Solar Thermal Process Heat
- Chances and Challenges

University Stellenbosch, Lunch Presentation

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Director Division
Solar Thermal and Applied Optics

Fraunhofer Institute for
Solar Energy Systems ISE

Stellenbosch, 15th May 2015

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Fraunhofer ISE – Short Profile

Director Prof. Eicke Weber

Founded 1981

12 Business areas

Budget 2013 88 Mio €

Revenues from Industry average 42% (over last seven years)

1250 Employees

Strong growth rate 2008-2012

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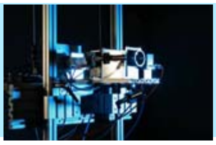
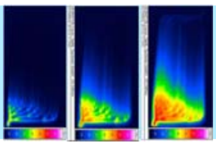
R&D Fraunhofer ISE - Solar Thermal


Solar thermal domestic hot water and heating


Lifetime and durability of components


Solar refrigeration


Heat transfer and heat transport


Solar process heat


Solar thermal facades


Concentrated solar thermal power


Decentralized water treatment

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Solar Thermal Technology for Heat and Electricity

Optics and Material Science

- PVD coatings
- Surface analytics
- Vacuum technology
- Micro structuring
- Degradation

Solar Thermal Collectors

- Collector development
- Certified TestLab
- Heat transfer
- Concentrator optics
- Structural mechanics

Solar Thermal Systems Engineering

- DHW and heating
- Process heat
- Solar thermal power
- Thermal storage
- Water treatment

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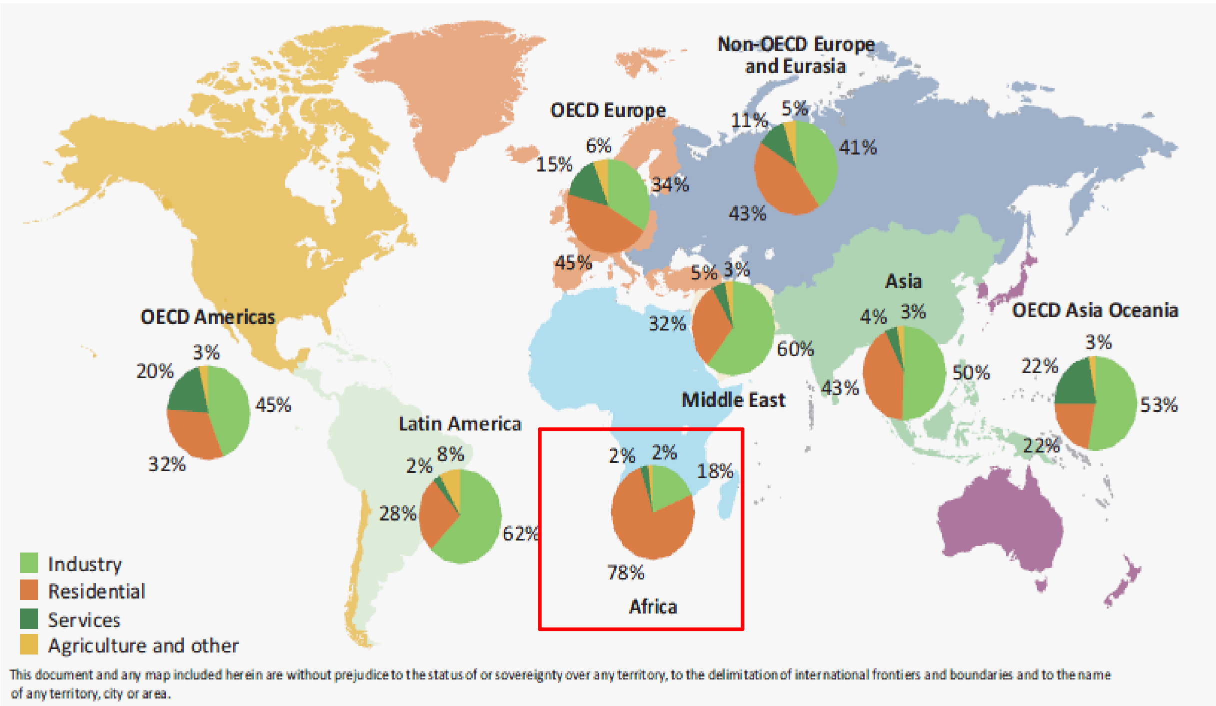
Heat plays important role worldwide



Note: Figure based on 2009 data
Source: Energy Technology Perspectives 2012

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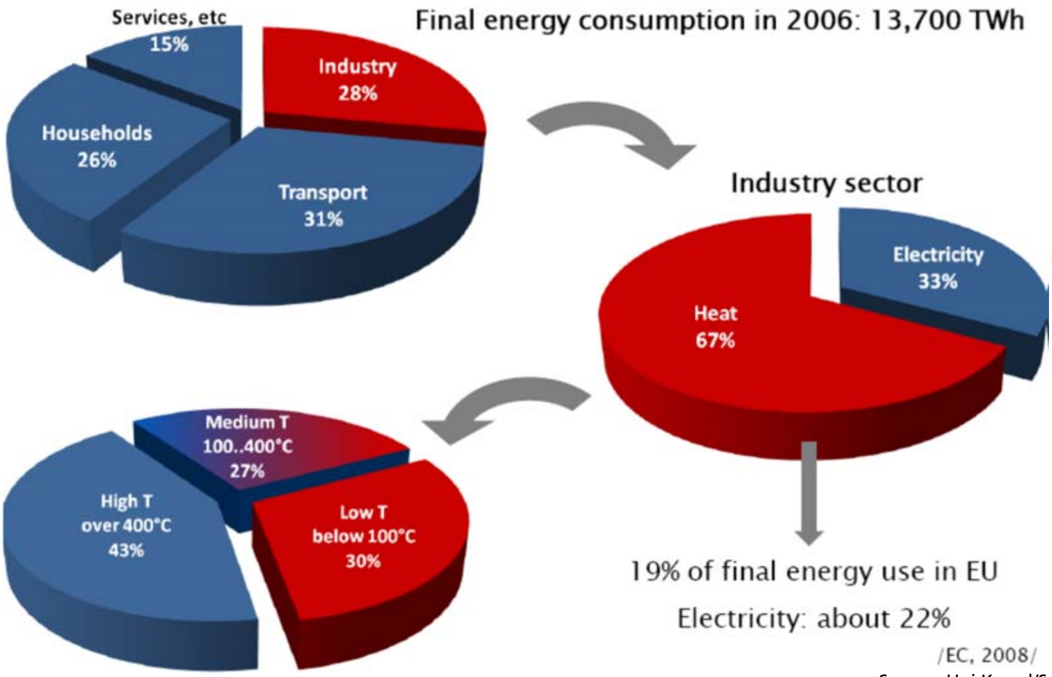
Final energy consumption EU27



Source: Uni Kassel/Schmitt

Technical Potential Solar Process Heat

Several studies of the past showed approximately:

- High percentage of process heat in industry is below 250°C (Europe 35% below 200°C, Germany 25% below 250°C)
  - Vannoni et.al. (2008) IEA Task 33
  - Lauterbach et.al. (2012) Projekt SOPREN
- Technical potentials have been estimated at about 3% (2.8 -4.5%) of total industrial heat demand (restrictions area, temperature, efficiency measures)

- Solar collector area required
  - Europe around 155 Mio. m2
  - Germany around 35 Mio. m2
- European market 2013: 3 Mio. m2

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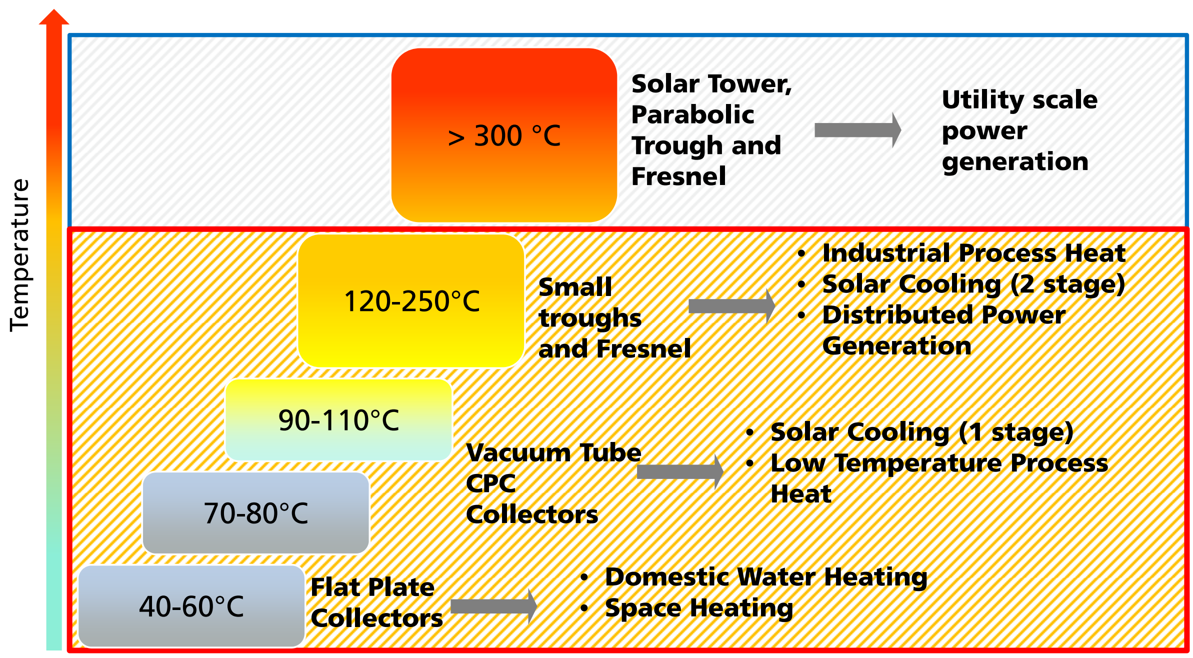
Solar Thermal Collectors – for Power, Cooling and Heat



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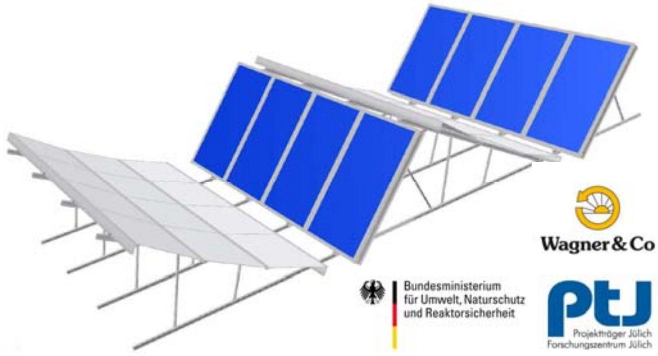
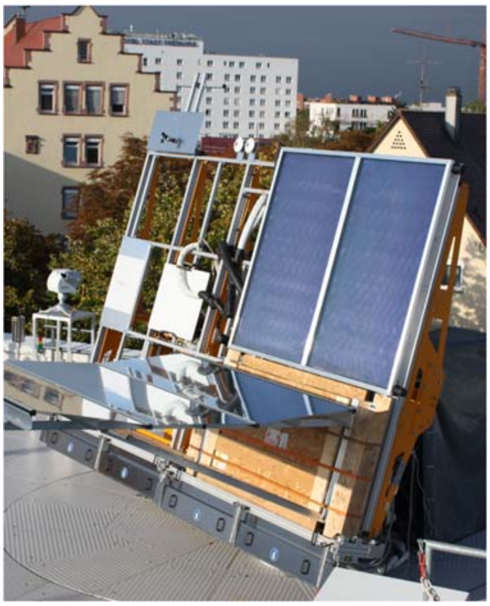
Process Heat: Collector Development



Visualisation of RefleC-Concepts

- Development of highly efficient flat plat collector wih reduced heat losses
- Working temperatures 80 °C to 150 °C -> medium temperature range



Prototype of RefleC-Collector Nov. 2010 on tracker facility of Fraunhofer ISE

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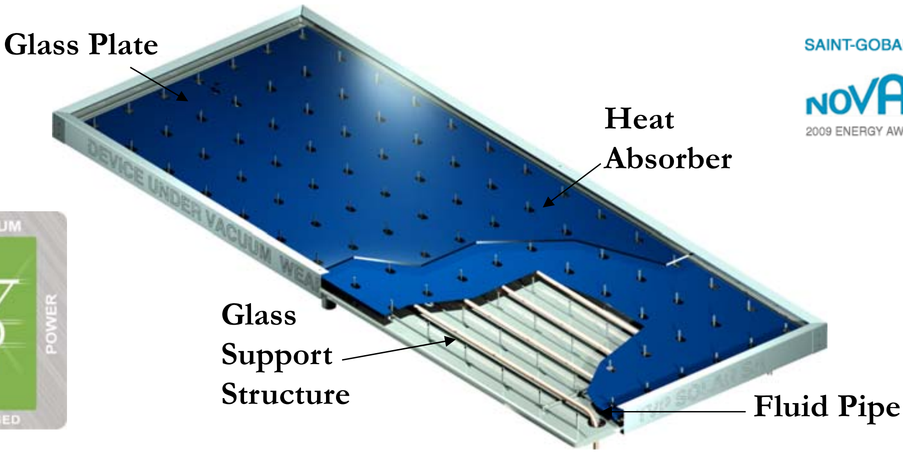
Thermal Vacuum Power Charged™

TVP charged panels allow for the first time to take full advantage of high vacuum insulation in a planar layout at low cost



SAINT-GOBAIN NOVA 2009 ENERGY AWARD WINNER

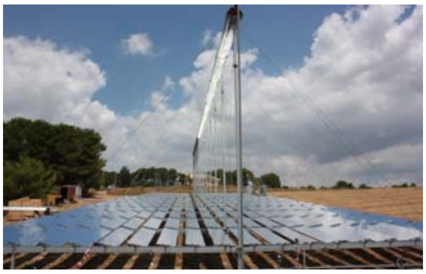
VACUUM THERMAL POWER CHARGED

TVP panels can operate at high temperature with high efficiency, without requiring any concentration (using direct AND diffuse light)

TVP SOLAR Fraunhofer ISE

Parabolic Throughs and Linear Fresnel Collectors

- Reduced temperature level for process heat compared to CSP
- Smaller solar field requires different installation procedures

Indigenous Technology: Scheffler Reflector

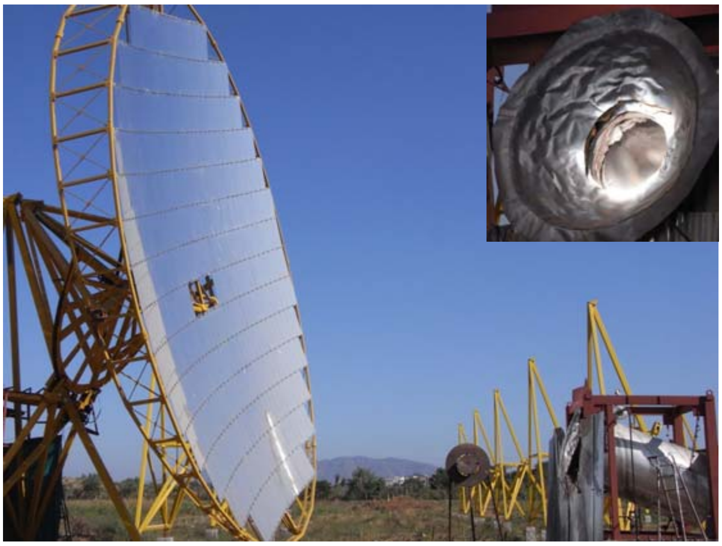
Main technical data:

- 770 Scheffler dishes with fix focus (60 m2 each)
- Reflector area: 45.000 m2
- 1 MW_{el} (Siemens turbine,
- 255 °C, 41 bar)
- 3.5 MW_{th} (hot water grid)
- Metal core storage for continuous operation

Supported by MNRE and BMU (Germany)

Consultant: Fraunhofer ISE

www.india-one.net



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Standardization of Performance Testing

- EN ISO 9806:2013 includes testing of tracking collectors
  QDT (Quasi-dynamic test method) can be applied
- Dynamic parameter identification compares well and offers the potential for field testing of large collectors under fluctuating conditions
- Non-invasive sensors (clamp-on) techniques have to be further tested and evaluated using uncertainty analysis

- Certification may be introduced with upcoming harmonized standard hEN 12975:1
  to be expected Spring 2015
- Experimental facilities for medium temperature are avaliable in several testing labs

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Heat Integration

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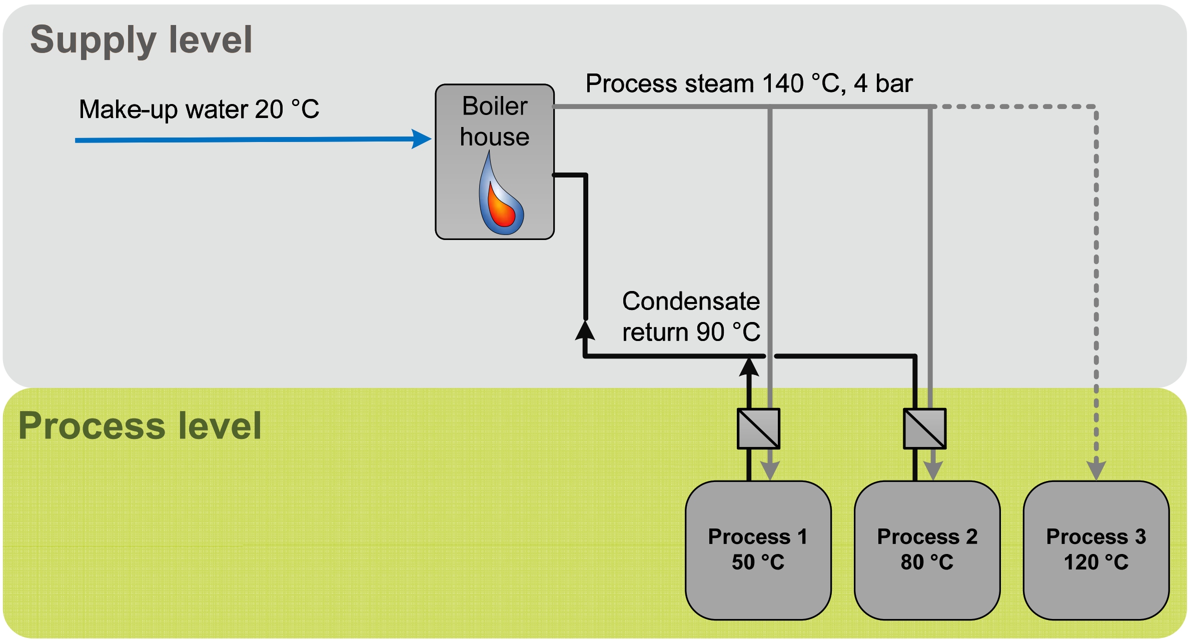
Solar Thermal Heat Integration
Process- or Supply Level?



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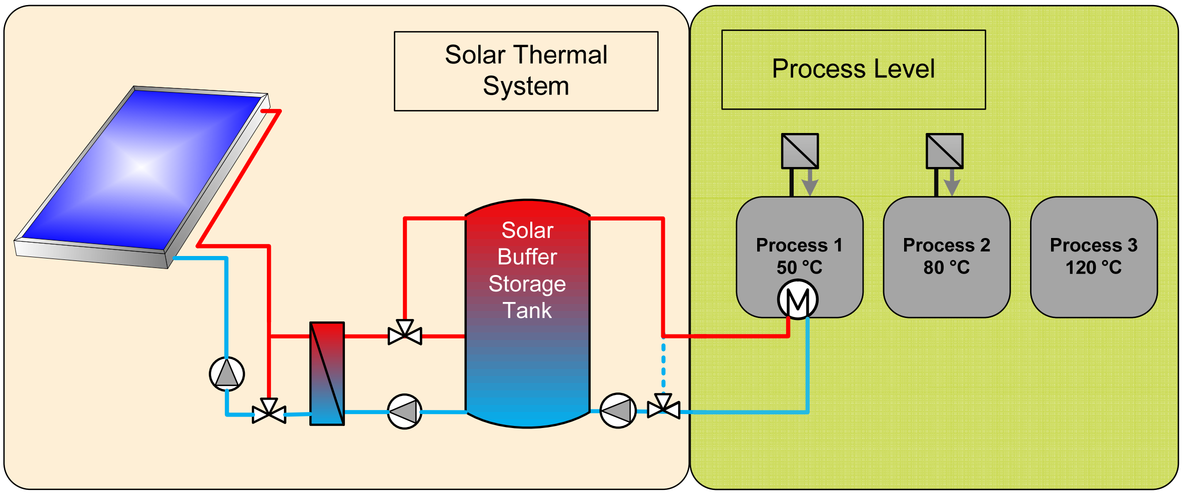
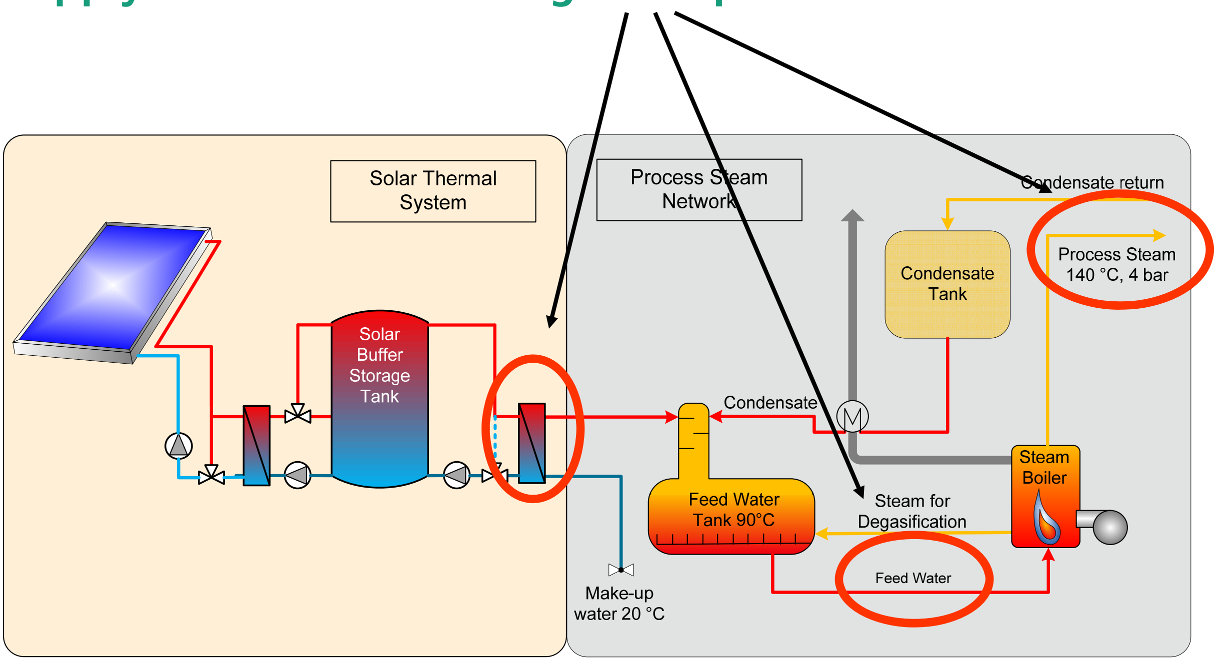
Solar Thermal Heat Integration
Process Level



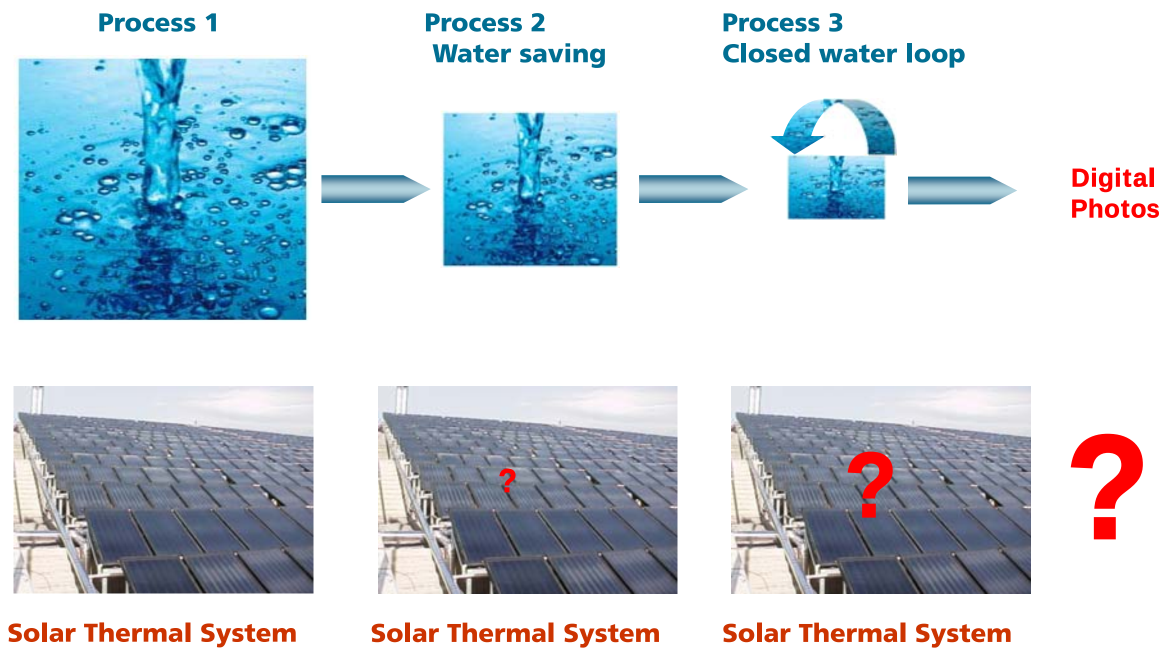
Simplified system concept for direct process heating

Solar Thermal Heat Integration
Supply Level: Possible integration points



Simplified system concept for heating of make-up water

What is the demand in future?



Source: C. Brunner/AEE

Integration concepts

- Process Level
  - Solar heat is directly supplied to the process.
  - Can be used for processes where the temperature of heat required is of low grade (until 100 °C) such as washing, cleaning, heating of industrial baths, hot air drying.
  - Is useful most when the heat requirement is restricted to one or two processes.
- Supply Level
  - Solar heat is supplied to all the processes through the heat distribution network.
  - Used in steam networks and high temperature networks where the solar thermal system may deliver pre-heated feed water or direct high-temperature steam
  - Flexible against process and demand changes!

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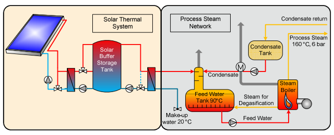
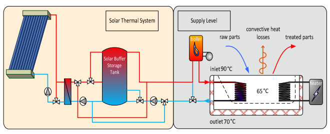
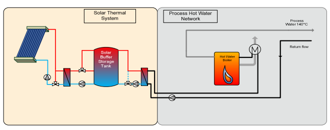
IEA Task 49 Simulation Cases



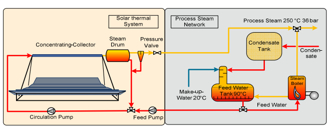
Make-up water preheating
20°C -> 90°C



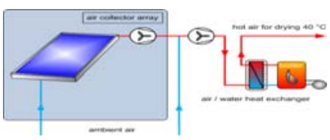
Bath Heating
70°C -> 90°C



Water Heating (Return Flow Temperature Lift)
110°C -> 130°C



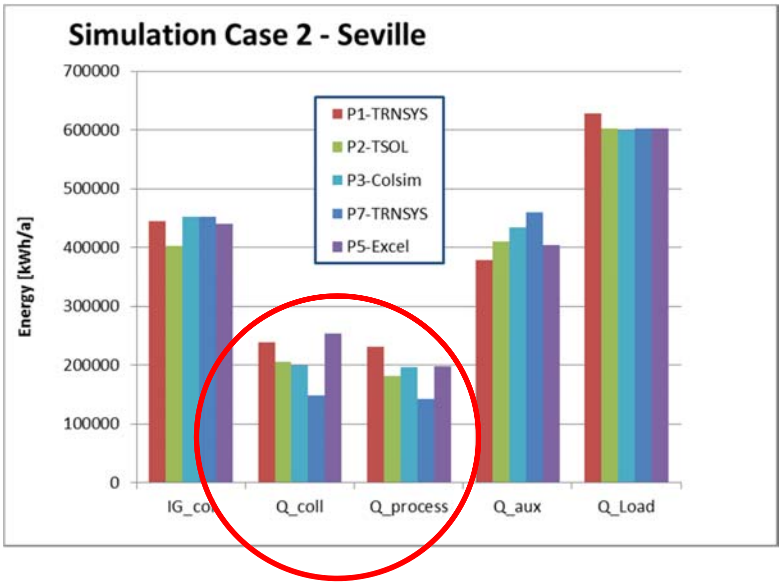
Direct Steam Production
140°C up to 210°C



Drying with Air

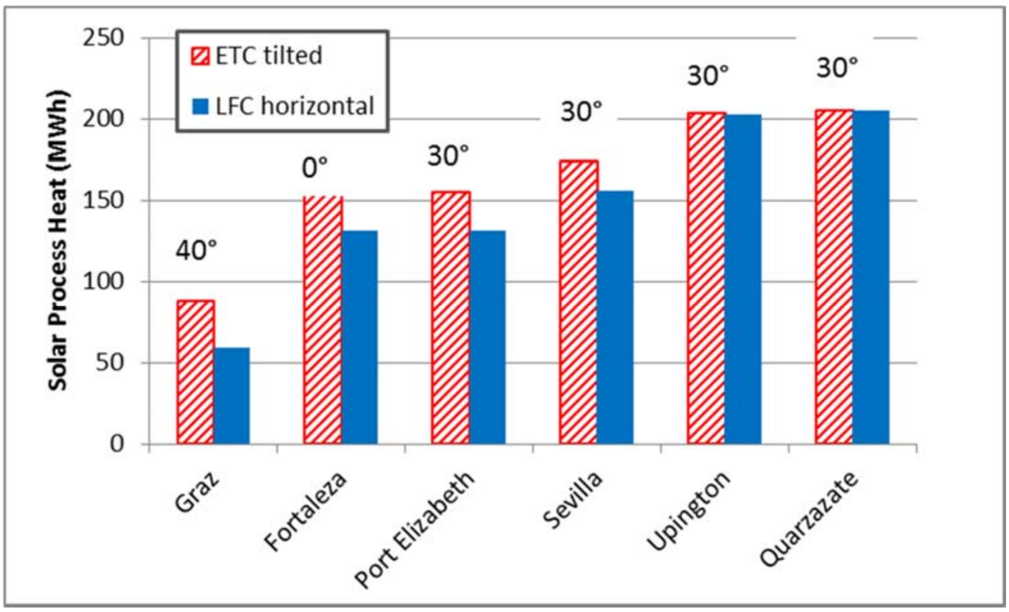
Case descriptions available

Comparison of preliminary results– IEA Case 2



- Even the use of the same tool does not guarantee identical results!

Comparison ETC tilted versus Linear Fresnel horizontal



200 m2 collector area in different climates
Lift of return flow from steam network 110°C -> 130°C,

First Results from Case Studies

- Daily and annual demand profiles (holidays! Weekends!) have a tremendous influence on levelized cost of heat (LCOH)
- Choice between non-concentrating collectors and concentrating ones is not easy, especially in temperature range around 100°C
- For supply level integration the steam network is important:
  - Open networks with high demand on freshwater -> Preheating
  - Closed networks with little steam loss -> Steam injection
- Required solar fraction and available roof space often dominates the selection process
- Storage can improve appreciably system utilization (especially over weekends, for batch-processes/discontinuous demand patterns)

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Important issues for selection

- Overheating protection – stagnation is easily avoided with tracking collectors
- Requirement of heat exchanger (DSG-collectors)
- Easy control of power output (e.g. mirror control Fresnel)

- Space requirements
- Local content of system
- Local installers expertise
- Cleaning procedures different

- **Cost**
  - **Installation**
  - **Operation and Maintenance**

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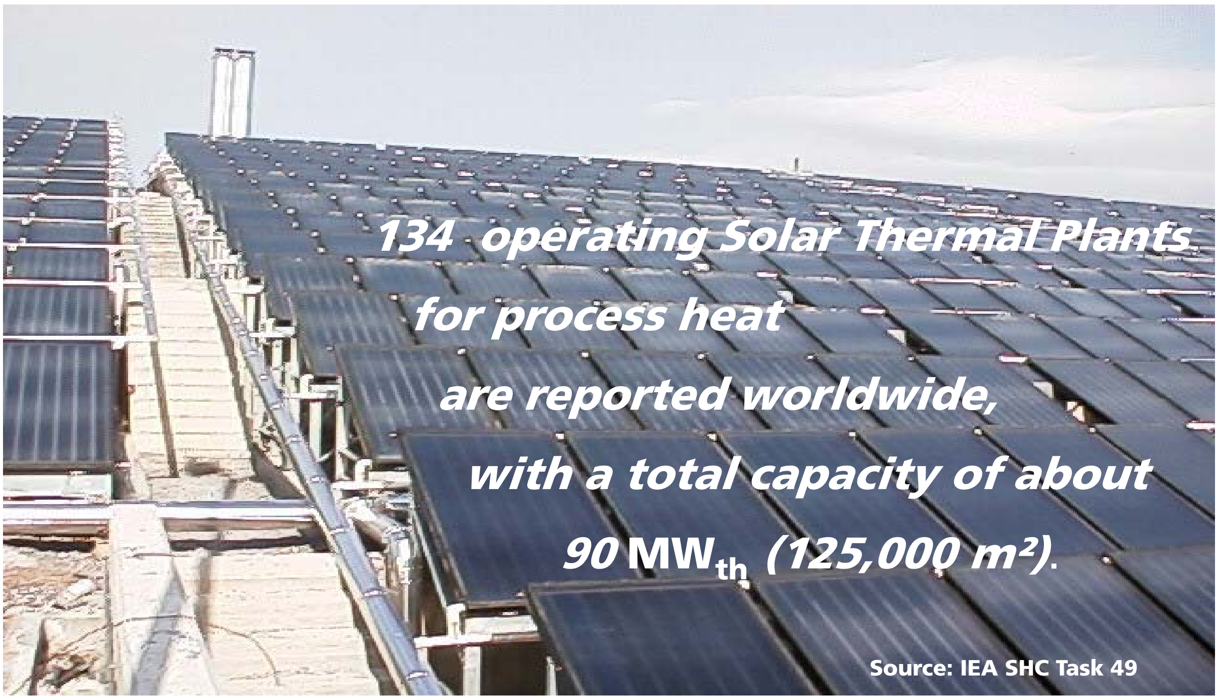
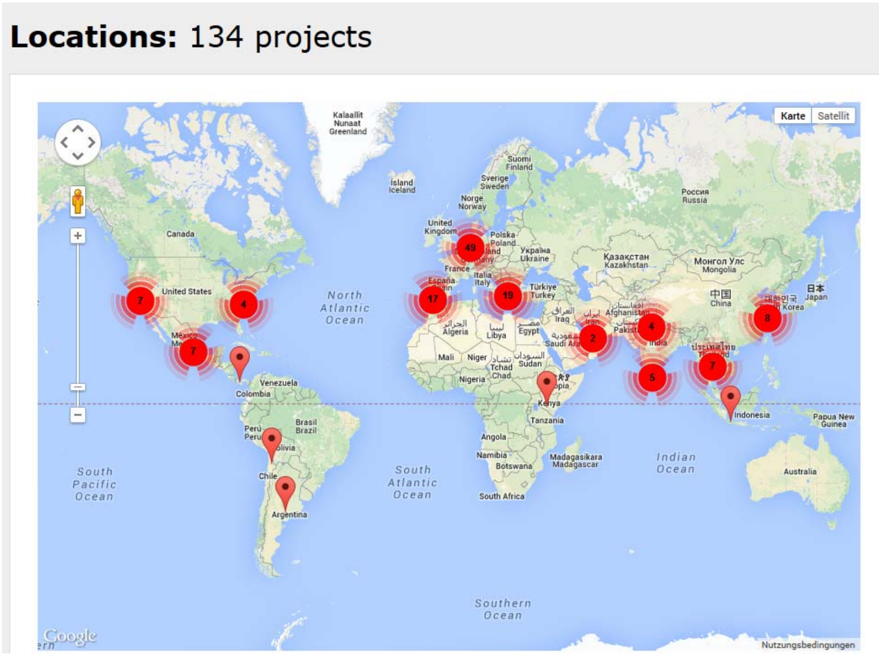
State of Solar Process Heat Applications

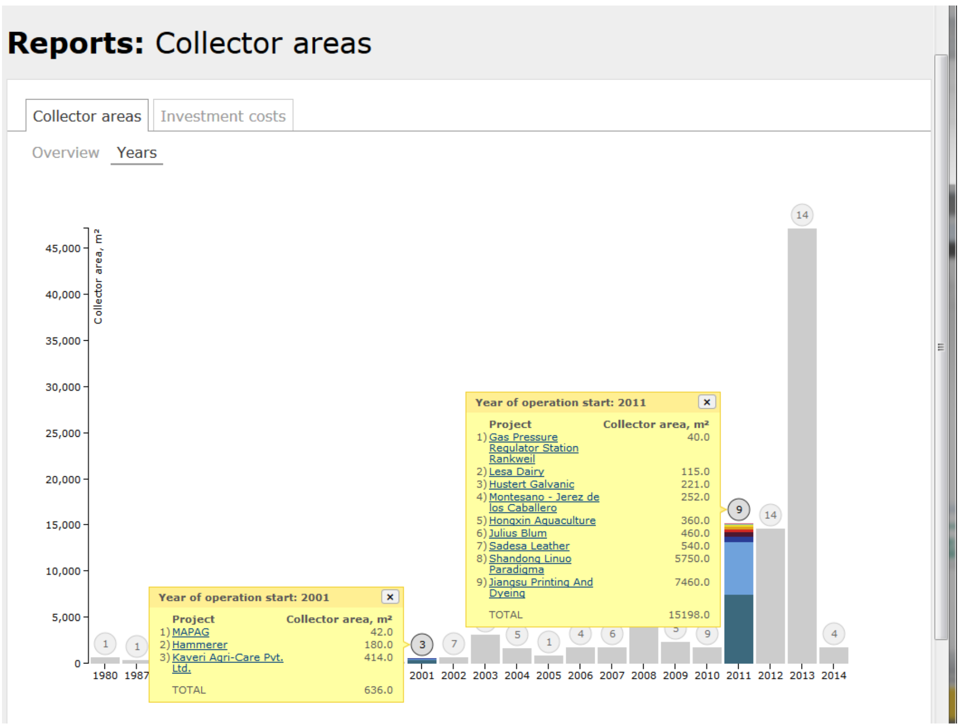


IEA Task 49 Database
Location with Google Maps

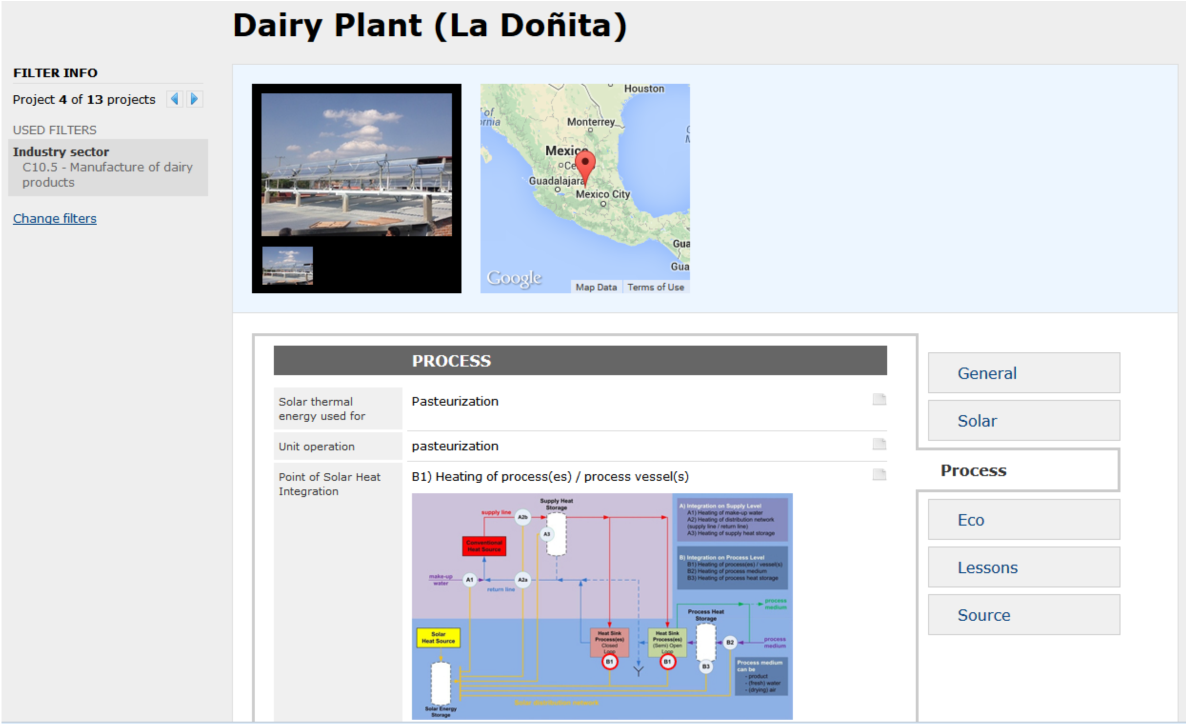


Source: http://ship-plants.info/locations
©2013-2014 AEE INTEC

Summary Reports from Database



Detailed Project Description



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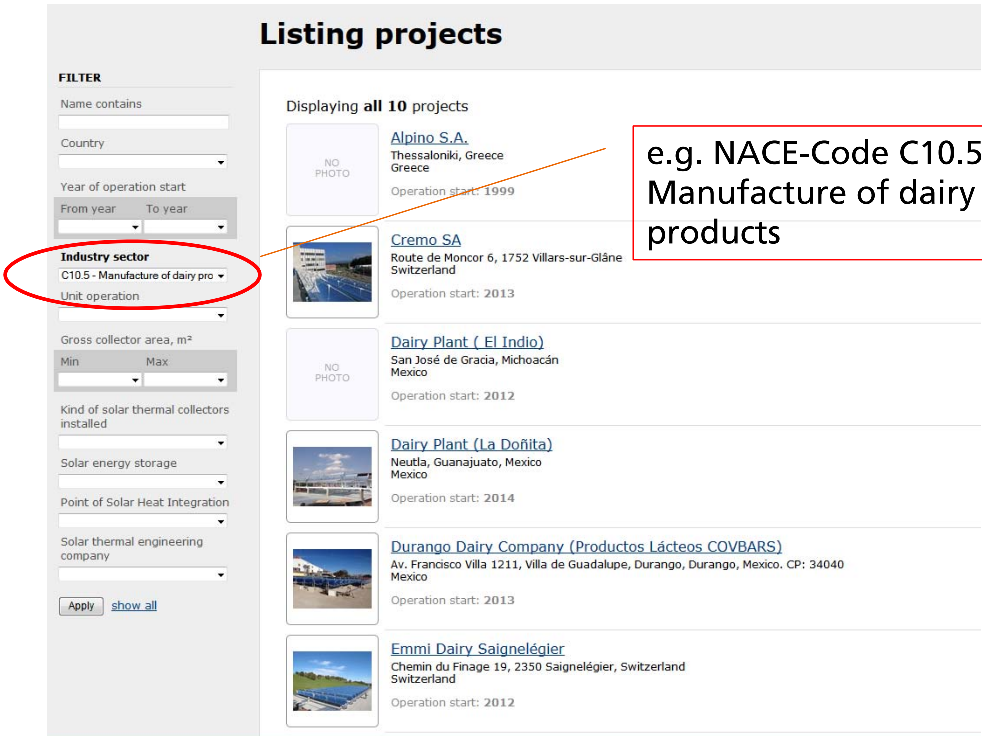
Filtering of Projects



e.g. NACE-Code C10.5 Manufacture of dairy products

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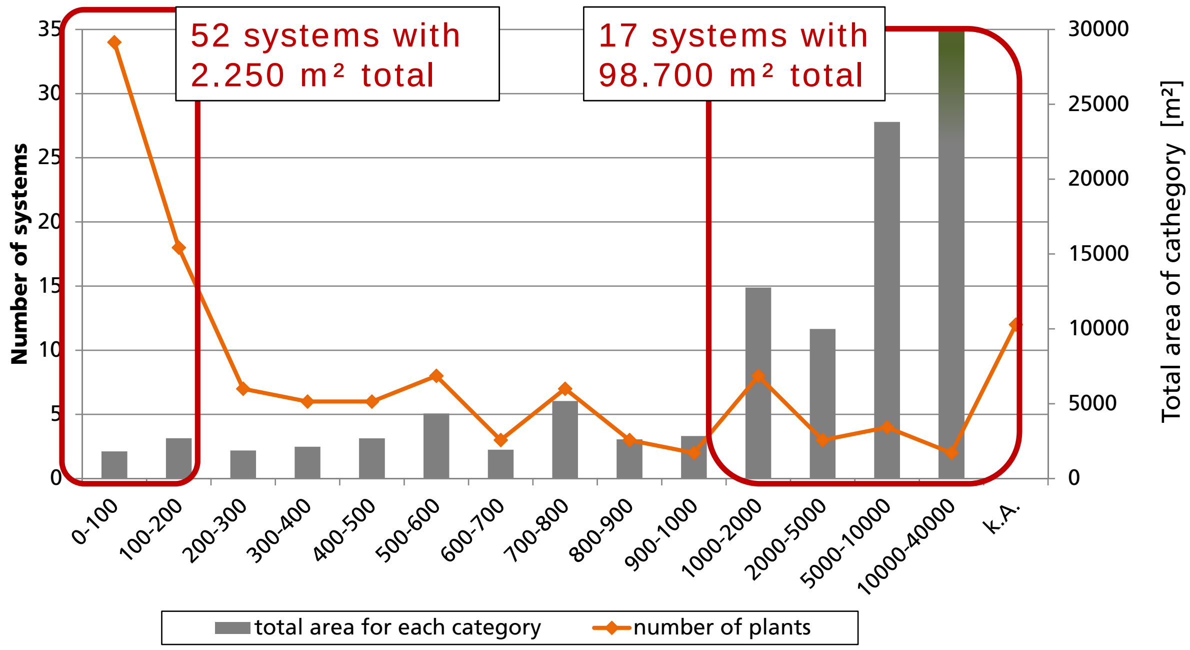
First Results – IEA SHC Task 49 Data base

124 systems, 125,600 m² , 87.8 MW



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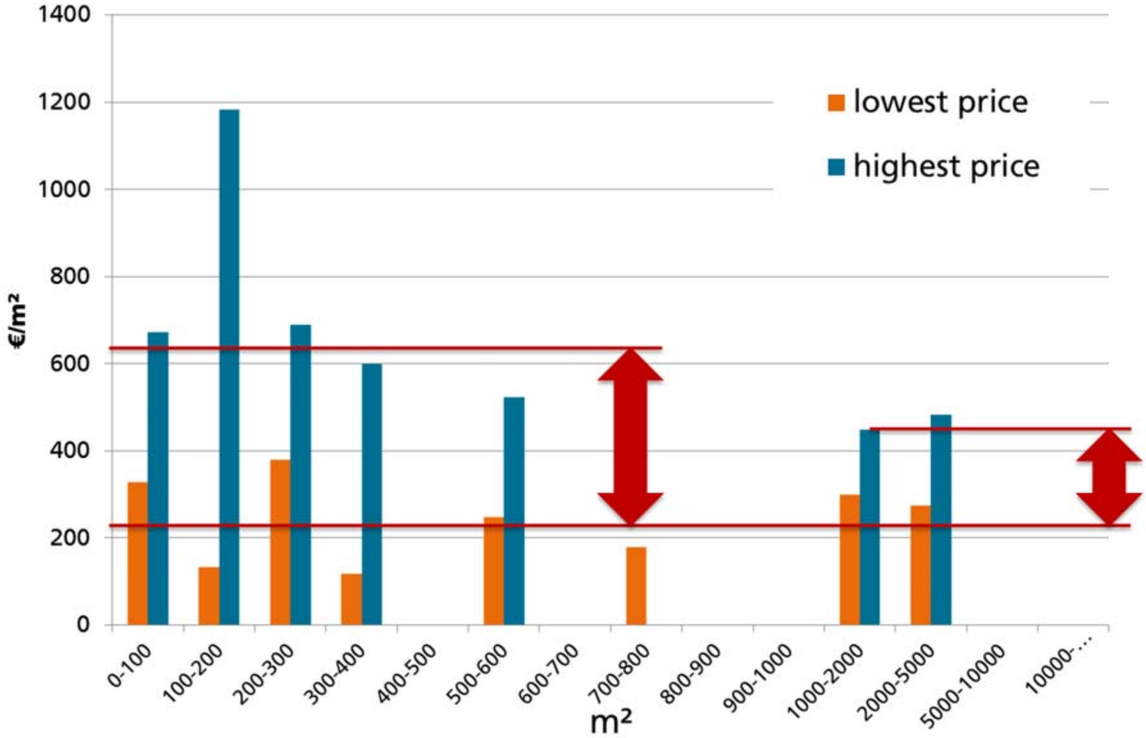
Source: IEA SHC Task 49

System price related to system size



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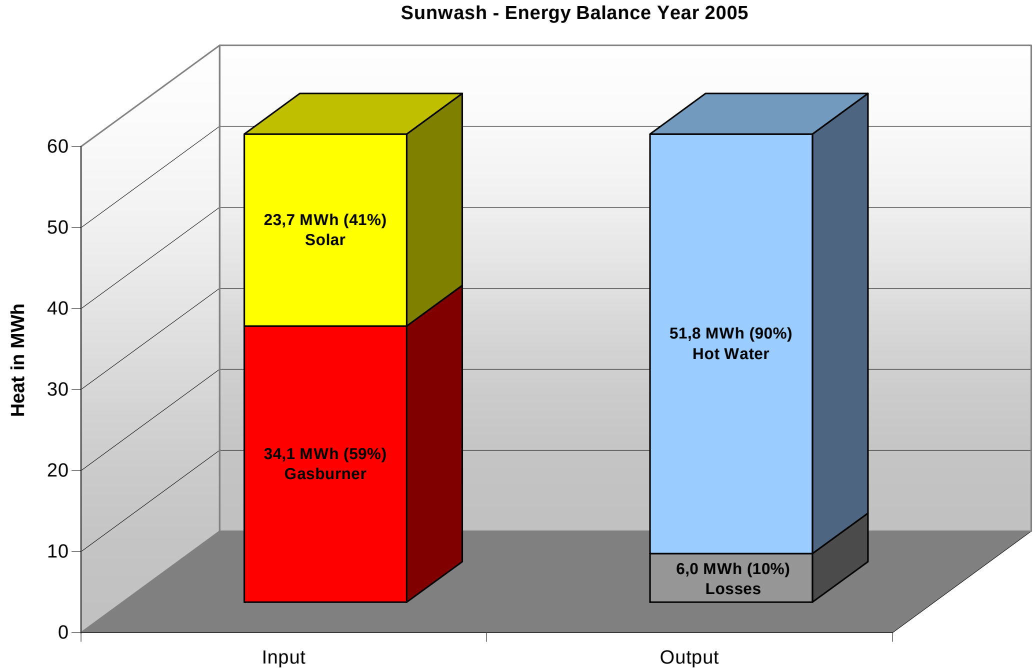
Hot Water for Solar Car Wash Plant

SunWash – Energy Balance



Source: AEE Intec

Brewery Göss, Austria

Integration into the mashing process

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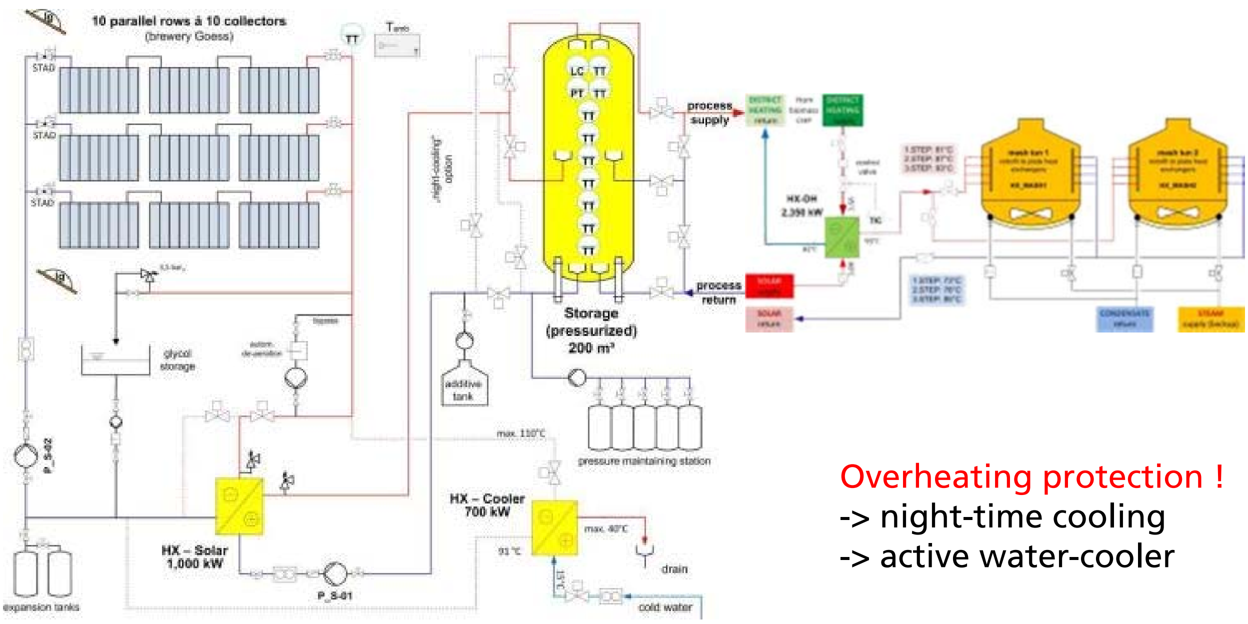
Integration into the mashing process



Overheating protection !
-> night-time cooling
-> active water-cooler

Source: AEE Intec

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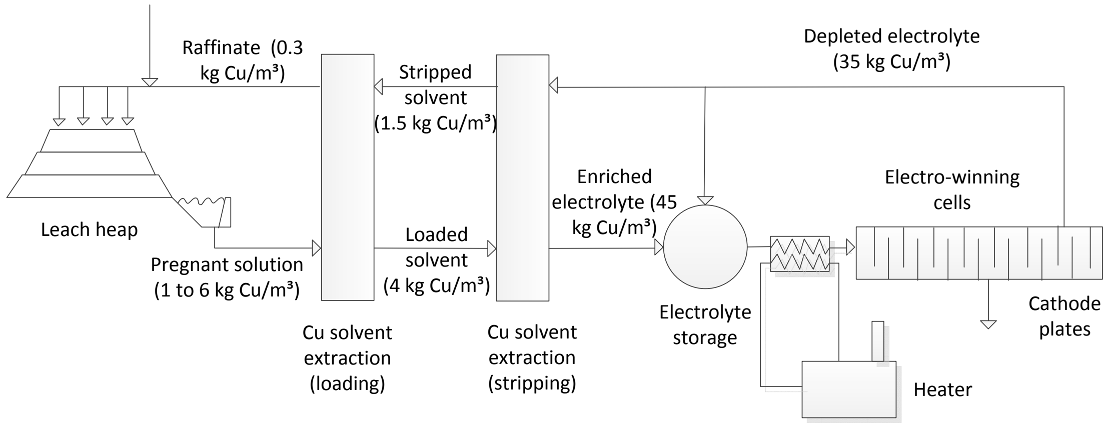
Copper Mining
Hydrometallurgical copper recuperation processes



Size of rock has been reduced by means of mills and grinders

Entails heap leaching, solvent extraction and electro-winning

Continuous process, aiming to increase copper concentration in every phase

Solar thermal energy integration

Great potential for solar thermal energy in electro-winning process

Temperatures needed are around 55-70°C

Two solar plants already operating

- 2010, Minera El Tesoro. Parabolic trough collector system. 16700 m² aperture area. 7.0 MWth. Turnkey project, executed by Abengoa, operated by Minera El Tesoro

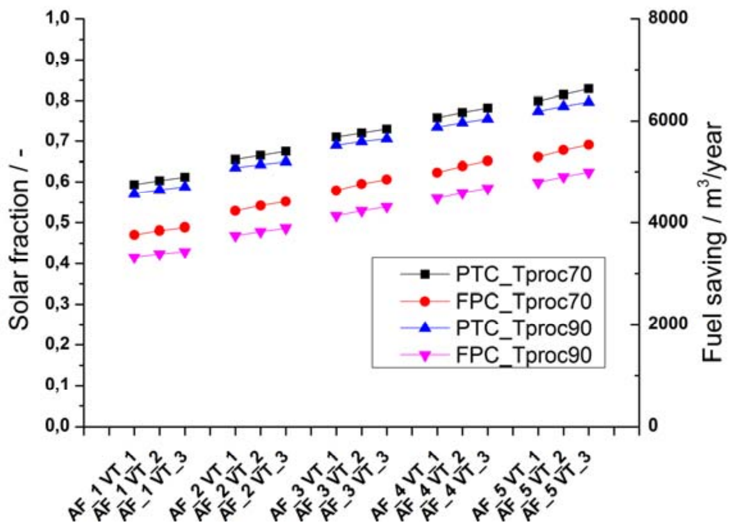
Abengoa. Installed plants

Solar thermal energy integration

- 2013, Minera Gaby. Flat plate collector system. 39000 m² aperture area. 32 MWth
- Consortium between Sunmark (Denmark) and Energia Llaima (Chile). Minera Gaby buys energy. Thermal Power Purchase Agreement contract for 10 years


Ian Nelson. ISES Webinar, 31.01.2014. Sun is shining on mining thermal processes. Replacing fosil fuels with solar supply

Simulation Study on Electrowinning



Solar field (m²)	30000 / 35000 / 40000/ 45000 / 50000
Corresponding notation	AF_1 / AF_2 / AF_3 / AF_4 / AF_5
Storage capacity (m³)	4000 / 5000/ 6000
Corresponding notation	VT_1 / VT_2 / VT_3

Source: Cuevas, F. et.al., SHC 2014, Energy Procedia

Variable energy demand

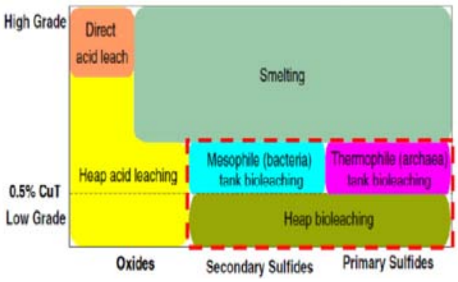
- Annual energy consumption decreases considerable (from ~ 14000 m³/year to ~ 8000 m³/year)
- As the storage size increases, the solar fraction increases. Solar system covers a significant part of the demand during the night

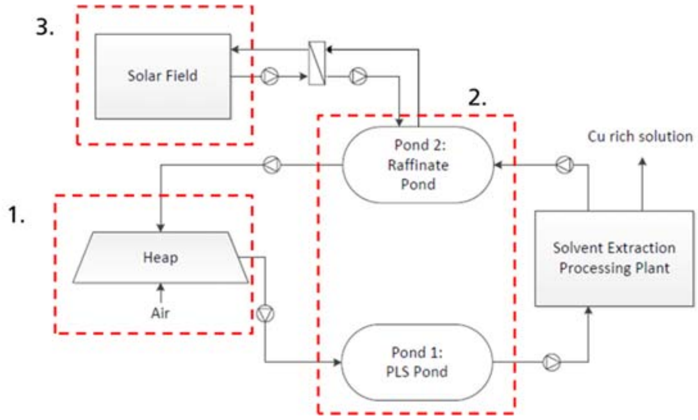
Under no demand conditions

- Worst case: after two days solar tank reaches 120 °C. Increasing solar storage capacity extends the period of time

Further work

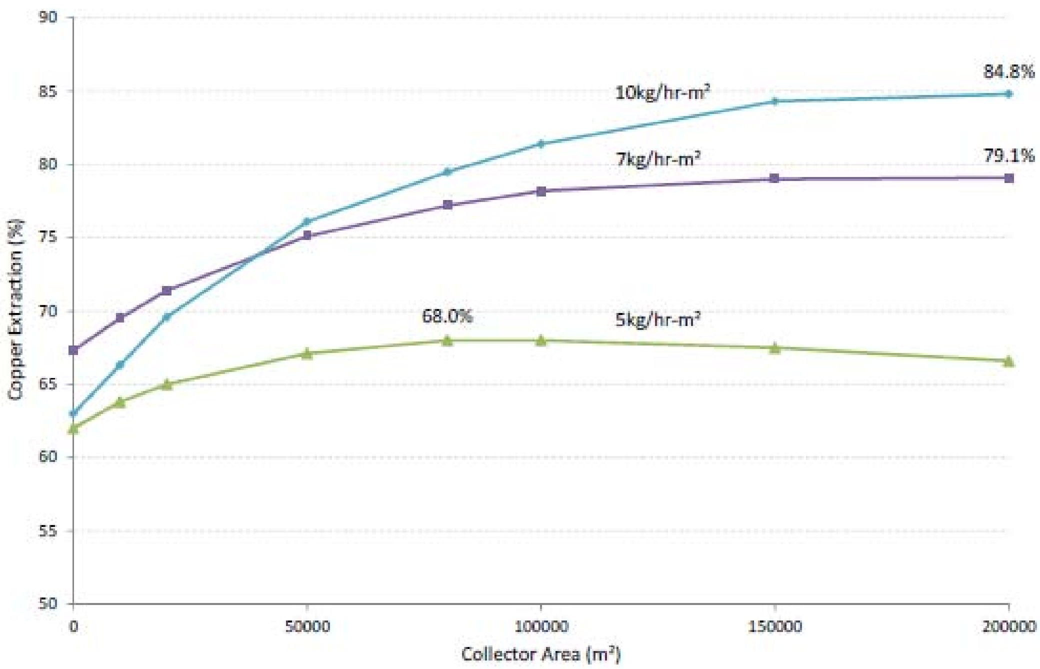
Integration of solar thermal system in heap bioleaching
-> Increase of productivity, lower grade ore may be used?





HeapSim-Model by Petersen and Dixon, UCT, 2003

Solar Thermally Assisted Heap Bioleaching



Source: Murray, C., MSc Thesis Univ. Freiburg, 2015

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Conclusion Solar Process Heat

- Integration on the supply level is more flexible than on the process level

- Non-concentrating collectors work in all climates
- Concentrating collectors may serve steam networks with temperatures above 170°C, but they need high DNI (about 1800 kWh/m2a)

- Optimizing of systems very individual -> good simulation required
- Demand pattern very much influences economics
- Low solar fraction : Possibility of cost-effective systems when demand exceeds production at any time
- High solar fraction needs storage
  -> research for steam storage for medium temperature and pressure level (e.g. PCM) required

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Conclusion Solar Process Heat

- Collector field cost are still too high in many cases, also subsidies for conventional fuels in many countries too high!
- Financing schemes and risk management are a key issue

- IEA Task 49 is working on support
  - Handbook Solar Process Heat
  - Simulation tools
  - Collector testing
  - Prevention methods overheating
  - …..

Visit http://www.iea-shc.org/tasks-current

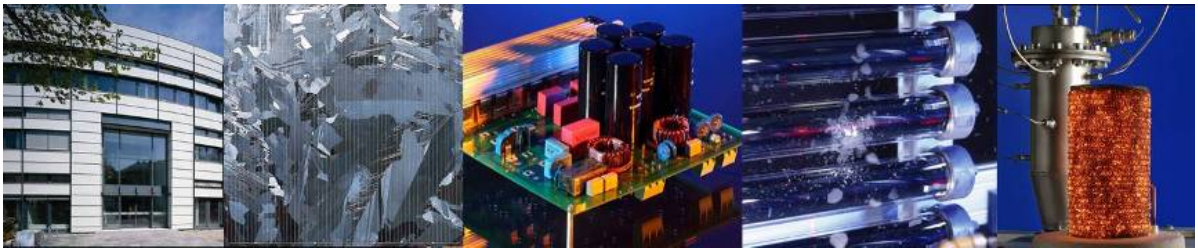
IEA-SHC-Task 49/IV: Solar Heat for Industrial Processes and Advanced Applications

- Operating Agent:
  Christoph Brunner
  c.brunner@aee.at
- Duration:
  Feb. 2012 – Jun. 2016
- Next meeting:
  16th/17th September 2015
  in Perpignan, France

Kick-off meeting at Fraunhofer ISE: 29 Feb. 2012

- Subtasks:
  - A: Process Heat Collectors (Pedro Horta, ISE)
  - B: Process Integration and Intensification (Bettina Muster, AEE)
  - C: Design Guidelines, Case Studies, Dissemination (Werner Platzer, ISE)

Thank you for listening!



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Climate and DNI

DÜRR INDUSTRIAL SOLAR thermal solutions