Overview of global solar process heat market and trends

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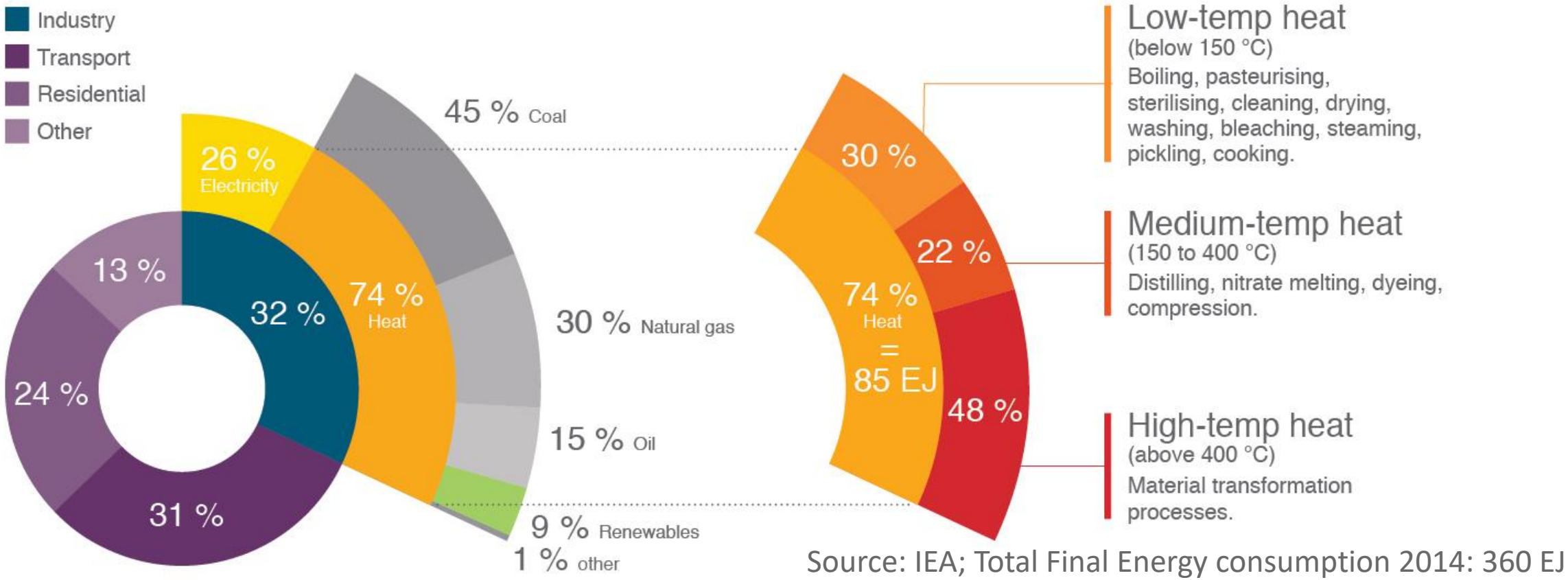
Enormous global heat demand in industry



Source: IEA; Total Final Energy consumption 2014: 360 EJ

There is more final energy consumption of heat in the global industrial sector than there is electricity consumed worldwide! Source: www.solar-payback.com

Dynamic market development of solar industrial heat

125 SHIP systems
(end of 2012)

➢817 SHIP systems
(end of 2019)

20 SHIP systems with concentrating collectors commissioned in 2019

→ Adding up to 267,280 m^2 (187 MW_{th})

→ vast majority are parabolic trough collectors

→ installed in China, India, Mexico, Belgium, Oman, Senegal, Spain, USA, Portugal, Turkey, Cyprus

Source: Solar Payback

Driving factor: Growing and submitted supply chain

Suppliers of Turnkey Solar Process Heat Systems

Supplier ready-to-offer	13
Collector producer ready-to-offer	5
Supplier with references	22
Collector producer with references	42

https://www.solar-payback.com/suppliers/
available in English, Spanish and Portuguese

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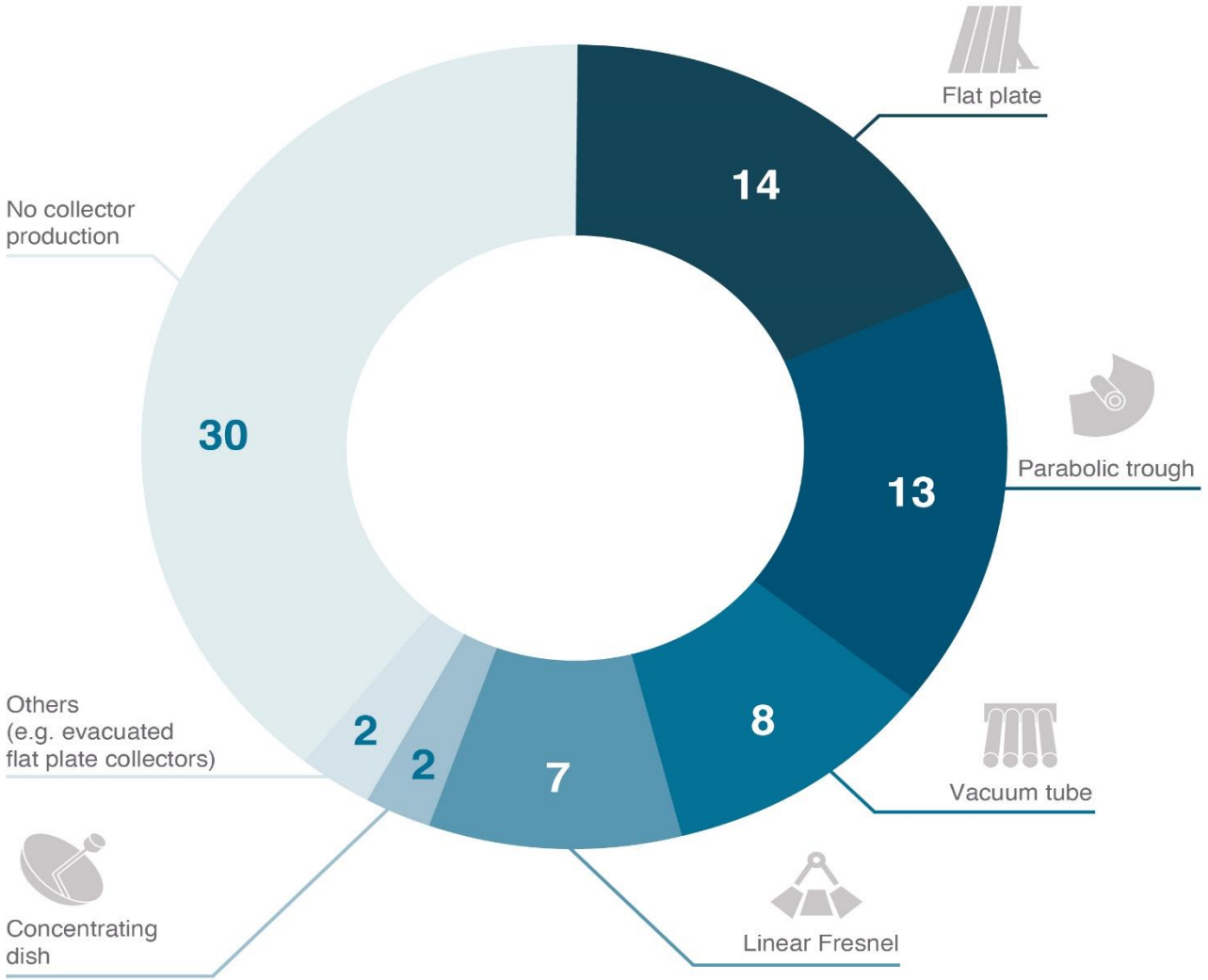
DLR solrico Solar Payback

76 turnkey SHIP suppliers are currently depicted on the world map

61 % of the listed companies produce collectors in-house or on-site



Solar Payback

Ranking of the most experienced SHIP technology suppliers

Turnkey solar industrial heat suppliers with more than 10 reference projects at the end of 2019

89	**Módulo Solar** Mexico	22	**Millennium Energy Industries** Jordan
72	**Sunrain** China	21	**Inter Solar Systems** India
66	**Inventive Power** Mexico	20	**Soliterm** Germany
47	**Linuo Paradigma** China	16	**Sunda** China
32	**Megawatt Solutions** India	15	**Himin** China
29	**Ritter XL Solar** Germany	15	**Solid Energy Systems** Austria
28	**SEA Sistemas de Ecotecnias Ambientales,** Mexico	14	**Casolar** Mexico
24	**Vicot Solar Technology** China		

Industry hubs: China, Mexico, India and Germany

Established suppliers of concentrating collectors

Source: Solar Payback surveys

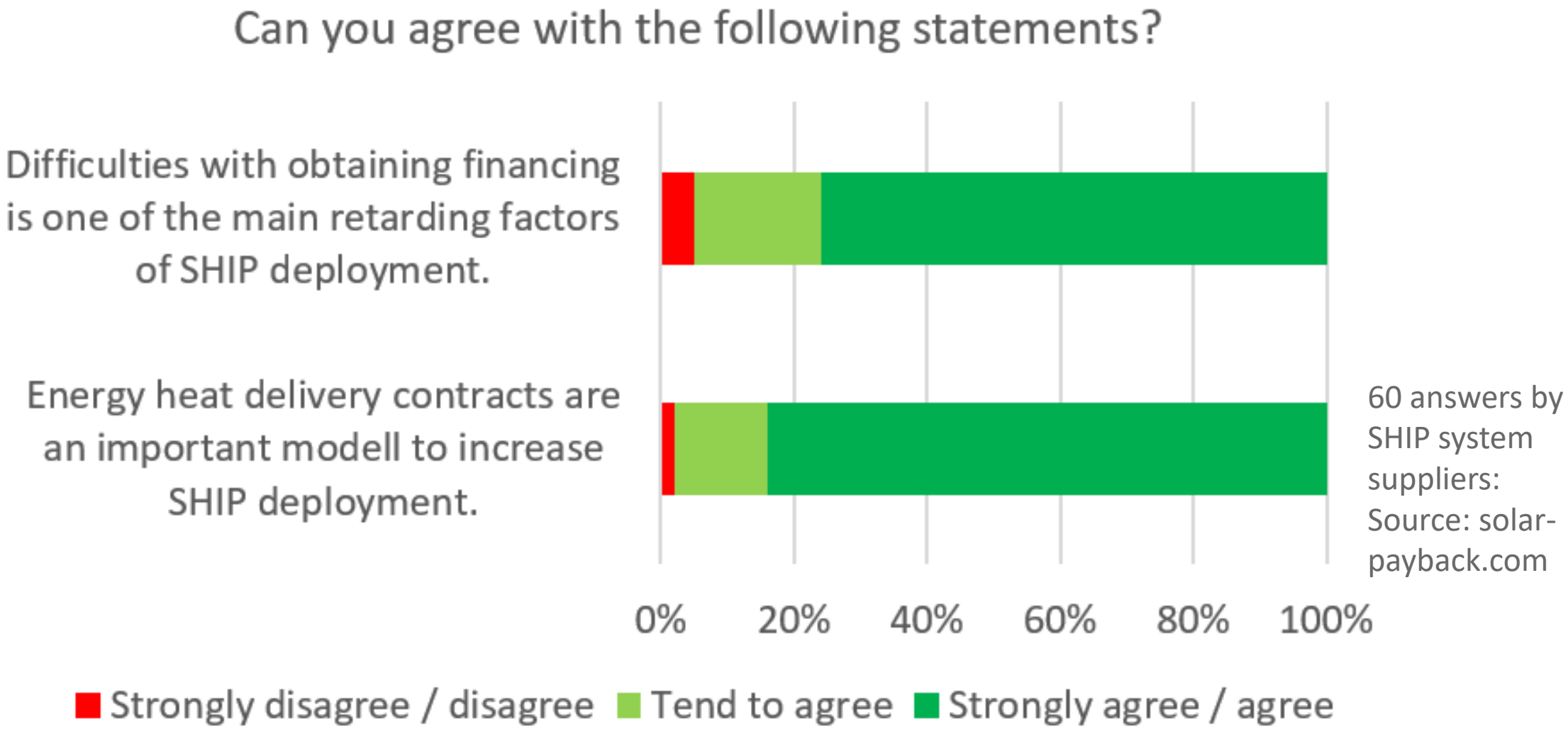
The MW-class: 360 MW of parabolic troughs in glasshouses are in operation in Oman for Enhanced Oil Recovery

Second phase with 360 MW transferred to customer in spring 2020

May 2020 bankruptcy of GlassPoint

Photos: GlassPoint

Heat supply contracts: Popular but hard to implement



60 answers by SHIP system suppliers: Source: solar-payback.com

ESCO SHIP projects – Mega Trend in France

Project Developer **NewHeat**, France, closed a EUR 13 million EUR bank loan deal in August 2020 to finance five ESCO solar heat projects in France with 28 MW_{th} in total

Photo: NewHeat

Kyotherm, a renewable heat third party financer, has the largest SHIP project in Europe under construction

- 14,000 m^2 flat plate collectors (10 MW) for a malting plant in the south of France
- EUR 6 million CAPEX
- Negotiated heat price: 26 EUR/MWh plus inflation over 20 years

Commercial role-out of SHIP systems in Mexico

Inventive Power commissioned at least 66 SHIP systems between 2010 and 2019

>100 installations process heat and domestic heating

Many installations provide pre-heating in steam systems or hot water

Total costs including: Collector field and circuit - Solar storage tank - Planning and installation costs (Not included: equipment for integration into client's network, financing costs, subsidies and VAT)

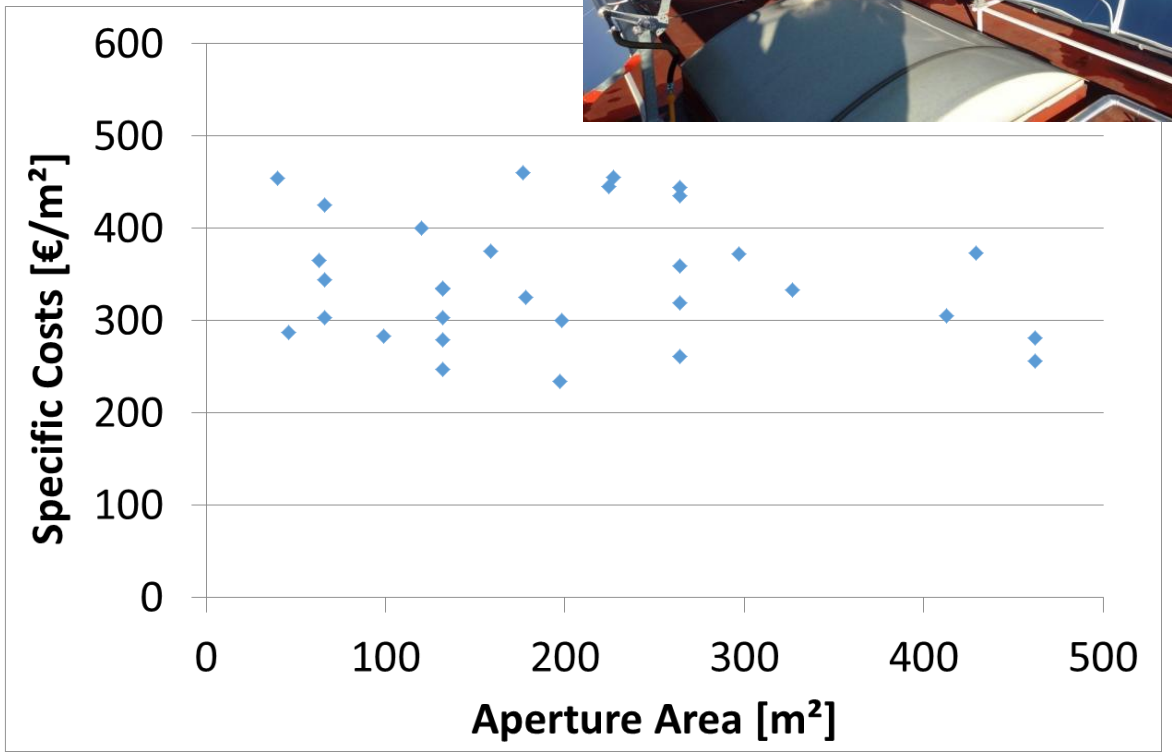


Photo: Inventive Power / AEE Intec http://ship-plants.info

Installations in Turkey and Afghanistan

Collector supplier and EPC Soliterm

2020: Izmir, Turkey – 6,000m² process heat for packaging industry

2018: 5 Plants in total 14,558 m² e.g. Bursa/Turkey – 4,320 m² steam for textile process

Herat Afghanistan – 3,240 m2 butchery

2017: Kaya Laundry, Turkey – 4,996 m² steam support of the laundry

Motivations customers:

- Replace gas
- Sustainable and manageable heat supply reducing dependency on volatile fuel prices
- CO_2 reduction – avoid CO_2 taxes

Combination trough with concrete storage and CPC collectors

Juice production in Cyprus

EPC and collectors protarget

PTC 283 m², steam at 11barg and 188°C

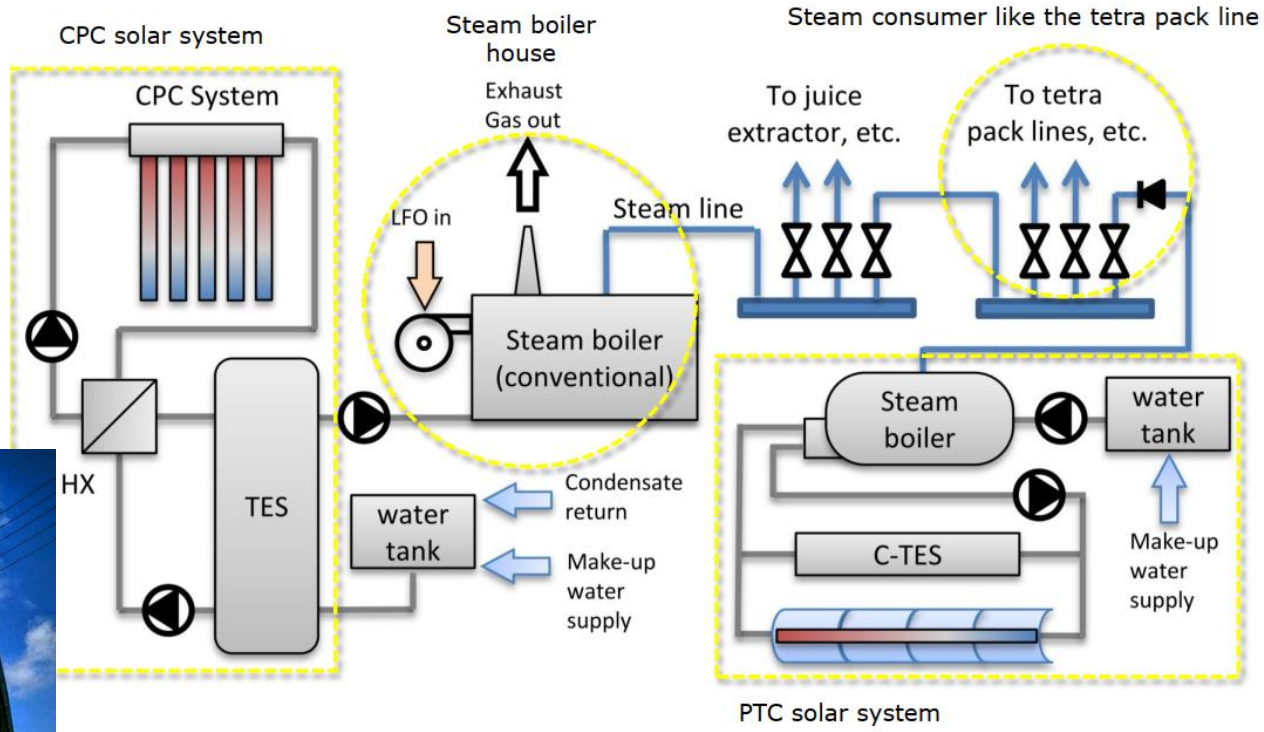
Solar field up to 410°C to load a concrete storage

CPC 225 m², hot water at 95°C for feedwater

Integration and Design

Layout of the steam network

protarget SOLAR POWER SYSTEMS



Photo, layout: protarget

Direct steam generation with Ruth storage

Amman, Jordan, JTI – Japan Tobacco International

Collectors and EPC: Industrial Solar

1,254 m² Fresnel collector field in operation since 2017

Rooftop installation

Max. 220°C steam temperature

15 m³ steam drum allows 1 hour storage at full load

Steam for production and for double-effect absorption chiller for climatisation

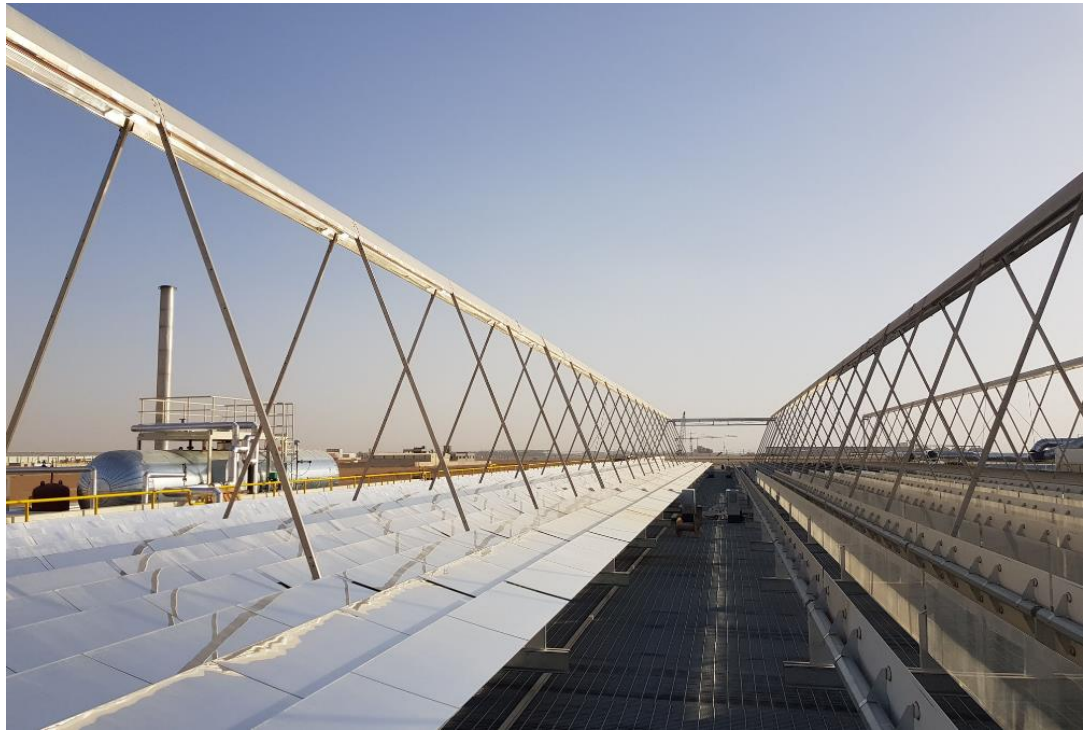


Photo: Industrial Solar

Collector certified according to ISO 9806

Collector with glass cover instead of receiver glass pipe

Producer Absolicon

Certificate:
reliable information for customers on efficiency
annual yield for collector comparison

Photo: Absolicon

Green heating policy in China drives huge investment in parabolic fields

Site: Baotou, Inner Mongolia, China

Collectors, EPC, operator: Xuchen Energy, Inner Mongolia

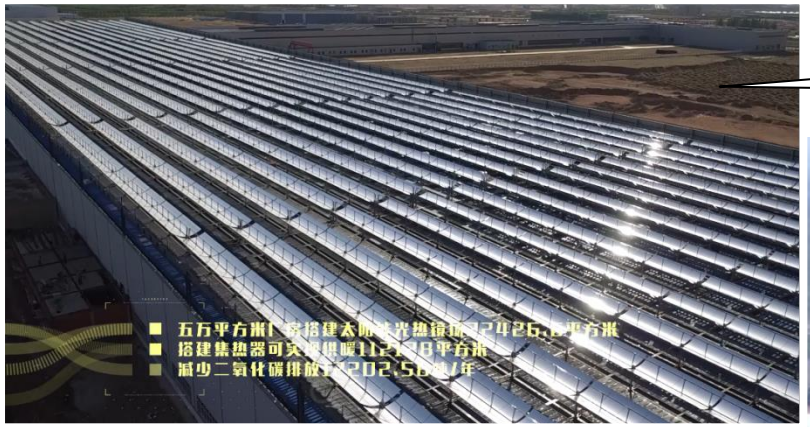
93,000 m³ in operation since 2016 of which 22.000m² on roof

66,000m³ water storage up to 95°C

Up to 220°C in solar field

Space heating for buildings

100 % subsidised by the central government within green heating policy



Roof top installation

Ground field mounted in east-west axis

Photos: Xuchen

ESCO collector fields Belgium for chemical industry

Azteq - ESCO, Solarlite - EPC

Commissioned 2019/2020, in operation

Parabolic trough collectors 1100 m²

Field temperatures 220°C/330°C

Process steam generation at 6 bar, 155 °C and 11 bar, 185 °C

Roughly 1 hour of cold start early morning,
warm start in summer 20 minutes,
hot start-up 1 to 3 minutes

Cleaning by rain

Antwerpen, Belgium
Photo: DLR

Oostende, Belgium
Photo: Solarlite

Trends I

Customers ask for a **high solar share** or even for a vision to supply 100% of the heat, influencing the technology choice.

=> to which extend can solar thermal systems cover the demand over the full year

=> moves storage more into focus

For component suppliers the industrial market offers much shorter development times as products are applied quicker and with less risk => **Faster renewal** and price reduction

Troughs in **east-west axis** => Less annual yield but better distribution along year (away from equator)

Trends II

Customers choice of **technologies relates with the producers** in the same country:

- Spain: 3 of 4 installations have been realised with Fresnel and the three Spanish suppliers Solatom, Rioglass Solar and Covalersa all produce Fresnel collectors.
- Mexico: all installations parabolic trough technology from Inventive Power.
- India: many installations with dishes by Megawatt Solutions and Quadsun.

Operating temperatures in solar field significantly above demand requirements - **high delta T** in solar fields – small pump and heat exchanger

District heating also realised by Aalborg in Denmark, other suppliers aim at this application

Final remarks

- An increased number of concentrating collector manufacturers discovers the huge potential of industrial solar heat
- Carbon taxes or/and mandatory renewable energy quotes are needed to raise awareness of industrial clients for green heat supply
- ESCO is a suitable business model to convince reluctant industrial decision makers
- Research: Find answers on near to 100% renewable heat supply
- Research: Storage solutions: developments for > 150°C required
- District heating is also an application of interest for collector suppliers
- Results in paper for SolarPACES 2020 „Developments in solar heat from concentrating solar systems” in preparation