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Construction and Operation of Parabolic Trough Collector Plant

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Cristina Prieto
Solar Technology

Abengoa PTC Evolution

Roadmap of PTC Evolution

- **1,500 MW** of PTC designed, built and operated in Abengoa

- Near **10,000,000 m² of mirrors** built and operated in Abengoa
- More than **3,000 loops**

- **220.000 tons** of molten salt melted and operated in TES systems by Abengoa

- **20 turbines** built and operated in PTC plants with oil
- **20 SGS built** and operated in PTC plants with oil

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1 Construction in PTC

Components of PTC

Lessons learned in PTC

Parabolic trough collector → **Solar trough structures (Abengoa capabilities)**

Technical departments involved in Collector development

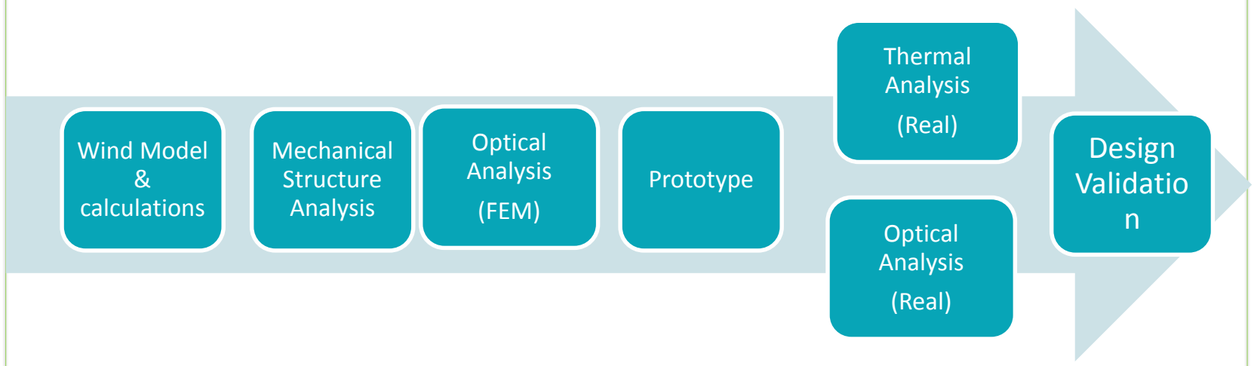
- R&D Engineering
  - Definition of structure
  - Wind tunnel & CFD calculations
  - FEM calculations & 3D Models & Manufacturing drawings
  - Prototypes
- Optical department
  - Optical efficiency calculations
  - Perform procedures for optical evaluations on site
  - Photogrametry measurements
  - Deflectometry measurements
- Manufacturing & quality process
  - MAB Definition and manufacturing line lay-out
  - Assembly procedures (workshop & field erection)
  - Suppliers Quality supervision & process control

Thanks to this organization:

1.The information flows from the final stages in construction and test prototypes to feed the engineering and R&D departments.

2. This allows applying the lessons learnt to adapt the new designs to real needs and minimize manufacturing issues during commercial implementation

3. This result in better quality design and more competitive solutions in terms of cost and assembly time.



Components of PTC

Lessons learned in PTC

Parabolic trough collector

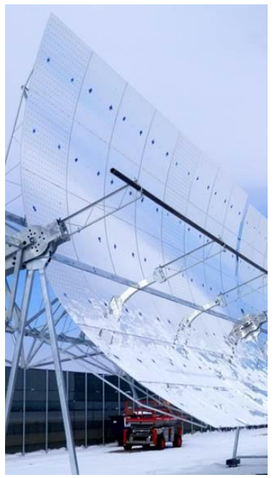
Solar trough structures Evolution

- **E2**
  - The most extended version in plants in USA & SA triangular truss with 12 mts length and 1.65 mts high.
  - This truss support the torsional moment and the bending effect .
  - Element connections designed to improve assembly process

- **ST8.2 (14 mts &16 mts)**
  - Innovative design regarding wider aperture 8.2 mts aperture
  - X-flow wind calculations considered to apply realistic loads to the structure
  - Improved assembly design to reach high efficiencies in manufacturing shop
  - The new design is capable to rotate 240º and to stow in both (east & west) directions
  - Improved thermal efficiency
  - High compactabilty allowing to reduce solar field extension
  - Version of14 mts & 16mts adaptable to different tubes lengths


Collector E2


Collector ST



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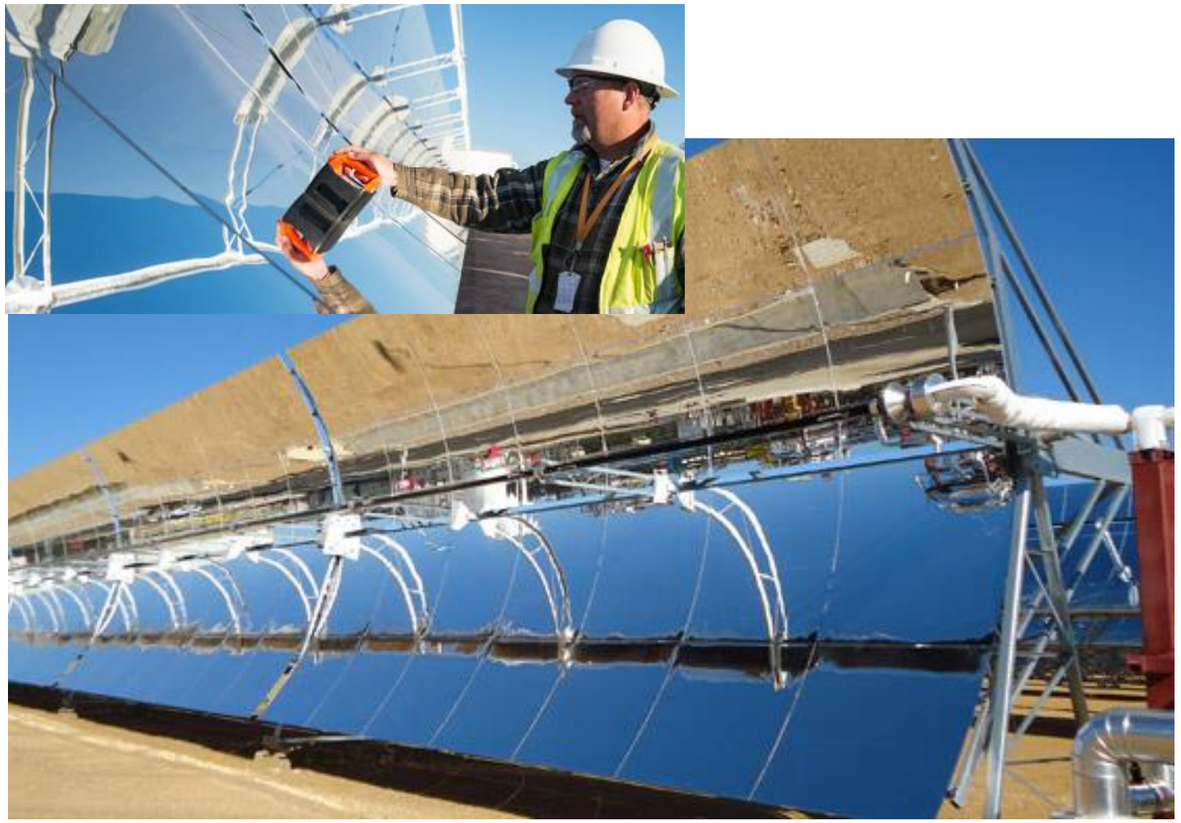
Components of PTC

Lessons learned in PTC

Parabolic trough collector » **Mirrors**

Mirrors

- The guarantee average reflectivity of these mirrors is higher than 94.5 ± 0.2% (according with ISO 9050 standard).
- Automatic Manufacturing Line
- Energy Reflectance Measurement:
  - Spectral hemispherical reflectance in the range from 300-2500 nm
  - Values weighted according to relevant spectrum (ISO 9050)
- Equipment:
  - Ultra high performance
  - Calibration in a yearly basis by external lab (certificate provided)
- Quality Management:
  - Plan of Inspection established (according ISO 9001)
  - Frequency of Inspection: At least 2 measurements per shift



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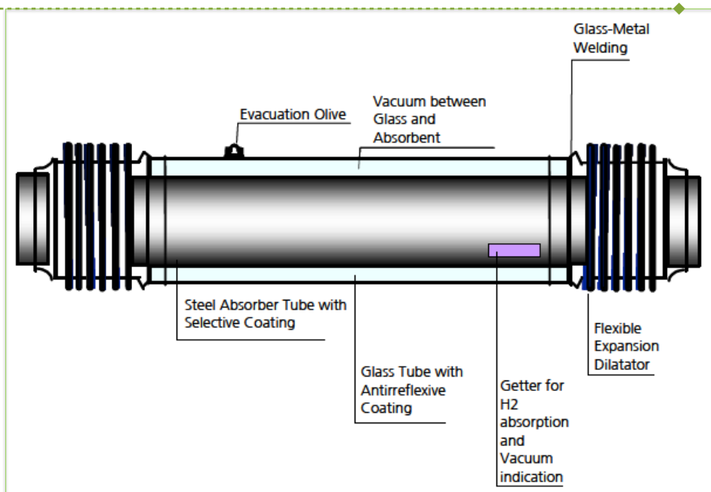
Components of PTC

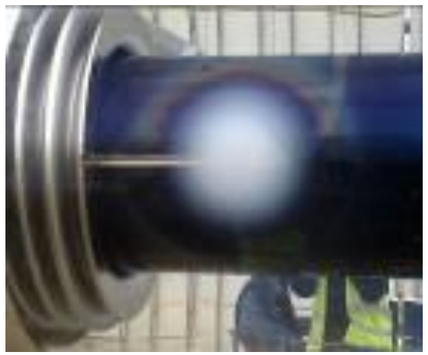
Lessons learned in PTC

Parabolic trough collector » **Absorber tubes**

Absorber tubes

- Assembly on the field with alignment on site and focusing strategies
- Thermal evaluation (Vacuum evaluation and efficiency of receiver (optical and thermal))
- Shield to protect glass-metal welding and increase thermal efficiency
- Cleaning procedure





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Components of PTC

Lessons learned in PTC

Parabolic trough collector >> **HTF system**

Heat transfer fluid

Heat Transfer Fluid (HTF): eutectic mixture of difenil oxide (C6H5-O-C6H5) and bifenil oxide (C6H5-C6H5).

Piping system to distribute the cold HTF and collect the hot HTF coming from the collectors. The main characteristics are:

- Expansion bend to decrease thermal stress.
- Ball joints or flexible hoses to accommodate thermal expansion and allow different movements between collectors.
- Material: ASTM SA 106 Gr B

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Components of PTC

Lessons learned in PTC

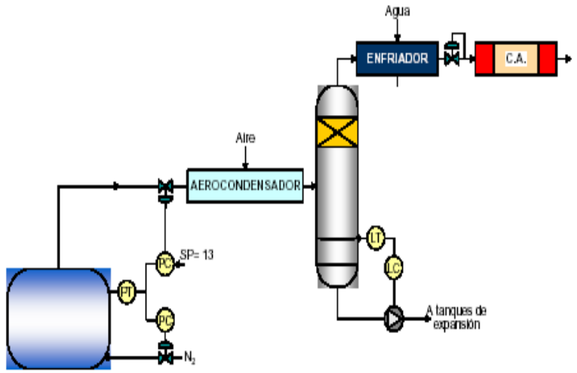
Parabolic trough collector >> **HTF system**

Expansion vessel

- Its main function is to provide fluid expansion due to changes in density (temperature)
- Nitrogen is mandatory
- It also serves as the main venting point of the system (pressure control)
- Very reliable system due to its simple operation and lack of control loops

Ullage system

- Eliminating high boilers from the HTF system
- Recuperating the expansion system vaporized HTF



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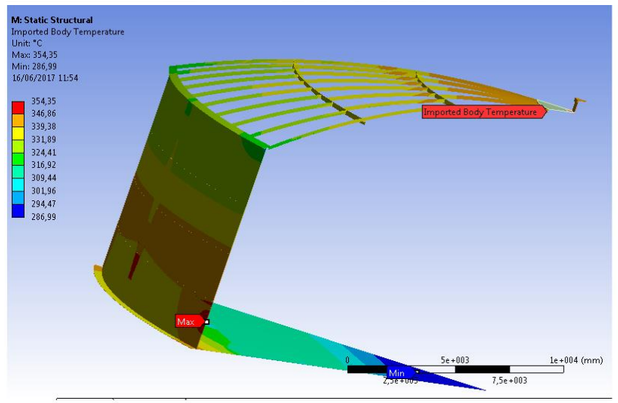
Components of TES

Lessons learned in PTC

Molten salt storage system >> **Molten salt tanks**

Design and construction of molten salt tanks

- Design of molten salt storage tanks:
  - Selection of design codes
  - Optimization of dimensions and thickness:
    - Solana 1+1 : 37 x 11,4m
    - Xina 1+1: 49 x14,8 m
    - Atacama 1+2: 50,4 x 14 m / 36,3 x 14 m (2)
  - Selection of materials
  - Heat losses evaluation
  - Expansion requirements
  - Thermomechanical analysis: Fatigue/ heat losses/ efficiency
- Construction procedures/ welding on site
- Abengoa has designed, built and operated **16 molten salt tanks**



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Components of TES

Lessons learned in PTC

Molten salt storage system >> **Heat exchangers**

Design of heat exchanger

- **Thermomechanical analysis to validate design limits and adjust of operation to fulfill the limits**

  Design of train of molten salt heat exchanger for:

  - High thermal efficiency
  - Low heat losses
  - Drainage procedure
  - Freezing recovery

- **Abengoa has built and operated 9 MS heat exchanger train system**
- Definition of O&M procedure. Control parameter to guarantee design efficiency

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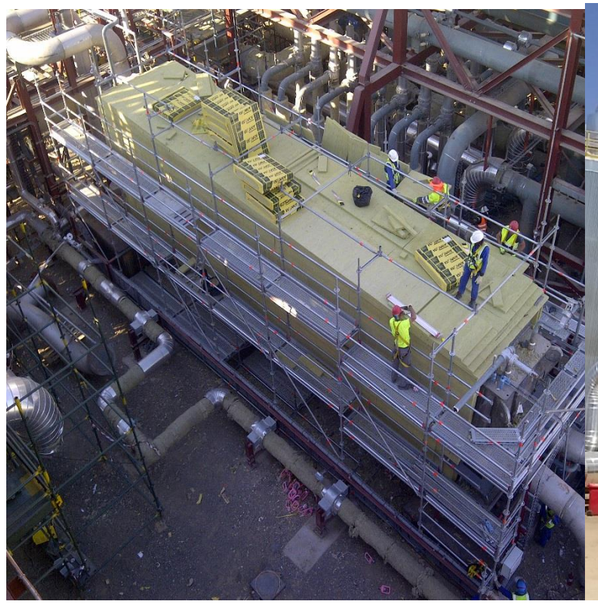

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2 Operation in PTC

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1

Solar Field & Power Block Recirculation

Night operation mode.

2

Warm-up Solar Field and Power Block

HTF System preheating operation mode.

3

Solar production only

All the amount of energy absorbed by the Solar Field is transferred to the water-steam cycle and then to the Turbine in order to generate electricity.

4

Production from Solar Field + accumulation charge (operating priority)

The daily weather forecast points out there is enough energy to operate full load and accumulate thermal power at the storage tanks reaching its full capacity. Net generation is prioritize and the TES System stores the energy surplus.

5

Production from Solar Field + accumulation charge (accumulation priority)

The daily weather forecast points out there is NOT enough energy to operate full load and accumulate thermal power to reach the needed level to operate during all the priority period. Energy sent to accumulation and energy sent to electric production is balanced to maximize production on priority period.

6

Solar energy to accumulation

Thermal energy delivered by the Solar Field goes to the TES System to be stored.

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7

Production from both Solar Field and accumulators

There is thermal energy delivered by the Solar Field but the turbine is not working at full capacity. Also, the accumulators contributes to the power generation.

8

Production from accumulators only

The molten salts accumulated on the Thermal Energy Storage System is working as the energy source. The turbine load is set to maximize the production on the priority hours considering the thermal power accumulated on the storage tanks.

9

HTF antifrezzing with heaters

HTF heaters are turned on due to a HTF freezing hazard.

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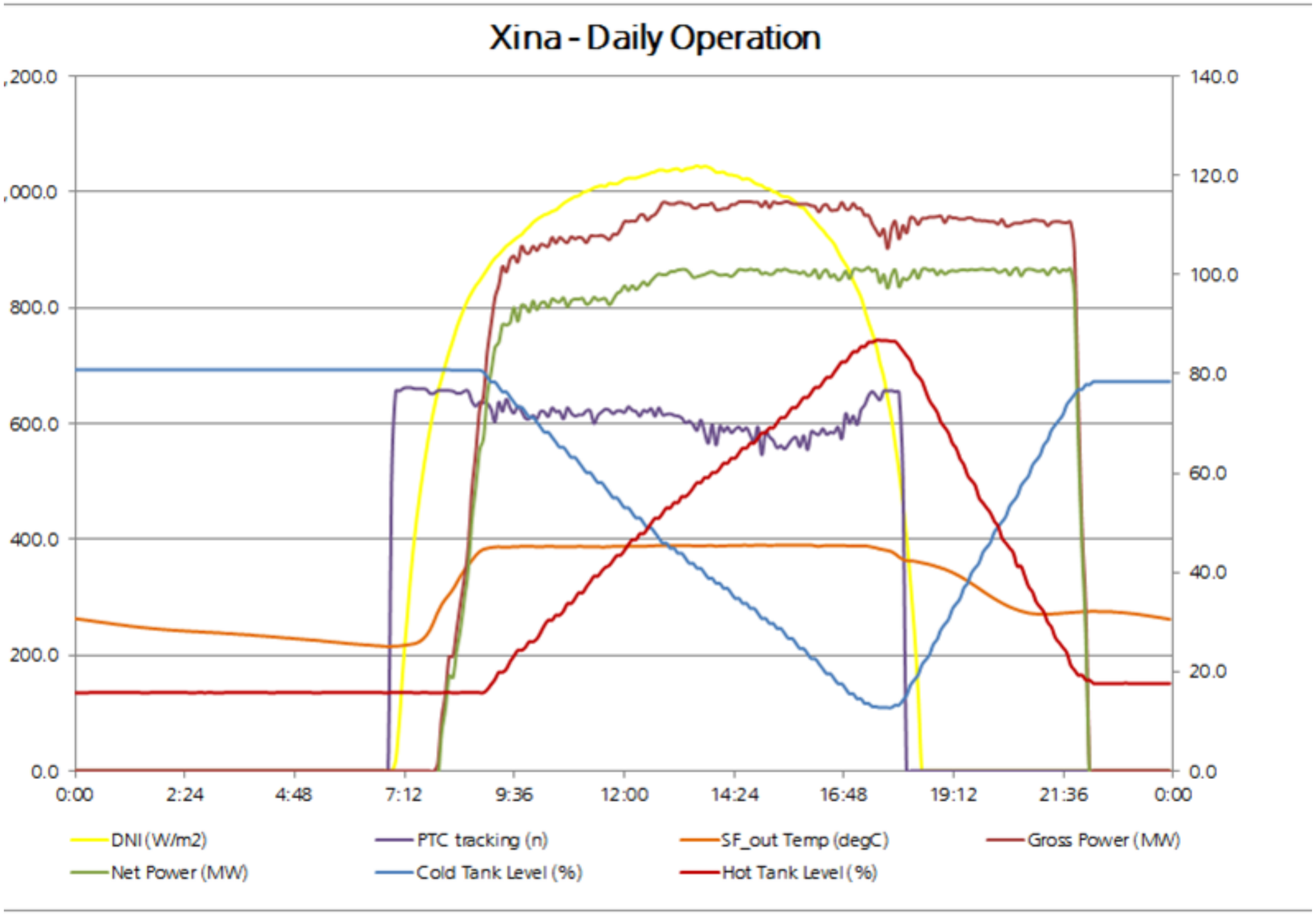
Xina typical operation day



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3 Relevant pictures PTC

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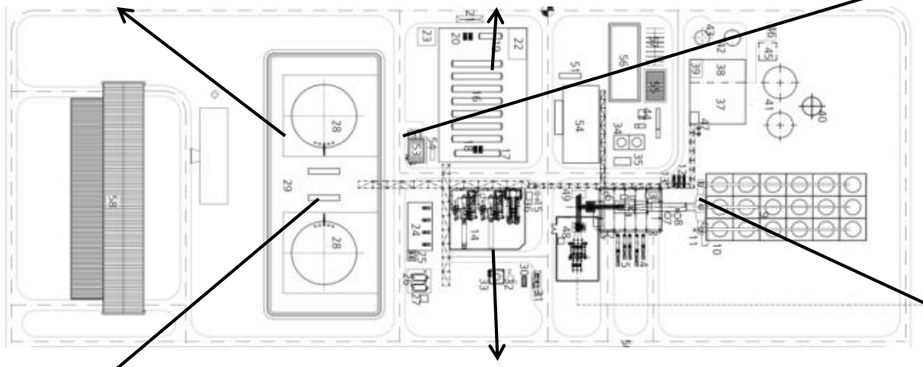
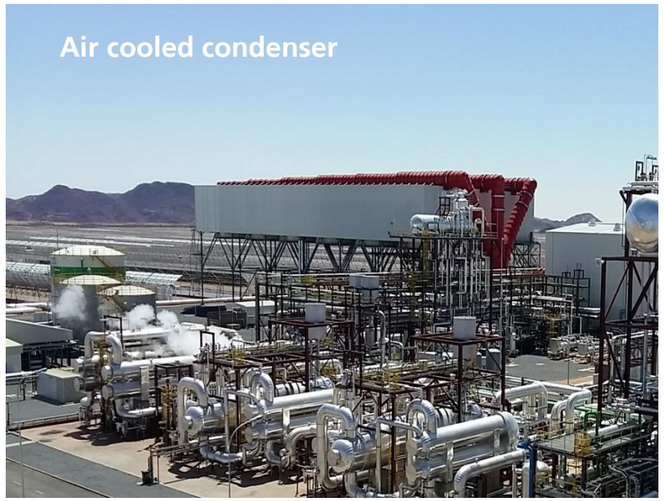
100 MW Xina power island and storage system

Molten salt tanks





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Xina solar field

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Thank you

Cristina Prieto
cristina.prieto@abengoa.com