

ABENGOA

ABENGOA SOLAR

World Bank – November 6, 2012

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Our credentials

Technologies

Advantages of CSP

Abengoa is an international company that applies innovative technology solutions for sustainability in three business segments

Concession type

27%



20 MW CSP tower (Spain)

Industrial production

33%







100,000 m³/day desalination plant (India)

Eng. & construction

40%



Transmission line

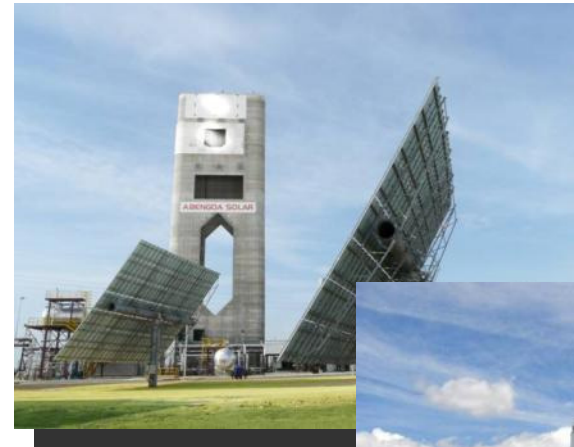
-  Solar CSP (Concentrating solar power)
-  Transmission
-  Water
-  Cogeneration

-  Biofuels
-  Recycling

- Power
- Industrial plants
- Water

Technology as a source of competitive advantage

- > €90 million invested in R&D in 2010
- > 900 people in R&D+i
- Collaboration with leading research centers



Eureka pilot plant
(superheated steam)



Cellulosic ethanol pilot plant
using enzymatic hydrolysis

- World leader in the development of **2nd generation** ethanol
- Global pioneer in **CSP technology**
- Development of new alternatives in **hydrogen, marine energy and biomass**



Water R&D Centre

Europe

- **PS10 & PS20**, the first and the biggest commercial solar power towers in operation worldwide
- **Solnova 1, 3 & 4**: three parabolic trough plants in operation (50 MW each)
- **Helioenergy 1&2, Solacor 1&2, Helios 1&2, Solaben 2&3**: 8 parabolic trough plants in operation (50 MW each)
- 2 more parabolic trough plants under construction (50 MW each)
- 5 photovoltaic plants in operation



U.S.A.

- **Solana (AZ)**: the largest solar power plant in the world, a 280 MW parabolic trough plant with 6 hours of storage, under construction
- **Mojave (CA)**: 280 MW parabolic trough plant, under construction



Africa & Middle East

- **Hassi R'mel (Algeria)**: 150 MW ISCC hybrid plant in operation
- **Shams-1 (Abu Dhabi)**: 100 MW parabolic trough plant under construction
- **Kaxu Solar One & Khi Solar One (South Africa)**: 100 MW trough plant and 50 MW solar power tower starting construction



Our credentials

Technologies

Advantages of CSP

ABENGOA

What is CSP?

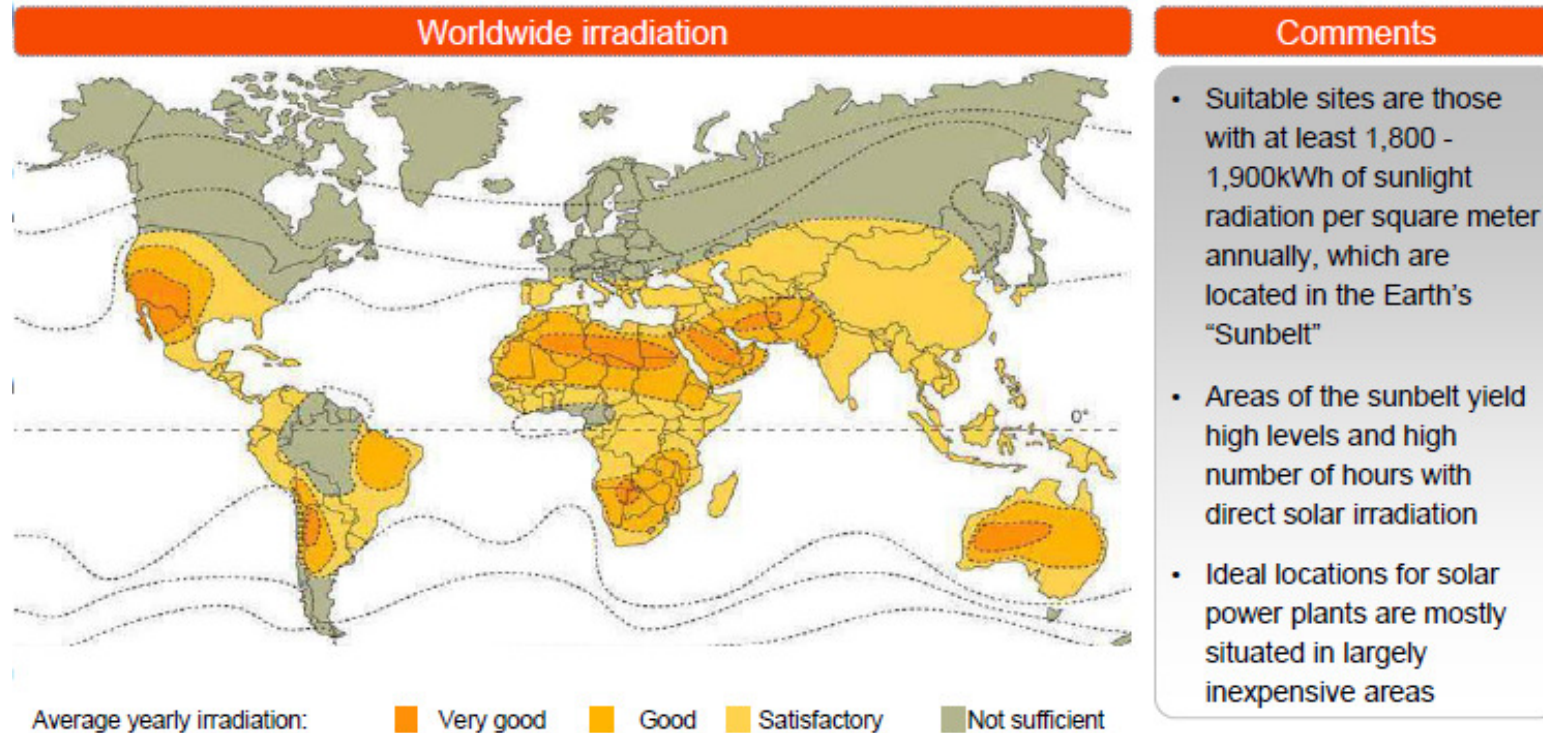
Solar Tower



Solar Trough



CSP power plants are ideally suited for the sunbelt of the earth



CSP has the potential to meet up to 7% of the world's projected power needs in 2030 and a full quarter by 2050^(a)

(a) Global CSP outlook 2009, advanced industry developed scenario
Source: Global concentrated solar power markets and strategies, 2009 – 2020, Emerging Energy Research, April 2009

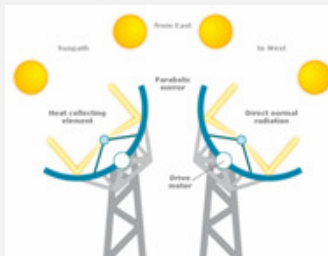
CSP involves four main solar technologies, two of which are mature and commercially available



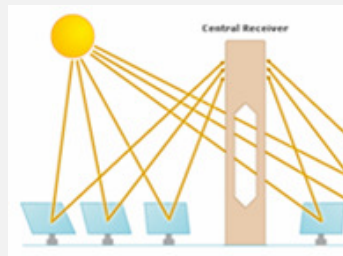
Maturity



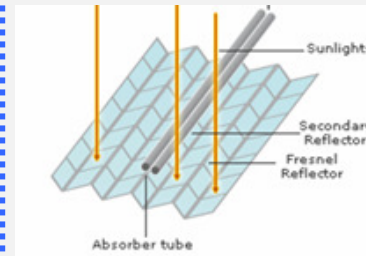
Commercially proven for utility scale power



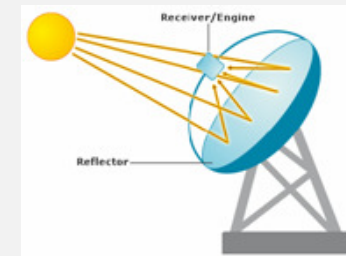
Parabolic Trough



Tower



Fresnel



Dish Stirling

Description

- The reflector concentrates the sunlight to a receiver tube, through which the heat transfer fluid (HTF) is circulated

Track record

- ✓ 30 years

Application

- ✓ Utility scale power

Key Feature

- ✓ Modular

- Heliostats follow the sun to reflect the sunlight to the top of a tower where the heat transfer fluid is heated.

- ✓ 3 years

- ✓ Utility scale power

- ✓ High temperatures

- Rows of mirrors concentrate the sunrays onto a receiver tube where the HTF is pumped

- ✓ Demonstration

- ✓ Heat applications

- ✓ Low cost

- A group of mirrors with a parabolic shape reflect the sun to an engine located in the focus point

- ✓ Demonstration

- ✓ Distributed power

- ✓ High power conversion

Mature and commercially viable technologies

Tower



Operating principle

- A circular array of heliostats (2-axis tracking mirror) is used to concentrate sunlight to a central receiver system mounted on the top of a tower
- The concentrated solar irradiation is used to generate steam that feeds a conventional turbine to generate electricity

Key features

Track record

Five years in operation

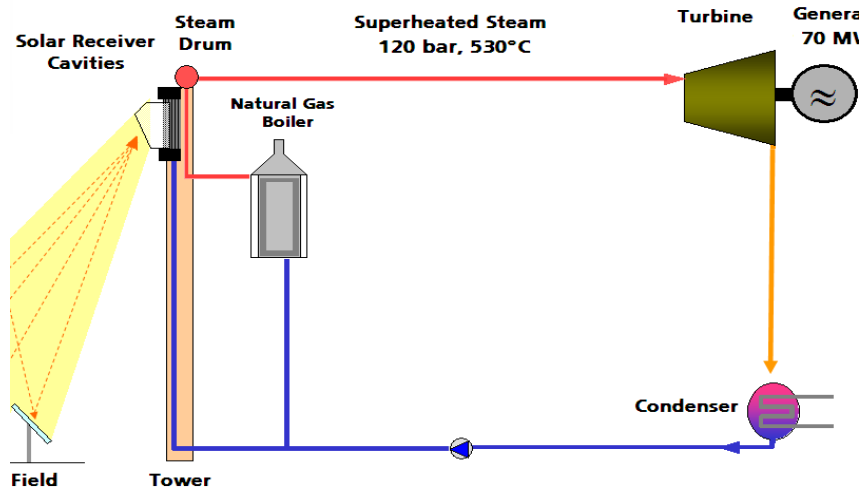
Key feature

High temperatures / efficiency

Abengoa experience

Two towers in operation in Spain
PS50 in South Africa

Solar power tower operating principal



- ▶ Cold water is pumped to the receiver located at the top of the tower
- ▶ The concentrated sunrays from the heliostat field focused in the receiver heat up the water, producing superheated steam
- ▶ Part of the steam is directed to the steam storage tanks that release this steam when it is needed
- ▶ The superheated steam runs through a turbine that generates electricity

Mature and commercially viable technologies

Parabolic Trough



Operating principle

- Parabolic mirrors are used to track the sun and concentrate sunlight onto receiver tubes placed in the trough focal line
- A heat transfer fluid is circulated through the tubes, which is later pumped through heat exchangers to generate steam
- The steam is used to generate electrical energy in a conventional steam turbine

Features

Track record

Decades

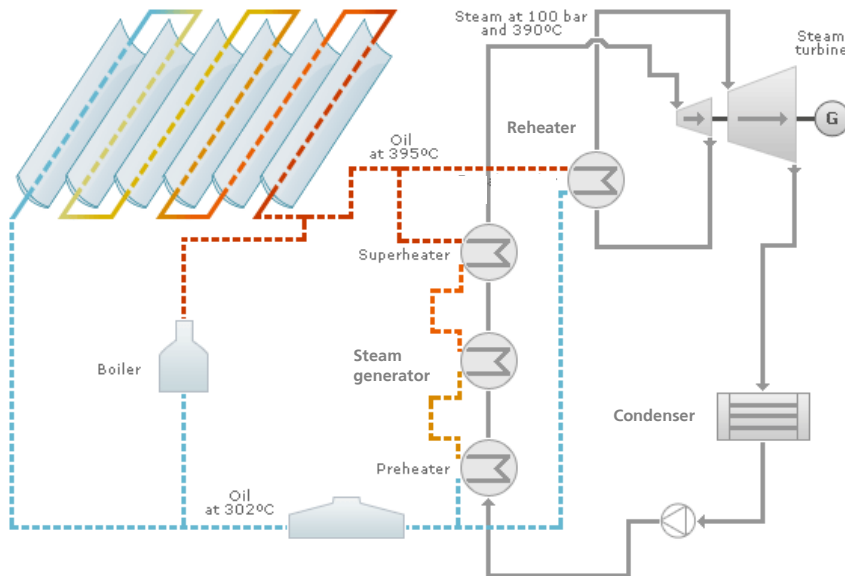
Key feature

Modular

Abengoa experience

700 MW in operation; almost 760 MW under construction

Parabolic trough operating principal

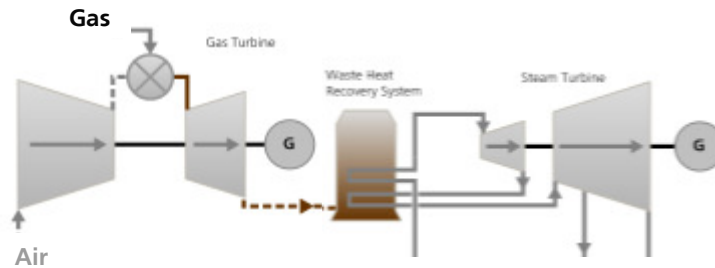


- ▶ Oil is pumped through the solar field
- ▶ The parabolic mirror concentrates the sunrays in the evacuated tube where it is heated at approximately 400°C.
- ▶ This oil exchanges its heat with water, producing superheated steam
- ▶ The superheated steam runs through a turbine that generates electricity

Hybrid plant

Combined cycle

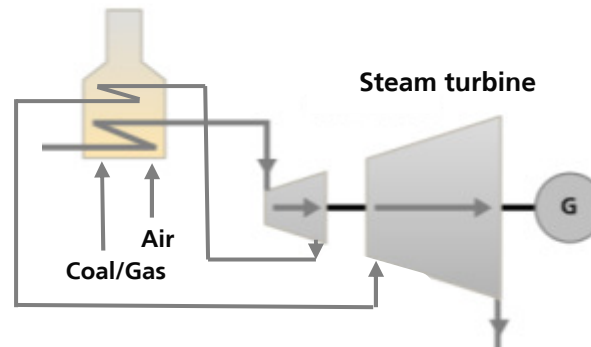
- ✓ High fossil fuel to electricity efficiency (50-60%)
- ✓ Base/Mid/Peak load and quick answer to electricity needs



Coal Plant

- ✓ Inexpensive fuel source but medium efficiency (30-40%)
- ✓ Base load solution

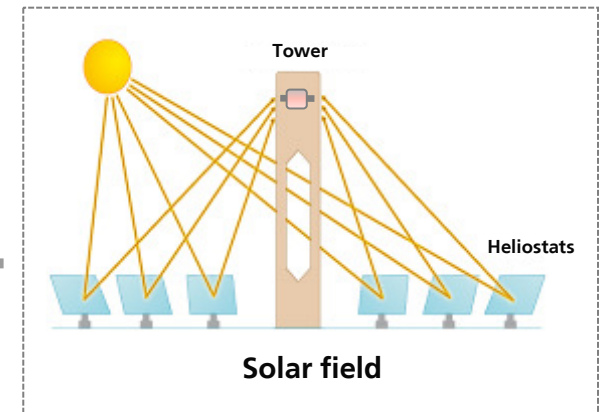
Coal/Gas boiler



Simple gas plant

- ✓ Medium efficiency (40%)
- ✓ Intermediate/Peak load solution

+



Able to customize the hybrid solution to the customer's needs

- Renewable percent desired
- Solar input in any steam conditions:
 - ✓ Preheating
 - ✓ Saturation
 - ✓ Superheating

Tower add-on



- **Coal & Gas/Diesel Steam:** Superheated power tower that can work in parallel with the coal or gas facility
- **Combined Cycle**
 - Low capacity factor: Superheated tower
 - Large capacity factor: Saturated tower substituting duct firing (post-combustion)

Trough add-on



- **Coal & Gas/Diesel Steam :** Preheating
- **Combined Cycle**
 - Preheating
 - Saturated steam substituting duct firing

A variety of non-utility applications are cost effective with industrial solutions solar technology



Applications

- Process heat applications for:
 - Mining, minerals processing
 - Food processing
 - Cleaning & sanitation
 - Enhanced oil recovery
 - Desalination

- Space heating and cooling
 - Thermal energy for heating
 - Absorption chillers for cooling

- Domestic hot water

- Electric power production as supplemental heat source
 - Geothermal
 - Biomass
 - Coal and natural gas

Abengoa Solar case studies

Tower technology:

PS20 Power Tower

**Trough technology
with storage:**

Solana

Hybrid technology:

Algeria (Gas)

Cameo (Coal)



**PS20, the first commercial tower in the world (Solúcar Platform, Spain)
In operation since 2009**



- Provides energy to around 11,000 households
- 12,200 t of CO₂ saved
- 1,255 heliostats of 120 m² (1,300 sq ft) each one
- Tower height: 160 m (535 ft)
- Proprietary Technology
- Excellent performance track record

**Solana (Arizona, U.S.), the largest solar plant in the world
280 MW of trough technology with 6 hours of storage
Expected to operate in 2013**



- Will produce electricity for 70,000 households
- 450,000 t of CO₂ avoided yearly
- Financed by Federal Financial Bank in December 2010
- 6 hours molten salt heat storage
- Proprietary technology

**Abengoa's proven hybrid technology
Algerian combined cycle hybrid (ISCC)
150 MW in operation**



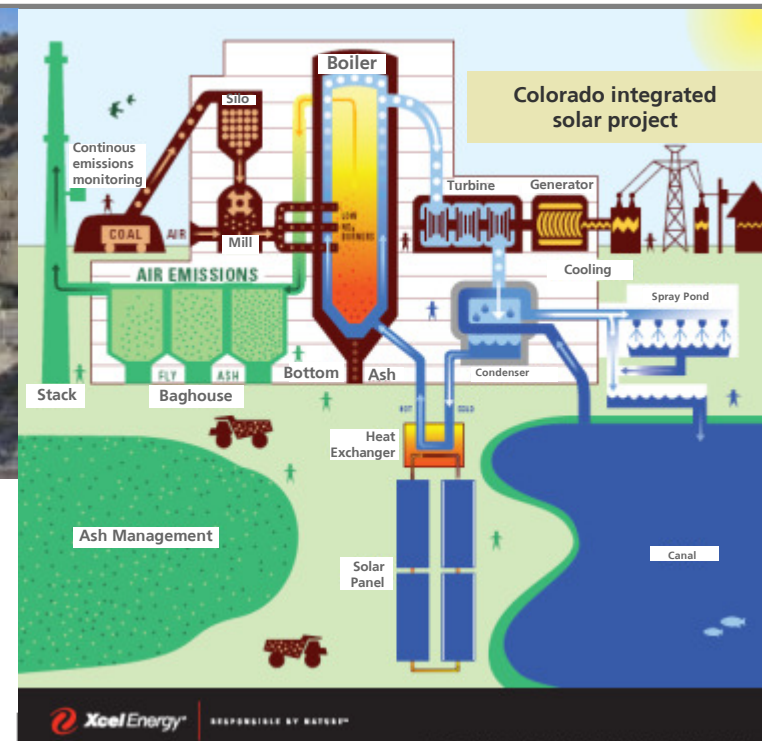
- Combined cycle with solar trough field already in operation
- 25 MW from solar troughs, balance from natural gas
- 250,000 m² of reflective surface
- Thermal oil as heat transfer fluid
- Ownership by Abengoa and NEAL

Abengoa's proven hybrid technology U.S. ISCoal

Test complete



- CSP technology: Parabolic troughs
- Prototype test completed to evaluate the hybridization in a conventional coal installation of Xcel Energy, Cameo, Colorado



Cameo (Proof of concept)

Our credentials

Technologies

Advantages of CSP

CSP has fundamental advantages over other renewable sources of energy

- 1 Mature & commercially **viable technologies**
- 2 High **cost reduction potential**
- 3 **Dispatchable** renewable energy source
- 4 **Hybridization with conventional power**
- 5 **Energy security**
- 6 **Source of employment**
- 7 **Source of technological development** for the country



CSP is the only renewable power source that assures dispatchability and a guaranteed power supply



CSP



PV



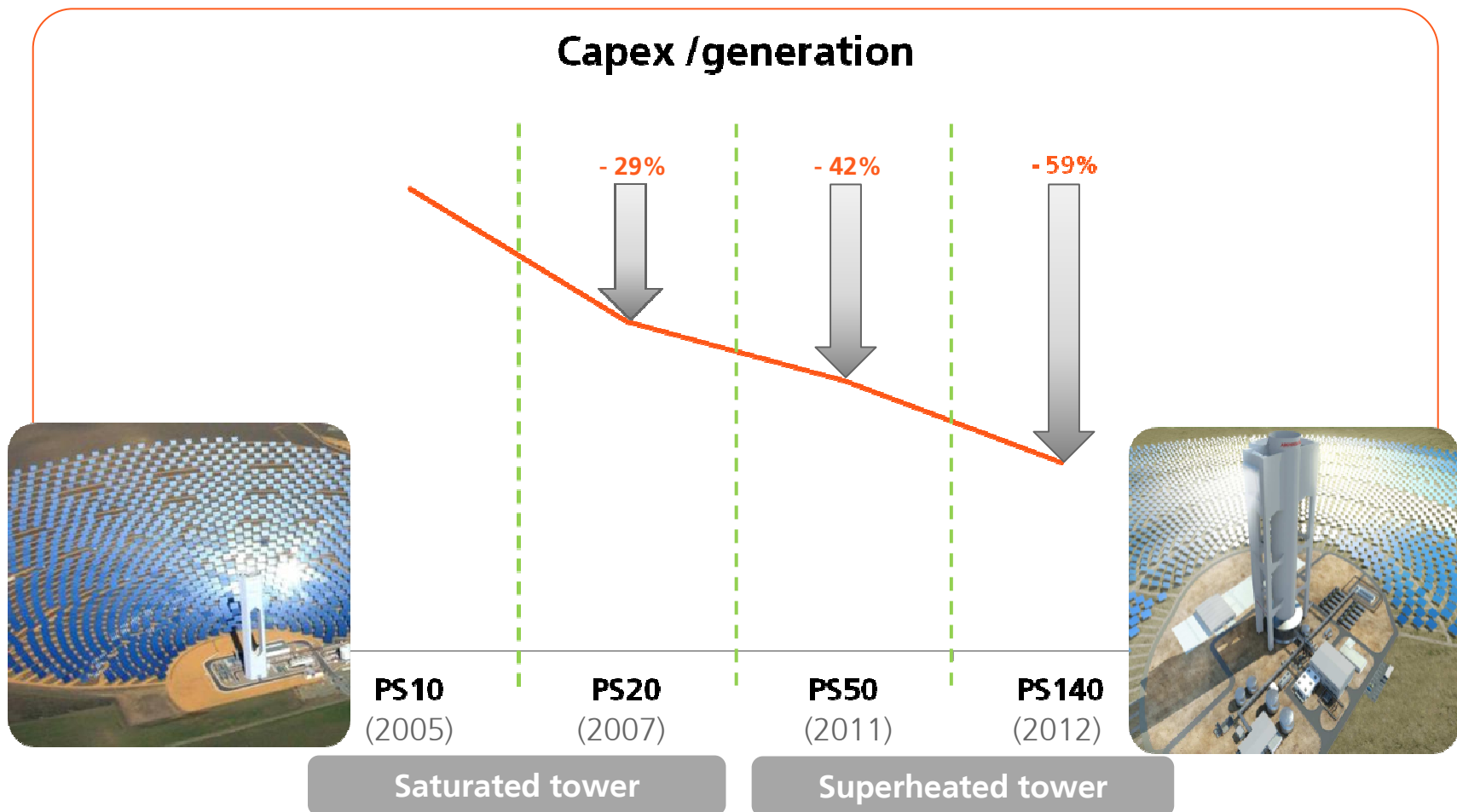
Wind



Biomass

	CSP	PV	Wind	Biomass
Dispatchability	+ High Thermal inertia Hybridization Storage	- None	- None	+ High
Forecasting	= Average / High	- Average / Low	- Low	+ High
Security of supply	+ High	+ High	+ High	- Dependent on cost and offer

Abengoa's CSP has followed its predicted roadmap and will keep reducing costs according to it





CSP is a special RE product, a bit more expensive but with a higher added-value

- High job creation
- Attached local industrial growth

- Savings in social costs
- Increase of GDP

- Dispatchable
- Local source
- Secured supply

- Savings in back-up capacity/infrastructure
- Saving in fuel imports
- Energy security

Renewables share is a regulator's decision. CSP is necessary to enable it.

