CSP in India- an AREVA perspective

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AREVA Solar India




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Statutory Statement

Statutory Statement: This is an overview presentation and no part of this can be considered as a quote to the press ; however ,the esteemed members of the press are requested to approach for a focused interaction to get more insights or quote from an organisation stand point. We will be happy to address the same. We have collated just the Estimates, expectations, and business plans in this. It may have forward looking statements.Actual future results, including project plans, capacities, costs, and schedules, could differ materially due to changes in market conditions political developments. This is an overview and my views are from an industry standpoint.

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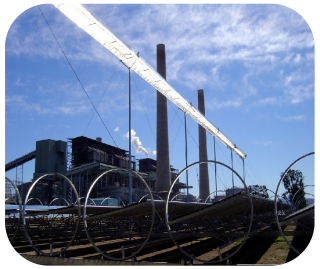
1. **AREVA at a glance**
2. **Myths and facts about CSP in India**
3. **Solar steam generators**
4. **CLFR in action**







AREVA Group offers one-stop solutions for carbon-free power generation

World leader in nuclear power and major player in renewable energy

Bioenergy Power Generation

More than 100 bioenergy plants built by AREVA worldwide

2800 MWe

Offshore Wind Power Generation

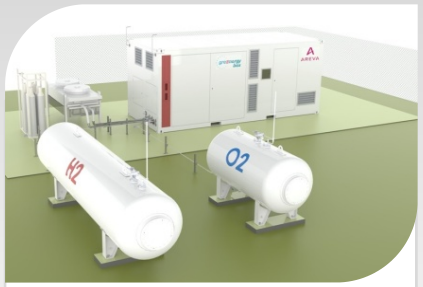
250 AREVA wind turbines chosen for use in offshore wind parks in Europe

1200 MWe

Concentrated Solar Thermal

Most cost-effective, utility-scale turnkey concentrated solar power (CSP) solution

300 MWe in operation/ construction



Hydrogen & Storage

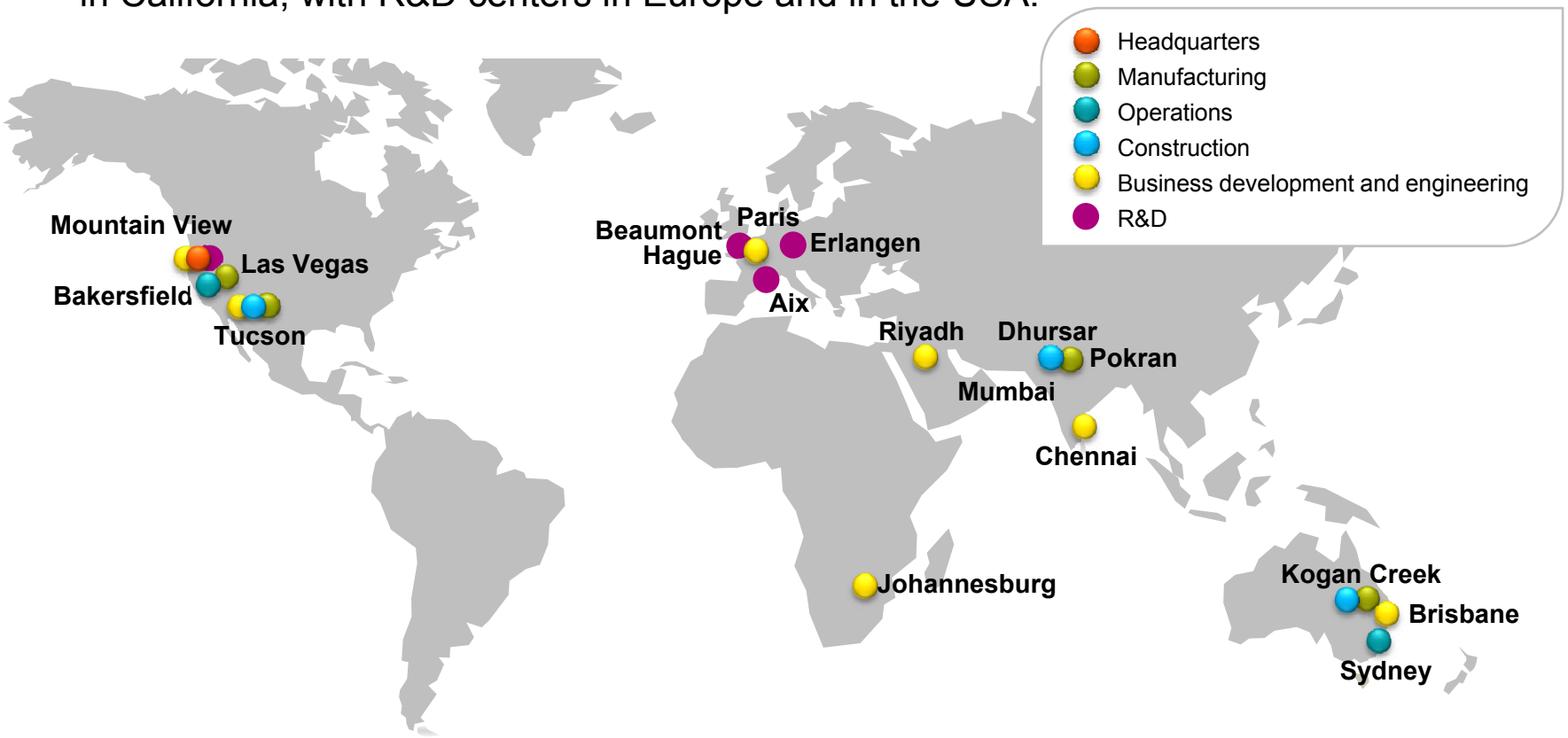
Energy Storage solutions with GreenergyBoxTM and Myrte fuel cell system

100 kWe

Source: AREVA

AREVA Solar
Across the Globe

- AREVA Solar, a global Business Unit of the AREVA group, is headquartered in California, with R&D centers in Europe and in the USA.



Specializes in the design, manufacture and installation of steam-generating solar systems for power generation and industry

AREVA Solar
Projects track record

- AREVA Solar currently has close to 300 MW of CSP projects in operation, under construction or in advanced development

First coal/solar booster prototype	Booster 3 MWe	Prototype
Construction of world's largest coal/solar booster	Booster 44 MWe	Construction
First CSP plant commissioned in the USA in 20 years	Stand-alone 5 MWe	Operation
High-temperature booster demo for additional applications	Booster 5 MWe	Construction
Delivery of a large-scale, high-temperature CSP plant	Stand-alone 2x125 MWe	Construction

AREVA, one the fastest-growing CSP technology providers

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4. Focus on boosters





➔ Projects are delayed due to technology

- **NSM Phase 1 CSP projects are delayed due to technology issues**

Fact

- Projects started late due to the financial closure
- Uncertainty/erroneous projection of satellite data on DNI resulted in engineering modifications
- Infrastructural clearances took time for some projects
- 28 months execution period should have been considered from financial closure date
- One 50MW project has been commissioned with less than one month delay

However, CSP is a different solar technology and will have more installation time compared to PV

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➔ Project Economics
CSP projects are very expensive

Fact

- **Cost effective CSP solution possible both in Capex and Energy**
  - AREVA ensures relatively low Capex and low Levelized Cost of Energy thanks to its simple design features
  - Establishment of in-country expertise and a fairly large supply chain base with right strategic partnership with local EPC company drives down CAPEX
- **Full performance guarantees are offered and backed by AREVA**
- **Simpler technology also ensures much lower water usage and O&M cost**
- **With storage, CSP projects have very high capacity utilization factor**

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➔ CSP Plants are costly on asset life cycle

Fact

- **Easier maintenance, optimized power output**
  - Reflectors maintenance is performed without halting power generation
  - The design avoids using land otherwise needed for crane access roads: individual reflectors can be swapped from underneath the plant in minutes

- **Higher resistance to external hazards**
  - Steel-backed mirrors can be “stowed” upside down for self-protection
  - They present a horizontal profile suited to resist high winds or hailstorms
  - At night, this minimizes dust build-up, reducing mirror washing needs

** Supervisory Control And Data Acquisition*

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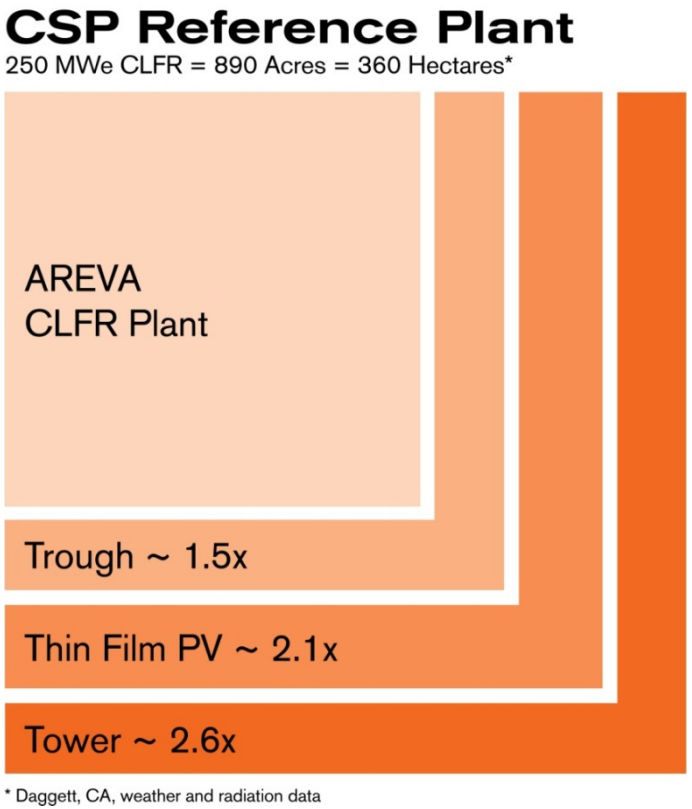
➔ High Use of land and water

- **The most land-efficient solar technology**
  - AREVA's CSP footprint is 50% less than that of thin film PV
  - It is even less when compared with CSP towers
- **Low water usage**
  - Thanks to its night stowage, water usage is minimized for washing mirrors
  - AREVA closed-loop technology can incorporate dry cooling, needing only top-up water to compensate unavoidable losses



Easier siting increases projects opportunities and robustness

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➔ Local Value creation
Truly local added-value

- **AREVA's solar solutions can be sourced locally up to 95%**
  - **A unique modular design and local manufacturing**
  - **Reduced capital and fabrication costs**
  - **Maximized local production using commodity materials**
  - **For a 50MWe plant: Construction: 200 FTE for 2 years**
    Manufacturing: 20-80 FTE, O&M: 4 FTE

From hybrid–manual assembly line…

Low labor cost location

…to fully automated…

High labor cost location

…within a challenging logistic context

Minimized shipping risks and costs

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Need for CSP in India
AREVA recommendations

1 Continuity of projects

Need to have more capacity additions

Projects need to be continuous in nature

2 Technology selection

Technology needs to be locally suitable

Local component of the technology important

Presence on the ground should be rewarded

3 Thermal applications

Potential of boosters need to be tapped

Hybrid of CSP-Bio crucial for distributed generation

Boosters need to be RPO eligible

4 Secure site

Reserve high DNI sites for CSP projects

Capture field data **of** last 2 years for a robust DNI database

*Jobs are Full Time Equivalent jobs

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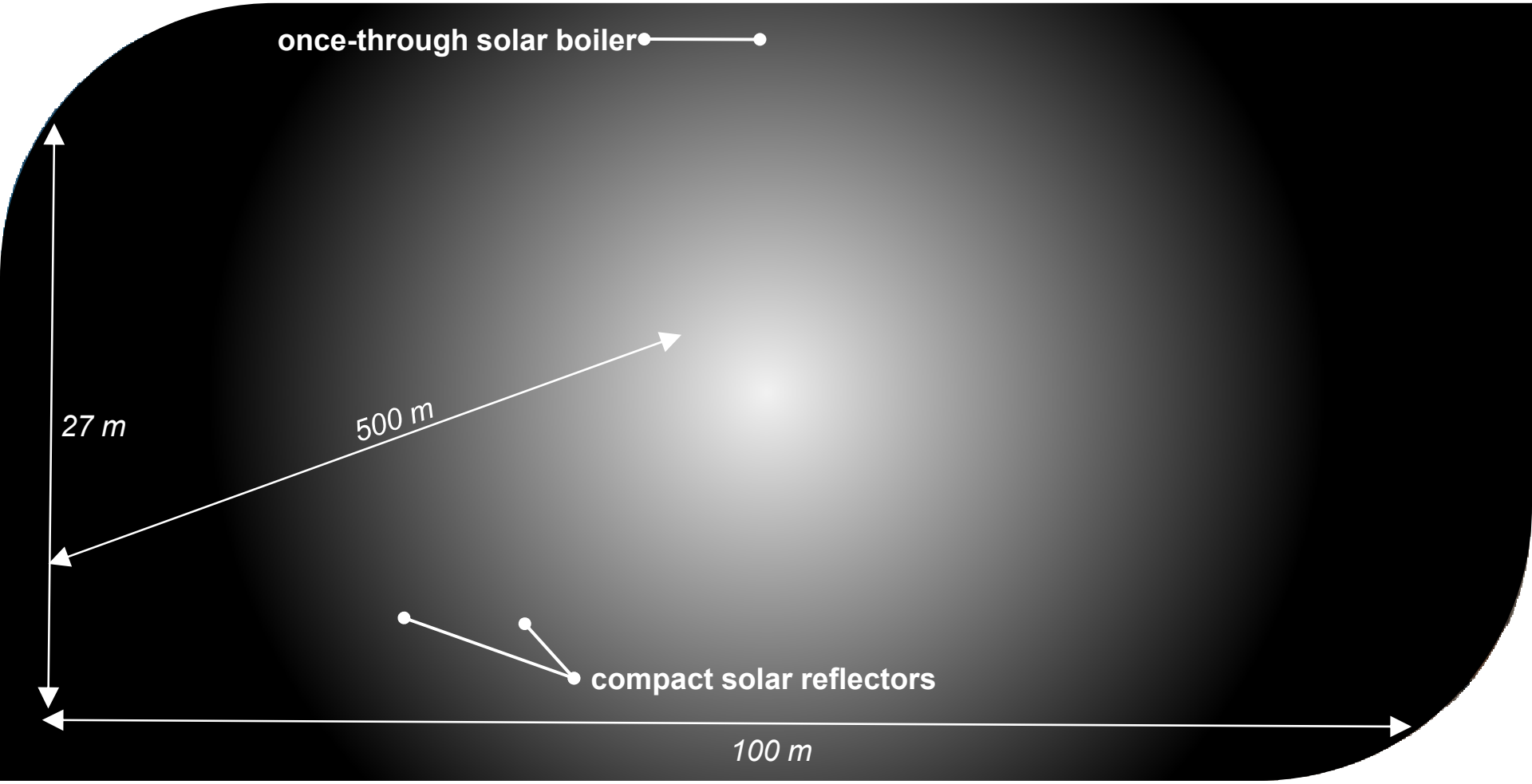
AREVA's solar technology of choice
Compact Linear Fresnel Reflector



One Solar Steam Generator = up to 22 MWth or 7.7 MWe peak

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Specifications sheet
Standard Solar Steam Generator

Solar Steam Generator Unit Performances depend on local conditions	
Temperature	Up to 485°C (905°F)
Pressure	Up to 2,400 psia (165 bara)
Thermal Output	Up to 22 MWth
Electric Output	Up to 7.7 MWe
Water Usage (dry cooling)	0.3 m^3/MWhe 80 gal./MWhe
Land Use (acres/hectares)	15.44 acres 6.2 hectares
MWe per acre/hectare	0.5 MW/acre 1.24 MWe/hectare
Grade	East – West = up to 1.6% North – South = <1%

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power

Kimberlina Solar Thermal Power Plant

Generating high-pressure, superheated steam

- Kimberlina 5 MW solar thermal power plant near Bakersfield, CA
- First new solar thermal plant in California to be built in 20 years
- Demonstrated thermal performance with high availability
- Direct, high-pressure superheated steam generation
- Advanced product development facility

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booster

Tucson Electric Power: Sundt Solar Boost Project

Online: 2014

- **CLFR Solar steam augmentation project**
  - High-pressure, superheated steam for feedwater heating
  - U.S.-designed and manufactured technology
- **Clean solar power "boost" for Sundt's 156 MWe dual-fueled, coal-/gas-fired Unit 4**
- **Additional 5 MWe of solar-generation; no added emissions**
- **CO_2 emissions avoidance/year (U.S. tons) when fueled by:**
  - Coal: 8,500 tons/year
  - Natural Gas: 4,600 tons/year
- **Fuel conservation with increased output**
  - Coal savings: 3,600 tons/year
  - Natural gas savings: 46 MCF/year
- **Job creation and other economic benefits**
  - 50 peak construction jobs
  - US high-volume manufacturing

booster

Under construction now in Australia
The world's largest coal booster

- CLFR solar addition to 750 MWe Kogan Creek Coal Station
- Located in Queensland, Australia – Online 2014
- Up to 44 MWe additional output using same amount of coal
- Avoids ~35,600 metric tons of CO_2 per year

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power

125 MWe Reliance Power, India

Reliance will use AREVA Solar's CLFR technology.

- Size: 125 MWe solar thermal power project; under construction
- Technology: AREVA Solar CLFR
- Location: Rajasthan, India
- Sponsor: India's Jawaharlal Nehru National Solar Mission (NSM)
- Non-recourse debt financing from:
  - Asian Development Bank (ADB) ~$100M
  - US Export – Import Bank ~$80M
- Online: By end of 2013

power

CLFR and Molten Salt Installation at Sandia National Labs

AREVA Solar's storage solution combines its proven CLFR technology with an established molten salt storage system.

- **Using Molten Salt Test Loop at Sandia National Laboratories National Solar Thermal Test Facility in Albuquerque, NM**
- **60% Sodium Nitrate + 40% Potassium Nitrate "Solar Salt"**
- **Salt Temperatures Up to 585 C**
- **Online Q4 2013**
- **Full Scale CLFR Salt Receiver with 1.4 MWth solar field**

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44 MWe Kogan Creek Booster

Project construction in progress

44 MWe Kogan Creek Booster

Reflectors and towers installation

booster

44 MWe Kogan Creek Booster

On-site mirrors manufacturing line

44 MWe Kogan Creek Booster

On-site robotic welding line

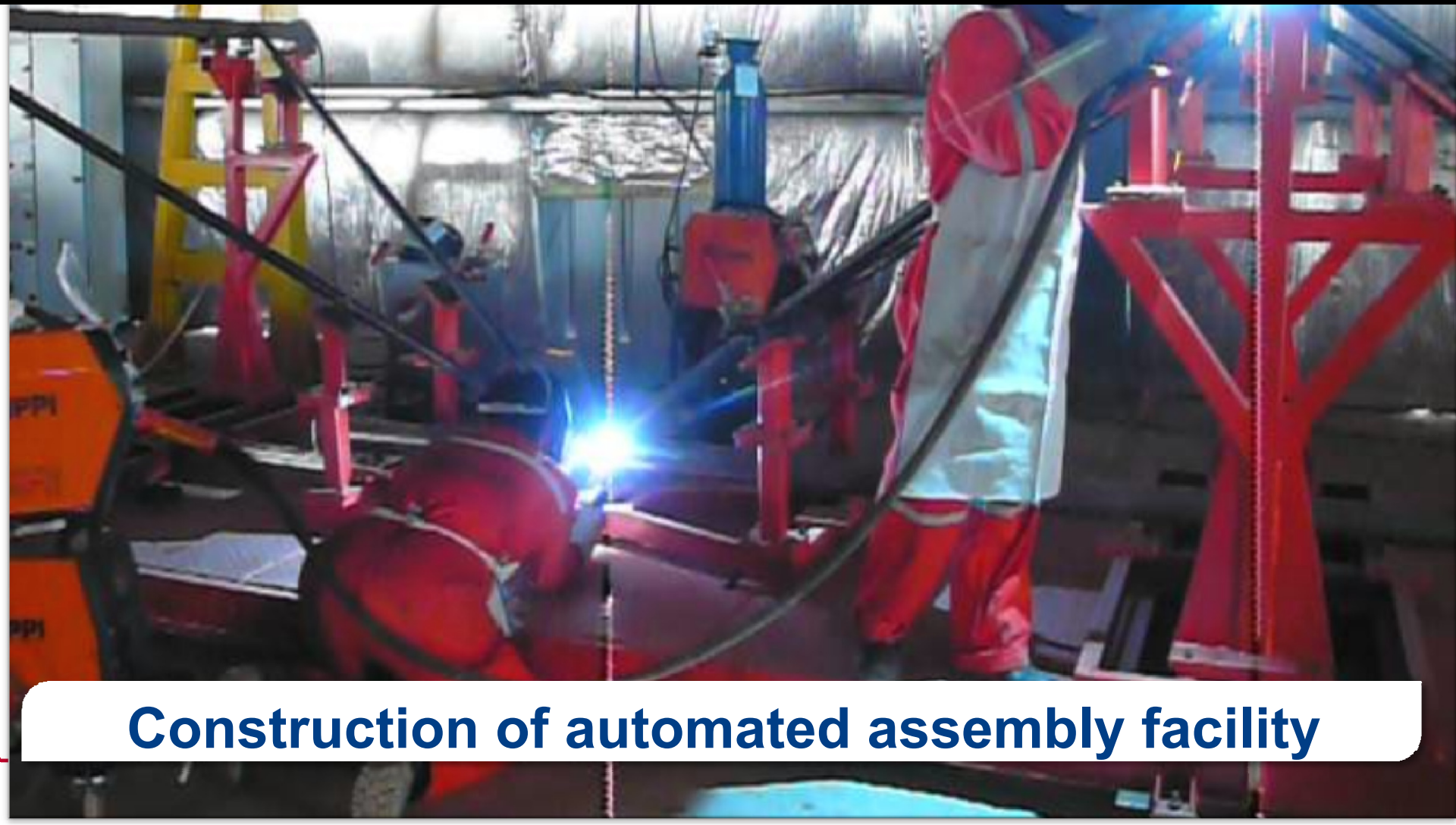
125 MWe Reliance CSP Project

Towers and reflectors installation

125 MWe Reliance CSP Project

Part view of solar field

125 MWe Reliance CSP Project



Construction of automated assembly facility

power

125 MW

Reflectors use standard materials

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forward-looking energy