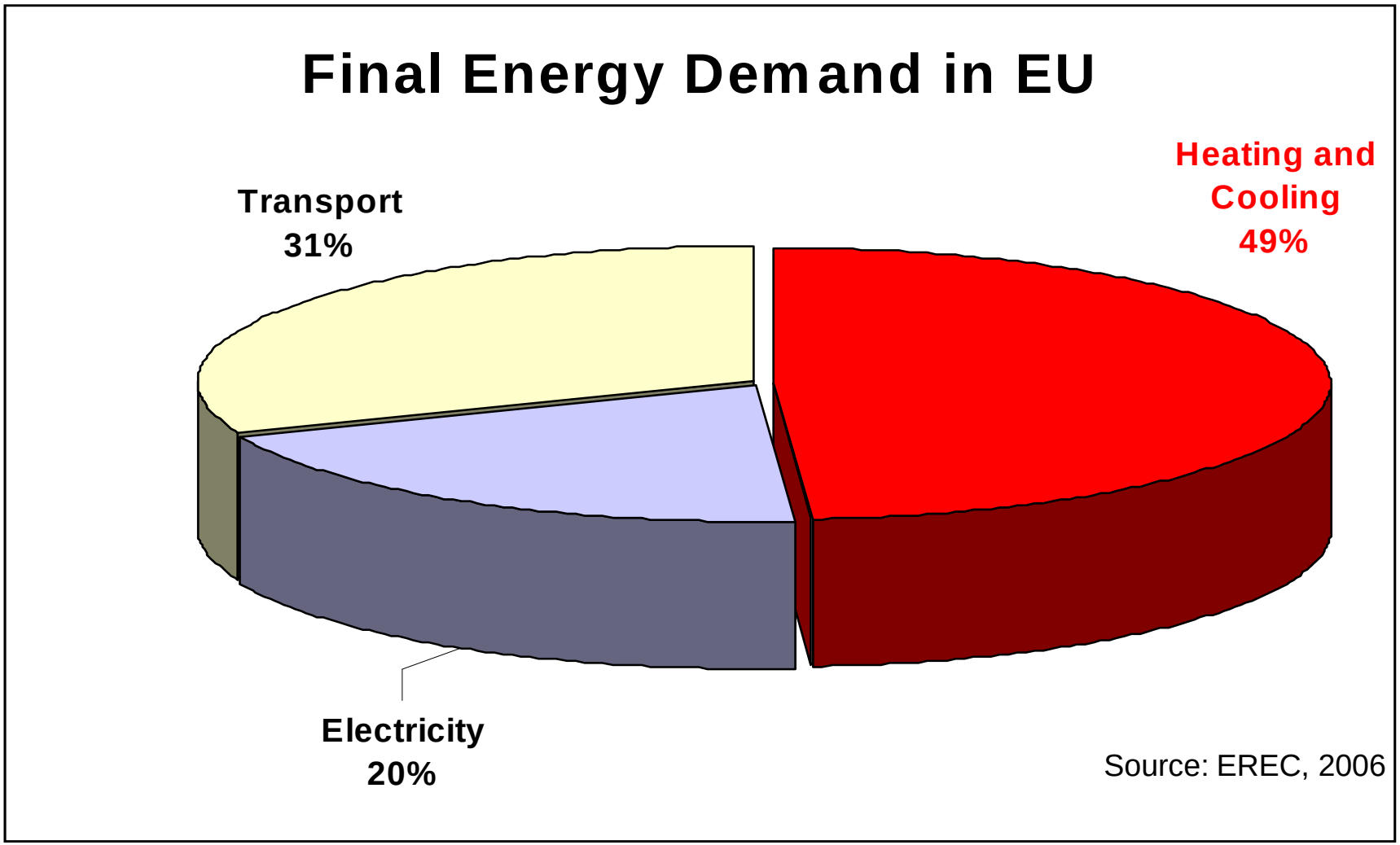
SOLAR HEAT FOR INDUSTRIAL APPLICATIONS

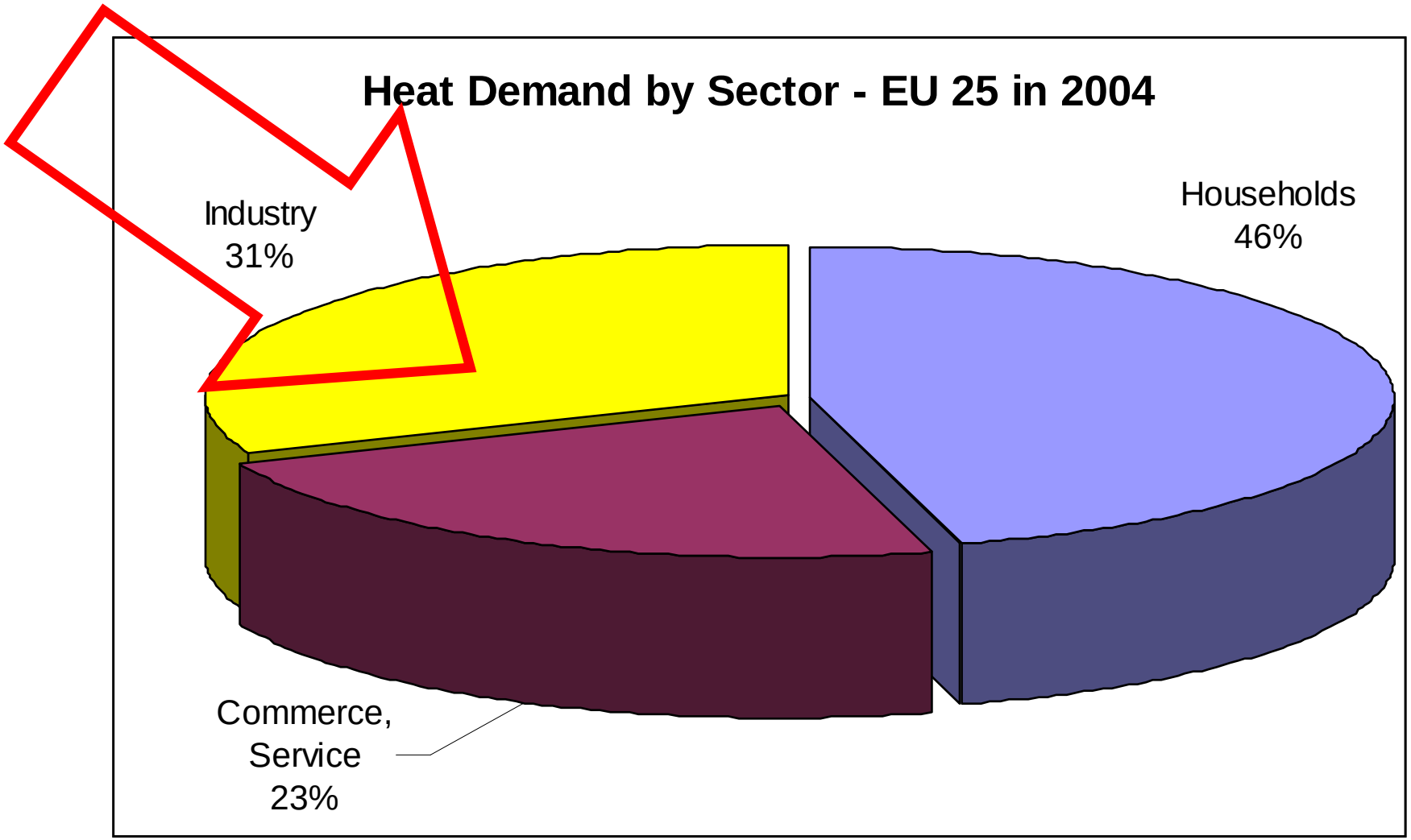
Werner Weiss

AEE INTEC - Institute for Sustainable Technologies
AUSTRIA

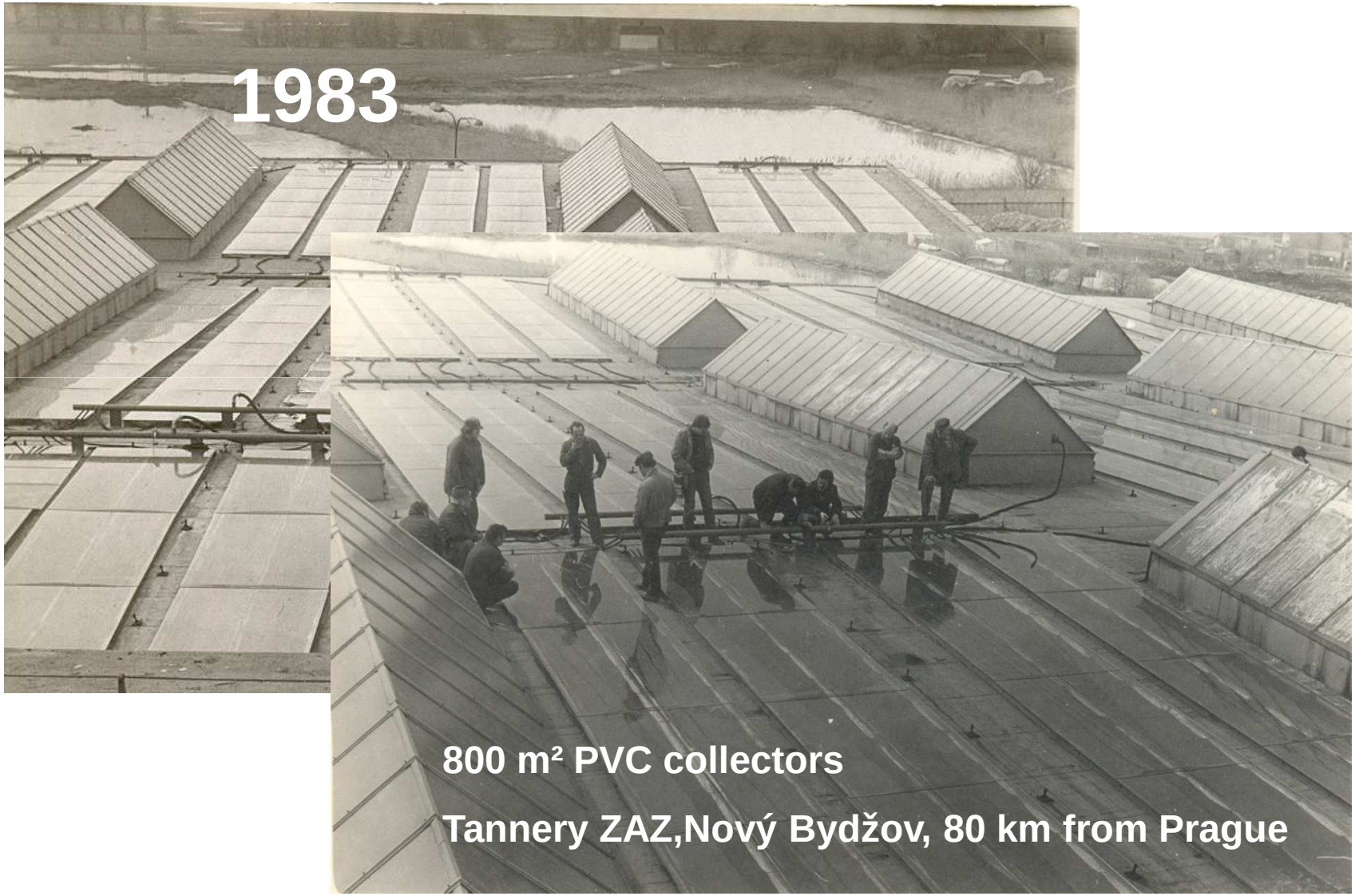
Heating and Cooling – The sleeping giant



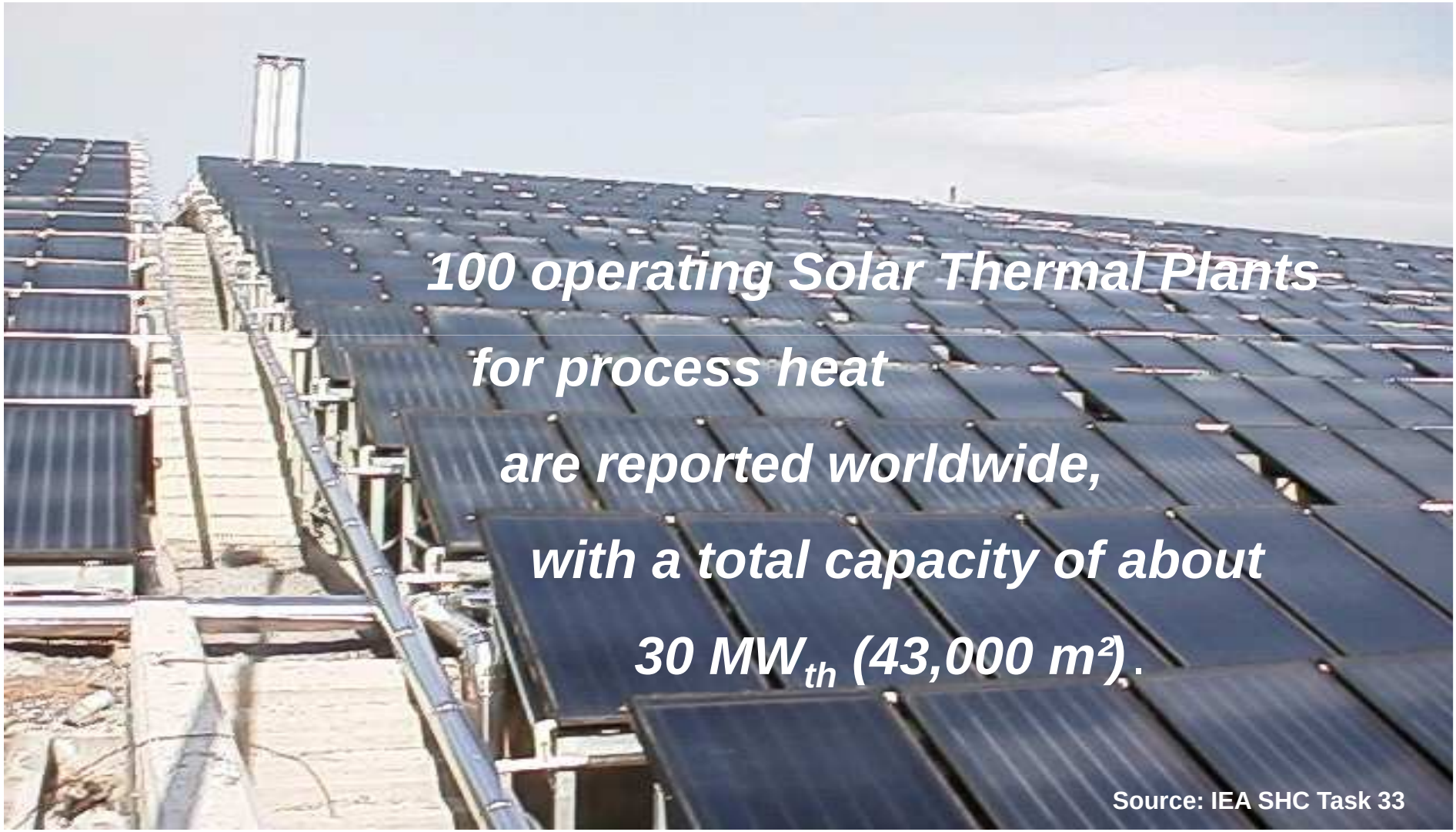
Heat Demand by Sector – EU 25 in 2004



Solar Heat for Industry – A New Application?



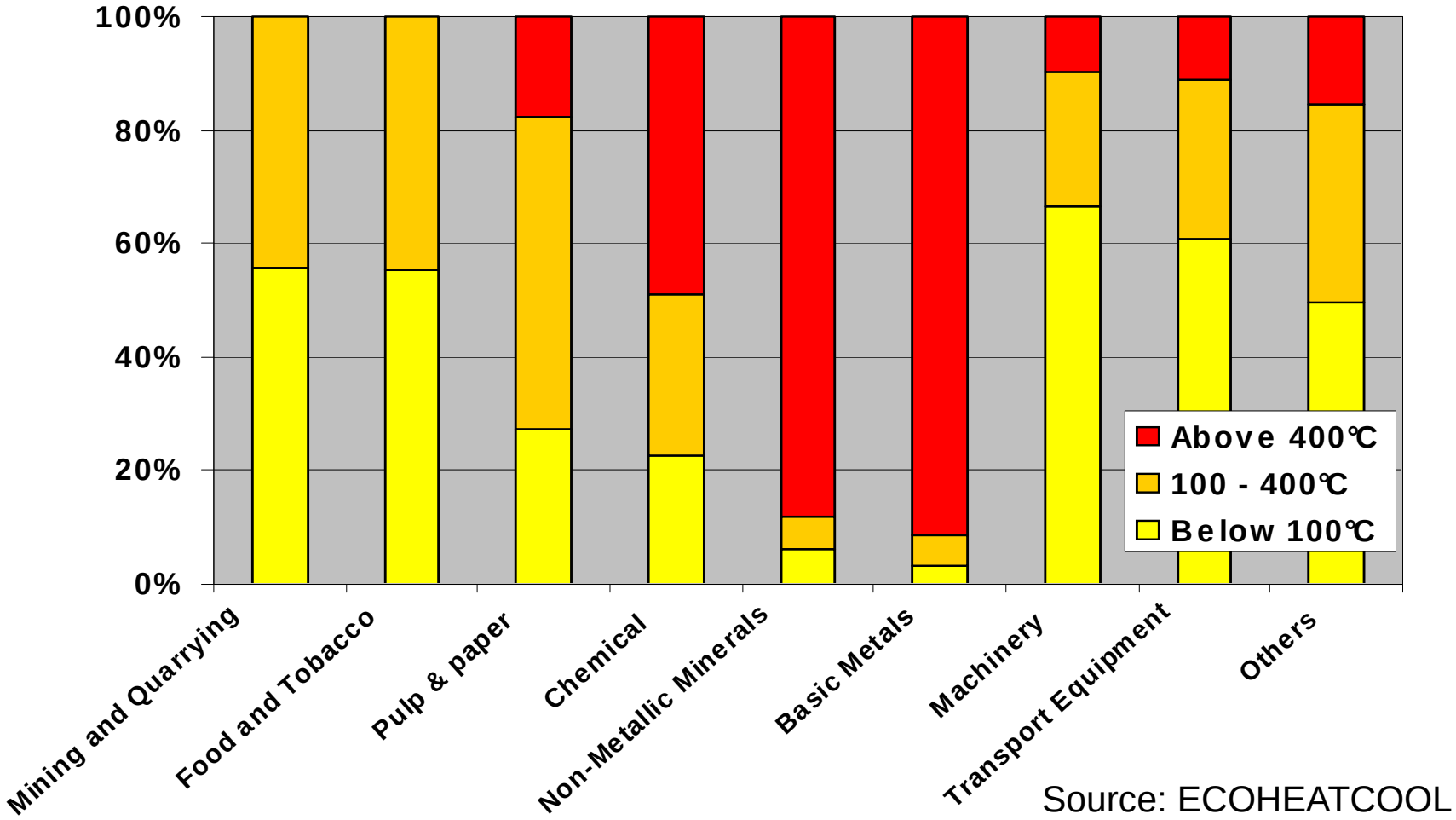
State of Application



100 operating Solar Thermal Plants for process heat are reported worldwide, with a total capacity of about 30 MW_{th} (43,000 m^2).

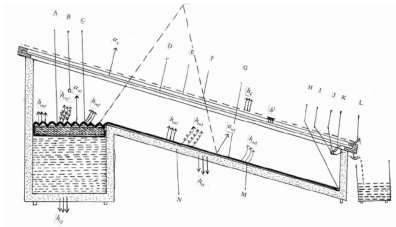
Source: IEA SHC Task 33

Industrial heat demand by temperature level and industrial sector – Data 2003

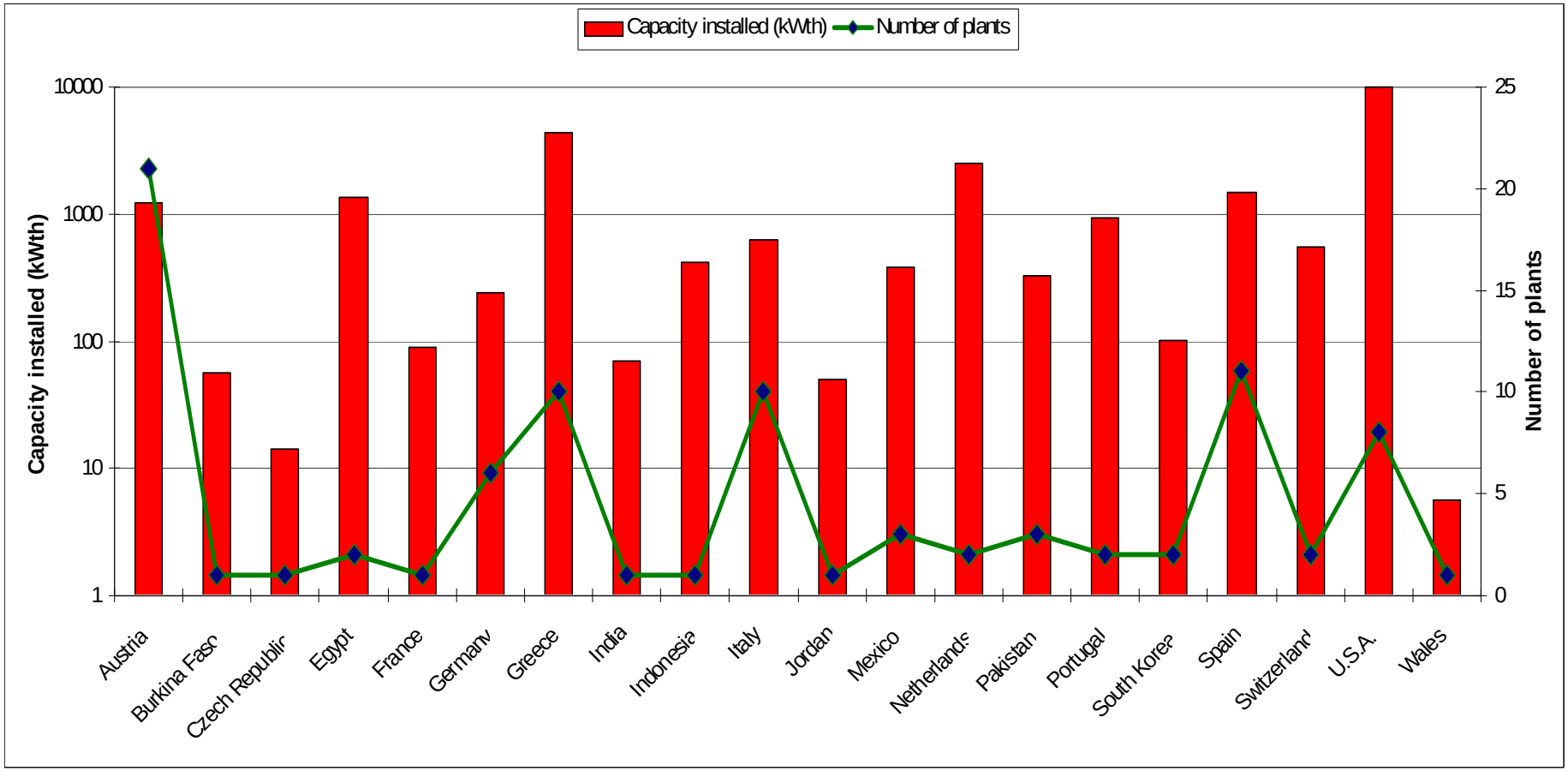


Source: ECOHEATCOOL

Industrial Applications

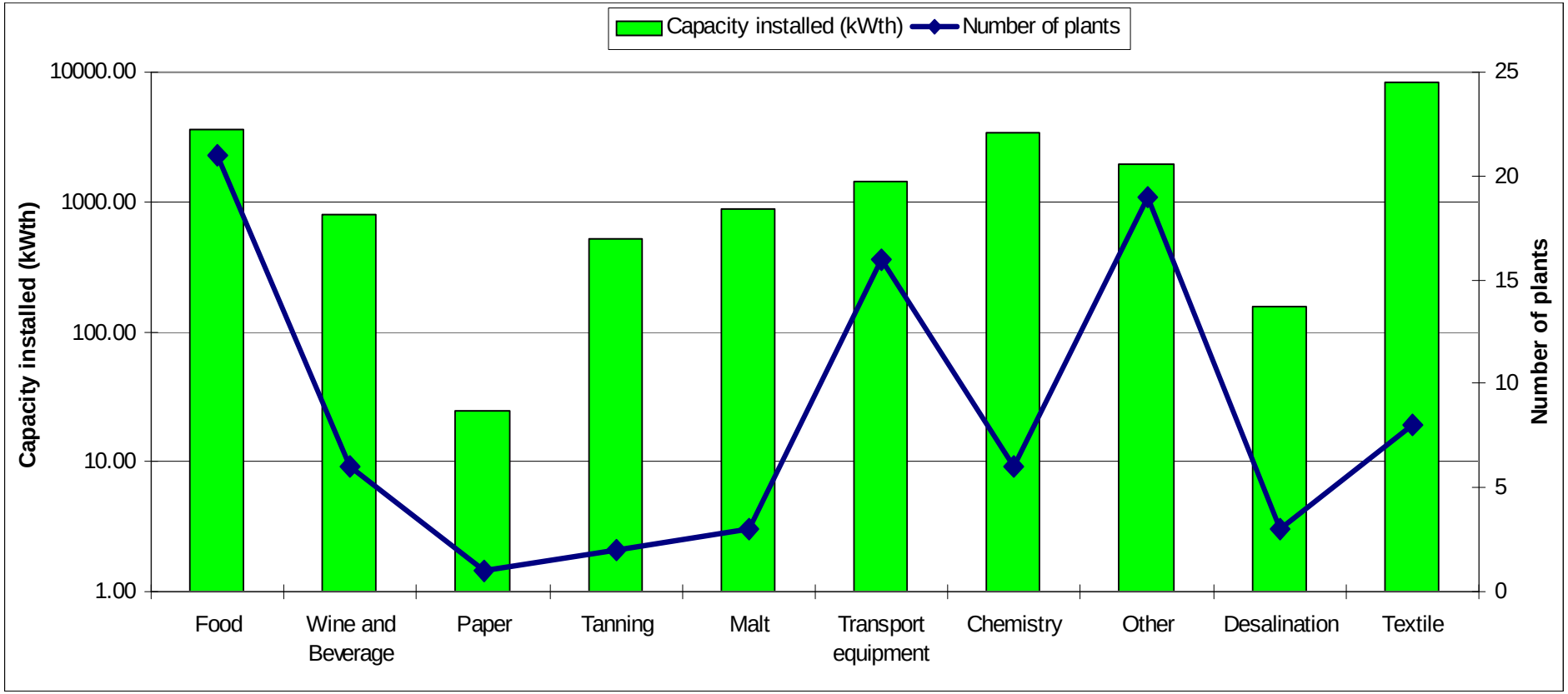
Space heating of industrial buildings	
Low- and medium temperature heat for industrial processes	
Water treatment **(e.g. Sea water desalination)**	
Refrigeration and cooling	

Solar industrial process heat plants - by Country



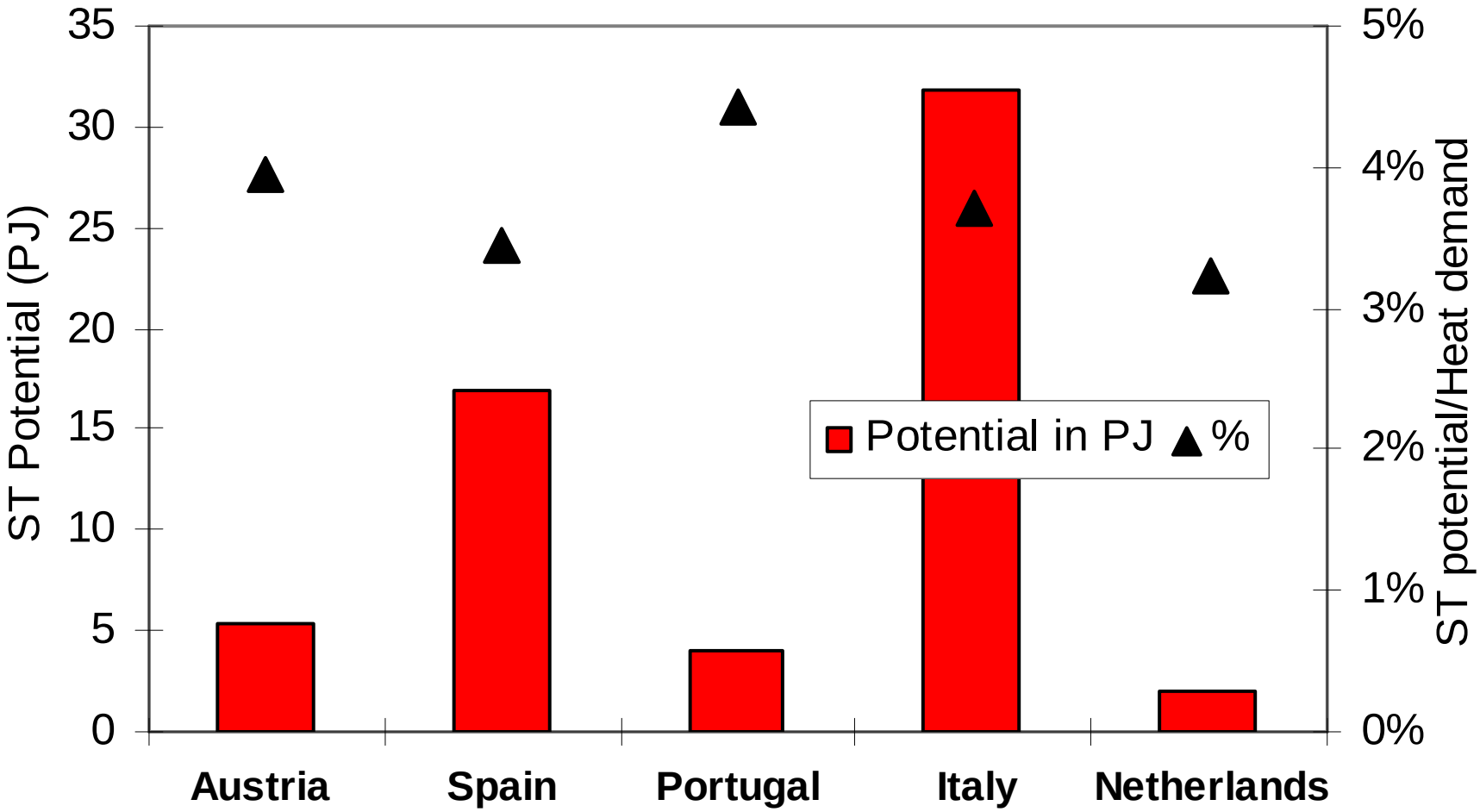
Source: IEA SHC Task 33, R. Battisti, C. Vannoni

Solar industrial process heat plants - by Sector



Source: IEA SHC Task 33, R. Battisti, C. Vannoni

Potential for solar process heat in Europe



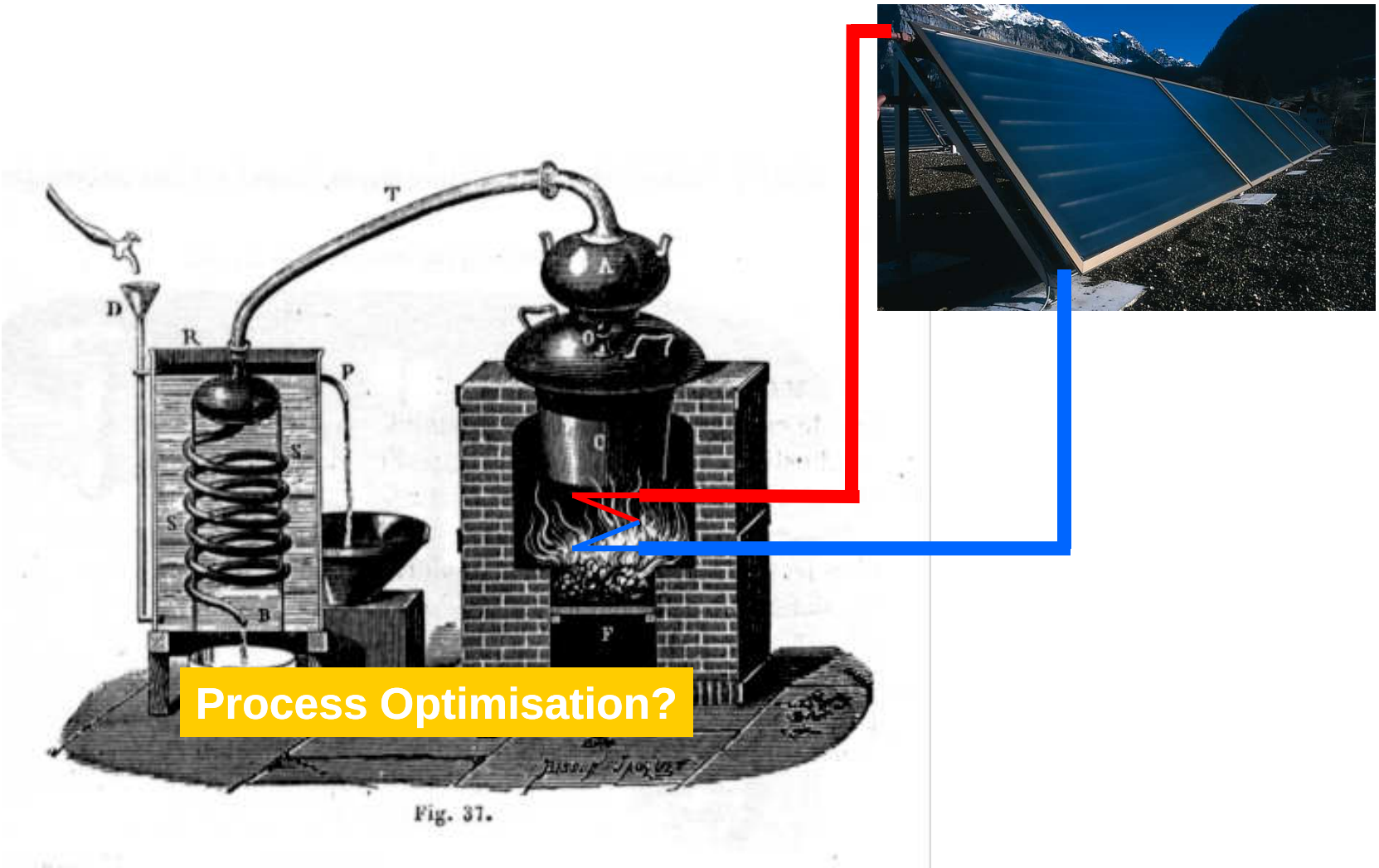
Source: IEA SHC Task 33, R. Battisti, C. Vannoni

Potential for solar process heat in Europe

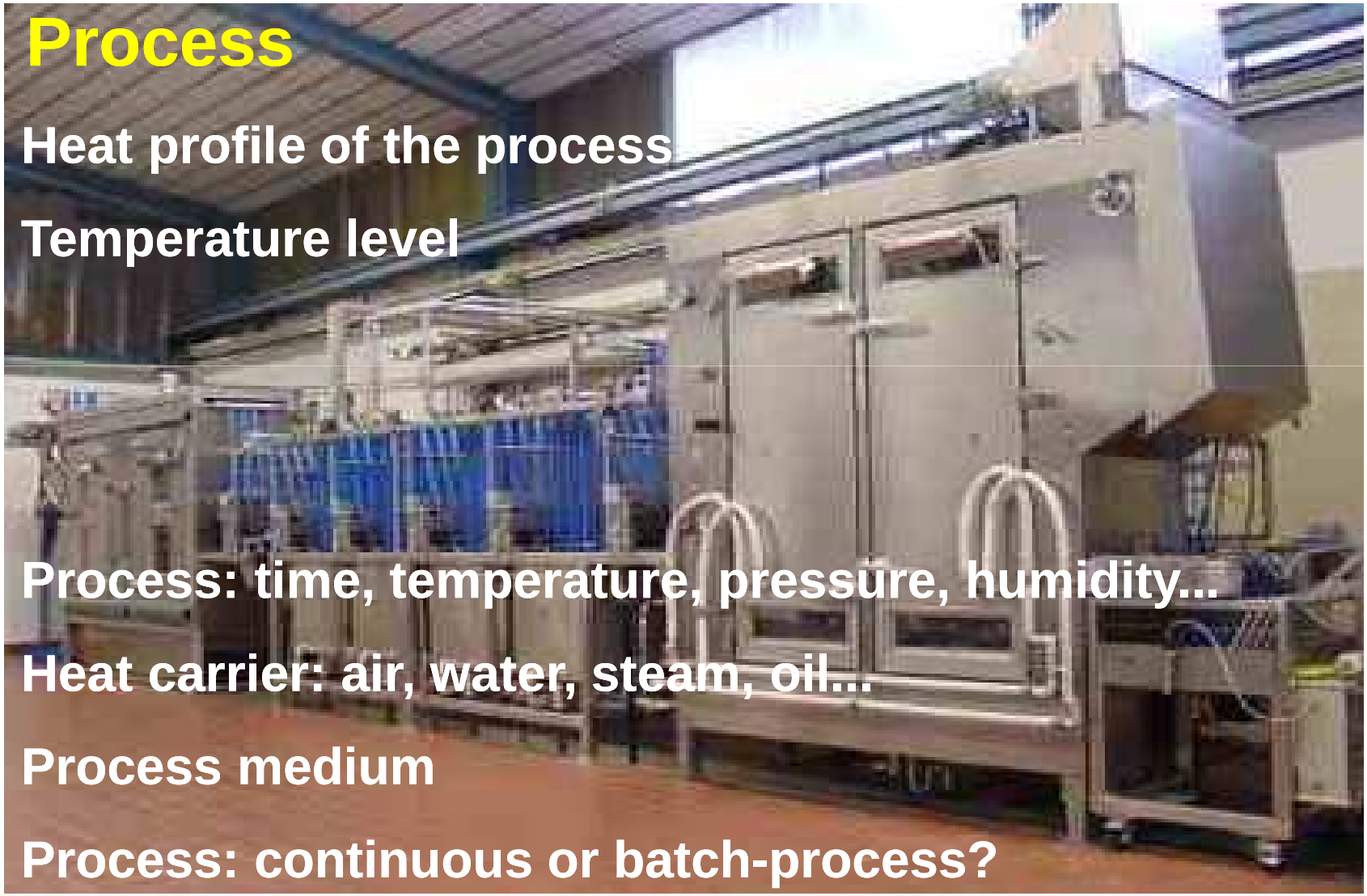
Country	Industrial final energy consumption in 2002 [PJ/year]	Industrial heat demand in 2002 [PJ/year]	Solar process heat potential [PJ/year]	Solar heat on industrial heat demand [%	Solar process	process potential W]
Austria	297	220	5			3
Spain	1175	841			10	7
Portugal	243			2.2	2.5	1.7
Italy			32	2.8	15.4	10.8
Netherland		425	1.5 - 1.95	0.3 - 0.5	0.8 - 1	0.7
G	2416	1575	50	3.2	35	24.5
EU 1	***11372***	***7880***	***199***	***2.5***	***110 - 138***	***77 - 97***
EU 25	***12964***	***9145***	***230***	***2.510***	***128 -160***	***90 - 112***

This would lead to a market volume up to 112 GW_{th} of new capacity installed (160,000,000 m^2) for the solar industry. Furthermore this would lead to 160,000 jobs

Integration into Industrial Processes



Integration into Industrial Processes



Process

Heat profile of the process

Temperature level

Process: time, temperature, pressure, humidity...

Heat carrier: air, water, steam, oil...

Process medium

Process: continuous or batch-process?

Knowledge about future trends needed

Process 1

Water saving Process 2

Closed water loop Process 3

Digital Photos

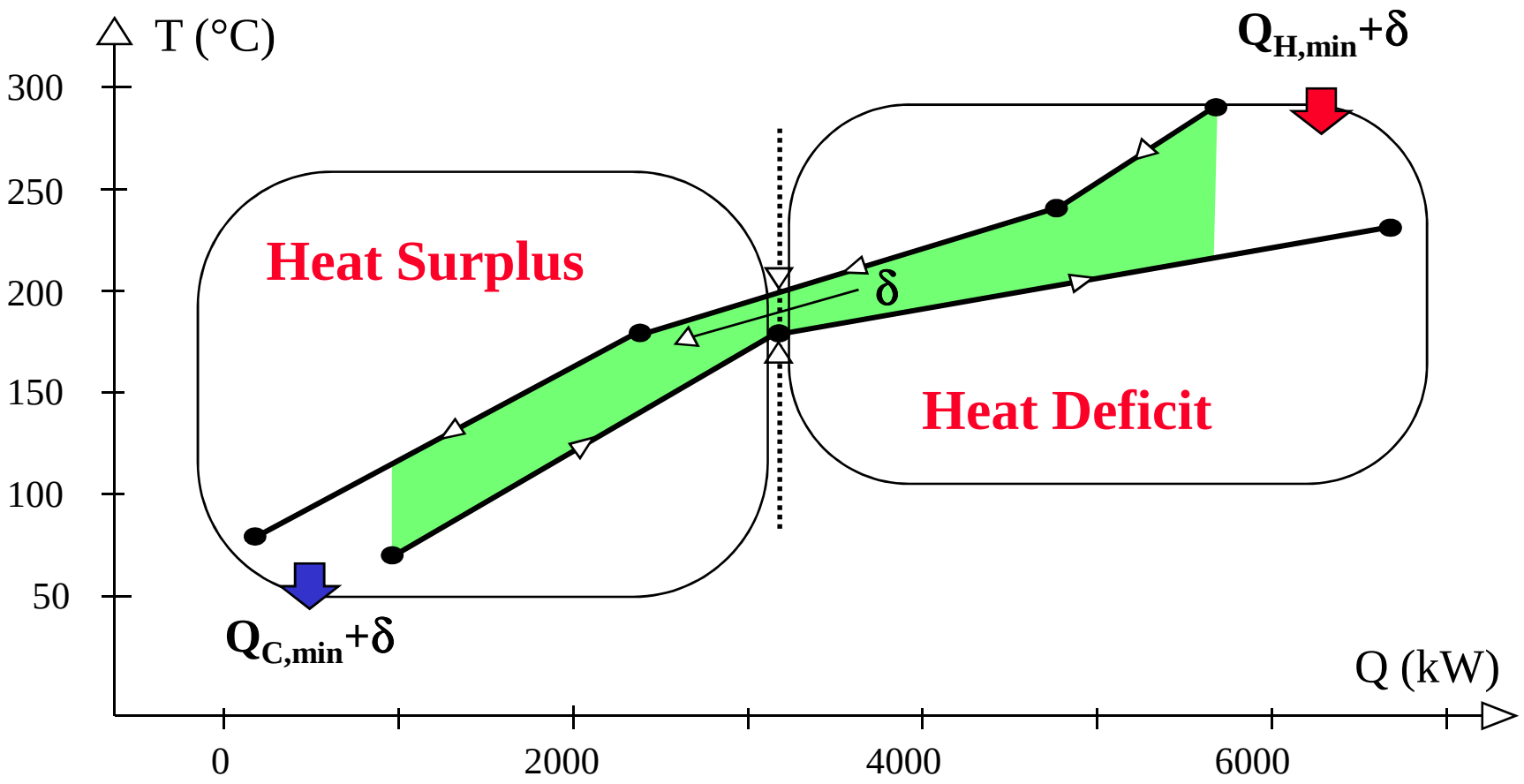
Solar Thermal System

Solar Thermal System

Solar Thermal System

?

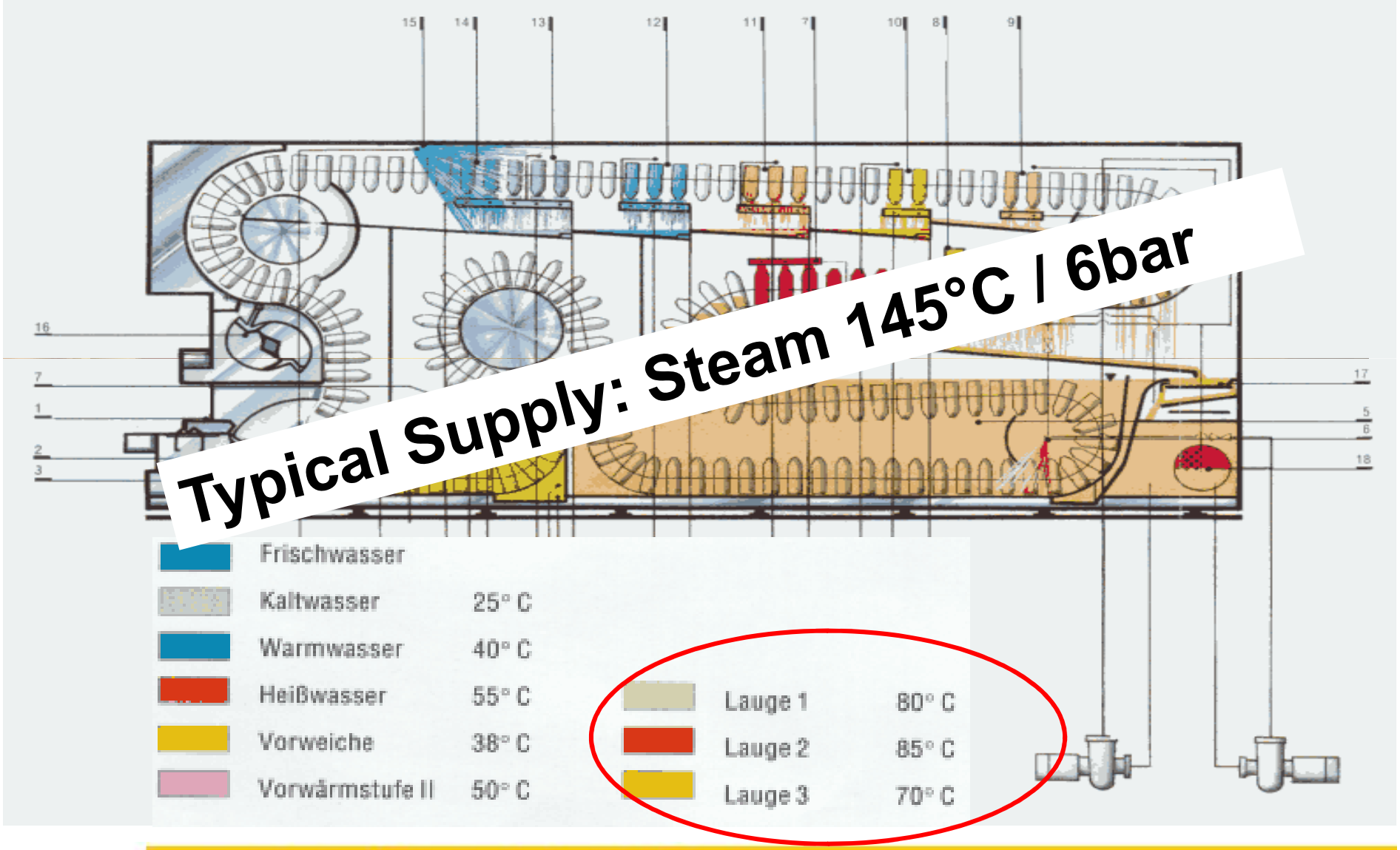
Optimisation of the Processes



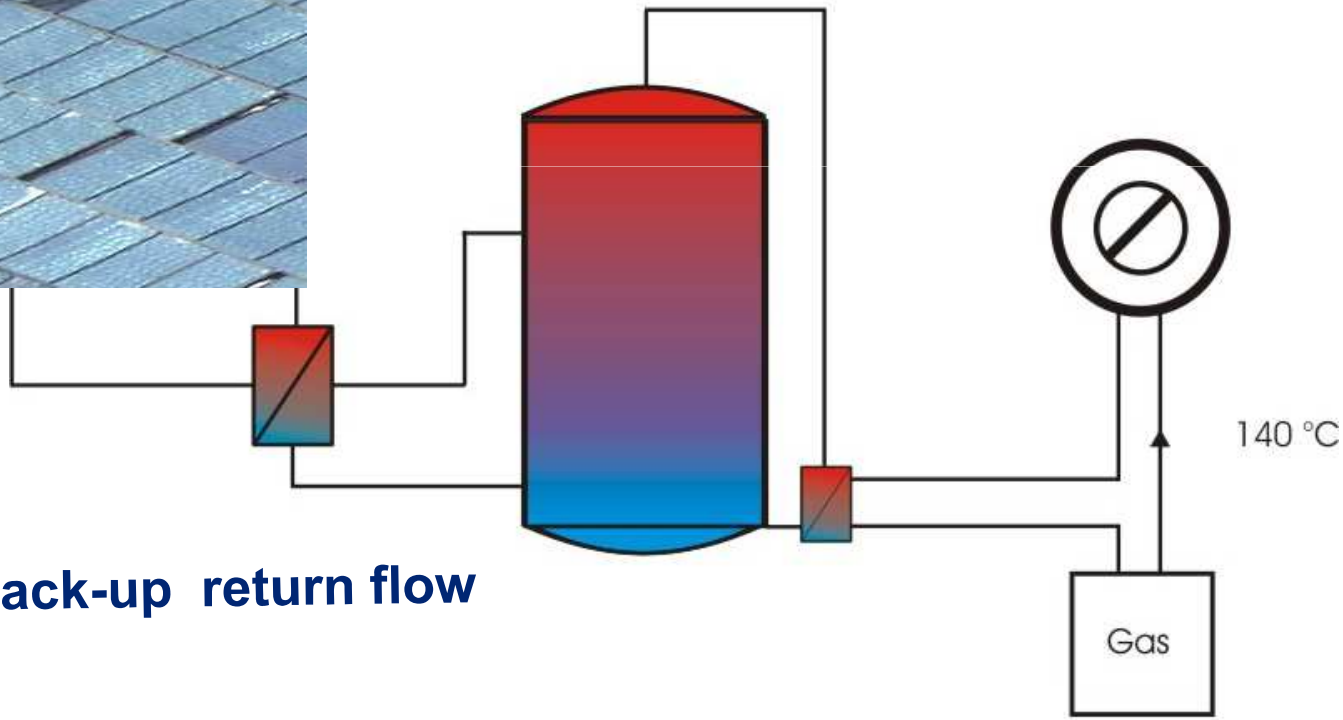
Source: T. Gundersen

Beverage Industry – Bottle Washing

Beverage Industry – Bottle Washing



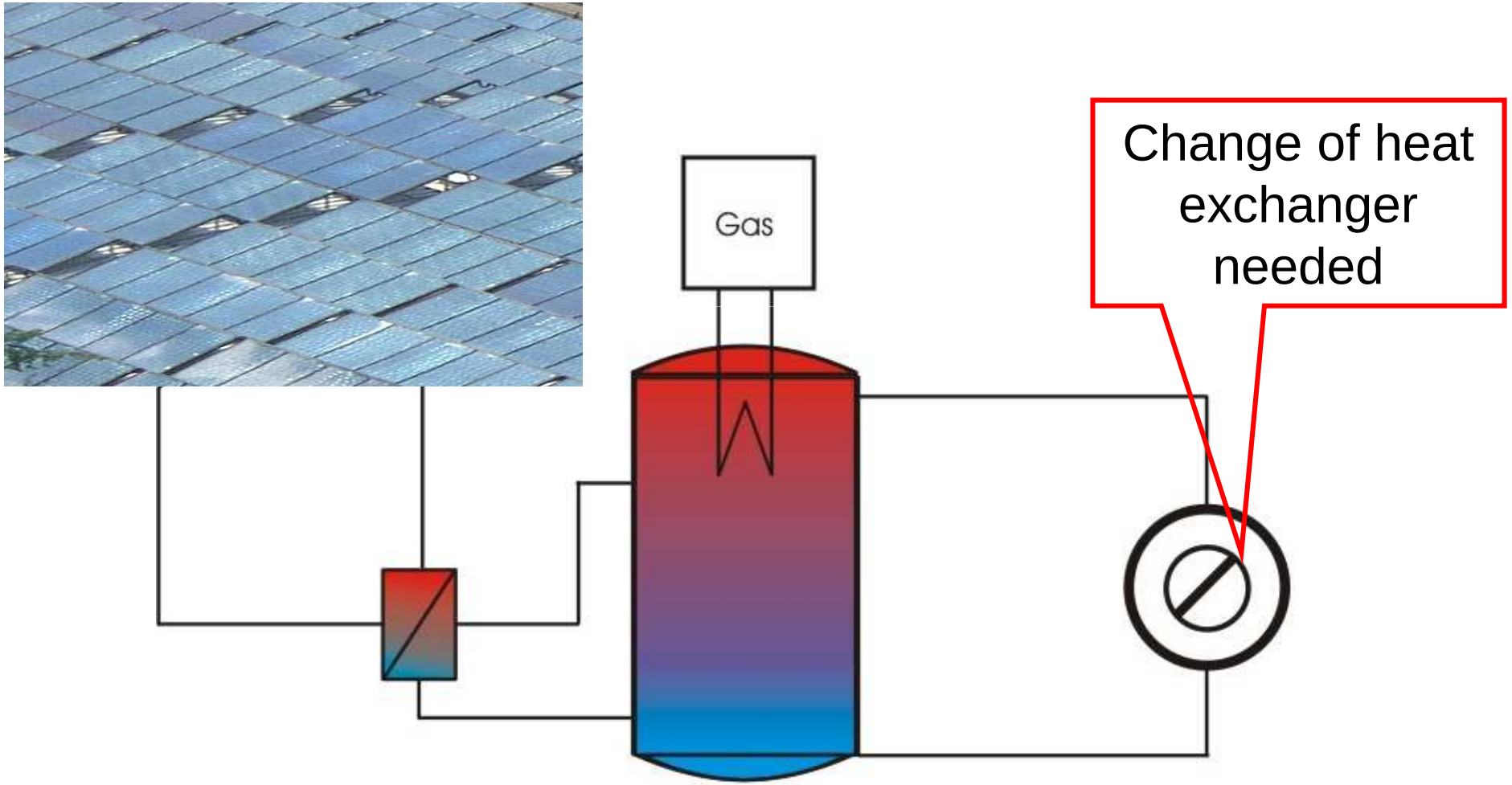
Integration of Solar Heat ?



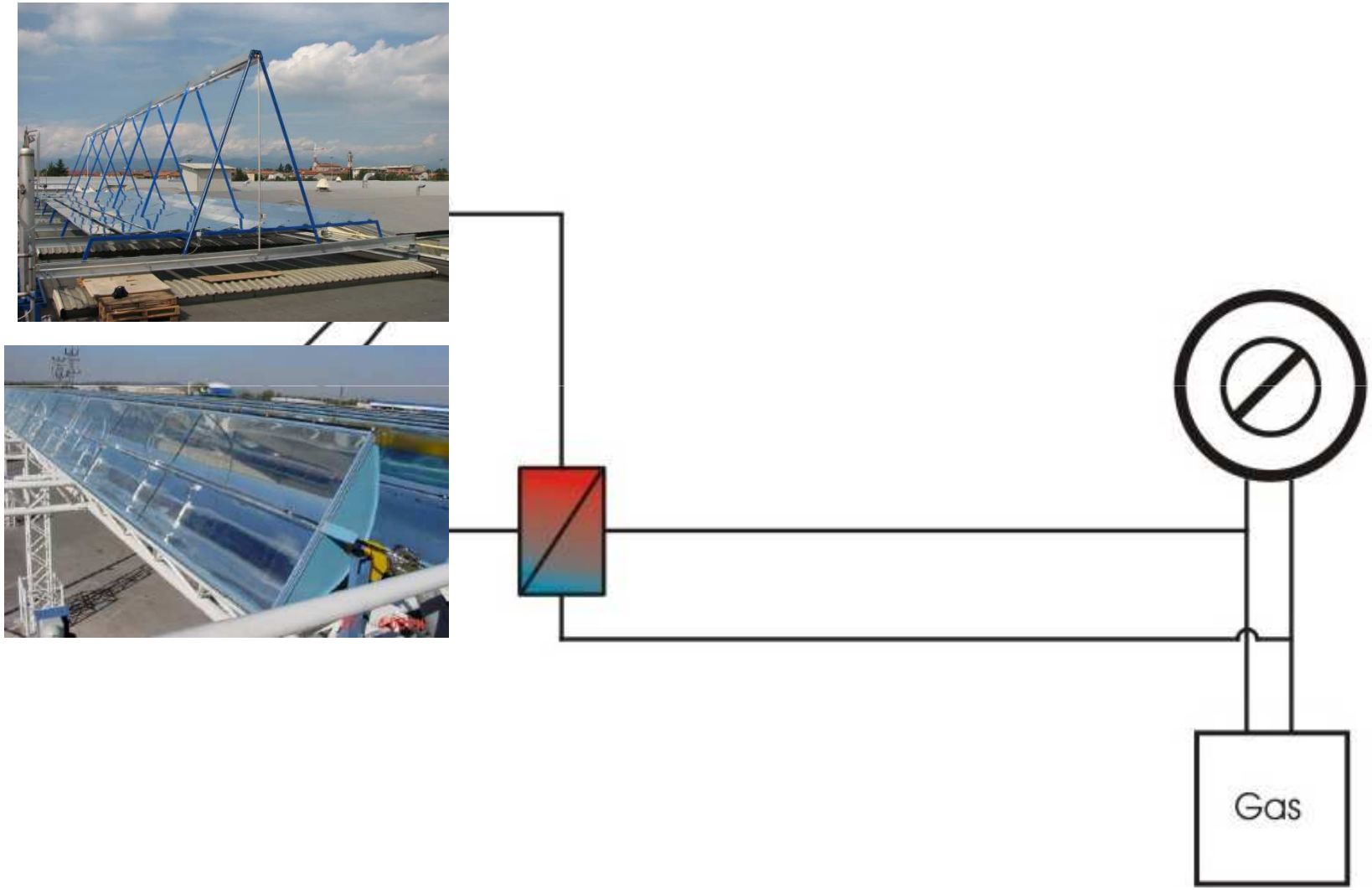
Back-up return flow

Integration of Solar Heat ?

Switch to hot water supply

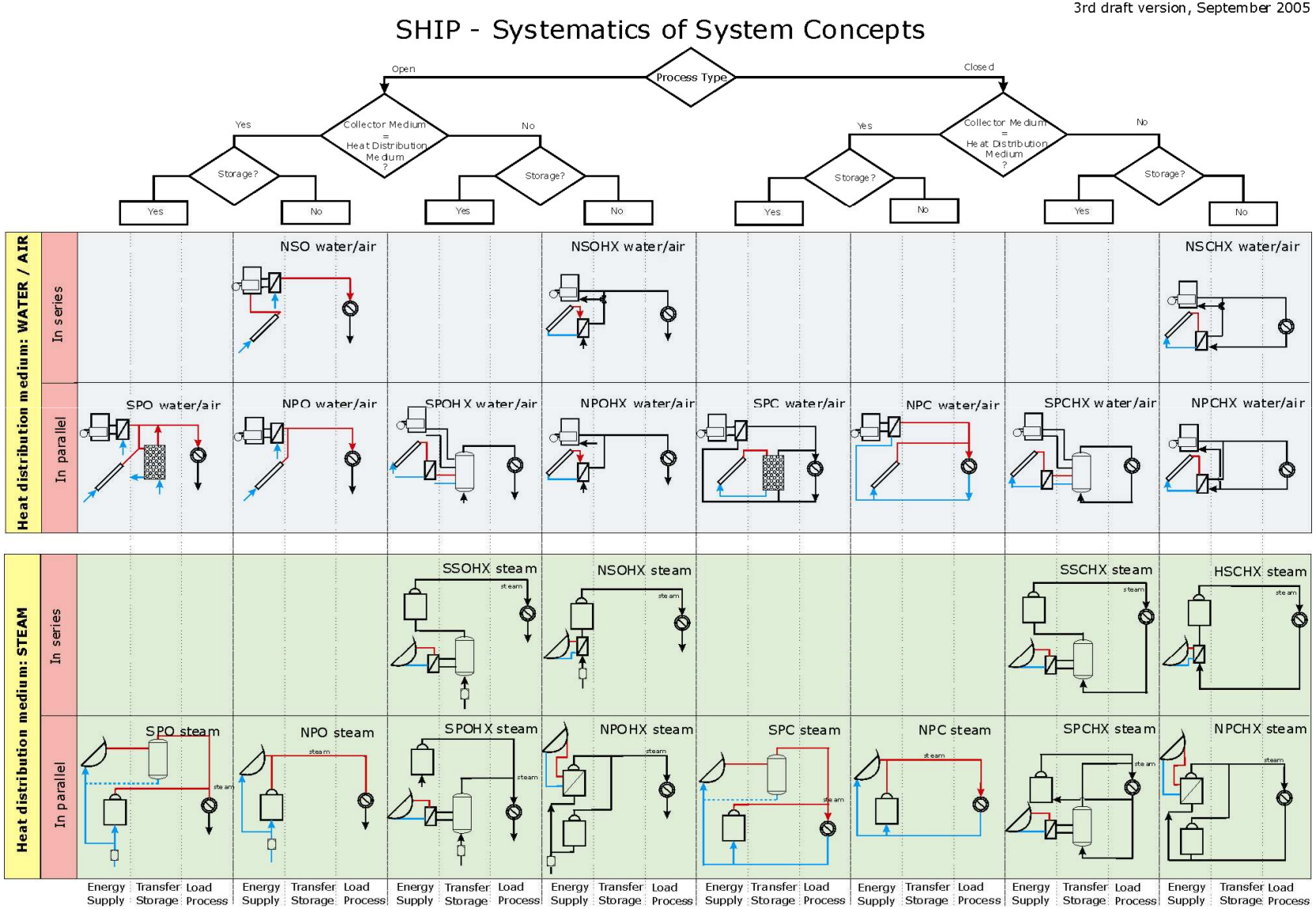


Integration of Solar Heat ?



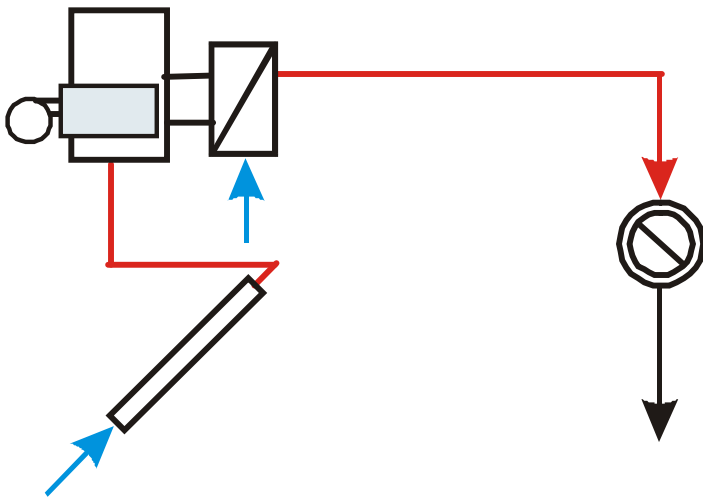
23 System Concepts

3rd draft version, September 2005



Built Examples

Generic System - 1Nso



Main Applications

- Coffee Drying
- Tea Drying
- Maize Drying
- Tobacco Drying

Temperature range for the processes: 30 - 80℃

Heat carrier: air

Recommended Collector Types:

- **glazed or unglazed air collector**
- **Solar Wall ®**

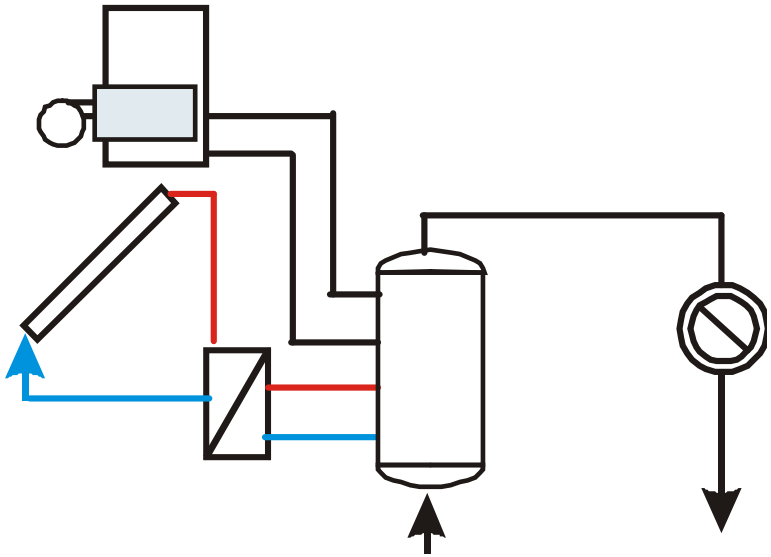
Air based Drying System

Air based Drying System in Guatemala

Palo Amontonado
planta de deshidratación solar

Source: CONA

Open Process - Water



Main Applications

cleaning of:

- bottles
- textile
- cars

Temperature range for the processes: 40 - 90°C

Heat carrier: water

Recommended Collector Types:

- **flat-plate collector**

Built Examples

Built Examples

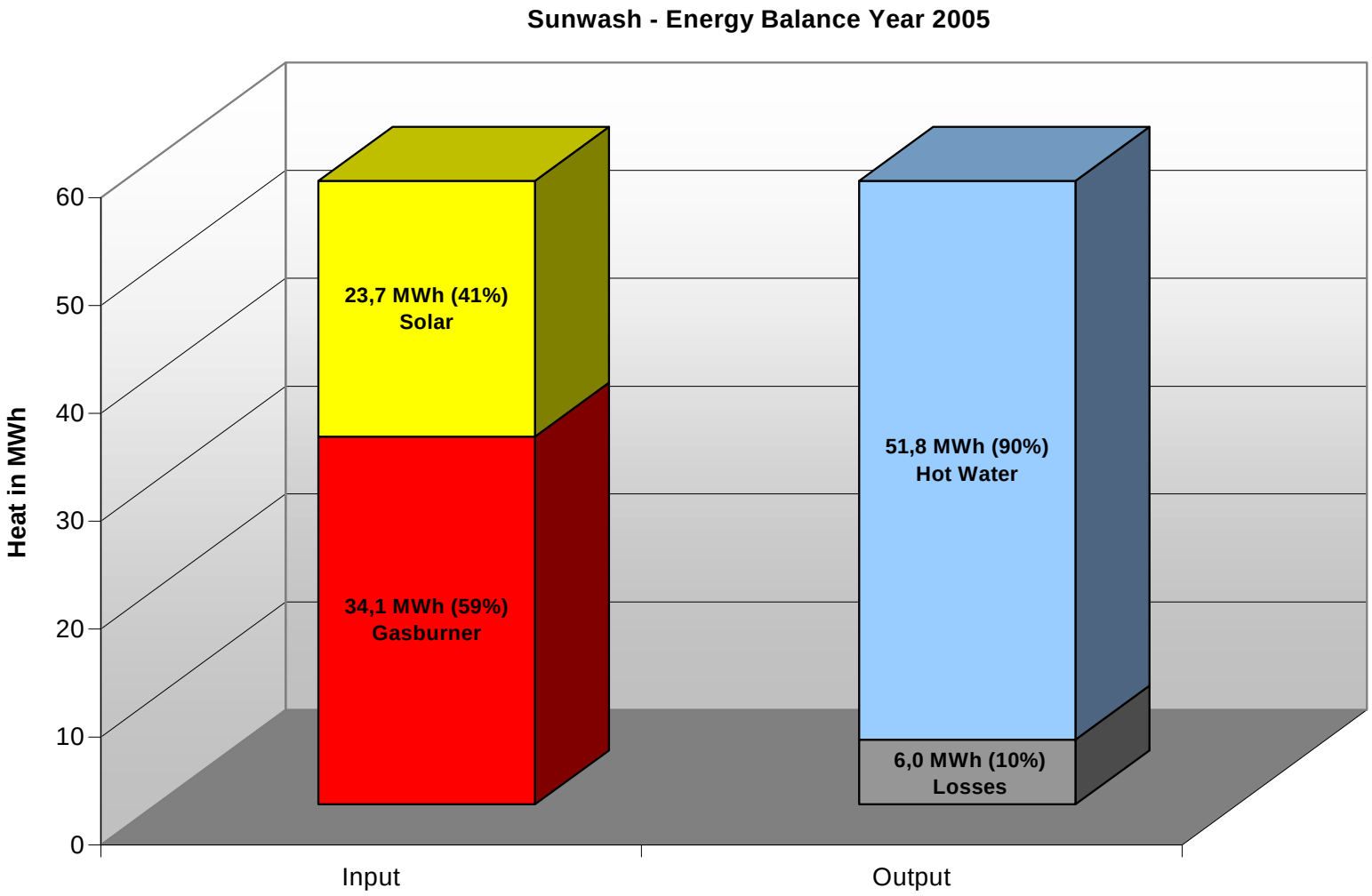
Textile Industry Hangzhou China 13000㎡ (9 MW_{th})

Built Examples

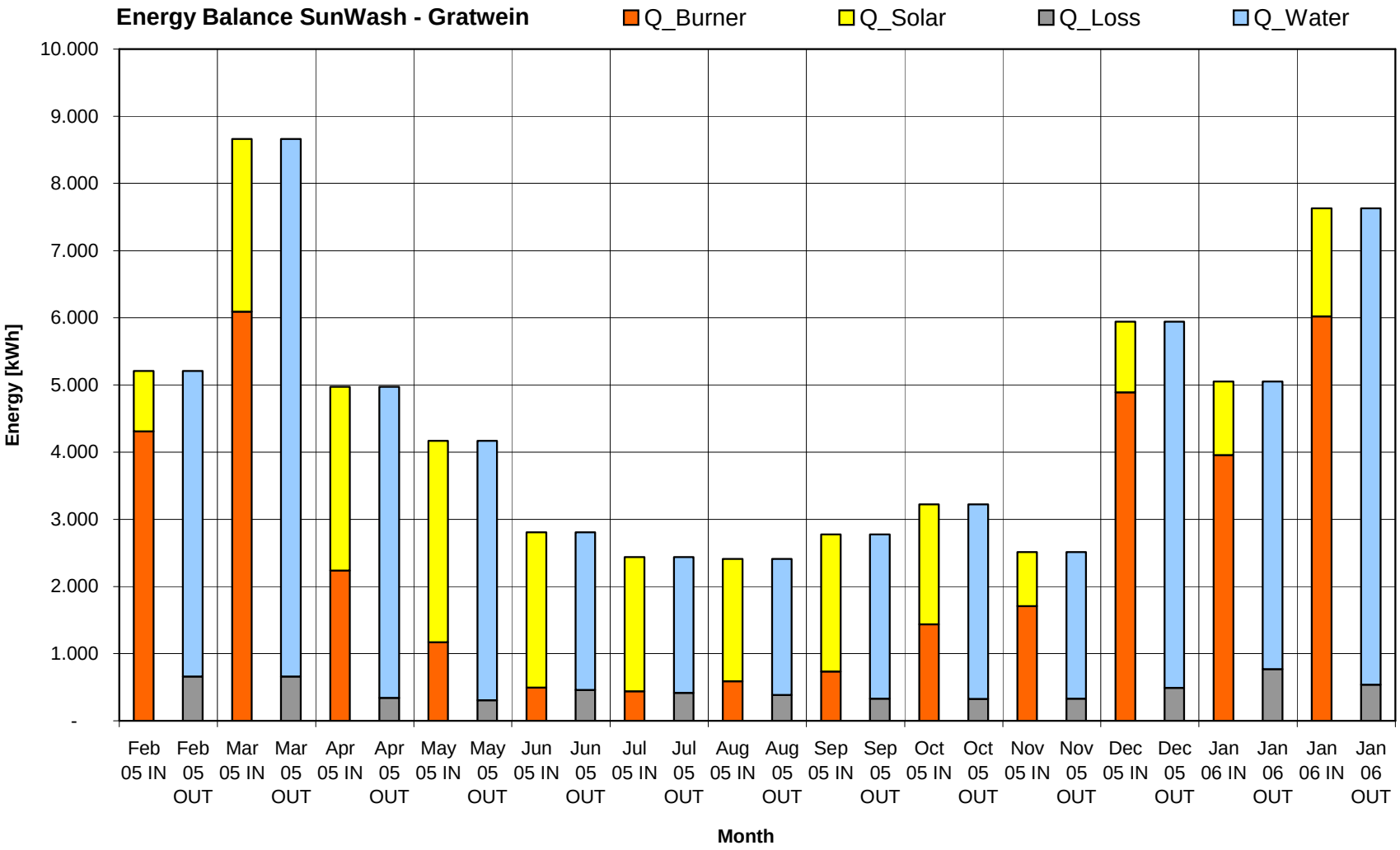
Solar car wash plant, Köflach, Austria

Installed capacity: 30 kW_{th} (43 m² flat plate collector)

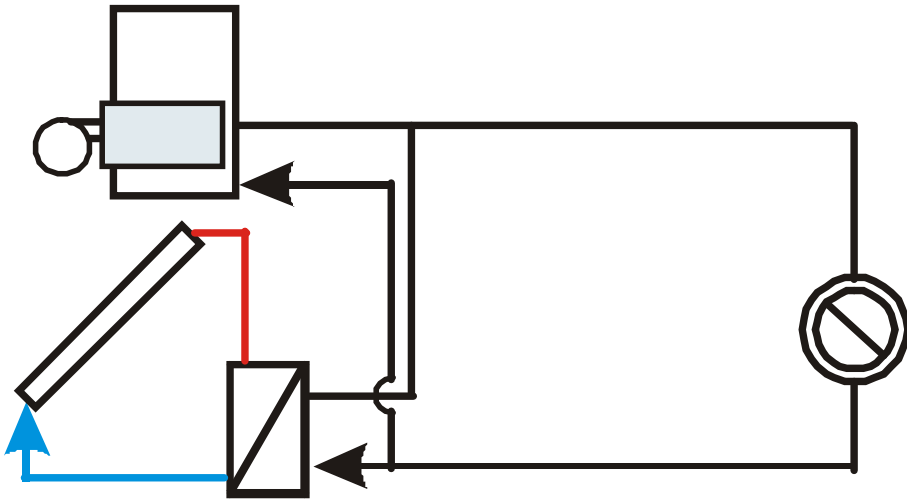
SunWash – Energy Balance - 2005



SunWash – Energy Balance - 2005



Necessity of a Storage Tank



Main Applications

- Galvanic industry
  - Food industry

Temperature range for the processes : 30 - 90℃

Heat carrier: Water

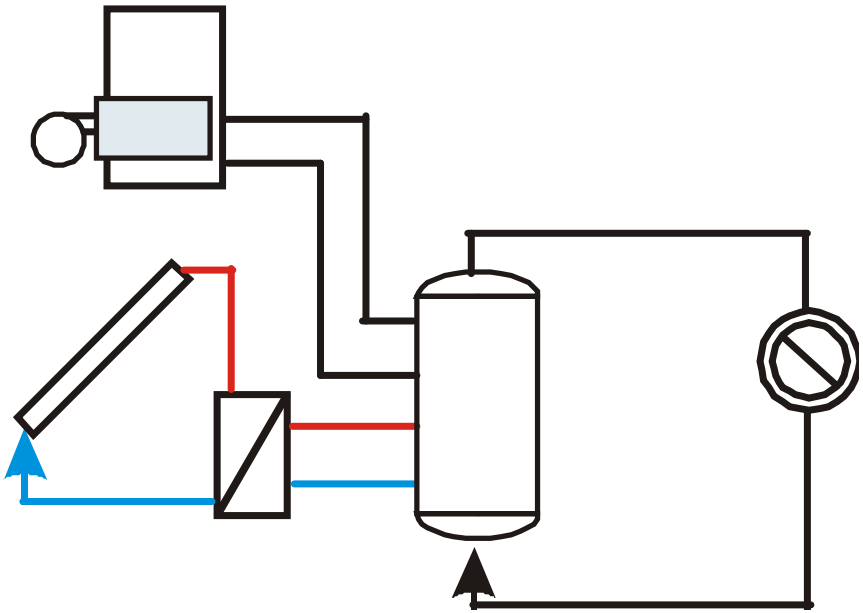
Recommended Collector Types: FP, ETC, CPC

Demonstration Plants

Galvanic Industry, Germany

70 kW evacuated tube collectors

Closed Systems



Main Applications :

- Textile Industry
- Tanneries
- Dairy
- Breweries

Temperature range for the processes : 60 - 110°C

Heat carrier: Water / Steam

Recommended Collector Types : FK, CPC, VR

Demonstration Plants

COOLING AND REFRIGERATION

PSE, Germany

Pilot Installation

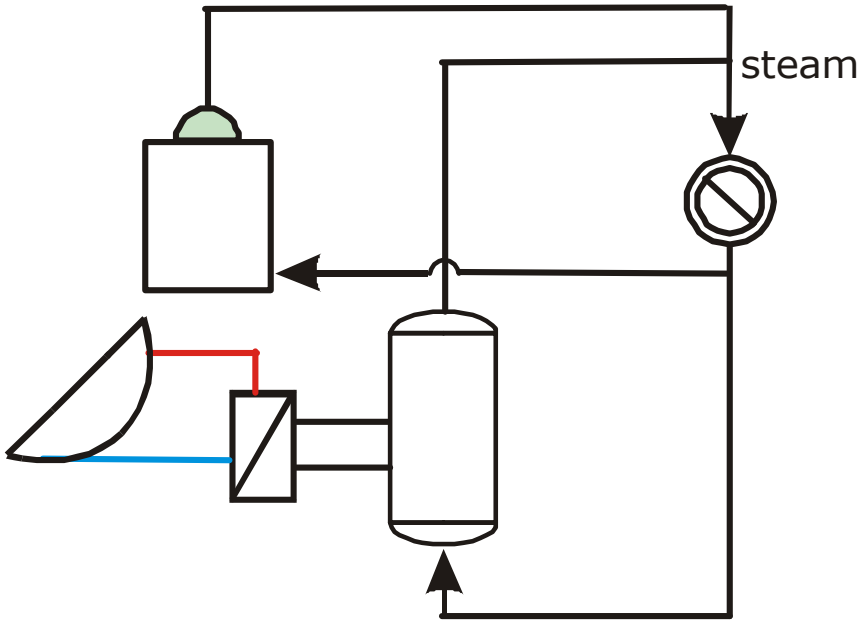
Bergamo, Italy

Rooftop installation to power a NH_3/H_2O Absorption Chiller.

Aperture: 132 m²

Operation temperature: max. 200℃

Steam Systems



Main Applications:

- Food Industry
- Laundries

Temperature range for the processes : 120 - 200℃

Heat carrier: Steam

Recommended Collector Types : PTC

Built Examples

Hotel, Turkey, Steam is
laundry

70 kW$_{th}$ (180 m² PTC)
Steam Production: 120

Source: SOLITEM , DLR

Built Examples

Overview on Desalination Techniques

system technology	*feed water*	*salt content of product water [ppmTDS]*	*main energy to be supplied*	*system capacities [m³/d]*
MSF (Multi-Stage Flash)	sea water	10 – 50	heat	5 000-60 000
MED (Multi-Effect Distillation)	sea water	10 – 50	heat	5 000-20 000
VC (Vapour Compression)	sea water	10 – 50	electricity	2 400
SWRO (Sea Water Reverse Osmosis)	sea water	350 – 500	electricity	128 000
BWRO (Brackish Water Reverse Osmosis)	brackish water	350 – 500	electricity	98 000
EDR (ElectroDialysis Reversal)	brackish water	350 – 500	electricity	45 000

Source: ISE, M. Rommel

Energy demand of large scale desalination systems

desalination technique	*energy demand*	*form of energy required*
MED	20 to 40 kWh/m³ plus 5 kWh/m³	heat electricity
MSF	20 to 40 kWh/m³ plus 5 kWh/m³	heat electricity
RO (sea water)	5 to 15 kWh/m³	electricity
ED (brackish water)	3 to 15 kWh/m³	electricity

Source: ISE, M. Rommel

28000 m³/day MED-plant in Las Palmas de Gran Canaria

Source: ISE, M. Rommel

Sea Water Desalination

Infra-structure developed:

- conventional energy available
- water demand > 10 m^3/day

Infra-structure not developed:

- renewable energy sources
- site-specific:
  thermal collectors, PV, wind
- water demand:
  100 litres/day to 10 m^3/day

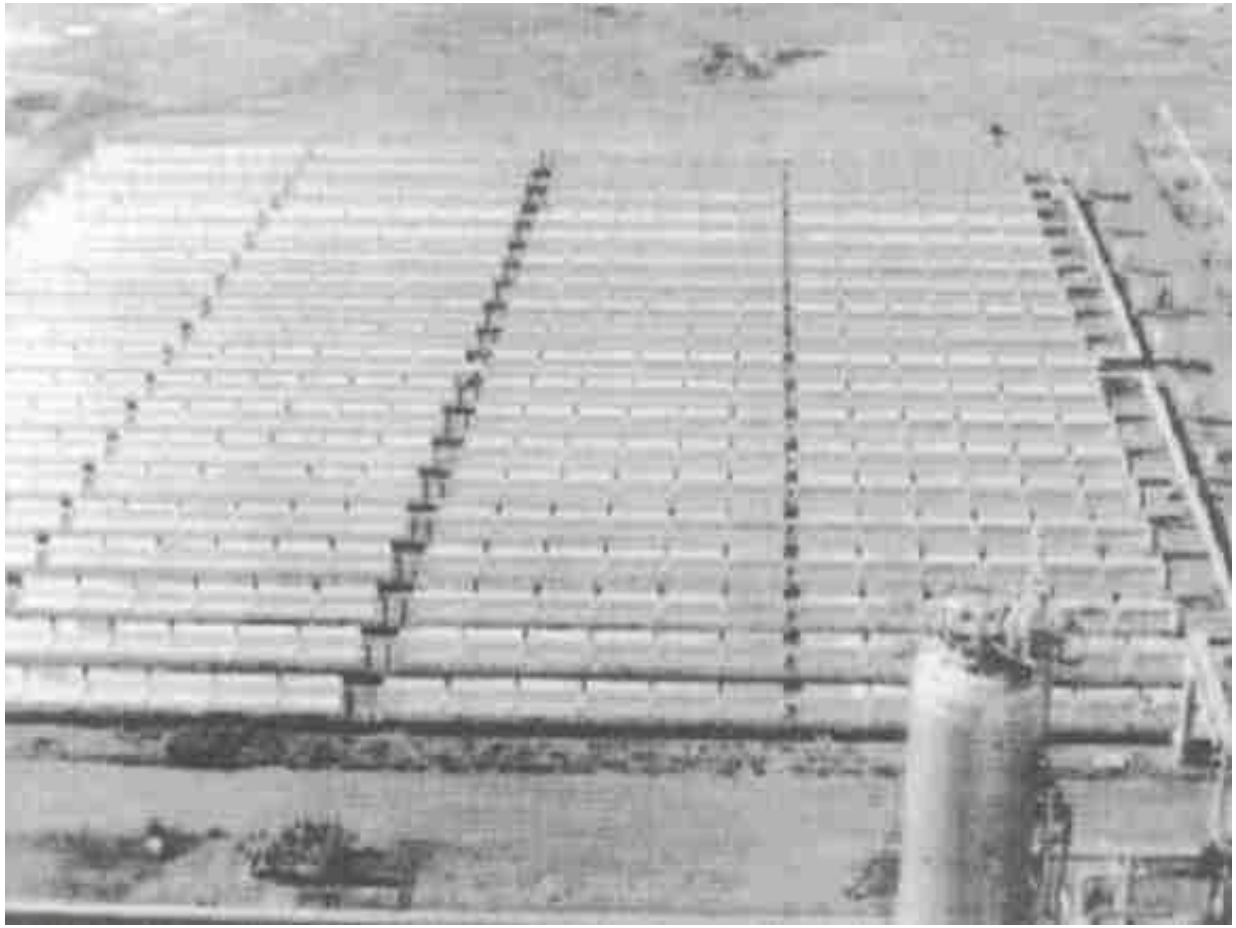
Source: ISE, M. Rommel

Process heat for desalination plant in Abu Dhabi

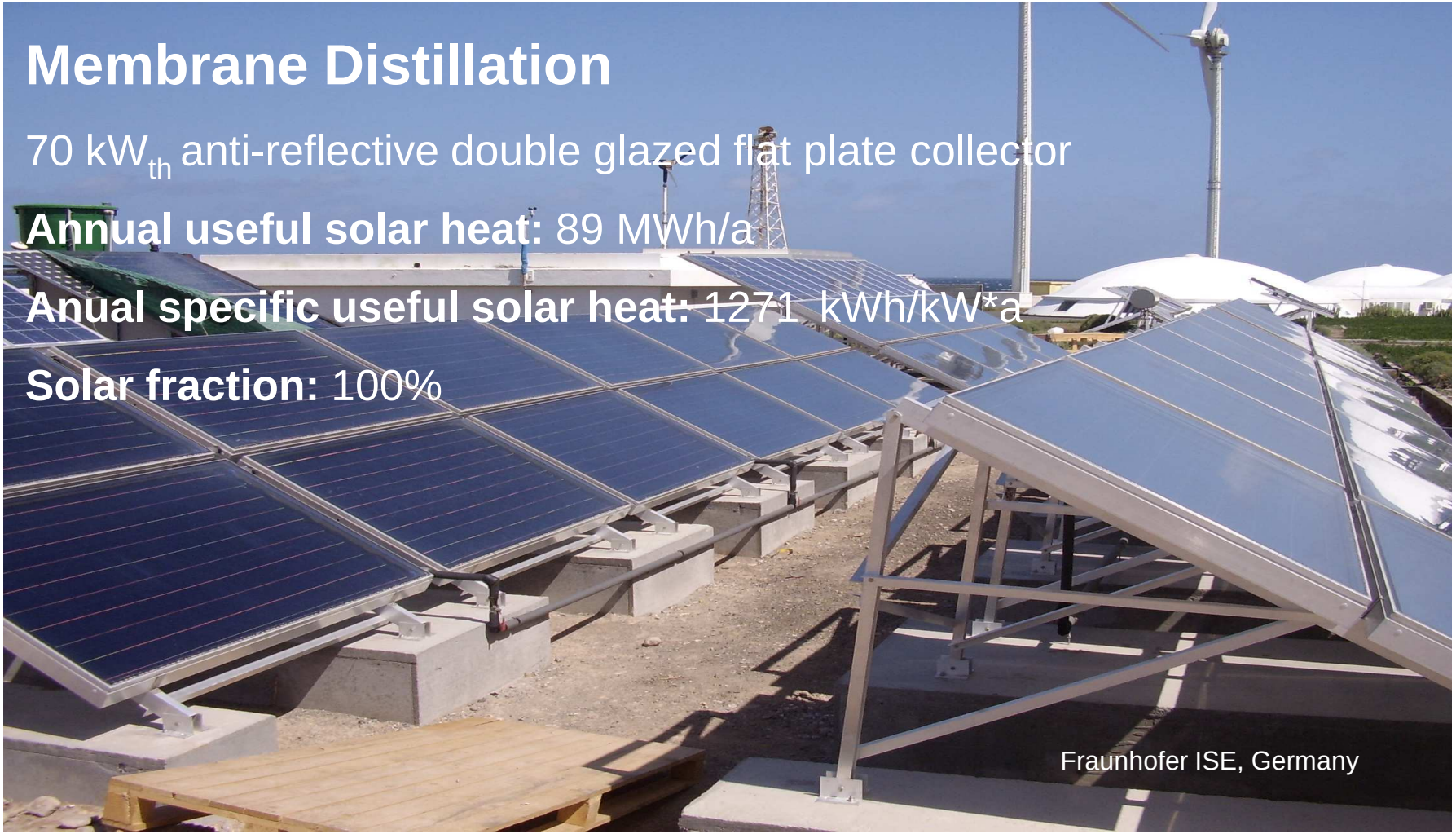
- Installed in 1985
- 1864 m^2 vacuum tube collectors
- 300 m^3 hot water storage tank
- MED with 18 effects
- capacity 80 m^3/day
- 49 kWh_{th}/m^3
- continuous 24 h operation with back-up energy

MED solar desalination plant in Almeria

- 14 effect MED
- 2672 m² one-axis tracking parabolic-trough collector field
- 115 m³ thermal storage oil tank



Seawater Desalination – Gran Canaria, Spain



Membrane Distillation

70 kW_{th} anti-reflective double glazed flat plate collector

Annual useful solar heat: 89 MWh/a

Anual specific useful solar heat: 1271 kWh/kW*a

Solar fraction: 100%

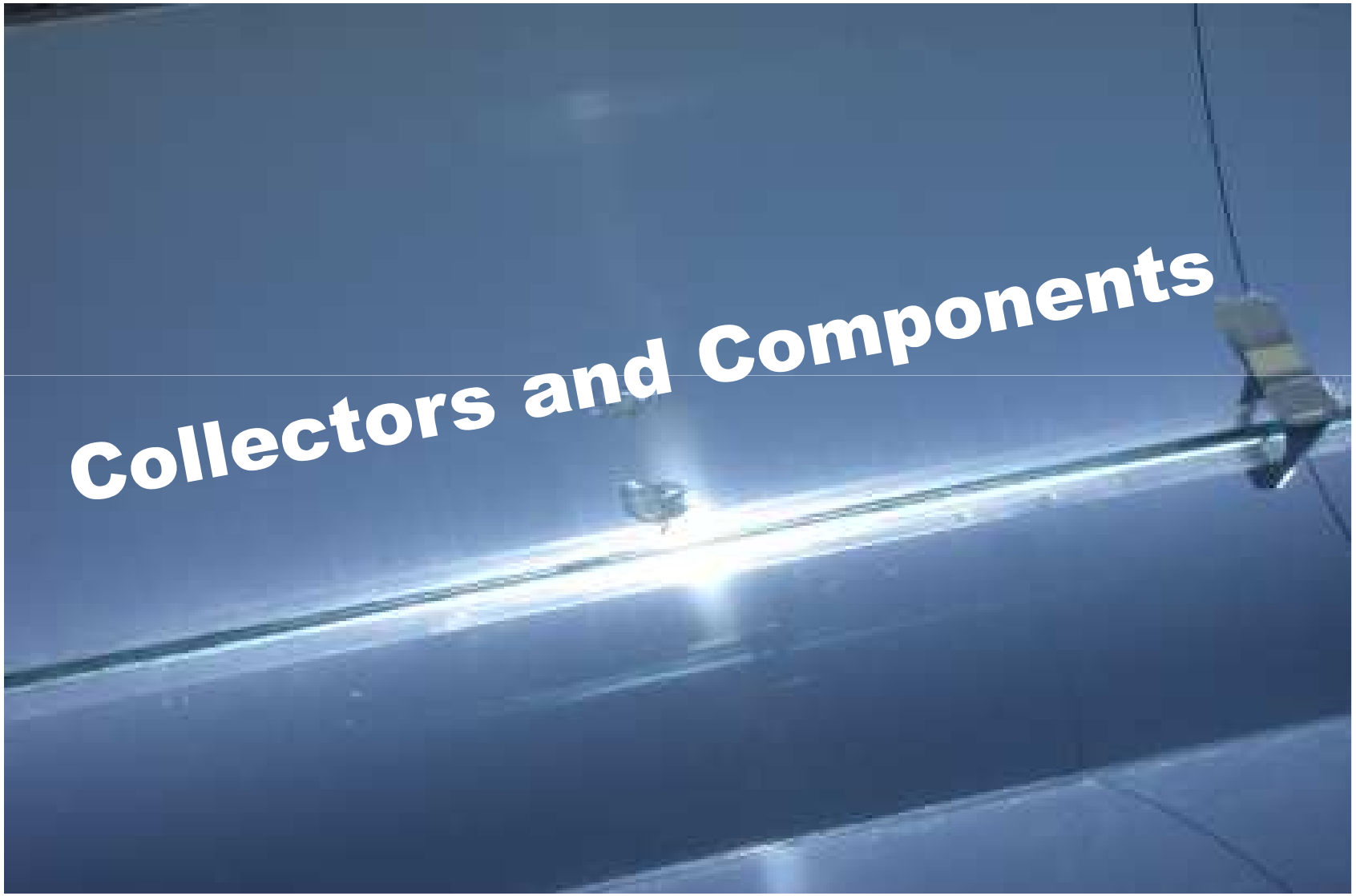
SODESA: 56 m² collector field and house for 6.3 m³ storage tank, MEH destillation and water treatment unit

- 56 m² collector with corrosion-free absorber
- 6.3 m³ sea water storage tank for 24 hours per day operation of the distillation unit set up in Gran Canaria, test field of CIEA, Pozo Izquierdo
- Installed and put into operation in May 2000
- Production rate 600 litres per day MEH (Multi Effect Humidification) distillation unít
- Treatment of distilled water to get drinking water of high quality

Processes and Temperature Levels

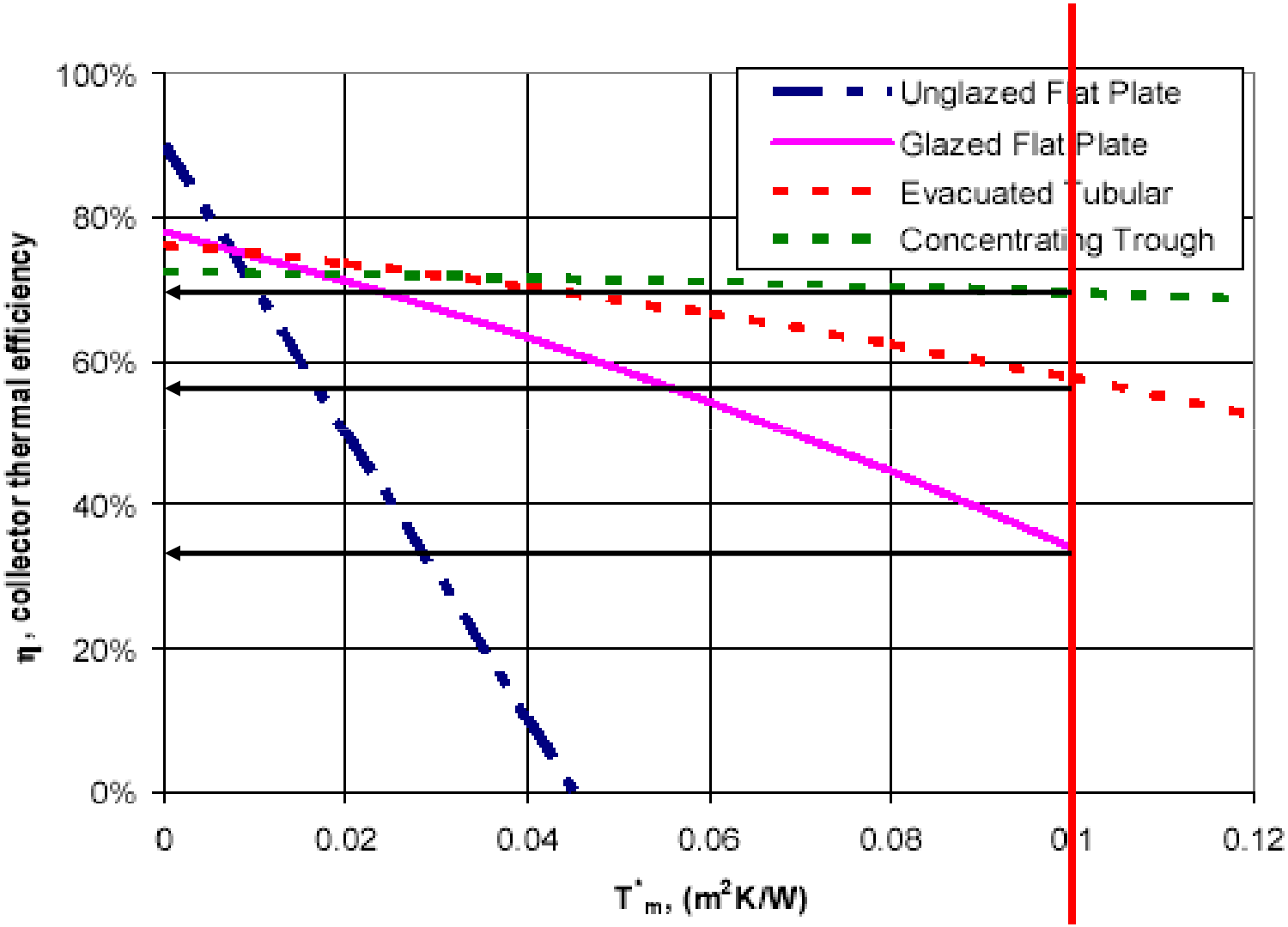
Industrial Sector	Process	Temperature Level [°C]
Food and Beverages	Drying Washing Pasteurizing Boiling Sterilizing Heat Treatment	30 - 90 40 – 80 80 – 110 95 – 105 140 – 150 40 – 60
Textile Industry	Washing Bleaching Dyeing	40 –80 60 – 100 100 – 160
Chemical Industry	Boiling Distilling Various chem. Processes	95 – 105 110 – 300 120 - 180
All Sectors	Pre-heating of Boiler Feed-water Heating of Factory Buildings	30 – 100 30 – 80

AEE INTEC

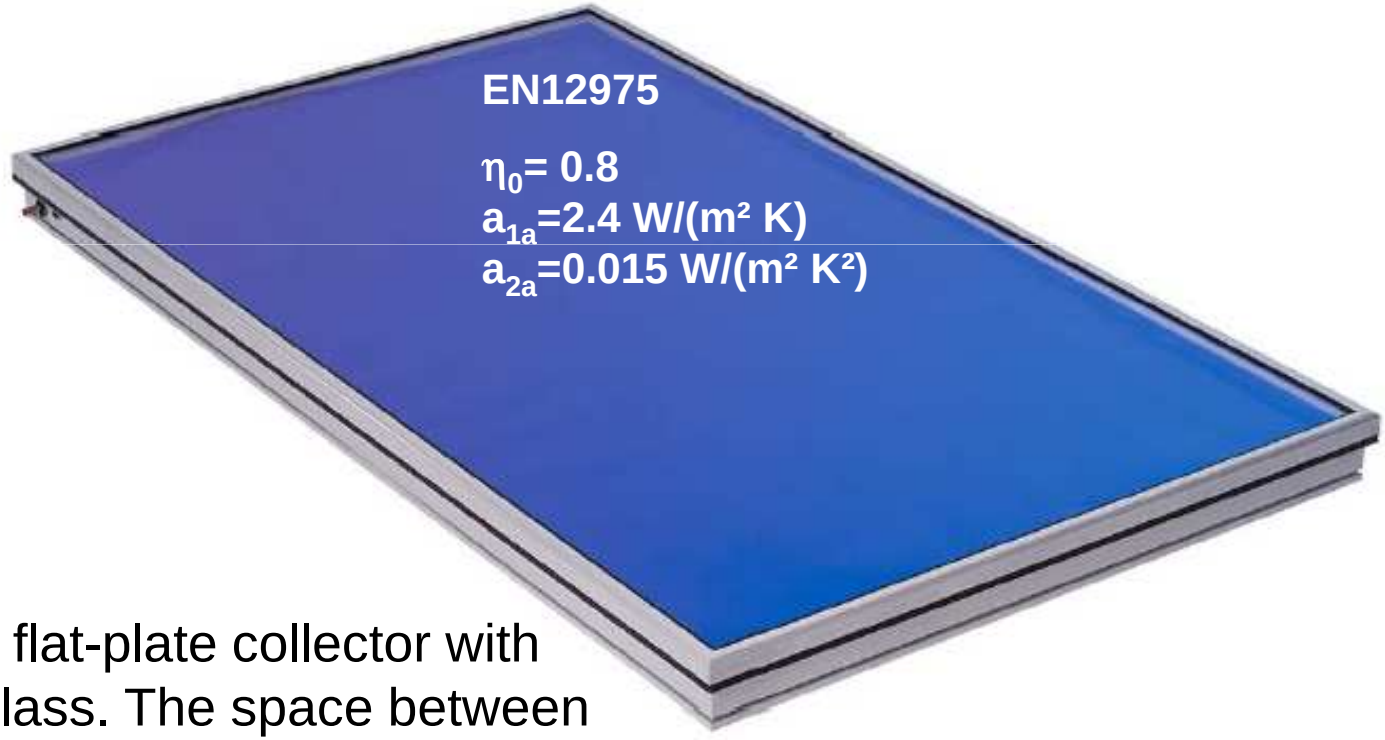


Collectors and Components

Efficiency of different collector types



Development of Medium-Temperature Collectors

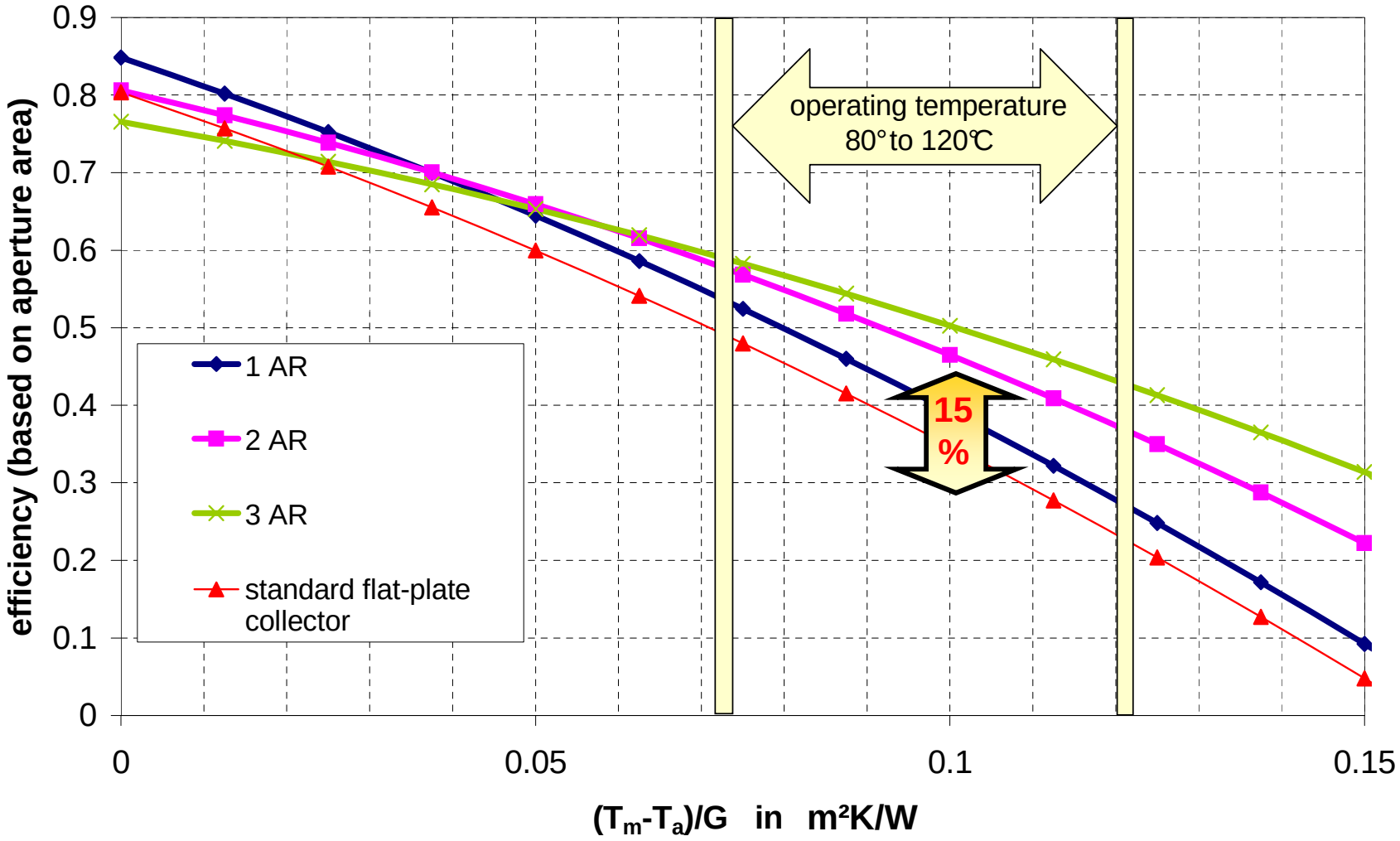


EN12975

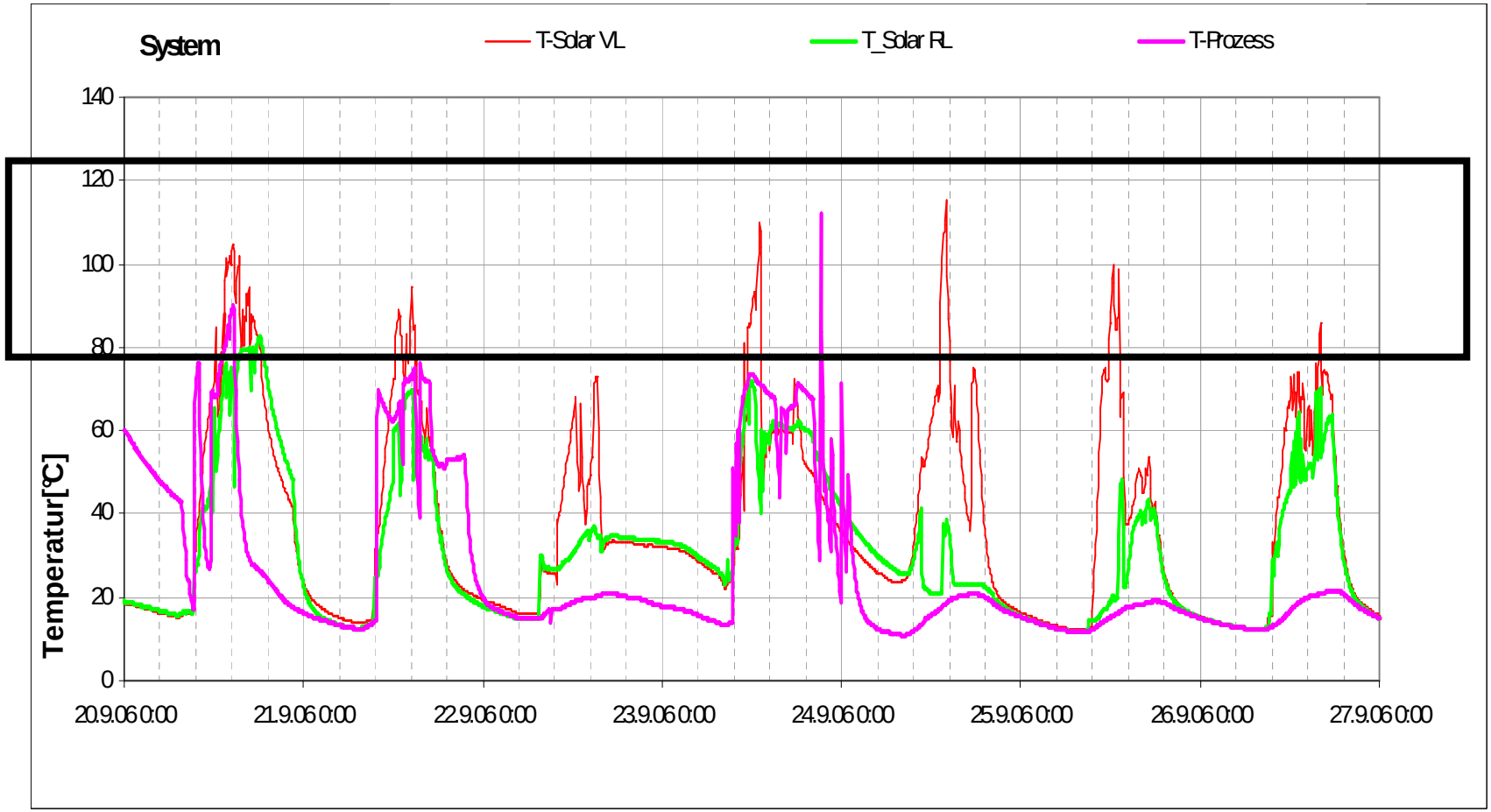
η_0= 0.8
a_{1a}=2.4 W/(m² K)
a_{2a}=0.015 W/(m² K²)

Double-glazed, flat-plate collector with anti-reflective glass. The space between the glass panes is filled with an inert gas to reduce the heat conductivity.

IMPROVEMENT OF EFFICIENCY

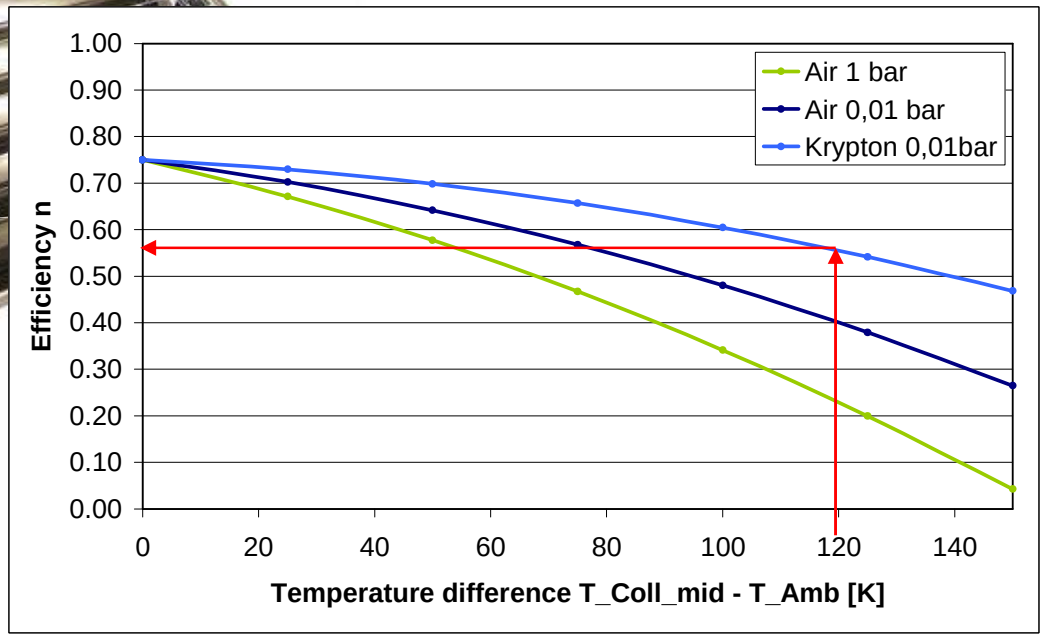


Monitoring Results



Process Heat Collectors

CPC Collector

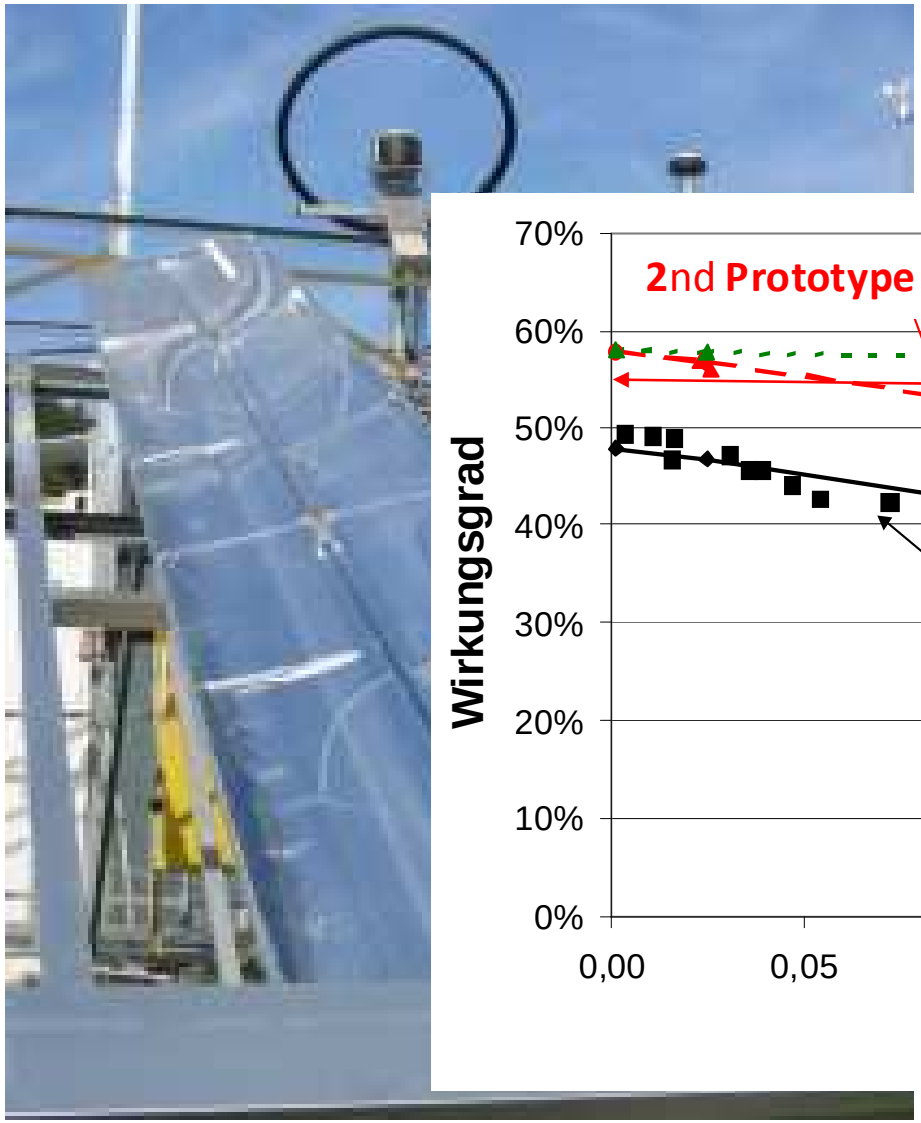


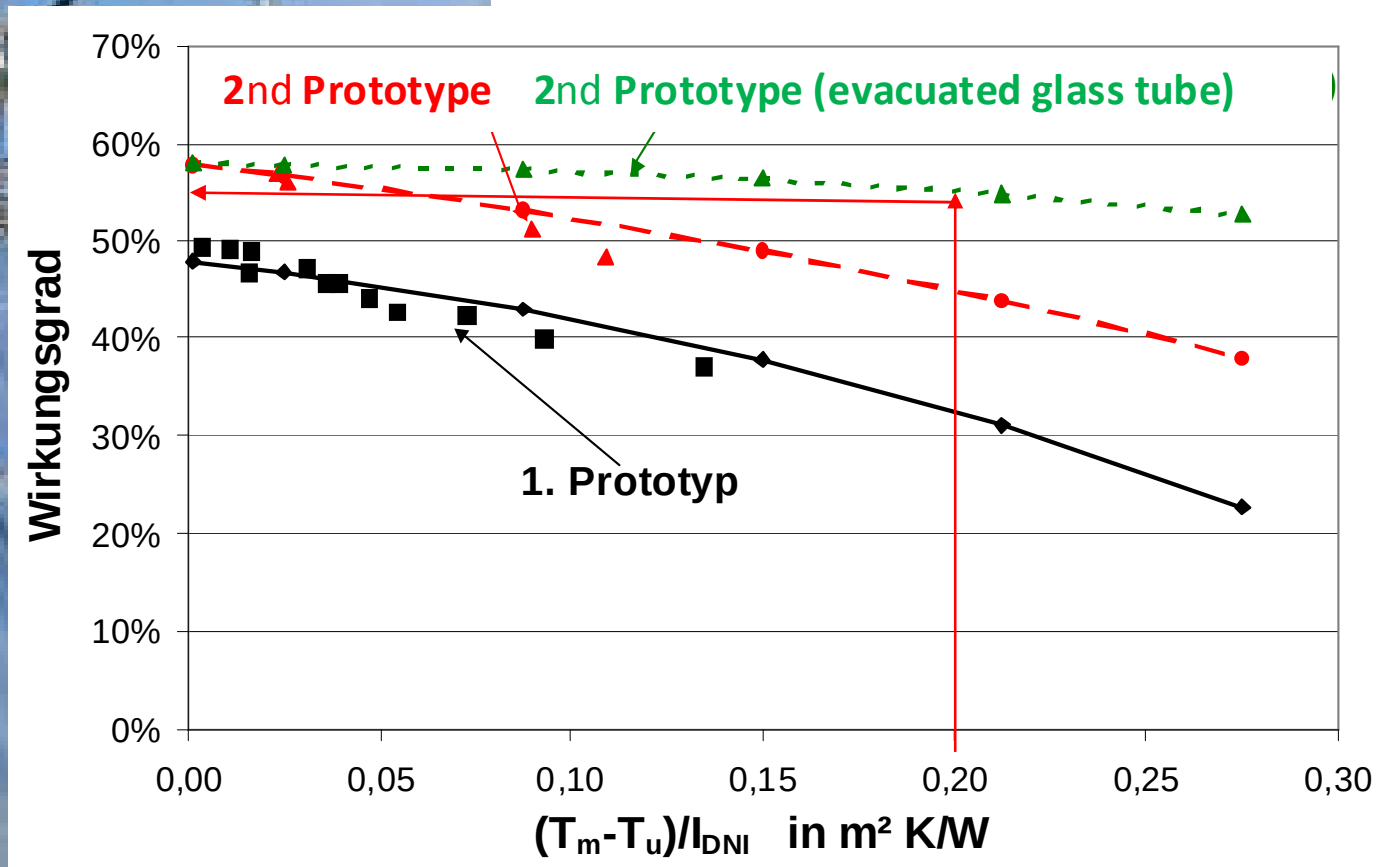
Concentration: 1,8x

LoCo EvaCo (Low concentrating evacuated flat collector), ZAE Bayern

Process Heat Collectors

AEE INTEC and Button Energy

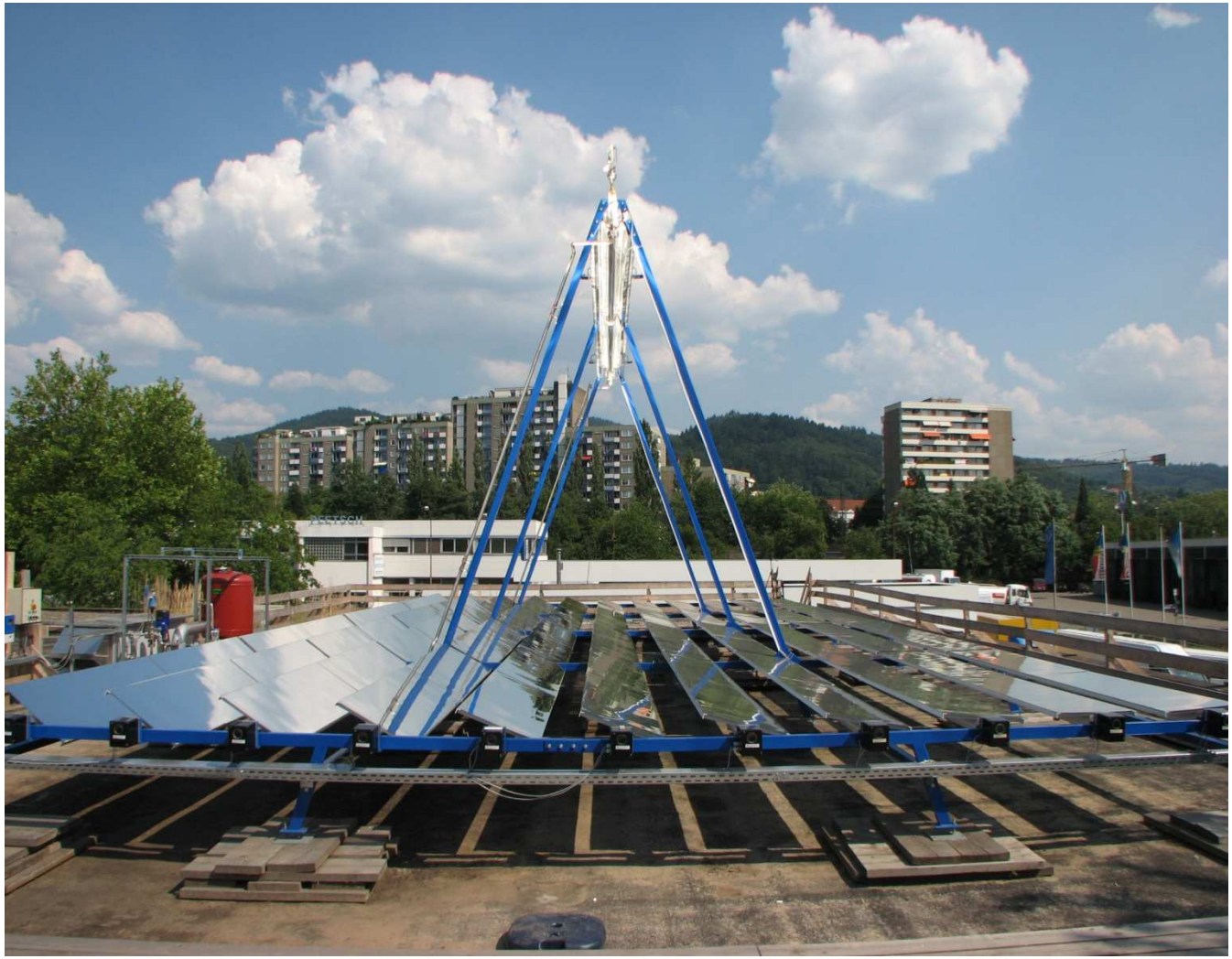




Built Examples

Fresnel Process Heat Collector

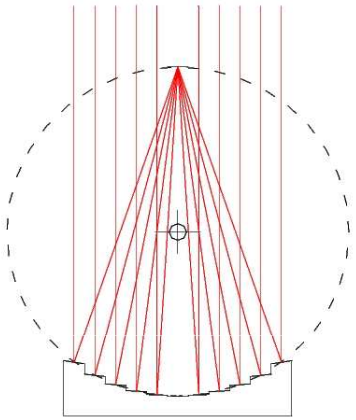
PSE AG
Germany

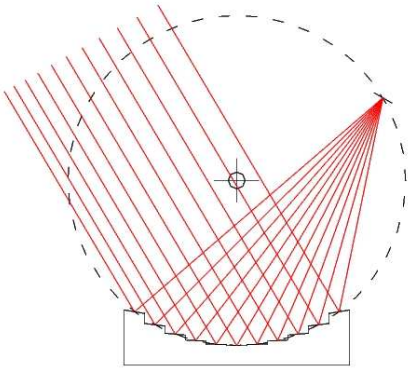


Aperture area: 88 m²

Working temperature:
max. 200℃

CONCENTRATING COLLECTORS - CCSTaR





CONCENTRATING COLLECTORS - CCSTaR

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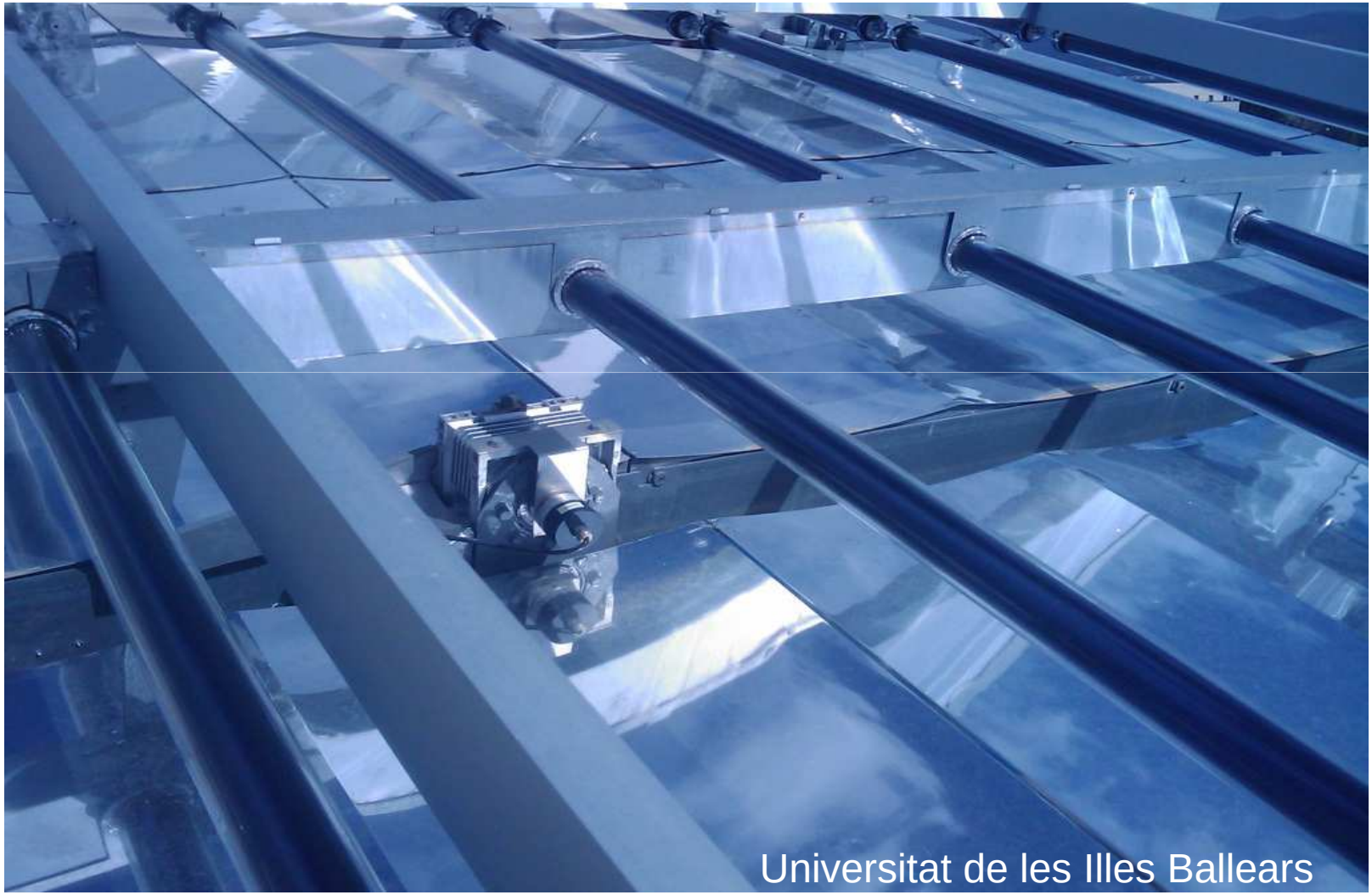

Further Information

Download: www.iea-shc.org/task33