



sbpsonne

Concentrated Solar Power



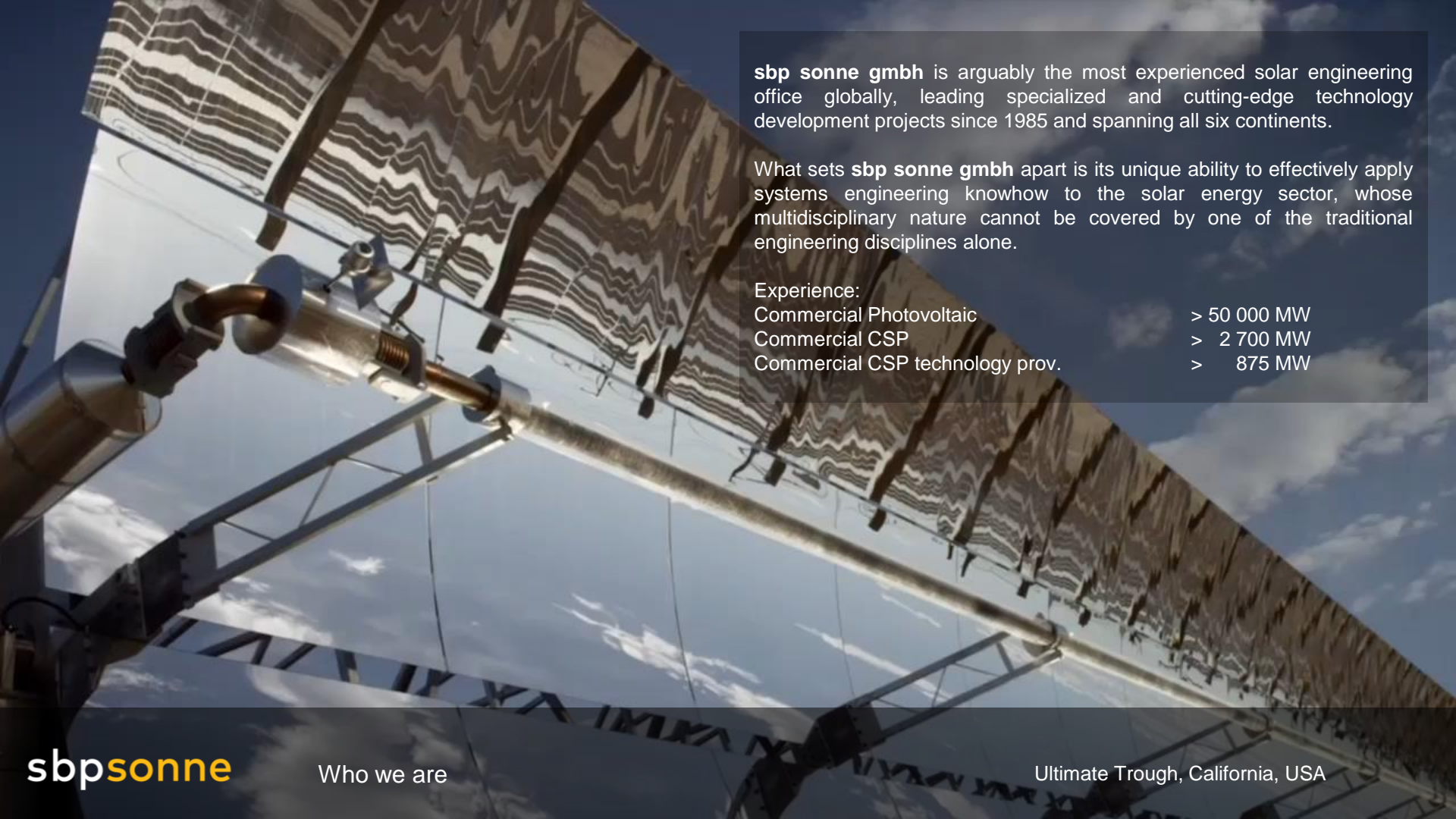


schlaich bergermann und partner contributes in the classical and sophisticated fields of structural engineering.

Our focus lies on light-weight structures in bridge design, membrane and cable structures, glass architecture and all related fields. Open to all kinds of material as well as to innovation, we look for solutions that suit a building project technically, economically and ecologically.

All these structural activities are bound in our main office in Stuttgart With our branch office in Berlin and its connection to the Technische Universität Berlin, as well as our office in New York, schlaich bergermann and partner Ip, and our offices in Sao Paulo, Paris and Shanghai, we are ready to take on any kind of challenge.





sbp sonne gmbh is arguably the most experienced solar engineering office globally, leading specialized and cutting-edge technology development projects since 1985 and spanning all six continents.

What sets **sbp sonne gmbh** apart is its unique ability to effectively apply systems engineering knowhow to the solar energy sector, whose multidisciplinary nature cannot be covered by one of the traditional engineering disciplines alone.

Experience:

Commercial Photovoltaic

> 50 000 MW

Commercial CSP

> 2 700 MW

Commercial CSP technology prov.

> 875 MW



schlaich bergemann partner – our parent company are independent consulting civil and structural engineers.

We strive to design sophisticated engineering structures ranging from wide-span lightweight roofs, a diversity of bridges and slender towers to innovative solar energy power plants. Our ambitions are efficiency, beauty and ecology.

For the sake of holistic solutions, we seek the collaboration with developers, EPCs, academic institutions and product companies from all fields of expertise who share our goals.



sbp sonne gmbh offers the following services:

- Multidisciplinary consulting for client and owner
 - Interpretation and statistical analysis of meteorological data
 - Efficiency calculation and yield analysis
 - Optical evaluations and optimizations (intercept factors, flux density distribution, and flux control)
 - Structural reviews, conceptualization, calculation and optimization services
 - Techno-economic optimisation of all solar energy systems with special focus on structures
 - Conceptualization and logic of structural stow behaviour
 - Feasibility studies
- Conception, development, and implementation of solar technologies
 - Planning of prototype and series production
 - Assembly supervision and quality management during construction
 - Controls engineering and drive units design and specification
- Technology provider / licensor of EuroTrough, UltimateTrough, Stello heliostat, PV Tracker, Floating PV, Agricultural PV and Parking lot PV

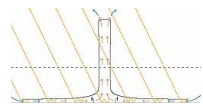
sbp

schleich
bergmann partner

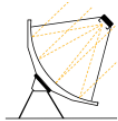
sbp is
founded



1980



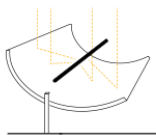
Solar
Updraft
tower



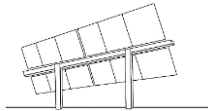
designs and
put the first
Dish Stirling
systems into
operation



1986



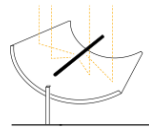
develop the
EuroTrough
collector



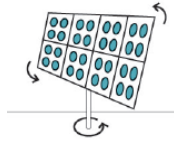
first PV tracker
development
project



2009



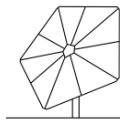
develop the
UltimateTrough
collector



first commercial CPV
technology
developed



2012



develop the
award winning
Stellio heliostat

2014

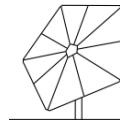
sbpray

schleich
bergmann partner

sbpRAY raytracing
software wins the
CSP Today CSO
engineering
performance award

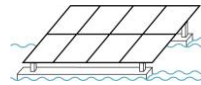


2016



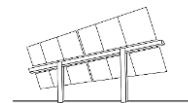
Stellio heliostat is
implemented in
50MWe Hami CRS

2017



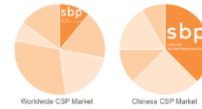
first FPV concept
developed

2017



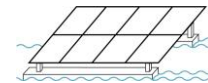
sbp consultation
tasks exceed
**10 GWe worth of
commercial PV
projects**

2019



sbp-licensed
technology is
implemented in
**13 % of the global
CSP market and
45 % of the CSP
market in China**

2020



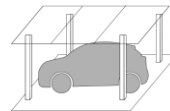
first **bifacial**
floating PV
prototype
in Hungary

2021

STELLIO

STELLIO
Heliostat
technologies
gmbh
established

2023



first solar
car park
prototype
in Hungary

2023

sbpsonne

Key achievements

PV / PV-single-axis tracker

Introduction: Since 2016

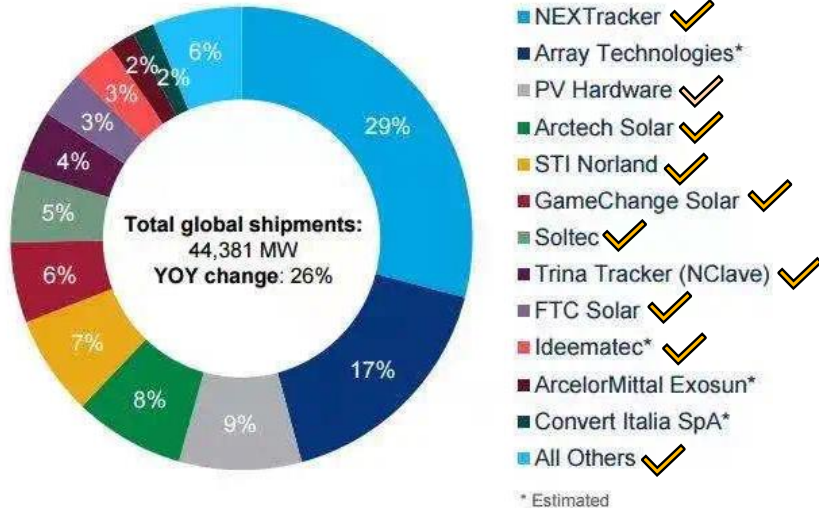
- Relevancy of PV in the medium-long term
- Commitment of the company with this technology

Consequences:



PV engineering services track record (2016-2023)

sbp sonne reviewed **70%-80%** world leading tracker technology.

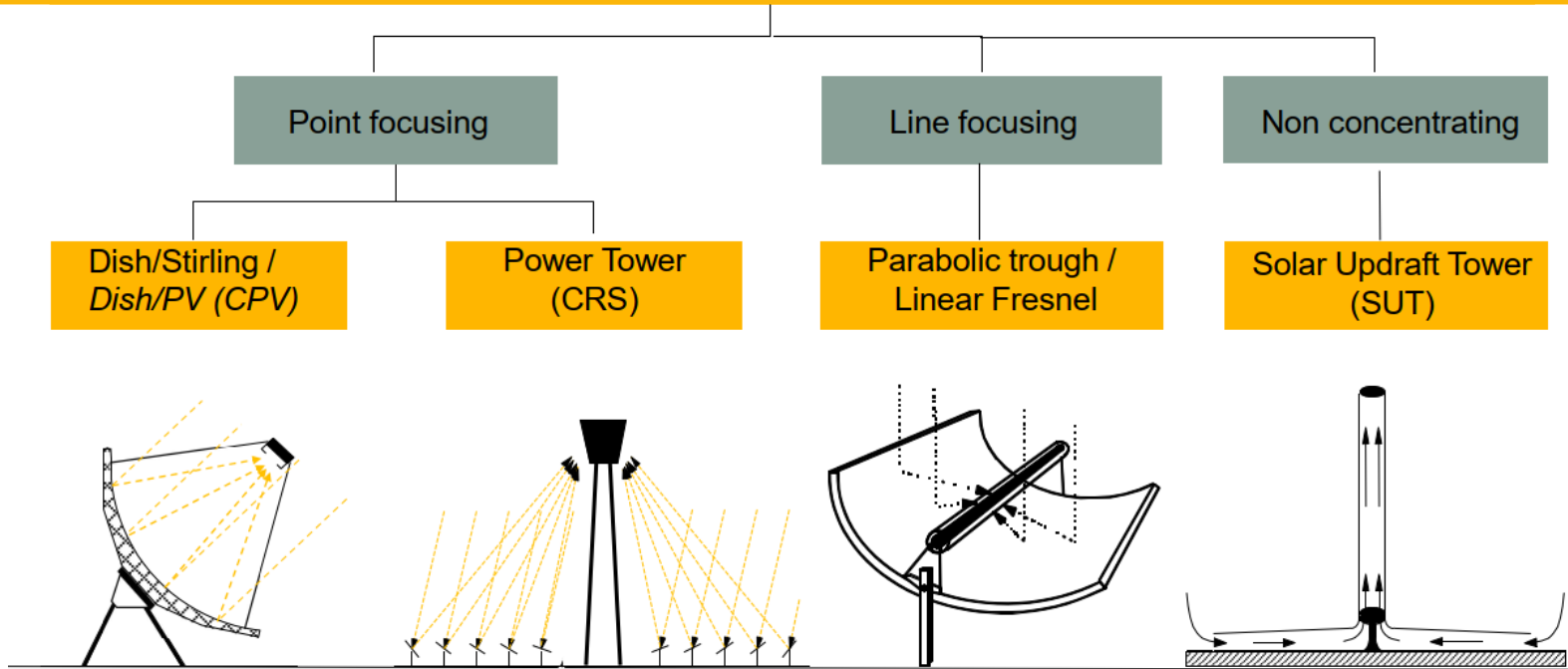


Global PV Tracker Market Share Rankings by shipment, 2020

Clients that **specify** sbp sonne structural review:

- **ACWA Power** (compulsory exclusive)
 - **Statkraft** (formerly Solar Century, compulsory exclusive)
 - **Total Energies**
- Tracker Technologies Solutions
 - 5** developments/design assistances
 - Root Cause Analysis
 - 15** for insurance companies
 - 8** for owners
 - 1** for component manufacturer
- Tracker Reviews (*since 2018*)
Issued projects: **62**
On progress projects: **6**
Capacity: **+50 GW**

Solar thermal power plants





EuroTrough Technology

- Engineering
- License
- Training
- Quality Control



UltimateTrough Technology

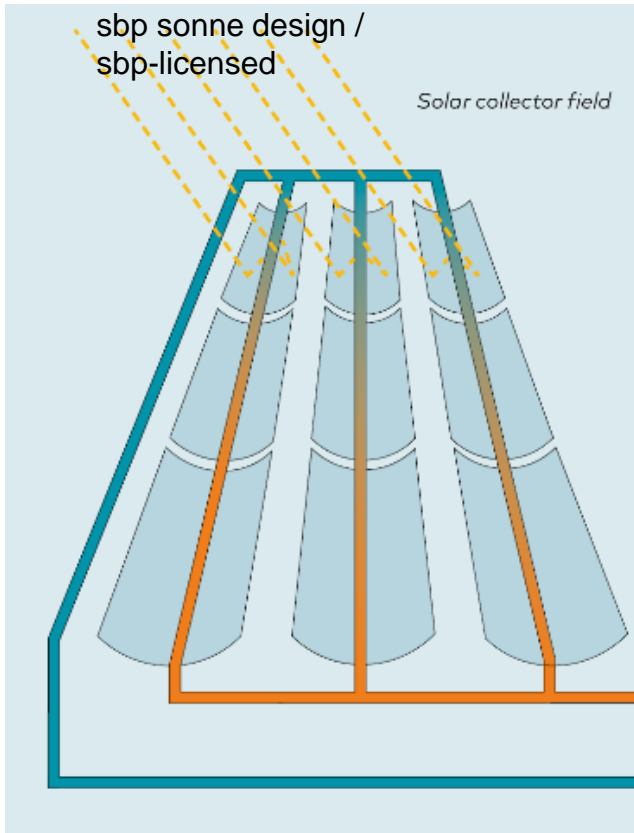
- Engineering
- License
- Training
- Quality Control



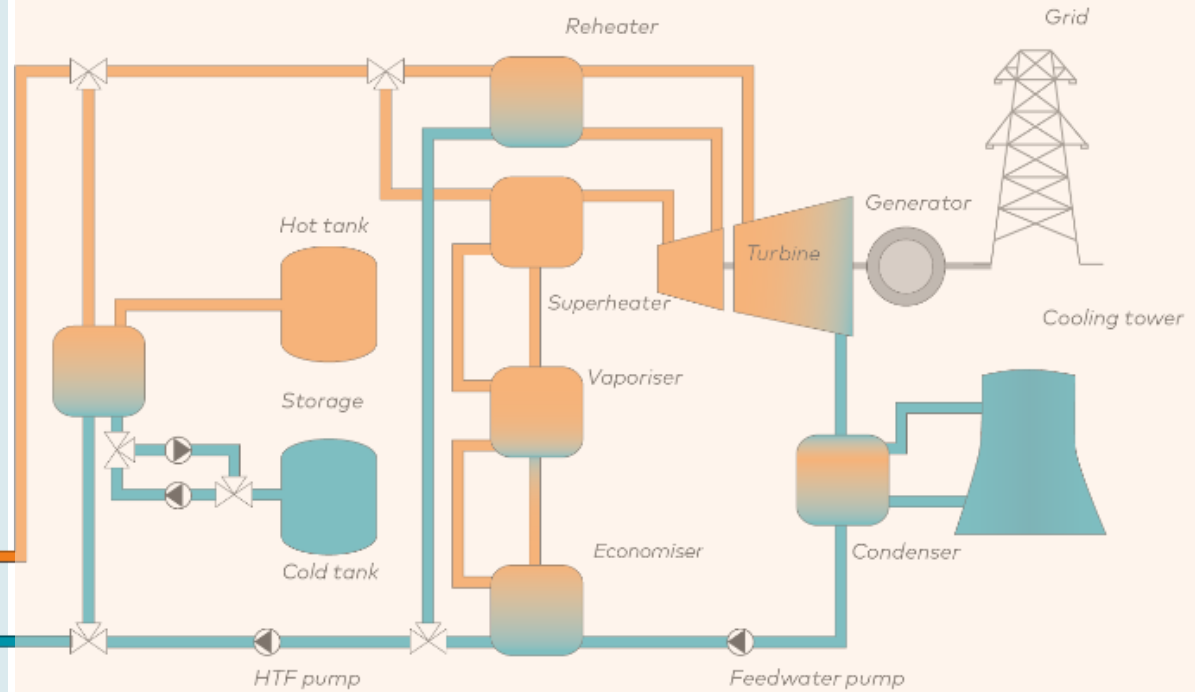
Stello Technology

- Engineering
- Turnkey/specialist items supply
- Solarfield warranties

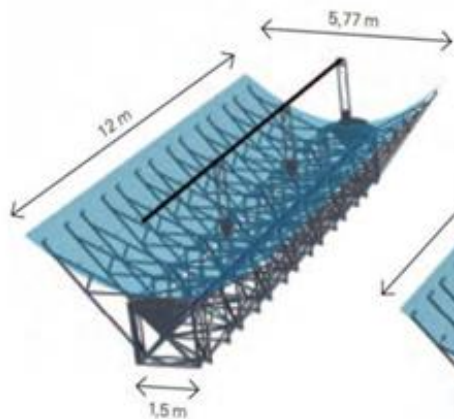
Parabolic trough CSP plants



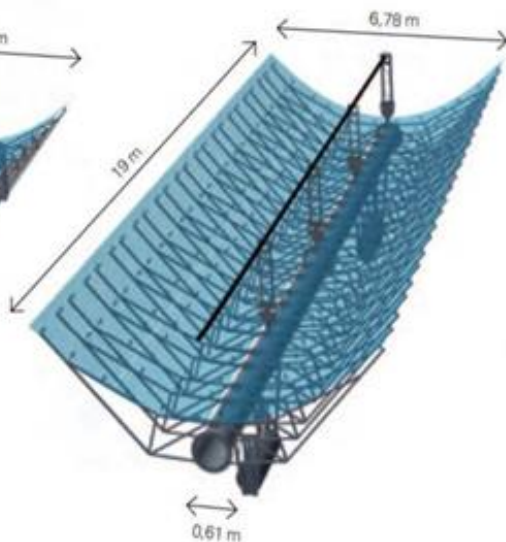
Not included in natural scope of sbp sonne
Potential worldwide experienced suppliers might be suggested by sbp sonne



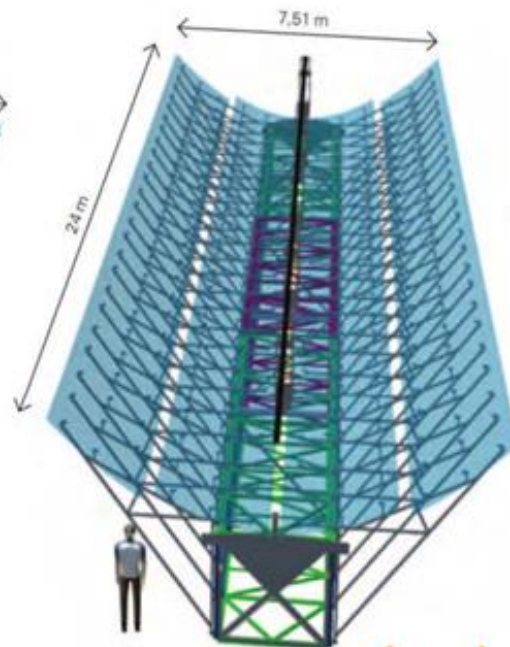
EuroTrough (2003)



HelioTrough (2009)



Ultimate Trough (2013)





- **Largest** collector in the world (1,720 m² aperture area, 6,880 m² per loop)
- **Highest** optical efficiency (intercept > 99% at nominal operation conditions), leading to up to 10% smaller solar field size
- Validated and certified by third party (NREL)
- **First** commercial project (DUBA) in operation since 2020



EuroTrough Parabolic Trough Collector

Technology provider: sbp sonne, Germany

Industrial development partner : Flagsol GmbH

Focus of the design

- Cost effective + high performance PTC
- Thermal oil as HTF
- Mid size solar fields / 0.5 Mio m²

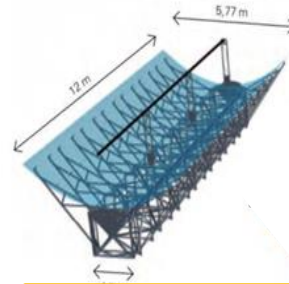
Prototype

- EuroTrough II Prototype 2002, Spain



Test Loop

- SKAL ET Test Loop 2003, USA



Commercialization

- 50 MW Andasol I 2008, Spain



Continuous Optimization + Localization (Egypt, India, China)

- 50 MW Andasol II, 2009
- 50 MW Andasol III, 2011
- 30 MW Kuraymat, 2011
- 50 MW Astexol, 2012
- 50 MW Moron, 2012
- 50 MW, Godavari, 2013
- 50 MW, Shagaya, 2017
- 50 MW Delingha, 2017
- 100 MW Urat, 2020
- 40 MW Zhabuye, 2024



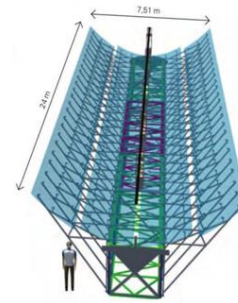
UltimateTrough Parabolic Trough Collector (Thermal Oil)

Technology provider: sbp sonne, Germany

Industrial development partner: Flabeg SE (+ new partner)

Focus of the design

- +20 % solar field cost reduction
- Molten salt Thermal oil as HTF
- Large size solar fields / 1.0 Mio m²



Thermal Oil Road Map



Prototype

- Ultimate Trough Prototype 2011, Germany



Test Loop

- UT Test Loop 2013, USA



Commercialization

- 40 MW Duba Green ISCC 2018, KSA



Continuous Optimization + Localization (KSA, China)

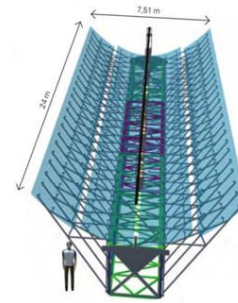
Project development pipeline China 2024

UltimateTrough Parabolic Trough Collector (Molten Salt)

Technology provider: sbp sonne, Germany

Industrial development partner: Local Chinese Partner

Focus of the design (see previous slide)



Molten Salt (MS)

Road Map 2024+

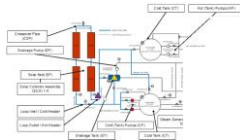


Thermal Oil experience + MS engineering

- Ultimate Trough Prototype 2011, Germany
- UT Test Loop (Oil) 2013, USA
- 40 MW DUBA Green ISCC 2018, KSA



MS Test Loops UT Test Loop 2024+, China



- Demonstrate feasibility of critical parts and procedures
- Swivel joints
- Filling and drainage procedures
- Chinese Partner familiarizes itself with the technology
- Establish supply chain
- Localization (optional)

Commercialization

- Project development pipeline by Chinese Partner China 2025

Continuous Optimization + Localization (China)

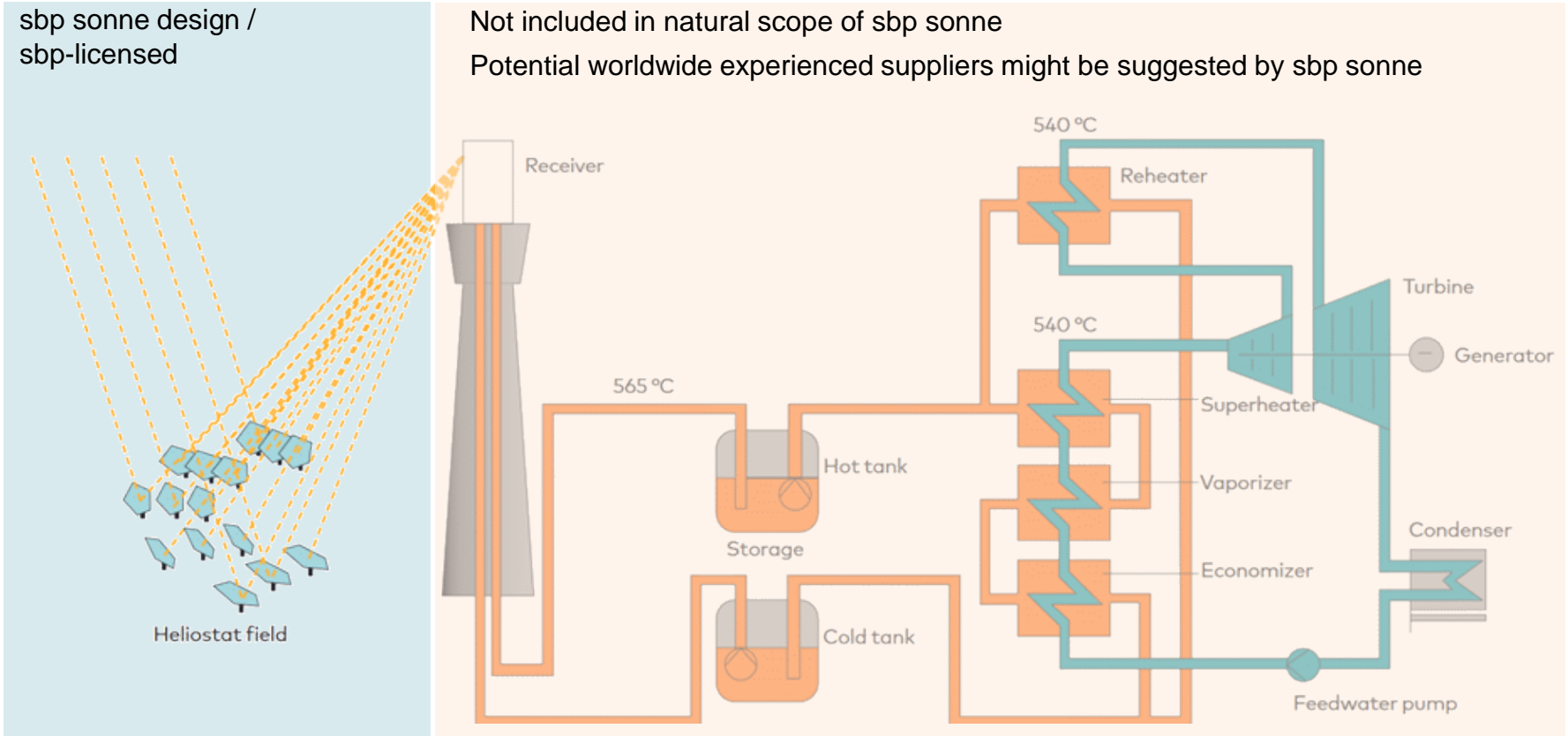
Project development pipeline China + international 2026

Power tower CSP plants

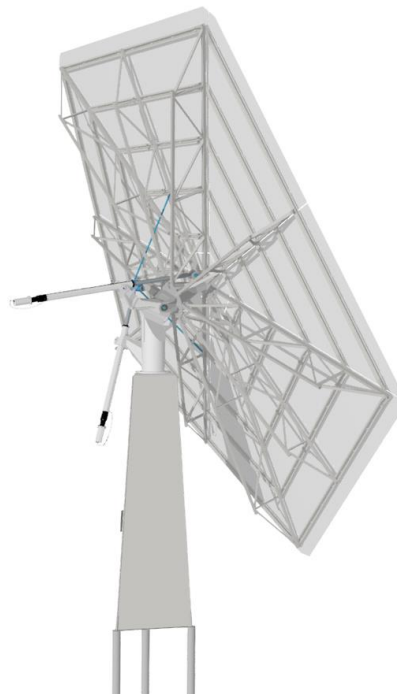
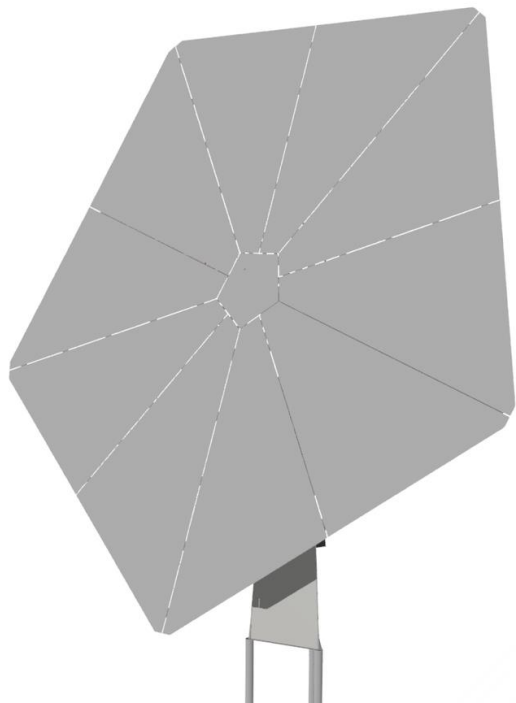
sbp sonne design /
sbp-licensed

Not included in natural scope of sbp sonne


Potential worldwide experienced suppliers might be suggested by sbp sonne



STELLIO Heliostat (2015)



Heliostat size, optical quality, tracking strategy, shading/blocking, astigmatism effects

 Solar energy yield, mirror area & solar field size

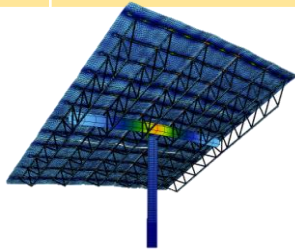
Structure/material, manufacturing, assembly, installation

 Heliostat cost

Why is Stellio different? Don't compare apples to oranges...

Holistic approach: Not only cost/m² is optimized but...

	Conventional Heliostat	Stellio Heliostat	Effect	Pro /Con
Shape	rectangular	pentagon	à denser solar field	+
Size	5-100 m ²	50 m ²	à optimized kg/m ² + RMB/m ²	+
Structural usage	unbalanced	even	à better stiffness + optics	+
Optical quality	standard	high	à equals to 8.2% investment cost saving	+
Continuous tracking	not available	available	à equals to 0.7% investment cost saving	+
Shading blocking	standard	optimum	à equals to 0.6% investment cost saving	+
Astigmatism effects	standard	optimum	à equals to 0.9% investment cost saving	+



Stress under dead weight

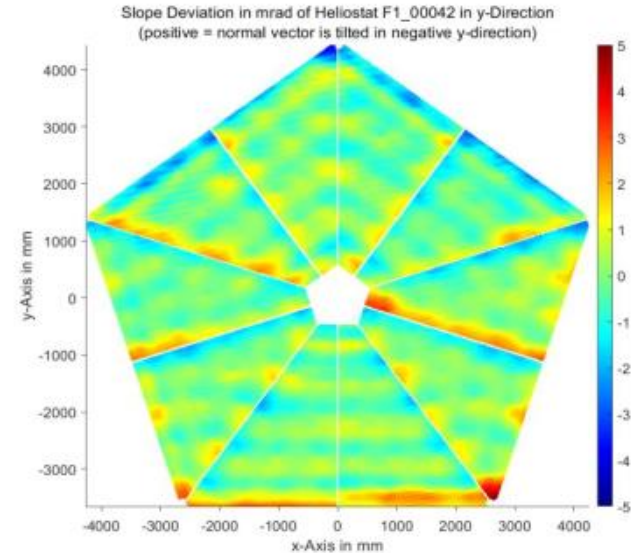


	Conventional Heliostat	Stellio Heliostat	Effect	Pro /Con
Kinematics	simple	complex		-
Mirror assembly	no jigs	precision jigs	à higher optical quality	+
Procurement cost efficiency	standard steel structure (heavy)	customized steel structure	à equals to 8-14% investment cost saving through high industrialization potential	+




QDec Measurement Summary


Value	Measurement	Specification	Description
SDx	0.81 mrad		Slope deviation in x-direction (rms)
SDy	0.87 mrad		Slope deviation in y-direction (rms)
SDrad	0.81 mrad		Slope deviation in rad-direction (rms)
SDtan	0.87 mrad		Slope deviation in tan-direction (rms)
SDtotal	1.19 mrad	<= 1.30 mrad	Slope deviation total (rms)



Performance (yield) improved by 10% due to advanced engineering

 appropriate consideration in tenders required and Stellio quality to be maintained

Cost only partially optimized

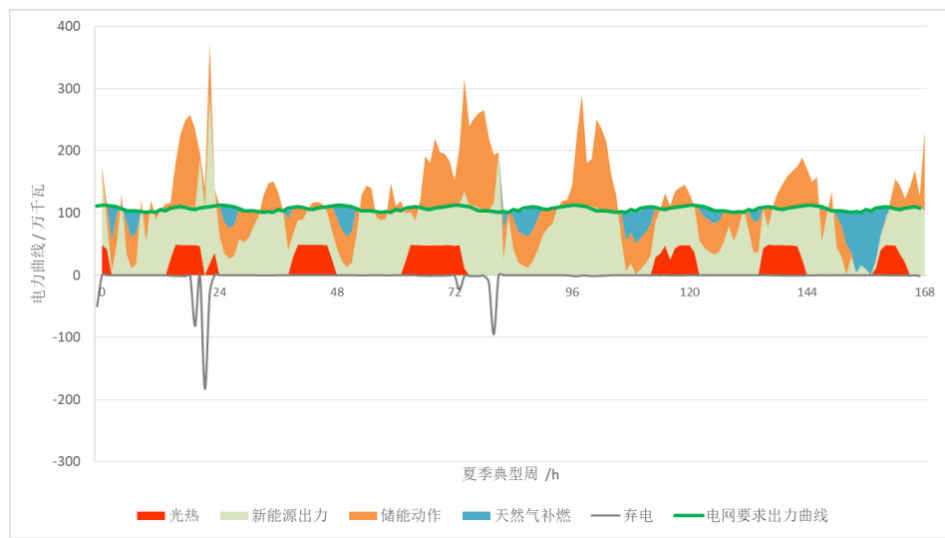
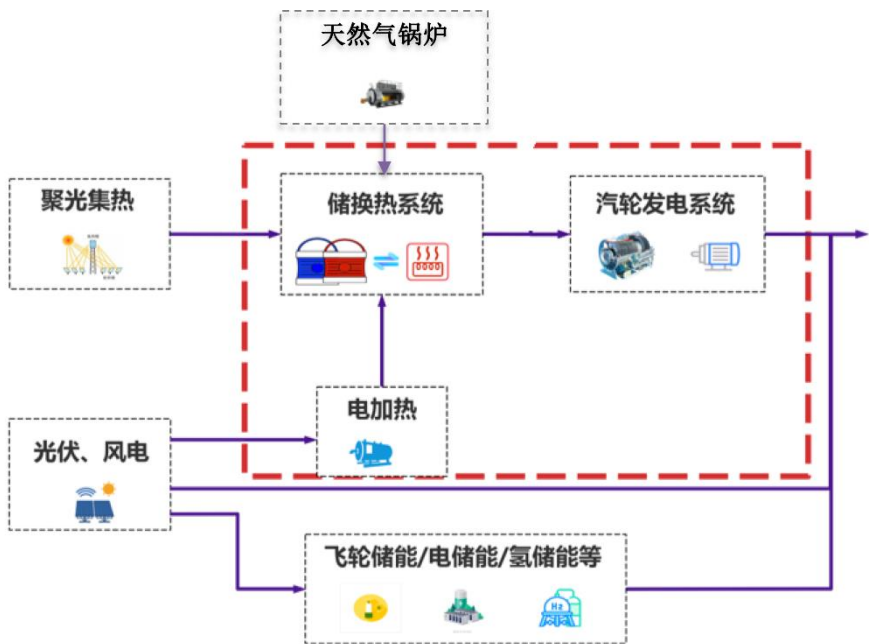
 further cost savings possible (10-15%) by industrialisation of manufacturing, assembly, installation

Multidisciplinary consulting for client and owner (CSP) – selection –

Service	Content	Related Companies	Power Tower	Parabolic Trough
<p>Solar Power Plant + Solar Field Layout</p> <ul style="list-style-type: none"> • Feasibility studies • Conceptual design • Detailed design • Optimization 	<ul style="list-style-type: none"> • Interaction with combined PV + wind systems • Application of requested electricity delivery schemes • Implementation of Chinese Energy policy requirements for grid friendliness: <ul style="list-style-type: none"> ➤ Peak shaving ➤ Reduction of dumped share of PV & Wind ➤ Reduction of natural gas/ purchased electricity ➤ Provision of grid stability • Efficiency calculation • Yield analysis • Economic optimization of power plant components: (Power block, TES, eTES, battery, heat exchanger etc.) • Comparison of competing technologies 	<p>All services by sbp sonne</p>	<p>X</p>	<p>X</p>

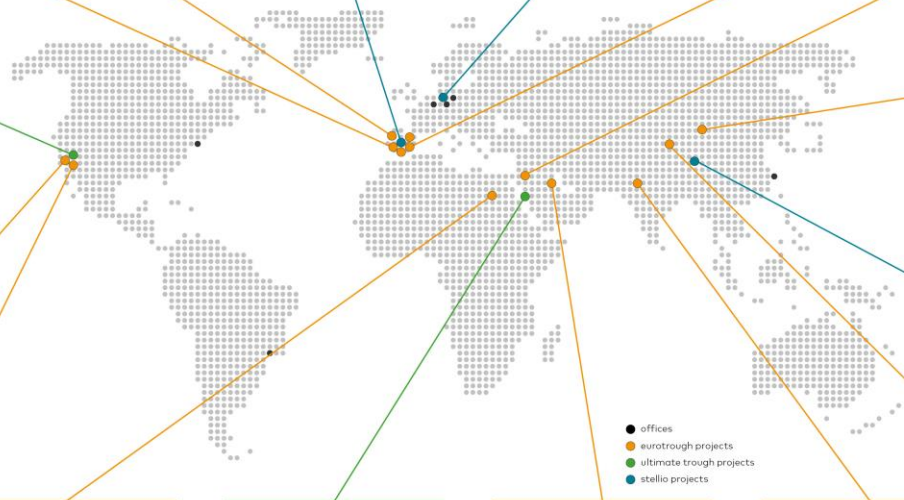
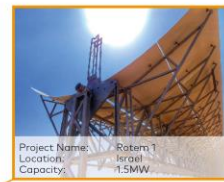
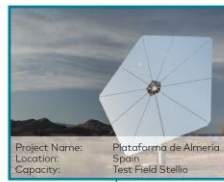
Multidisciplinary consulting for client and owner (CSP)

Implementation of Energy policy requirements for grid friendliness



Multidisciplinary consulting for client and owner (CSP) – selection –

Service	Content	Related Companies	Power Tower	Parabolic Trough
Interpretation and statistical analysis of meteorological data	<ul style="list-style-type: none"> • Extreme wind analysis • Definition of design wind load according to Chinese code 	sbp sonne Wind Engineer	X	X
Foundation design	<ul style="list-style-type: none"> • Optimzation of foundation systems according site conditions 	sbp sonne Geotechnical Engineer	X	X
Aim point strategy Solar field control	<ul style="list-style-type: none"> • Optimization of intercept and energy yield • Adoption of operation strategies • Interface to Powerblock control • Cloud passages • Flux control and interface to receiver 	sbp sonne CSP Services	X	
Solar field / collector characterization	<ul style="list-style-type: none"> • Determination of optical parameters, errors, intercept 	sbp sonne CSP Services Volateq	X	X
Quality management	<ul style="list-style-type: none"> • On site support during fabrication, construction, erection, commissioning 	sbp sonne	X	X
and more	...			





Client: Marquesado Solar S.L, Spain
Location: Aldeire, Spain
Scope of work: EuroTrough licence package, design, structure, drive technology, detailed engineering, tender documents, fabrication and site supervision
Aperture: 497,000 m²

The 50 MW solar thermal power plant Andasol III is based on the Eurotrough design. The plant is situated in close vicinity to the power plants Andasol 2 and 3. The collector field covers an area of approximately 1,300 m x 1,500 m and consists of 152 loops respectively 7,296 solar collector elements (SCEs). The thermal storage allows an operation of the plant with nominal output for 7.5 hours after sunset. The power plant produces approximately 179 GWh annually, providing up to 200,000 people with electricity.



Client: CGN Delingha Solar Energy Co.

Location: Delingha, China

Scope of work: EuroTrough license package for tender and execution phase including engineering supervision during fabrication and assembly

Aperture: 620,000 m²

The 50 MW solar thermal power plant Delingha is designed on the base of the EuroTrough design. The collector field consists of 190 loops respectively 9,120 single trough collector elements (SCEs). One solar collector assembly (SCA) consists of 12 solar collector elements which are 12 m long each. The design was adapted to the local wind loads, 1% sloped ground, low temperatures and Chinese standards. The thermal storage allows an operation of the plant with nominal output for 9.5 hours after sunset. schlaich bergemann partner provided the EuroTrough technology on a licensing basis and actively assisted fabrication and assembly.



Client:	Urat 100MW Parabolic Trough CSP Project
Location:	Urat, Inner Mongolia, China
Scope of work:	EuroTrough license package for tender and execution phase including engineering supervision during fabrication and assembly
Aperture:	1,115,000 m ²
Owner:	China Shipbuilding New Power (CSNP)
Solar field EPC + technology licensee:	Royal Tech CSP Ltd.

The 100 MW solar thermal power plant Urat is designed on the base of the EuroTrough design. The collector field consists of 352 loops respectively 16,896 single trough collector elements (SCEs). One solar collector assembly (SCA) consists of 12 solar collector elements which are 12 m long each. The design was adapted to the local wind loads, 1% sloped ground, low temperatures and Chinese standards. The thermal storage allows an operation of the plant with nominal output for 10 hours after sunset.

schlaich bergemann partner provided the EuroTrough technology on a licensing basis and actively assisted fabrication and assembly.



Client: Zhabuye 40MW Parabolic Trough CSP Project

Location: Zhabuye, Tibet, China

Scope of work: EuroTrough license package for tender and execution phase including engineering supervision during fabrication and assembly

Aperture: 621,000 m²

Owner: Baowu

Solar field EPC + technology licensee: China Shipbuilding New Power (CSNP)

The 40 MW solar thermal power plant Zhabuye is designed on the base of the EuroTrough design.

The collector field consists of 190 loops respectively 9,120 single trough collector elements (SCEs). One solar collector assembly (SCA) consists of 12 solar collector elements which are 12 m long each.

The thermal storage allows an operation of the plant with nominal output for 16 hours after sunset.

schlaich bergemann partner provided the EuroTrough technology on a licensing basis and actively assisted fabrication and assembly.



Client: 565 MWe Duba Green ISCC Power Plant
Location: Duba, Saudi Arabia
Scope of work: UltimateTrough license package for tender and execution phase including engineering supervision during fabrication and assembly
Aperture: 170,000 m²

The 170,000 m² UltimateTrough Solar field contributes a net output of 40 MWe to the 565 MWe Duba Green ISCC plant nearby. The collector field consists of 31 loops respectively 992 single trough collector elements (SCEs). With over 247 m length and 7.5 m aperture width, the Ultimate Trough is the industry's biggest trough while maintaining high optical performance values and reducing specific costs e.g. pylons. schlaich bergemann partner provided the UltimateTrough technology on a licensing basis and actively assisted fabrication and assembly.



Client: Dongfang Boiler Group Co., Ltd.

Location: Hami Kumul, China

Scope of work: Structural design incl. adaptations. Solar field layout, performance calculation. Support for: Chinese procurement, site works, QA, commissioning. Design of a BCS (beam characterization system), and software development.

Output: 50 MWe

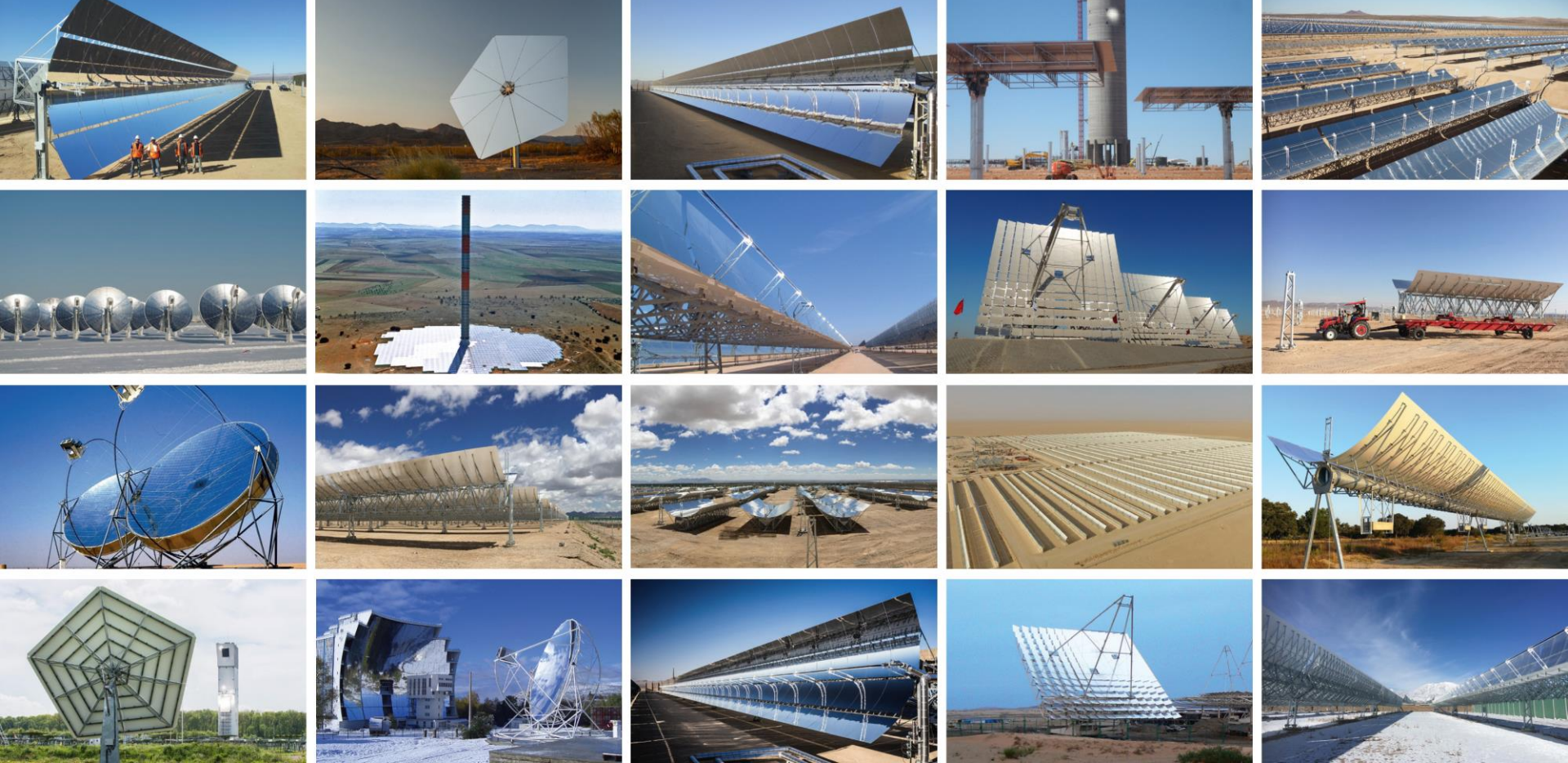
The project is part of the first batch of Concentrated Solar Power demonstration projects in China. The Stello heliostat developed by sbp with partners is used here for the first time. The entire solar field was planned in cooperation with our Spanish partners. Steel construction, mirrors, electrical system and part of the control technology are supplied by local companies. For the assembly of the 14'500 heliostats a semi-automatic assembly line developed by our Spanish partner and leased to the client was installed and operated on site. Apart from the first commercial use of the heliostat, particular challenges lie in the coordination of the companies involved, in the quality assurance of components and assembly as well as the working conditions in winter at temperatures below -20 °C.



中国电力工程顾问集团西北电力设计院有限公司
NORTHWEST ELECTRIC POWER DESIGN INSTITUTE CO., LTD. OF CHINA POWER ENGINEERING CONSULTING GROUP



Collaborations & Partnerships



sbpsonne

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