INDUSTRIAL SOLAR HEAT PAYS OFF

There is more final energy consumption of heat in the industrial sector than there is electricity consumed worldwide. Electricity, however, is talked about more.

**ENORMOUS GLOBAL HEAT DEMAND IN INDUSTRY**

**What is SHIP?**

SHIP is the acronym for Solar Heat for Industrial Processes and describes systems which provide solar heat in a factory. A collector field heats a process fluid by means of solar radiation and a heat exchanger transfers this heat to a supply system or production process in the factory as hot water, air flow or steam. Storage units make it possible to use the generated heat at night-time.

**GROWTH PATH FOR SHIP UP TO 200°C**

More than **500** industrial manufacturers trust solar heat worldwide.

More than **400,000 m²** of collector and mirror area (≈ 280 MWth) produce Solar Heat for Industrial Processes around the globe.

**POWERFUL RESOURCE**

- Solar collectors produce heat
- Photovoltaic modules produce electricity

**VENOMOUS CIRCLE OF LOW DEPLOYMENT RATES**

- Three ways to break the vicious circle
  - Greatly step up communication efforts to raise awareness of the technology among potential customers in industry.
  - Support financing models to reduce risks and initial costs to small and medium industrial investors.
  - Implement measures for raising energy prices (e.g. carbon tax) or stipulating a renewable quota in certain industries.

**MAJOR INDUSTRIES**

Industry segments with highest number of realised SHIP plants

- Food and beverage: 40 %
- Machinery: 24 %
- Textile: 18 %

**Total final energy consumption 2014:** 360 EJ (EXAJOULE, see Glossary page 17) [1]

26 % Industry
32 % Transport
17 % Residential
31 % Other

**TOTAL FINAL ENERGY CONSUMPTION 2014:** 360 EJ [1]

**IEA CONFIRMS**

More than **500**

**1.7 %**

Average annual growth of industrial heat demand until 2030 [4]

**24 %**

Low-tem temp heat (below 100 °C)
- Heating, pasteurizing, boiling, pasteurising, cleaning, drying, pickling, cooking.

**30 %**

Medium-tem temp heat (100 to 300 °C)
- Melting, dyeing, compression.

**48 %**

High-tem temp heat (above 300 °C)
- Material transformation processes.

**90 %**

Met by coal, oil and gas

**23.7 %**

Renewable energy share (including hydropower) in final global electricity consumption across all sectors

**9 %**

Renewable energy share in final heat consumption of global industrial sector

**0.001 %**

Solar share in final heat consumption of global industrial sector

**IEA CONFIRMS**

Solar heating and cooling not on track for 2 °C scenario

**Vicious circle of low deployment rates**

- High upfront investment costs plus low energy prices
- Long payback periods
- Little visibility of existing systems
- Small number of plants
- Low awareness
- Low energy prices
- High upfront investment costs

**Profit from the most powerful energy resource on earth**

**Harvest three times more energy from the sun than with photovoltaics**

**Replace imported fuels with local jobs**

**Increase competitiveness of domestic manufacturing**

**Four reasons for solar heat**

**Solar energy**

- Reliable for millions of years
- No transportation
- No taxation
- Independent of geopolitical crisis

**Energy share**

- Electricity: 70 %
- Heat: 30 %

**Electricity consumption**

- Coal: 30 %
- Natural gas: 22 %
- Oil: 13 %
- Renewables: 9 %
- Other: 1 %

**Heat consumption**

- Industry: 74 %
- Transport: 15 %
- Residential: 9 %
- Other: 2 %

**31 %**

Industrial heat demand

**30 %**

Industrial heat production

**26 %**

Industrial heat demand

**22 %**

Industrial heat production

**IEA CONFIRMS**

More than **500**

**24 %**

Reliable for millions of years

**9 %**

Reliable for millions of years

**1 %**

Reliable for millions of years

**IEA CONFIRMS**

More than **500**

**70 %**

Turnkey SHIP suppliers (strongly) agree that SHIP has already been competitive in many markets, but is not known well enough to customers.

**40 %**

Turnkey SHIP suppliers (strongly) agree that heat supply contracts / ESCO models are an important means of increasing deployment.

**79 %**

Turnkey SHIP suppliers (strongly) agree that heat supply contracts / ESCO models are an important means of increasing deployment.
SOUTH AFRICA
Cape Brewing Company • Brewery

The solar system was integrated within one day, so we succeeded to have minimum interruption of our day-to-day operation. At current rate, a realistic ROI is +/-6 years.

Andy Kung, Chief Operating Officer, Cape Brewing Company

VIETNAM
ISA TanTec • Tannery

Solar heat helps us to reduce energy costs significantly and more important, it keeps them predictable and stable. In fact, it also makes us more competitive and attractive on the market, as our customers are increasingly looking for eco-friendly suppliers.

Tom Schneider, Co-founder, ISA TanTec
We strongly believe green energy to be the future of sustainable development. The concentrating solar thermal project was implemented as a pathbreaking showcase, with more to come. It delivers the projected output, and we are exploring to replicate this at several other union member’s dairy plants.

*Heiner Schürch*, Project Manager, Zehnder Group International

---

**SWITZERLAND**
Zehnder Group Produktion
Gränichen • Heating / Cooling / Ventilation Appliances

<table>
<thead>
<tr>
<th>Year of installation</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar fraction</td>
<td>50 % of the total heat demand in the paint shop</td>
</tr>
<tr>
<td>Subsidy</td>
<td>CHF 164,000 (USD 163,000)</td>
</tr>
<tr>
<td>Annual savings</td>
<td>16,800 kg liquefied petroleum gas</td>
</tr>
<tr>
<td>Turnkey supplier</td>
<td>Eisenmann / Ritter XL Solar, Germany</td>
</tr>
</tbody>
</table>

---

**INDIA**
Amul Fed Dairy • Dairy

<table>
<thead>
<tr>
<th>Year of installation</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar fraction</td>
<td>0.59 % of total steam demand of dairy plant</td>
</tr>
<tr>
<td>Subsidy</td>
<td>INR 3,322,944 (USD 46,500)</td>
</tr>
<tr>
<td>Annual savings</td>
<td>53,000 m³ natural gas</td>
</tr>
<tr>
<td>Turnkey supplier</td>
<td>Thermax India</td>
</tr>
</tbody>
</table>

---

We want to be the most attractive provider of energy-efficient solutions for healthy and comfortable room conditions. Not only for our products and system solutions, but also for our own buildings and production plants.

*Arvindkumar Dhagat*, Senior General Manager, Amul Fed Dairy

---

**Process heat for the paint shop**

- **Amul Fed Dairy** • Dairy
- **Dairy**

- **Zehnder Group Produktion** • Heating / Cooling / Ventilation Appliances
- **Gränichen**

- **Aperture mirror area**
  - **394 m²** (393 kW)
  - **CHF 477,737** (USD 475,000)
  - Investment incl. installation

- **Gross collector area**
  - **394 m²** (276 kW)
  - **CHF 477,737** (USD 475,000)
  - Investment incl. installation

---

**Steam heating for milk pasteurisation, evaporation and sterilisation**

- **561 m²** (393 kW)
- **INR 15,682,635** (USD 942,000)
- **Aperture mirror area**
- **INR 15,682,635** (USD 942,000)
- **Investment incl. installation**

---

**We strongly believe green energy to be the future of sustainable development. The concentrating solar thermal project was implemented as a pathbreaking showcase, with more to come. It delivers the projected output, and we are exploring to replicate this at several other union member’s dairy plants.**

*Arvindkumar Dhagat*, Senior General Manager, Amul Fed Dairy

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**Photo: Amul Fed Dairy**

**Photo: Zehnder Group International**

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**Photo: Amul Fed Dairy**

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**Photo: Zehnder Group International**

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**Photo: Amul Fed Dairy**
AUSTRIA
Fleischwaren Berger
• Meat Products

"Year in, year out, we had thought about using solar energy for our ham production. What ultimately helped us to turn this idea into a reality was the in-depth advice and expertise of Austrian service providers. Running an environmentally friendly business is a wonderful experience."

Rudolf Berger, Chief Executive Officer, Fleischwaren Berger

<table>
<thead>
<tr>
<th>Year of installation 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar fraction</td>
</tr>
<tr>
<td>Subsidy</td>
</tr>
<tr>
<td>Annual savings</td>
</tr>
<tr>
<td>Turnkey supplier</td>
</tr>
</tbody>
</table>

Photo: Fleischwaren Berger

JORDAN
RAM Pharma
• Pharmaceuticals producer

"RAM Pharma is committed to reduce its CO₂ emissions. We decided to use Fresnel collector technology, as it’s the best option for generating solar process steam. Our system was commissioned in March 2015 and cut diesel consumption by 42%, exceeding expectations."

Dr. Mahmoud Al Najami, General Manager, RAM Pharma

<table>
<thead>
<tr>
<th>Year of installation 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar fraction</td>
</tr>
<tr>
<td>Turnkey supplier</td>
</tr>
</tbody>
</table>

Photo: Silke Anders

Photo: RAM Pharma

Photo: JORDAN RAM Pharma

Photo: AUSTRIA Fleischwaren Berger
We have greatly profited from our solar investment. It not only allows us to use the sun's energy to pasteurise 350,000 litres of milk ten hours a day, but pasteurisation has become easier to manage. The solar heat system provides much more stable temperatures than the steam boilers we use.

*Mario Tellez, Chief Operating Officer, Lechera Guadalajara*

---

We use the sun's power to dry precast concrete elements in summer and heat our facilities in winter. It is a most effective way of preparing for the challenges ahead and boosting competitiveness and productivity.

*Anton Karner, Managing Director, Habau Group*
SURPRISINGLY POPULAR

Solar Heat for Industrial Processes (SHIP) is still far from being a standard, but the market has already grown to a considerable size: The first World Map of Solar Process Heat Specialists 2017 (see page 10/11) shows, all in all, 71 suppliers of turnkey SHIP systems. The following charts show the most relevant results from the accompanying survey (see glossary, page 17).

Parabolic trough is the most common collector type

42 turnkey SHIP suppliers depicted on the world map own collector facilities

High rating for Solar Payback markets

An overwhelming majority of SHIP suppliers acknowledged the (extremely) good market potential of the four Solar Payback countries.

Turnkey suppliers based on number of reference projects

Austria
S.O.L.I.D.
Chile
Pampa Elvira Solar
China
Sunrain Group
Vicot Solar Technology
Himin Solar
Linuo Paradigma
Denmark
Aalborg CSP
India
Inter Solar Systems
Germany
Soliterm Group

Turnkey suppliers that sold SHIP systems with a total of more than 10,000 m²

Turnkey suppliers based on number of reference projects

<table>
<thead>
<tr>
<th>Country</th>
<th>Turnkey Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunrain Group</td>
<td>49</td>
</tr>
<tr>
<td>Inventive Power</td>
<td>35</td>
</tr>
<tr>
<td>Modulo Solar</td>
<td>33</td>
</tr>
<tr>
<td>Ritter XL Solar</td>
<td>29</td>
</tr>
<tr>
<td>Linuo Paradigma</td>
<td>24</td>
</tr>
<tr>
<td>Millennium Energy</td>
<td>21</td>
</tr>
<tr>
<td>Vicot Solar Technology</td>
<td>20</td>
</tr>
<tr>
<td>Inter Solar Systems</td>
<td>20</td>
</tr>
<tr>
<td>SEA Sistemas de Ecotecncias</td>
<td>18</td>
</tr>
<tr>
<td>Sunda Solar Energy</td>
<td>15</td>
</tr>
<tr>
<td>Soliterm Group</td>
<td>12</td>
</tr>
<tr>
<td>Taylor Solar</td>
<td>12</td>
</tr>
<tr>
<td>Megawatt Solutions</td>
<td>10</td>
</tr>
<tr>
<td>Aschoff Solar</td>
<td>8</td>
</tr>
<tr>
<td>Industrial Solar</td>
<td>8</td>
</tr>
</tbody>
</table>

High rating for Solar Payback markets

<table>
<thead>
<tr>
<th>Country</th>
<th>Extremely good potential</th>
<th>Good potential</th>
<th>Low potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>12</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Mexico</td>
<td>10</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>South Africa</td>
<td>10</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>Brazil</td>
<td>6</td>
<td>24</td>
<td>11</td>
</tr>
</tbody>
</table>

High rating for Solar Payback markets

An overwhelming majority of SHIP suppliers acknowledged the (extremely) good market potential of the four Solar Payback countries.
Were you satisfied with your business development in 2015?

- Extremely / very satisfied: 15%
- Satisfied: 45%
- (Fairly) dissatisfied: 40%

All 71 turnkey suppliers

26 turnkey suppliers from the Solar Payback countries* were more satisfied than turnkey suppliers globally

HEAT SUPPLY CONTRACTS ARE AN IMPORTANT MEANS TO INCREASE DEPLOYMENT

Most turnkey SHIP suppliers (strongly) agree with the following statements:

- 54% mention difficulties with securing funds as one of the main retarding factors
- 63% believe that huge efforts are needed to make solar process heat projects bankable
- 79% see heat supply contracts / ESCO models as an important means to increase deployment
- Only 34% have offered solar heat supply contracts so far

To foster the growth of the industry, ESCOs will need much more support in the form of low-interest loans and contingency or cancellation insurance.

HIGH FOSSIL FUEL COSTS AND ENVIRONMENTAL REGULATIONS STRENGTHEN INDUSTRY

When asked about market barriers, the SHIP planners often mentioned low fossil fuel prices. Other frequently cited issues were the high cost of systems and, consequently, long payback periods. Hence, 41% of respondents chose high energy prices as the most important factor in growing the market.

Which are the most relevant criteria for a good market development? (two answers possible)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>High fossil energy prices</td>
<td>41%</td>
</tr>
<tr>
<td>Political regulations that require solar process heat</td>
<td>20%</td>
</tr>
<tr>
<td>Financial support schemes</td>
<td>18%</td>
</tr>
<tr>
<td>Easy to access project financing</td>
<td>11%</td>
</tr>
<tr>
<td>Growing economy</td>
<td>9%</td>
</tr>
</tbody>
</table>

Answers from 71 SHIP suppliers

*India, Mexico, South Africa and Brazil

“..."The acute lack of awareness about how solar heat can be a reliable and economically feasible option for high-temperature supply can be addressed by pioneering efforts and showcase projects..."

Bhoovarhan Thirumala
CEO of Aspiration Energy, India
SOLAR COLLECTORS FOR INDUSTRIAL APPLICATIONS

COLLECTOR

A solar thermal collector captures solar radiation hitting a surface, the absorber, to heat a fluid in a hydraulic circuit.

COLLECTOR TYPES

Stationary
Fixed tilt or seasonally adjusted

Tracking
Linear or two-axis tracking

- Flat plate collector
- Vacuum tube collector

- Parabolic trough collector
- Linear Fresnel collector
- Concentrating dish collector

WHAT TO CONSIDER WHEN CHOOSING A COLLECTOR TYPE

- Typical operation temperature of the collector type meets the requirements for the industrial heat (see next page)
- Design accommodates chosen heat transfer fluid
- Certified according to national or international standard, such as:
  - Solar KEYMARK (Europe)
  - Solar Rating & Certification Cooperation, SRCC (USA)
  - Bureau of Indian Standards (BIS)
  - NMX-ES-001-NORMEX (Mexico)*
  - South African Bureau of Standards (SABS)*
  - National Institute of Metrology, Quality and Technology, INMETRO (Brazil)*
  - Chinese National Standard *
- Energy output certified by accredited third party
- Enough pressure resistance
- Adequate stagnation handling and overheating prevention (see glossary, page 17)
- Suitable weight for rooftop installation or appropriate size for ground-mounting

* These standards do not yet include concentrating collectors.
MARKET SEGMENTS

Solar collectors supply heat at different temperatures for production processes in several industries. The chart below shows the market segments most suitable for each collector type.

<table>
<thead>
<tr>
<th>INDUSTRY</th>
<th>LOW</th>
<th>MEDIUM</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Boiling</td>
<td>Distilling</td>
<td></td>
</tr>
<tr>
<td>Food and beverage</td>
<td>Drying, Boiling, Pasteurising, Sterilising</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery</td>
<td>Cleaning, Drying</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mining</td>
<td>Copper electrolytic refining, Mineral drying processes</td>
<td>Nitrate melting</td>
<td></td>
</tr>
<tr>
<td>Textile</td>
<td>Washing, Bleaching</td>
<td>Dyeing</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>Steaming, Pickling, Cooking</td>
<td>Compression, Drying</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HEAT DEMAND

The total heat demand for low and medium temperature applications accounts for 44 EJ (exajoule) globally (=12,222 TWh). The chart below shows this heat demand in selected industries.

<table>
<thead>
<tr>
<th>INDUSTRY</th>
<th>LOW</th>
<th>MEDIUM</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>3.1 EJ</td>
<td>4.0 EJ</td>
<td></td>
</tr>
<tr>
<td>Food and beverage</td>
<td>3.3 EJ</td>
<td>2.2 EJ</td>
<td></td>
</tr>
<tr>
<td>Machinery</td>
<td>1.5 EJ</td>
<td>0.6 EJ</td>
<td></td>
</tr>
<tr>
<td>Mining</td>
<td>1.1 EJ</td>
<td>0.7 EJ</td>
<td></td>
</tr>
<tr>
<td>Textile</td>
<td>0.4 EJ</td>
<td>0.9 EJ</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>0.4 EJ</td>
<td>0.2 EJ</td>
<td></td>
</tr>
</tbody>
</table>
SYSTEM INTEGRATION

Solar heat can be provided at different integration points. Preheating is the most common method of incorporating solar heat into the production cycle. However, it can also be used to generate steam or fed directly into the process loop.

**Preheating**
Cold water is preheated in the solar field and fed into a storage tank where it is heated up by a fossil fuel boiler to the required temperature of the production process.

![Example of solar thermal integration for preheating](IRENA [8])

**Direct steam generation**
Water is partly evaporated in the concentrating collectors. The solar-heated steam is then separated from the remaining water in the steam drum before being supplied to the industrial process or the steam network of the factory. The treated condensate – also called feed water – is fed back to the collector field. Another option is **indirect steam generation.** In this case, the collector field heats water or thermal oil in a closed circuit to generate steam via a heat exchanger.

![Example of solar heat integration to generate steam](IEA TASK 49 [9])
Process heating
The solar field provides heat at a certain temperature to maintain the temperature of a bath or a thermal separation process. Additional heat is provided to the production process by a fossil fuel boiler. Both circuits are closed so that the cooled off water returns to the collector field or the boiler respectively.

CHALLENGES
Integrating solar heat systems into industrial processes requires customised SHIP designs based on which production methods a company employs, which conventional heating system it has installed and which fuel is used. What do experts believe are the major barriers to successful integration?

"Despite there being a wide variety of low-temperature industrial processes, heat supply in industry often relies on steam boilers and steam distribution networks. The integration of solar process heat is a challenge in that it either acts directly on the processes, an approach that the industry is reluctant to implement, or on the heat supply system at the boiler preheating or steam network stage, which means higher pressures and temperatures than those required for the processes."

Dr Pedro Horta

"After having analysed many different production processes, I concluded that opportunities for solar integration heavily depend on the conventional heating equipment being used. A tunnel pasteuriser, which gets its heat from an external heat exchanger, is a suitable match for industrial solar heat, whereas commonly used flash pasteurisation is difficult to incorporate as an external solar heat source."

Dr Bastian Schmitt
Head of the Process Heat group at the Institute of Thermal Engineering (ITE) at University of Kassel, Germany

"Decision makers in manufacturing are sceptical. Production is their lifeblood. They are extremely reluctant to risk having a faulty or problematic system cause operational downtime."

Doran Schoeman
Group Director of E3 Energy, South Africa

"SHIP is not just about switching from fossil fuels to renewables, but you will also have to identify waste heat potential if you want to achieve mostly shorter payback periods. Efficiency improvements could help many production businesses."

Christian Holter
Managing Director of S.O.L.I.D., Austria
SHIP SUPPLIERS

EXPERIENCED AND “MARKET-READY” SUPPLIERS OF TURNKEY SHIP PLANTS SHOWN ON THE WORLD MAP OF SOLAR PROCESS HEAT SPECIALISTS 2017

AUSTRALIA
NEP Solar: www.nep-solar.com

AUSTRIA
Ecotherm Austria: www.ecotherm.com
Feichtinger: www.feichtinger-gmbh.at
Fresnex: www.fresnex.com
Gasokol: www.gasokol.at
S.O.L.I.D.: www.solid.at

BRAZIL
Bosch/Heliotek: www.bosch.com.br/termotecnoologia
Enalter Engenharia Indústria e Comércio: www.enalter.com.br
Imax Energia: www.imaxenergia.com.br
Konus Icesa: www.konus.com.br
Sunshine Engenharia: www.sunshineengenharia.com.br

CANADA
Rackam: www.rackam.com

CHILE
Pampa Elvira Solar: www.ellaima.cl
Reinstein: www.reinstein-energy.com

CHINA
Shandong Linuo Paradigma: www.linuo-paradigma.com
Beijing Sunda Solar Energy Technology: www.sundasolar.com
Himin Solar: www.himin.com
Vicot Solar Technology: www.vicot.com.cn

DENMARK
Aalborg CSP: www.aalborgcsp.com

FRANCE
Helioclim: www.helioclim.fr
Sunonim: www.sunonim.com
Sunit: www.sunit.fr

GERMANY
Aschoff Solar: www.aschoff-solar.com
CitrinSolar Energie- u. Umweltechnik: www.citrinsolar.de
Consolar: www.consolar.de
Enersolve: www.enersolve.de
Industrial Solar: www.industrial-solar.de
KBB Kollectorbau www.kbb-solar.com
Phönix Sonnenwärme: www.sonnenaermeag.de
Protarget: www.protarget-ag.com
Ratioplan: http://ratioplan.bayern
Ritter XL Solar: www.ritterxl-solar.com
Solarlite CSP Technology: www.solarlite.de
Solterm Group: www.soltermgroup.com
SunOyster Systems: www.sunoyster.com
Sunset Energietechnik: www.sunset-solar.de

GREECE
Sole: www.eurostar-solar.com

INDIA
ATE Enterprises: www.ategroup.com
Akson’s Solar Equipment: www.aksonsolar.com
Aspiration Energy: www.aspirationenergy.com
Inter Solar Systems: www.intersolarsystems.com
Megawatt Solutions: www.megawattsolutions.in
Oorja Energy Eng’g Services: www.oorja.in
Quadsun Solar: www.quadsunsolar.com
Taylormade Solar Solutions: www.tss-india.com

ISRAEL
Tigi: www.tigisolar.com

ITALY
Softigua: www.softigua.com
Trivelli Energia: www.trivellienergia.com

JORDAN
Millennium Energy Industries: www.meisolar.com

MEXICO
Agbel Ingeniería y Servicios: agbel sadecv@gmail.com
Ausgreen Energía: ausbertain70@austegrensenergia.com.mx
Calentadores Solares Bicentenario (Solarqro): www.solarqro.com
Energia Saubere: www.ecosystems.com.mx
Inventive Power: www.inventivepower.com.mx
Investti: www.investtienergy.com
Modulo Solar: www.modulosolar.com.mx
SEA Sistemas de Ecotecnias Ambientales: www.seaecotecnias.com

PAKISTAN
Krypton Energy: www.kryptonenergy.com.pk

SOUTH AFRICA
Energyweb: www.energyweb.co.za
Greenability Installations: www.greenability.co.za
E3 Energy: www.e3energygroup.com
Holms and Friends: www.holmsandfriends.co.za
Reach Renewable: www.reach-renewable.com
Solarzone: www.solarzone.co.za

SPAIN
Inersur: www.inersur.com

SWEDEN
Absolicon Solar Collector: www.absolicon.com

SWITZERLAND
TVP Solar: www.tvpsolar.com

TURKEY
Anitcam Sunstrip: www.sunstrip.com.tr

USA
Artic Solar: www.articsolar.com
Chromasun: www.chromasun.com
Skyfuel: www.skyfuel.com
Solargenix: www.solargenix.com

Solar associations and partner institutes in the Solar Payback countries can provide additional solar thermal suppliers and manufacturers:

BRAZIL: Abrasol, www.abrasol.org.br
INDIA: STFI, www.stfi.org.in
MEXICO: ANES, www.anes.org
SOUTH AFRICA: SANEDI, www.sanedi.org.za
SERVICES

FURTHER SOURCES OF INFORMATION

- **IEA SHC – Task 49**
  Solar Heat Integration of Industrial Processes
  [http://task49.iea-shc.org](http://task49.iea-shc.org)

- **SHIP Database**
  Database of Solar Heat Applications in Industrial Processes
  [http://ship-plants.info](http://ship-plants.info)

GLOSSARY

- **Exajoule** is a unit denoting large amounts of energy at regional or global level. The exa-prefix means that an amount is multiplied by a number which starts with a one followed by 18 zeros \((10^{18} = \text{quintillion})\). 1 EJ is roughly equal to 278 TWh (terawatt-hours).

- **Final Energy Consumption** is the energy amount delivered as fuel or electricity to anyone but the energy sector itself, meaning either a household or an organisation, such as a hospital or a manufacturing business. Losses from conversion, transport and distribution do not factor into the calculation.

- **SHIP** stands for Solar Heat for Industrial Processes and is used in this brochure as the standard acronym for technologies or plants which deliver solar heat to industrial facilities. Other publications use different abbreviations or names to describe this type of application: Solar Process Heat (Task 49 of the IEA Solar Heating and Cooling Programme); CST or Concentrating Solar Thermal (Ministry of New and Renewable Energy, India); SIPH or Solar Industrial Process Heat (National Renewable Energy Laboratory, NREL, USA).

- **Solar fraction** or solar saving fraction is the amount of energy provided by the solar technology divided by the total energy required.

- **ESCO** is short for Energy Service Company and describes a business model in which the supplier offers its customers a heat supply contract instead of a turnkey system solution. ESCOs finance, operate and maintain SHIP systems while customers pay them either instalments based on the energy costs saved or fixed rates based on the energy amount delivered. In European directives, this model is termed EPC or Energy Performance Contracting. In US publications, it is called a third-party energy services agreement.

- **Survey among SHIP specialists.** In October/November 2016 solrico carried out a worldwide survey among turnkey suppliers of SHIP plants. The questionnaire defined turnkey as a system planned, supplied and installed by the seller. Of the approximately 130 companies contacted, 71 provided data and filled in a 4-page questionnaire. All 71 companies are shown on the world map (page 10/11).

- **Collector area** is one way to describe the size of a SHIP system. In the context of flat plate and vacuum tube collectors, the reference approach is based on collector gross area, the maximum projected area of the complete collector. In the case of concentrating collectors, the aperture area is used to describe the size of the collector field. Its defined as the projected area of the reflectors/mirrors. With parabolic trough and concentrating dish collectors, the supplier refers to the flat, rectangular area specified by the outer perimeter of the mirrors (aperture). To arrive at a collector area for linear Fresnel technology, the usual method is to add together the flat area of all primary mirrors. In the case of solar tower plants, it is the total area of all heliostats (mirrors). These collector area definitions have been used on the world map and to calculate the total collector area of the reference cases on page 3.

- **Solar thermal capacity** is derived from the collector area by using a conversion factor of 0.7 kWth/m². The IEA SHC Programme agreed with trade associations on this factor to allow for the comparison of solar thermal collectors with other energy technologies. The factor is used in the case studies on pages 4 to 7. The actual output of a square meter may vary based on local solar radiation and the temperature level required for the process. You can find a definition of the “reasonable” collector output in reference 7, page 7.

- **Stagnation** describes the condition in which a collector reaches the maximum temperature, because there is no demand for energy, the pump is switched off and collector losses are equal to the radiation absorbed by the system. To prevent technical failures, all solar loop components must be resistant to high temperatures and pressure loads during stagnation. Suitable measures for stagnation management are a good emptying behaviour of the collector field, a well-designed expansion vessel, a drainback concept (water from collector loop is drained into the tank during zero-demand periods) and the defocusing of concentrating collectors [see reference 10].
ABOUT SOLAR PAYBACK

OBJECTIVE
Promoting the use of Solar Heat for Industrial Processes (SHIP) across the four partner countries by raising awareness of its technical and economic potential, and increasing willingness to invest in it.

COUNTRIES

Brazil  
www.abrasol.org.br

Mexico  
www.anes.org

India  
www.stfi.org.in

South Africa  
www.sanedi.org.za

www.ahkbusiness.de

www.mexiko.ahk.de

www.indien.ahk.de

www.suedafrika.ahk.de

DURATION
October 2016 to September 2019

BUDGET
Total funds available for all four countries: EUR 2,958,920

ACTIVITIES

Drafting a National Solar Process Heat Potential Study

Developing policy recommendations for the uptake of SHIP technologies at national level

Organising train-the-trainer workshops on planning and designing SHIP plants

Offering bankers and investors training on how to finance SHIP systems

Organising a local industry and stakeholder conference

Implementing an online matchmaking network for investors and technology providers

Developing a funding and business tool for planners and investors to create preliminary analyses of SHIP plants

Identifying reference cases in manufacturing to conduct three pre-studies, plus detailed monitoring of one site to facilitate the set-up of a demonstration system (in South Africa, Mexico and Brazil)

Identifying reference cases among existing SHIP plants to carry out detailed monitoring of one system (in India)
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KfW DEG
www.deginvest.de

Solrico
www.solrico.com

REFERENCES

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www.irena.org

www.estif.org

[5] AEE INTEC, Database of Realised SHIP Plants
www.ship-plants.info

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