



# Kälte und Wärme mit Solarenergie herstellen

# Informationsreise Algerien, 9<sup>th</sup> April 2019

www.efficiency-from-germany.info

Dr. Uli Jakob SOLEM Consulting / Green Chiller Association Karlsruhe, Germany, 09.04.2019





# Your presenter

Dr. Uli Jakob

### MITTELSTAND GLOBAL EXPORTINITIATIVE ENERGIE



### Lecturer Building Technology / Renewable Energy

University of Applied Sciences Stuttgart

General Manager SOLEM Consulting - Global consulting services for energy

systems

### My areas of research:

- Solar thermal, photovoltaic systems, solar cooling
- Combined heat, power and cold
- Energy storage, energy systems
- Energy efficiency in industry
- Sustainable energy supply of building districts





# **Global solar radiation**







# Solar thermal collectors for heating, cooling and process heat







Source: Fraunhofer ISE





Source: Ritter XL Solar



Source: Smirro



Source: Industrial Solar









# **Temperature ranges for solar thermal applications**









# **Opportunities – Solar thermal energy in Germany**

# German technology leaders (selected examples):

# Process Heat and CSP players

- Engineering and services:
- Component suppliers:
- Implementation:
- Research institutes:

# Solar Cooling players

- Engineering and services:
- Component suppliers:
- Implementation:
- Research institutes:

- 11 companies
- 28 companies
- 3 companies
- 3 institutes
- 3 companies
- 13 companies
- 3 companies
- > 10 institutes



fgrund eines Beschlusses s Deutschen Bundestages





# Solar Cooling

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Bundesministeriu für Wirtschaft

aufgrund eines Beschlusse

# Solar cooling – Solar resource vs. Cooling demand







# Solar cooling – Technology overview



Gefördert durch: Bundesministeriur für Wirtschaft und Technologie aufgrund eines Beschlusses des Deutschen Bundestage





# Solar collector technologies – Applications for solar cooling

Solar thermal collector		Heat transfer	Collector	Application for		
		medium	temperature	cooling		
Air collector		Air	40-60°C	Air-conditioning	20°C	
Flat plate collector		Water, Water-Glycol	70-90°C	Air-conditioning, slab cooling	15°C	
Evacuated tube collector		Water, Water-Glycol	90-120°C	Air-conditioning, slab cooling	0°C —	_
Parabolic trough / Fresnel collector		Thermal oil, Water	120-250°C	Refrigeration, air-conditioning, slab cooling	-20°C	Gefördert durch: Mudesministerium für Wirschaft und Technologie aufgrund eines Beschlusses des Deutschen Bundestages





# General scheme of a solar cooling system







# **Development of Solar Cooling Market**



TECSOL/SOLEM Consulting estimates about 1.350 installed solar cooling systems worldwide (2015)







# Cost development of solar cooling Kits (2007-2019)



Source: Solem Consulting / Green Chiller



Cost reduction of 45-55% between 2007 and 2011! ۲





# Commercial available standardised solar cooling kits

SolarNext (Germany) chillii<sup>®</sup> Cooling Kit WFC175 Schüco (Germany) LB15 System Package





Source: Schüco







# SAC Application (Cosmetic industry, Greece, 700 kW<sub>c</sub>)



Sources: Sarantis

Bundesministeriu für Wirtschaft und Technologie





# SAC Application (Greenhouse, Italy, 8 kW<sub>c</sub>)



Sources: CRA-VIV

Bundesministeriur für Wirtschaft und Technologie

Gefördert durch:





# SAC Application (Food cold storage, Germany, 12 kW<sub>c</sub>)



Source: Kramer

Source: Fraunhofer ISE







# SAC Application (Hotel, Spain, 125 kW<sub>c</sub>)



Source: belroy Hotel

Gefördert durch:

Source: PowerSol

für Wirtschaft und Technologie

Bundesministeriun





# SAC Application (Office building, Austria, 15 kW<sub>c</sub>)



Sources: SolarNext







# SAC Application (Residential building, Jordan, 15 kW<sub>c</sub>)



Source: Visser

Sources: SorTech







# **Solar Process Heat**

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# **Industrial Energy Consumption**

- 2/3 of industrial end energy consumption is thermal energy
- 1/3 of the industrial process heat demand is below 200°C









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# General scheme of solar process heat system



Source: JER

Bundesministerium für Wirtschaft und Technologie aufgrund eines Beschlusses des Deutschen Bundestages





# Solar process heat installations in Europe (2015)



Source: JER, Data from AEE Intec

Approx. 85 installations with a total capacity of 20 MW<sub>th</sub>







# World map of solar process heat specialists (2017)







# Cost of solar process heat

# System components:

- Solar collectors (air / flat plate / vacuum / parabolic trough / Fresnel)
- Mounting system
- Puffer storage
- Piping, heat exchangers, insulation, etc.
- Control system
- Hydraulic integration in the process

# Specific costs (net):

of a solar process heat system based on gross collector area

- 100 1.000 m<sup>2</sup>: 500 800 EUR/m<sup>2</sup>
- > 1.000 m<sup>2</sup>:
  450 600 EUR/m<sup>2</sup>



Source: Solem Consulting





# **REEMAIN** study on solar process heat potential in Europe



### Comparison of yearly costs

Source: REEMAIN (2016)

 Thermal output of 0.2 MW<sub>th</sub> at 80°C process temperature for a continuous process of a small company or a sub-process of a large company







# Industry specific potential of solar process heat







# SHIP Application (Galvanic, Germany, 221 m<sup>2</sup>)









# SHIP Application (Meat production, Austria, 1,067 m<sup>2</sup> + 122 m<sup>2</sup>)



Source: Fleischwaren Berger, Solera







# SHIP Application (Dairy, Spain, 1 MW<sub>th</sub> solar steam)



Source: Solera







# SHIP Application (Eco-Paintshop for car industry)









# Further information

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# Links

- **IEA SHC Task 49** on Solar Process Heat (<u>http://task49.iea-shc.org</u>)
- IEA SHC Task 48 and Task 53 on Solar Cooling (<u>http://task48.iea-shc.org</u>, <u>http://task53.iea-shc.org</u>)
- EU funded SHIP projects InSun, FRESH NRG, REEMAIN, HyCool (<u>http://www.fp7-insun.eu</u>, <u>http://fresh-nrg.eu</u>, <u>http://www.reemain.eu</u>, <u>http://hycool-project.eu</u>)
- BMU funded "<u>Solar Payback</u>" project Solar Heat for Industry (involved countries Brazil, Mexico, India and South Africa, <u>https://www.solar-payback.com</u>)
- SHIP plant database (<u>www.ship-plants.info</u>)







# Thanks for your attention!

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Contact: Dr. Uli Jakob SOLEM Consulting <u>uli.jakob@solem-consulting.com</u>

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