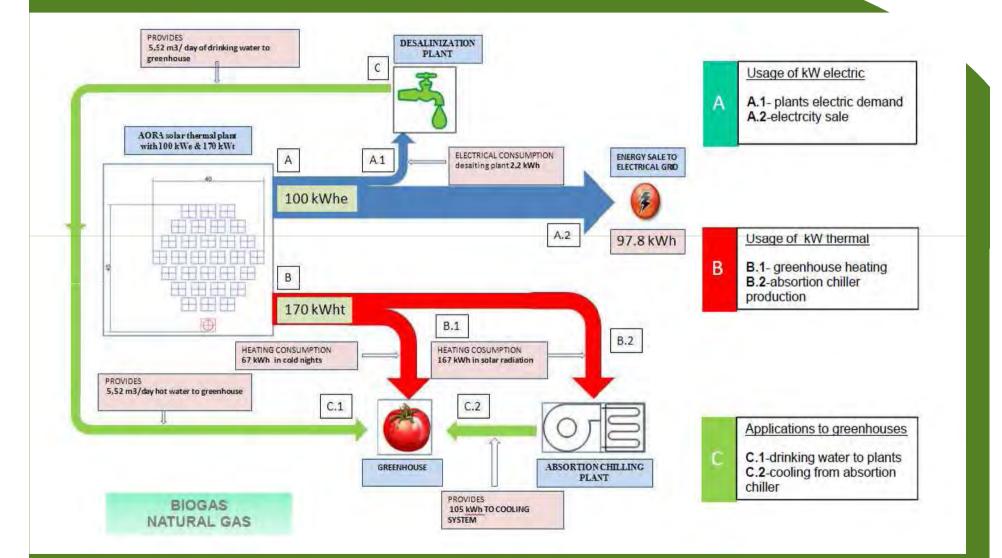
500.000€ (*)

(*) Installation cost in Spain

Source: <u>www.aorasolar.es</u>

Greenhouse Application





Source: www.aorasolar.es





