International Energy Agency (IEA) PVPS Task 12: Environment, Health and Safety

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with contributions from:

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Mariska de Wild-Scholten, ECN

Karsten Wambach, SolarWorld

European Industry Association PV Industry Forum

22nd EUPVSEC, Milan, Italy, Sept. 5, 2007

Motivation

- Promote international collaboration on EH&S and sustainability
- Facilitate a common understanding of technical and perceived EH&S issues
- Disseminate knowledge to stake holders and energy-policy decision makers

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Justification

- The growth of PV is based on the promise of environmentally friendly energy generation and is sustained by the support of the environmentally conscious public
- Competitive interests try to undermine PV environmental benefits and prospects
- We need to be proactive, ahead of environmental regulations
- International collaboration is needed as “we are all partners in safety”

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Task 12 Objectives

- Quantify the EH&S profiles of PV in comparison to other energy technologies
- Define and address EH&S and sustainability issues that are important for market growth

Task 12 Technical Experts/Contributors

(committed during kick-off meeting, March 16/07, Brussels)

Name	First Name	Country	Company/ Organization
Alsema	Erik	The Netherlands	Utrecht University
Despotou	Eleni	Belgium	EPIA
Fthenakis	Vasilis	USA	Brookhaven National Laboratory
Held	Michael	Germany	LBR Stuttgart University
Jungbluth	Niels	Switzerland	ESU-services
Polz	Werner	Austria	Umweltbundesamt GmbH
Shibasaki	Maiya	Germany	LBP Stuttgart University
Salomon	Oliver	Germany	ZSW
Glockner	Ronny	Norway	ELKEM Solar
Wambach	Karsten	Germany	Deutsche Solar
de Wild-Scholten	Mariska	The Netherlands	ECN

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Task 12 Organisation

- Sub-task 1: Recycling of manufacturing waste and spent modules
- Sub task 2: Life cycle assessment
- Sub-task 3: EH&S in Manufacturing Facilities
- Sub-task 4: Information Dissemination

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Activities /Expertise in Europe (partial list)

1. Utrecht/ECN: Energy analyses, risk assessments and LCA's for PV technology, since 1990;
2. Crystal Clear project – Sustainability and recycling (2004-2008);
   - crystalline silicon technology – existing and future
   - up-to-date LCI data collected, published and analysed
3. RESOLVED project – recycling of thin film modules: LCA study

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Activities /Expertise in Europe (partial list)

4. PV CYCLE

- Aims in:
  - Supporting recycling research projects,
  - Defining a voluntary take back and recovery system for PV modules,
  - Supporting education and information programs for owners of PV modules,
  - Promoting industry-leading sustainable product life cycle management.

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Planned and Proposed Activities in Europe

1. Further work within CrystalClear (c-Si) :
   - Evaluation of new processes
   - Update of LCI industrial production (-> status 2008)
   - Use & abatement of fluorinated gases
2. Proposed FP6/FP7 projects
   - Concentrators
   - Dye sensitized cells
   - CdTe
   - All major cell technologies -Updates

Activities /Expertise in the United States

- Life Cycle Analysis
  - Greenhouse Gas Emissions
  - Energy Payback Times (EPBT)
  - Toxic Emissions
- Recycling (Collection Infrastructure, Recovery of Cd, Te, Se, In)
- Silane Safety
- Risk Analysis
- Comparisons of PV with other energy technologies
- Solar energy potential to satisfy all the US energy needs

SubTask 1 -Recycling

Task 12 PV EH&S	Leader	
	Country	**Name**
Activity 1a c-Si recycling	DEU	Karsten Wambach
Activity 1b Thin-film recycling	US	Vasilis Fthenakis
Activity 1c Collection Infrastructure	EPIA	PVCycle

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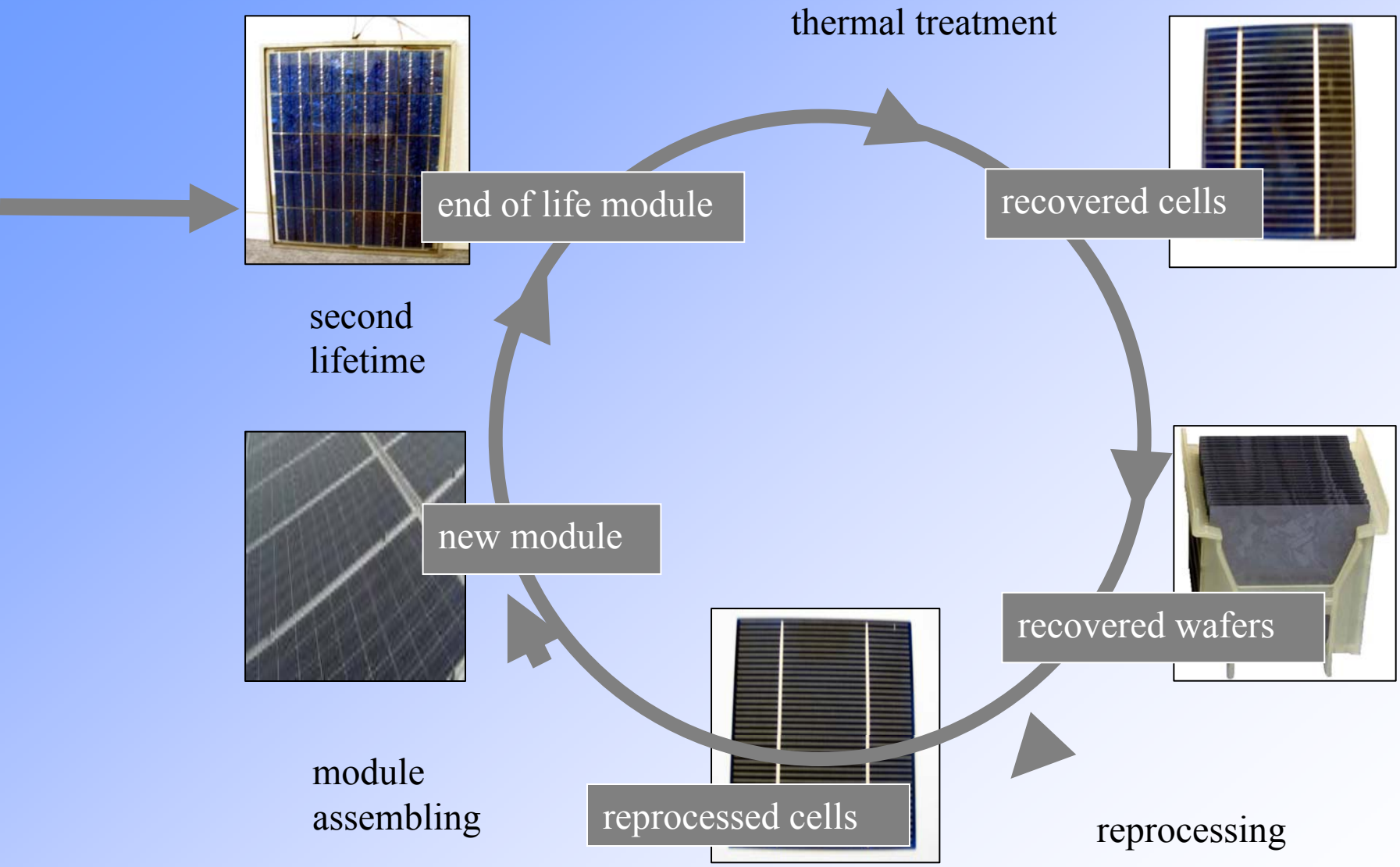
Highlights of Recycling Research & Implementation

Module Recycling -Deutsche Solar AG



Recycling Activities of SolarMaterial

Recycling of:

- by-products like sides of ingots
- defective semi-finished products like ingots, wafer, cells
- end-of-life modules and modules with transport damage or other defects

sides of an ingot

defective ingot

wafer breakage

cell breakage

modules

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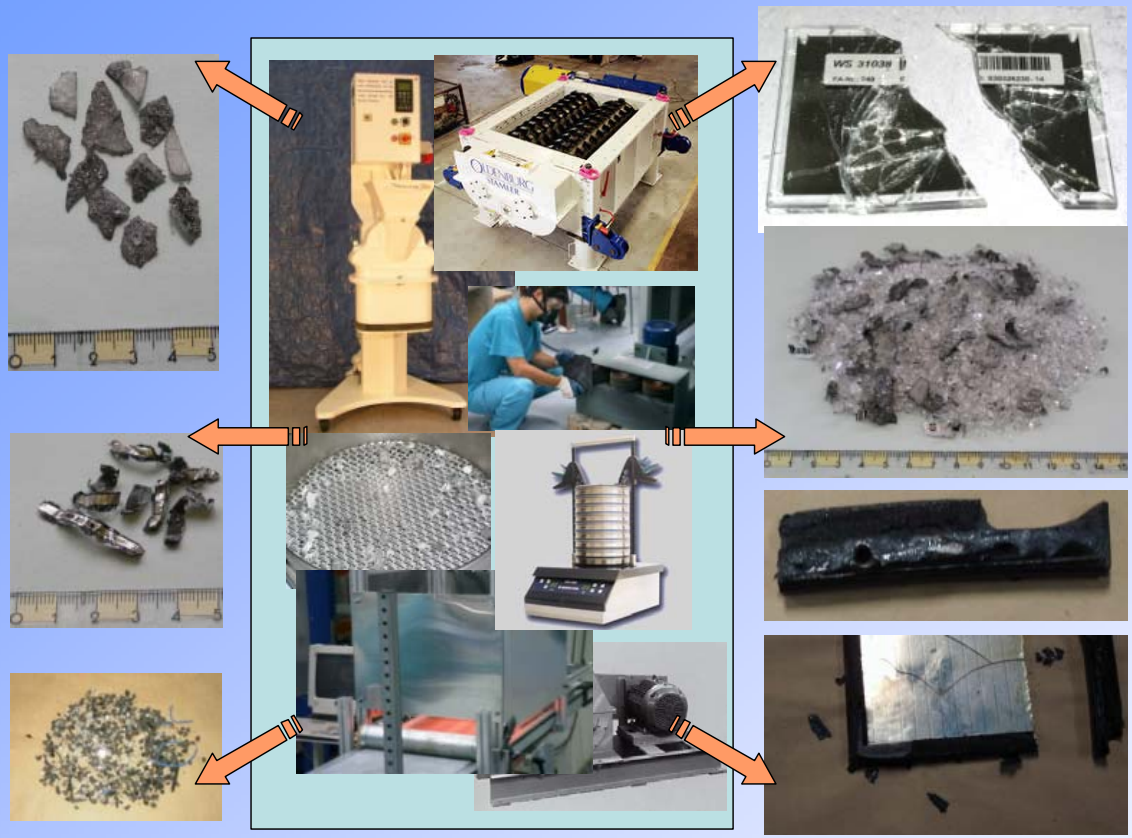
GaBi

Recycling of thin-film solar cells

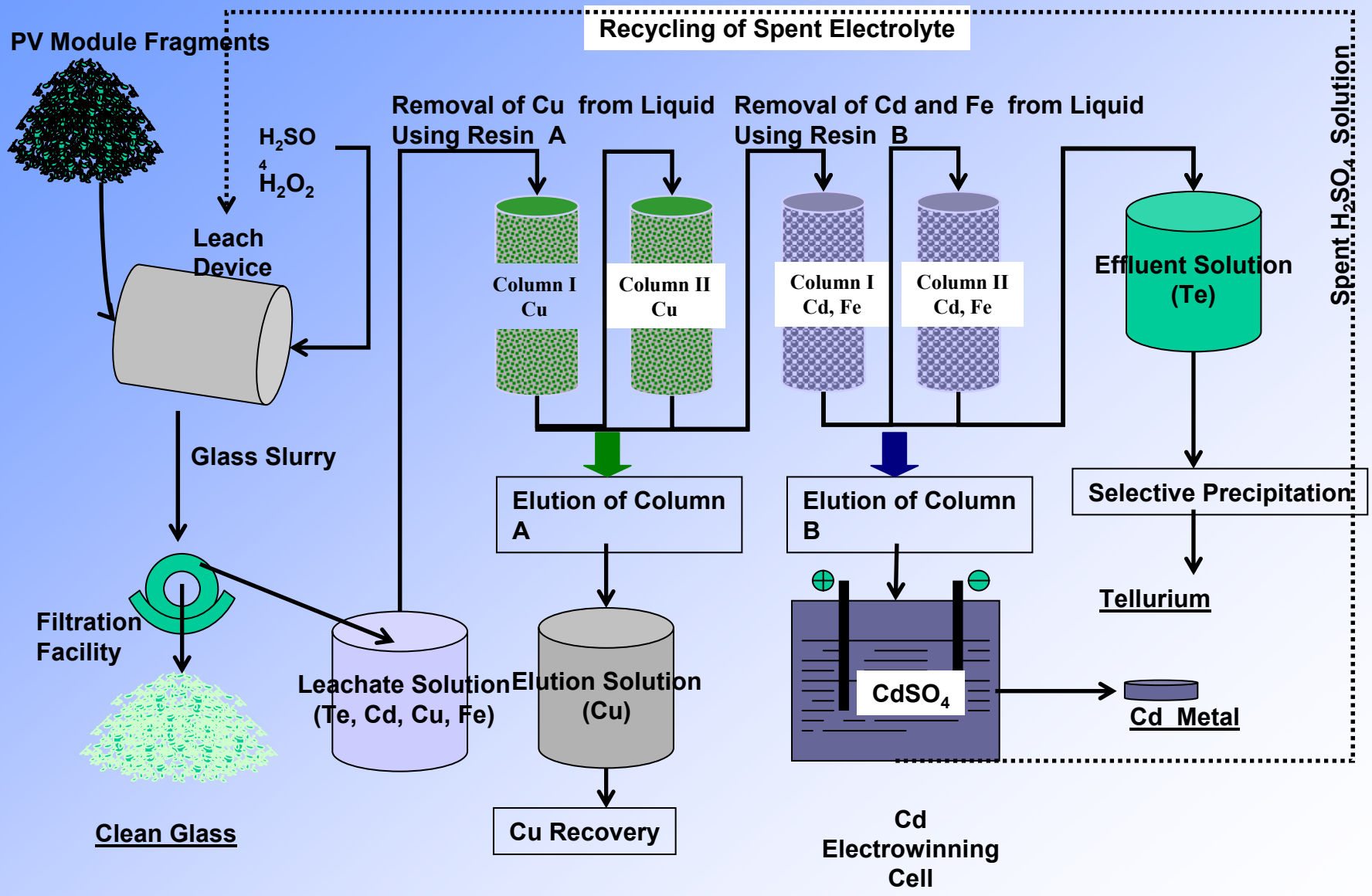
first tests



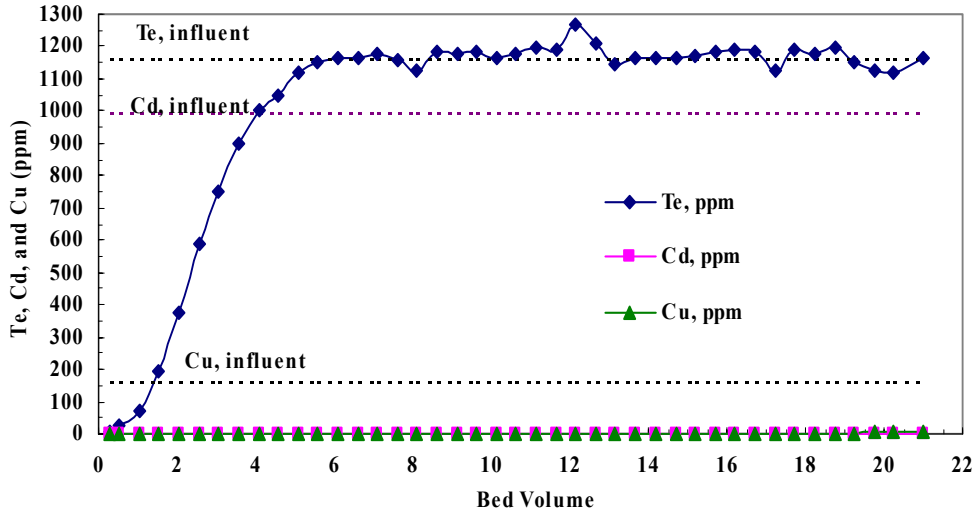
Recycling Steps

Dismantling
Crushing & Grinding
Thermal Treatment
Hot wire cutting
Ablation, Sanblasting
Water jet cutting
Chemical treatment
Glass melting

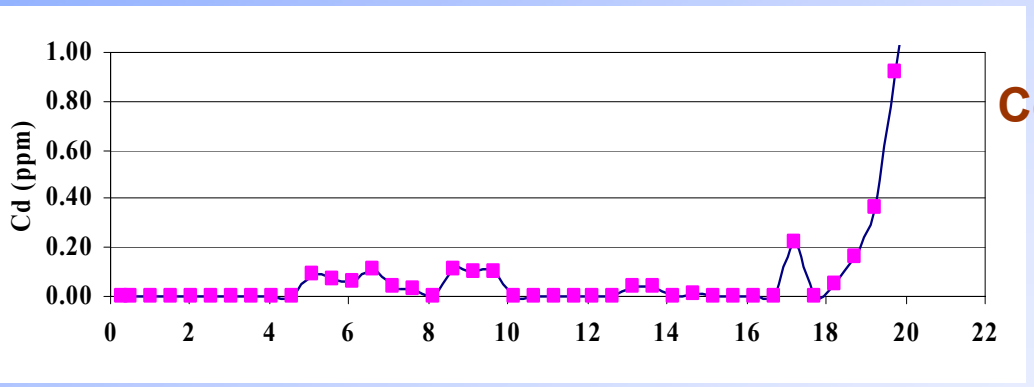
Recycling of Cd and Te from CdTe (Se and In from CIGS) PV Modules



Separation of Cd from Te in CdTe Recycling



Cd separation 99.99%



Cd effluent concentration <0.3 ppm

RESULT: Cd, Te extraction & separation completed at a projected cost of 1 ¢/W_p

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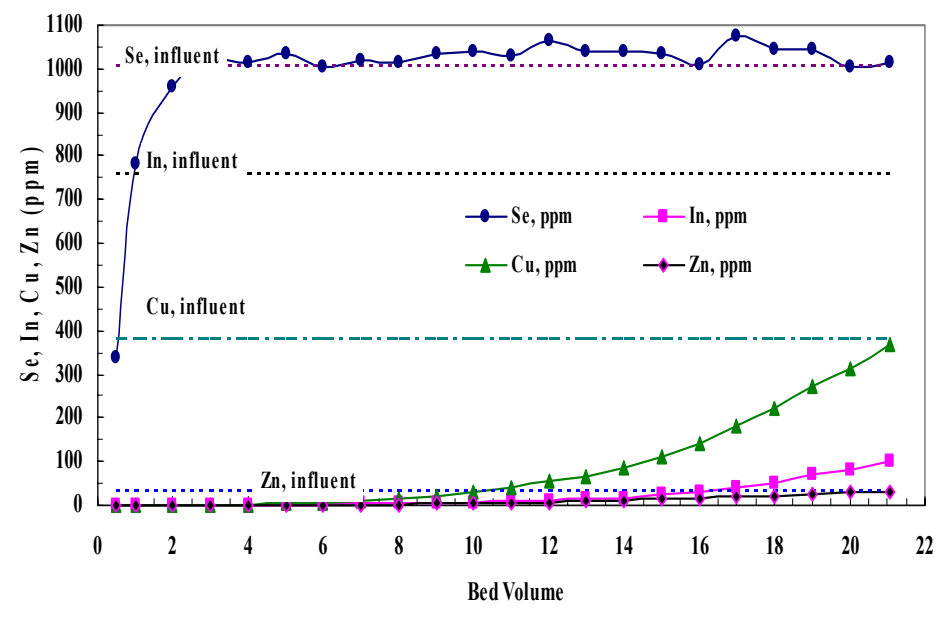
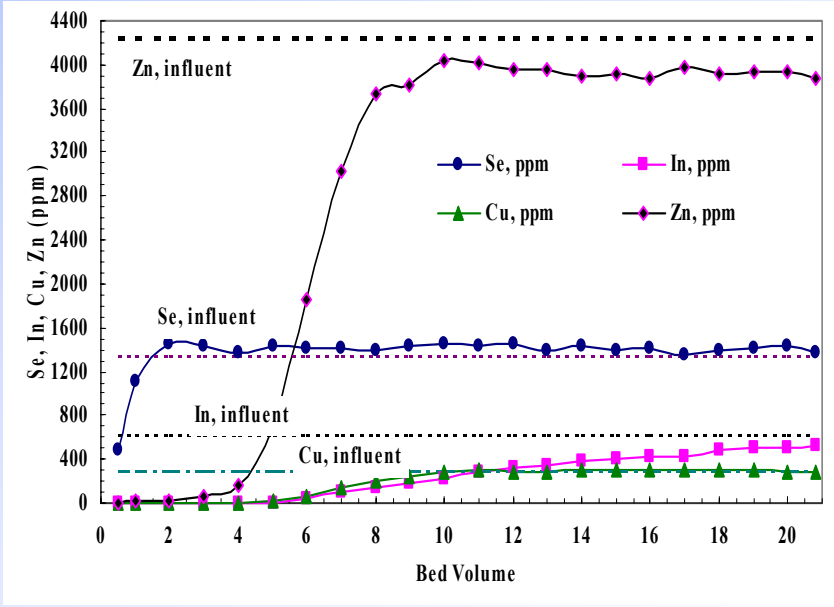
Separation of Se, In, Cd and Zn in CIGS Recycling





Research in progress

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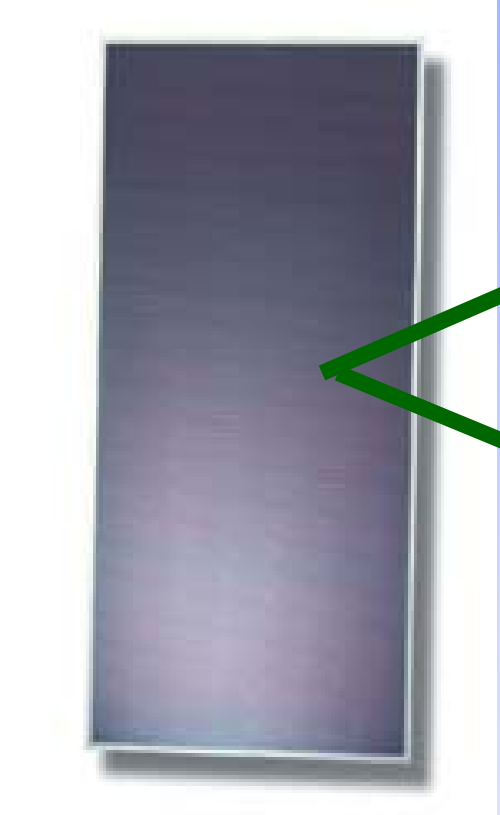
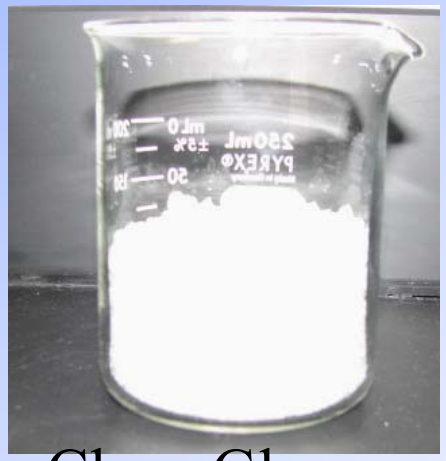
First Solar Module and Manufacturing Scrap Recycling

Recycling Steps

- Module/scrap size reduction
- Film removal
- Solid-Liquid separations
- Glass-EVA separation
- Glass rinsing
- Precipitation
- Dewatering

First Solar Process Results





Clean Glass

Module (and manufacturing scrap)

Metals rich filter cake

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Subtask 2 –Life Cycle Analysis

Task 12 PV EH&S	Leader	
	Country	**Name**
Activity 2a Guidelines for common approach	All	Erik Alsema / Niels Jungbluth/ Vasilis Fthenakis
Activity 2b Mono and multi- c-Si US	NL	Erik Alsema/ Mariska deWild
Activity 2c Ribbon c-Si	NL	Mariska deWild/ Erik Alsema
Activity 2d a-Si		
Activity 2e CIGS	DEU/IT	Maiya Shibasaki/ Marco Raugei
Activity 2f CdTe	US/IT	Vasilis Fthenakis/Marco Raugei
Activity 2g Concentrator PV	SPAIN/US/NL	TBD/ Vasilis Fthenakis/Mariska de Wild
Activity 2h Production of Si feedstock	NORWAY	Ronny Glockner
Activity 2i Incorporate data in Ecoinvent	SWISS	Niels Jungbluth

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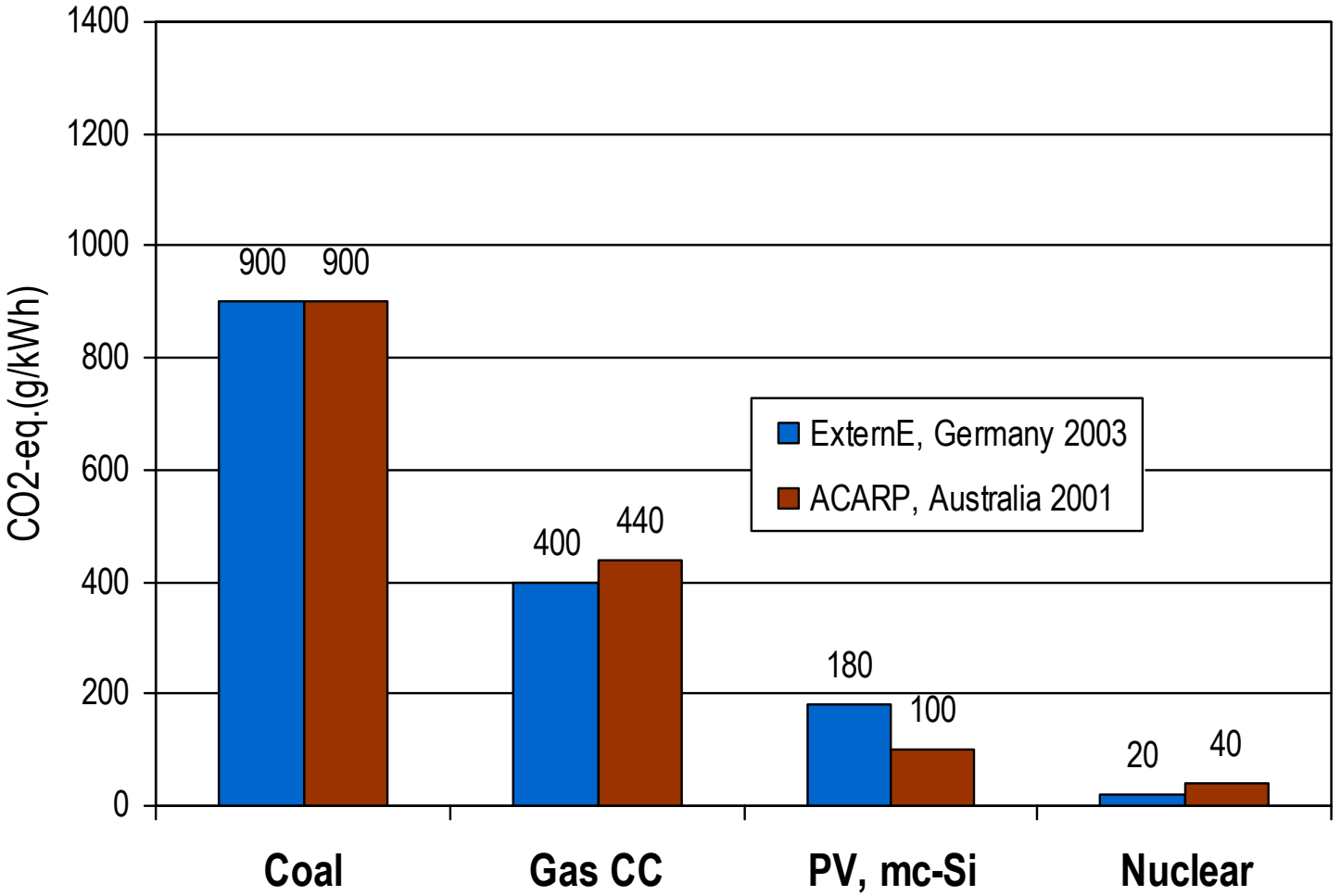
Competitive interests try to undermine PV environmental benefits

-GHG Emissions -ExternE & Australian Coal Association Research Programs-



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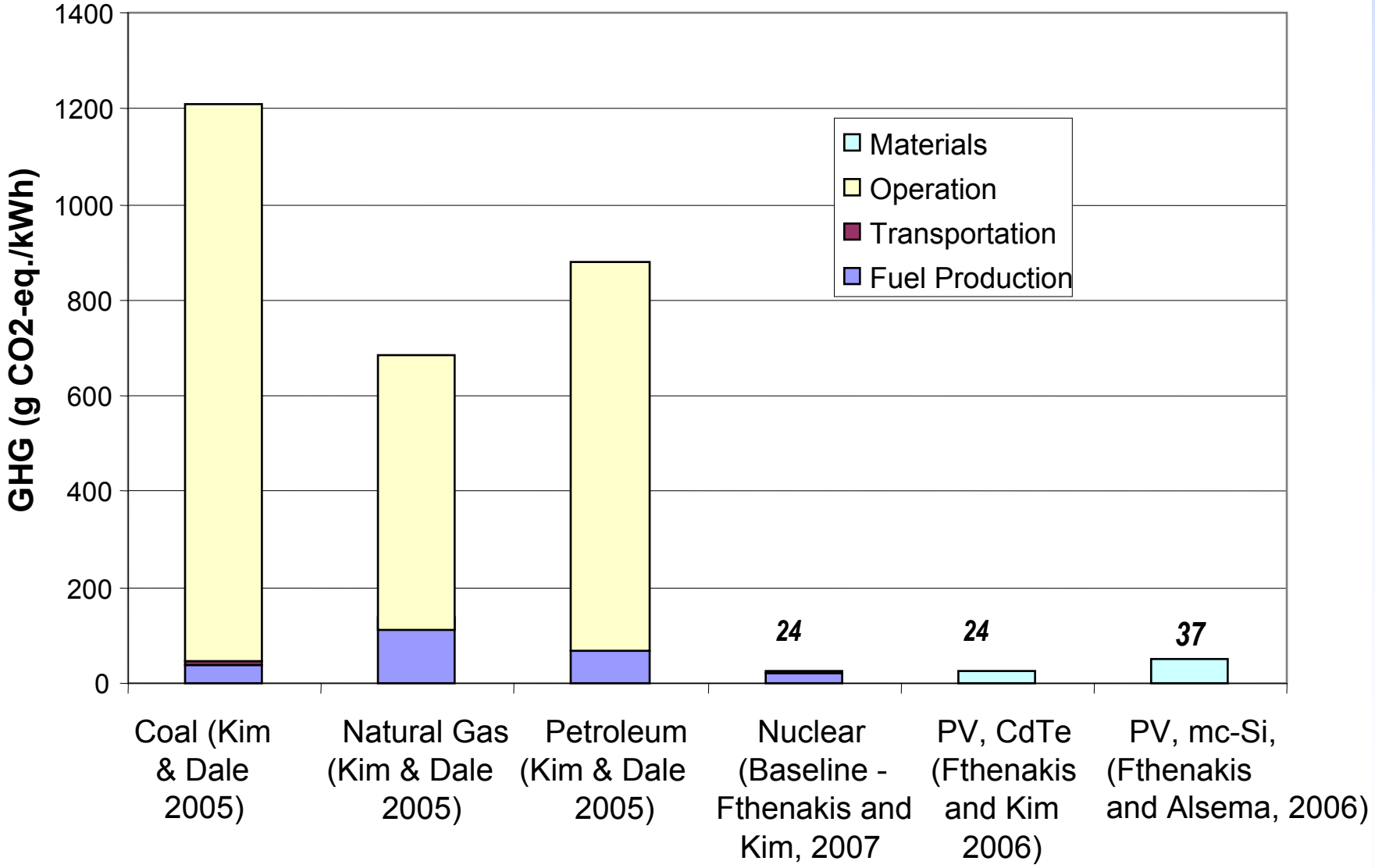
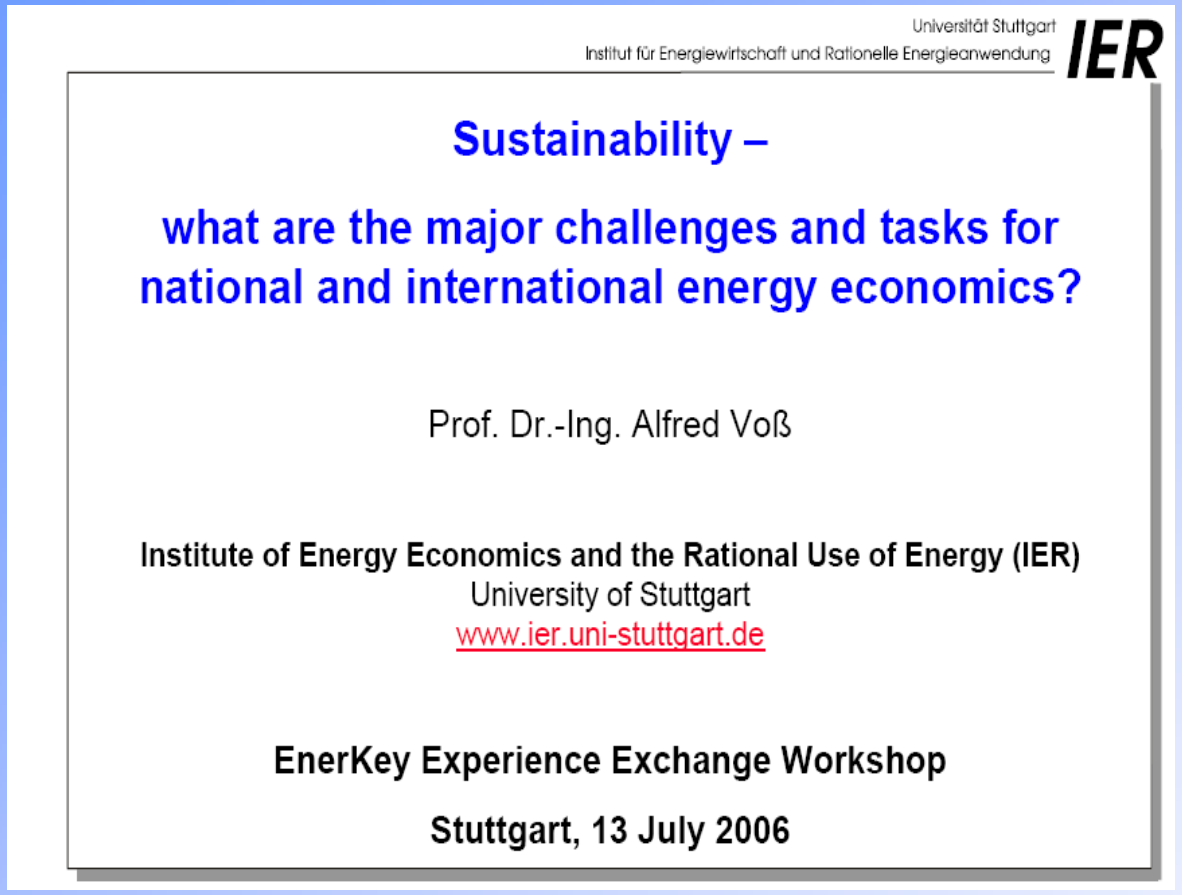
Life Cycle GHG Emissions: *BNL/Utrecht/ECN Updates*



Energy Payback Times (EPBT): Studies by Others



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Institut für Energiewirtschaft und Rationelle Energieanwendung
IER

Sustainability –

what are the major challenges and tasks for national and international energy economics?

Prof. Dr.-Ing. Alfred Voß

Institute of Energy Economics and the Rational Use of Energy (IER)
University of Stuttgart
www.ier.uni-stuttgart.de

EnerKey Experience Exchange Workshop

Stuttgart, 13 July 2006

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Energy Payback Times (EPBT): Studies by Others

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Sustainability –

what are the
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EnerKey

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Specific Cumulated Energy Demand (CED) and Energy Pay-Back Time (EPBT)

	Cumulative Energy Demand (CED) (without fuel) [kWh_{Prim} / kWh_{el}]	Energy Pay-Back Time (EPBT) [months]
Hard Coal	0,27	3,1
Lignite	0,16	3,2
Gas CC	0,17	0,8
Nuclear (PWR)	0,07	2,8
Wood CHP	0,08	13,2
PV-Modul poly 5 kW	0,61	66,3
WEA 1500 kW (5,5)	0,06	4,9
WEA 1500 kW (4,5)	0,08	7,2
Hydro 3,1 MW	0,04	11,0

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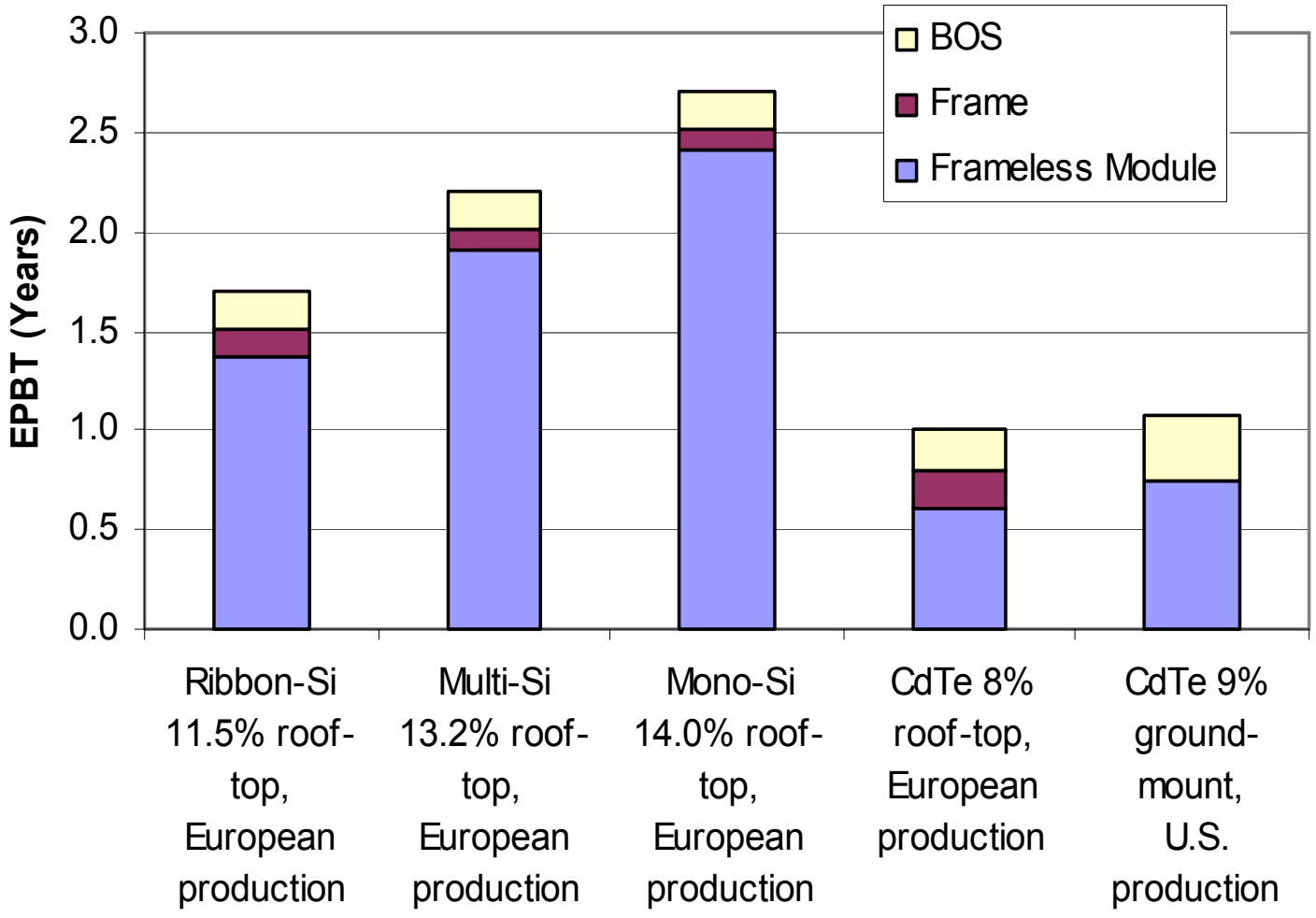
Updated Energy Payback Times



-Alsema & de Wild, *Material Research Society, Symposium vol. 895, 73, 2006*

-deWild & Alsema, *Material Research Society, Symposium vol. 895, 59, 2006*

-Fthenakis & Kim, *Material Research Society, Symposium vol. 895, 83, 2006*

-Fthenakis & Alsema, *Progress in Photovoltaics, 14, 275, 2006*

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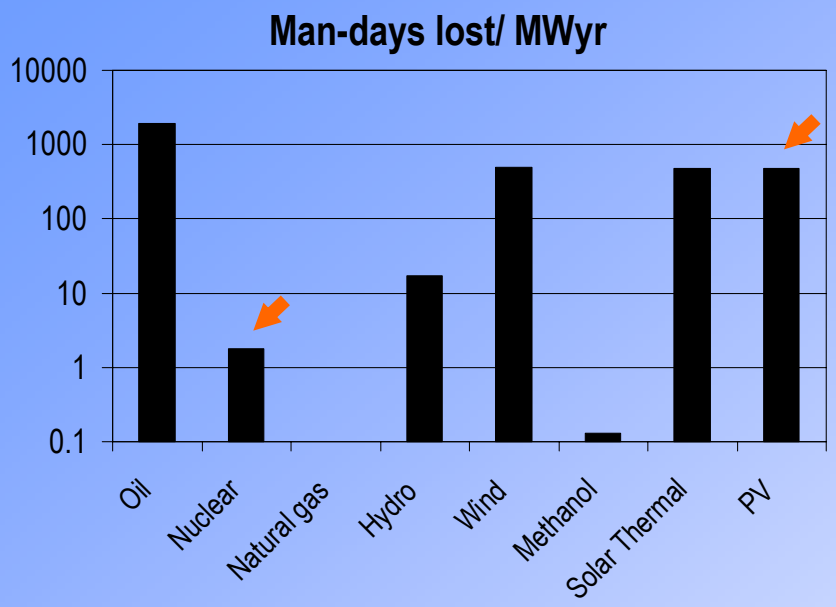
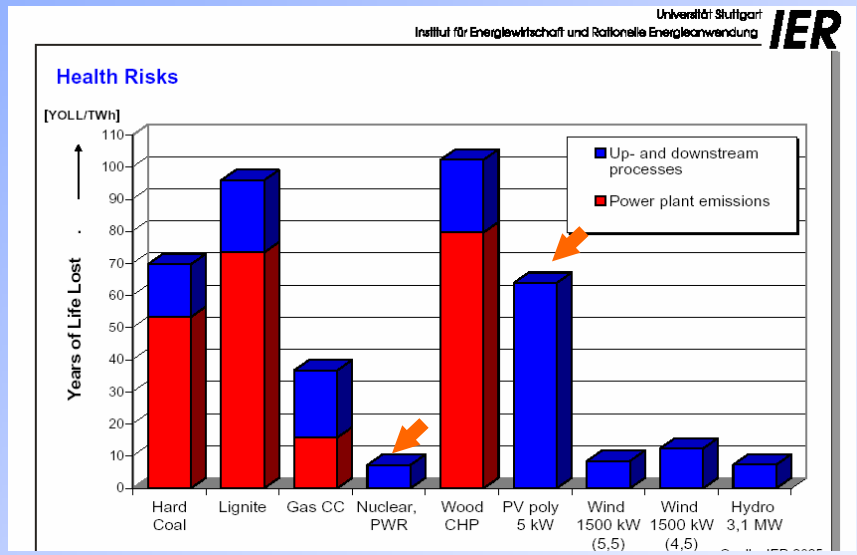
PV Risks: Studies by Others

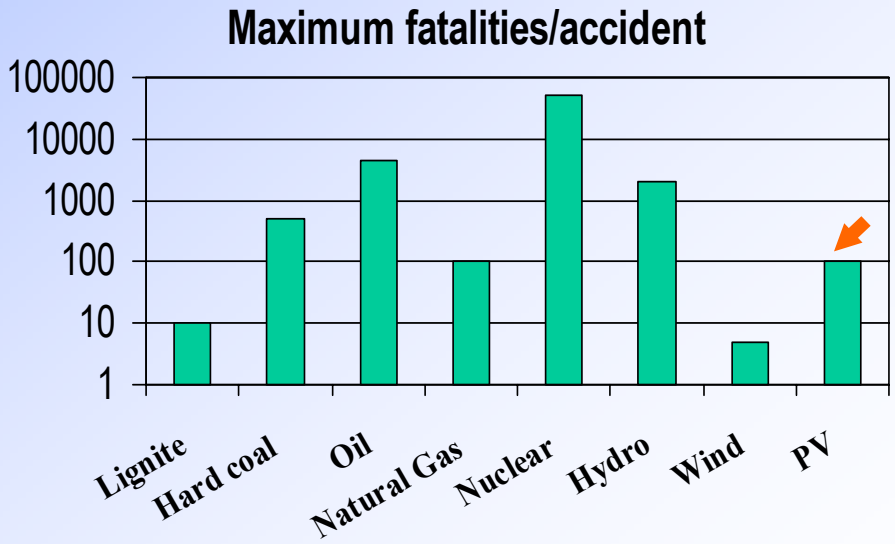


"Solar energy systems have greater material requirements .., so public risks from emissions will be greater"(Inhaber, *Science,* 1979*)*

"Commercial nuclear power is 10-15 times less risky than PV" (Bezdek, *Energy, 1993)*



IER Stuttgart, Voß, 2006



Paul Scherrer Institute (PSI), Hirschberg et al., 2004)

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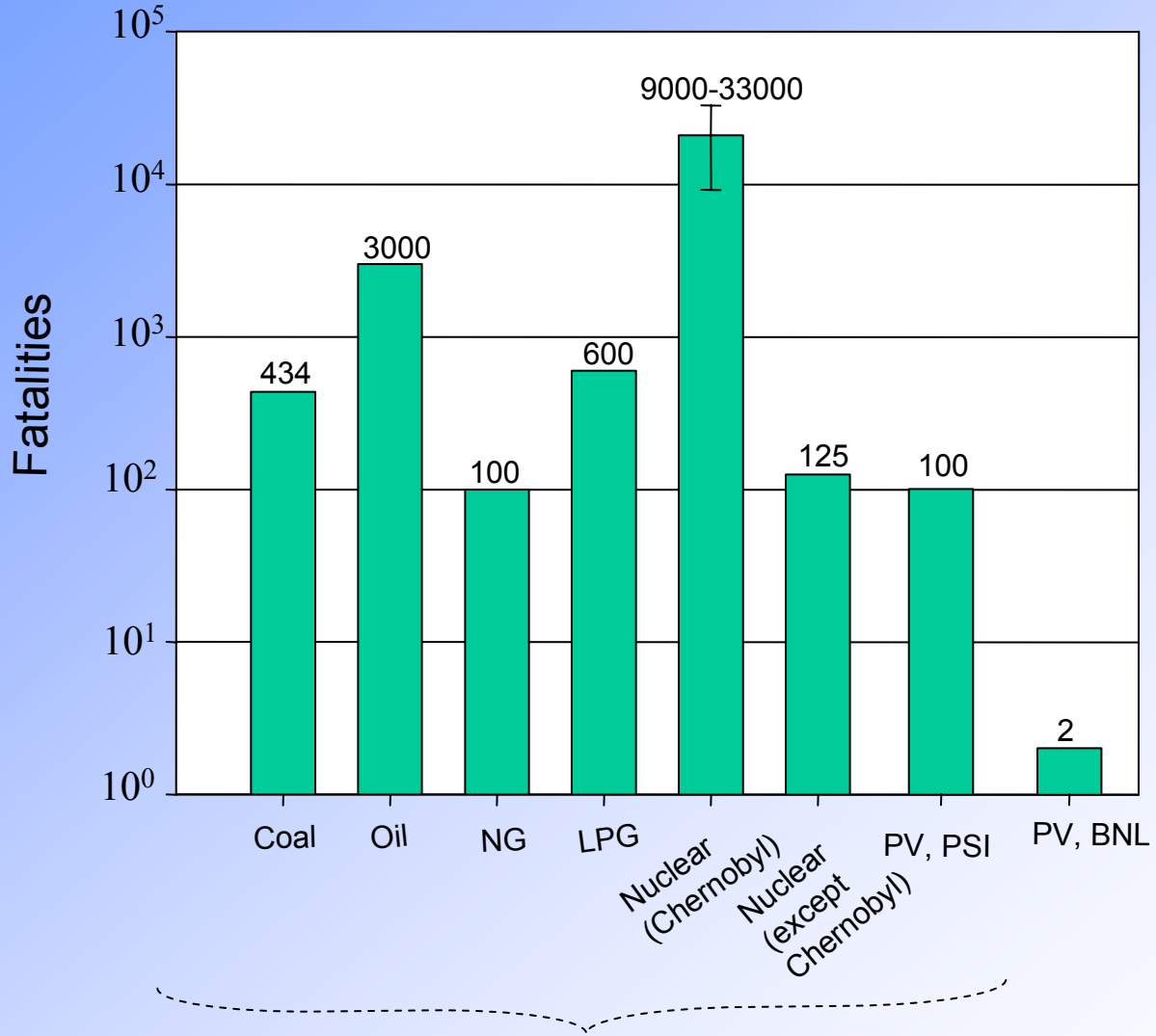
PV Risks –BNL Update

Maximum Consequences per Accident: *BNL Update*

Presented at the California Energy Commission Nuclear Issues Workshop, Sacramento, CA, June 28, 2007



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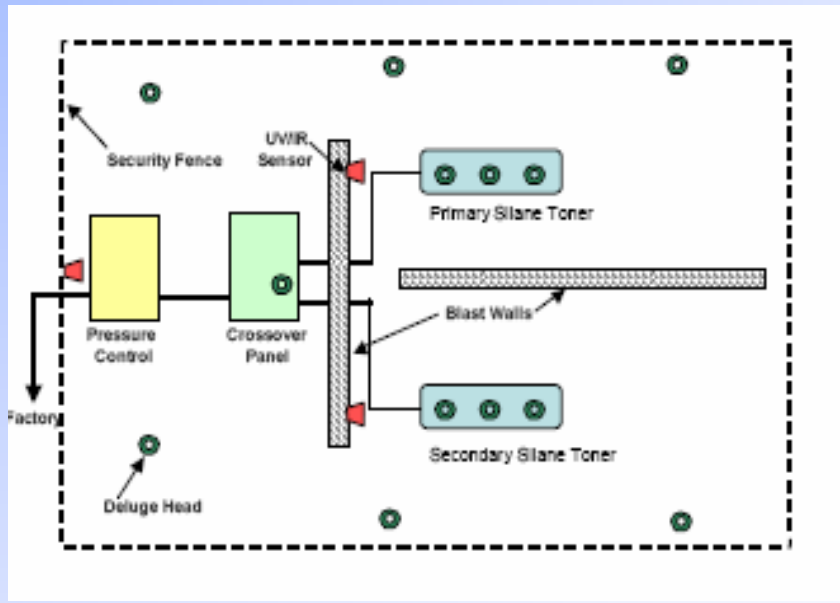
Subtask 3- Facility Safety



Analysis of a silane explosion in a photovoltaic fabrication plant,

AIChE Process Safety Progress, 2006

Guidelines for semi-bulk silane safety, 21nd EUPVSEC, Dresden, GR, 2006

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Task 12 PV –EH&S Forthcoming Workshops

- Workshop on recycling infrastructure in collaboration with PV Cycle

- Expert Workshop on Life Cycle Assessment of PV technology

Additional participations are welcome!

"We are all partners in safety"

Email: VMF@BNL.GOV

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Task 12 PV –EH&S

Working together means winning together !

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