



ABENGOA

Constructing CSP Plants in the Kalahari Desert

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SolarPACES Symposium**
17 July 2014
Stellenbosch, South Africa



SOLAR THERMAL ENERGY
RESEARCH GROUP

17 July 2014

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Abengoa

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Why CSP for South Africa?

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100 MW Kaxu Parabolic Trough Project

4

50 MW Khi Superheated Tower Project

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



We are a global solar power company that offers proven proprietary technologies and uses them to develop, own and operate power plants. Our EPC is carried out by Abeinsa, a company within Abengoa



- More than **twenty year commitment** to the development of both CSP and PV technology
- **Portfolio of 1961MW** (excl development) - making us the largest owner and operator of CSP plants world-wide
 - **1211MW in commercial operation,**
 - **430MW under construction and**
 - **320MW in pre-construction**
- **Proprietary solar technologies** (parabolic trough, tower, thermal storage, high concentration photovoltaics, hybrids)
- A **world class team of solar experts**, with unsurpassed collective experience and skills and more than 800 professionals worldwide

ABENGOA SOLAR

Our projects

Europe

693 MW

- **PS10 & PS20**, the first and the biggest commercial solar power towers in operation worldwide
- **Solnova 1, 3 & 4, Helioenergy 1&2, Solacor 1&2, Helios 1&2, Solaben 1, 2, 3&6**: 13 parabolic trough plants in operation (50 MW each)
- 5 photovoltaic plants in operation

U.S.A.

560 MW

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

MENA, Africa & Latam.

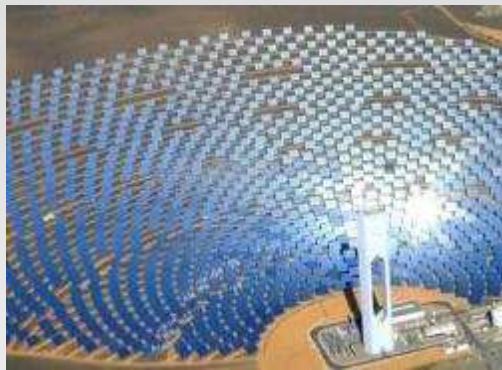
720 MW

- **Hassi R'mel (Algeria)**: 150 MW ISCC hybrid plant in operation
- **Shams-1 (Abu Dhabi)**: 100 MW parabolic trough in operation
- **Kaxu Solar One & Khi Solar One (South Africa)**: 100 MW trough and 50 MW solar power tower under construction
- **Xina Solar One (South Africa)**: 100 MW parabolic trough with 5 hours of storage, in pre-construction phase.
- **Ashalim (Israel)**: 110 MW parabolic trough with thermal storage, in pre-construction phase.
- **Cerro Dominador project (Chile)**: 110 MW tower plant using molten salt technology with 17 hours of storage, in pre-construction phase.



Abengoa Solar is a global solar power company,
technology provider, developer and operator

Solar thermal



Solar towers



Trough plants

Hybrid plants



Solugas



Conventional + solar

Photovoltaic



HCPV



PV

Technology as a competitive advantage for Abengoa

R&D

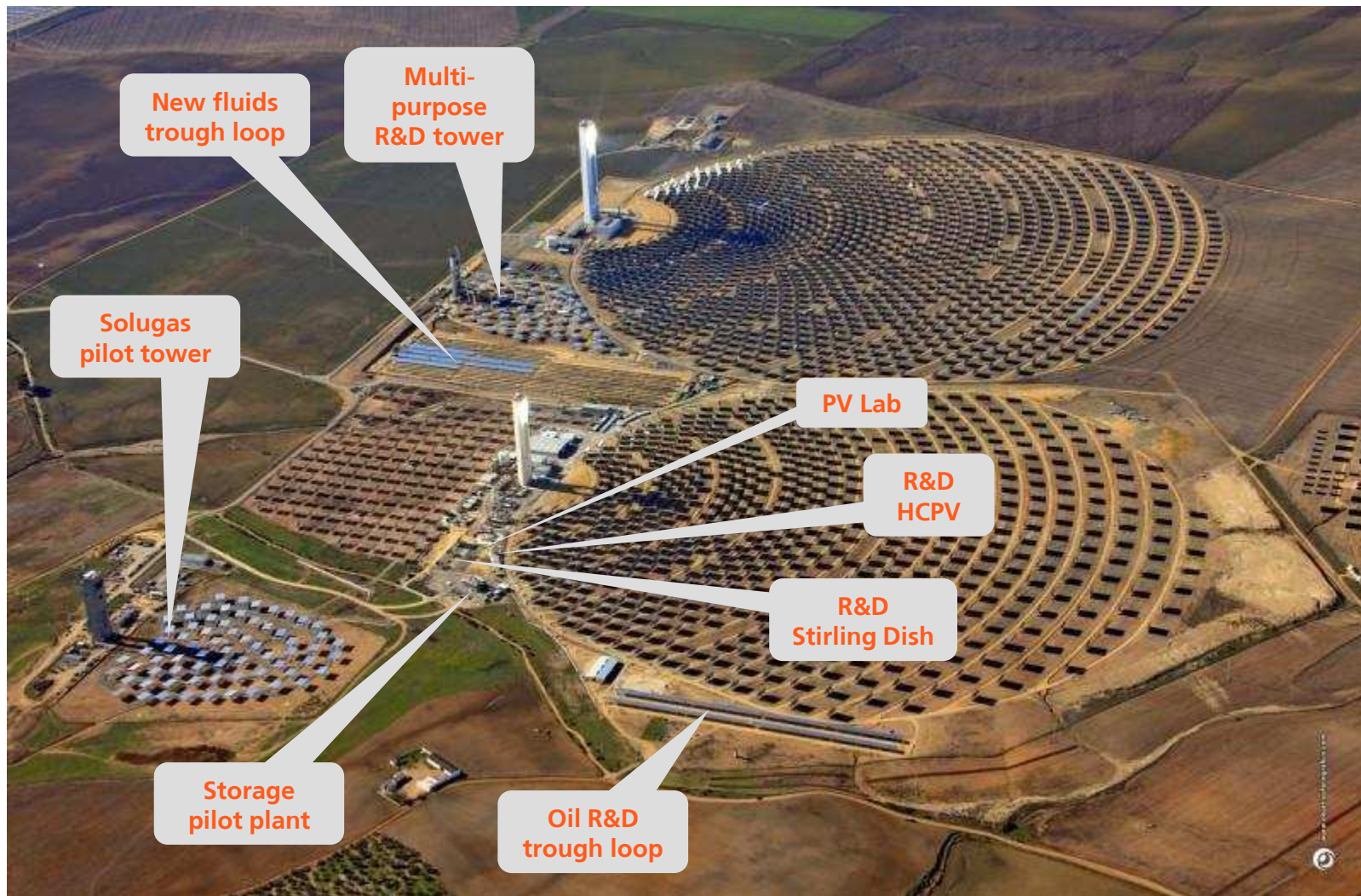
Pilot plant or real test

Commercial project

- >150 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



Solúcar Complex is a world reference: a unique solar complex that combines operating and pilot plants of several technologies, as well as a R&D center













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Enabler of other technologies: CSP adds value to regulators and utilities by increasing the security of the energy supply

CSP helps to hedge against the volatility of fossil fuels

- By offering a cost effective alternative to conventional power plants

CSP helps to increase the share of renewables in the local energy mix

- By offering dispatchable energy that can backup wind and PV

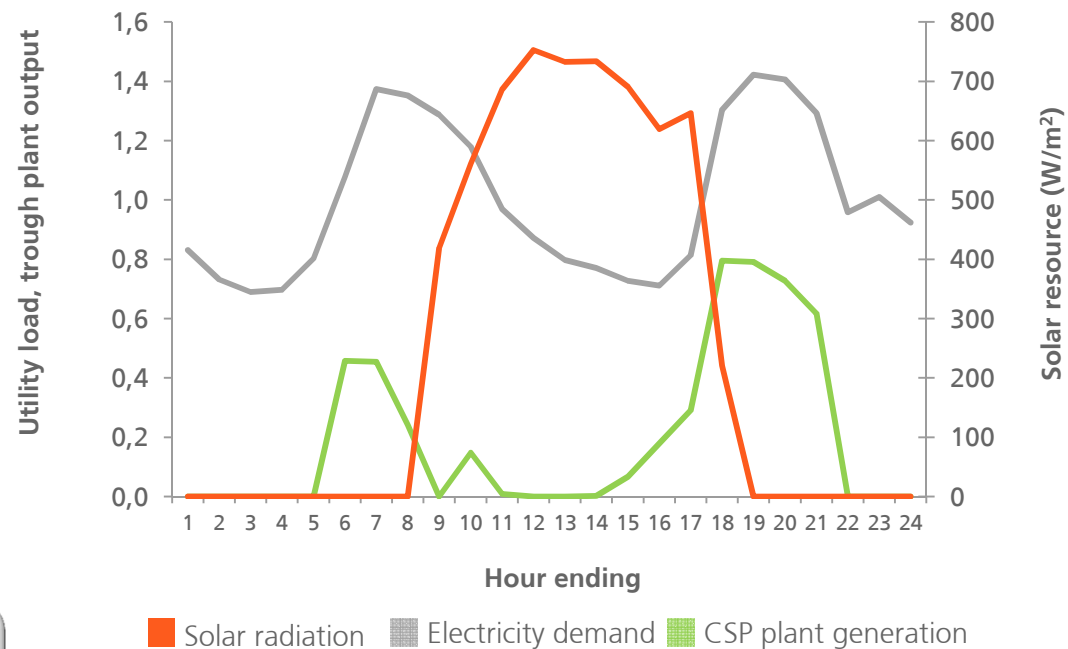
CSP helps to boost local industry and create jobs

- 40% local content and qualified job creation

Dispatchability : Main advantage of CSP over other renewable energies

Solar radiation vs. demand vs. generation

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



Heat storage

Hybridization

No storage system for PV or wind power has been commercially deployed

CSP technology adds value to utilities by generating energy on demand

Our storage solutions

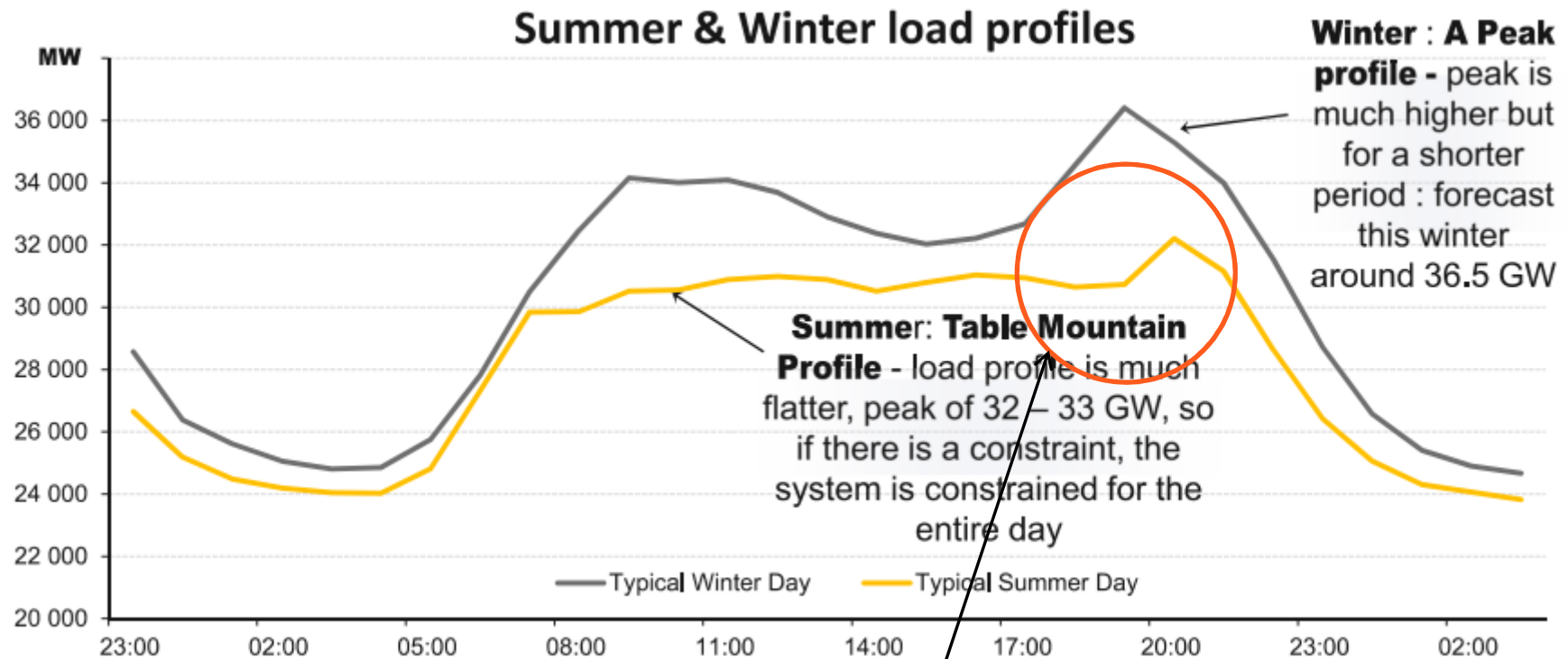
Thermal storage

Steam accumulators



Molten salt tanks





Source – State of the Power System Quarterly Update; Brian Dames (Eskom)

Critical 5 hour evening peak – currently met with diesel or some pumped storage

Showcase South Africa

Request for qualification and proposals for new generation capacity under the ipp procurement programme

- First call in August 2011 provided for procurement of 3725MW in five different rounds, including 200MW CSP
- In December 2012, the DoE determined that a further 3200MW of renewables generation capacity was to be procured
- An additional allocation of 200MW for CSP was made available for bidding in Bid Window 3, and another 200MW for CSP in Bid Window 3.5
- 200MW in 3 CSP plants of rounds 1 and 2 are under construction now
- 200MW in 2 CSP plants of round 3 have been awarded and are closing finance
- 200MW CSP of round 3.5 will be awarded this year



energy

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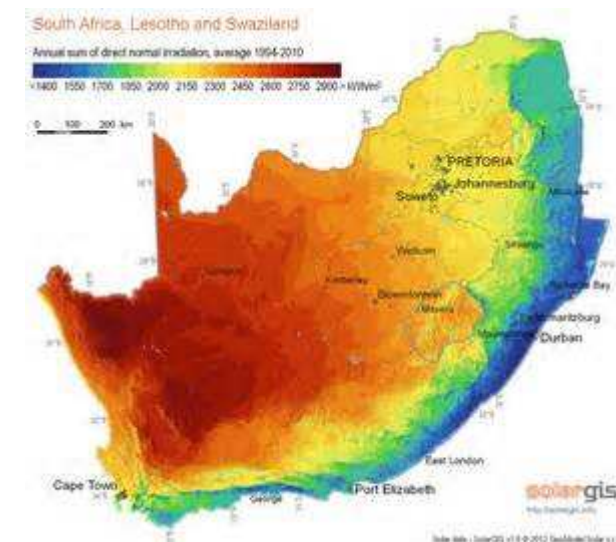
South Africa Keys to Success

- RfP Schedule for Publication, Evaluation, Award and Financial close was strictly kept
- Very detailed and well prepared RfP documents
- Government backs up offtaker Eskom in Direct Agreements with lenders, to step in if offtaker fails
- Bidders were required to have land, resource qualification, all servitudes and permits, technical and legal due diligence done and submit committing support letters from equity and loan providers that allow fast closing after award
- Transparent and secure legal framework for the acquisition or long term lease of project land by private national and international investors
- Transparent and efficient process for award of grid connection
- Transparent and efficient processes for obtainment of permits and licenses



energy

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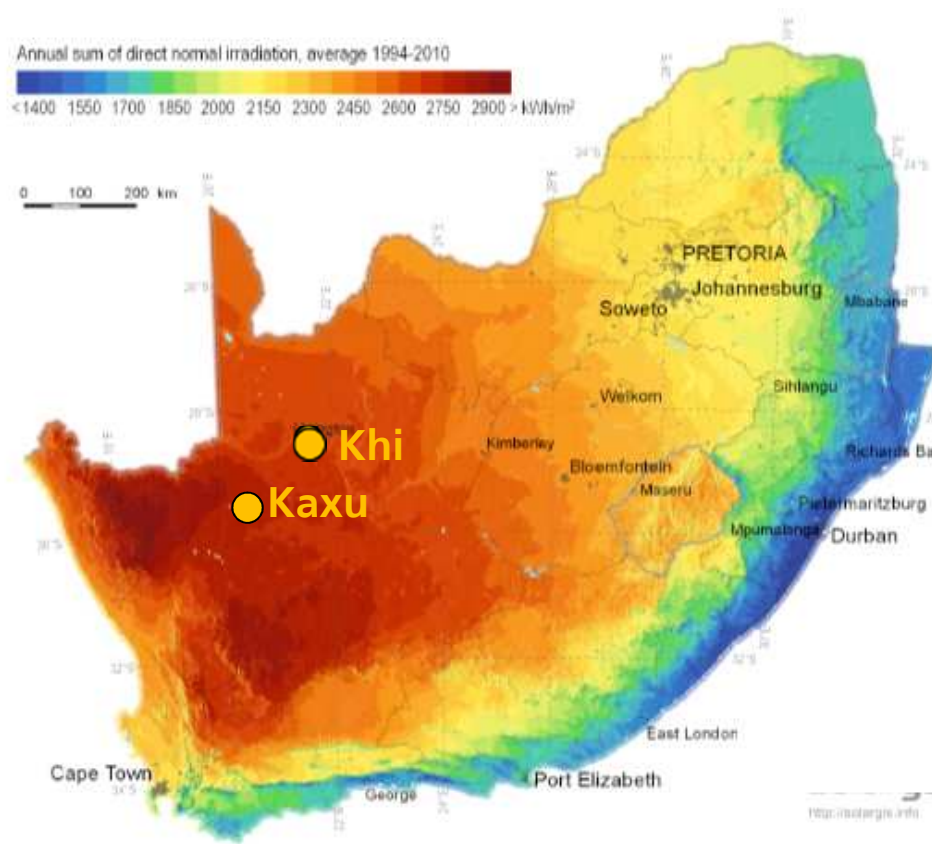


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Two CSP Projects under Construction

100MW Kaxu Parabolic Trough

50MW Khi Superheated Solar Tower



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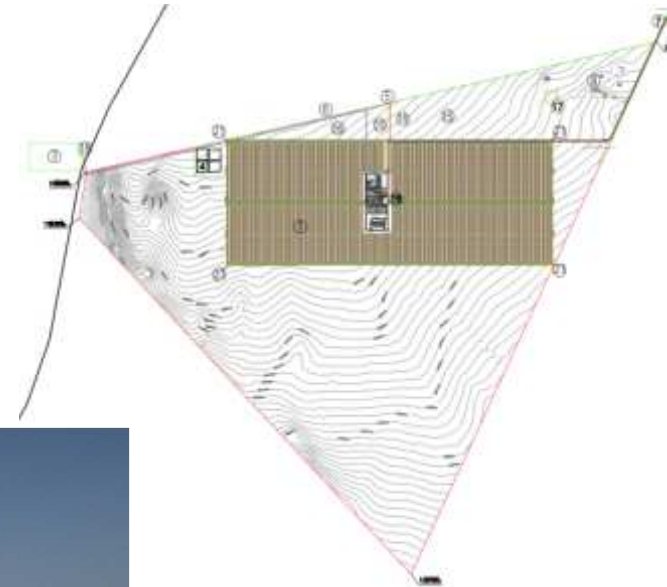
50 MW Khi Superheated Tower Project

100 MW Kaxu to start operation in 2014



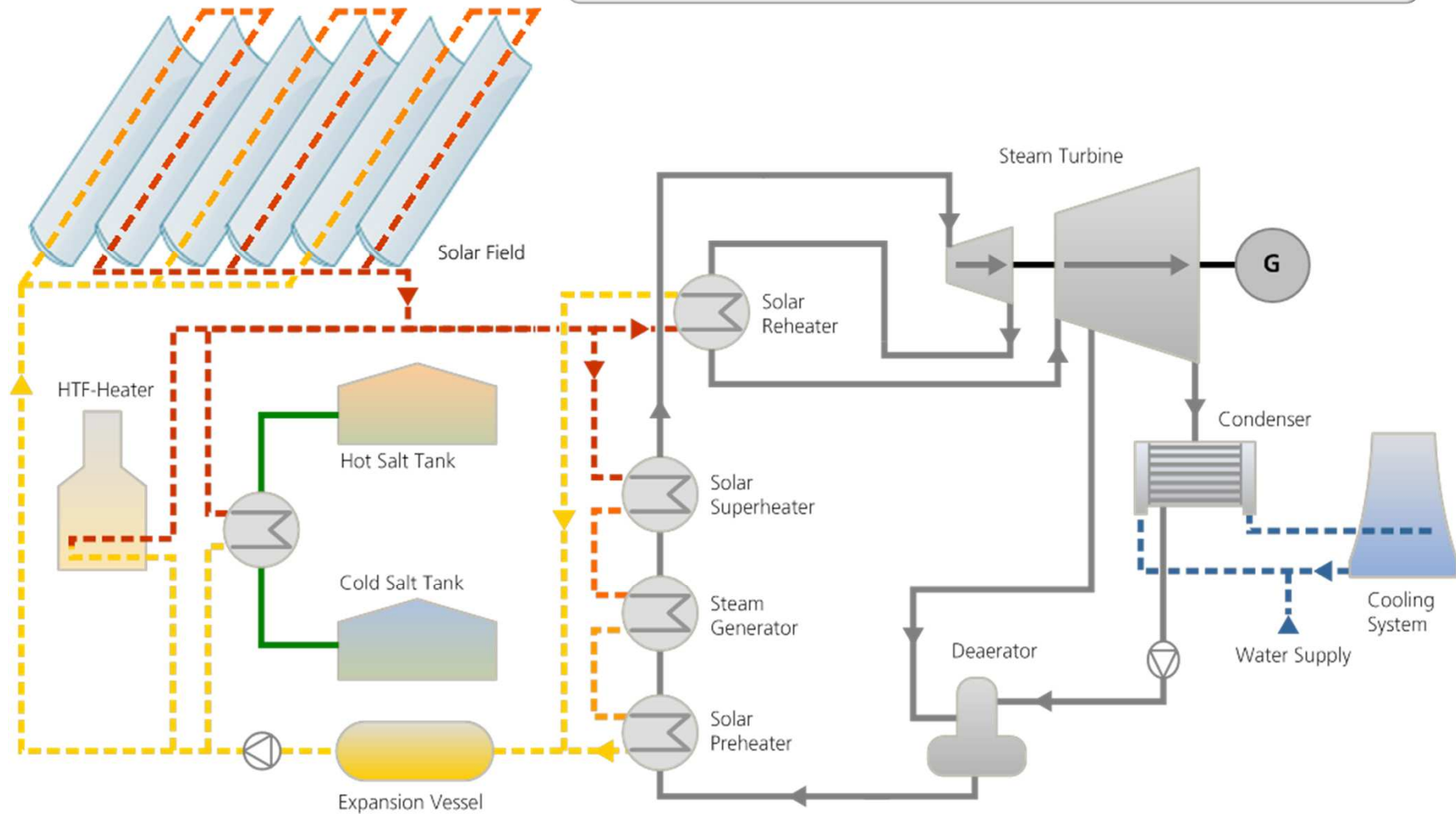
Kaxu project details

- Located app 40km NE from the town of Pofadder – !Khai Ma municipality.
- Capacity of 100MW.
- 2.5 hours of molten salt storage.
- 12,000 parabolic trough modules, 1200 collectors.
- Construction initiated in November 2012.

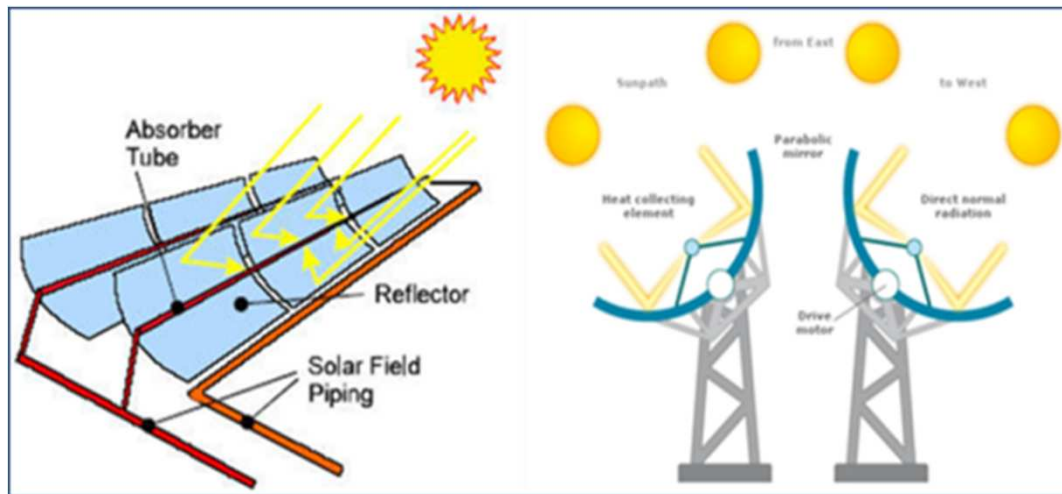


Kaxu Solar One construction site

General trough plant overview



Parabolic trough principle



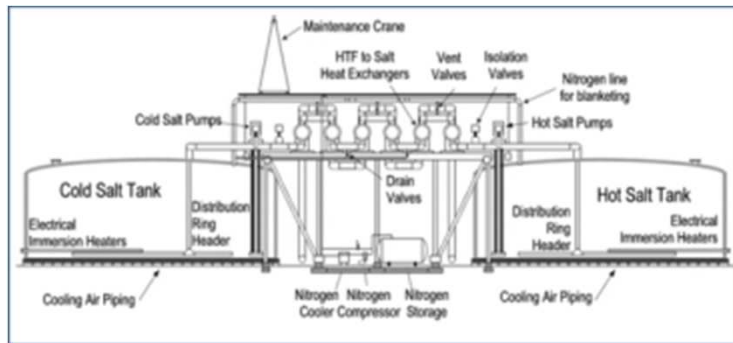
The concentrated solar irradiation heats up the HTF circulating inside the absorber tube, converting the direct solar radiation into thermal energy. This optical concentration process only uses direct solar irradiation and requires continuous sun tracking of the collector during sunshine hours to achieve maximum possible collection of the solar radiation at any time of the day

Mirror washing



- Two different types of cleaning depending on the track arm used:
 - Scrub cleaning
 - Deluge cleaning
- Common characteristics:
 - High water pressure
 - Nozzles to spray the absorber tube
 - Control system for automatic arm movements
 - Camera and lighting system

2-Tank molten salt storage system



- 2,5 hours storage capacity
- 2-Tank molten salt storage
 - 291°C cold tank temperature
 - 381°C hot tank temperature
 - ca. 20.000t of eutectic salt, binary mixture of NaNO_3 and KNO_3 , with a melting temperature of 221°C

Kaxu Solar One powerblock

HTF expansion vessels



Molten salt storage tanks

Water storage and cleanup



Air cooled condenser



HTF pumps

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Steam generators

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Kaxu project – construction information

- As of end of June the project is app 90% complete, with all of the 12,000 trough modules installed.
- All major plant components have been installed on the site. If the good progress continues, the project may reach its COD some several months before the scheduled date, but this is not confirmed.
- The project has done very well in terms of employment created and economic contribution to the region:
 - 91% of subcontracted companies are South African, from which 26% are from the Northern Cape.
 - Employment on the site peaked at more than 1200 jobs.
 - More than 700 of these positions were filled by workers from local communities.
 - Local content and preferential procurement has to date exceeded our estimations and commitments.



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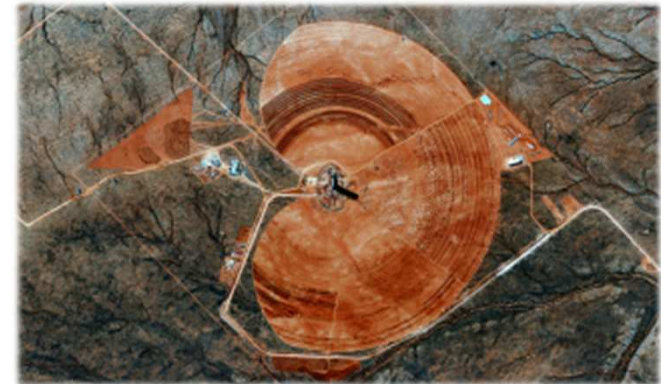
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50 MW Khi Superheated Tower Project

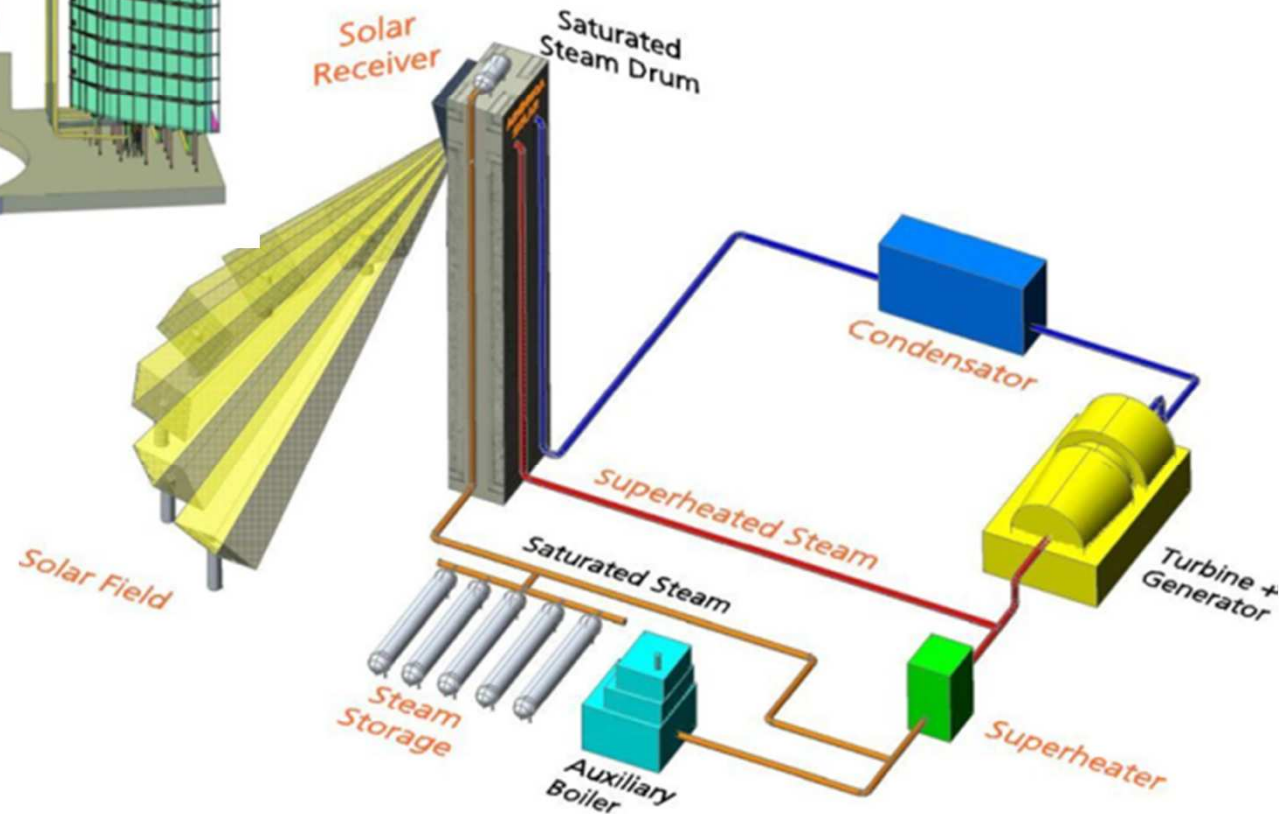
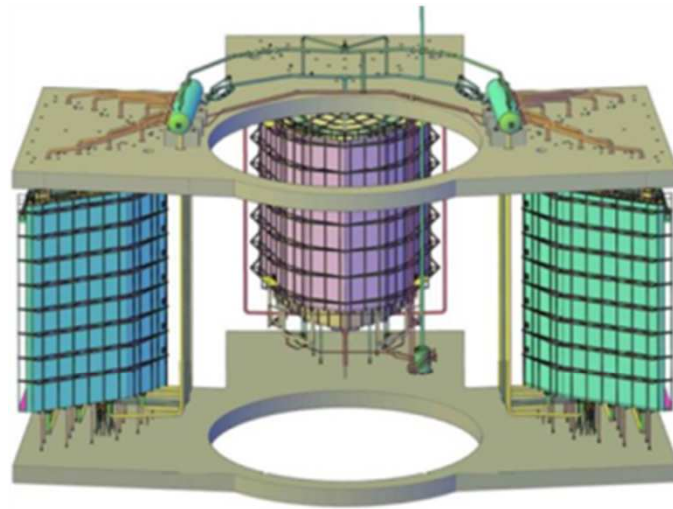
Khi project details

- Located app 20 km SW from the town of Uptington – Kai Garib Municipality.
- CSP Tower, with steam receiver.
- Capacity of 50MW and app 2.7 hours of steam storage.
- Some 4100 heliostats, of 140m².
- Construction initiated in November 2012.

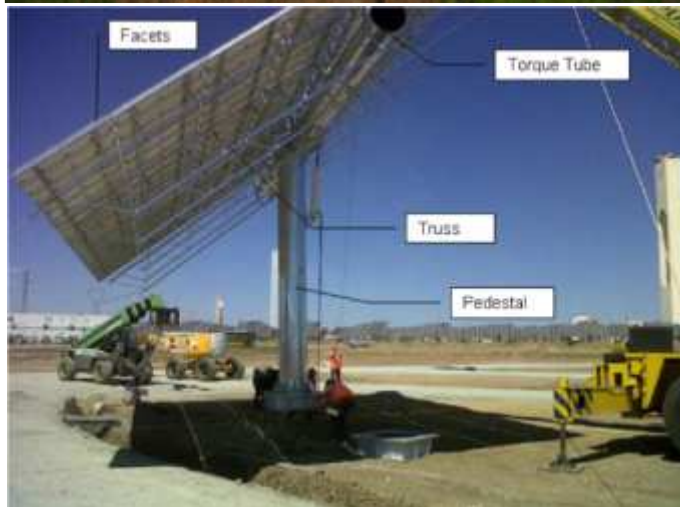


Khi Solar One construction site

Innovative superheated steam receiver

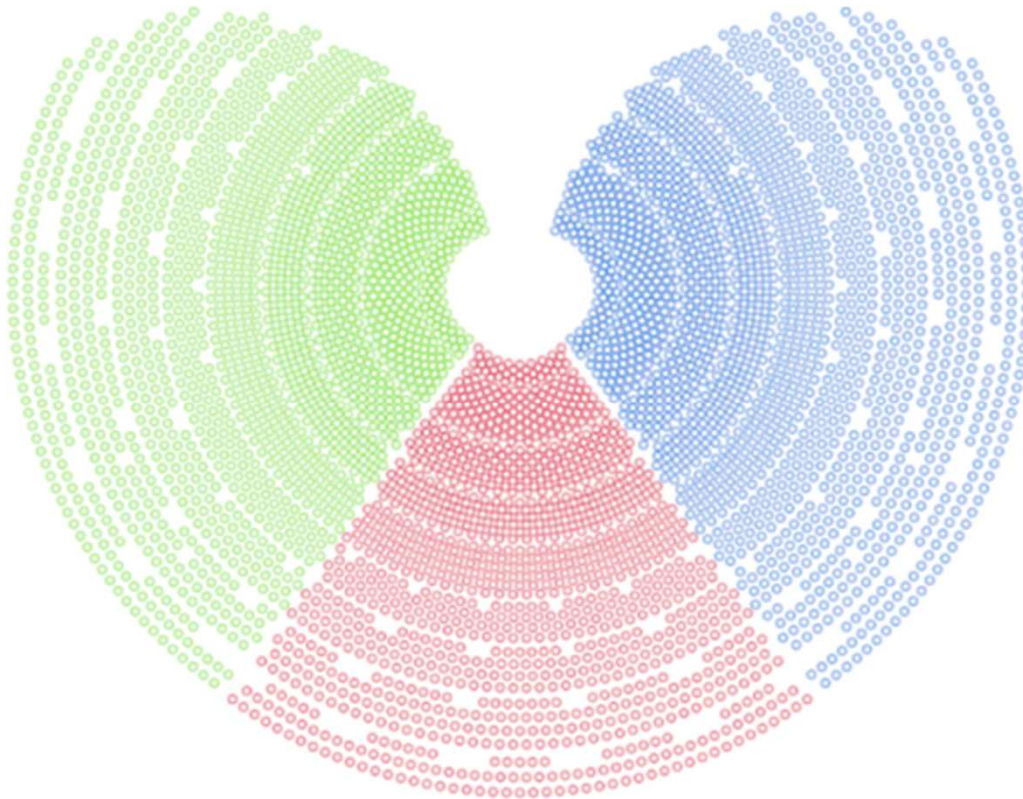


Heliostats



- The heliostat is used to maintain continuous focus of the direct solar radiation on the receiver while energy is being collected.
- Heliostat: a mirror mounted on an axis moved by clockwork, by which a sunbeam is steadily reflected to one spot.
- Components of the heliostat
 - Mirror
 - Structure
 - Tracking system
 - Control system

Khi heliostat field layout



- The Khi heliostat field is divided in three sections oriented to South, East and West
- It comprises 4,120 heliostats of 140 m² each with a total reflective surface of about 571,320 m²

Steam storage



Turbine & generator

Plant substation



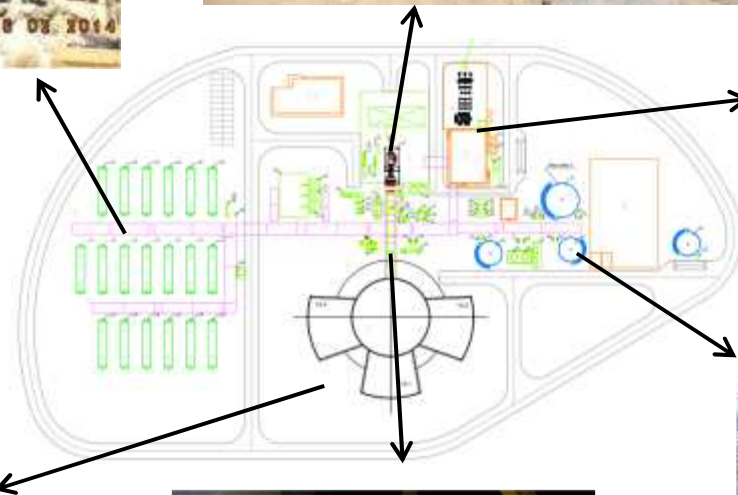
Water reservoir and clean up



Tower



Turbine exhaust



Khi project – construction information

- As of end of June the project is over 80% complete, with all 4100 heliostats installed.
- Progress has been acceptable, given the complexity of working at a 200m height. It is expected that the project will reach its scheduled COD.
- The project has done very well in terms of employment created and economic contribution to the region:
 - 93% of subcontracted companies are South African, from which 44% are from the Northern Cape.
 - Employment on the site peaked at more than 1000 jobs.
 - More than 800 of these positions were filled by workers from local communities.
 - Local content and preferential procurement has to date exceeded our estimations and commitments.



What has experience shown us regarding construction

- There is a learning period, where the international technology supplier has to understand the local rules and environment.
- It takes some time to identify local companies that gel with international suppliers. Some do, some don't.
- CSP EPC and specifically international experience is invaluable. If you haven't done this before you will struggle. As such a proven EPC and technology supplier is critical.
- Labour does exist in these remote areas.
- Local content can be increased if we could move past once-off projects. Often, producing a once-off order locally is more expensive than importing internationally.



The Rioglass factory in Upington manufactures the panels for the Khi heliostats and employs some 80 local people