CSP PROJECTS FROM THE SPANISH INDUSTRY

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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.
- 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
- Is highly modular and suitable for both small stand-alone, decentralized off-grid power systems and large grid-connected power systems.

Linear Fresnel

- Uses flat mirror desíng to concentrate sun, enabling simpler production and installation
- Enables other industrial uses such as steam processing.
- Has high land-to-electricity ratio due to linear desíng and the usability of space below support structure
- Provides heat storage capabilities.


Ciudad Real
Badajoz
In operation (12)
Under construction (22)
Alicante
Granada
Seville
Malaga
Almeria
Gibraltar strait

	Nombre	Localidad	Potencia MW	Fase	Provincia	Tecnología
OPERATIVAS	PS10	San Lúcar la Mayor	11	Fase	Sevilla	Torre y helióstatos
	ANDASOL 1	Aldeire	50	Fase	Granada	Canales parabólicos
	PS20	San Lúcar la Mayor	20	Fase	Sevilla	Torre y helióstatos
	PUERTOLLANO IBERSOL	Puertollano	50	Fase 1	Ciudad Real	Canales parabólicos
	PUERTO ERRADO 1	Calasparra	1,4	Fase 1	Murcia	Fresnel
	LA RISCA	Alvarado	50	Fase 1	Badajoz	Canales parabólicos
	ANDASOL 2	Aldeire	50	Fase 1	Granada	Canales parabólicos
	EXTRESOL 1	Torre de San Miguel Sesmero	50	Fase 1	Badajoz	Canales parabólicos
	SOLNOVA 1	San Lúcar la Mayor	50	Fase 1	Sevilla	Canales parabólicos
	SOLNOVA 3	San Lúcar la Mayor	50	Fase 1	Sevilla	Canales parabólicos
	SOLNOVA 4	San Lúcar la Mayor	50	Fase 2	Sevilla	Torre y helióstatos
	CENTRAL SOLAR TERMOELÉCTRICA LA FLORIDA	Alvarado	50	Fase 1	Badajoz	Canales parabólicos
	PL. TERMOELÉCTRICA DE PALMA DEL RÍO II	Palma del Río	50	Fase 1	Córdoba	Canales parabólicos
CONSTRUCCIÓN AVANZADA	PUERTO ERRADO 2	Puerto Errado	30	Fase 1	Murcia	Fresnel
	ANDASOL -3	Aldeire	50	Fase 1	Granada	Canales parabólicos
	PL. TERMOELÉCTRICA DE MAJADAS	Majadas	50	Fase 1	Cáceres	Canales parabólicos
	PL. TERMOELÉCTRICA DE PALMA DEL RÍO I	Palma del Río	50	Fase 1	Córdoba	Canales parabólicos
	CENTRAL SOLAR TERMOELÉCTRICA LA DEHESA	La Garrovilla	50	Fase 1	Badajoz	Canales parabólicos
	MANCHASOL-1	Alcázar de San Juan	50	Fase 2	Ciudad Real	Canales parabólicos
	PLANTA TERMOSOLAR EXTRESOL-2	Torre de San Miguel Sesmero	50	Fase 2	Badajoz	Canales parabólicos
	GEMASOLAR	Fuentes de Andalucía	17	Fase 2	Sevilla	Torre y helióstatos
	HELIOENERGY 1	Écija	50	Fase 2	Sevilla	Canales parabólicos
	HELIOENERGY 2	Écija	50	Fase 2	Sevilla	Canales parabólicos
	LEBRIJA 1	Lebrija	50	Fase 2	Sevilla	Canales parabólicos
	TERMESOL-50	San José del Valle	50	Fase 3	Cádiz	Canales parabólicos
	ARCOSOL-50	San José del Valle	50	Fase 3	Cádiz	Canales parabólicos
	PL. TERMOSOLAR 1MW CASAS DE LOS PINOS	Villarrobledo	1	Fase 1	Albacete	Discos parabólicos
PREASIGNADAS	PL. SOLAR TERMOELÉCTRICA	Espejo	50	Fase 1	Córdoba	Canales parabólicos
	C. TERMOSOLAR "LA AFRICANA"	Fuente Palmera	50	Fase 1	Córdoba	Canales parabólicos
	PL. TERMOELÉCTRICA DE CONSOL ORELLANA	Orellana	50	Fase 1	Badajoz	Canales parabólicos
	HELIOS I	Puerto Lápice	50	Fase 1	Ciudad Real	Canales parabólicos
	HELIOS II	Puerto Lápice	50	Fase 1	Ciudad Real	Canales parabólicos
	C. SOLAR TERMOELÉCTRICA "ASTE-1A"	Alcázar de San Juan	50	Fase 2	Ciudad Real	Canales parabólicos
	C. SOLAR TERMOELÉCTRICA "ASTE-1B"	Alcázar de San Juan	50	Fase 2	Ciudad Real	Canales parabólicos
	SOLACOR I	El Carpio	50	Fase 2	Córdoba	Canales parabólicos
	SOLACOR 2	El Carpio	50	Fase 2	Córdoba	Canales parabólicos
	PL. TERMOSOLAR DE MORÓN	Morón de la Frontera	50	Fase 2	Sevilla	Canales parabólicos
	MANCHASOL-2	Alcázar	50	Fase 3	Ciudad Real	Canales parabólicos
	PL. TERMOSOLAR DE OLIVENZA 1	Olivenza	50	Fase 3	Badajoz	Canales parabólicos
	PL. TERMOSOLAR EXTRESOL – 3	Torre de San Miguel Sesmero	50	Fase 3	Badajoz	Canales parabólicos
	C. SOLAR TERMOELÉCTRICA "ASTEXOL -2"	Badajoz	50	Fase 3	Badajoz	Canales parabólicos
	SOLABEN 1	Logrosán	50	Fase 3	Cáceres	Canales parabólicos
	SOLABEN 2	Logrosán	50	Fase 3	Cáceres	Canales parabólicos
	SOLABEN 3	Logrosán	50	Fase 3	Cáceres	Canales parabólicos
	TERMOSOL 1	Navalvillar de Pela	50	Fase 4	Badajoz	Canales parabólicos
	TERMOSOL 2	Navalvillar de Pela	50	Fase 4	Badajoz	Canales parabólicos
	TERMOSOLAR BORGES, S.L.	Algües Blanques	22	Fase 4	Lérida	Canales parabólicos
	EXTREMASOL 1	Villanueva de la Serena	50	Fase 4	Badajoz	Canales parabólicos
	SOLABEN 6	Logrosán	50	Fase 4	Cáceres	Canales parabólicos
	C. SOLAR TERMOELÉCTRICA CÁCERES	Garisteo	50	Fase 4	Cáceres	Canales parabólicos
	CASABLANCA	Talarrubias	50	Fase 4	Badajoz	Canales parabólicos
	C. SOLAR TERMOELÉCTRICA ENERSTAR VILLENA	Alicante	50	Fase 4	Alicante	Canales parabólicos
	PL. TERMOSOLAR 8MW PUERTOLLANO	Puertollano	8	Fase 4	Ciudad Real	Discos parabólicos
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4	Ciudad Real	Discos parabólicos
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4	Ciudad Real	Discos parabólicos
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4	Ciudad Real	Discos parabólicos
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4	Ciudad Real	Discos parabólicos
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4	Ciudad Real	Discos parabólicos
	PL. TERMOSOLAR 14 MW PUERTOLLANO	Puertollano	12	Fase 4	Ciudad Real	Discos parabólicos
	ARENALES	Morón de la Frontera	50	Fase 4	Sevilla	Canales parabólicos

Total de Plantas 60

LOCALIZACIÓN DE CENTRALES TERMOSOLARES EN ESPAÑA

PROTERMO SOLAR

CLUSTER de la Energía en Extremadura

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

CLUSTER
Energía en Extremadura

ANDASOL 1
and
ANDASOL 2

CLUSTER de la Energía en Extremadura

EXTRESOL 1

CLUSTER de la Energía en Extremadura

CTS Puertollano

CLUSTER de la Energía en Extremadura

LA RISCA, Alvarado

CLUSTER de la Energía en Extremadura

LA FLORIDA, Alvarado

CLUSTER de la Energía en Extremadura

PUERTO ERRADO 1

CLUSTER de la Energía en Extremadura

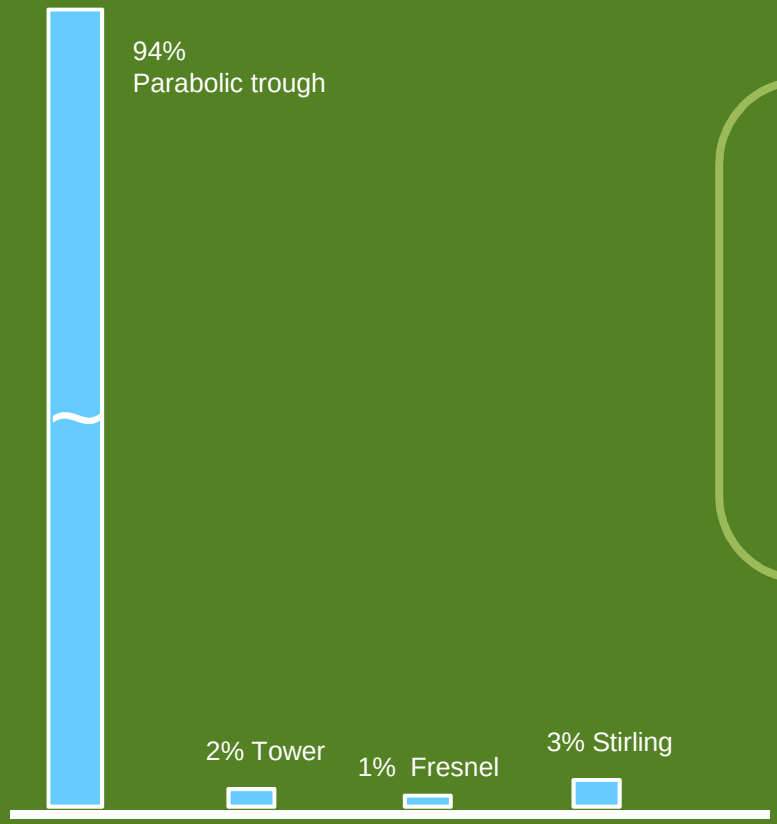
Villarrobledo

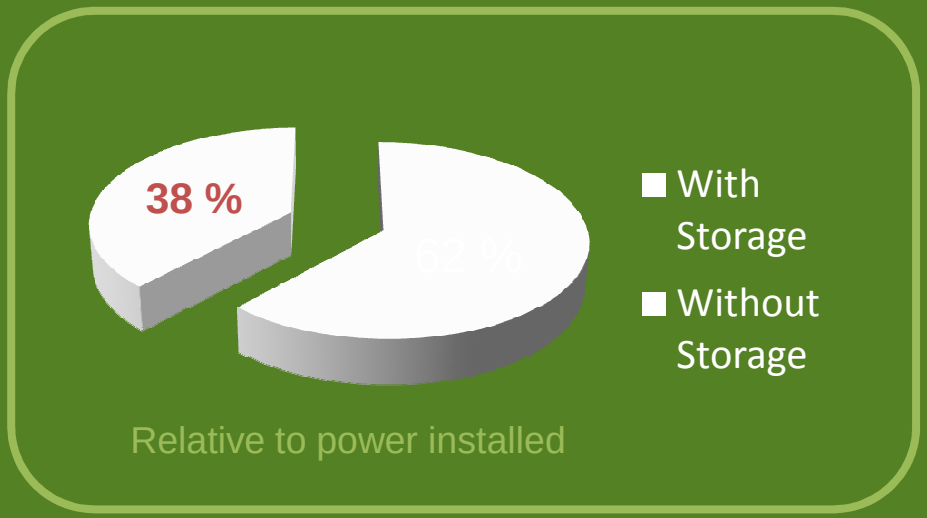
CLUSTER de la Energía en Extremadura

GEMASOLAR, Fuentes de Andalucía

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

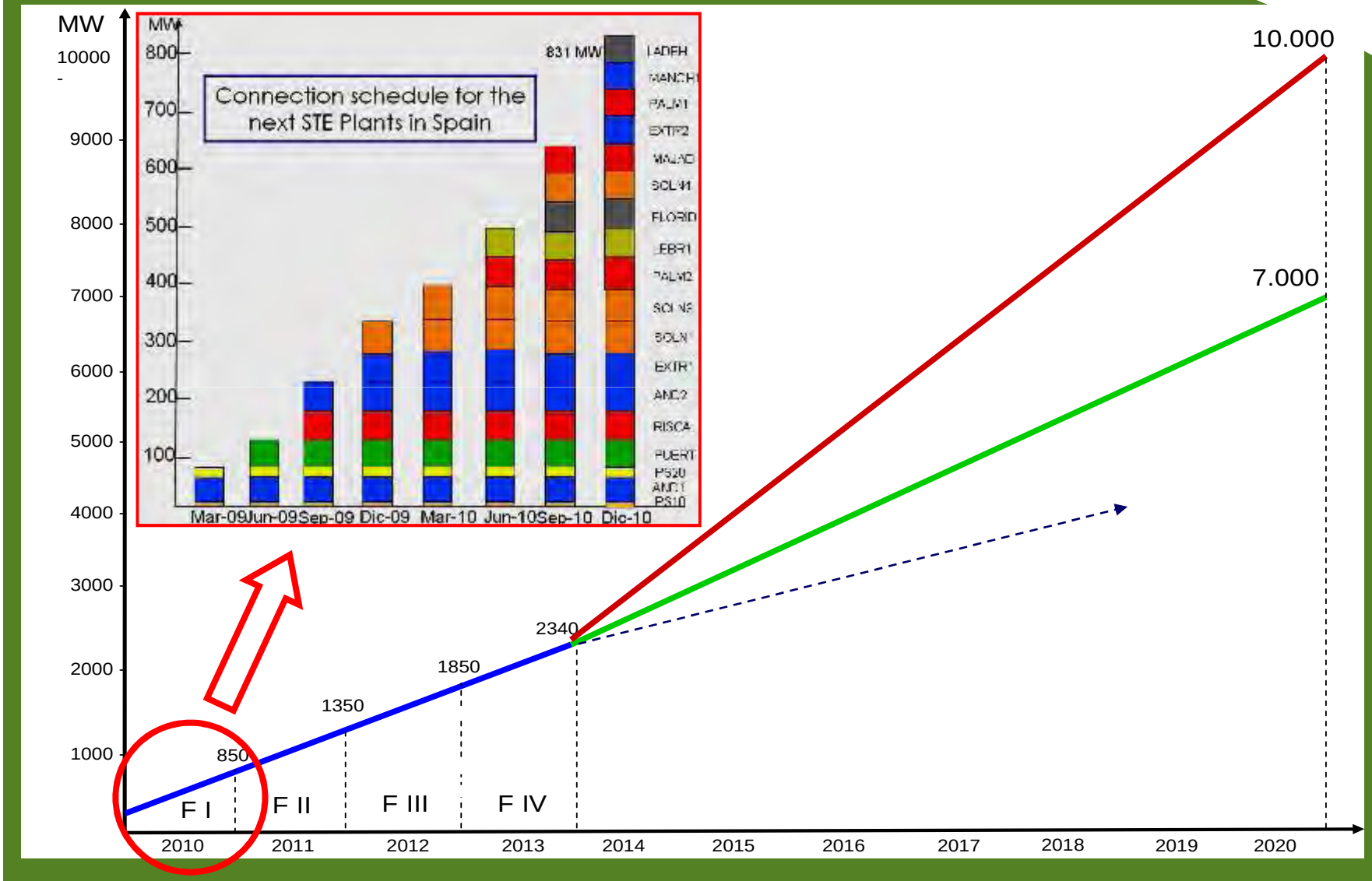
Total: 2423 MW (In operation by the end of 2013)





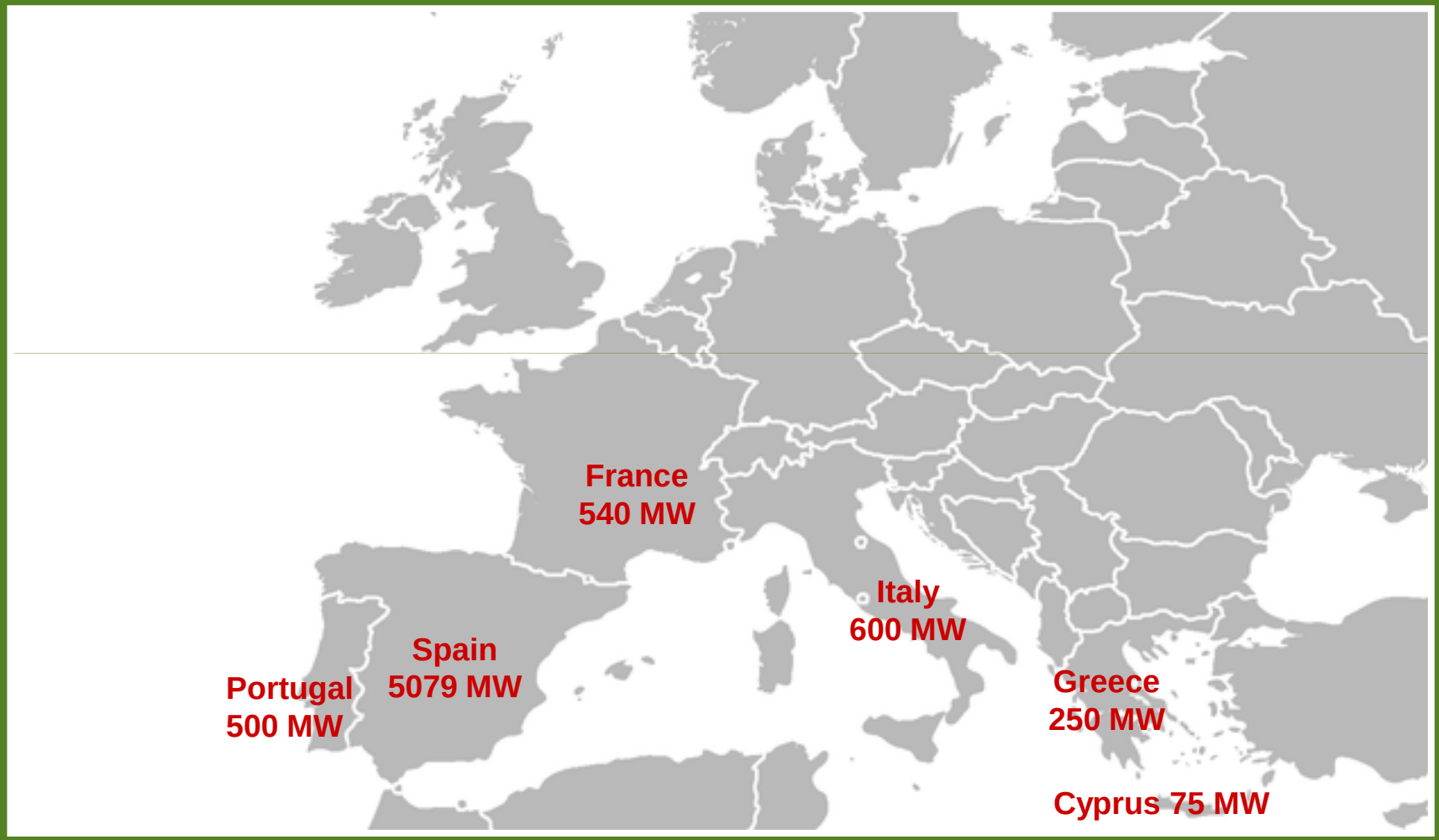
Source: PROTERMOSOLAR

Forecast for STE plants in Spain



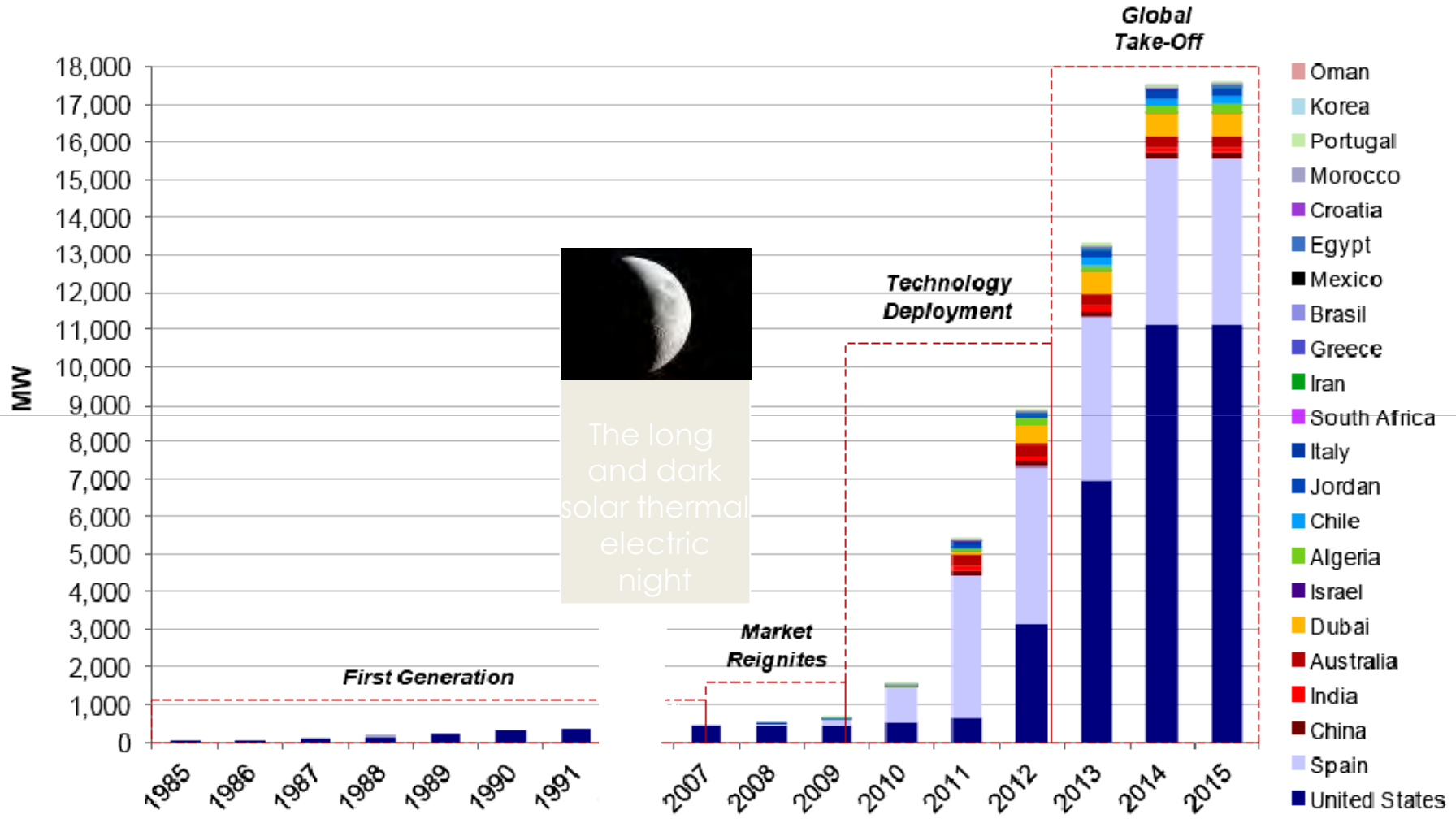
Source: PROTERMOSOLAR

Forecast in European countries by 2020 (NAP's)



Source: PROTERMOSOLAR

FORECAST BY COUNTRIES 2009-2015



The long and dark solar thermal electric night

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

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 €

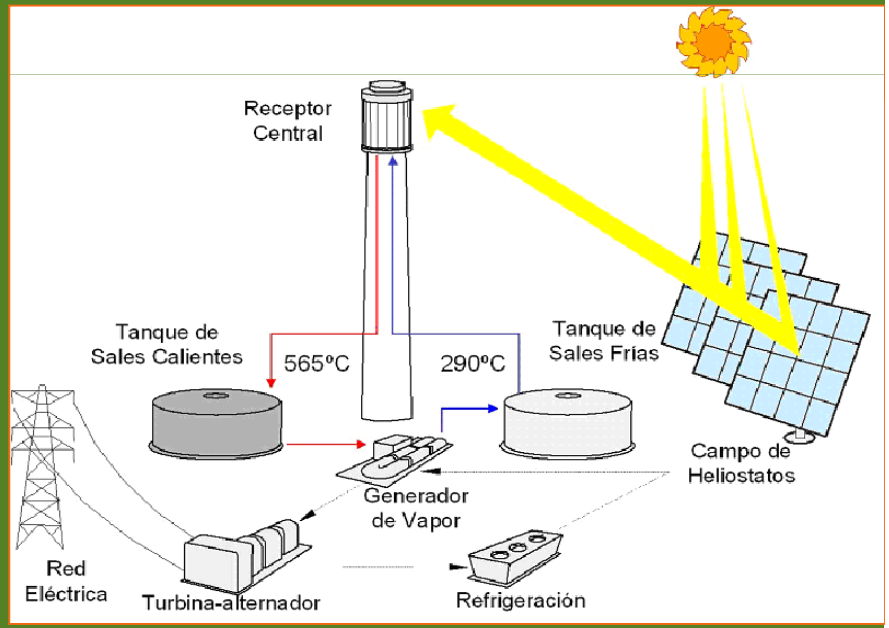
  solar field 45%

  Receiving system 15%

  Storage System 9%

  Steam generation system 7%

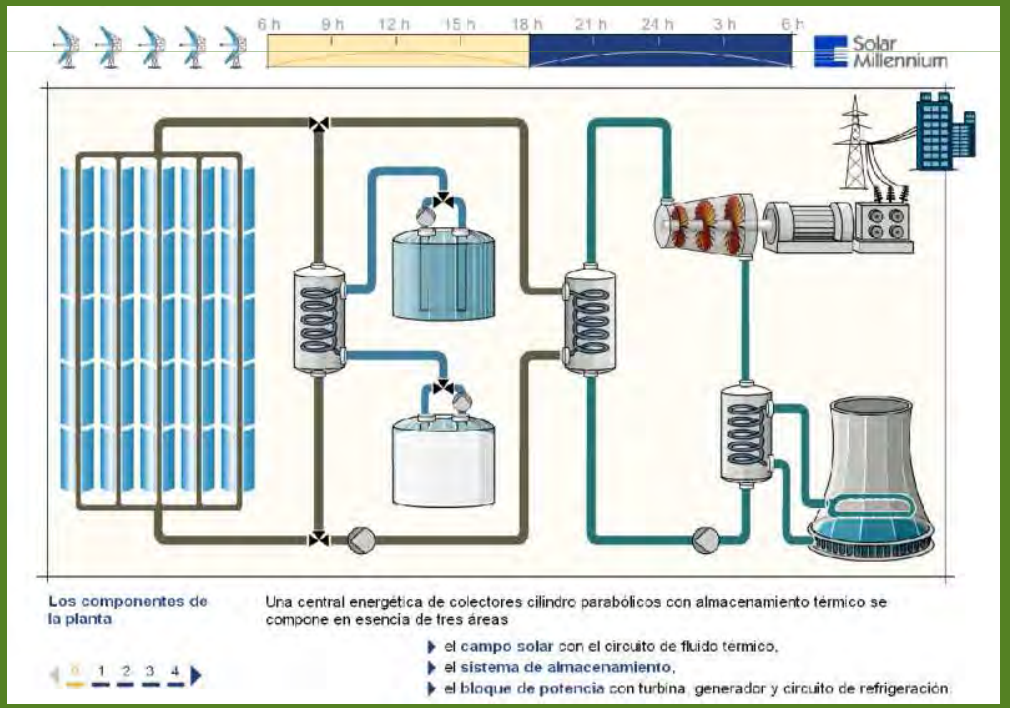
  Power generation system 24%



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



Source: SOLAR MILENIUM

❖ Solar field : 30%

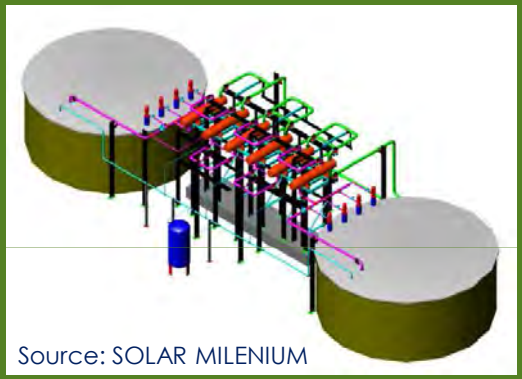
- ❖ 220 ha, 230.000 mirrors(550.000m2), corresponds to nominal thermal output 300MWt.
- ❖ 25.000 absorber tubes (100 km), 2.8 million litres of thermal fluid (298ºC-393ºC).
- ❖ 2 expansion tanks and an overflow tank of thermal fluid , 3 pumps (2+1 back-up) 70.500 l/min.
- ❖ 3 natural gas auxiliary boilers 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 380ºC, 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(292º-386º)



Source: SOLAR MILENIUM

❖ 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, 255ºC)
- ❖ Electrical Equipment to transmision of electrical energy from the generator to the main transformer (current 3.500ª, 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	(2 years)
Engineerring planning	30-50%	50-70%	75-95 MY	
Technology (procurement)	30-60%	40-70%	145-220 MY	
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

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

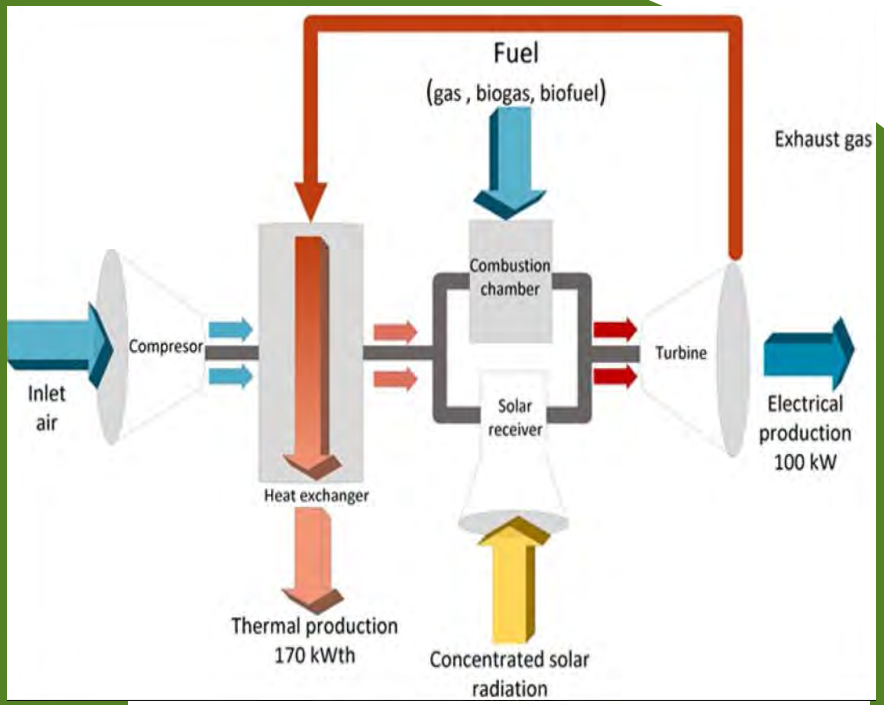
Source: www.aorasolar.es

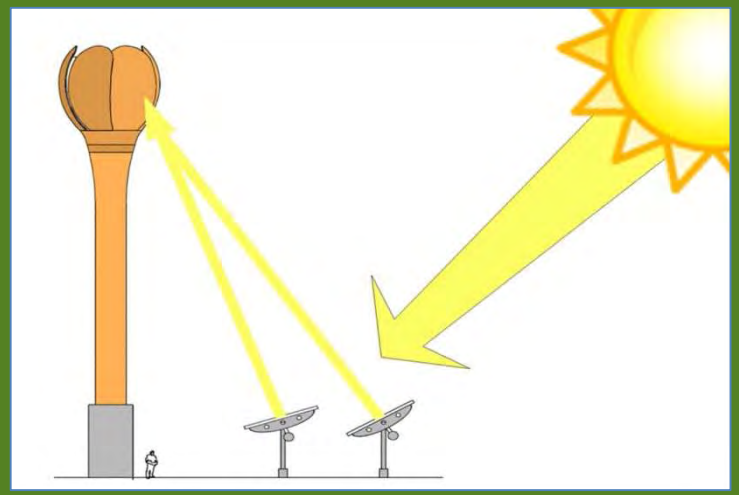
The turbine´s inner process is the following:

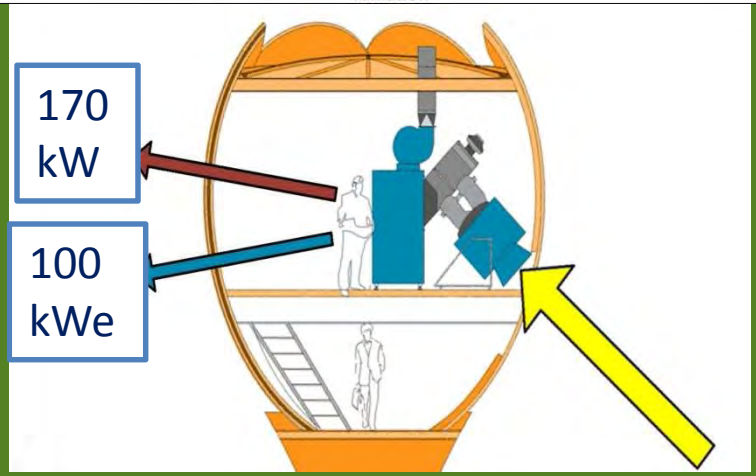
• The air is compressed and partially heated in the turbine. Then, the pre-heated compressed air is circulated through the solar receiver where is reheated to very high temperatures thanks to the concentrated solar radiation from the heliostats field.

• 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.







Source: www.aorasolar.es

Investment

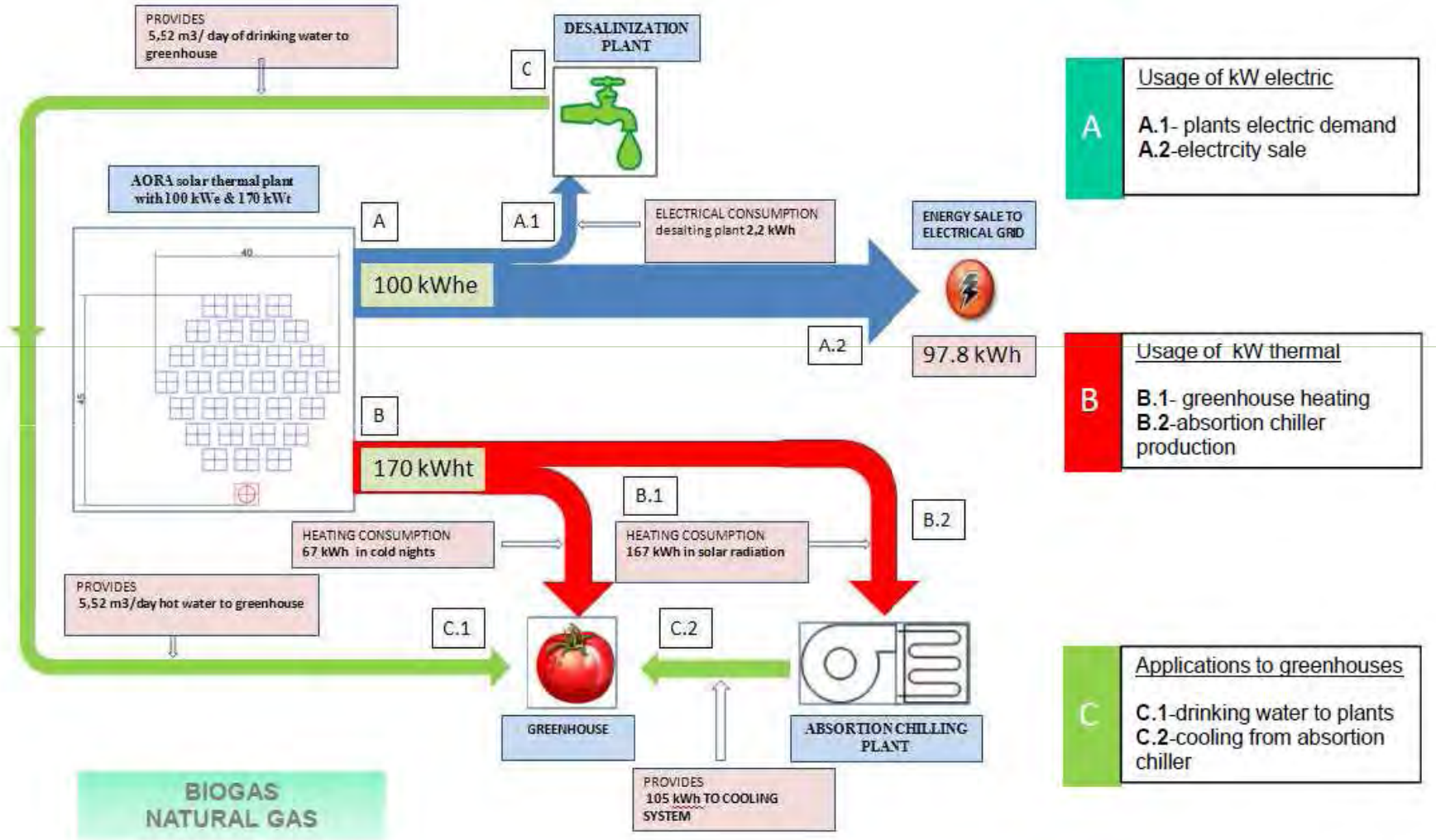
100 kW MODULAR UNIT COST

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: www.aorasolar.es

Greenhouse Application



Source: www.aorasolar.es


Thank you for your attention!
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