

Bringing photovoltaics to maturity

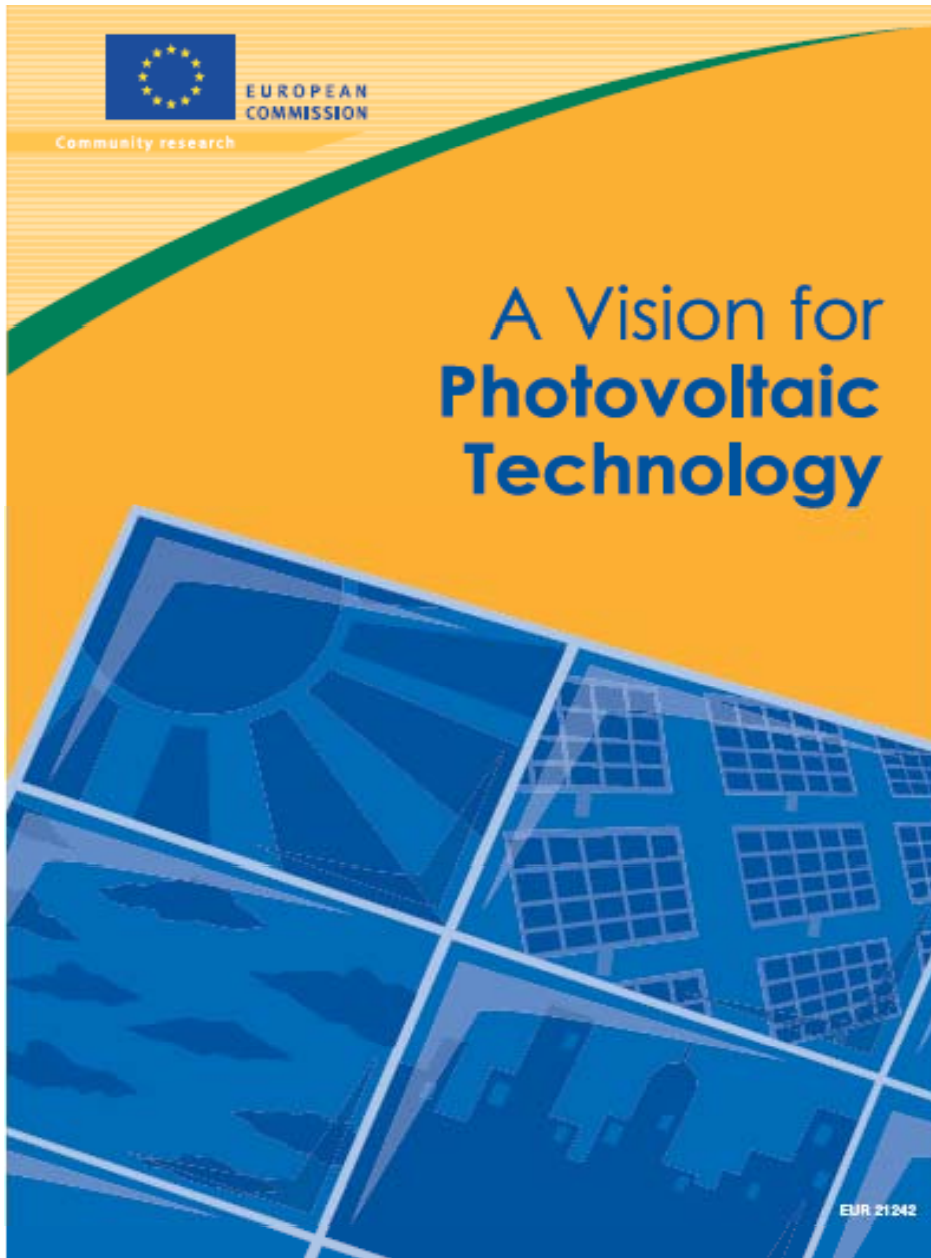
The Strategic Research Agenda of the EU PV Technology Platform and its Implementation Plan

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*on behalf of the Steering Committee and
the Working Group 3: Science, Technology & Applications*

ESFRI Energy Working Group meeting

Brussels, 10 November 2009

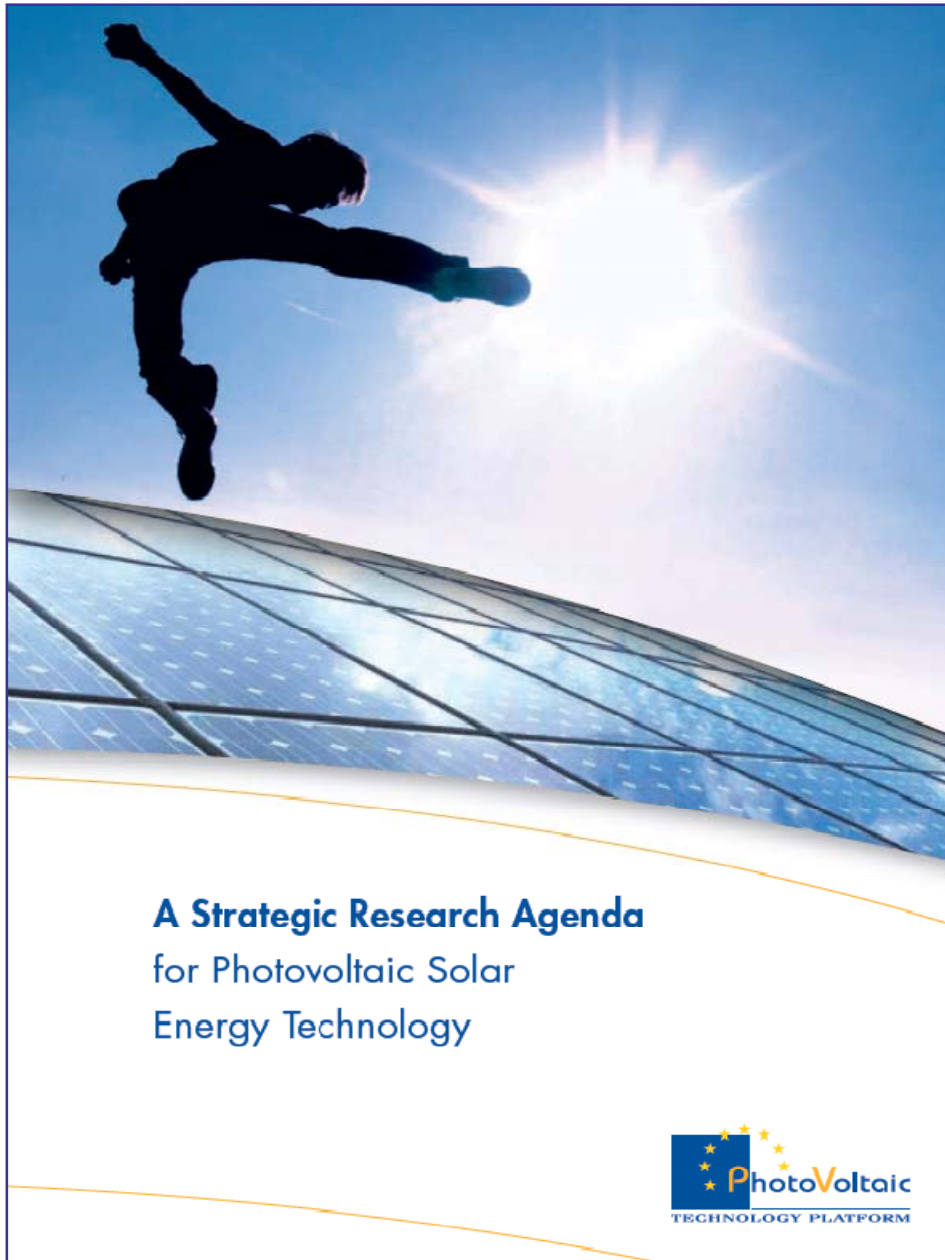


2005



- R&D crucial for realisation of the Vision
- Address EU and member states
- Need for a common document describing R&D fields, topics and priorities

→ **Strategic Research Agenda**



2007



- Describes *what* needs to be done
- To be used as a *reference* document for R&D programming
- Apply country-specific templates

www.eupvplatform.org

SRA governing principles



- Dedicate short-term research to competitiveness of EU PV industry
- Address all parts of the value chain and distinguish short, medium and long term
- Portfolio approach: no technology exclusivity, common indicative targets

SRA aims quantified

Overall short term target

reach grid parity (on consumer level) in Southern Europe by 2015

- typical turn-key system price ≤ 2.5 €/Wp
- typical turn-key system cost < 2 €/Wp

⇒ grid parity in most of Europe by 2020

SRA contents summarised

R&D fields distinguished



- **Cell & module technologies**
 - wafer-based crystalline silicon
 - existing thin-film technologies (Si, CIGSSe, CdTe)
 - emerging & novel technologies
- **Concentrator technologies**
- **Balance-of-System components and systems**
- **Standards, QA, safety and environmental aspects**
- **Socio-economic and enabling research**

SRA contents summarised

selected R&D issues

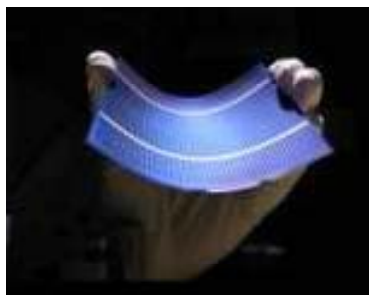
➤ Cell & module technologies: *common aspects*



- high-productivity manufacturing (processes and equipment)
- high efficiency devices
- low-cost transparent conductors
- low-cost, durable encapsulation for rigid and flexible modules
- environmental sustainability (energy & materials)

PV technology development status and potential

➤ Wafer-based crystalline silicon

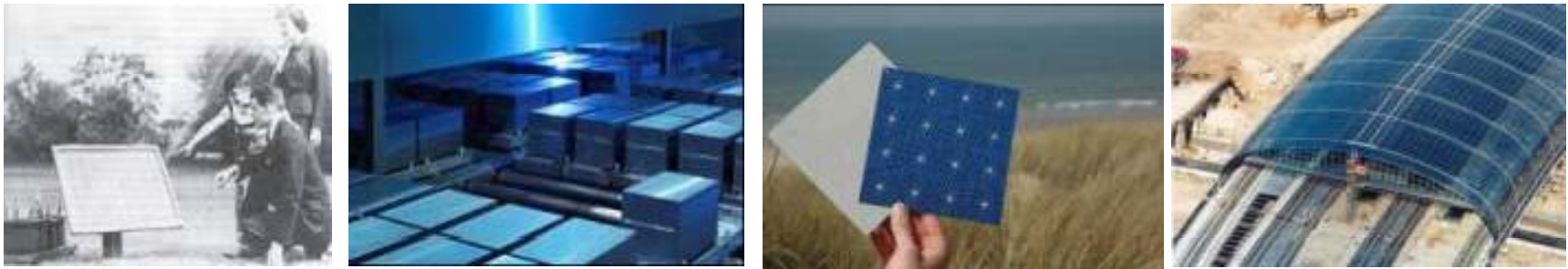


- 1/2 century of manufacturing experience
- high performance
- cost reduction is main overall challenge
- typical module efficiency range:
 - 12 ~ 20% (now)
 - 15 ~ 23% (longer term)

SRA contents summarised

selected *specific* R&D issues

➤ Wafer-based crystalline silicon



- low silicon consumption (g/Wp)
- integrated cell & module concepts

PV technology development status and potential

➤ Thin-film silicon



- low-cost potential and new application possibilities
- revival because of introduction of new silicon materials
- efficiency enhancement is main challenge
- typical module efficiency range:
 - 6 ~ 9% (now)
 - 10 ~ 15% (longer term)

SRA contents summarised

selected *specific* R&D issues

➤ Thin film silicon



- high-rate, large-area deposition of $\mu\text{c-Si}$ and nc-Si
- new materials and utilisation of quantum effects

PV technology development status and potential

➤ Copper-indium/gallium-selenide/sulphide (CIGS)



- high performance potential (partly already demonstrated)
- cost reduction is main issue
- typical module efficiency range:
 - 11 ~ 13% (now)
 - 14 ~ 18% (longer term)

SRA contents summarised

selected *specific* R&D issues

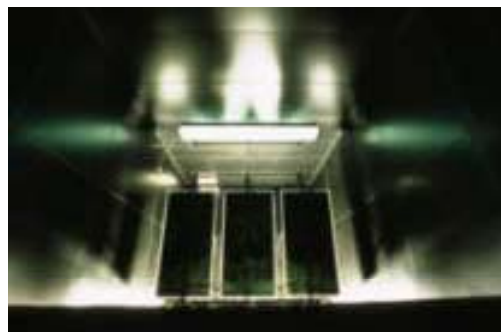
➤ Copper-indium/gallium-selenide/sulphide (CIGS)



- alternative processes (e.g. roll-to-roll and non-vacuum)
- alternative active materials

PV technology development status and potential

➤ Cadmium telluride

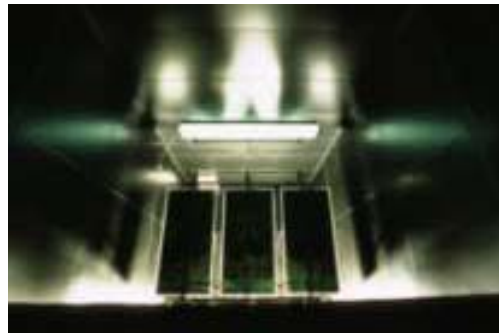


- low-cost potential (partly already demonstrated)
- take-back and recycling systems implemented
- typical module efficiency range:
 - 9 ~ 11% (now)
 - 12 ~ 15% (longer term)

SRA contents summarised

selected *specific* R&D issues

➤ Cadmium telluride

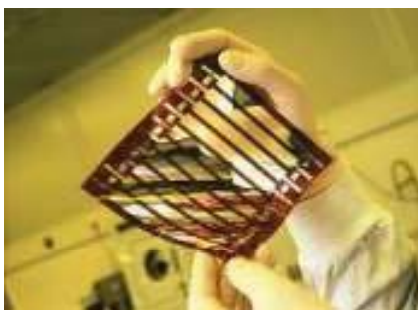


- new device concepts for thinner active layers
- alternative processes and back contacts

PV technology development

status and potential

➤ Emerging and novel technologies



polymer PV



dye PV



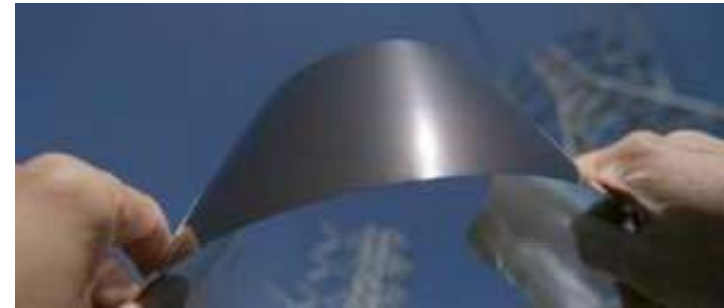
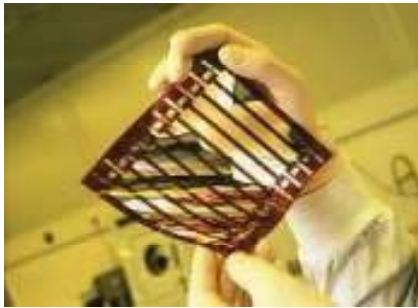
printed CIGS

- 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

SRA contents summarised

selected *specific* R&D issues

➤ Emerging and novel technologies

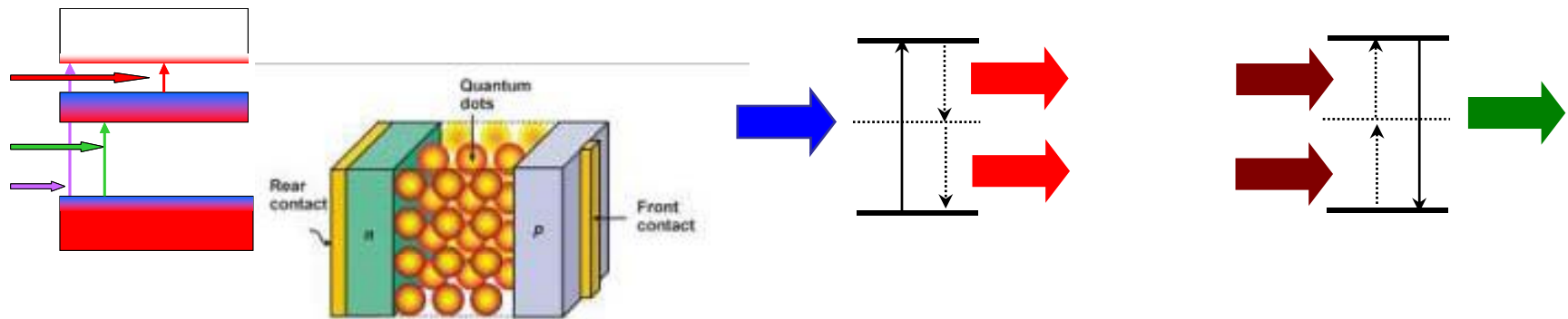


- improvement of efficiency and stability to the level needed for first commercial applications
- encapsulation of organics-based concepts

PV technology development

status and potential

➤ Emerging and novel technologies

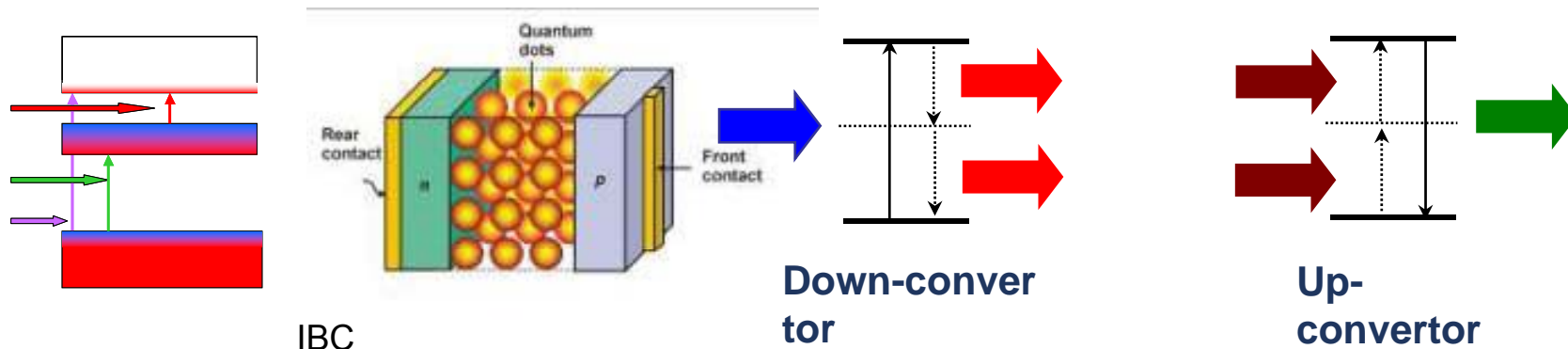


- wide variety of new conversion principles and device concepts
- mostly aimed at very high efficiencies (“full spectrum utilisation”)
- very important in view of long term potential of PV (model systems or nuclei for “disruptive” technologies)

SRA contents summarised

selected *specific* research issues

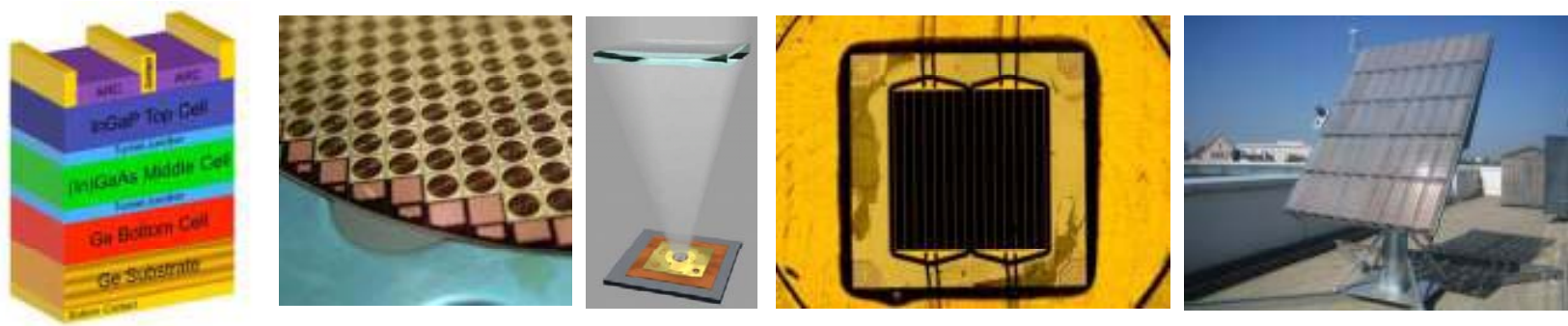
➤ Emerging and novel technologies



- proof-of-principle of new conversion concepts
- processing, characterisation and modelling of (especially) nanostructured materials and devices

PV technology development status and potential

➤ Concentrator technologies

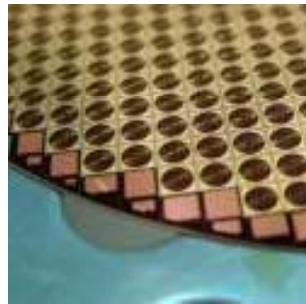
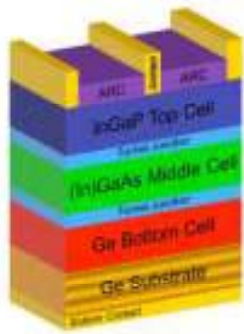


- application form of choice for high cost/m², super-high efficiency cells
- EU world record cell efficiency 41% (Fraunhofer ISE)
- 23% AC *system* efficiency demonstrated
- only concrete way to system efficiencies >30% as yet

SRA contents summarised

selected R&D issues

➤ Concentrator technologies



- super-high efficiency (>45%) cells for use at high X
- low-cost, high-performance solutions for optical concentration and tracking

PV technology development status and potential - selection

➤ 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)

SRA contents summarised

selected R&D issues

➤ BoS-components and PV systems

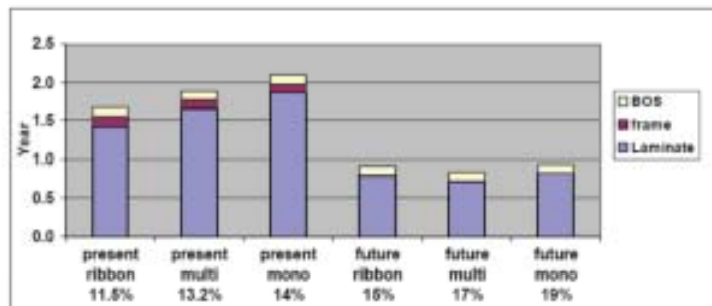


- inverter lifetime and reliability
- concepts and components for grids at high PV penetration levels
- *storage technologies for small and large applications*

SRA contents summarised

selected R&D issues

➤ Standards, quality assurance, safety and environmental aspects

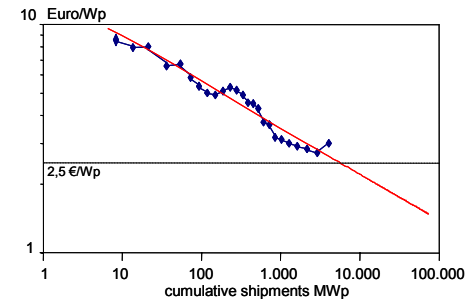


- QA guidelines for the whole value chain
- LCA studies and recycling processes

SRA contents summarised

selected research issues

➤ Socio-economic aspects and enabling research



- non-technical costs and benefits of PV
- required skills base for a growing PV sector