PV technology development

Achievements, challenges and opportunities

The Implementation Plan for the Strategic Research Agenda

Wim Sinke
on behalf of Working Group 3: Science, Technology & Applications

4th General Assembly
Vienna, 19 June 2009

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PV technology development:

- where are we & where do we want to get?

Research in support of the Solar Europe Initiative and beyond – the Implementation Plan:

- categories
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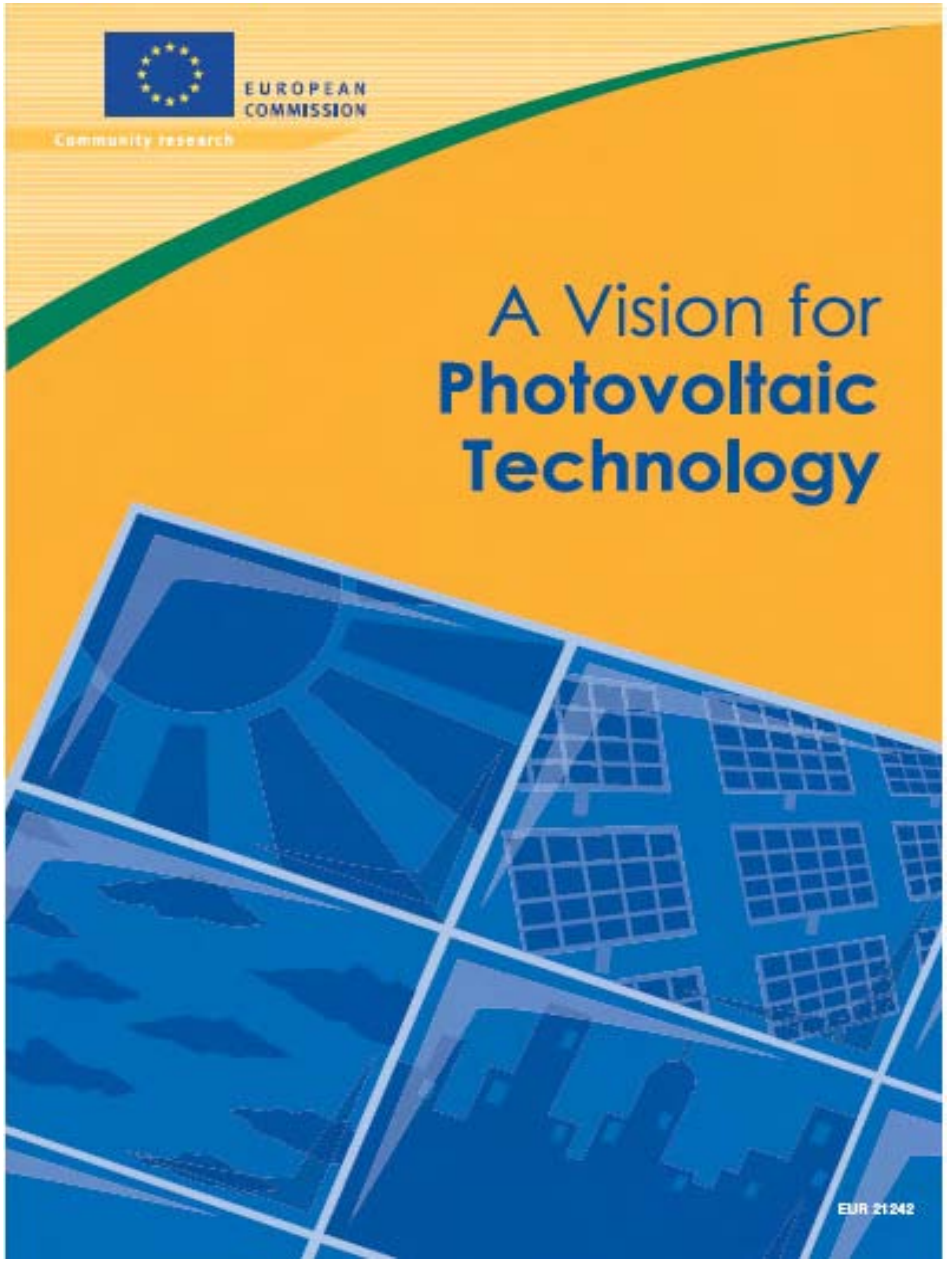
- instruments
- interactions

Outlook



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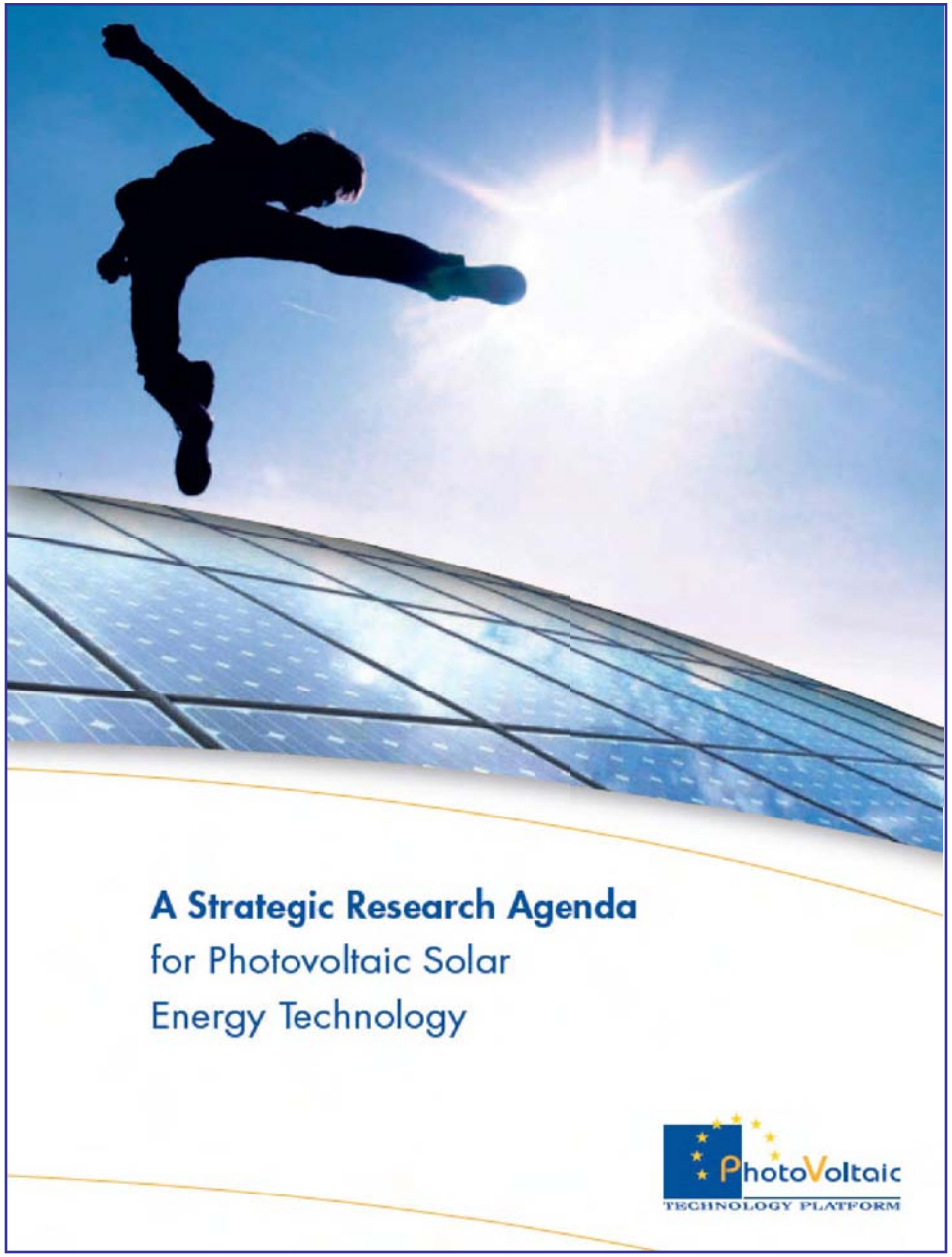
TECHNOLOGY PLATFORM

R&D crucial for realisation of the Vision

Addresses EU ánd member states

Need for a common document describing R&D fields, topics and priorities

→ **Strategic Research Agenda**



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Describes ***what*** needs to be done

www.eupvplatform.org

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Describes ***how***
the SRA findings and
recommendations
can be put into practice

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PV technology development
status and targets

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Rounded, indicative figures	**1980**	**2009**	**2020**	**2030**	**Long term potential**
Typical turn-key system price (2009 €/Wp)	**>30**	**4** ***(range 3 ~ 7)***	**2** ***(range <1.5 ~ 3)***	**<1**	**0.5**
Typical electricity generation costs Southern Europe (2009 €/kWh)	**>2**	**0.25**	**0.12** ***(<0.10 ~ 0.18)***	**<0.06**	**0.03**
Typical commercial *flat-plate* module efficiencies	**up to 8%**	**up to 15%**	**Up to 20%**	**up to 25%**	**up to 40%**
Typical commercial *concentrator* module efficiencies	**(~10%)**	**up to 25%**	**Up to 30%**	**up to 40%**	**up to 60%**
Typical system energy pay-back time Southern Europe (yrs)	**>10**	**2**	**1**	**0.5**	**0.25**

PV technology development

status and potential

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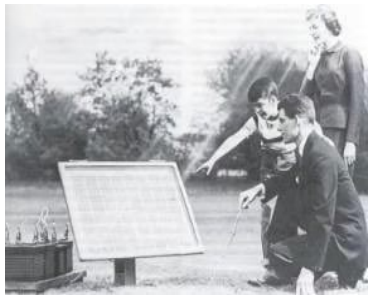
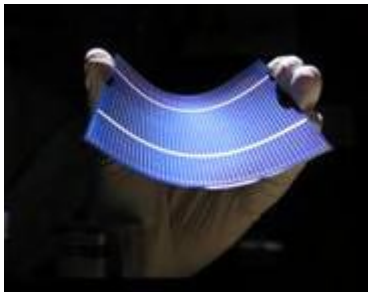
Wafer-based crystalline silicon

½ century of manufacturing experience

high performance

typical module efficiency range:

- 12 ~ 20% (now)
- 18 ~ 22% (longer term)

PV technology development

status and potential

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Thin-film silicon




low-cost potential and new application possibilities

new silicon materials introduced

typical module efficiency range:

- 6 ~ 9% (now)
- 10 ~ 15% (longer term)

PV technology development

status and potential

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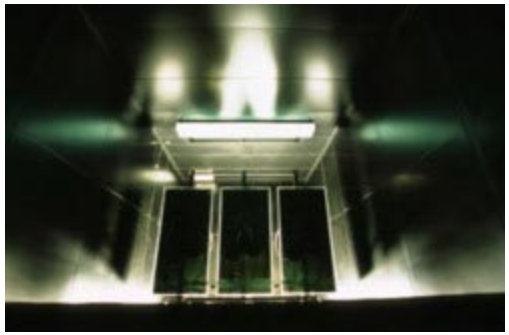
Cadmium telluride


low-cost potential
take-back and recycling systems implemented
typical module efficiency range:

- 9 ~ 11% (now)
- 12 ~ 15% (longer term)

PV technology development

status and potential

Copper-indium/gallium-selenide/sulphide (CIGSS)



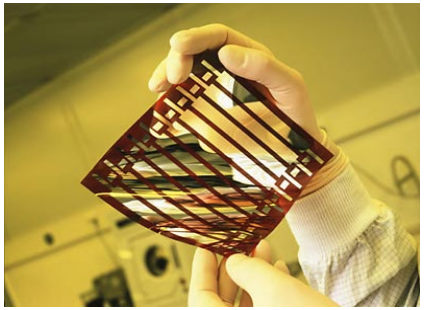

high performance potential
material flexibility
typical module efficiency range:

- 11 ~ 13% (now)
- 14 ~ 18% (longer term)

PV technology development

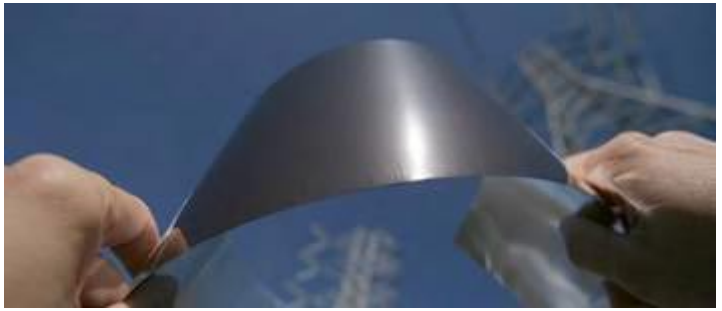
status and potential

Emerging and novel technologies



polymer PV

dye PV

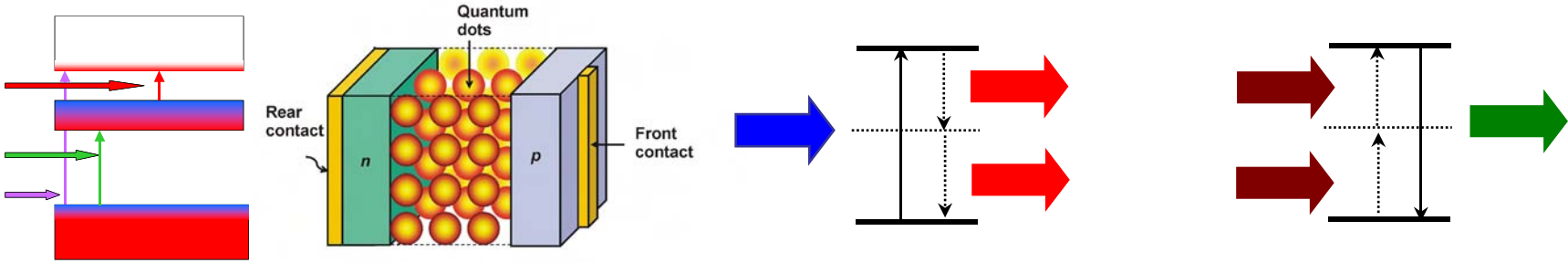


printed CIGS

current emerging technologies primarily candidates for very low cost or new application forms (i.e. not for very high performance)

for some, first applications may appear in niche markets

Emerging and novel technologies



wide variety of new conversion principles and device concepts

mostly aimed at very high efficiencies (“full spectrum utilisation”)

very important in view of long term potential of PV (model systems or nuclei for “disruptive” technologies)

PV technology development

status and potential

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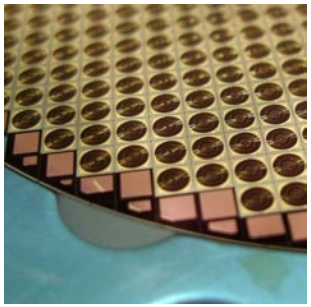
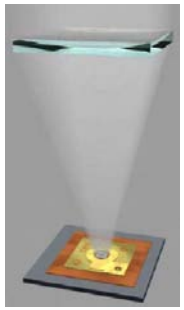
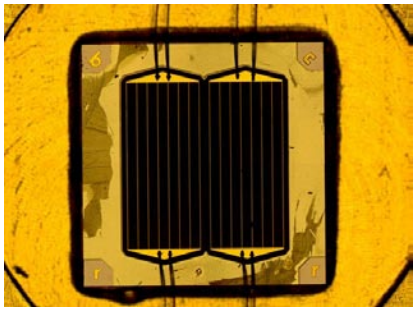
Concentrator technologies


application form of choice for high cost/m^2, super-high efficiency cells

EU world record cell efficiency 41% (Fraunhofer ISE)

23% AC *system* efficiency demonstrated

only concrete way to system efficiencies >30% as yet

PV technology development

status and potential - selection

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BoS-components and PV systems




Now:

- overall system performance -yield, reliability and availability- (even) further improved
- multifunctionality of components and systems gaining interest

Future:

- technology and concepts for very high penetration levels
- dedicated products (e.g. BIPV)

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Outlook

The Implementation Plan

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Introduction: context and overall challenges

Research landscape: R&D strategies worldwide

SRA research needs classified and quantified

Instruments for funding

Knowledge from (and to) other sectors

Education and training

Implementation Plan

Use SRA as basis, but re-structure topics (i.e., not along technology lines):

Enhancing Performance (devices and systems)
Improving Manufacturability & Reducing Cost
Promoting Sustainability
Addressing Applicability

Implementation Plan

Bottom-up quantification and characterisation of R&D needs in terms of:

Project type (basic, applied, industrial)

Public/private funding shares (100/0, 75/25, 50/50, 25/75, “12.5/87.5”)

Funding level (<20, 20-50, 50-100, >100 M€)

Timescale for exploitation (ST, MT, LT)

Implementation Plan

Example of bottom-up quantification and characterisation

Technology Area	Action	Project Type	Funding Public / Private	Funding Level	Timescale for exploitation
Advanced device concepts					
c-Si	• Back-contact cell structures • Heterojunctions for emitters and passivation • Low recombination contacts • New device structures	Industrial	12.5/87.5	300 - 400	Short
All thin films	• Implementation of advanced optical concepts and device structures into industrial processes • Novel contact patterns • Novel series connection schemes and (laser) patterning methods • Patterning for BIPV applications	Applied	25/75	100	Short
Concentrators	• Metamorphic triple cells • Optical concepts for very high concentration, increased acceptance angle	Basic	75/25	20-50	Short
	• Low recombination contacts				

Implementation Plan

Budget shares 5 year period

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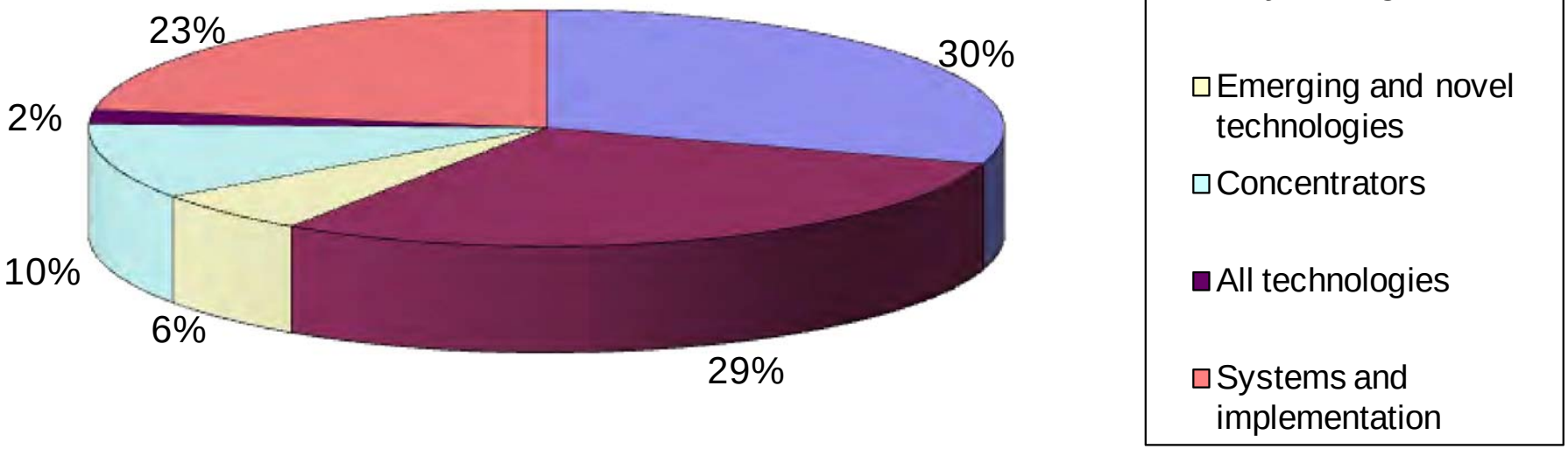
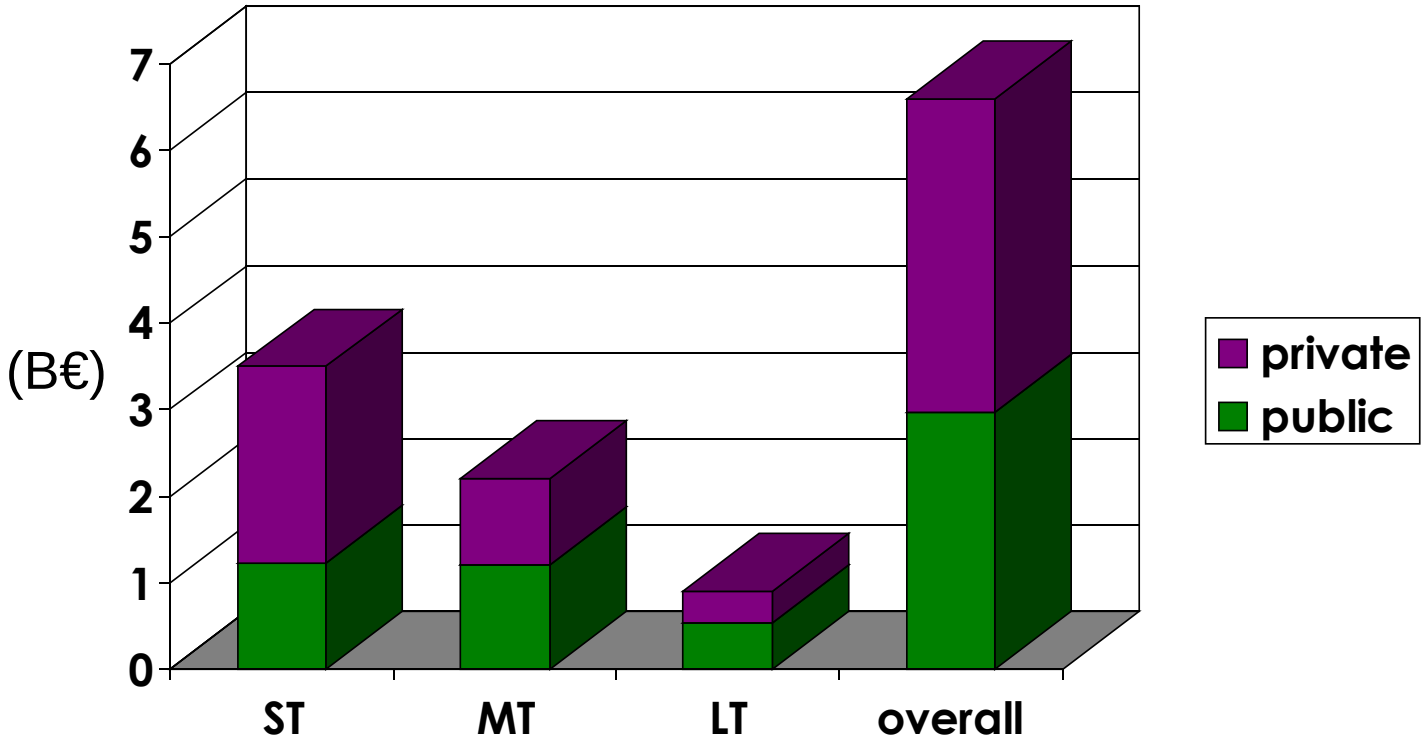
Overall distribution of budget
(total = 6.6 B€)



Implementation Plan

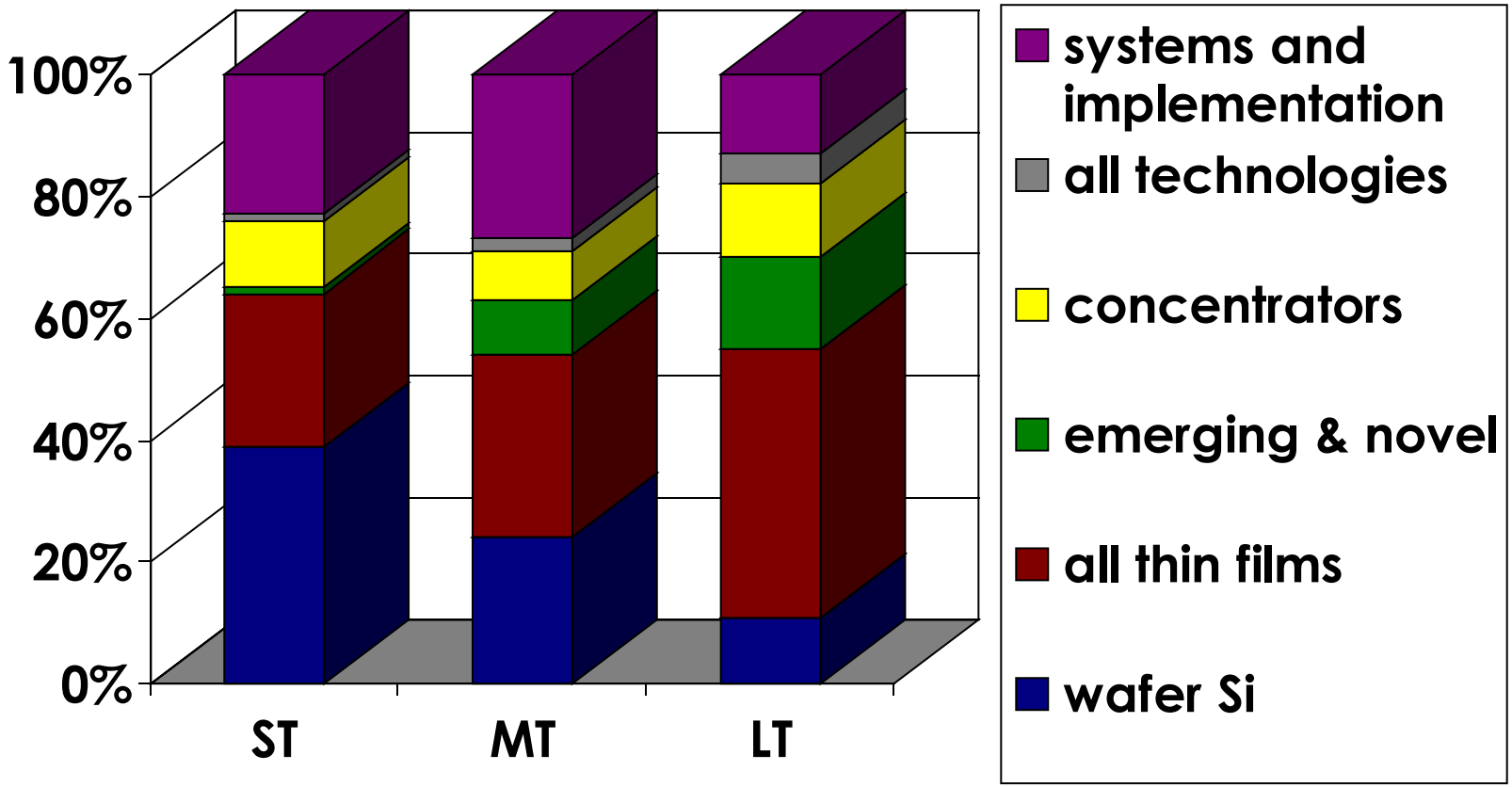
Budget shares 5 year period



Enhancing performance:	55%
Improving manufacturability:	35%
Promoting sustainability:	5%
Addressing applicability:	5%

Implementation Plan

Budget shares vs exploitation timescale



Implementation Plan

Instruments for funding

New stage of PV development and new challenges call for new approaches

Make optimum use of R&D throughout EU

Coherent implementation of R&D policies (EU & MS)

Further shaping of FP7/8, EIT/KICs, (E)ERA, etc., towards an efficient and effective set of instruments

Implementation Plan

Interaction with other sectors

Joint efforts required or preferred:

- grid integration
- building integration
- sustainability
- …

Interaction and joint priority setting:

- other (EU and other) Technology Platforms
- financial sector
- E-sector (grid operators, regulators)
- education
- …

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The Solar Europe Initiative provides framework for highly ambitious development

EU PV TP and EPIA will face this challenge *together*

2020 is a only a first step

SRA and IP now (almost) ready to support reaching 2020 targets ánd (far) beyond

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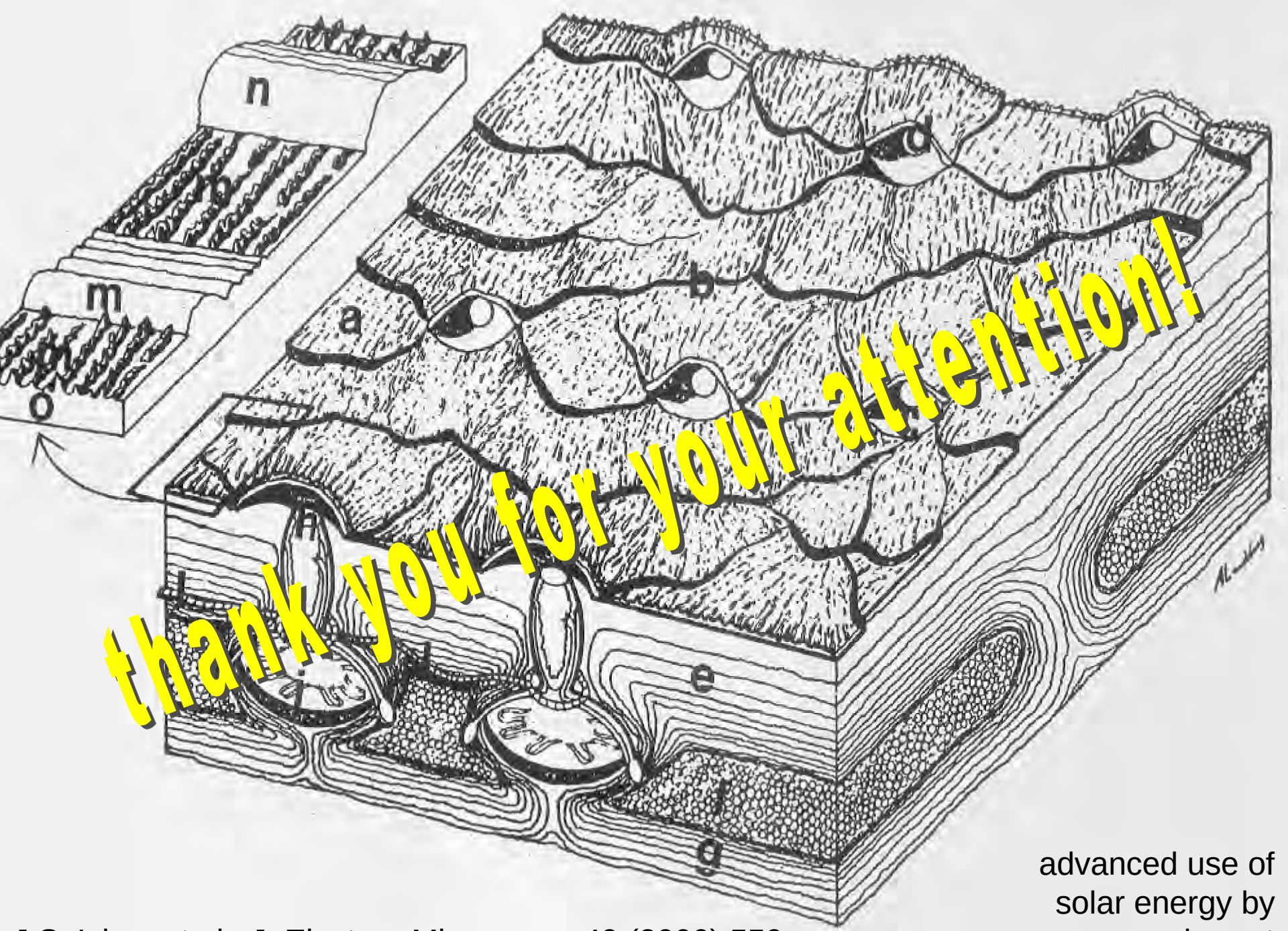
Working Group 3 members:

thank you for your contributions and very pleasant cooperation!



advanced use of solar energy by a hornet

J.S. Ishay et al., J. Electron Microscopy 49 (2000) 559