Polymeric Materials for Solar Thermal Applications

2006 – 2014

Subtask B: Collectors and Components

Dr. Michael Köhl
Operating Agent

Fraunhofer ISE
Freiburg, Germany
michael.koehl@ise.fraunhofer.de

Dr. Michaela Meir
Subtask Leader A

University of Oslo
Oslo, Norway
mmeir@fys.uio.no

Dr. Stephan Fischer
Subtask Leader B

University of Stuttgart
Stuttgart, Germany
fischer@itw.uni-stuttgart.de

Prof. Dr. Gernot M. Wallner
Subtask Leader C

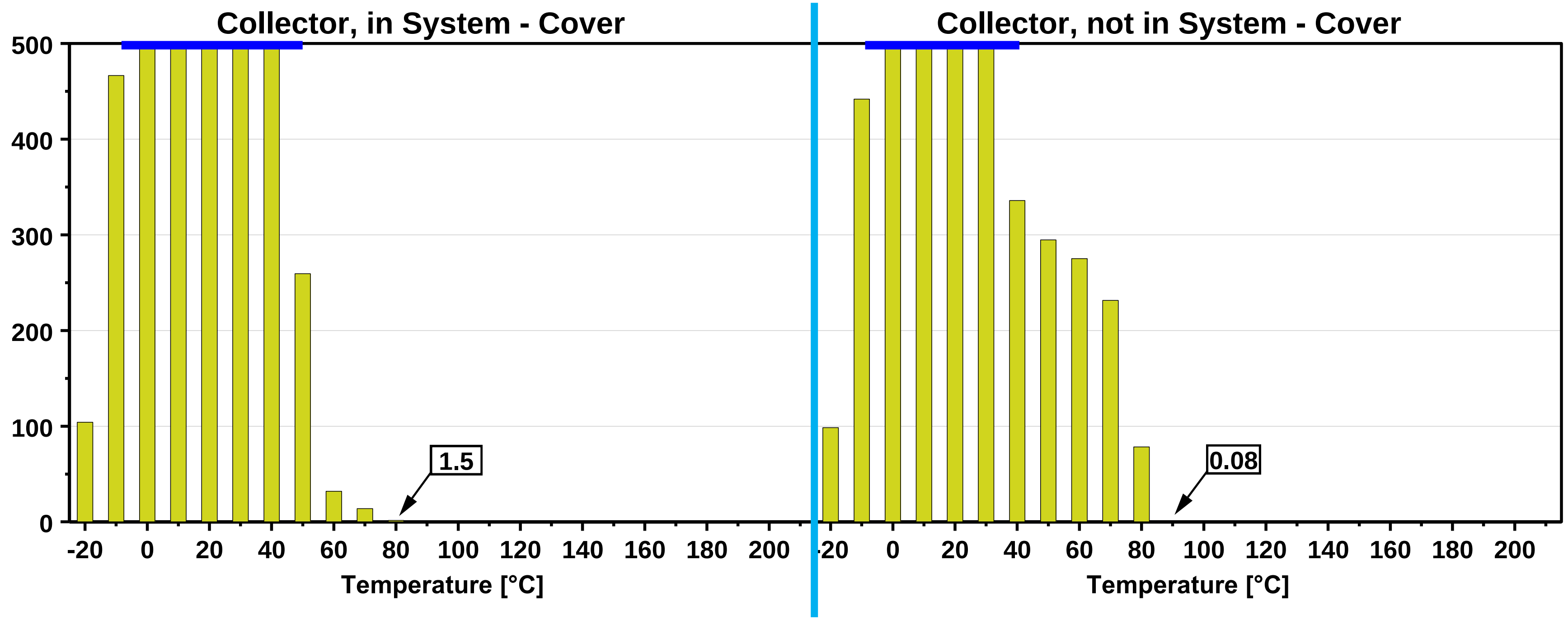
Johannes Keppler University
Linz, Austria
gernot.wallner@jku.at

Content

- Thermal loads on solar collectors and components
- Overheating protection
- Selected products and concepts
- High lights, conclusion and outlook

Temperature transparent cover

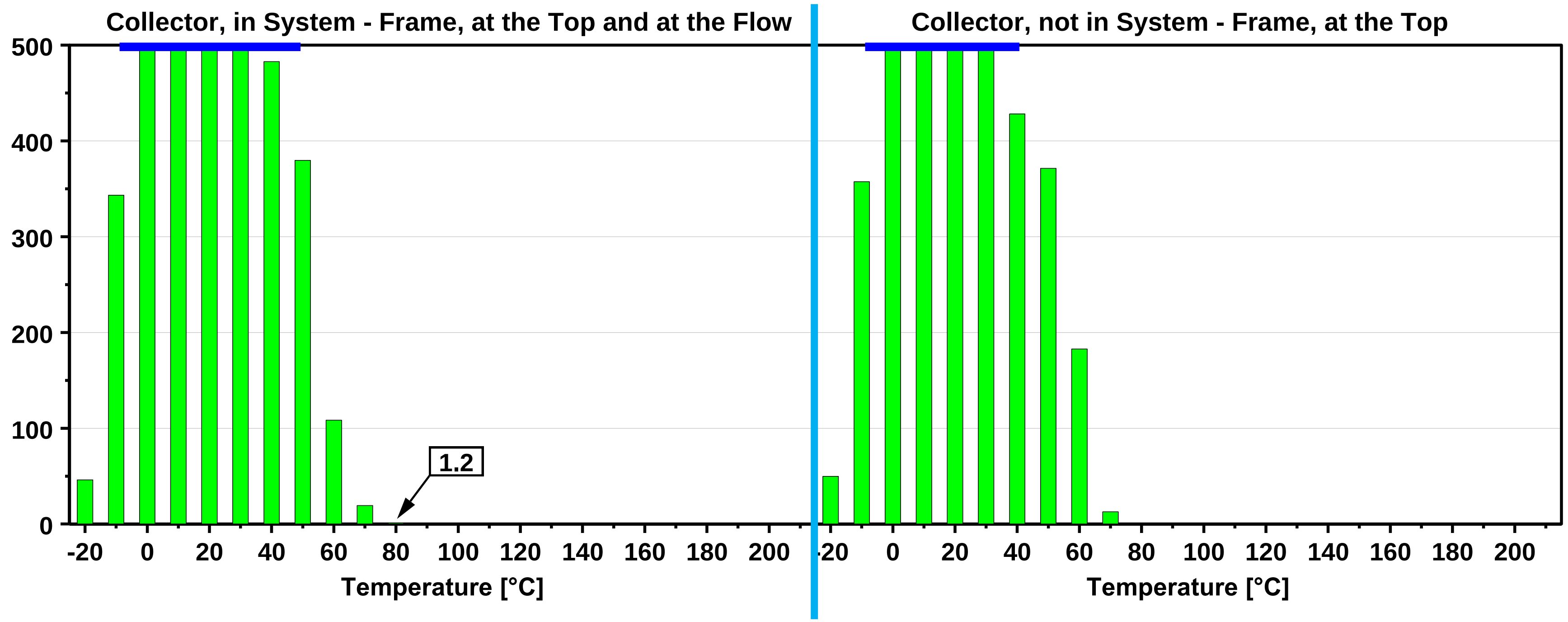
- Relatively Low Peak Temperatures (→ 86 °C)
- Only Short Durations at High Temperatures
- Most Low-Cost Polymers Useable



Source: Ch. Reiter, Ingolstadt University of Applied Sciences

Temperature collector frame

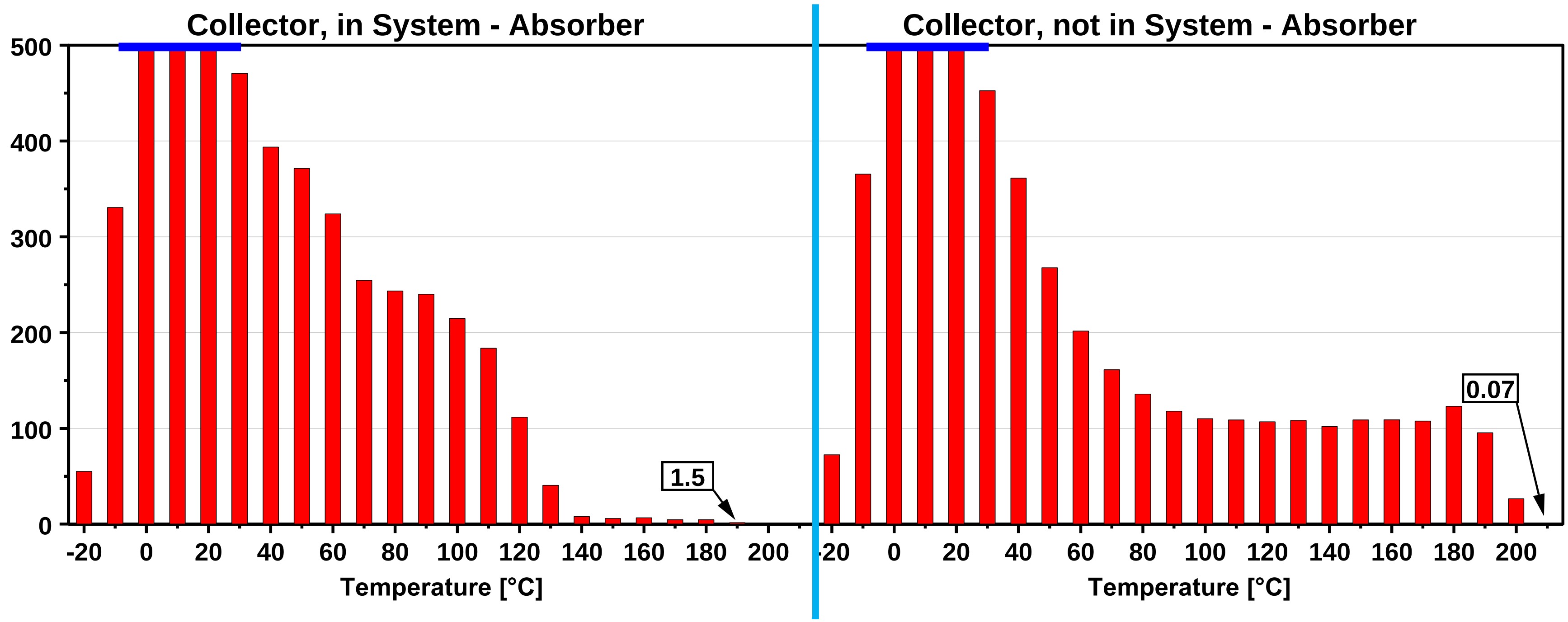
- Low Peak Temperatures (→ 79 °C)
- Temperature Mainly Below 65 °C
- Perfectly Suitable for the Use of Low-Cost Polymers



Source: Ch. Reiter, Ingolstadt University of Applied Sciences

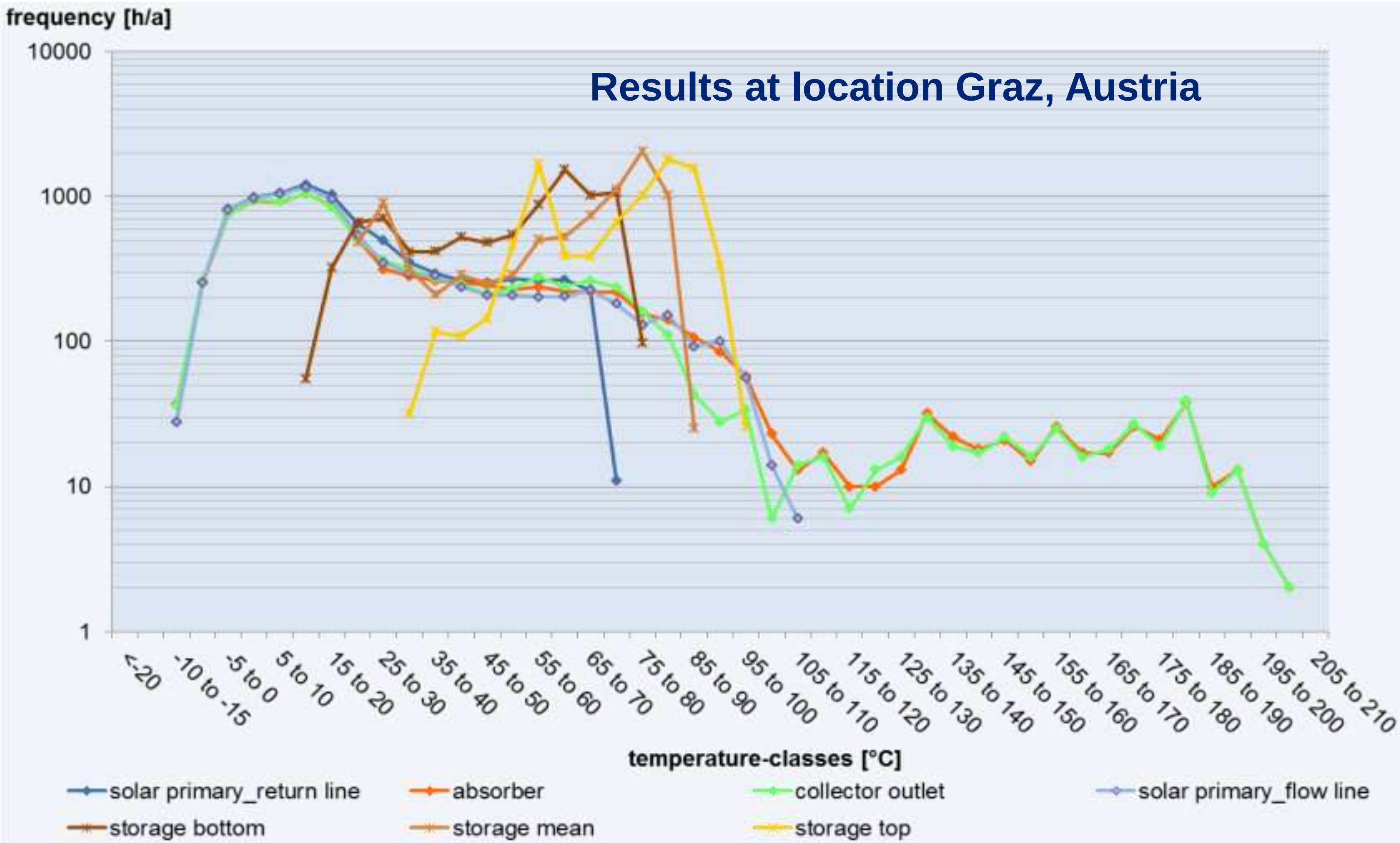
Temperature absorber

- Considerable Temperature Loads during Operation (→ 140 °C)
- Extreme Temperature Loads in Stagnation (→ 208 °C)



Source: Ch. Reiter, Ingolstadt University of Applied Sciences

Temperatures Solar thermal system



Source: D. Preiß, AEE – Institute for Sustainable Technologies

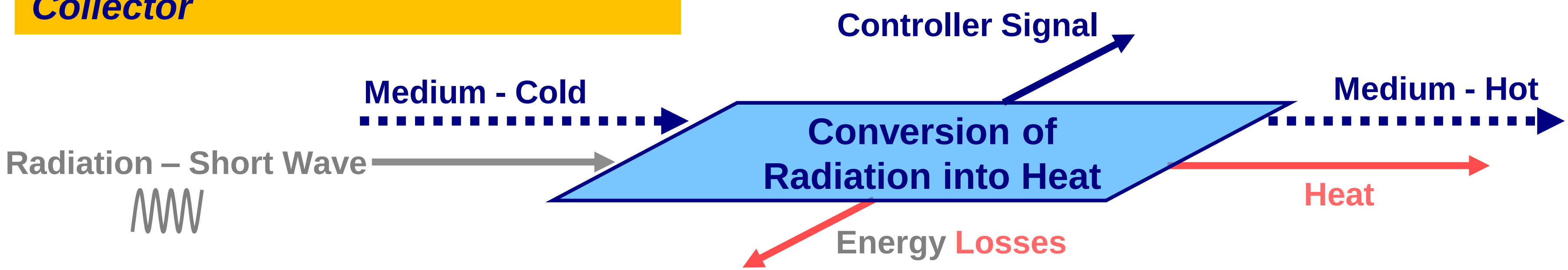
Consequences and solutions

- High performing (expensive) polymers
- Over heating protection

Source: A.. Thür, University of Innsbruck, Unit for Energy Efficient Buildings

Overheating protection measures

Basic Function Scheme of the Collector



Overheating Protection

Reduction of the <u>Optical Efficiency</u>		Removal of <u>Thermal Energy</u>	
Reduction of <u>Transmission Properties</u>	Reduction of the <u>Absorption Properties</u>	Raising of the <u>Thermal Losses</u>	<u>Active Cooling</u> of Collector Parts

Source: Ch. Reiter, Ingolstadt University of Applied Sciences

Vents mechanism (MAGEN)

Active cooling

Vents

Patented unique venting mechanism builds from four ventilation orifices at the collector’s 4 corners that open and close, depending on temperature driven mechanism the casing structure, to eliminate the risk of overheating damage to the plastic absorber

Source: M. Plaschkes, Magen Eco-Energy

Measured absorber temperatures

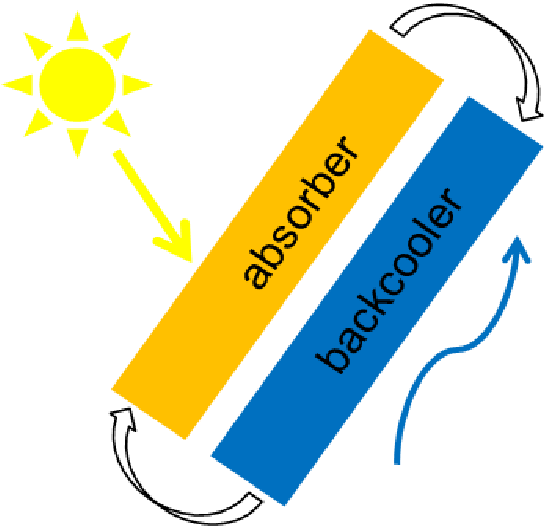
Source: M. Plaschkes, Magen Eco-Energy

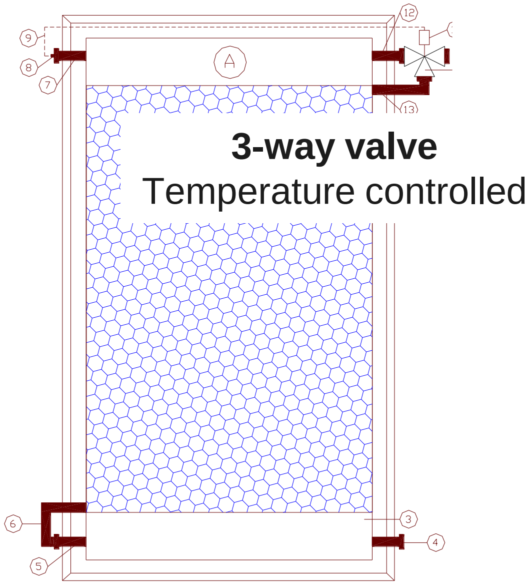
Back cooler (active cooling)

Goal	**Fail Safe Temperature Limited Plastic Collector** Maximum Temperature of ca. 90°C
Method	Concept, Material, Simulation, Production and Measurements of Modell-Collectors
Materials	Cheap Mass-Produced Plastics (Polyolefine)

Problem

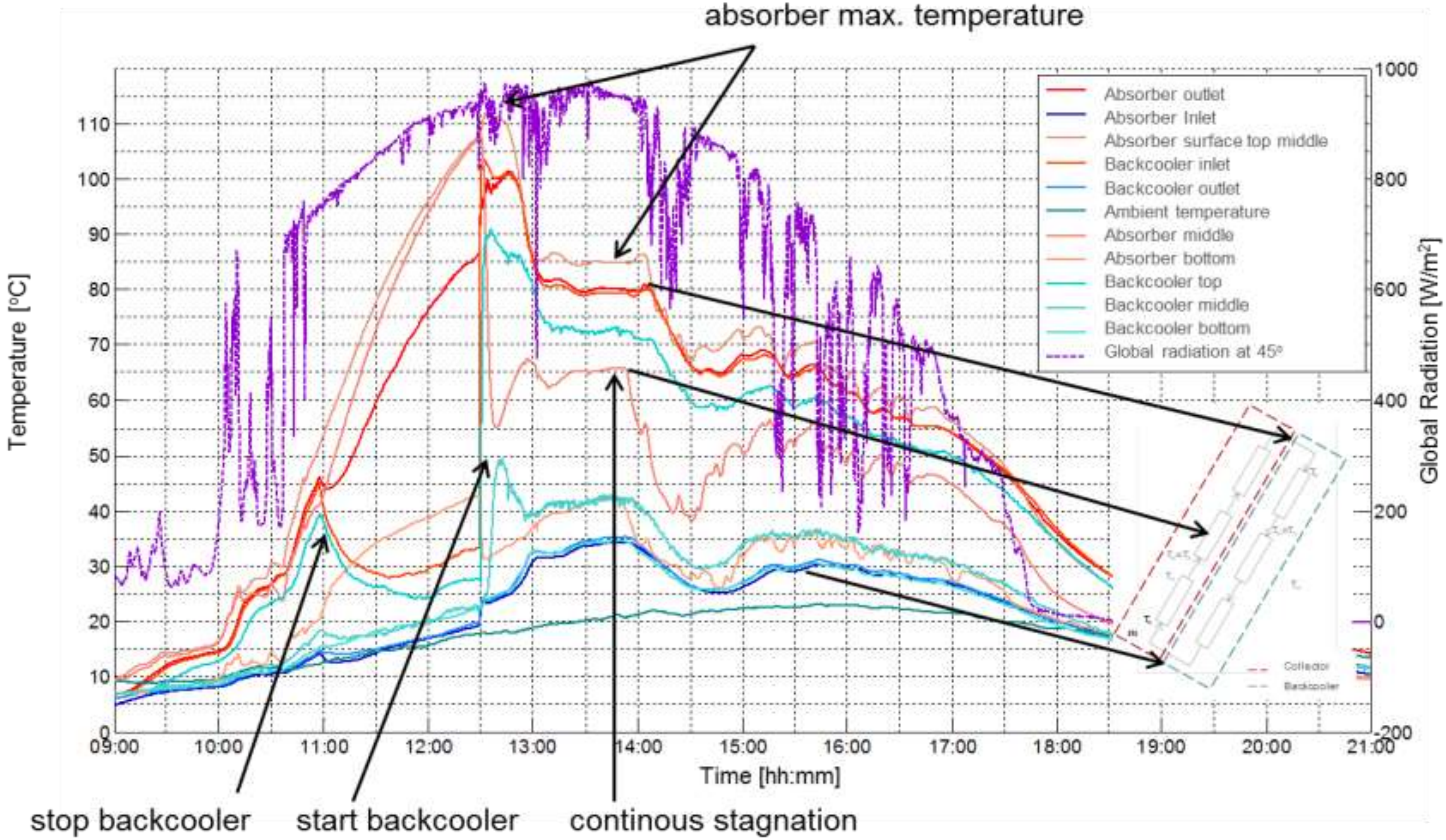
Principle





Source: A.. Thür, University of Innsbruck, Unit for Energy Efficient Buildings

Back cooler in operation

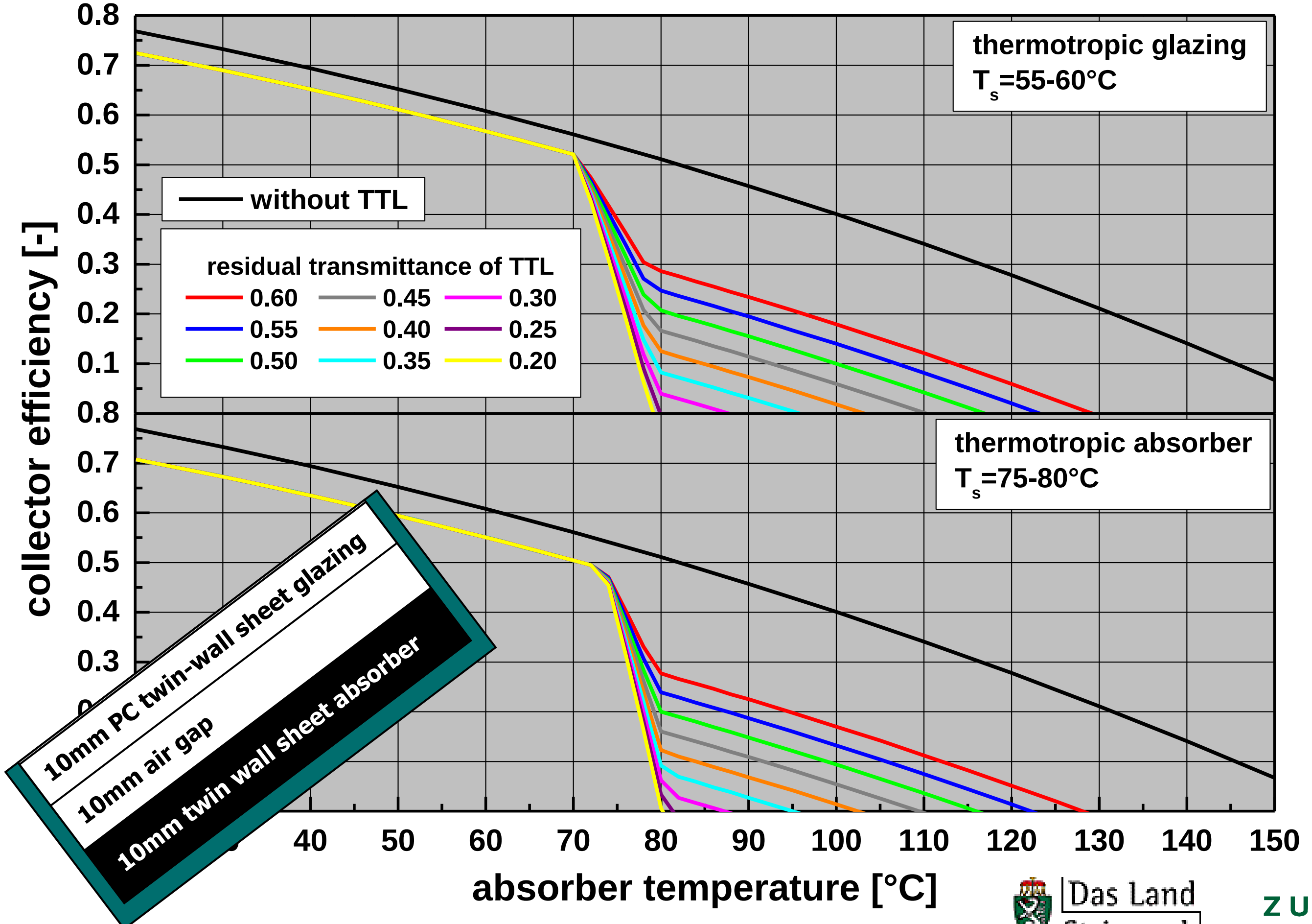


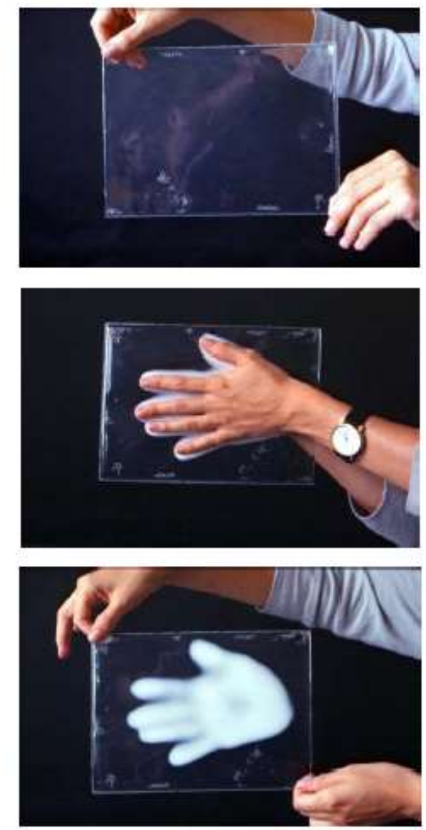
Source: A.. Thür, University of Innsbruck, Unit for Energy Efficient Buildings

Thermotropic Overheating Protection

Theoretical Potential and Material Requirements

Source: Wallner et al. (2008) Solar Energy Materials & Solar Cells





Source: Hartwig, 2003.

Das Land Steiermark

ZUKUNFTSfonds STEIERMARK

Thermotropic Overheating Protection

Application demonstrations in conventional solar thermal collectors

Source: Fraunhofer ISE.

Source: Austrian Institute of Technology.

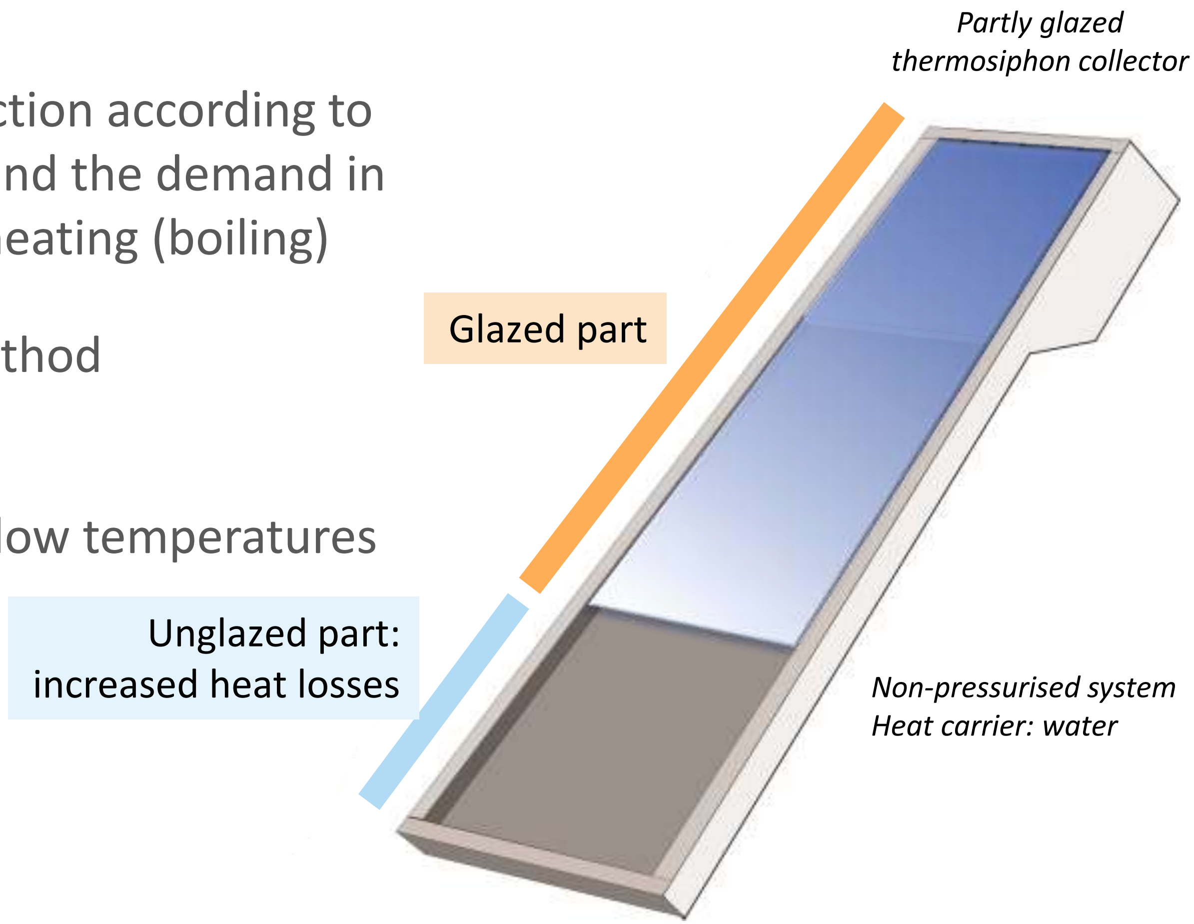
Significiant reduction of maximum absorber temperatures (<90° C) with thermotropic layers

To do: **optimization of large scale manufacturing**

Source: K. Resch, Montanuniversität Leoben

Overheating protection by partial glazing for AventaSolar Thermosiphon system

- Tune the glazing fraction according to the climatic region and the demand in order to avoid overheating (boiling)
- Easy and flexible method
- Additional benefit
  Higher efficiency at low temperatures



Source: M. Meir, Aventa

Selected products and concepts

One world solar collector

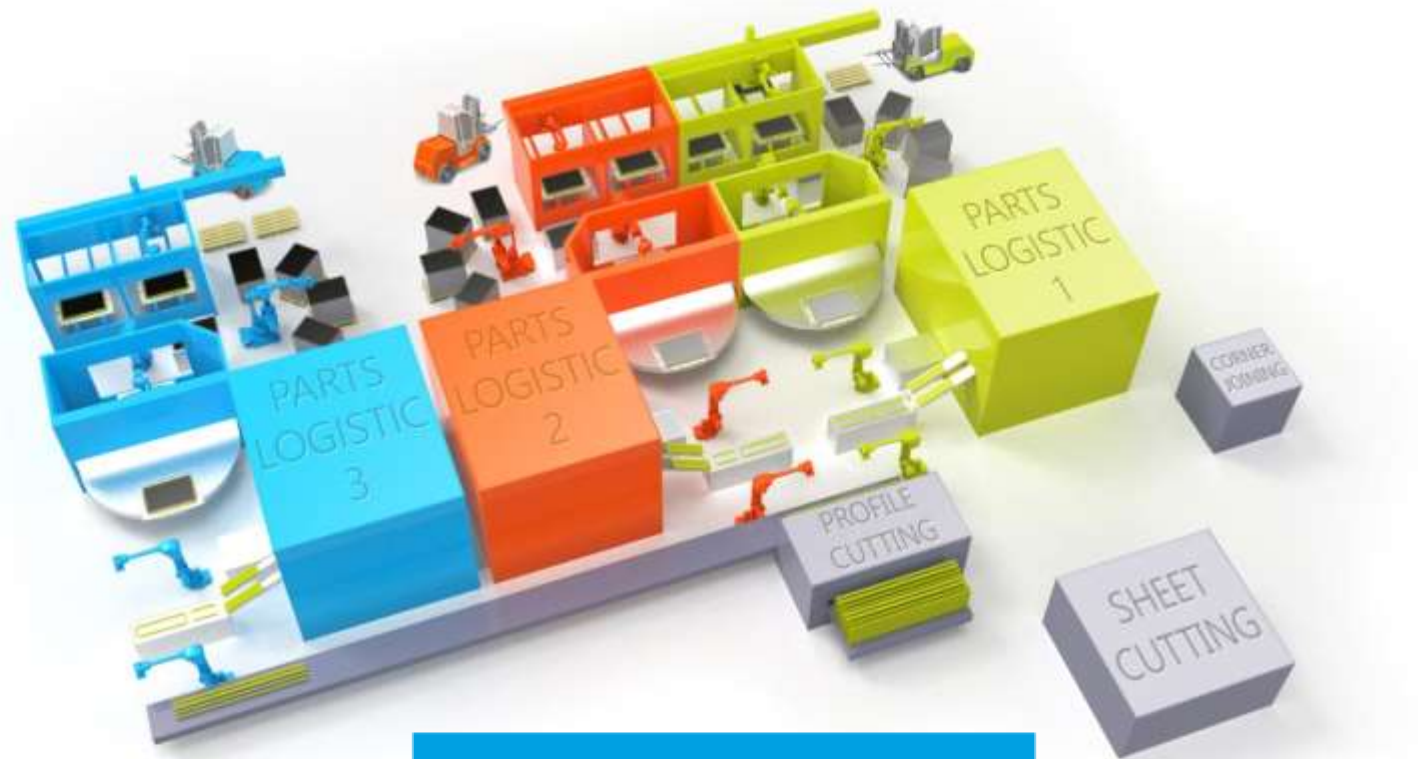
|| The design concept:

|| functional - modern - trendy - smart - unique - intelligent - handy - practical

World premiere of One World Solar Collector at Fakuma fair 14th -15th October 2014 (www.fakuma-messe.de/en/fakuma/)

Source: R. Buchinger, Sunlumo

One world solar collector conceptional production line



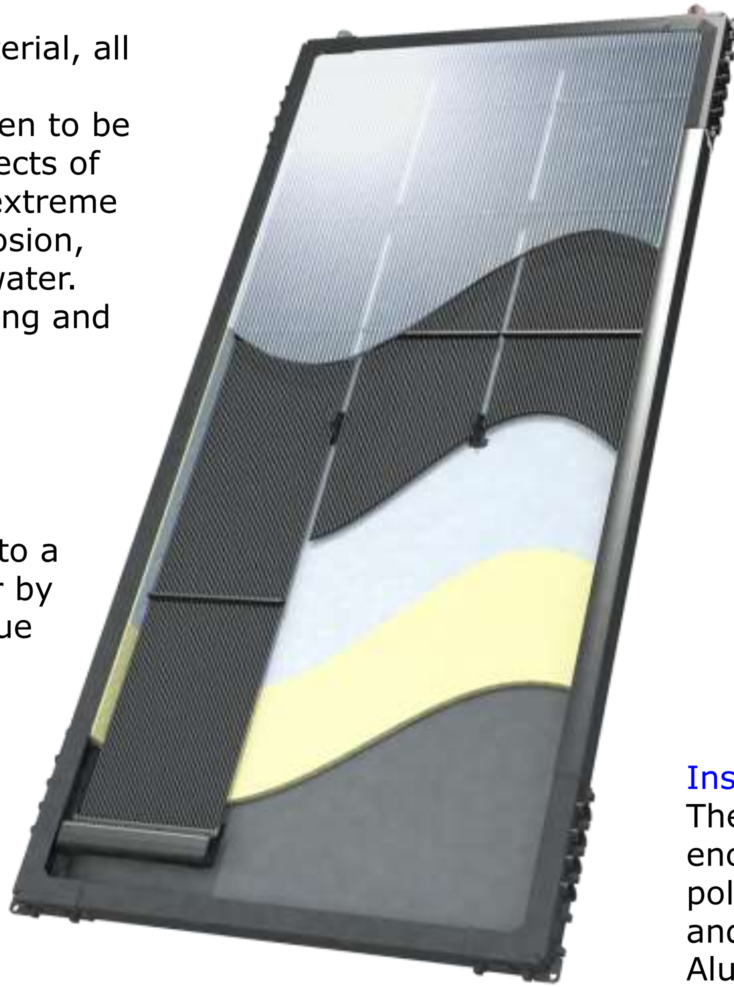
Fully automated modular factory

Source: R. Buchinger, Sunlumo

One world solar collector production line (prototype)

Source: R. Buchinger, Sunlumo

MAGEN Eco-Flare collector



Material
Specially formulated material, all plastic made, tested in authorized labs and proven to be stabilized against the effects of sustained UV radiation, extreme weather conditions, corrosion, limescale, salts and seawater. High resistance for freezing and pressures

Absorber
117 + Individual plastic tubes @6.5mm diameter, connected to a unique square manifold header by Over-Molding injection technique

Back Plate
UV stabilized Polypropylene back plate

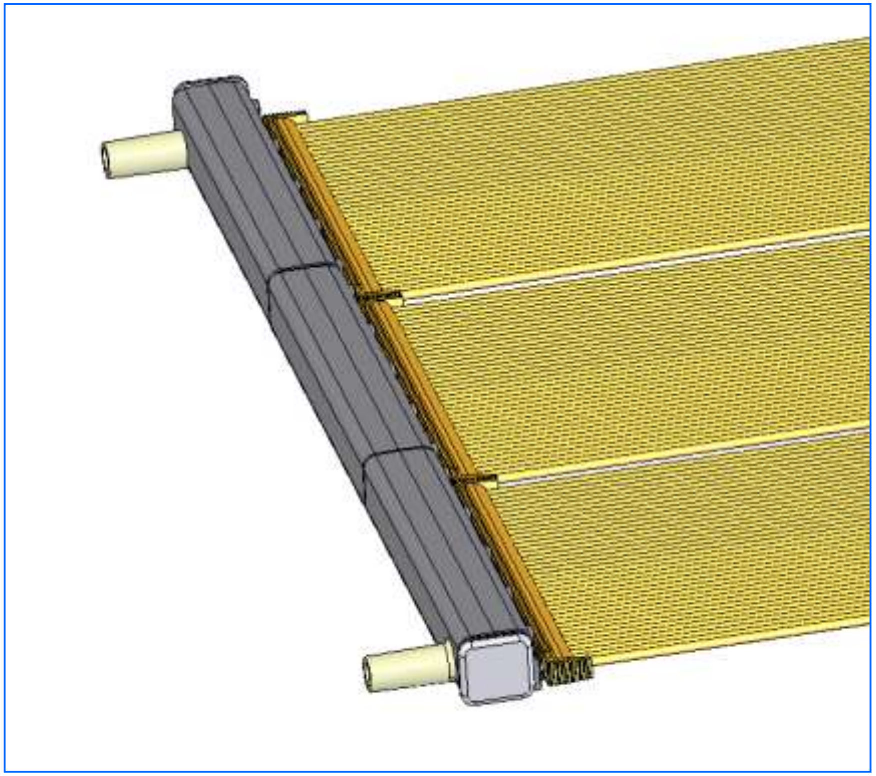
Casing & frame
Reinforced plastic and Aluminum components with a very light weight, for easy installation and minimal roof load

Glazing
Multiwall Polycarbonate glazing with additional UV blocking tissue. Light weight with extreme impact resistance (200 times more than glass)

Insulation
The collector is encased in polyurethane foam and Polyester coated Aluminum foil

Source: M. Plaschkes, Magen Eco-Energy

MAGEN Absorber and header



- Patent Pending
- Bursting Pressure: 50 bar
- Freeze Resistance: -18 °C
- Max. Operating Pressure: 5 bar @ 77 °C

Source: M. Plaschkes, Magen Eco-Energy

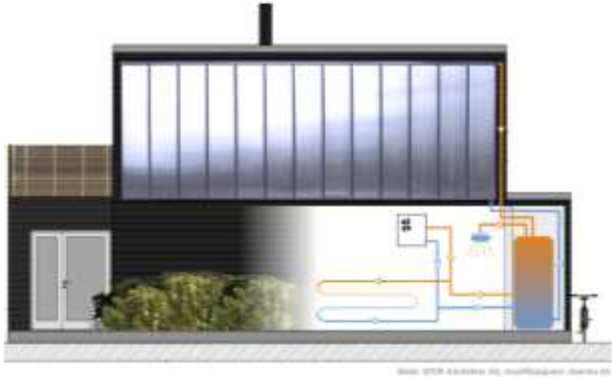
AventaSolar collector

- New collector concept based on extruded polymeric sheets (absorber and glazing)
- Collector design adopted to the use of polymers
  - Pure water as heat carrier
  - Non-pressurised collector loop
  - Solar loop with drain-back design
- Light weight with approx. 8 kg/m^2 :
  Easy handling, transport, installation

Source: M. Meir, Aventa

AventaSolar collector system

- Collector designed for building integration: Roof and facade integrated collectors replace conventional building materials
- Advantage: Modular collector design with various collector standard lenghts
- Simple system design: "Direct system"
- Favorable applications:
  Low- and midtemperature applications: Combisystems, low temperature heating systems, system with large DHW demand;



Source: M. Meir, Aventa

AventaSolar collector / system - New solutions overcome barriers for Solar Thermal

- Cost reduction by mass production (extrusion, IR welding)
- Replacing conventional building covers
- Modular concept & simple hydraulic design: Installation & distribution in collaboration with building industry instead of HVAC installers
- Building modules with well-known installation process: NorDan Solar window concept (NorDan, OSO Hotwater, Uponor)
- Mass-produced housing: AventaSolar in catalogue house programme

NorDan Solar

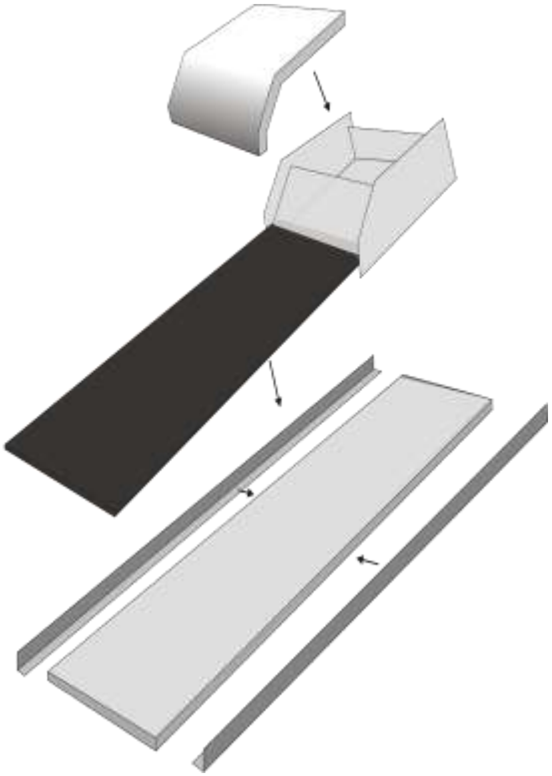
Collaboration with building industry, OBOS

Catalogue house programme

Co-operation with building industry

AventaSolar Thermosiphon system

Illustration of the AventaSolar TSS. The flat design with integrated storage (left) consist of polycarbonate glazing, a twin-wall sheet absorber, rear and storage tank insulation and framing for façade or roof mounting (right).
Non-pressurised design.
Indirect system with immersed tank heat exchanger.

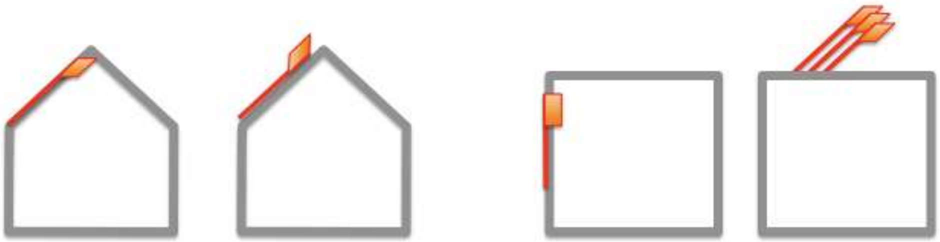


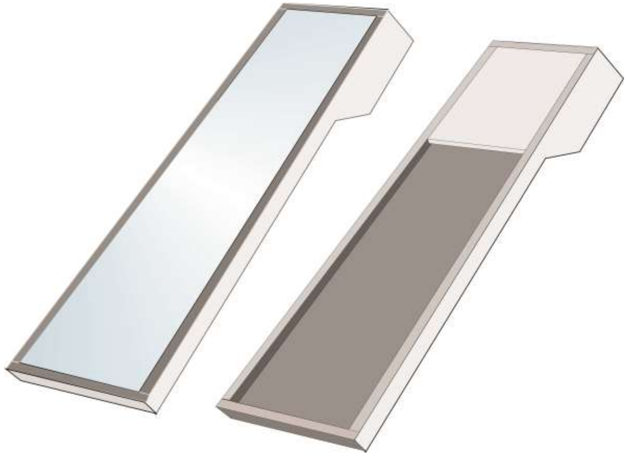
Advantages:

- Light-weight
- Low cost through mass production
- Integrated design (tank and collector)
- Option for easy integration

Source: M. Meir, Aventa

AventaSolar Thermosiphon system





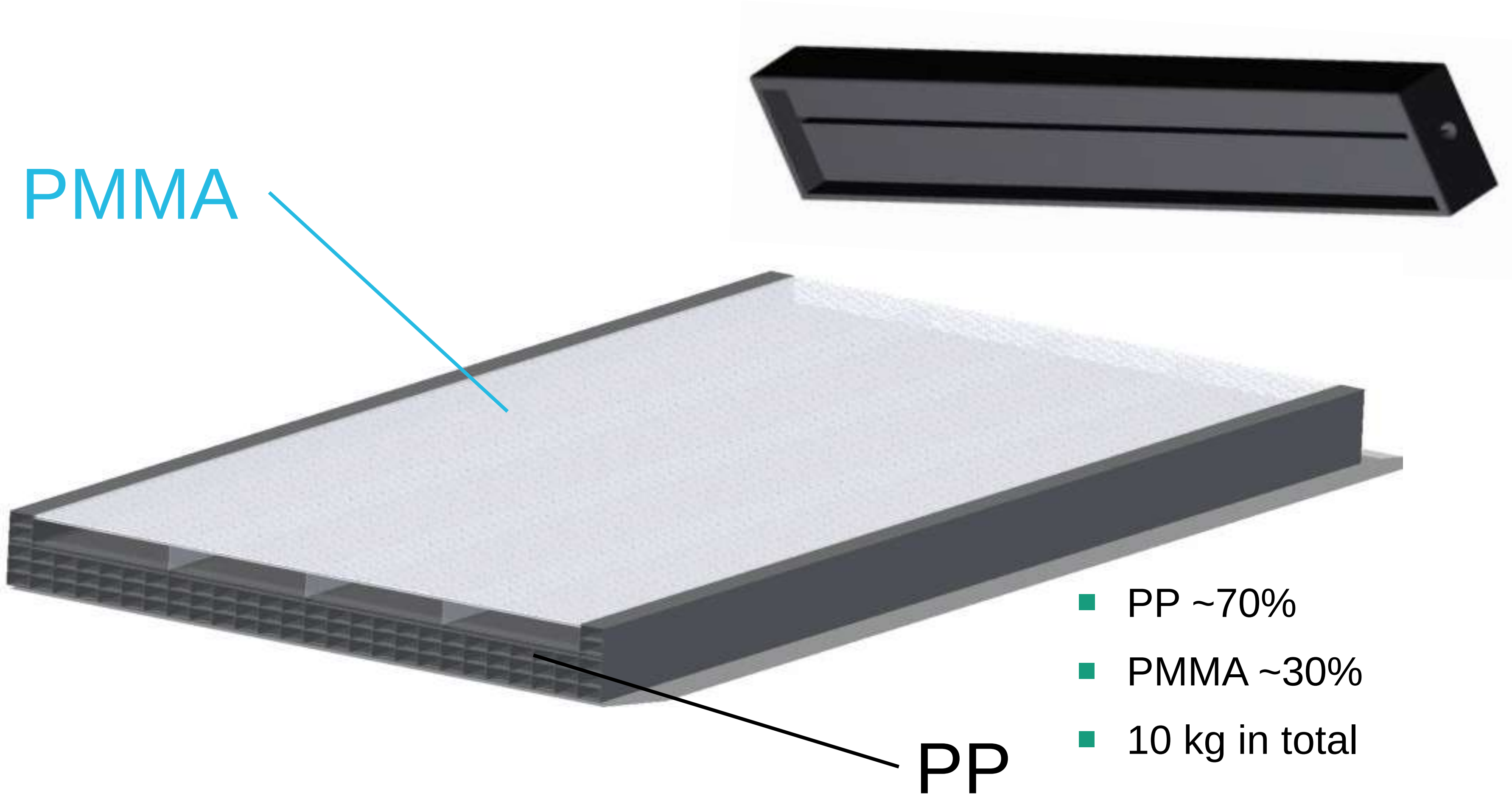
Storage tank in front:
Easy mounting on flat surfaces

Storage tank behind:
Integrated design with flat-plate look

Source: M. Meir, Aventa

Concept Study of a (Co-)Extruded PP Collector

Cost optimized modell

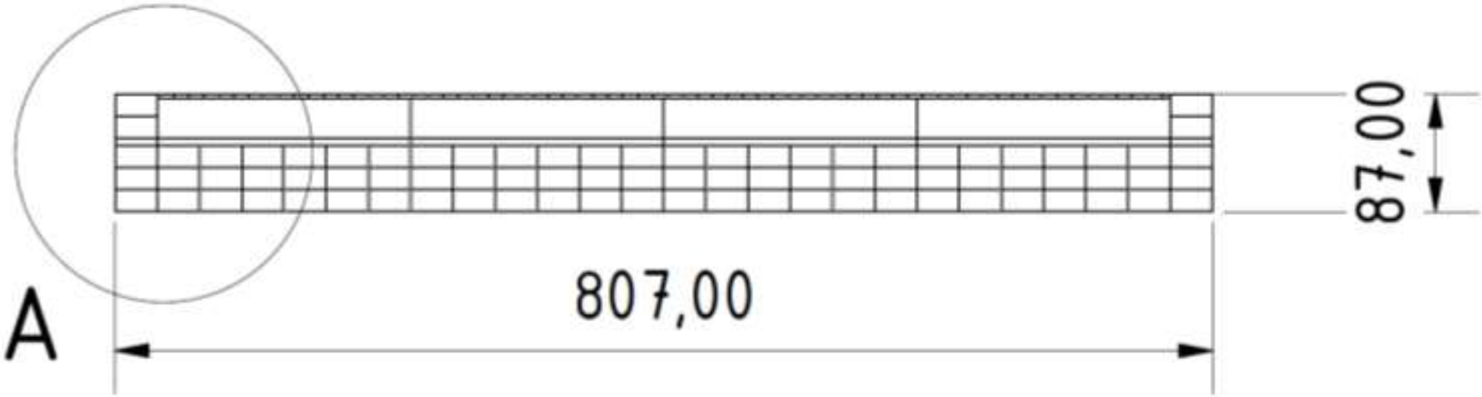


- PP ~70%
- PMMA ~30%
- 10 kg in total

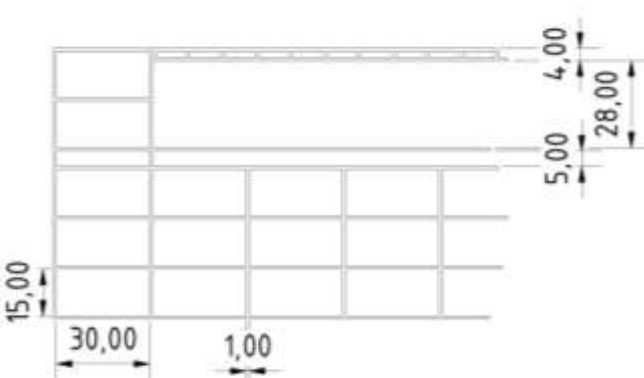
Source: A. Piekarczyk, Fraunhofer ISE

PP-Collector

Extruded profile and injection molded end caps



A (1 : 2)

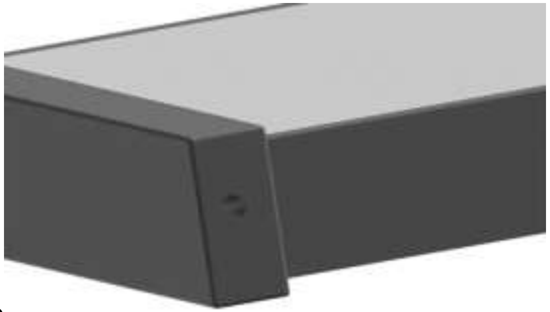


See: „Simulationsgestützte Qualifizierung neuer Konzepte zur Gestaltung von thermischen Solarkollektoren auf Polymerbasis“ Steffen Jack (2008)

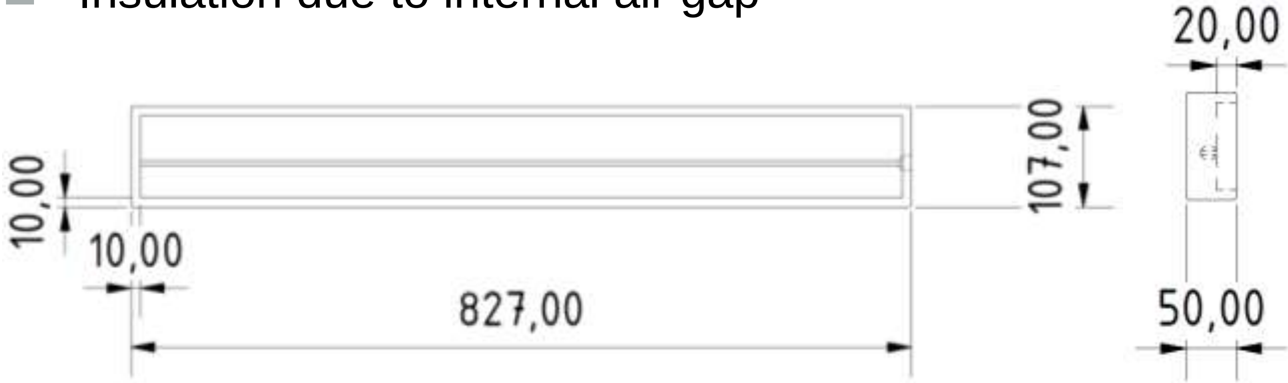
Source: A. Piekarczyk, Fraunhofer ISE

PP-Collector

Extruded profile and injection molded end caps



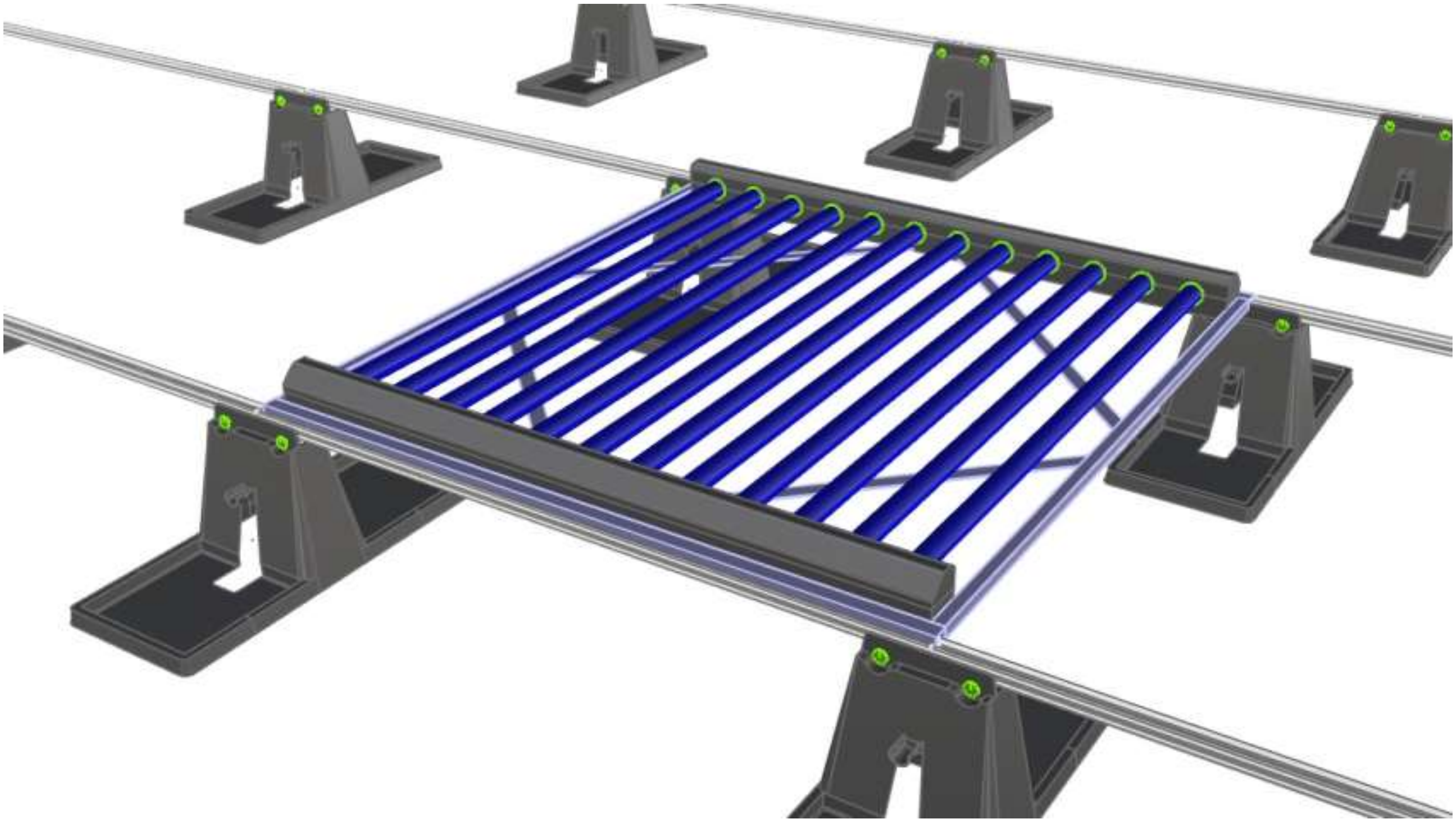
- End caps
  - Injection molded
  - Insulation due to internal air gap



  - Weight ~0,8 kg PP

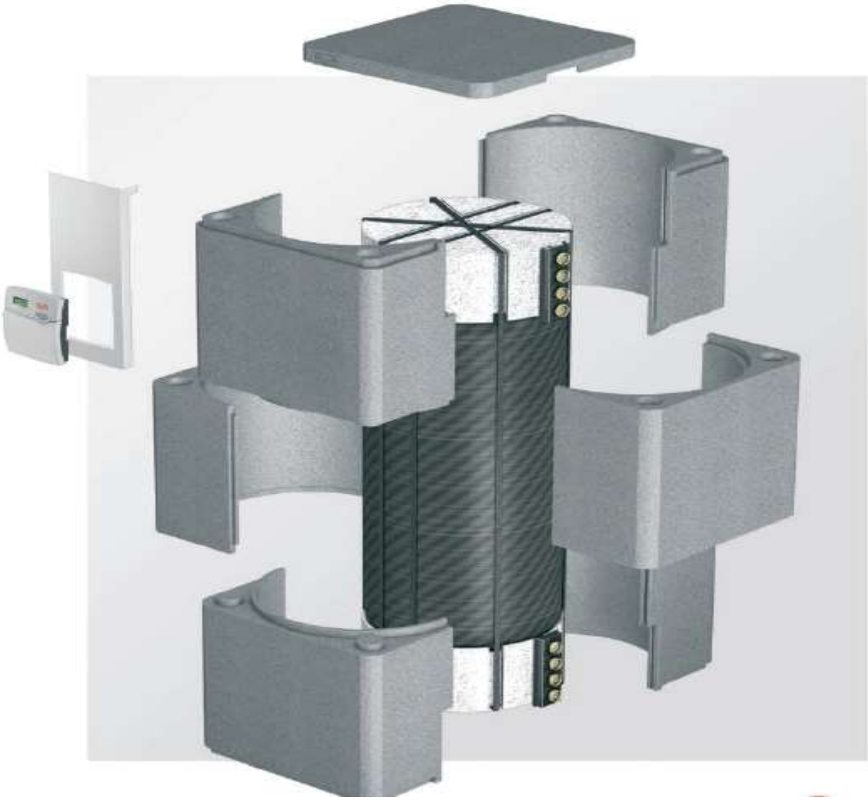
Source: A. Piekarczyk, Fraunhofer ISE

Collector support and framing



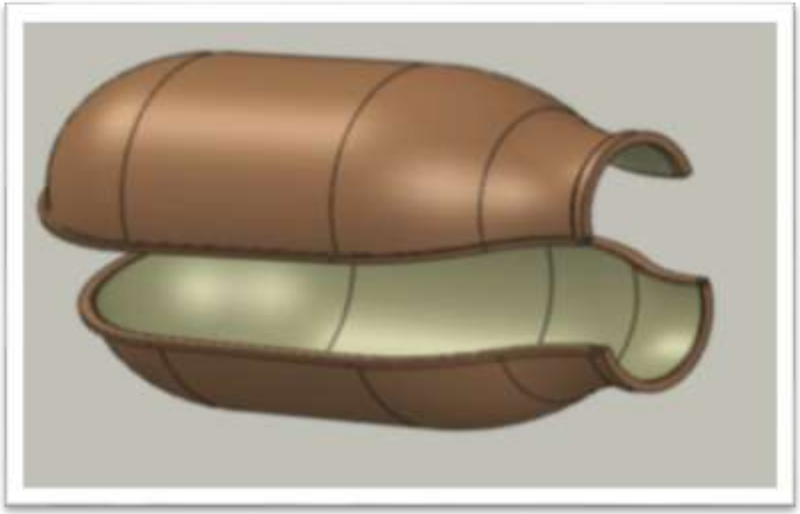
Source: R. Buchinger, Sunlumo

Thermal storage



Thermo-tank QUADROLINE by ROTH WERKE GmbH

Fibre / Plastic composite and EPS blocks



Injection moulding of two half shells made from glass reinforced engineering materials (Concept Magen)

High lights, conclusion and outlook

- Solar thermal has been brought to another level due to the participation and interest of big plastic producing companies (BASF, Chevron Phillips Chemicals, Du Pont, Borealis, Sabic, EMS, Solvay)
- First profil extruded with PPS
- First mass production of polymer collector in sight
- Collectors made from polymers pushed Norvegien solar thermal market
- Promising products for emerging markets

High lights, conclusion and outlook

- World market is and will increase this is why the big companies are interested
- Market development was not supportive (Europe)
- Lacking processing capacity
- Solar thermal industry is not yet interested in plastic production
- Investment for production line is very high compared to conventional production and will only be pay back with mass production

Plastics are the future for solar thermal

- Real mass production is possible
- Cheaper products can be realised
- Higher freedom in design and building integration is possible

Thank you for the attention!

Thanks to all participants of Subtask B

and their contribution to this presentation!!!