

## ***Kunststoffe (Polymerwerkstoffe) als Schlüsselwerkstoffe für die Solartechnik***

**solpol** – Eine wissenschaftsgetriebene, österreichische  
FuE-Initiative zu Kunststoffen in der Solartechnik

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*Institut of Polymeric Materials and Testing  
Johannes Kepler Universität Linz  
Linz / Austria*



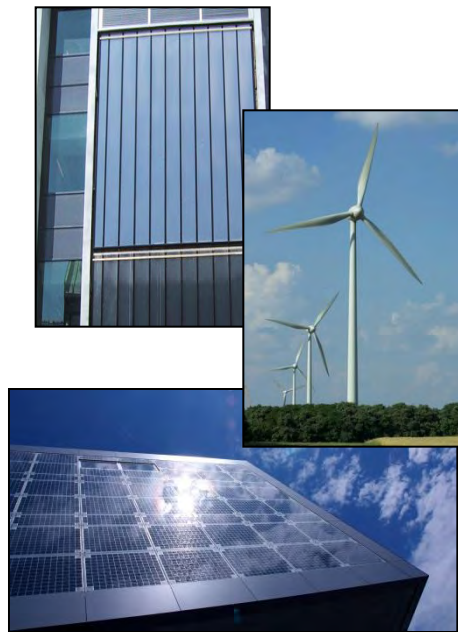
**Impulsprogramm Nachhaltig Wirtschaften – Fabrik der Zukunft**  
Mit zukunftsfähigen Produktionstechnologien und Materialien zur „Ökonomie der Zukunft“  
Wien, 31. Mai 2011

## IPMT Research Profile: 4 major areas of technology orientation

### **Water** (supply, disposal)



### **Energy** (solar, wind, water)



### **Mobility** (ultra-light vehicles)



### **“Regenerative“ Plastics** (renewable resource base)



### **The Millenium Development Goals (MDG) - United Nations, 2008**

- **Water:** ~ 1 bill. people without access to clean and sufficient water  
~ 2.5 bill. people without proper sanitation
- **Energy:** > 2 bill. people with insufficient access to energy

IPMT Research Profile: **Polymeric Materials & Sustainable Development**  
*Methodology and Approach*

**Scientific Approach:  $msp^3$ -relationships**

(material structure-property-processing-performance)

**Molecular  
structure**

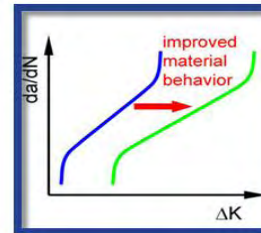
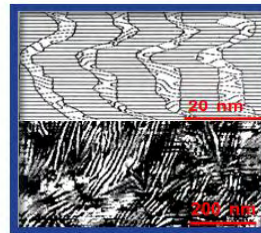
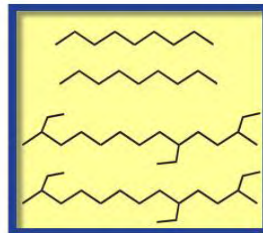
**Morphological  
structure**

**Material  
properties**

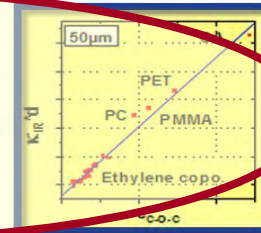
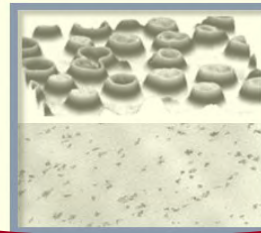
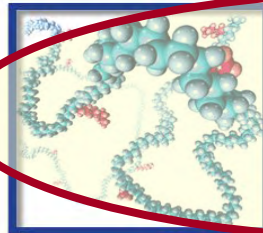
**Processing  
& Design**

**Aim: Service  
performance**

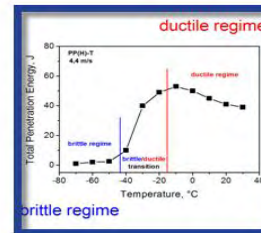
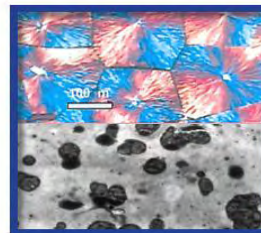
**Polyolefin  
Pipes**



**Solar-thermal  
collectors**



**Ultra-light  
vehicles**



**Focus of research**



## 3 Hypothesen zum Thema

R.W.Lang; *Energy 2030*, Abu Dhabi (UAE), Nov. 2006

### Hypothese 1: Innovation & Performance

**Polymerwerkstoffe** (Kunststoffe, Elastomere, Composites) bieten ein **hohes Potenzial für innovative Weiterentwicklungen** in der Solartechnik.

### Hypothese 2: Konvergenz der Interessen

In der nächsten Transformation des globalen Energiesystems werden die **Interessen der Öl/Gas-Industry, der Kunststoff-Industrie und der Solar-Industrie konvergieren.**

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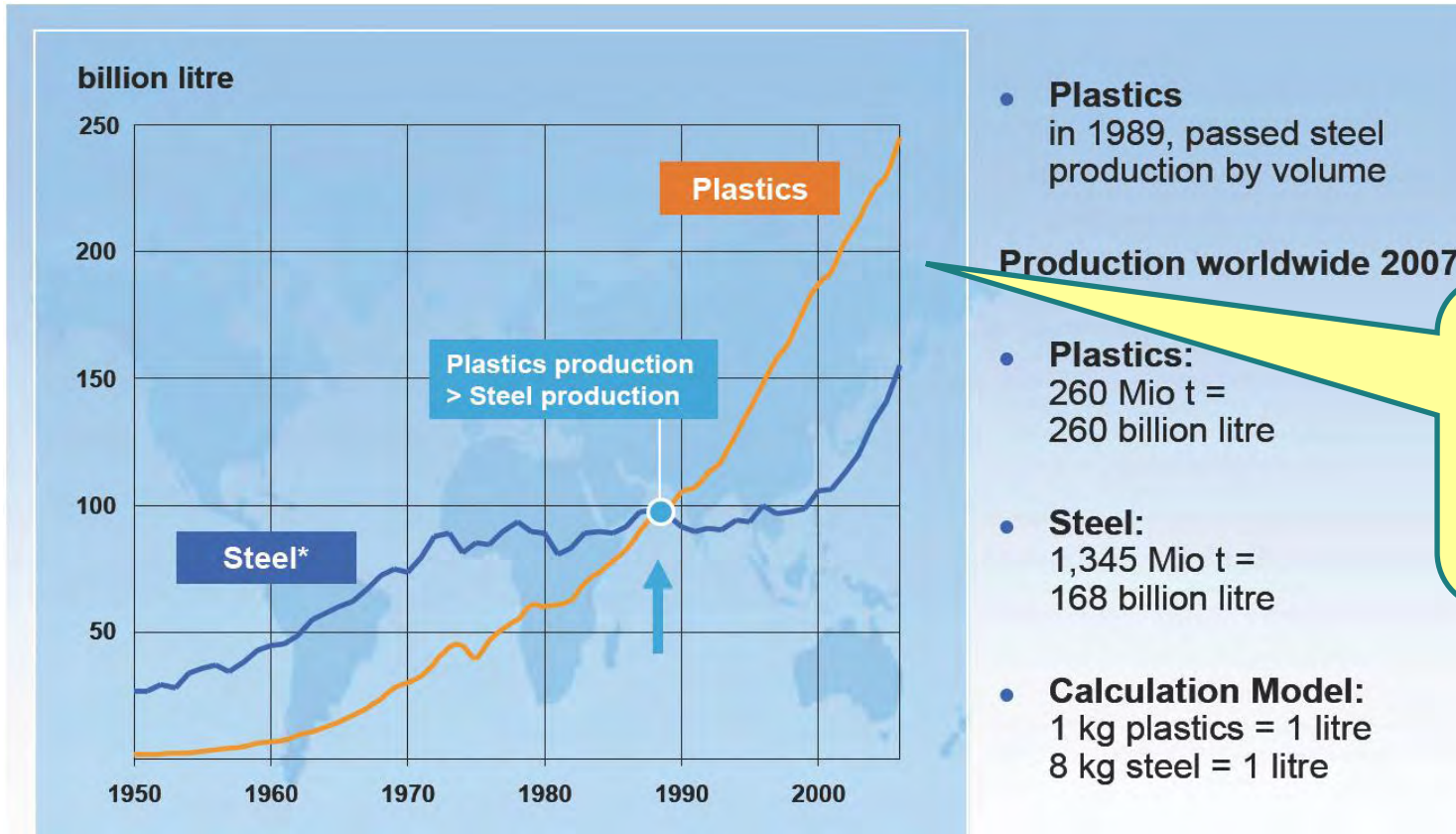
**BP:** [www.bpalternativenergy.com](http://www.bpalternativenergy.com)

**Shell:** [www.shell.com/home/content/rw-br](http://www.shell.com/home/content/rw-br)

### Hypothese 3: Kooperation & Partnerschaft

Ein Schlüsselement für die erfolgreiche Umsetzung von Innovationspotentialen in der Solartechnik liegt in der **Vernetzung der Kunststoff- und Solarenergieforschung sowie der Kunststoff- und Solarwirtschaft.**

## Development of Plastics and Steel Worldwide (1950 to 2007 in terms of volume)



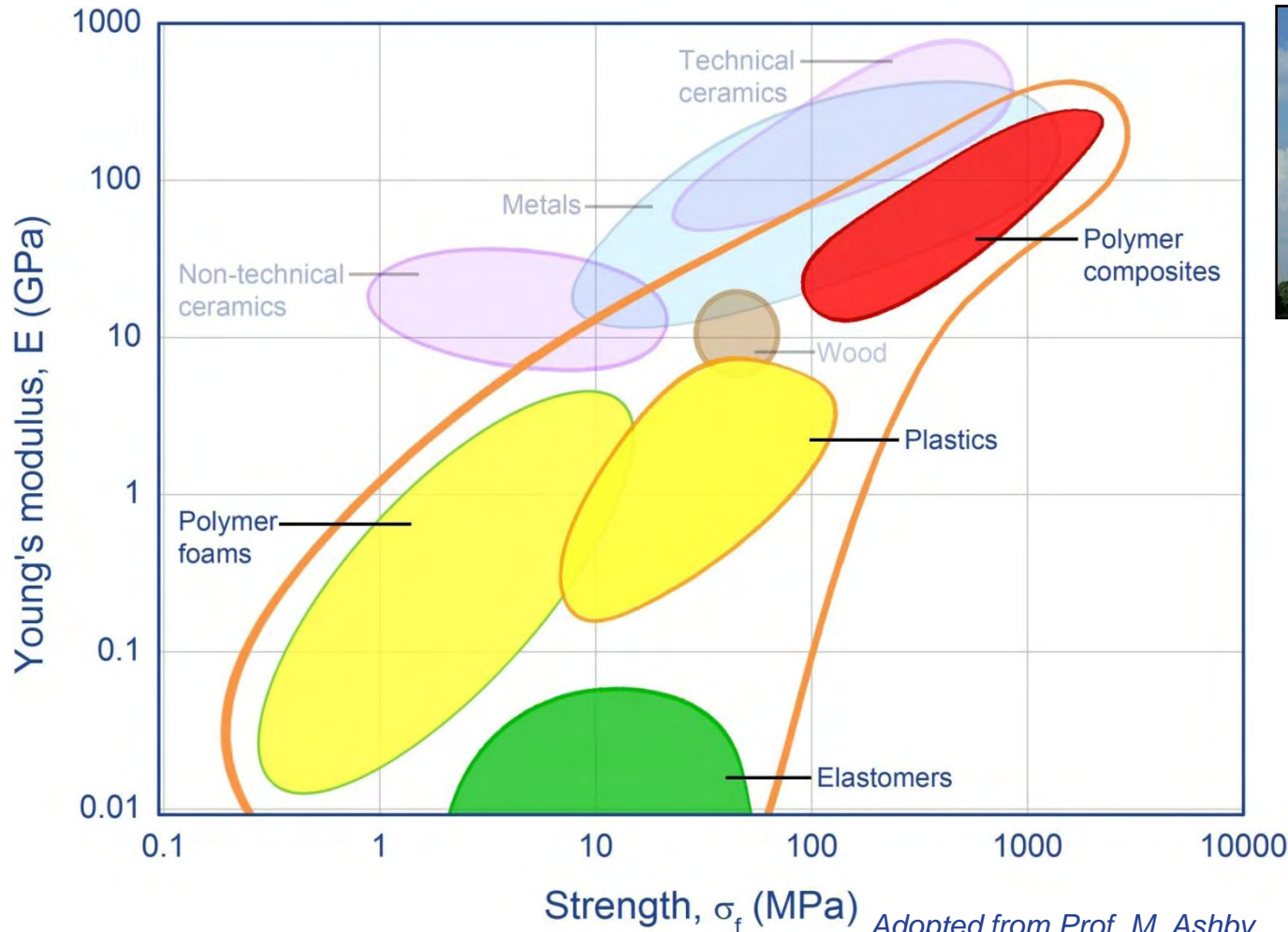
*Compared to other material classes plastics exhibit the highest growth rates over the last decades (> 6% p.a.).*

Source: Plastics Europe, D (2008)

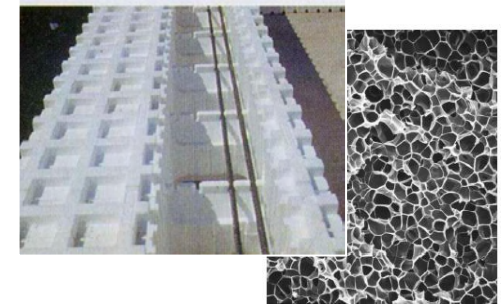
***In terms of volume, plastics production surpassed steel production in the 1980s.***

## Reasons in support of Hypotheses 1: *Polymeric Materials & Solar Technologies*

### **Mechanical Property Chart: Metals & Ceramics vs. Polymeric Materials**



Adopted from Prof. M. Ashby  
(Univ. of Cambridge, UK), 2005



Reasons in support of Hypotheses 1 and 3:

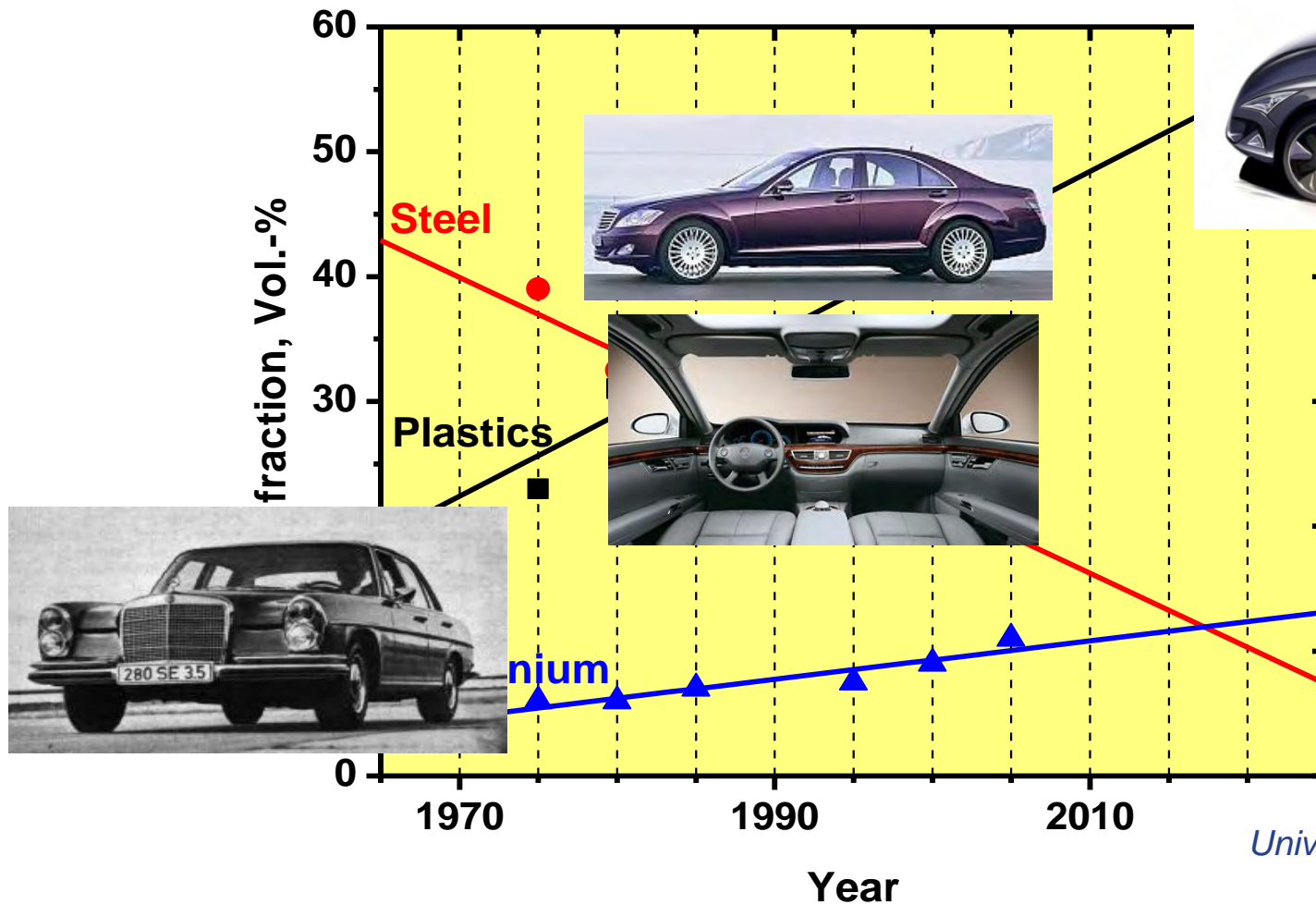
*Innovation & Collaboration*

**Relative Importance of Materials in Automotive Applications**

Foto: Bitter



Future light-weight  
electric vehicles



Source/Courtesy:  
Prof. A. Schlarb (2007)  
University of Kaiserslautern (D)

# Solar Energy for Buildings and Living



**„Energy autonomous solar building Freiburg“  
(Freiburg, D; 1992)**



**Ultra-low energy solar country house  
(Graz, A; 1998)**



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(material structure-property-processing-performance)

*Molecular structure*

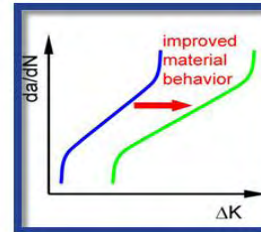
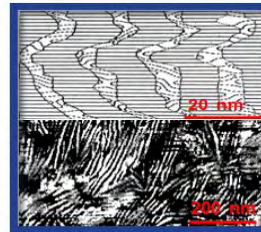
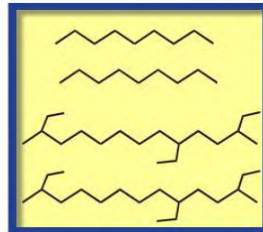
*Morphological structure*

*Material properties*

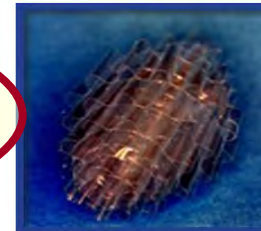
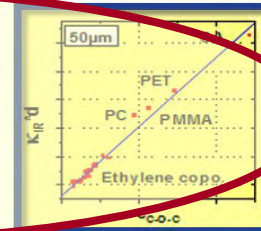
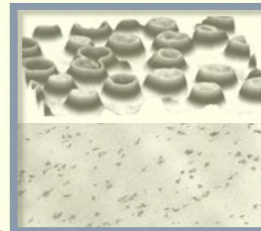
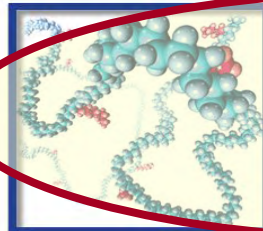
*Processing & Design*

*Aim: Service performance*

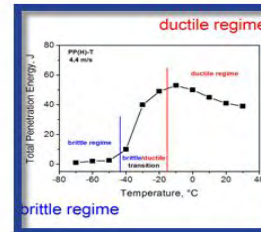
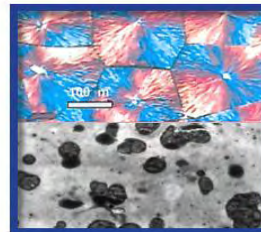
**Polyolefin Pipes**



**Solar-thermal collectors**



**Ultra-light vehicles**



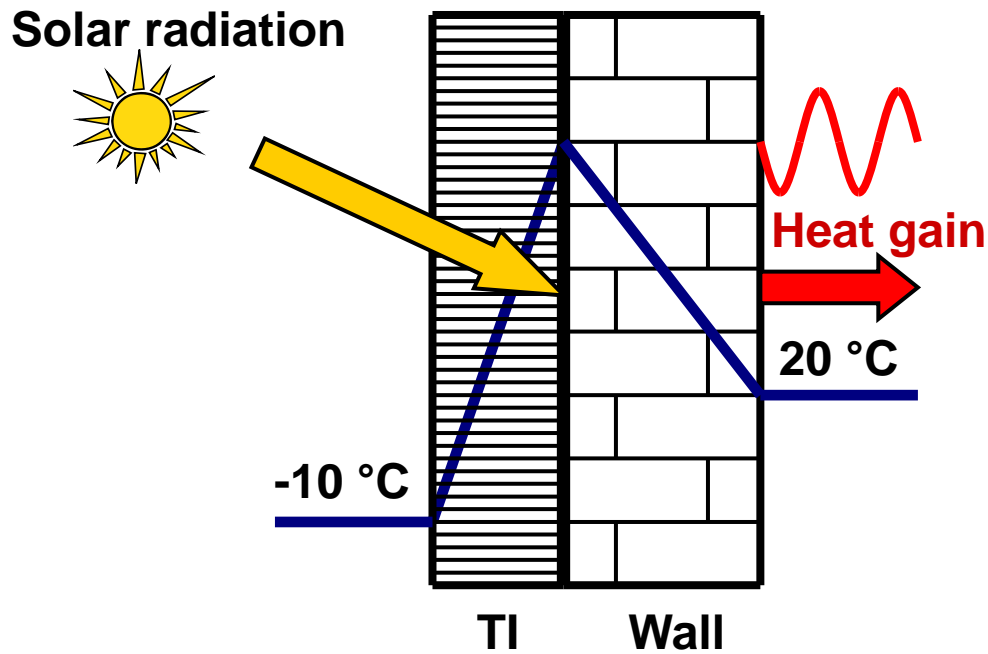
**Focus of research**



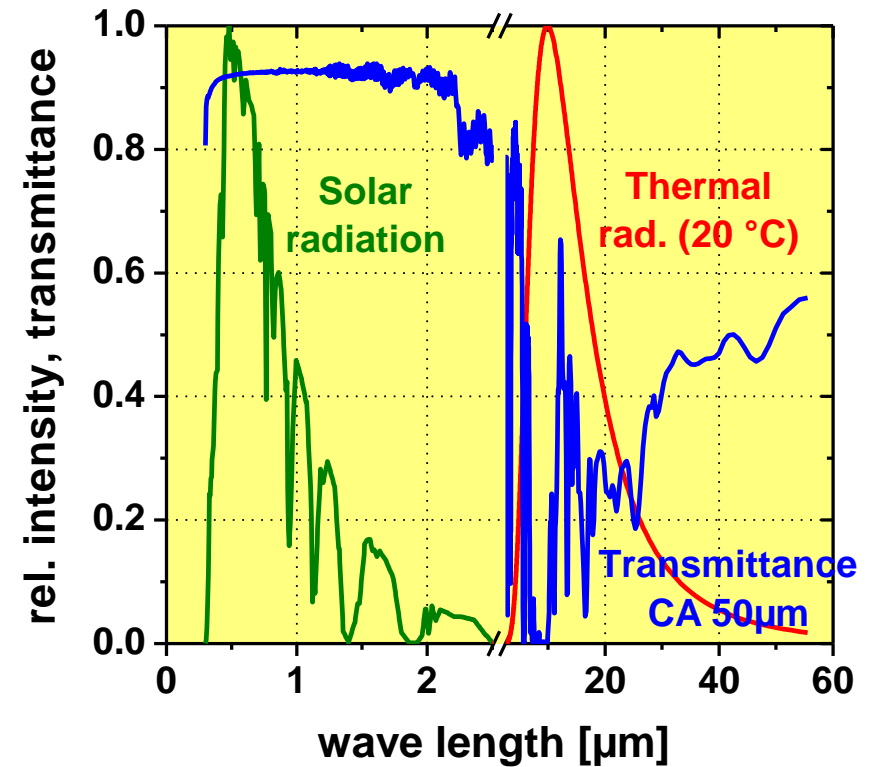
# Solar Energy Research

# Transparent Insulation (TI)

## Functional principle



## Optical requirements

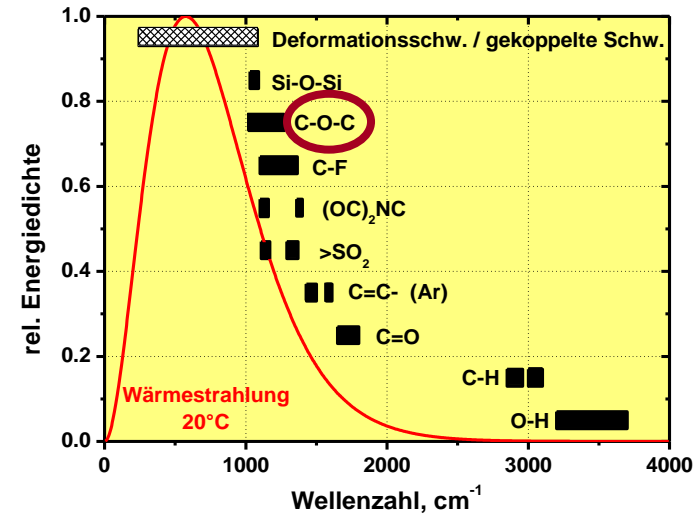
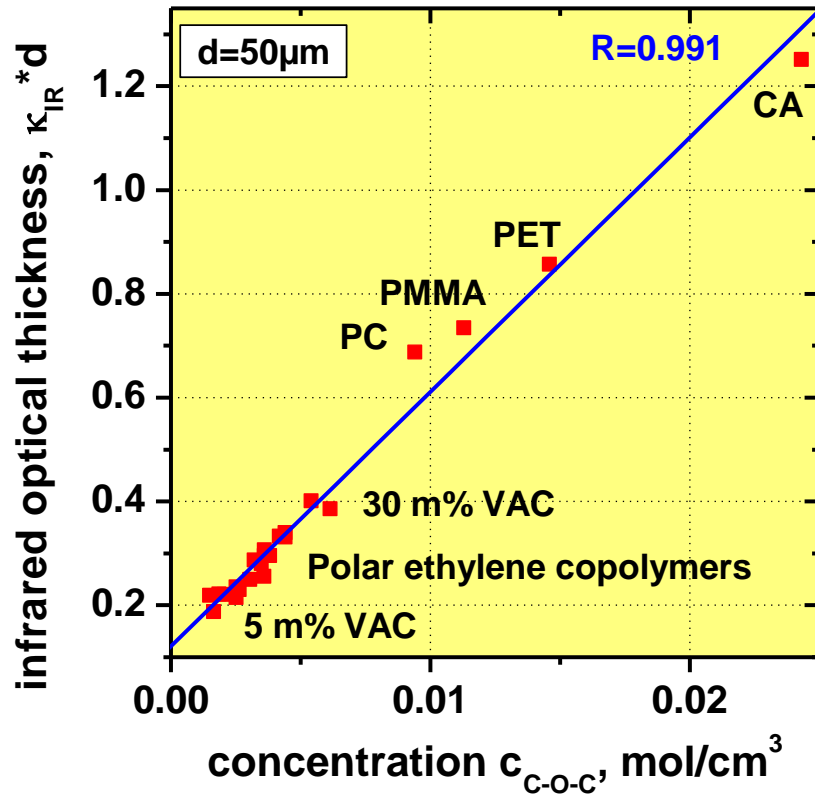


$\tau$  - Solar transmittance

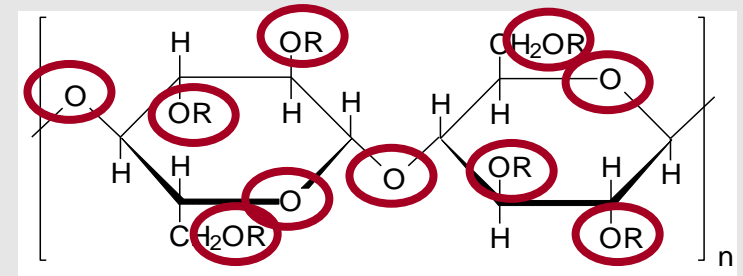
$\Lambda$  - Heat loss coefficient

## Transparent Insulation – Thermal properties

### Structure-property correlations



### Cellulose triacetate (CTA)



G.M. Wallner, W. Platzer, R.W. Lang (2005). *Solar Energy*, 79, 593-602.

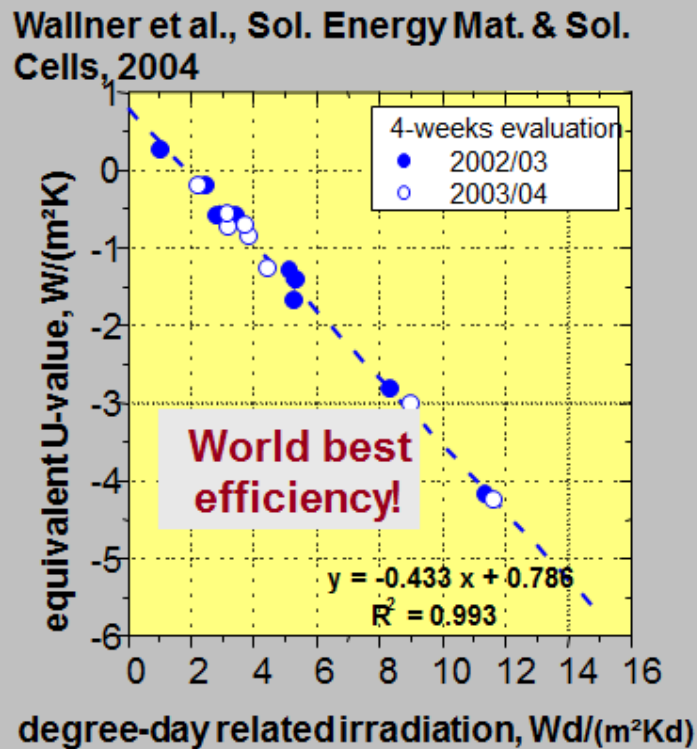
G. Oreski, G.M. Wallner (2006). *Solar Energy Materials & Solar Cells*, 90, 1208-1219.

# Solar Energy Research

# Transparent Insulation (TI)

## Performance improvement by

systematic development and optimization of transparent insulation system



### Improved energy services:

- more systems intelligence and more efficiency
- less energy and material
- utilization of renewable resources



Dieter P. Gruber

G.M. Wallner, R.W. Lang,

H. Schobermayr, H. Hegedys, R. Hausner (2004). Solar Energy Materials & Solar Cells, 84/1-4, 441-457.

## 3 Hypothesen zum Thema

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### Hypothese 3: Kooperation & Partnerschaft

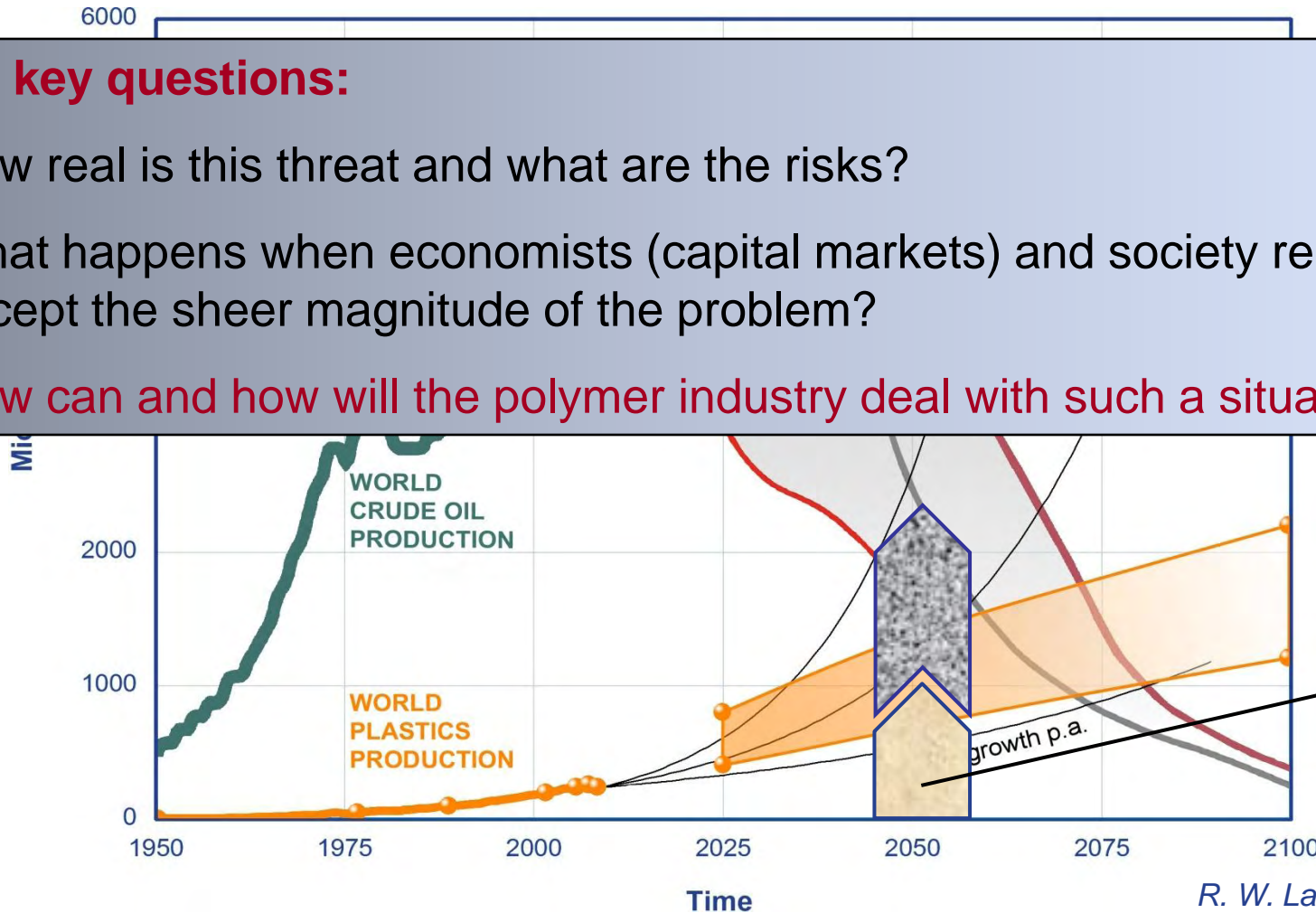
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## Reasons in support of Hypotheses 2: *Convergence of Interests*

### Plastics Growth Scenarios & Peak Oil – Problems and Consequences?

#### Some key questions:

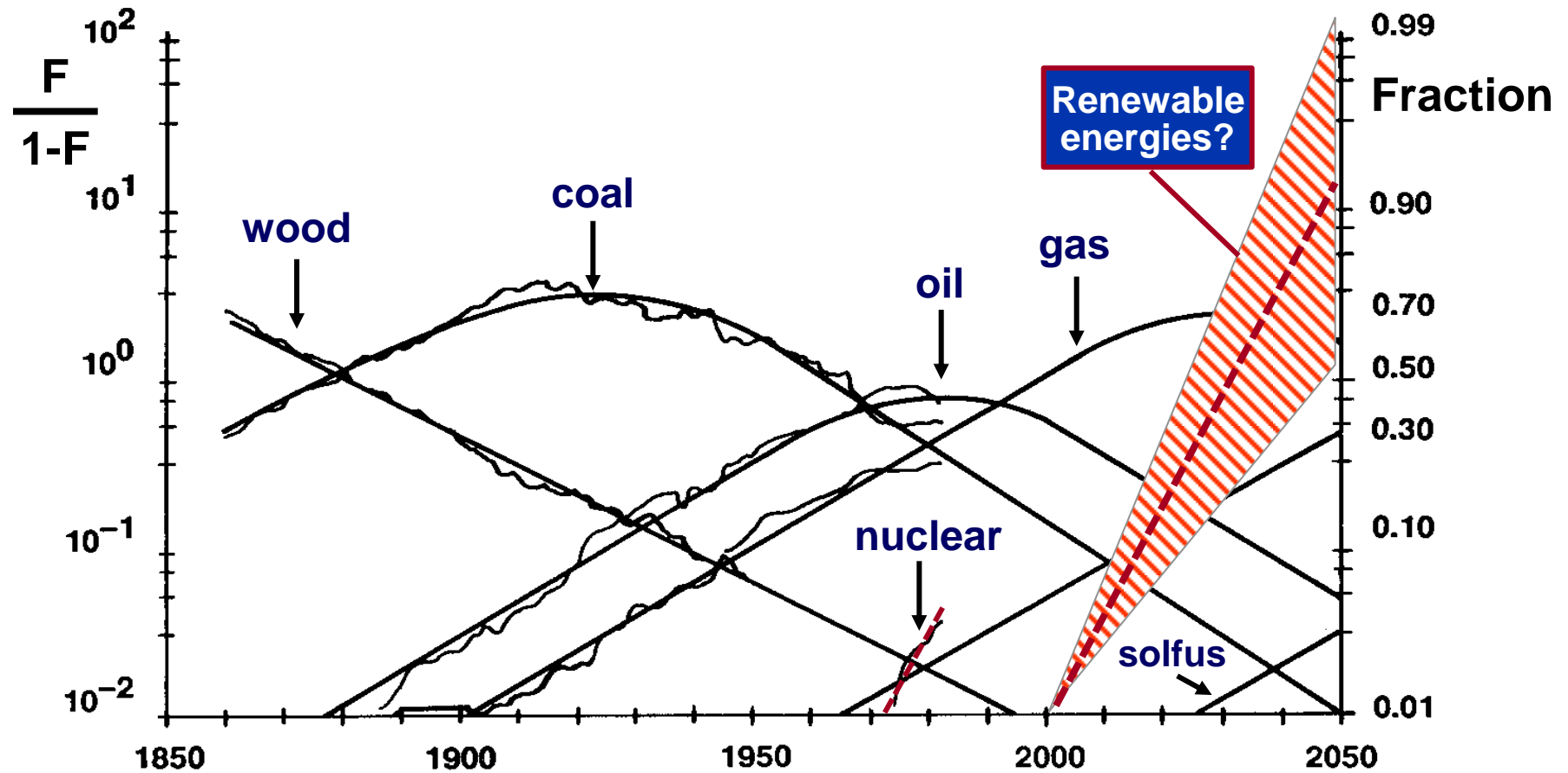
- How real is this threat and what are the risks?
- What happens when economists (capital markets) and society realize and accept the sheer magnitude of the problem?
- How can and how will the polymer industry deal with such a situation?



**2050:**  
**~ 20 - 50 %**  
**for plastics?**

## Reasons in support of Hypotheses 2: *Convergence of Interests*

### Technology life cycles of primary energy classes



Source: IIASA (Laxemburg, A)

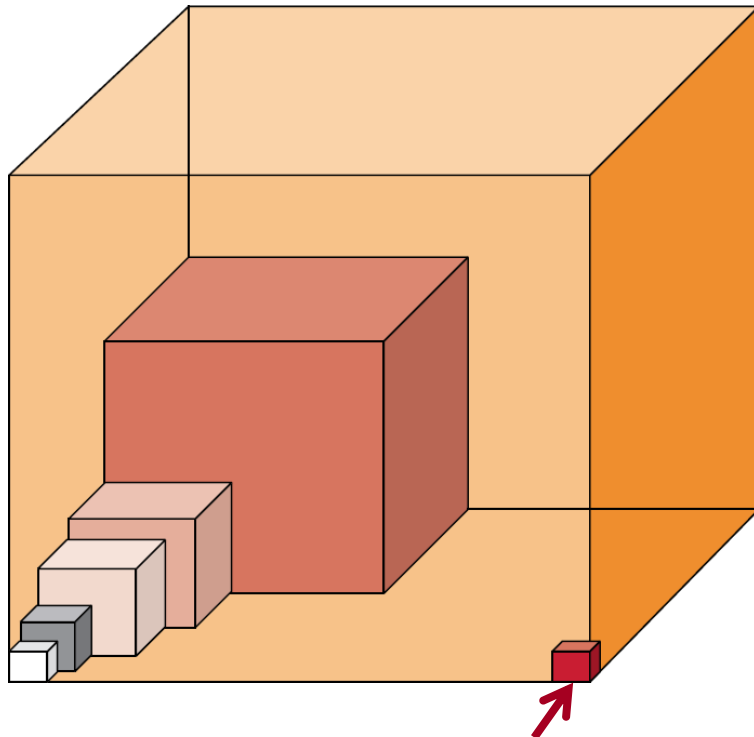
C. Marchetti u. N. Nakicenovic, 1997

A. Grübler u. N. Nakicenovic, 1987

## Reasons in support of Hypotheses 2:

## Energy Transition

### The physical potential of renewable energies



Current annual Global Primary Energy Consumption (GPEC)

- Solar power (continents, 1,800 x GPEC)
- Wind energy (200 x GPEC)
- Biomass (20 x GPEC)
- Geothermal energy (10 x GPEC)
- Ocean and wave energy (2 x GPEC)
- Hydro energy (1 x GPEC)

### Renewable Energy Capacity 2009 (excl. biofuels)

Energy Technologies	Total Capacity in GW 2009	Added in 2009
<b>Solar</b>	~ 210	<b>+28 %</b>
<b>Wind</b>	159	<b>+31%</b>
Biomass	~ 324	(+6%)
Geothermal	~ 71	(+4%)
Ocean & Wave	0.3	(~0%)
Hydro	<b>980</b>	<b>+3%</b>

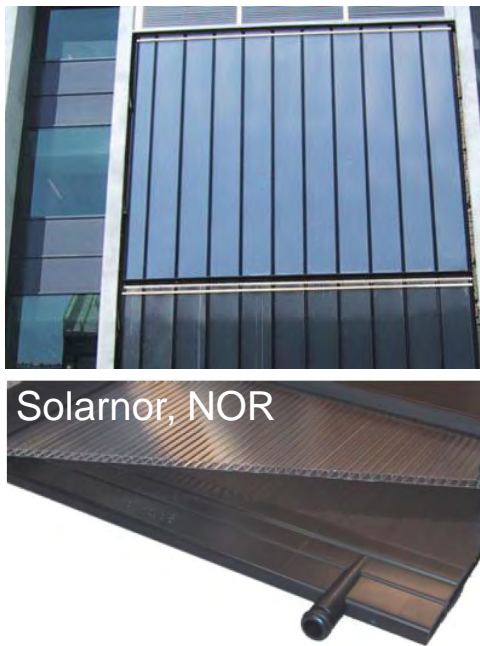
Source: *RENEWABLES 2010 GLOBAL STATUS REPORT (07/2010)*

Source: J. Nitsch, "Technologische und energiewirtschaftliche Perspektiven erneuerbarer Energien", Deutsches Zentrum für Luft- und Raumfahrt (DLR, Stuttgart), 2007; illustration from EPIA-Report "SET FOR 2020"



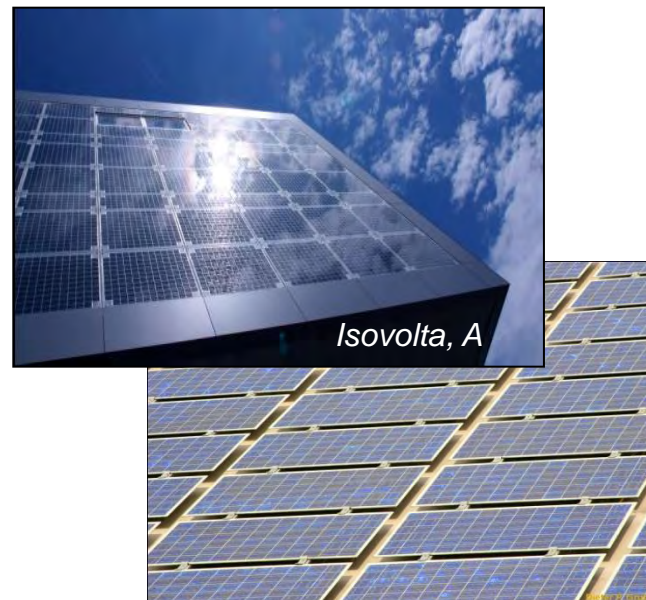
## Solar market potential for polymeric materials: *Facts & Figures*

### **Solar collectors** *(hot water/heat/cooling)*



**World capacity: 180 GW<sub>th</sub>**  
**Av. growth rate: 19 % p.a.**  
*(past 5 years)*

### **Solar PV** *(grid connected)*



**World capacity: 21 GW<sub>el</sub>**  
**Av. growth rate: 60 % p.a.**  
*(since 2000)*

### **Wind power** *(electricity all size scales)*

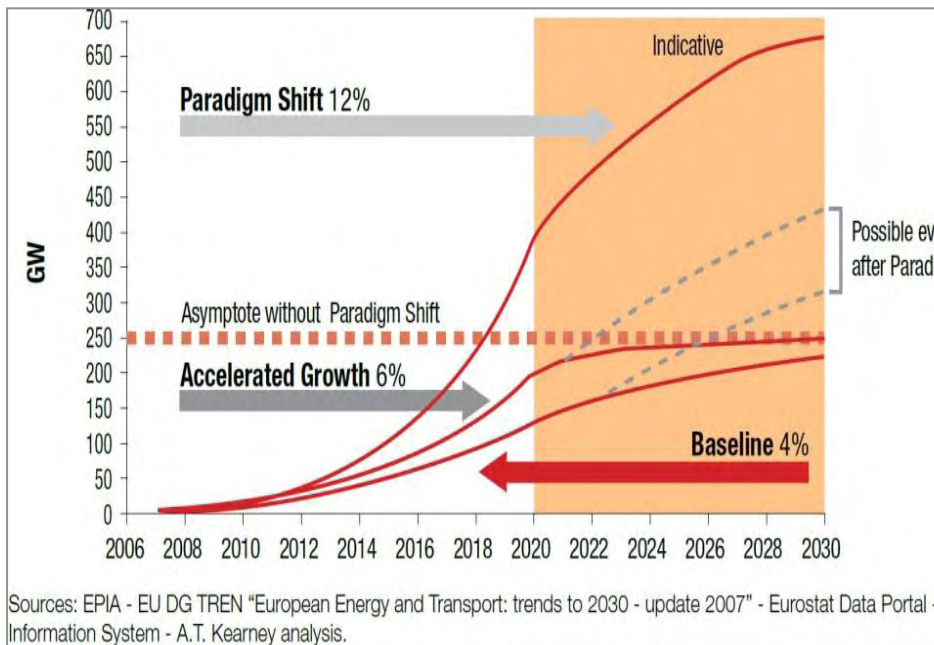


**World capacity: 159 GW<sub>el</sub>**  
**Av. growth rate: 27 % p.a.**  
*(past 5 years)*

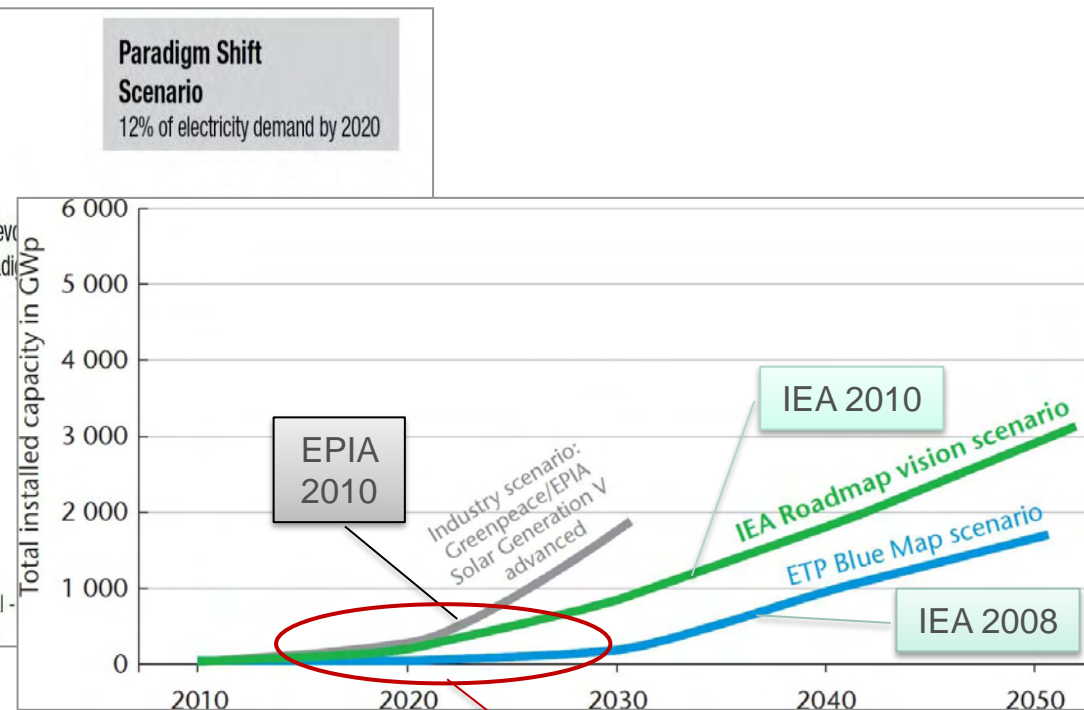
*Source: RENEWABLES 2010 GLOBAL STATUS REPORT (07/2010).*

## Facts & Figures: *Photovoltaics (PV) – A fast growing global Market*

- Due to the high dynamic PV market growth, **market forecasts and scenarios vary substantially and are continuously revised.**
- **Any advanced/accelerated future deployment scenario** for PV, in particular the EPIA “Paradigm Shift Scenario”, will depend on **substantial contributions from polymer science & technology development** and from the **polymer industry.**

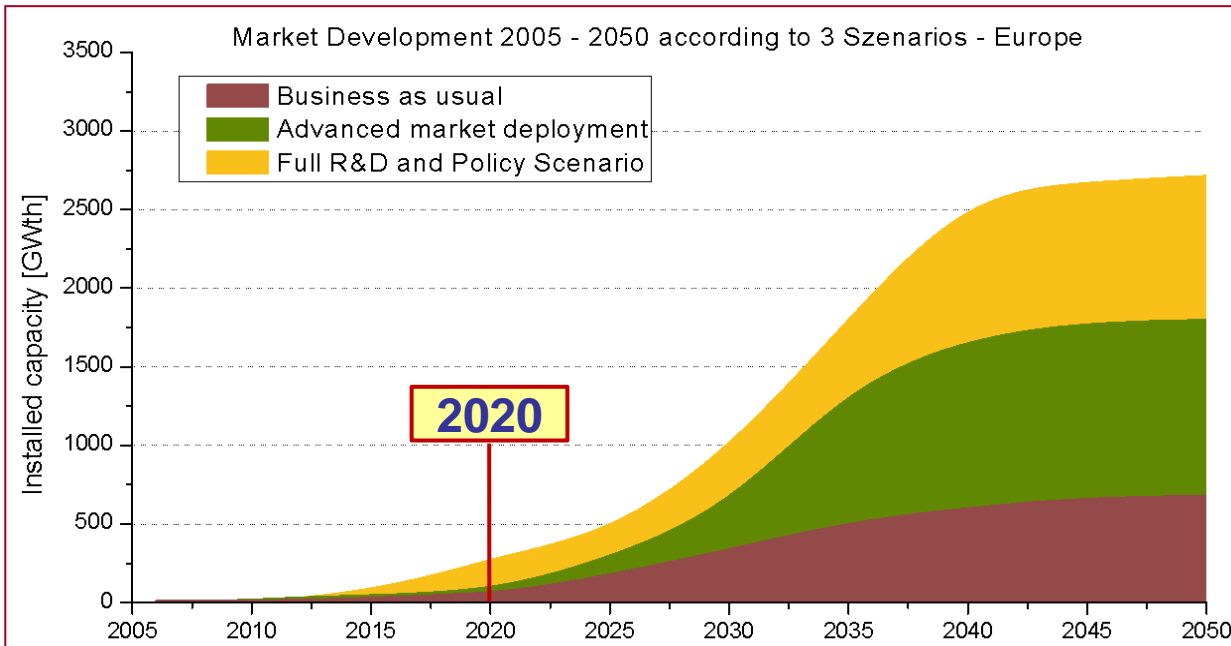


Source: EPIA (2010)



Role of Polymer Industry ?

# Market potential for polymeric materials: *Solar-thermal vs. PV*



## Solar-thermal deployment scenarios (Europe; ESTTP/ESTIF, 2007)

### Europe 2020: Full R&D scenario

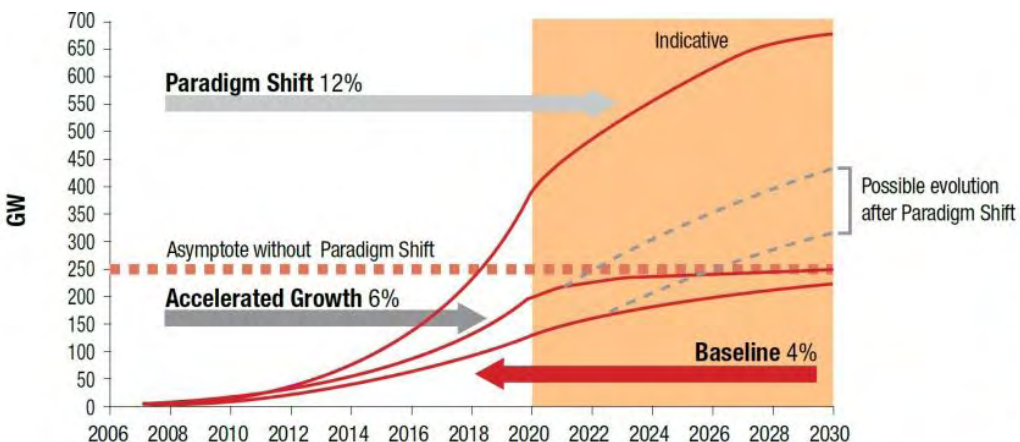
Total	0.4 bill. m <sup>2</sup>
Per person	0.5 m <sup>2</sup>
<b>Cumulated plastics demand (30% penetration)</b>	<b>1 mio. t</b>

*Discrepancy in approach?*

### Europe 2020: Paradigm shift scenario

Total	4.5 bill. m <sup>2</sup>
Per person	5.5 m <sup>2</sup>
<b>Cumulated plastics demand (encapsulation)</b>	<b>8 mio. t</b>

## PV deployment scenarios (EU 27, Norway, Turkey; EPIA, 2010)



- Paradigm Shift Scenario**  
12% of electricity demand by 2020
- Accelerated Growth Scenario**  
6% of electricity demand by 2020
- Baseline Scenario**  
4% of electricity demand by 2020

## 3 Hypothesen zum Thema

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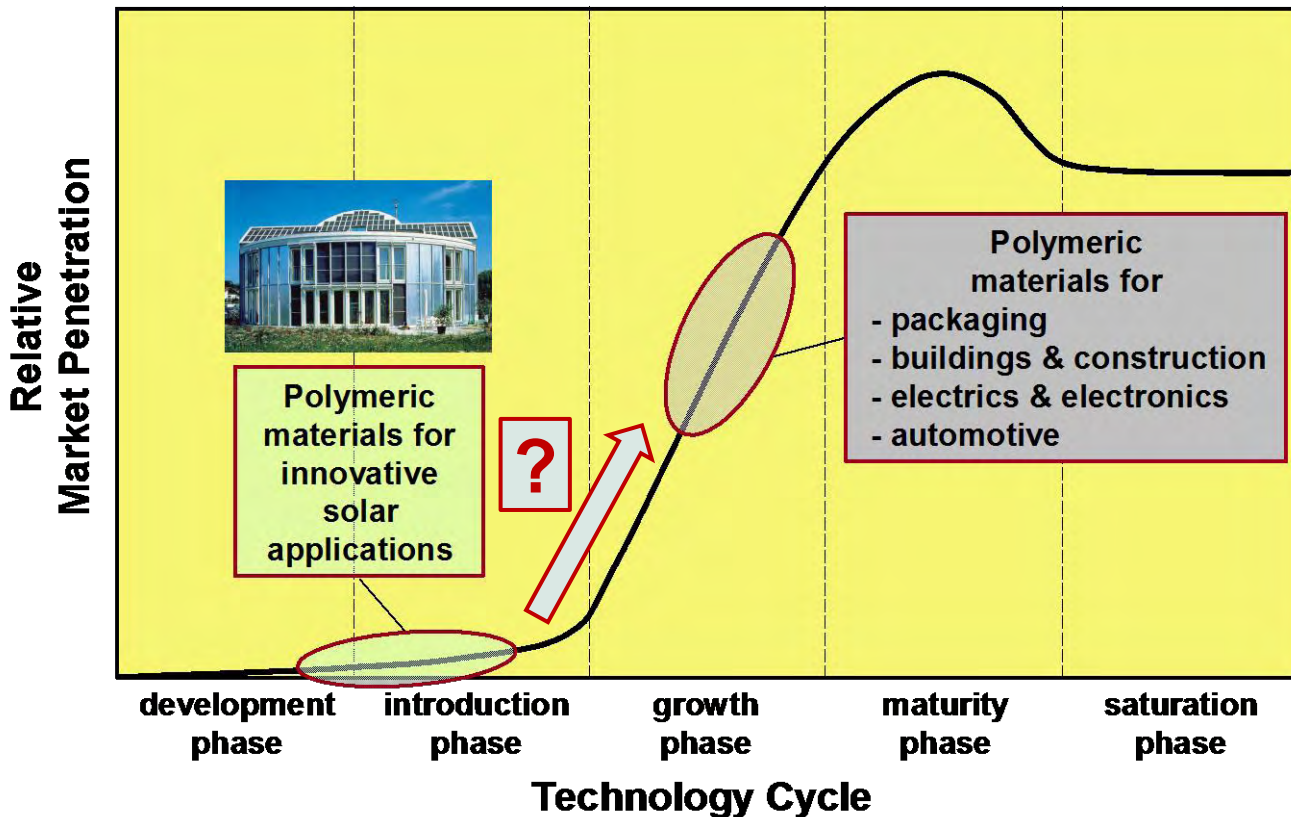
**Shell:** [www.shell.com/home/content/rw-br](http://www.shell.com/home/content/rw-br)

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## Reasons in support of Hypotheses 3: *Polymeric Materials & Solar Technologies*

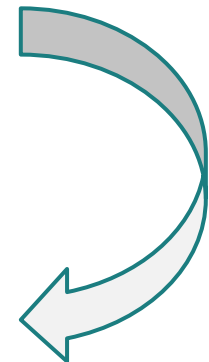
### Market penetration of polymer technologies



#### Prerequisites for broad market acceptance:

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

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

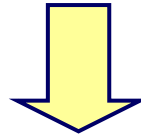


## *SolPol* – Solar Systems based on Polymeric Materials

*A new multi-partner Austrian RDT initiative*

### ***Overall Aim and Objective:***

*SolPol* aims to foster and strengthen the worldwide (leading) position of the Austrian solar industry by novel polymer based product developments and innovations.



Incorporation and combining the scientific and industrial expertise in the field of solar technologies and polymer technologies in Austria.

**Duration: 4 years**  
(07/2010 - 06/2014)

**Total Budget:**  
**~ 7.5 Mio. EURO**

Die neue Qualität multi-lateraler FTE-Programme am Beispiel der Johannes Kepler Universität als FTE-Partner und Konsortiumsleiter

Projekt	Anzahl der Partner *	Projektbudget (Mio. €)	Laufzeit (Jahre)
Neue Energien 2020 (KLI.EN) Solarthermische Kollektoren (SolPol-1,2)	10 UP 9 WP	5,1	3-4 (Start: 07/2010)
Neue Energien 2020 (KLI.EN) Solarelektrische Systeme – PV (SolPol-3)	7 UP 3 WP	2,3	3 (Start: 07/2011)

\* UP: Unternehmenspartner

WP: Wissenschaftliche Partner (Institute)

### Herausragende Merkmale (u. a.):

1. Mittel- und längerfristige **Kooperationen von Wissenschaft & Wirtschaft** und von Akteuren der **gesamten Wertschöpfungskette**
2. Effektiver und effizienter Einsatz von Forschungsmitteln durch **hervorragende Hebelwirkung** bezogen auf die Kostenbeteiligung einzelner Partner (*Faktor 5 -20 !*)
3. Starke Rolle der **wissenschaftlichen Partner als Initiator, Koordinator & FTE-Partner** in enger Abstimmung mit Unternehmen und Fördergeber (FFG)

### Positioning of Project Partners along the Value Creation Chain

#### 9 Scientific Partners

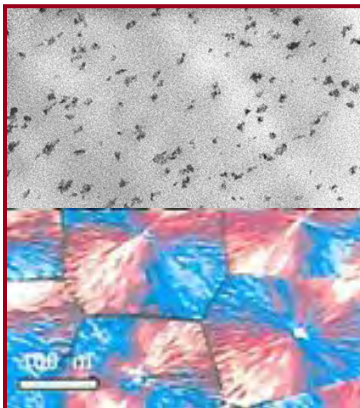
**JKU-CTO**  
**JKU-IAC**  
**JKU-ICP**  
**JKU-IPMT**

**JKU-IPIM**

**AEE-INTEC**  
**JKU-IPIM**  
**JKU-IPMT**  
**UFG-ID**  
**UIBK-EGEE**

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**UIBK-EGEE**

**AEE-INTEC**  
**JKU-IPMT**  
**WIFO**  
**UIBK-EGEE**



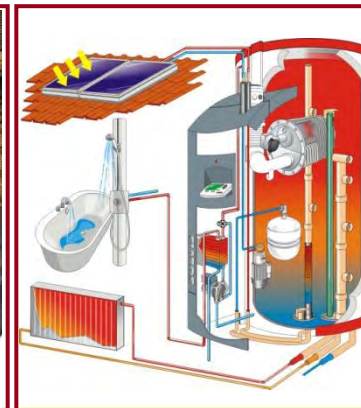
**Materials**



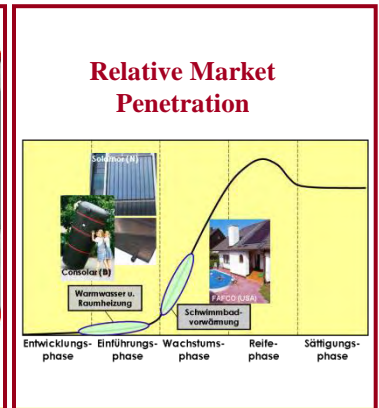
**Processing Technologies**



**Subcomponents, Components**



**Solar-thermal System**



**Perspectives and Effects**

**AGRU**  
**APC**  
**Borealis**  
**KE KELIT**

**AGRU**  
**ENGEL**  
**Greiner**  
**Schöfer**  
**Lenzing**

**ENGEL**  
**Greiner**  
**Schöfer**  
**Sunlumo**  
**SUN MASTER**

#### 10 Company Partners

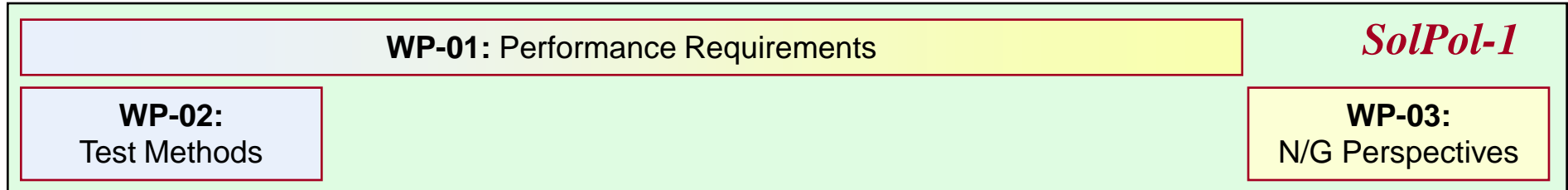
**Total Budget SolPol-1&2:** 5.1 Mio. €  
**Duration:** 2011-2013  
**Cost for Company A (In-Kind):** 0.3 Mio. €  
**Leverage effect:** factor 17 (!)



# Overview SolPol-1,2

## Structure of the Research Program

### Positioning of Work Packages along the Value Creation Chain



**Materials**

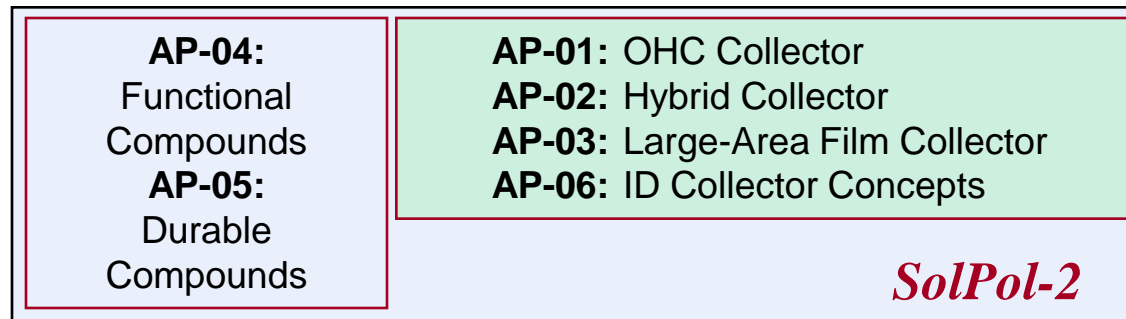
**Processing Technologies**

**Subcomponents, Components**

**Solar-thermal System**

**Relative Market Penetration**

**Perspectives and Effects**



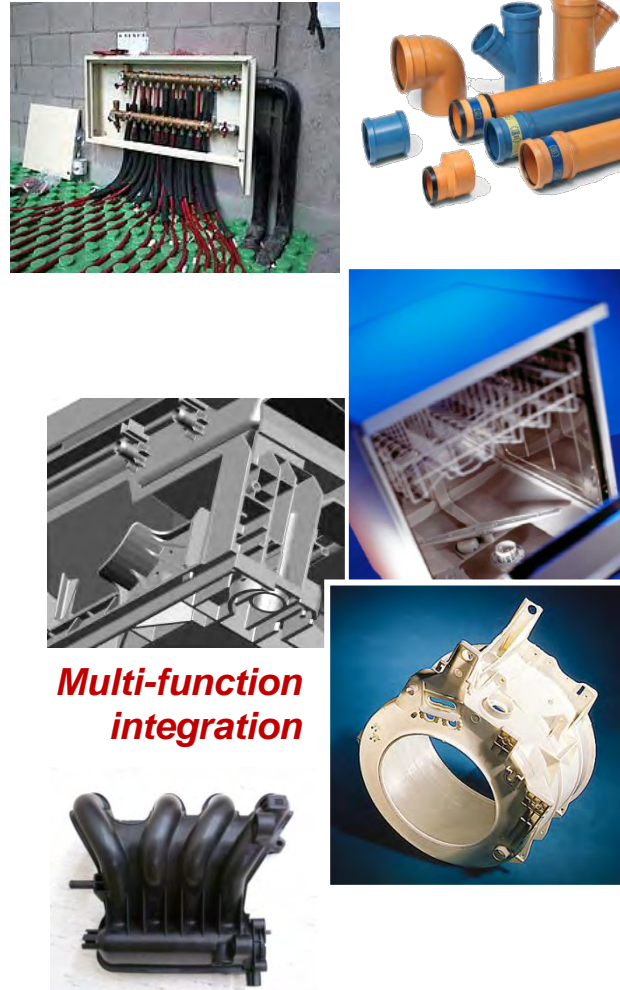
# Overview SolPol-1,2

## Hypothesis 3: Collaboration & Learning from Others

**Glazing & insulation**  
(optical & thermal properties)



**Pressure vessels & liquid containers**  
(mechanical & therm prop.)



**Building integration**  
(multifunctional & attractive design)



### SolPol-3: Solarelectrical Systems based on Polymeric Materials Novel Polymeric Encapsulation Materials for PV Modules

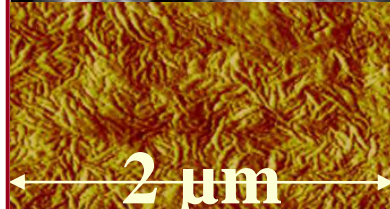
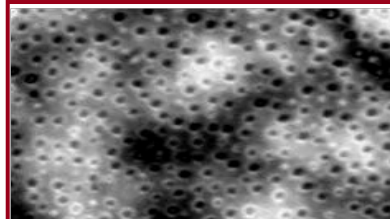
#### 3 Scientific Partners

**JKU-IPMT**  
**JKU-IAC**

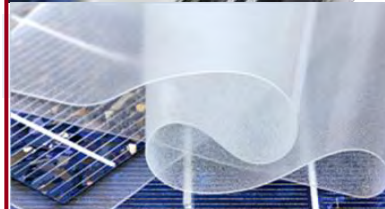
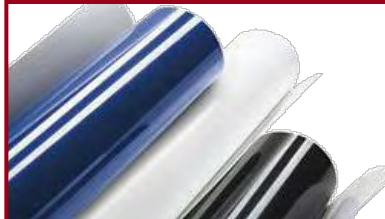
**JKU-IPMT**  
**JKU-IAC**

**AIT**

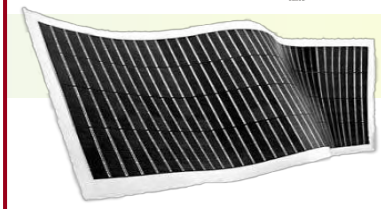
**JKU-IPMT**  
**AIT**



**Encapsulation  
Materials**



**Encapsulation  
Films**



**Rigid and flexible  
PV Modules**



**Integrated  
PV System**

**APC**  
**Borealis**  
**Perkin Elmer**

**Lenzing**  
**SENOPLAST**  
**Perkin Elmer**

**KIOTO**  
**Sunplugged**

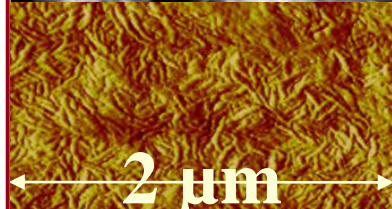
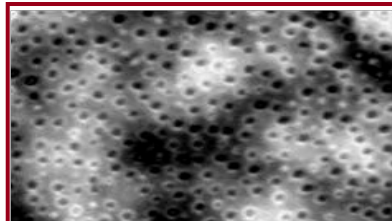
#### 7 Company Partners

# Overview SolPol-3

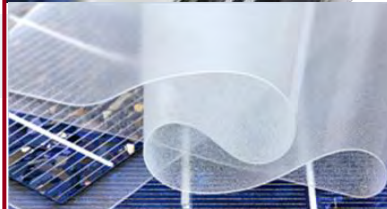
## Structure of the Research Program

### SolPol-3: Solarelectrical Systems based on Polymeric Materials Novel Polymeric Encapsulation Materials for PV Modules

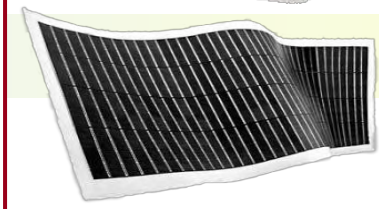
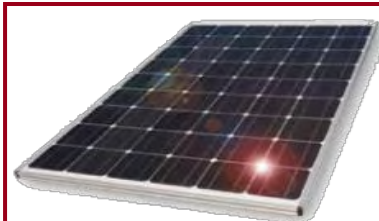
**WP-01: Performance and Test Methods**



**Encapsulation Materials**



**Encapsulation Films**



**Rigid and flexible PV Modules**



**Integrated PV System**

**WP-02: Embedding Films**

**WP-03: Backsheets and Frontsheets**

**WP-04: Rigid Modules**

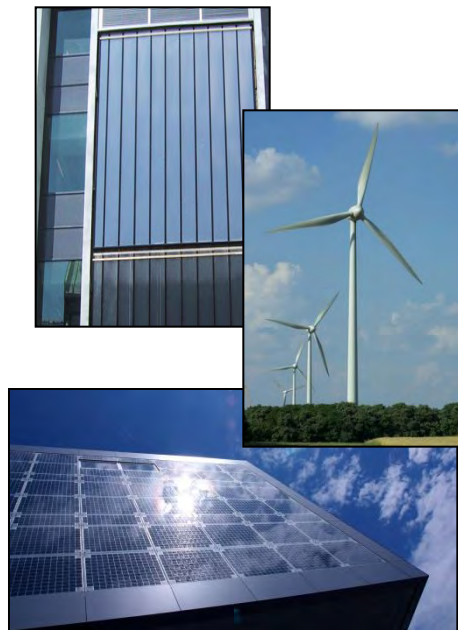
**WP-05: Flexible Modules**

## IPMT Research Profile: 4 major areas of technology orientation

**Water**  
(supply, disposal)



**Energy**  
(solar, wind, water)



**Mobility**  
(ultra-light vehicles)



**“Regenerative“ Plastics**  
(renewable resource base)



### **The Millenium Development Goals (MDG) - United Nations, 2008**

- **Water:** ~ 1 bill. people without access to clean and sufficient water  
~ 2.5 bill. people without proper sanitation
- **Energy:** > 2 bill. people with insufficient access to energy

## Future Perspectives and Outlook

### Individual Mobility: Ultra-lightweight Vehicles - From Vision to Reality ?

#### Current reality



#### Triathlon-Bicycle



Learning

#### Vision for Individual Mobility:

*Re-design of vehicles to highly efficient electric-ultralightweight vehicles of high safety and comfort.*

- 1 - 2 Persons: ca. 60 - 180 kg
- Vehicle mass: 1 - 2 t
- Power: >50 kW

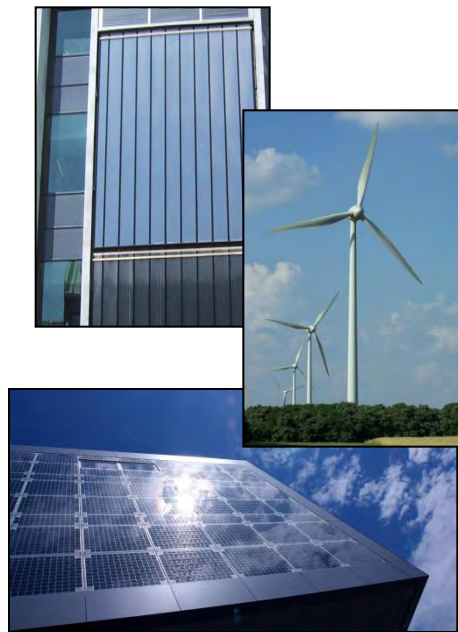
- 1 Person: 60 - 80 kg
- Vehicle mass: ca. 0.01 t
- Power: <1 kW

## IPMT Research Profile: 4 major areas of technology orientation

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