Tailor-made polymeric materials for collectors and heat storages

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Presentation Outline

Introduction and Background

- Development of Polymeric Materials
- Main Fields of Application and Success Factors

Subtask C: Structure, Partners and Selected Results

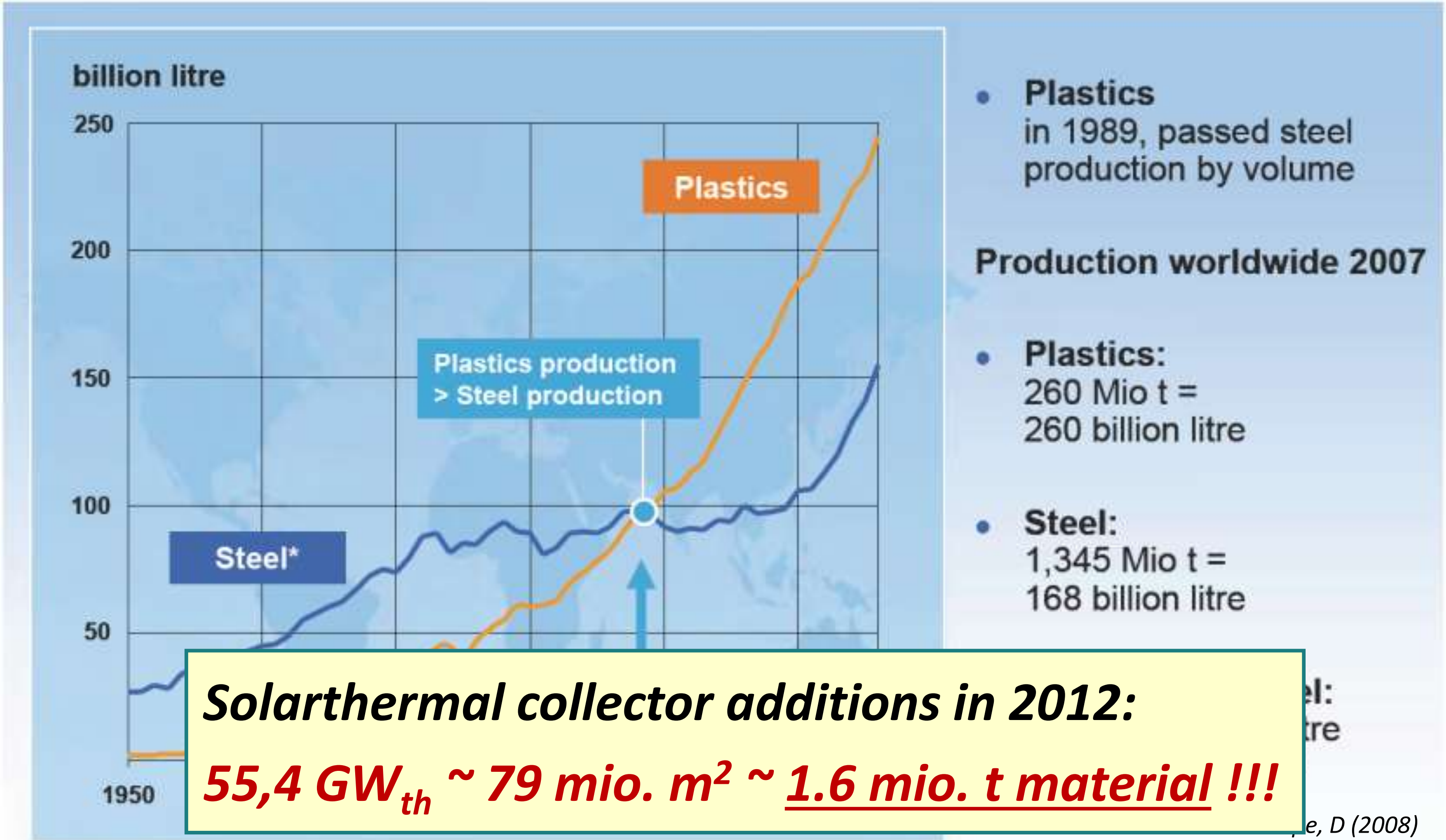
- Main Topics and involved Partners
- 3 selected Case Studies on Plastics for:
  - Overheating controlled flat-plate collectors
  - Drainback flat-plate collectors
  - Heat storage liner materials

Summary and Outlook

- Solarthermal Market Development
- Material Demand

The importance of the polymer industry

Development of plastics and steel worldwide (in terms of volume)



Solarthermal collector additions in 2012:

55,4 GW_{th} ~ 79 mio. m^2 ~ 1.6 mio. t material !!!

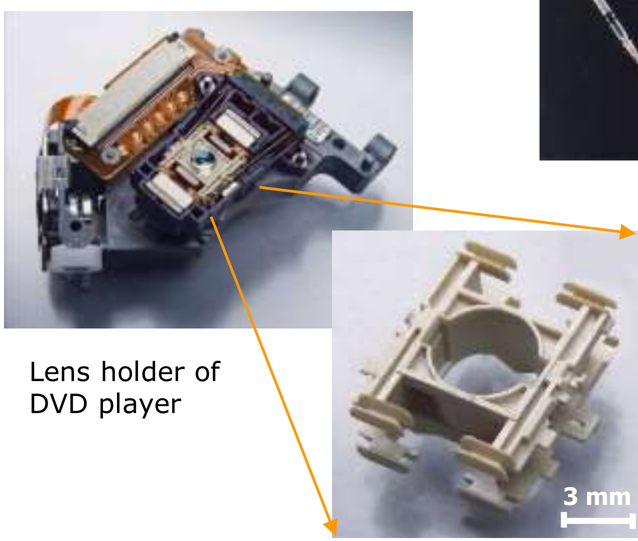
Plastics - most widely used material class

- Tele-communication

- Medical technologies

- Civil & infrastructure engineering (B&C)

- Automotive engineering

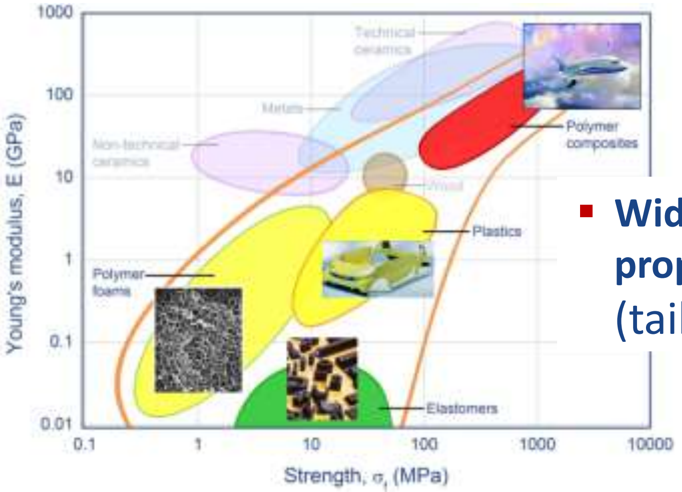


Lens holder of DVD player

- Precision engineering & mechatronics

- Packaging

Plastics - main features and success factors



- **Wide range: property/performance** (tailor-made materials)

LED optics

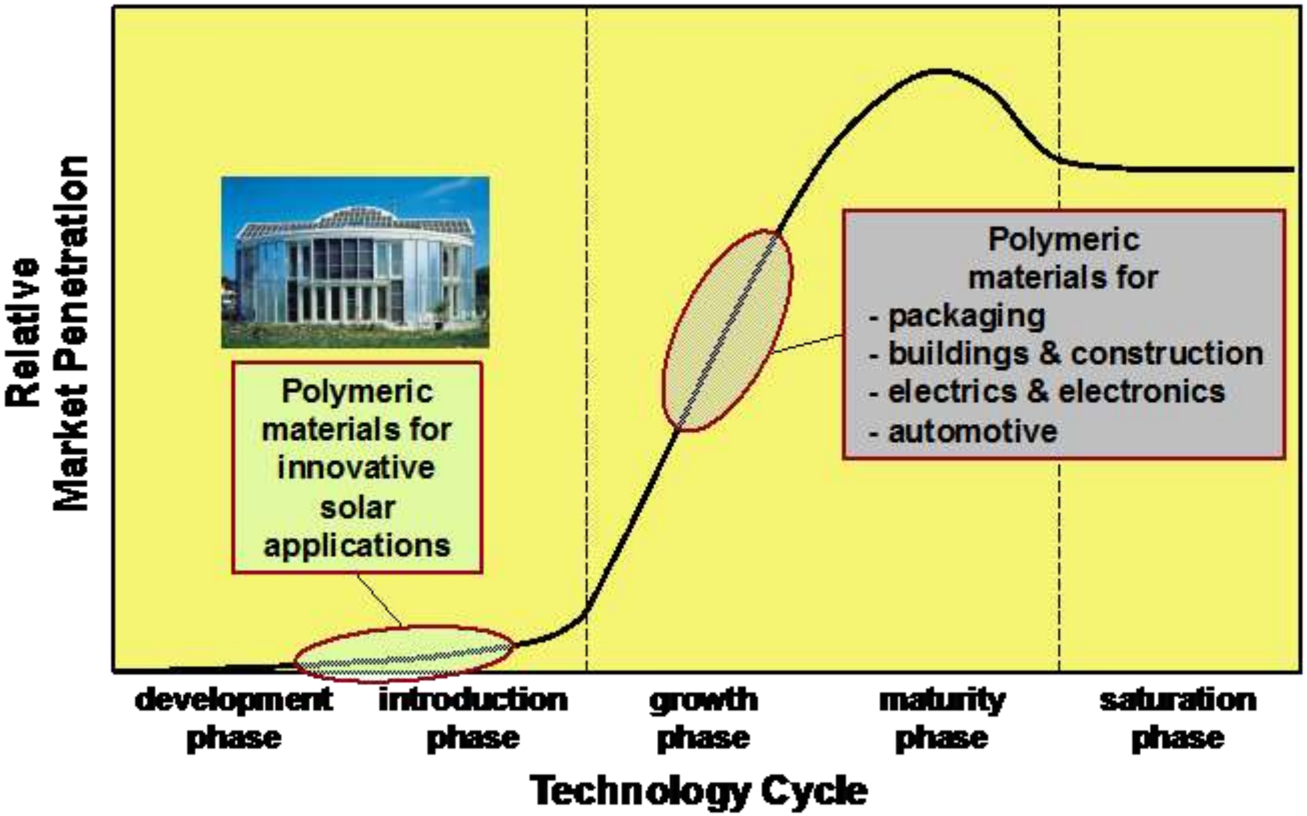
- **Freedom of design**

- **Composites & hybrid materials**

- **Combination of process technologies**

- **Multifunctional integration**

Plastics - Market penetration



4 main prerequisites for market acceptance:

- *improved performance (functionality)*
- *enhanced cost effectiveness*
- *guaranteed quality and durability*
- *attractive/multi-functional design*

What needs to be done to accelerate innovation & market penetration?

Projects of Subtask C on Materials

Project	Title	Focus
C1	**Multi-Functional Polymeric Materials**	• Materials for „All-polymeric“ Collectors • Materials for System Components incl. Heat Storages
C2	**Processing and Evaluation of Components**	• Extrusion and Injection Moulding of Components • Joining techniques
C3	**Methods for Testing and Characterization**	• Quality assurance • Aging and durability characterization

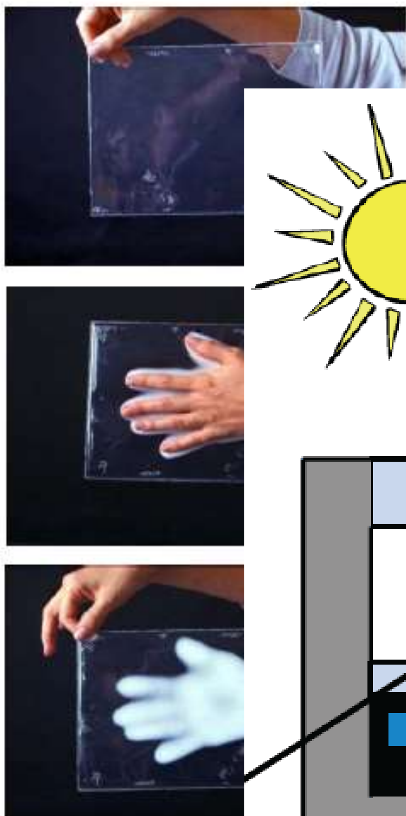
Partners of Subtask C on Materials

10 Countries	13 Company partners	10 Scientific partners
Austria, Belgium, Brasil, Germany, Netherlands, Norway, Portugal, Slovenia, Switzerland, USA	BOREALIS – SHAPING *the* FUTURE *with* PLASTICS; SOLVAY; سابك sabic; EMS-GRIVORY; BASF – The Chemical Company; Chevron Phillips Chemical Company LP; DU PONT; DS Smith; APC advanced polymer compounds; agru – Worldwide Competence in Plastics; BBT THERMOTECHNIK; Roth; Save; Color	JKU – Johannes Kepler Universität Linz; AIT; PCCL; Fraunhofer ISE; Fachhochschule Osnabrück – University of Applied Sciences; Humboldt-Universität zu Berlin; SPF; UiO Department of Physics – University of Oslo; Solar Energy Laboratory

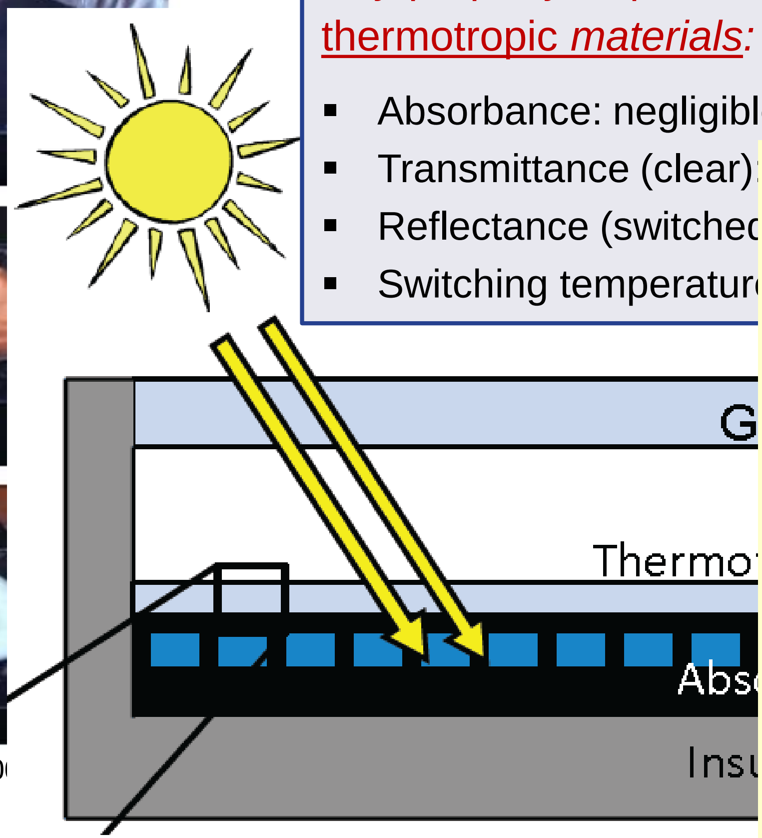
Overheating controlled collectors

Thermotropic materials – Requirements and Achievements

(Univ. of Leoben (Austria); Univ. of Minnesota (USA); EMS (Switzerland))

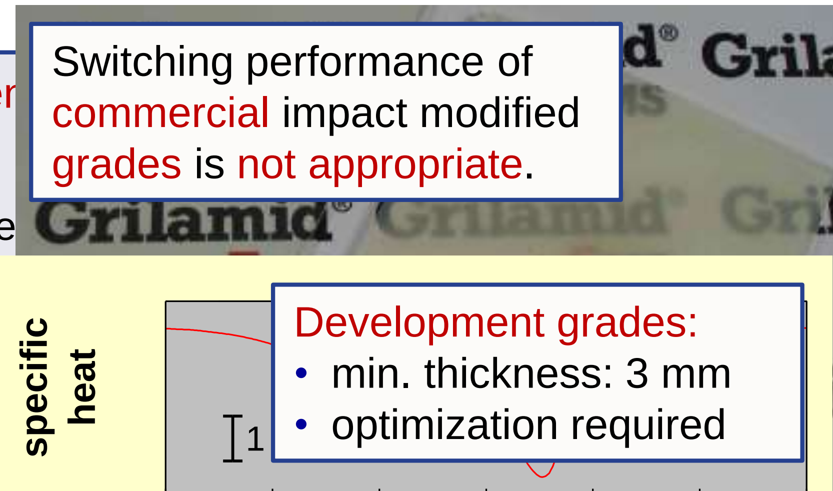


Source: Hartwig, 20

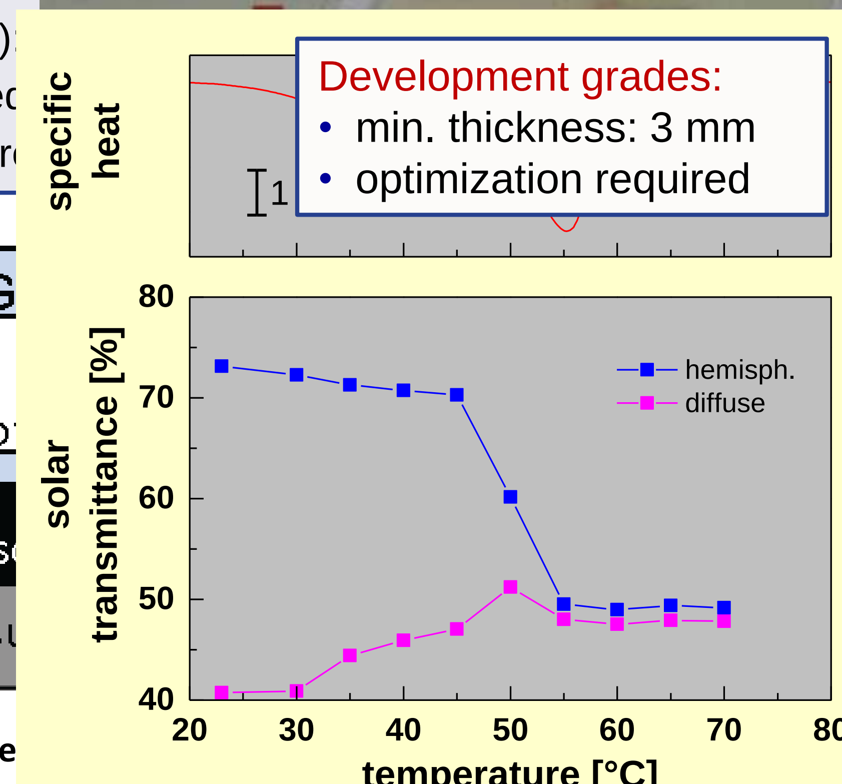


Key-property requiremen *thermotropic materials:*

- Absorbance: negligible
- Transmittance (clear):
- Reflectance (switched
- Switching temperatur



Switching performance of commercial impact modified grades is not appropriate.



Development grades:

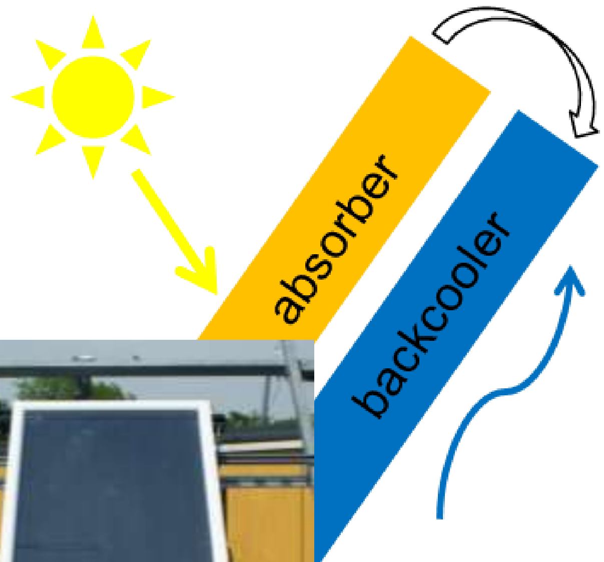
- min. thickness: 3 mm
- optimization required

Overheating controlled collectors

Absorber materials for overheating protected collectors

(Borealis, Univ. of Linz, AEE INTEC, Univ. of Innsbruck (Austria))

Overheating control by backcooling



Max. absorber temperature in stagnation: ~ 92°C

System type & service requirements

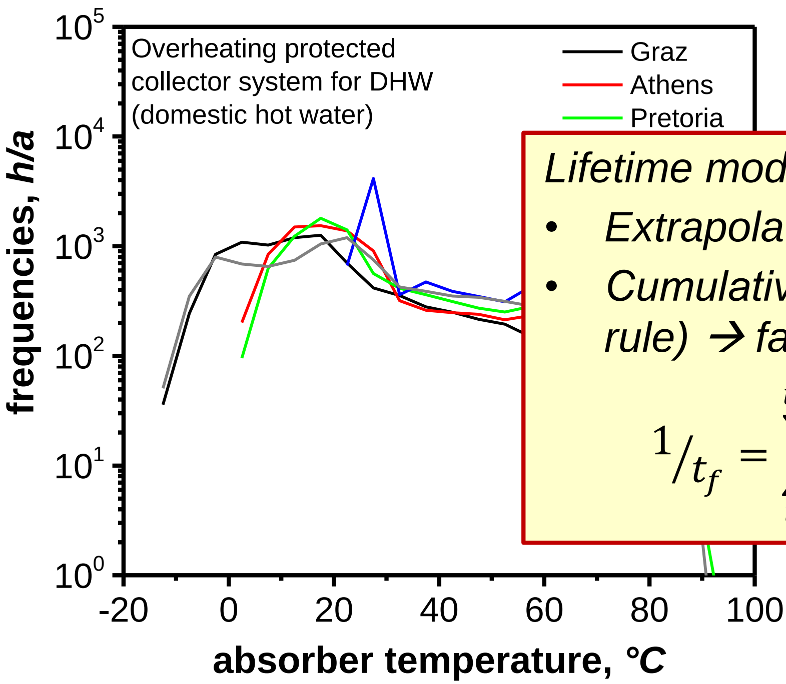
- Pressurized system with overheating protection
- service life: 20 years
- region: Graz (Austria)

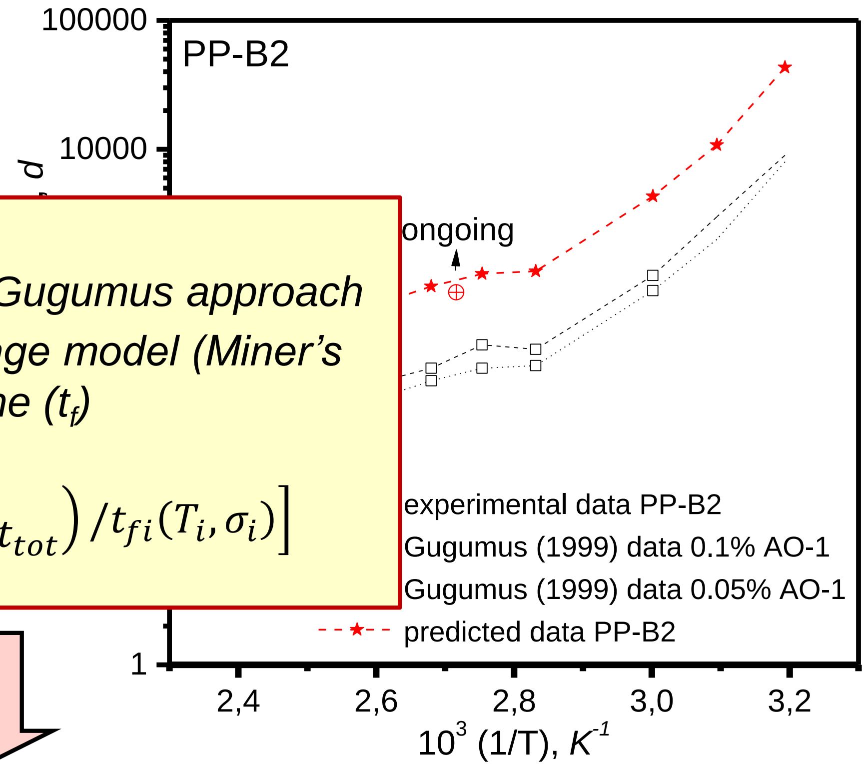
Key-property requirements for *absorber materials*

- solar absorption: 93-95%
- thermal stability: >100°C
- low temperature capability: -30°C
- long-term stability in water/glycol:
  - 75-100°C: > 3,500 h (DHW)
    > 7,000 h (SH)
  - 0-75°C: > 150,000 h
- pressure: max. 1,5 bar

Overheating controlled collectors

Development and lifetime estimation for PP absorber materials
(JKU IPMT; AEE INTEC, Austria)





Lifetime modelling:

- *Extrapolation by Gugumus approach*
- *Cumulative damage model (Miner's rule) → failure time (t_f)*

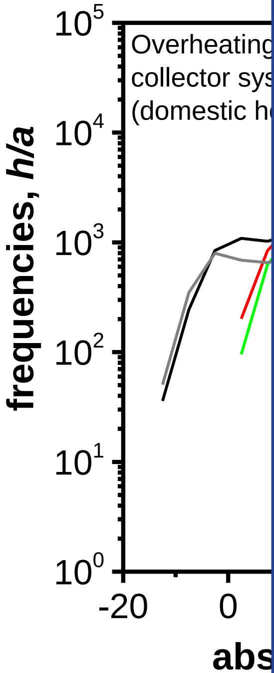
$$^{1}/_{t_f} = \sum_{i=1}^{i=n} \left[\left(^{t_i}/_{t_{tot}}\right)/t_{fi}(T_i,\sigma_i)\right]$$

Lifetime, years	Graz, AT	Athens, GR	Pretoria, RSA	Fortaleza, BR	Beijing, CHN
PP-B1	**21**	**15**	**14**	**8**	**23**
PP-B2	**32**	**25**	**24**	**15**	**34**

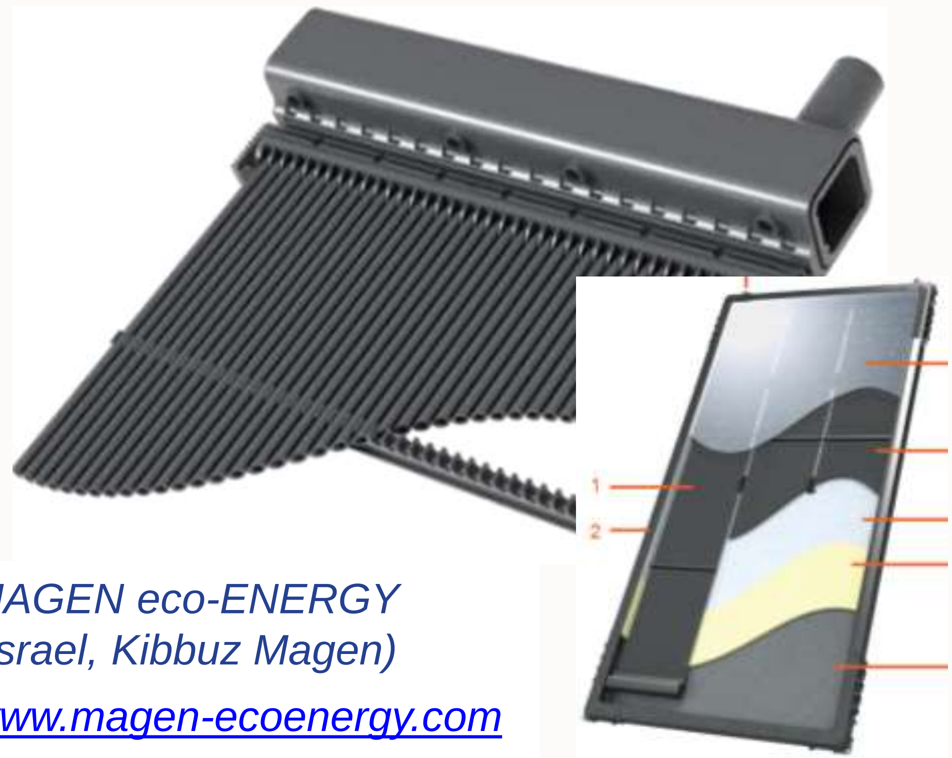
Overheating controlled collectors

Development and lifetime estimation for PP absorber materials

(Univ. Linz, Borealis, AEE INTEC (Austria))



Novel material PP-B2 is now used commercially!



MAGEN eco-ENERGY
(Israel, Kibbuz Magen)

[*www.magen-ecoenergy.com*](http://www.magen-ecoenergy.com)

Lifetime, years					**Beijing, CHN**
PP-B1					23
PP-B2	**32**	**25**	**24**	**15**	**34**

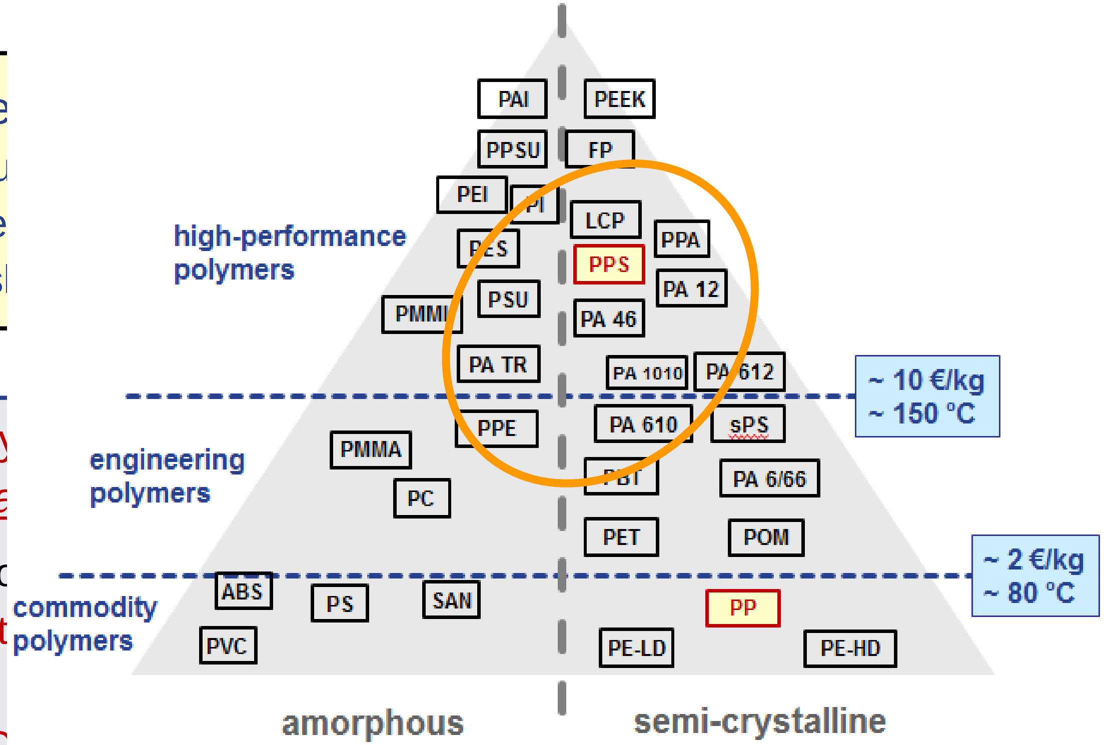
Drainback flat-plate collectors

Requirements for absorber materials in drainback collectors
(Univ. Oslo, Aventa (Norway))

System type
- low-pressu
- service life
- region: Osl

Key-property
absorber ma

- solar abso
- thermal st
- long-term
  - < 80°C: > 100,000 h
- short-term
  - 80-150
- no pressu



High performance plastics required; focus on:
- Polyphenylenesulfide (PPS)
- Polyphenyleneether (PPO)

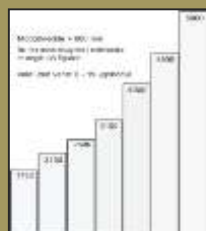
Drainback flat-plate collectors

Processing, testing and lifetime estimation of PPS

(Univ. Oslo, Aventa (Norway), Chevron Philips (Belgium), DS Smith (France), ISE (Germany))

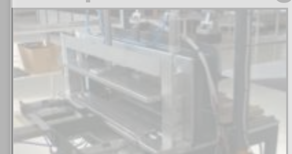
Extrusion
(XE4500BL)
Absorber sheet

Cutting
to standard lengths

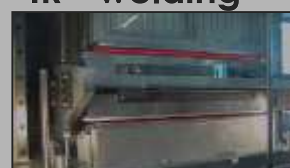


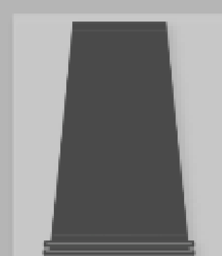
Welding

Hot-plate welding



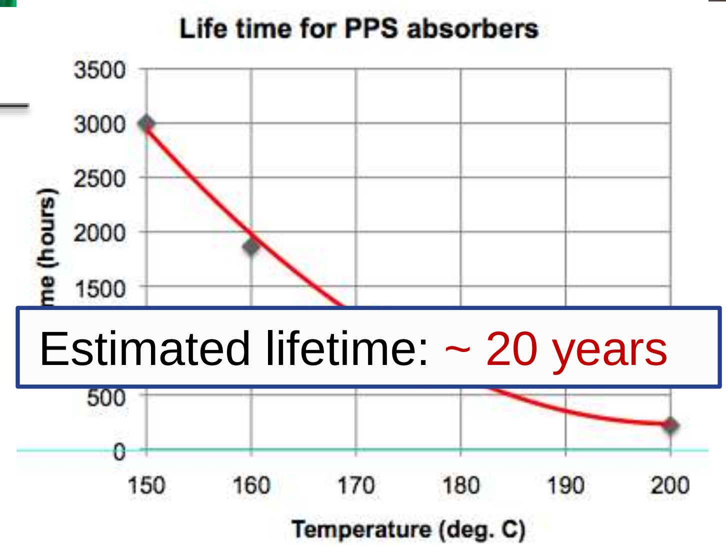
IR - welding





PPS Granulates

Blow molding of Endcaps
(XE5032 BL, 30%GF)

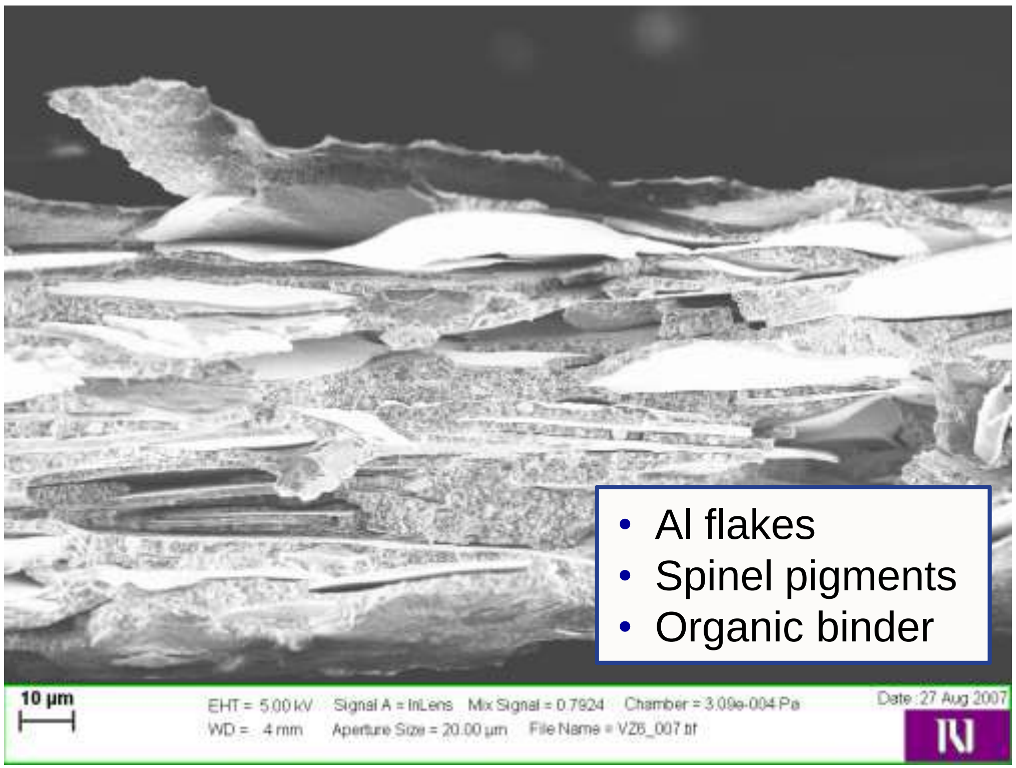


Estimated lifetime: ~ 20 years

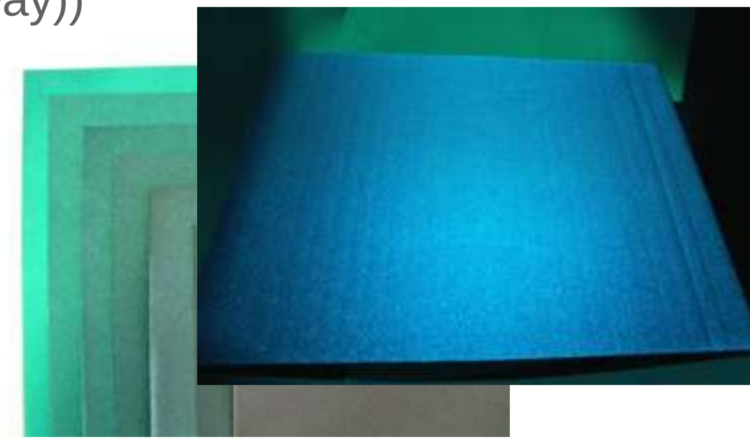
Drainback flat-plate collectors

Multifunctional coatings for PPS absorbers
(NIC, Color (Slovenia), Univ. Oslo, Aventa (Norway))

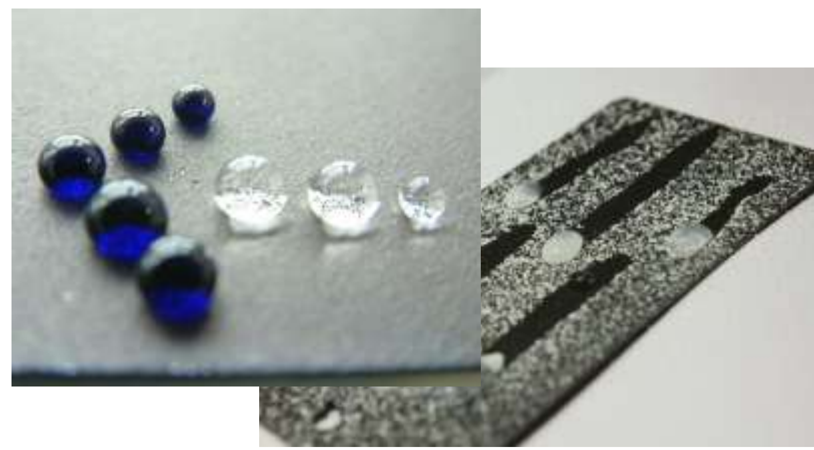
Thickness Insensitive Spectrally Selective (TISS) paints



Estethic colors



Self-cleaning capability



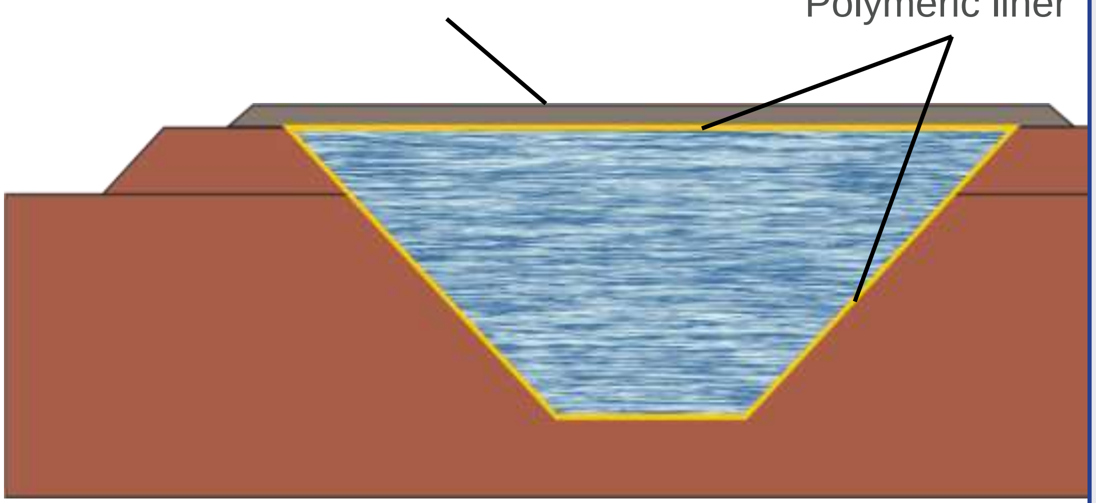
Heat storage liner materials

Liner materials for seasonal hot water storages

(AGRU, Univ. of Linz (Austria))

Example

SUNSTORE4, Marstal, DK (75 000 m³ water)



Dimensions:

- *Volume: 1.000 – 100.000 m^3*
- *Demand of liner: 250 – 25.000 m^2*

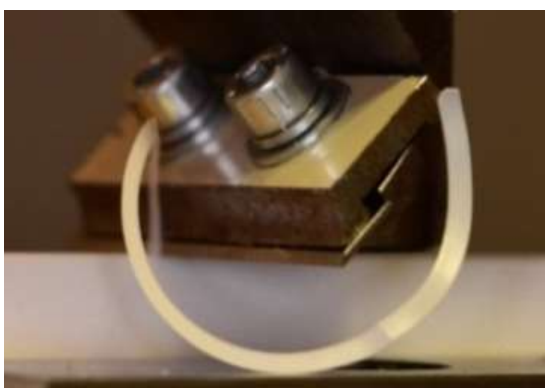
Criteria for *liner materials:*

- Flexibility for easy installation:
  - E ≈ 600 MPa (at RT)
  - Liner thickness: ≈ 2 mm
- Key requirements:
  - T_{max} = 95°C
  - 4,000 h/a ≈ 65-85°C
  - 4,000 h/a ≈ 30-60°C
- Environment:
  - Water heat carrier
  - Air / water vapor
  - Soil chemistry (minerals)
- Service lifetime: ≥ 30 years

Heat storage liner materials

Accelerated aging characterization by Specimen Miniaturization
(Univ. of Linz (Austria))

Automized production of micro-sized specimen



Aging equipment (air, water water vapor)

Aging characterization and indicators

Mechanics (Tensile Testing):

- Strain at break (ε_B)

Spectroscopy:

- Carbonyl index (C.I.)

Thermoanalytical Methods:

- Oxidation onset temperatur (OOT)

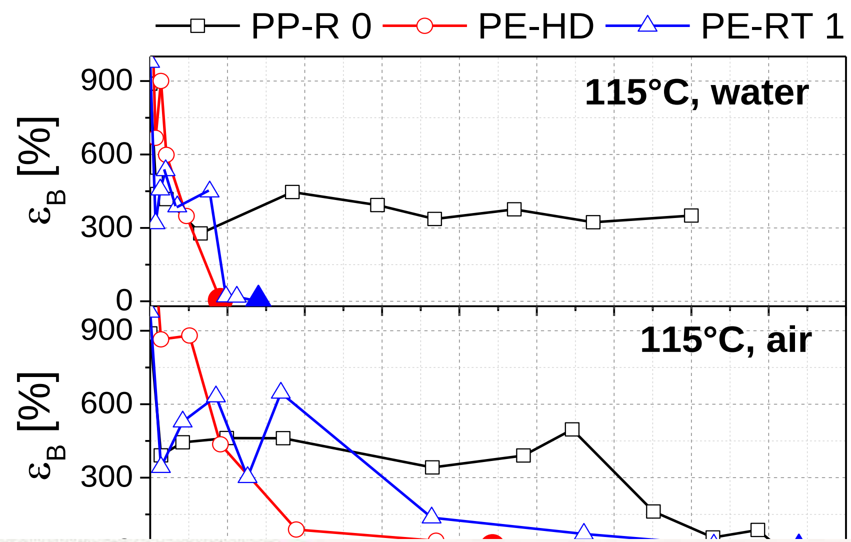
Chromatography:

- Content of stabilizers (esp. antioxidants)

Heat storage liner materials

Durability of polyolefin compounds (benchmark vs. novel grades)

(Univ. of Linz, AGRU, APC (Austria))



Polyethylene (PE) grades:

- Ranking: PE-RT 2 > PE-RT 1 > PE-HD

Water aging more severe than air aging.

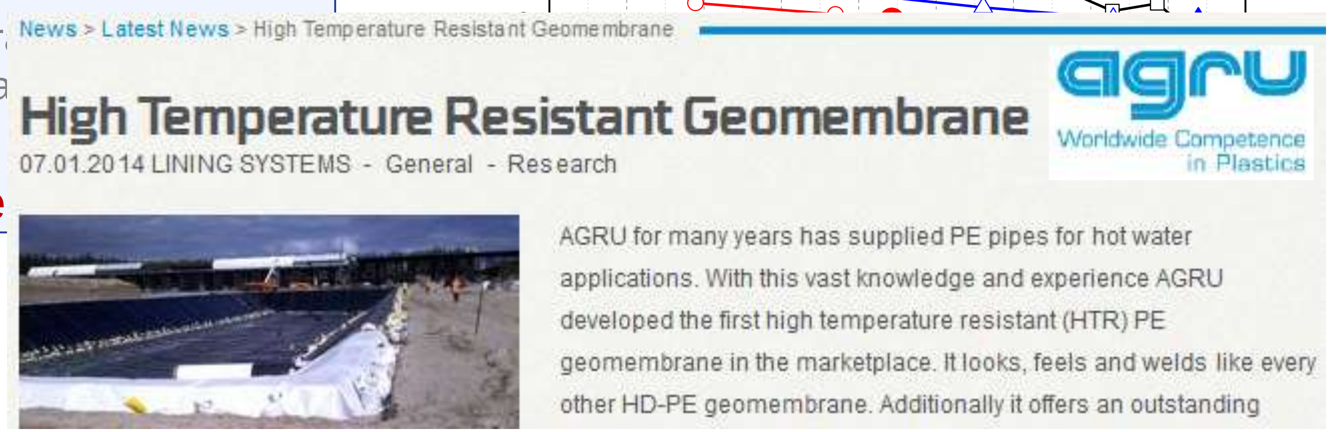
Novel polypropylene (PP) exhibit a better durability.

Lifetime estimation

- No embrittlement for all gr… exposure in hot air and wa… 900d (2.5 years).

→ Continuation of expe…

Spin-off:



News > Latest News > High Temperature Resistant Geomembrane

agru Worldwide Competence in Plastics

High Temperature Resistant Geomembrane

07.01.2014 LINING SYSTEMS - General - Research

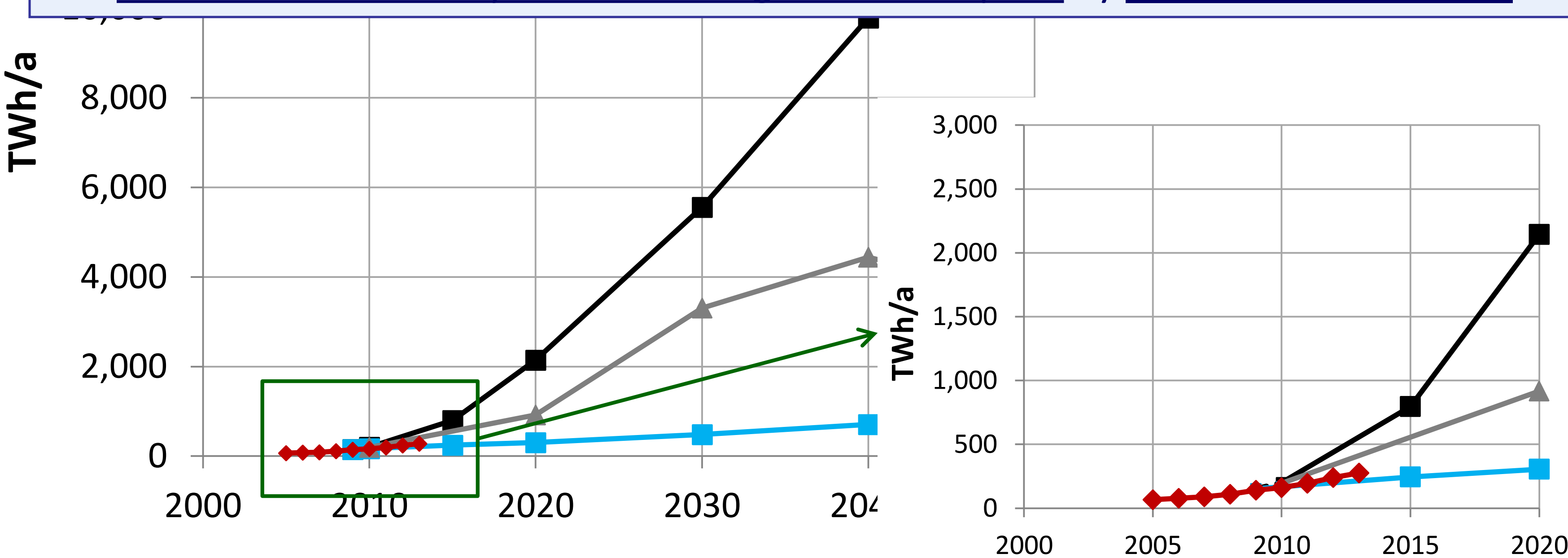
AGRU for many years has supplied PE pipes for hot water applications. With this vast knowledge and experience AGRU developed the first high temperature resistant (HTR) PE geomembrane in the marketplace. It looks, feels and welds like every other HD-PE geomembrane. Additionally it offers an outstanding

Global Solar Thermal Heat based on 100% Renewable Energy Scenarios

(1) To keep up with the ambitious 100% scenarios, and

(2) to strengthen (or even maintain) its position as a main component in a future solar technology mix,

the solar-thermal industry needs a strong innovation push by enhanced R&D efforts.



Source: K. Holzhaider (2014)

Summary and Outlook

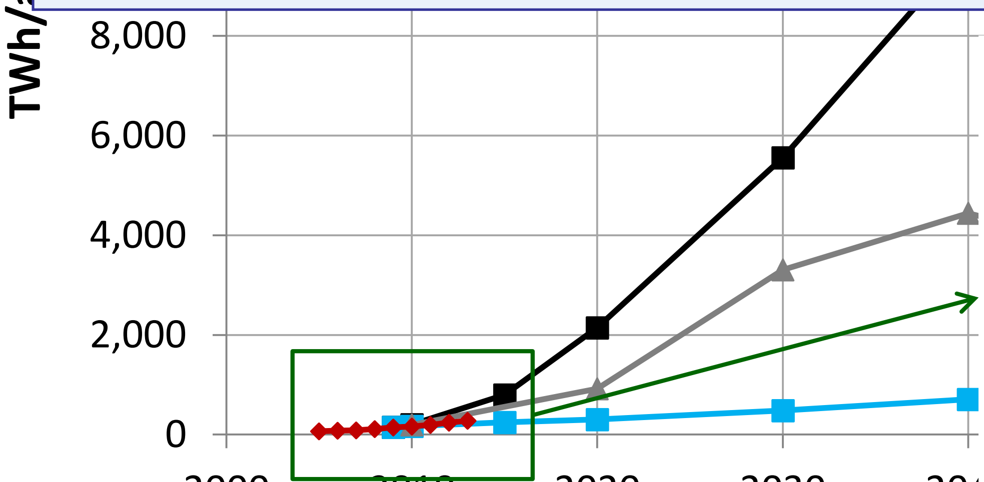
Global Solar Thermal Heat based on 100% Renewable Energy Scenarios

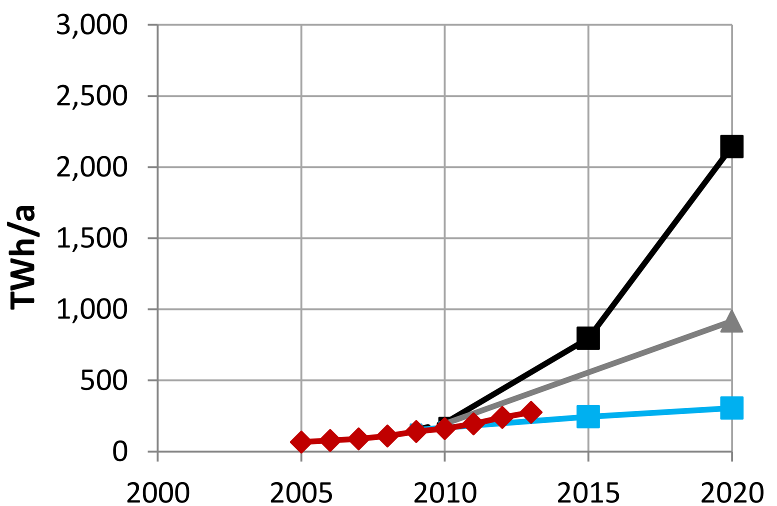
(1) To keep up with the ambitious 100% scenarios, and

(2) to strengthen (or even maintain) its position as a main component in a future solar technology mix,

the solar-thermal industry needs a strong innovation push by enhanced R&D efforts.

(3) Apart from significant polymer-induced innovations, there is no other single innovation driver in sight to achieve the more ambitious scenarios.

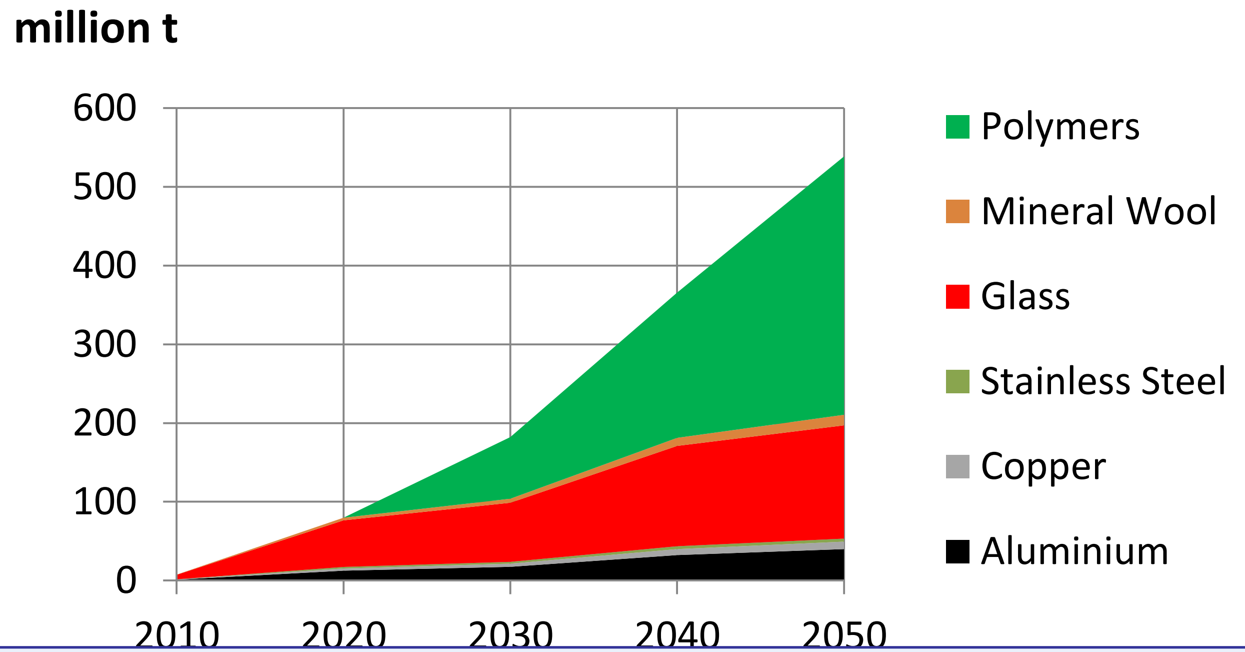




Source: K. Holzhaider (2014)

Summary and Outlook

Global Cumulative Material Demand for Polymer Based Solar Thermal Systems



(1) Low temperature heat supply is currently based on fossil (carbon) fuels.

(2) To achieve 100% renewable energy scenarios an average annual plastics demand of 8.2 million t/a would be needed.

→ Highly attractive market perspective for the oil/gas and plastics industry.