ABENGOA

Innovative technology solutions for sustainability

ABENGOA

Hybrid Solar Power Plants

September, 2013

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Abengoa focuses its growth on creating new technologies that contribute to sustainable development…

- Generating energy from renewable sources
- Generating and managing water
- Creating infrastructures that respect the environment
- Promoting new development and innovation horizons

To achieve this, Abengoa…

- invests in research, development and innovation (R&D+i)
- expands the technologies with the greatest potential
- develops the necessary talent, attracting and retaining the best professionals (more than 26,000 employees)
- dedicates economic and human resources to promoting social action policies that contribute to social progress

Abengoa's commitment to sustainable development is a priority in all its activities we try to reduce the impact of our activities with the support of an integrated management system

Abengoa's business is structured around three activities

1 Engineering and construction

- 70 years of experience in energy infrastructures
- Proprietary know-how
- Leading international contractor in T&D

2 Concession-type infrastructures

- Solar, transmission lines, desalination, cogeneration and others
- Very low market risk
- Average contract term: 25 years

3 Industrial production

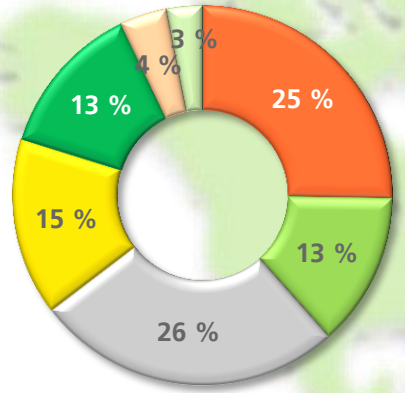
- Biofuels
- High growth markets
- Market leaders

We perform these three activities in two high growth sectors

Energy | **Environment**

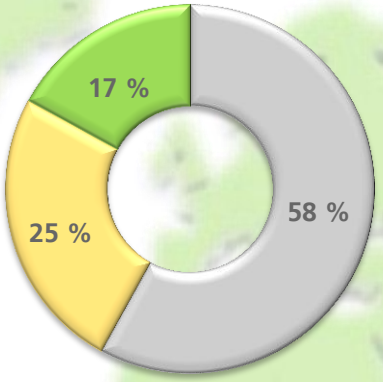
Abengoa (MCE: ABG) is an international company that applies innovative technology solutions for sustainable development in the energy and environment sectors, generating electricity from the sun, producing biofuels and desalinating sea water.

Sales 2012



€7,783 M

EBITDA 2012



€1,246 M

Regions

- Spain
- Brazil
- USA
- Rest of Europe
- Rest of Latin America
- Asia & Oceania
- Africa

- Engineering and construction
- Concession-type infrastructures
- Industrial production

Sales

€7,783 M

↑ **10 %** (€7,089 M in 2011)

EBITDA

€1,246 M

↑ **13 %** (€1,103 M in 2011)

Net income

€125 M

↓ **51%** (€257 M in 2011)

Net corporate debt – Corporate EBITDA

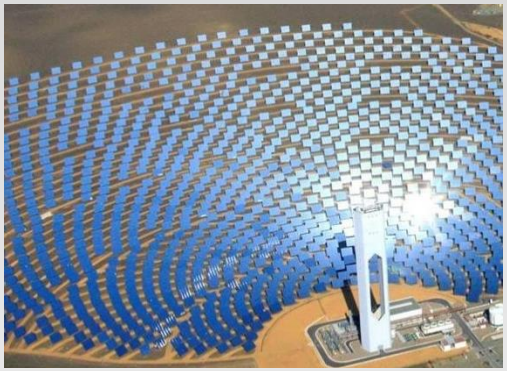
3.2x

↓ **3.4x** since September 2012

We are a global solar power generation company offering proven proprietary technologies, developing new ones and operating power plants

- A **twenty year commitment** to the development of both CSP and PV technologies
- **More than 1,200 professionals worldwide**
- **743 MW in operation and close to 910 MW under construction**
- **Proprietary solar technologies** (tower, parabolic trough, thermal storage, high concentration photovoltaic, hybrids)
- A **world class team of solar experts**, with unsurpassed collective experience and skills

Clean dispatchable plants



Solar towers

Trough plants

Hybrid plants

Conventional + solar

- ISCC (gas + solar)
- ISCoal (coal + solar)

Clean intermittent plants

HCPV

PV

Our commercial plants worldwide

743 MW in operation & 910 MW under construction

First commercial solar tower worldwide

Europe

- The so-called PS10 and PS20, 2 first commercial solar towers worldwide, 11 and 20 MW.
- 11 trough plants (50 MW each) with successful operation.
- 2 trough plants in construction.
- 5 photovoltaic plants in operation.

Our commercial plants worldwide

743 MW in operation & 910 MW under construction

The largest trough plant in the world, in USA

North America

Solana

- The largest trough plant in the world is located in AZ, USA. 280MW with 6 hours of storage.
- 475,000 t of estimated CO_2 saved per year.
- It will offer clean energy, without green house effect to around 70,000 homes.

Mojave (CA)

- 280 MW of oil trough technology plant in California.
- It will produce energy enough to supply to more than 54,000 homes.

Solana (280 MW)

Our commercial plants worldwide

743 MW in operation & 910 MW under construction

First Integrated Solar Combined Cycles (ISCC)

Africa

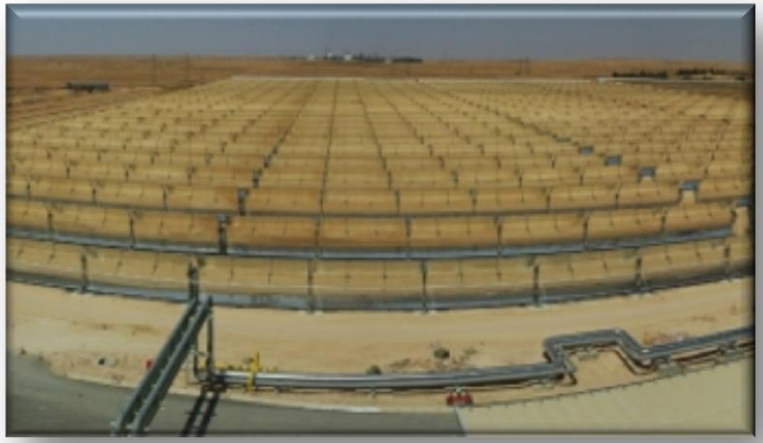
Hassi-R'mel

- First Integrated Solar Combined Cycle (ISCC), Algeria 150 MW (20 MW of CSP)

KaXu and Khi Solar One Plants

- 2 projects under construction in South Africa:
  - Khi Solar One : 50 MW tower
  - Kaxu Solar One : 100 MW trough plant with 3 hours of storage.

Hassi-R'mel (150 MW)



Our commercial plants worldwide

743 MW in operation & 910 MW under construction

First CSP plant in Middle East

Middle East

- First CSP plant in the Middle East, Abu Dhabi: 100 MW Shams-1
- 100 MW oil trough technology of parabolic trough with dry cooling
- 600,000 m^2 of solar field in the middle of the desert
- 175,000 t of CO_2 saved per year
- Proprietary technology

Shams I (100 MW)

Technology as a competitive advantage for Abengoa

R&D → Pilot Plant or Real Test → Commercial Project

- +100 in-house researchers
- R&D center in Denver, CO
- R&D center in Seville, Spain
- Abengoa Research
- Collaboration with key research institutions and companies worldwide

NREL National Renewable Energy Laboratory — Innovation for Our Energy Future

Ciemat — Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

DLR

Fraunhofer

Sandia National Laboratories

CSIRO

cnrs

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CSP is key in the future energy mix

1 Fossil based mix

Low gas prices will increase its share within the fossil based part of the mix, taking the place of other conventional sources

2 Renewable mix

Intermittent

+

Dispatchable

% share decided by **regulator directly or indirectly** (RES, FiTs, taxes, etc.)

- A significant **"renewable mix"** can only be achieved by using both intermittent and dispatchable resources
- **CSP** is one of the few options that can enable a significant renewables share

What is dispatchability?

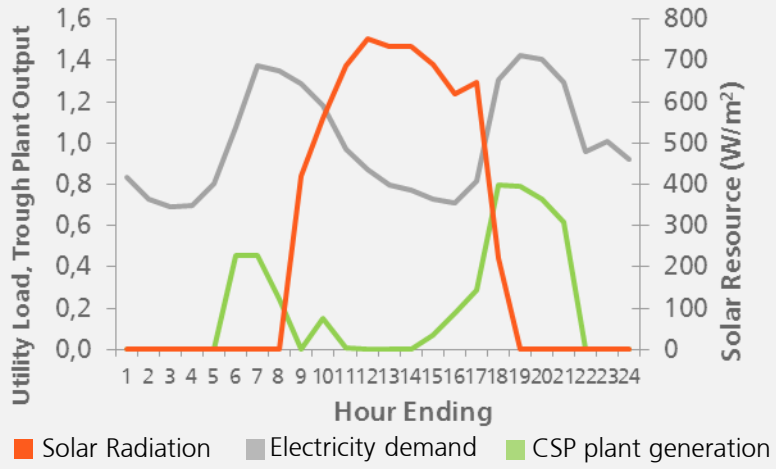
Dispatchability is the unique feature of CSP of adapting its generation to the required demand profile

CSP technology

+ **Thermal energy storage**

+ **Hybridization**

Solar plant in Arizona with storage vs utility system load - **Winter Period**



CSP: the clean dispatchable power

NREL* estimates the value of dispatchability in up to 4 cents/kWh relative to non-dispatchable energy sources

(*) NREL study "Tradeoffs and Synergies between CSP and PV at High Grid Penetration"

Concentrated Solar Power "CSP" has fundamental advantages over other renewables

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**

Generating electricity with solar hybrids has important advantages

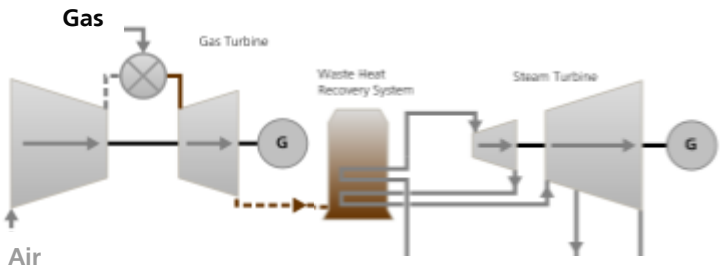
Electricity generation with solar-conventional hybrid

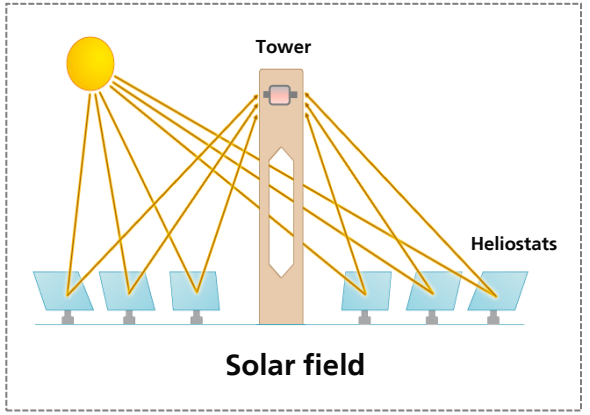
- **Dispatchability**
  High adaptation to demand profile
- **Reduction in fossil fuel consumption** and polluting emissions
- **2 optimal and already commercial technologies,** depending on the fossil source and with various configurations for a better fit to the conventional power plant:
  - **ISCC** (solar – gas hybrid)
  - **ISCoal** (solar – coal hybrid)

Solar field add-ons and greenfield projects

Combined cycle

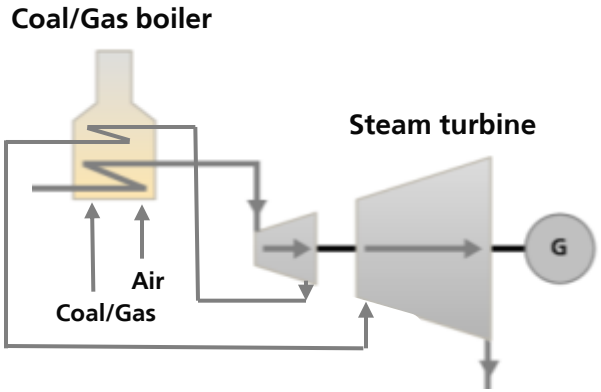
- High fossil fuel to electricity efficiency (50-60%)
- Base/Mid/Peak load and quick answer to electricity needs





Coal Plant

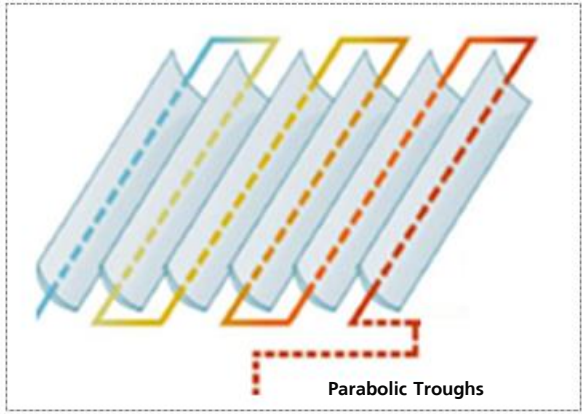
- Inexpensive fuel source but medium efficiency (30-40%)
- Base load solution



Gas power plant
Cogeneration
Industrial processes

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

+



Our hybrid portfolio

Abengoa Solar offers two types of hybrid solutions:

a **Hybridize gas/oil or coal operating facilities**

No impact or improved performance of the operating facility

- A cheap way to achieve renewable targets
- A way to extend facilities lifespan under tight regulation
- Feasible for combined cycle, gas, oil or coal steam plants
- Abengoa will own, co-own or build the CSP add-on for third parties

b **Build new CSP hybrid plants**

An "all-in-one product" that provides new installed capacity with a 20-30% renewable share

- The renewable solution for markets with high growth and ambitious renewable targets
- Feasible for combined cycle plants & coal plants
- Abengoa will own, co-own or build the plant for third parties

Benefits of hybridizing operating facilities

- A renewable solution that will reduce renewable needs
- Open the possibility to extend the lifespan of pre-existing facilities
- Provide grid robustness

1 Cheap Contribution reducing fuel volatility

- Cheaper electricity than PV or stand alone CSP
- Reduction of investment on transmission
- Strong impact on RE targets
- Reduction of fossil fuel consumption
  - ↓ Fossil fuel price volatility
  - ↓ Fuel external dependancy

2 Extender of fossil facilities lifespan

- Extend the useful life of the asset under thighter regulation
  - Partial substitution of fossil consumption
  - Full substitution of fossil consumption

3 No impact to the grid and operating facilites

- No Grid impact
  - Solar variability mitigated
  - Pre-existing transmission and grid interconection
- No Facility impact
  - Fossil fuel burnt at the same efficiency
  - No major modifications and hiddle operation for the CSP integration

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Abengoa's proven hybrid technology

In operation

ISCC plant

ISCC in Algeria 150 MWe

- Algeria. Combined cycle with solar trough field already in operation
- 20 MW from solar troughs; the rest from natural gas
- 250,000 m^2 of reflective mirror surfaces
- Heat transfer fluid (HTF) in the solar field passes through heat exchangers to produce high temperature steam
- Ownership by Abengoa and NEAL
- 33,000 t of CO_2 avoided yearly

Our hybrid experience
ISCC plant in Algeria

Integrated solar combined-cycle (ISCC) plant in Morocco

The integrated solar combined-cycle (ISCC) plant in Ain Beni Mathar Morocco, has a total power output of 470 megawatts (MW), 20 MW of which are obtained from a parabolic trough field composed of 224 parabolic trough collectors. The plant is in operation since 2011.

Location: Ain Beni Mathar, Morocco

Owner: Office National de l'Electricite

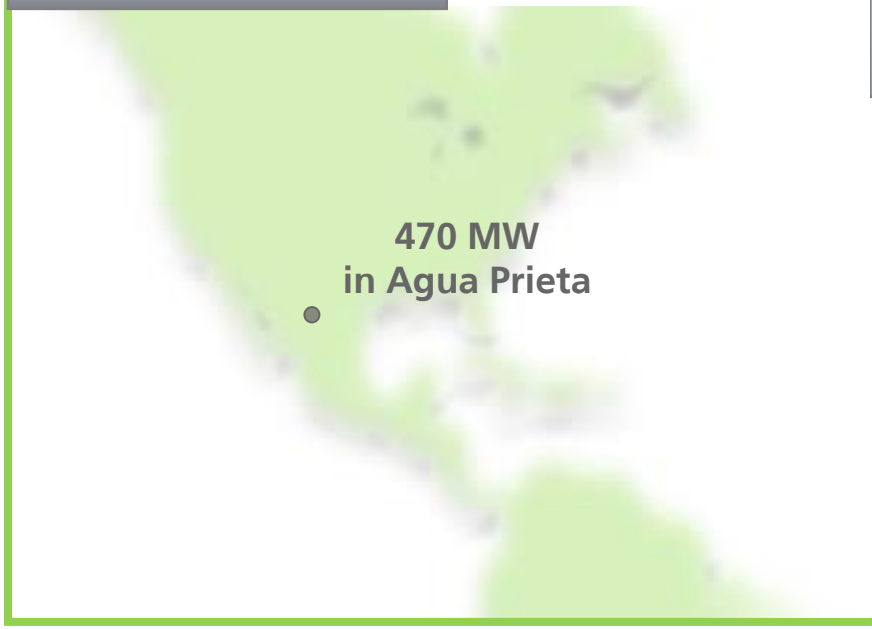
Output: 470 MW

Technology: integrated solar combined-cycle

Solar Field: 180,000 m^2

Agua Prieta project

Under construction



ISCC in Mexico 470 MWe

- 14 MW of trough technology integrated in a natural gas power plant
- Project promoted by the Mexican Federal Electricity Commission
- Supported by Global Environment Facility (GEF)
- Abengoa is in charge of the EPC of the solar field

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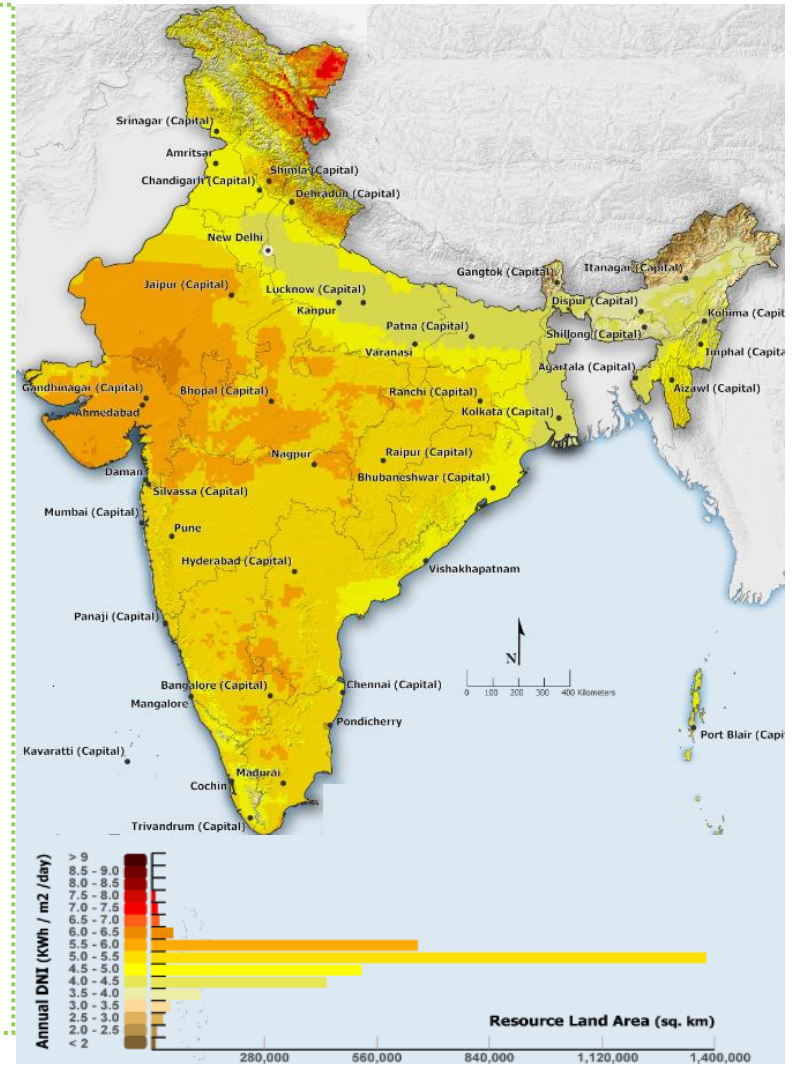
Benefits of hybridization for India

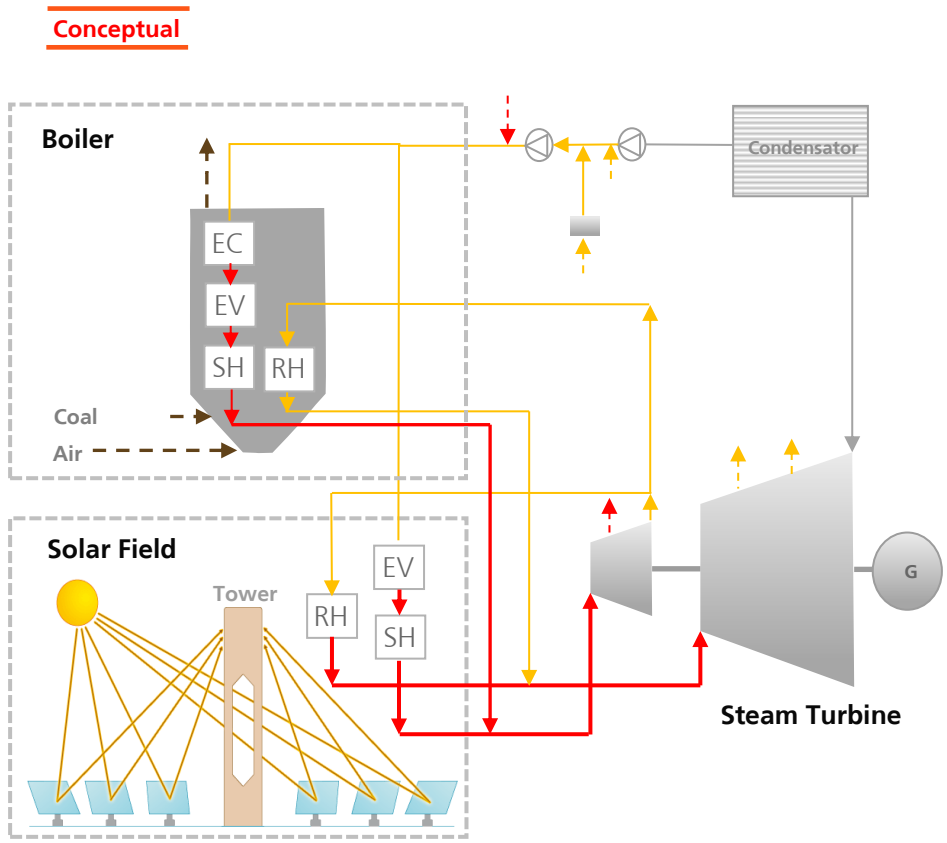
1. A renewable source with high power coverage reliability
2. Technological leadership due to the installation of an innovative cutting edge technology
3. Reduction of CO_2 emissions
4. Local industrial development for the manufacturing of CSP key components
5. Creation of highly qualified local employment during
   - Plant construction
   - Component manufacturing
   - Operation & Maintenance
6. Economic attractiveness of these plants due to the introduction of low cost fossil fuel lowers the overall energy cost from plant.



1.A

Parallel solar operation with coal plant

In case of a coal plant, parallel operation will allow to operate only solar even if the coal boiler is not working



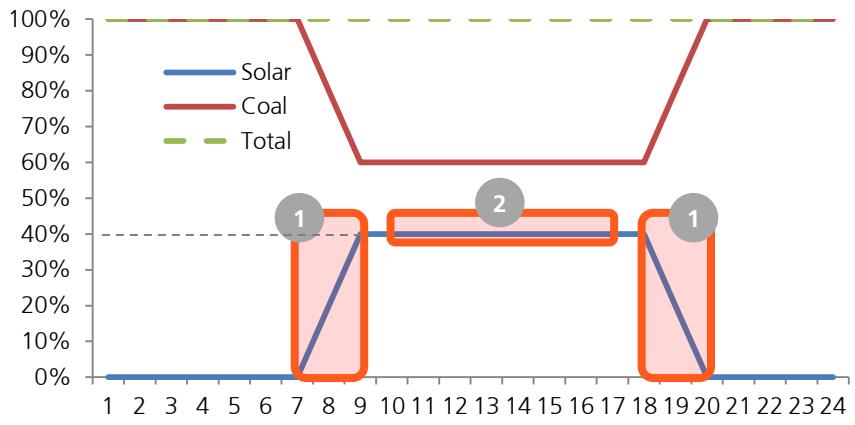
Benefits:

- Will allow the coal plant to operate just solar without coal
- Will not negatively impact the coal efficiency
- High annual renewable percentage
- Inexpensive renewable
- Customized renewable share

1.A

Parallel solar operation with coal boiler

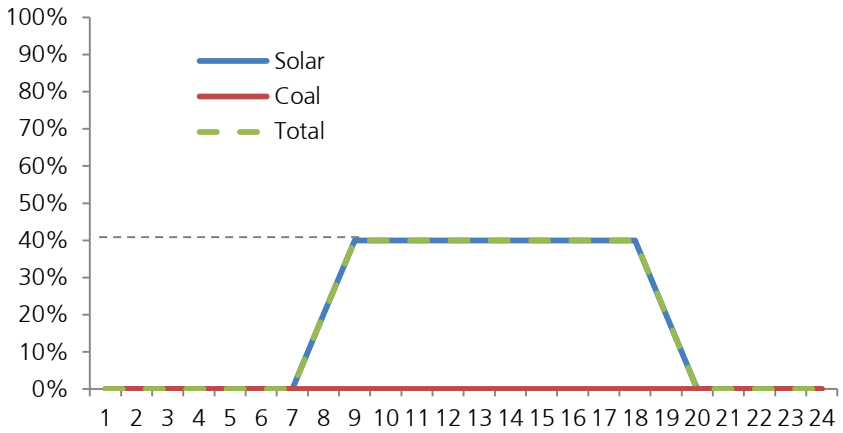
Coal boiler operating



1. Changing the coal feed rate is a simple and proven process
2. The sun variability is mitigated

- During sunny periods, solar energy is injected partly substituting the coal consumption.
- The coal feed rate adjusts according to weather in order to maintain turbine production.

Coal boiler <u>not</u> operating

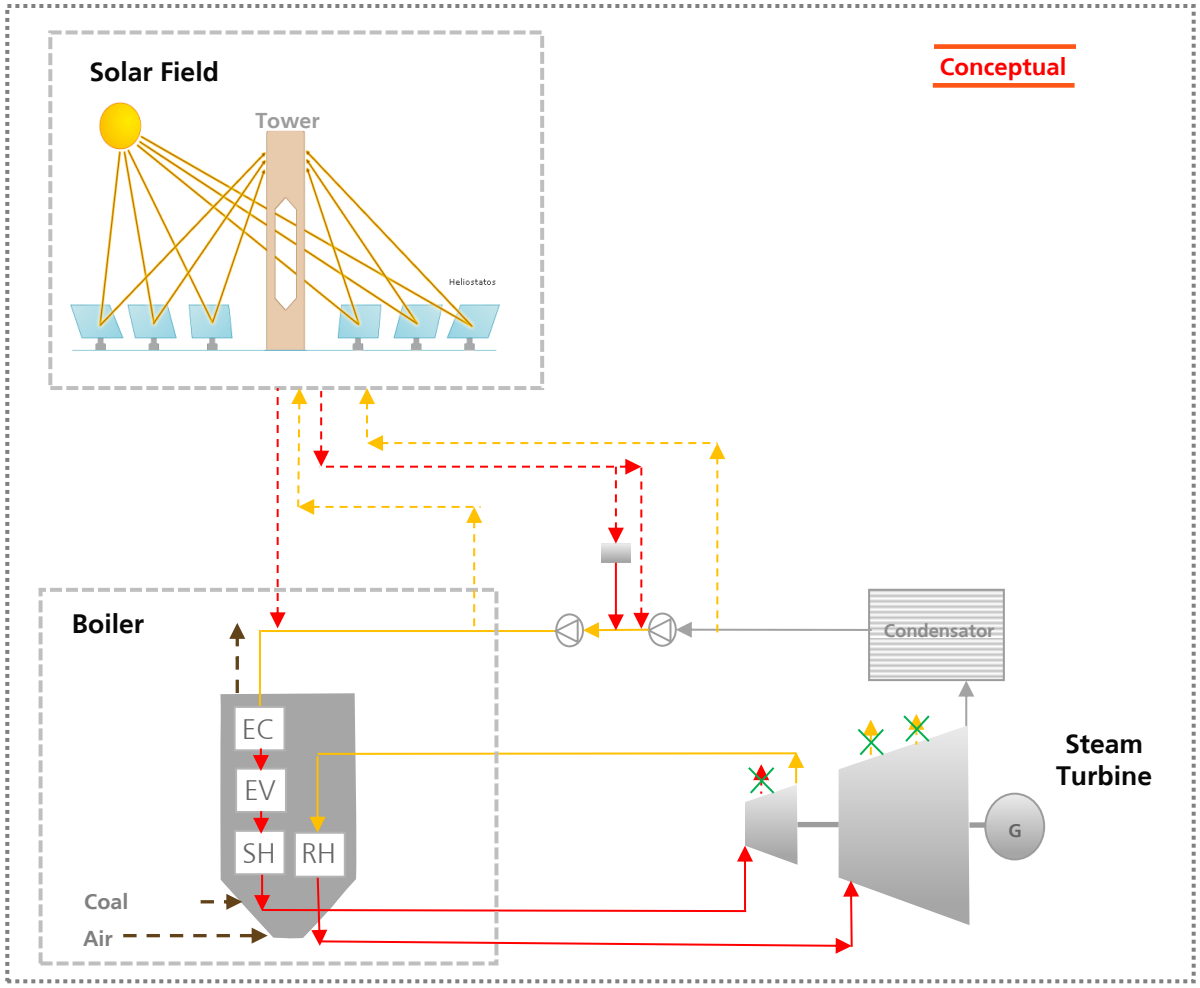


- If the coal boiler is not operating, the solar filed will provide energy so that the facility will operate only solar

1.B

Substitution of preheating in coal plants

Coal consumption could be reduced by substituting extractions with solar preheatings



Benefits

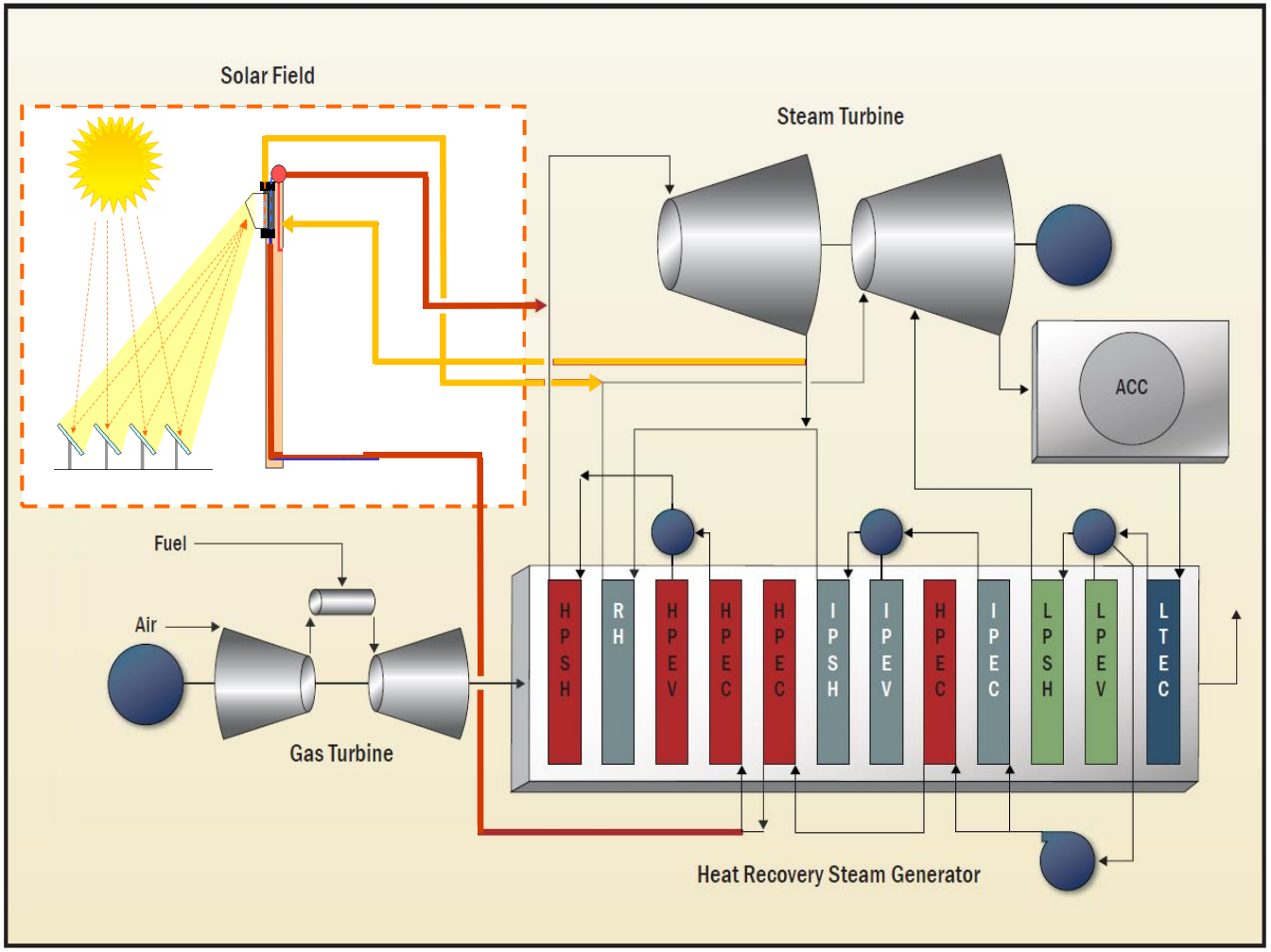
- Could provide a low cost solution per MWhth produced

Drawbacks:

- The solar field will only operate if the coal boiler is operating
- Will provide low renewable percentage depending on the number of extractions that are substituted

2

Parallel Solar operation with Combined Cycle



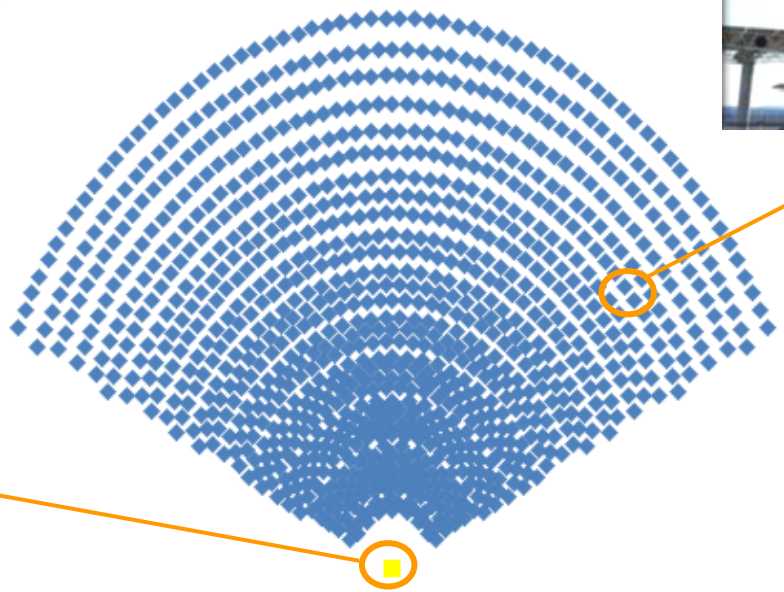
Benefits:

- Lower heat rate
- Will not negatively impact the cycle efficiency
- High annual renewable percentage
- Inexpensive renewable
- Customized renewable share

Hybridization example in India

Example of solar tower plant

- The solar tower technology is composed by a heliostat field and the solar tower.
- Heliostat field reflects the solar irradiation into a fix point (solar receiver) located up in the tower.

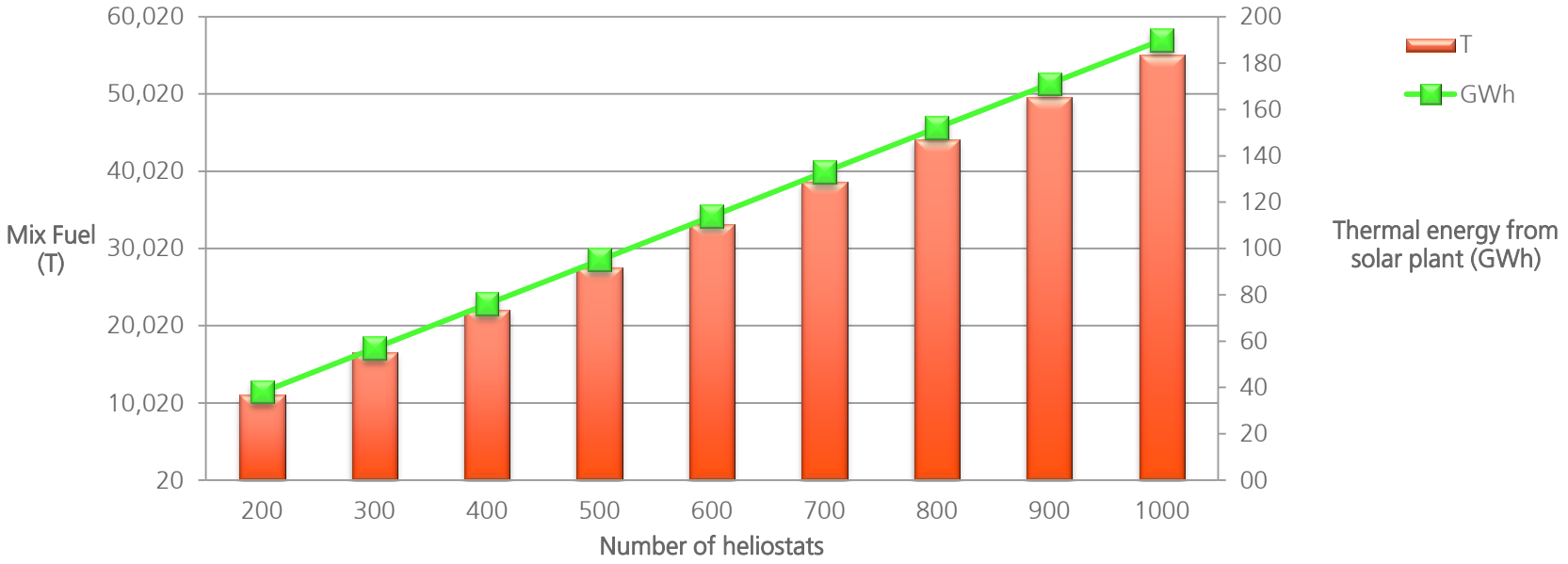


Solar field contribution: fuel savings

Below it is showed the yearly gross amount of coal (tonnes) that is possible to substitute in a coal power plant with the integration of a solar power plant.

The amount of coal that is possible to save with a solar hybridization is related with the size of the solar plant (the number of heliostats).

Also, it is showed the yearly thermal production (Gwh) of the solar power plant:



Results are calculated with a yearly direct normal irradiation of 2175 kWh/m2year and supposing a gross calorific value of the used coal around 3,40 GWth/T.

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Thank you. Questions?

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