# Subtask A

## Polymeric materials for solar thermal collectors - Market overview - life cycle study - dissemination

Michaela Meir, University of Oslo, Department of Physics, Norway

Funded by: enova

# State of the art - Inspiration : Polymers in automotive industry

Source: BMW

# Polymeric pool absorbers

Rodgau-Poolshop, Pfohl-Schwimmbadtechnik (D)

Fafco (USA)

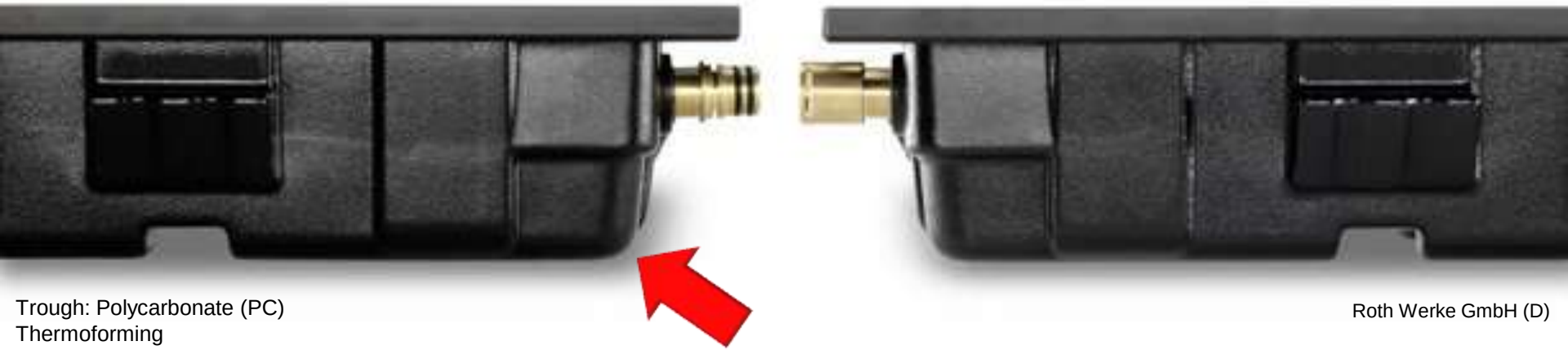
ROOS Freizeitanlagen GmbH (D)

ROTH-Werke GmbH (D)

Magen Eco Energy (ISR)

# Collector design: Replacing conventional materials with polymers (1)

Flat plate collector
(casing)



Trough: Polycarbonate (PC)
Thermoforming
- Smart Design, Installation

Roth Werke GmbH (D)

# Collector design: Replacing conventional materials with polymers (2)

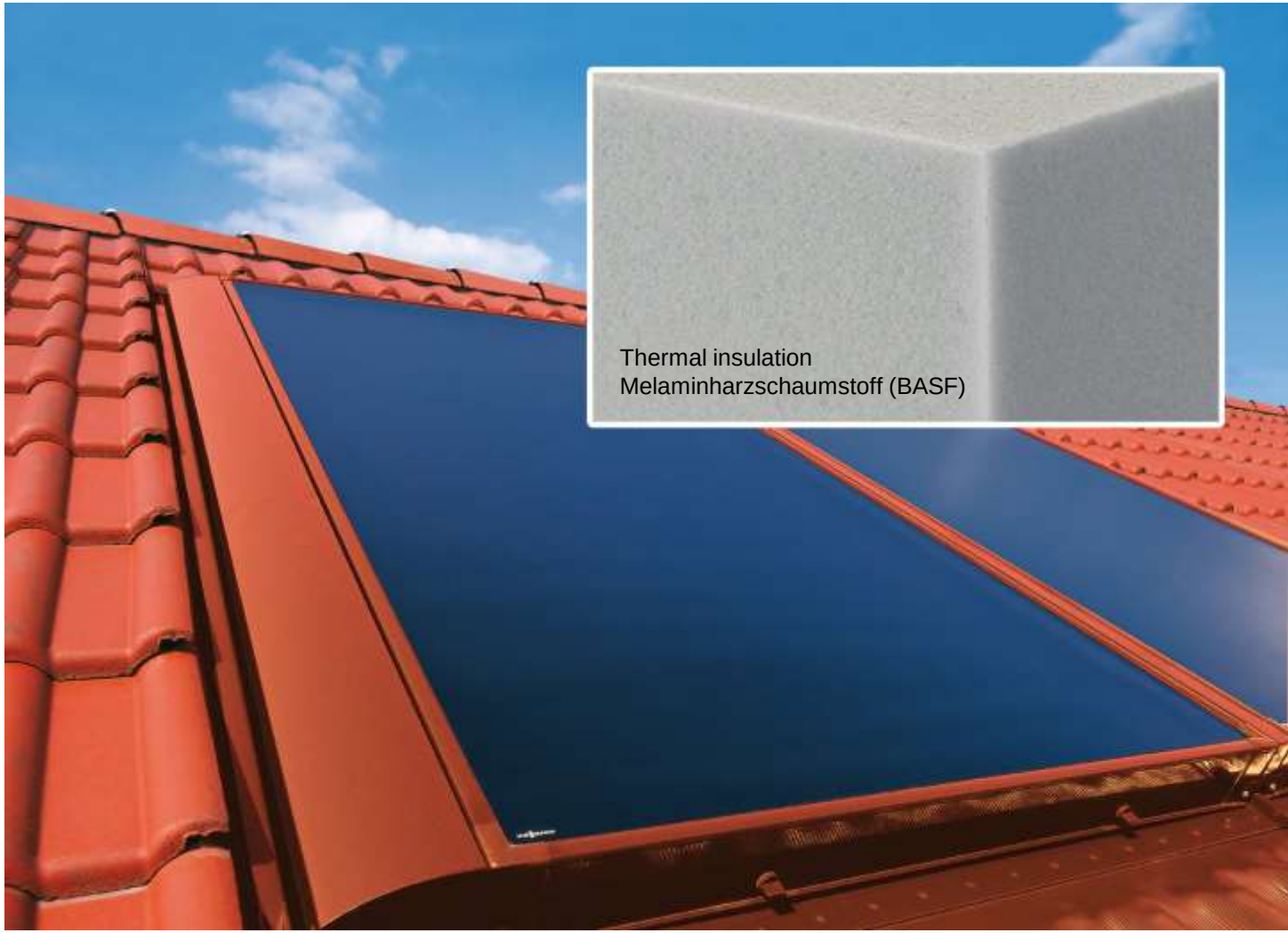
Flat plate collector
(casing)

Glasfibre reinforced plastics

Bosch Pressebild (AT)

# Collector design: Replacing conventional materials with polymers (3)

Flat plate collector
Insulation




Viessmann Werke GmbH & Co KG (D)

# Collector design: Replacing conventional materials with polymers (4)

Parabolic
trough collector
(supporting construction)

Parabolic trough, support, small components: PA, POM, PVC

Dr. Vetter, Gesellschaft für Med. Datentechnik, Bio- und Umwelttechnik mbH (D)

# Collector design: Replacing conventional materials with polymers (5)

Vacuum pipe collector

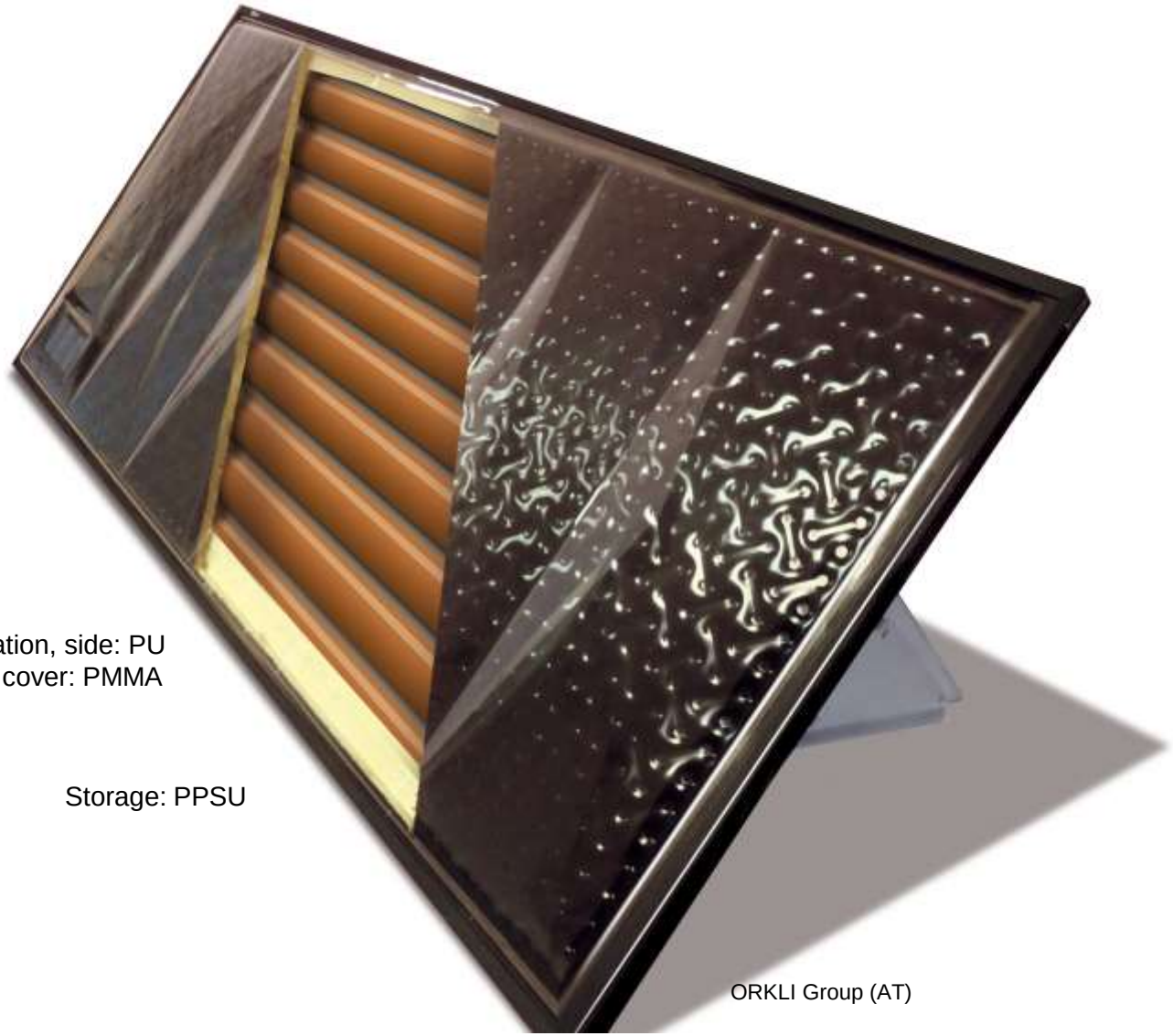

Kingspan Ltd. (UK)

# ICS – Integrated Collector Storage (1)

Endcaps and
manifold header: PA

SOLCRAFTE Kioto Energy (AT)

# ICS – Integrated Collector Storage (2)



Thermal insulation, side: PU
Collector cover: PMMA

Storage: PPSU

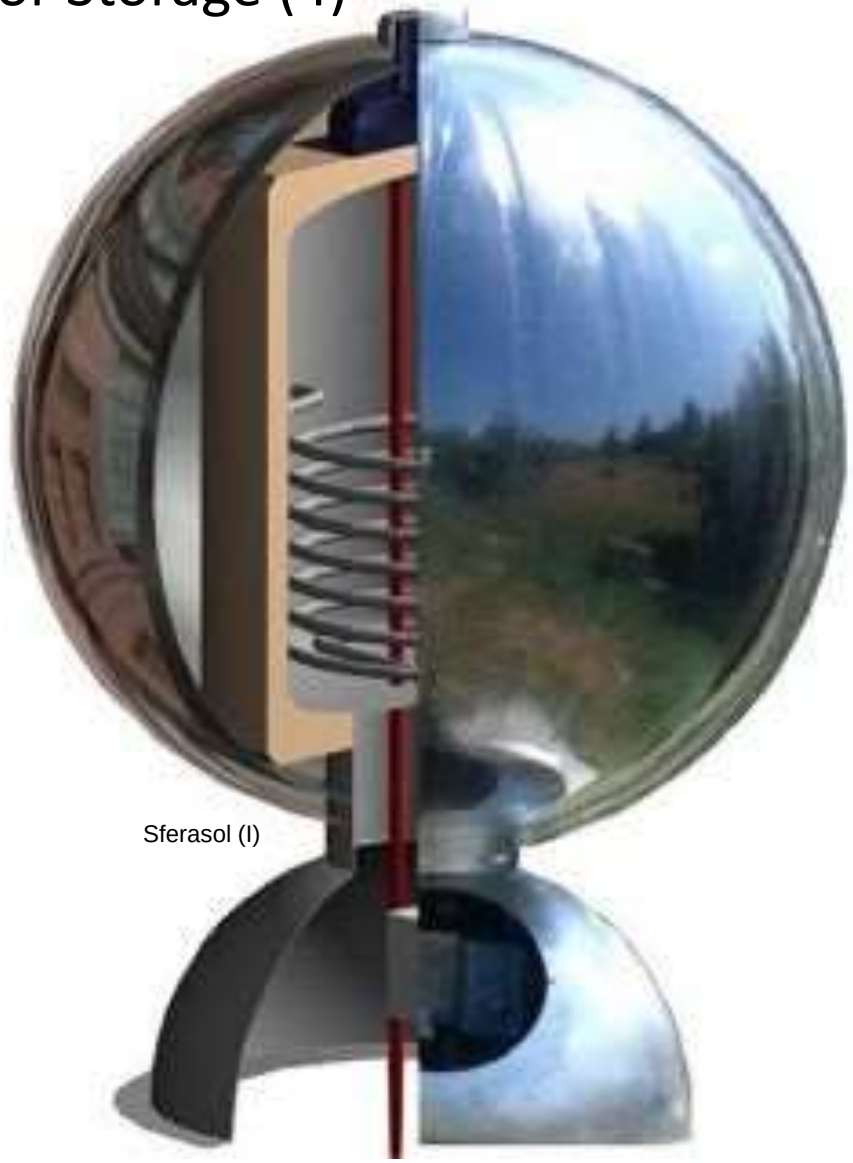
ORKLI Group (AT)

# ICS – Integrated Collector Storage (3)


Solior, Itho Daalderop (NL)

# ICS – Integrated Collector Storage (4)

Glazing: PMMA



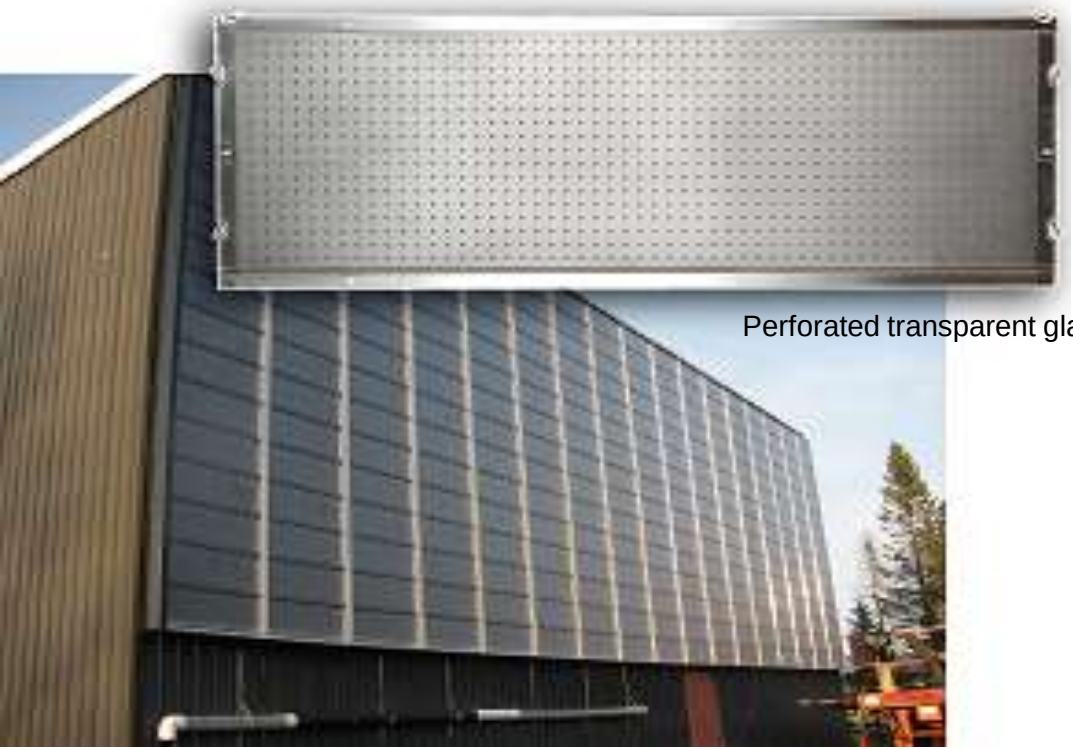
Sferasol (I)

# Polymeric air collectors

Glazing

PC Twin-wall sheet

Solarventi (DK)

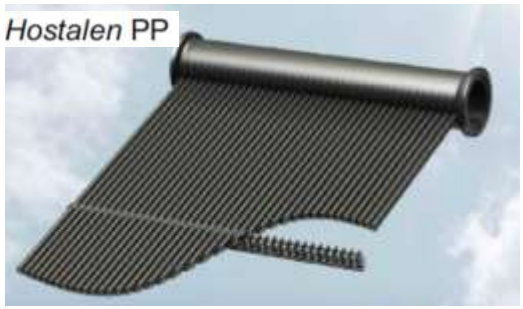


Perforated transparent glazing (PC)

Enerconcept (CA)

# All-polymeric collectors (1)

Absorber: commoditive Plastics
with overheat protection



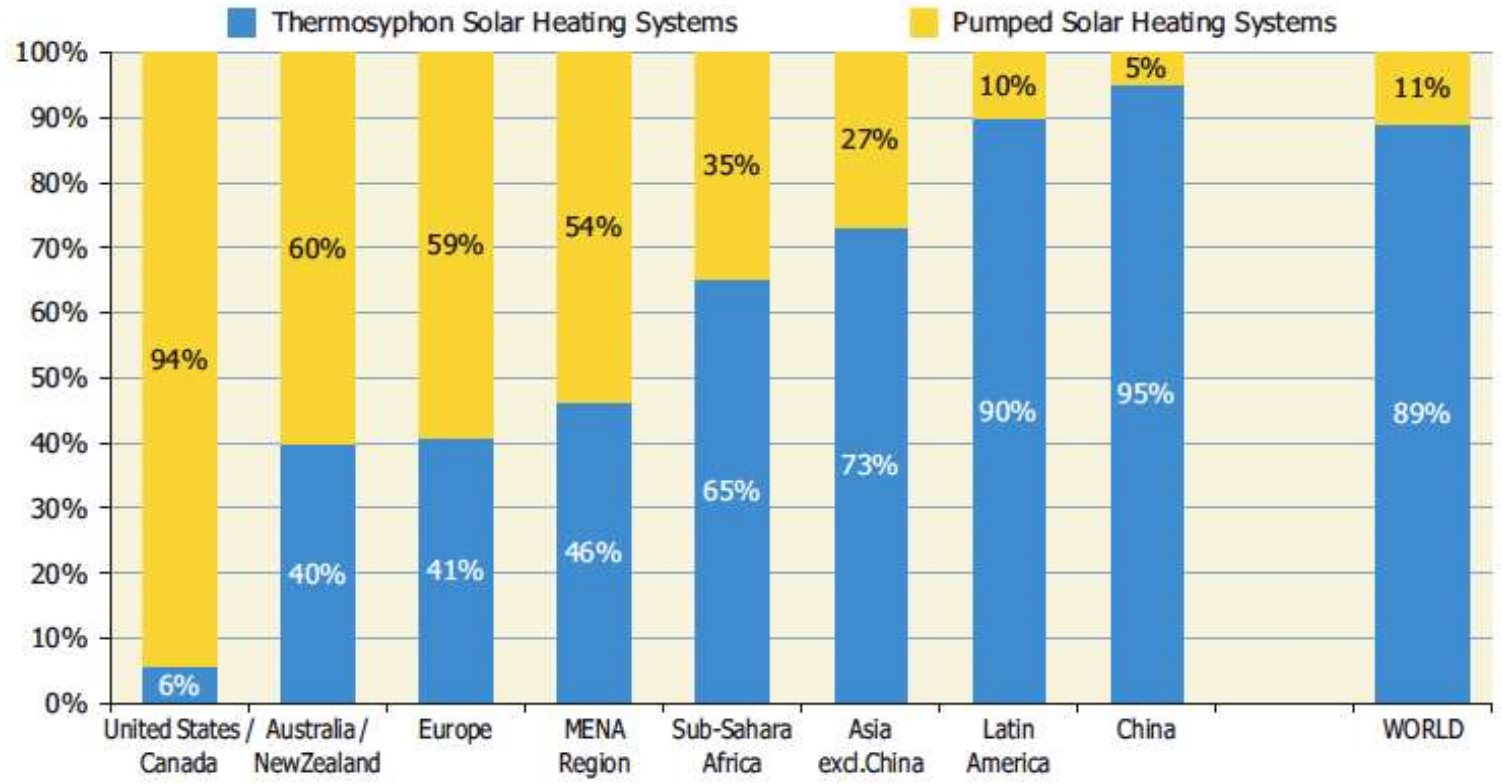

Magen Eco Energy (ISR)

# All-polymeric collector (2)

Absorber: high temperature performance polymers

Aventa AS (N)

# Polymers in Thermosiphon-collectors



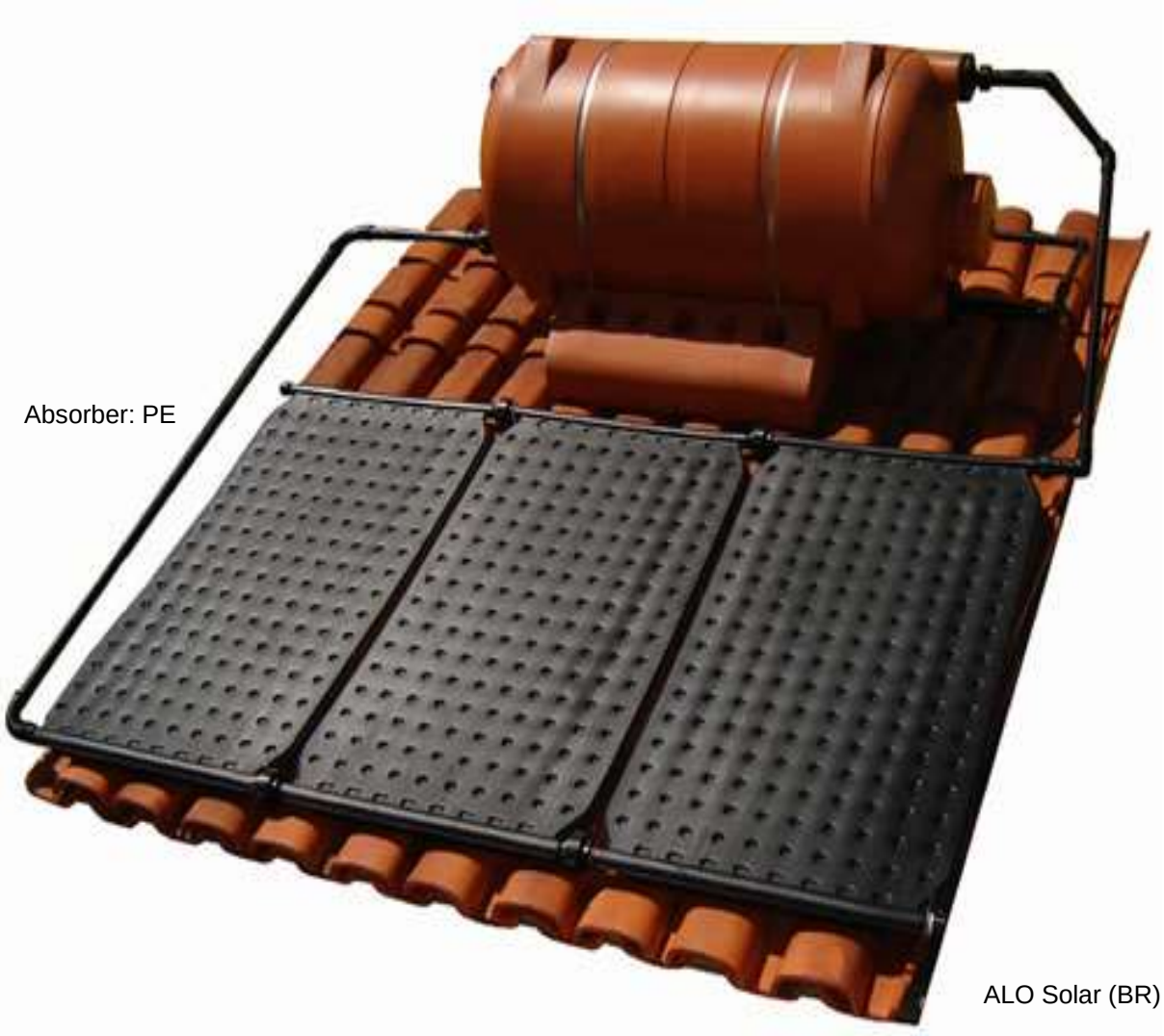

(Mauthner, Weiss, Solar Heat Worldwide, Edition 2013)

# Polymers in Thermosiphon-collectors (1)

"Unibody": PU

Aguasol (DK)

# Polymers in Thermosiphon-collectors (2)



# Polymers in Thermosiphon-collectors (3)

Absorber: PE


SOLCO (USA)

# Polymers in Thermosiphon-collectors (4)

Thinfilm absorber & storage
: PE

RhoTech Solar (USA)

*Prototype, not commercial (yet)

# Vaccum pipe collector integrated in roof tiles

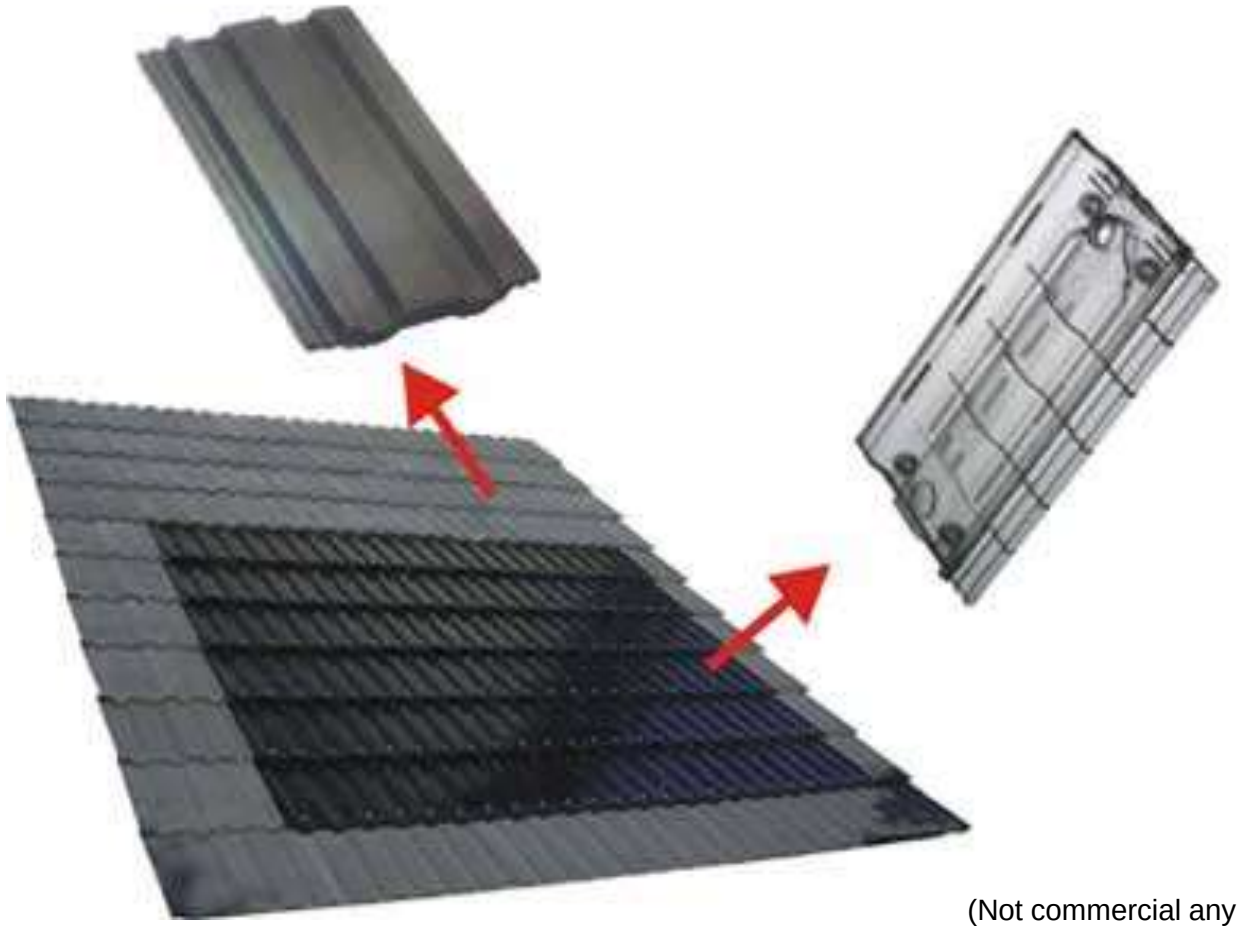

TECH TILE (IT)

# Adapted collector design: Roof integration (1)

(Not commercial any longer)
www.solarcentury.com (UK)


Collector frame = glass fibre re-inforced plastics (UP+GD+MD)

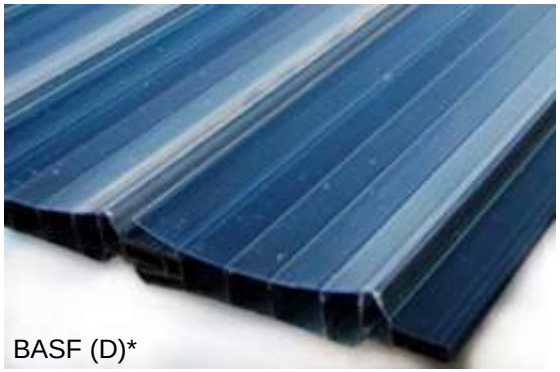
# Adapted collector design: Roof integration (2)



(Not commercial any longer)
GeaSOL (SI)
Solari stresnik (Si)

# Keyword: "Design freedom"

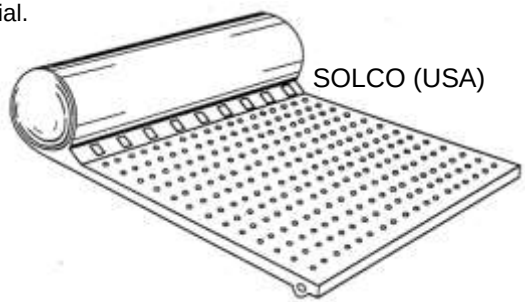
Roth Werke GmbH (D)



BASF (D)*

* not commercial.

Alo Solar (BR)



SOLCO (USA)

SOLCRAFTE Kioto Energy (AT)

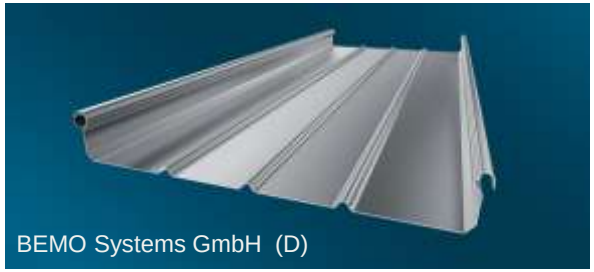
Speedsolar (DE)

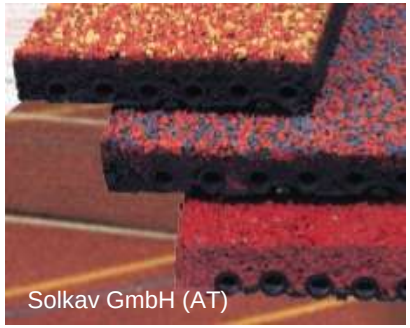
Polysolair (DE)

# Keyword: “Integrated design”





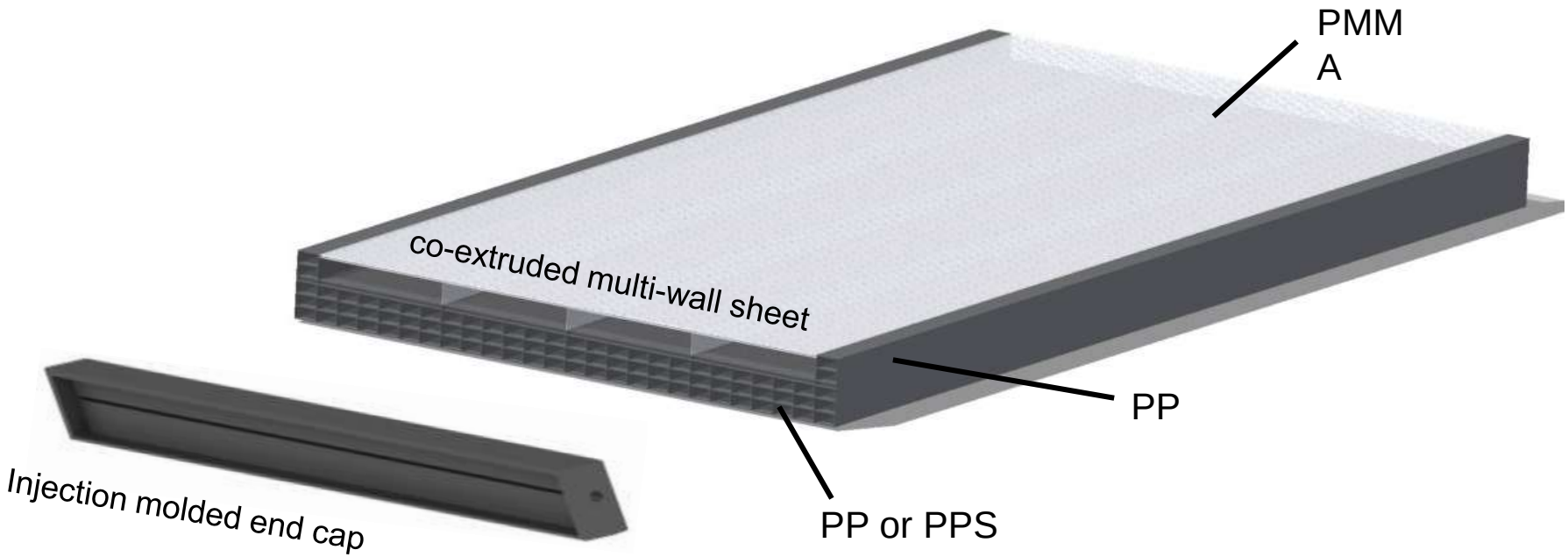



38 selected examples on Task 39 website:
http://projects.iea-shc.org/task39/projects/default.aspx

# Life Cycle Analysis of extruded polymeric collectors (1)

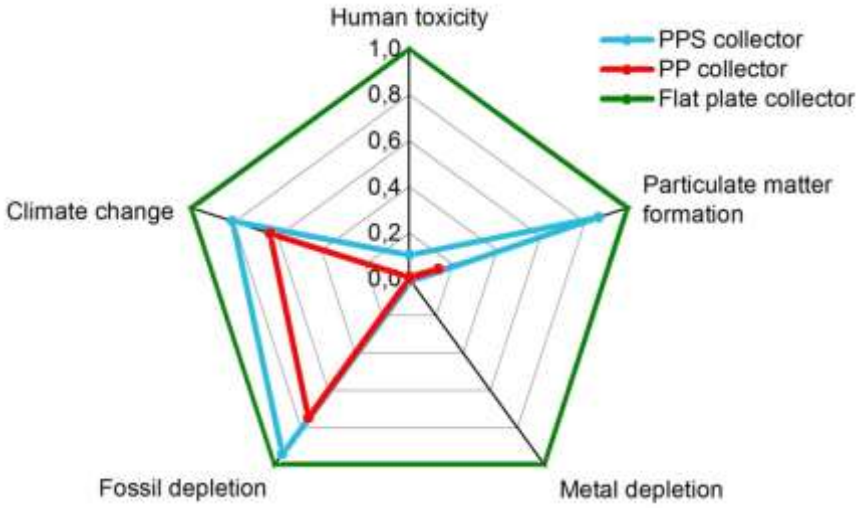
- PP collector concept
  - PP absorber
  - PP end caps
  - PMMA glazing
  - PP frame
  - 2.3 m², 22.0 kg
- PPS collector concept
  - PPS absorber
  - Selective coating
  - PPS end caps
  - PMMA glazing
  - PP frame
  - 2.3 m², 24.2 kg

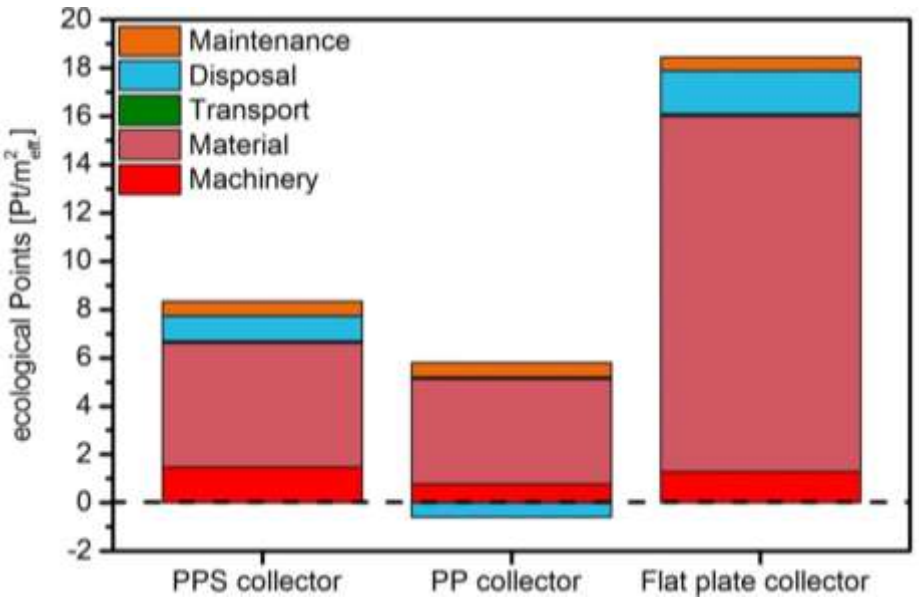



*Ref.: Regine Weiss et. al. , Fraunhofer, ISE*

# Life Cycle Analysis of extruded polymeric collectors (2)

- Greatest impact in the production phase mainly due to materials
  - Impact metals > Impact plastics
- Transport has no significant impact
- Flat plate collector has the highest impact even with ~50% secondary metals
- Lower impact with polypropylene (PP) based collector
- Environmental gain due to incineration of PP

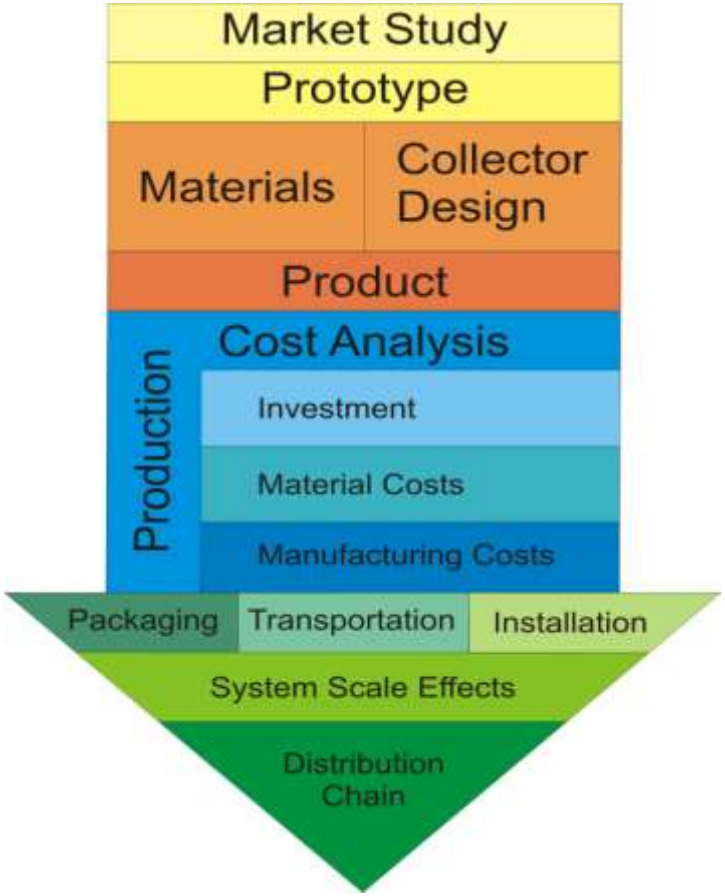


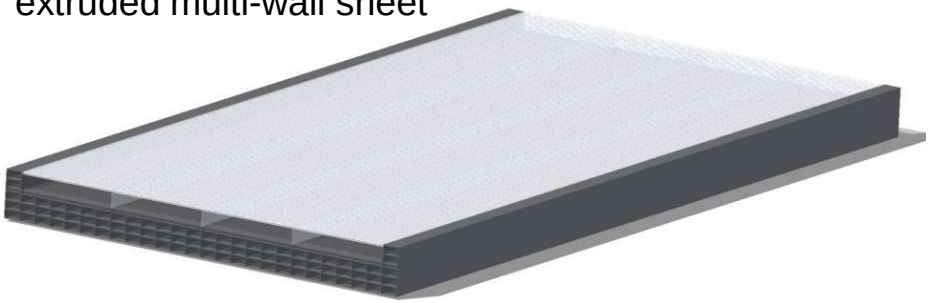

*Ref.: Regine Weiss et. al. , Fraunhofer, ISE*

# Cost optimization: Extruded polymeric collectors (1)

- Concept study performed by Fraunhofer ISE BMU project ExKoll
- Market study => market size => volume
- Polymeric collector concept based on extrusion – compared to conventional flat plate collectors (metal, glass)



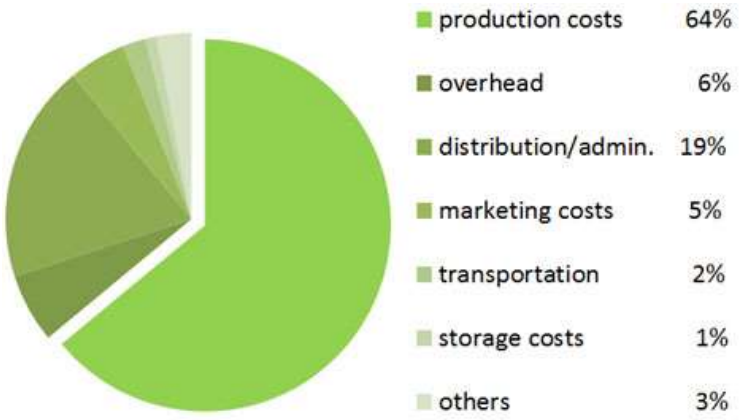

extruded multi-wall sheet

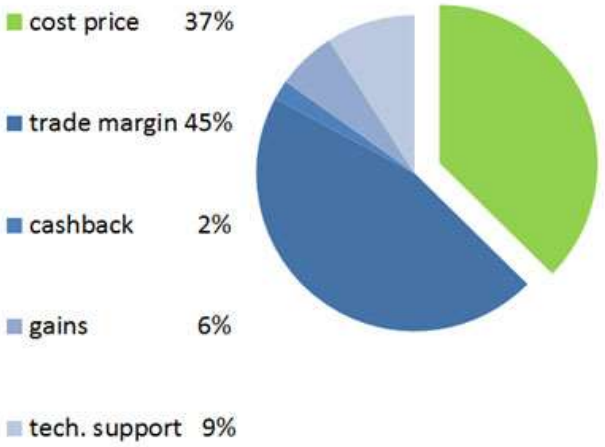


*Ref.: Andreas Piekarczyk et. al. , Fraunhofer, ISE*

# Cost optimization: Extruded polymeric collectors (2)

- Optimisation towards production cost (labor, energy, machinery, scale effects on solar thermal systems, collector level; different collector efficiency, life times considered)
- Result of this study: 8-16% cost reductions on system level can be considered realistic.
- But: Extruded polymeric collector technology has much higher potential for cost reduction.
- Limiting factor: presently low share of production costs on the market




*Ref.: Andreas Piekarczyk et. al. , Fraunhofer, ISE*

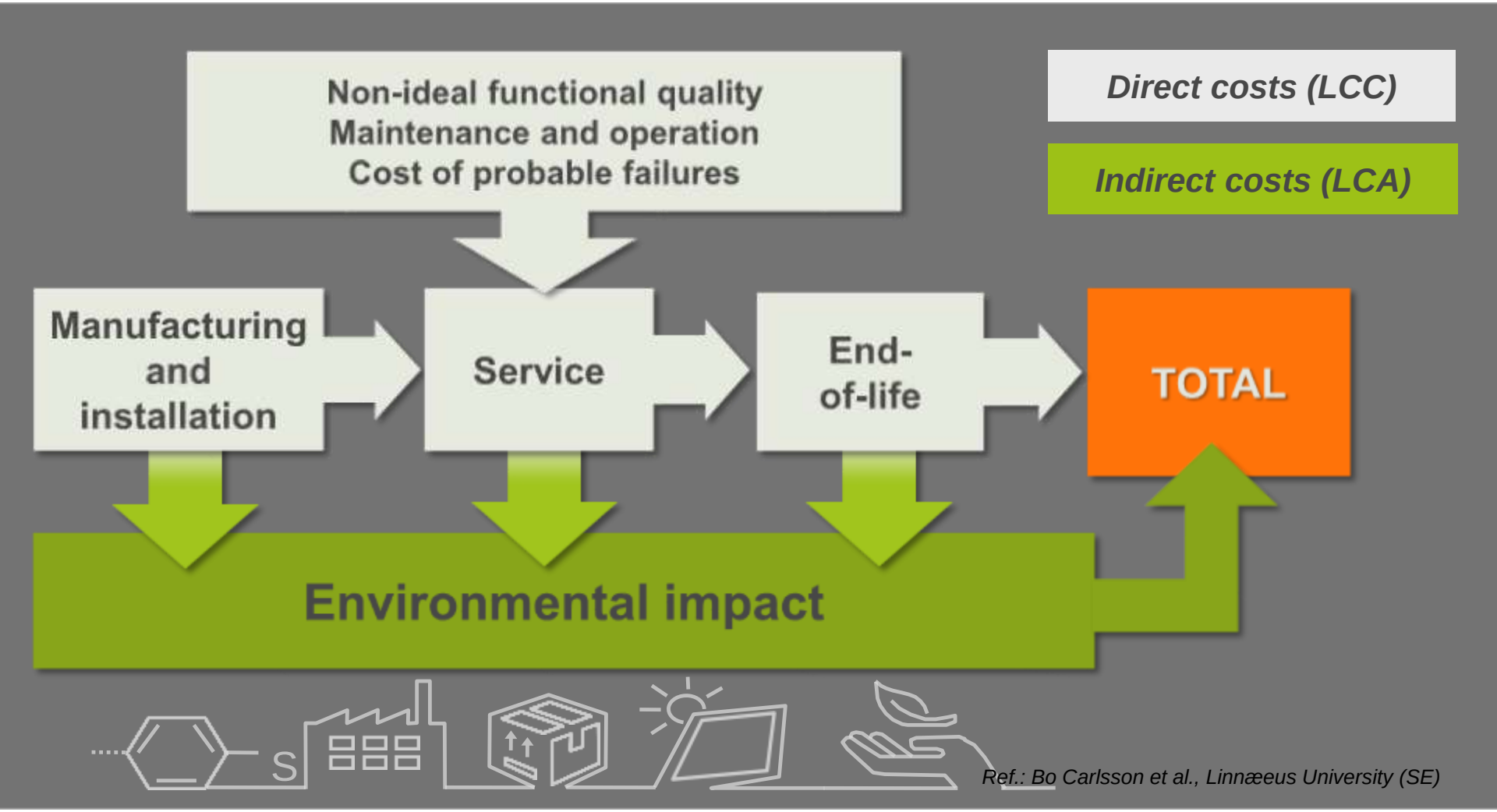
# A total cost accounting approach in evaluation of polymeric based solar systems versus those of more traditional design

***Direct costs (LCC)***

***Indirect costs (LCA)***

*Ref.: Bo Carlsson et al., Linnæeus University (SE)*

# A total cost accounting approach in evaluation of polymeric based solar systems versus those of more traditional design



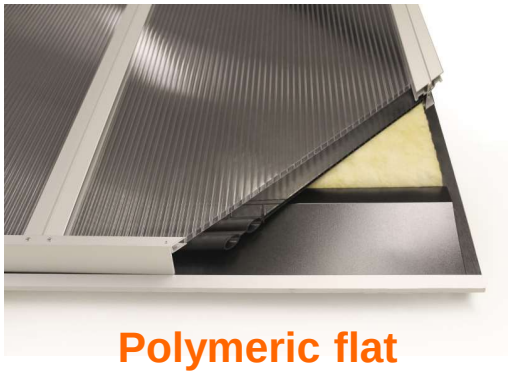

*Ref.: Bo Carlsson et al., Linnæeus University (SE)*

# Importance of costs for geen house gas emission relative to total cost

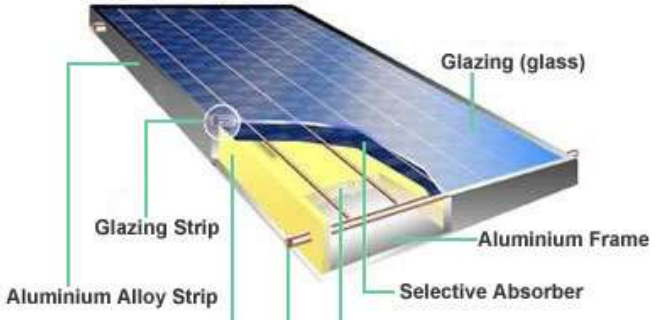
*Ref.* B. Carlsson et al. / Applied Energy 125 (2014) 10–20

| Heating system producing 0.12 TW h solar heat during a time period of 25 years in Stockholm | Climatic costs in € cent/solar heat collected based on a $CO_2$ emission rate per tonnes of | |
|---|---|---|
| | 20 $€^{eu}$ | 117 $€^{sw}$ |
| Solar heating system with polymeric collector (15 $m^2$) | 0.0301 | 0.175 |
| Reference solar heating system with flat plate collector (12.8 $m^2$) | 0.0415 | 0.243 |
| Reference solar heating system with evacuated tube collector (8.2 $m^2$) | 0.0312 | 0.182 |
| Equivalent heating system with natural gas boiler | 0.541 | 3.16 |

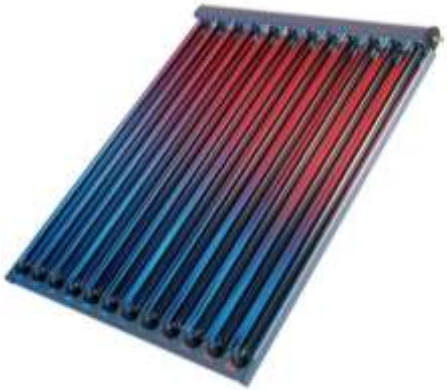
EU trade rate (2008); sw= Swedish general tax rate



Polymeric flat plate collector




Reference flat plate collector

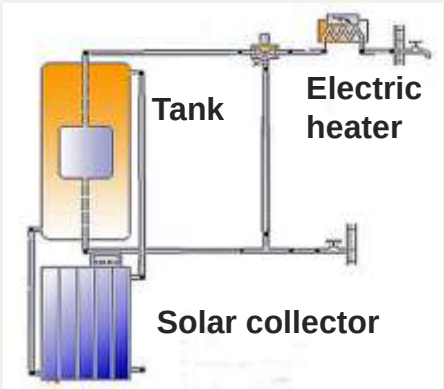


Reference evacuated tube collector

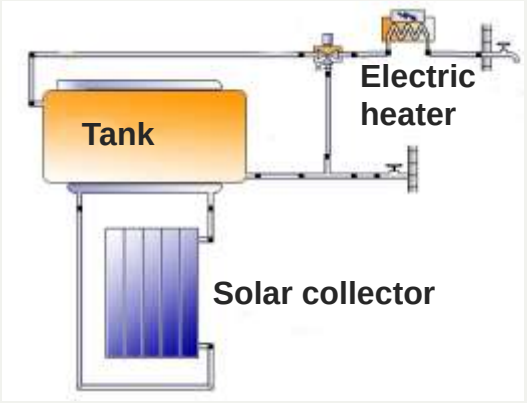
# Present value life cycle based **Energy costs** for two thermosiphon systems placed in Athens, service time: 15 years

*Ref.: Bo Carlsson et al., Linnæeus University (SE)*

**The Aventa polymeric based TSS**




**Reference TSS containing mainly metals**




## Costs related to the solar part of the TS systems

| System | Capital cost (€cent/kWh) | O&M cost* (€cent/kWh) | Climatic cost (A) (€cent/kWh) | Total cost (€cent/kWh) |
|---|---|---|---|---|
| Reference TSS | 11.9 | 1.8 | 0.06 | 13.8 |
| Aventa TSS | 7.9 | 1.2? | 0.02 | 9.1 |
| Difference | 4.0 | 0.6 | 0.04 | **4.6** |

## Costs related to the total useful produced heat by the TS systems

| System | Capital cost (€cent/kWh) | O&M cost* (€cent/kWh) | Climatic cost (A) (€cent/kWh) | Total cost (€cent/kWh) |
|---|---|---|---|---|
| Reference TSS | 9.3+X | 7.2 | 0.77+Y | 17.1+X+Y |
| Aventa TSS | 5.7+X | 8.5 | 0.99+Y | 15.2+X+Y |
| Difference | 3.6 | -1.3 | -0.22 | **1.9** |

X =End user cost of electric heater; Y = Climatic cost for producing electric heater;

# Industry Dissemination Workshops

- **4 Industry workshops**

02-2008 in Leoben (AT) by PCCL Leoben + AEE INTEC

06-2011 in Linz (AT) by JKU Linz + AEE INTEC

05-2012 in Berlin (D) by HU Berlin + Fraunhofer ISE

10-2013 in Linz (AT) arranged by JKU Linz + AEE INTEC


## Excursions: Production facilities and test laboratories (2006-2010)

- organised by local partners at experts meetings

- Sept. 2007: Excursion to solar heated brewery at Blumau Experts meeting, AT
- April 2008: Excursion to projects with polymeric ST collectors in Oslo, N
- Oct. 2008: Lab tour through LNEG at the Lisbon experts meeting, PT
- April 2009: Visit of test site of SPF during Rappersvil experts meeting, CH
- Oct. 2009: Lab tour through NREL during experts meeting at Golden, USA
- April 2010: Lab tour through INES during experts meeting at Aix-les-Bains, FR
- June 2010: Excursion to INTERSOLAR druing experts meeting in Munich, GE
- Sept 2010: Experts meeting in connection with EUROSUN 2010 in Graz, AT

NREL meeting, USA, 2009


INTERSOLAR meeting, Munich, 2010

## Excursions: Production facilities and test laboratories (2011-2014)

- organised by local partners at experts meetings

- May 2011: Lab tour through NIC at Ljubljana experts meeting, SL
- Sept. 2011: Excursion to **Bosch TT's production site** at Aveiro experts meeting, PT
- Oct. 2012: Guided tour: Technological Institute and visit of **Fraunhofer ISE's outdoor test site** at Gran Canaria experts meeting, ES
- April 2014: Factory visit of **Magen Eco Energy** and excursion **to Fraunhofer ISE's outdoor test site** at the Ben Gurion University, ISR
- Oct. 2014: Guided tour to **projects with polymeric ST collectors** in Oslo, N


Bosch TT, PT, 2011


Sde Boquer, ISR, 2014


Magen, ISR, 2014

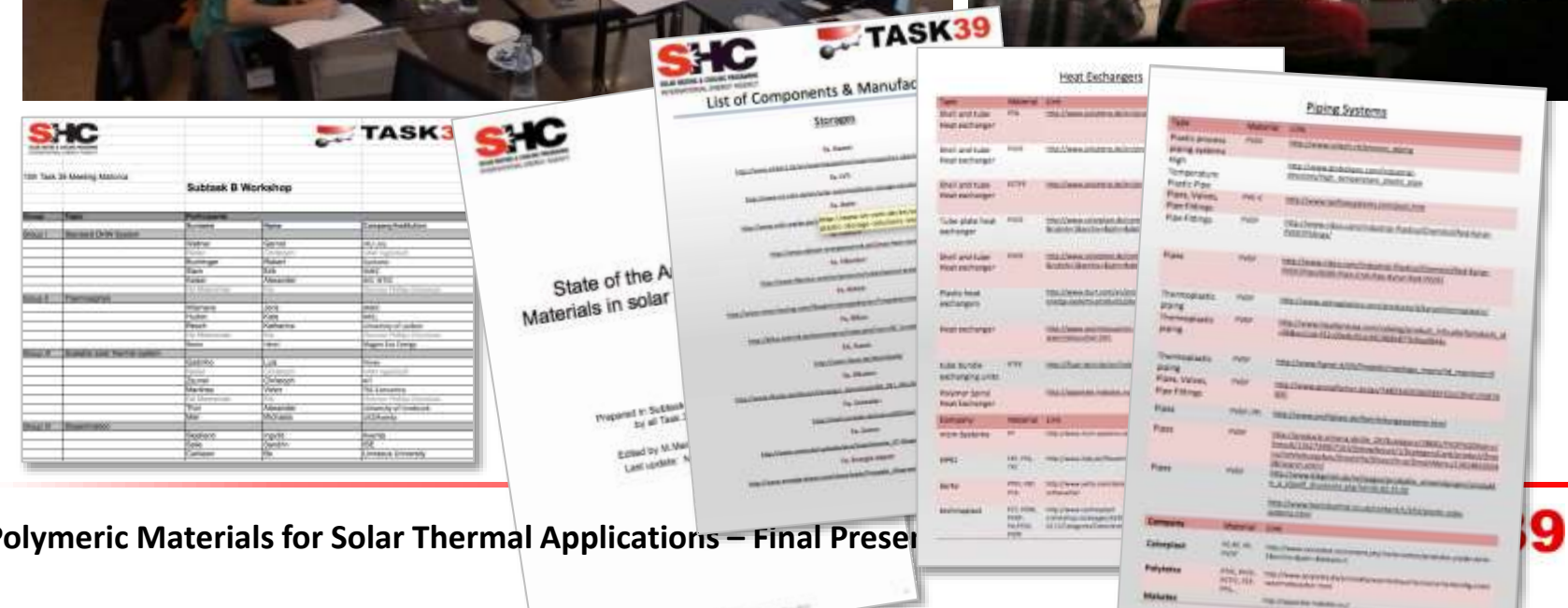

Pozo Izquierdo, ES, 2012

# Task 39 Newsletters: Summary of Project meetings

- 14 Newsletters, IEA-SHC internal newsletters
- Task 39 Website, Task 39 Highlights

# Dissemination: Task 39 Workshop ➔ SHC2013 Exhibition

Workshop, April 2013, arranged within Subtask B leading to SHC 2013 exhibition



# Dissemination: Task 39 Workshop ➔ SHC2013 Exhibition

Workshop, April 2013, arranged within Subtask B leading to SHC 2013 exhibition

SHC 2013 CONFERENCE SEPTEMBER 23-25 FREIBURG, GERMANY

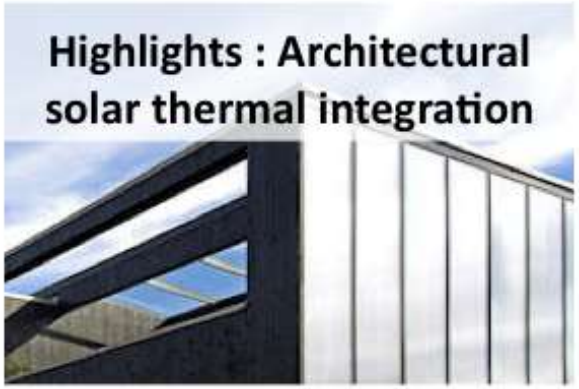
12 companies

Press release, Flyer

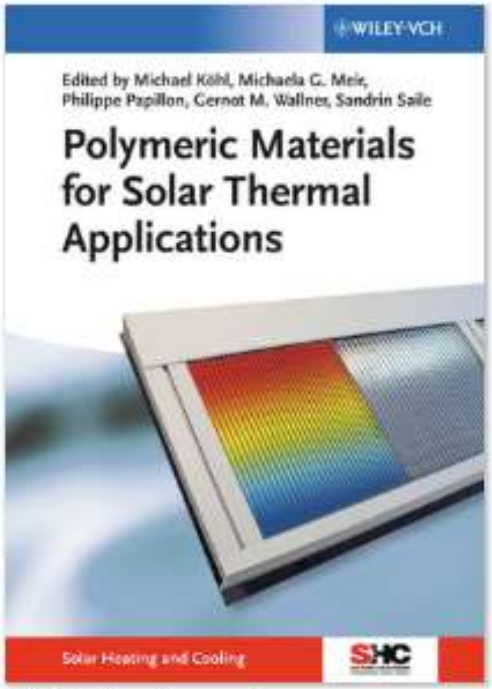
Major coodination effort by Fraunhofer ISE, Freiburg


# Final Task 39 Dissemination: Website

- Website: http://Task39.iea-shc.org


# Final Task 39 Dissemination 2006-2010: Handbook




Read an Excerpt

## Polymeric Materials for Solar Thermal Applications

Michael Köhl (Editor), Michaela Georgine Meir (Editor), Philippe Papillon (Editor), Gernot M. Wallner (Editor), Sandrin Saile (Editor)

ISBN: 978-3-527-33246-5

418 pages
October 2012

# Final Task 39 Dissemination 2011-2014: Info Sheets

- Subtask A : 7 - Subtask B : 16 - Subtask C : 10

# Example: “One Task 39 success story”

- Experts met for the first time at Task 39 kick-off meeting in Ingolstadt in 2006

# Example: “One Task 39 success story”

- Experts met for the first time at Task 39 kick-off meeting in Ingolstadt in 2006

Vanja Dobreva,
Chevron Phillips Chemicals

John Rekstad,
Aventa AS /
University of Oslo

# Example: “One Task 39 success story”

- Experts met for the first time at Task 39 kick-off meeting in Ingolstadt in 2006
- Last Task 39 meeting in Norway: Excursion to row house project in Oslo: 34 passive houses heated with polymeric solar collectors

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Aventa AS (N)
Chevron Phillips Chemicals (B)
DS Smith Kaysersberg
University of Oslo

AEE INTEC
APC
Austrian Institute of Technology
Fraunhofer ISE
HTCO
ITW Stuttgart
J. Kepler University Linz
National Institute of Chemistry
PCCL
Prirev
University of Aveiro
University of Leoben

# Example: “One Task 39 success story”

Thank you!