CPVMATCH

Concentrating **P**hotovoltaic **m**odules using **a**dvanced **t**echnologies and **c**ells for **h**ighest efficiencies

Simon P. Philipps, Andreas W. Bett, and all CPVMatch partners

Fraunhofer Institute for Solar Energy Systems ISE

3rd Workshop and General Assembly of the EU PV Clusters

Barcelona, 25.05.2016

www.ise.fraunhofer.de

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Quick Facts on the CPVMatch Project

- Type: Collaborative project
- Project duration: 42 months (3 and a half years)
- Dates: May 2015 - October 2018
- EC Contribution: 4.95 M€
- Effort: 536 Person/Months
- Participants: 9 Partners
  (4 Research Institutions, 1 University, 2 Industry Partners and 2 SMEs)
- Coordinator: Fraunhofer ISE
- TRL: From 3 to 5

Project Partners

AIXTRON

CYCLeco

FROM RESEARCH TO INDUSTRY
cea tech

tecnalia Inspiring Business

UNIVERSIDAD POLITÉCNICA MADRID
POLITÉCNICA
Instituto de Energía Solar

AZURSPACE SOLAR POWER GMBH

Fraunhofer ISE

ASSE

RSE Ricerca Sistema Energetico

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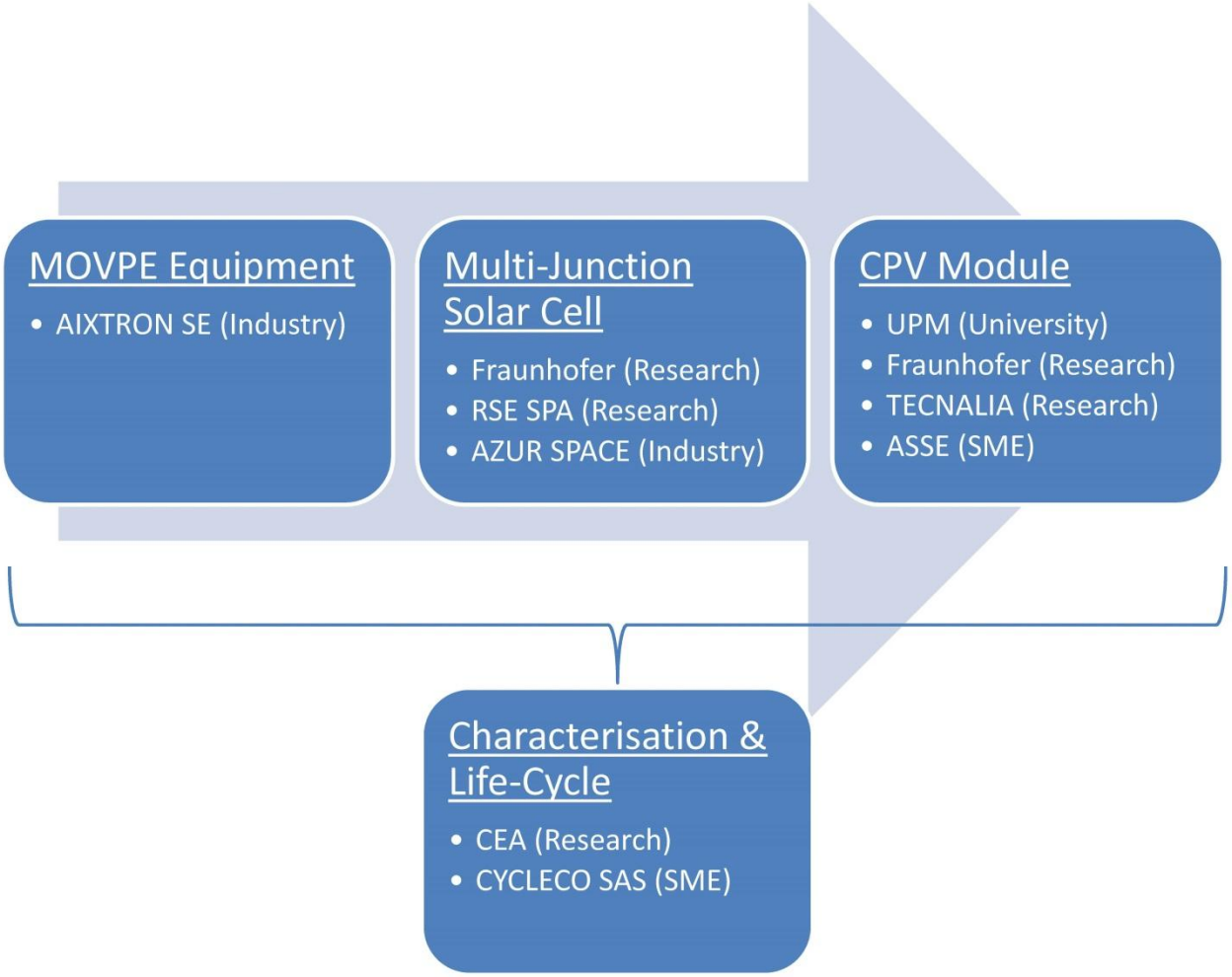
Covering the Value Chain



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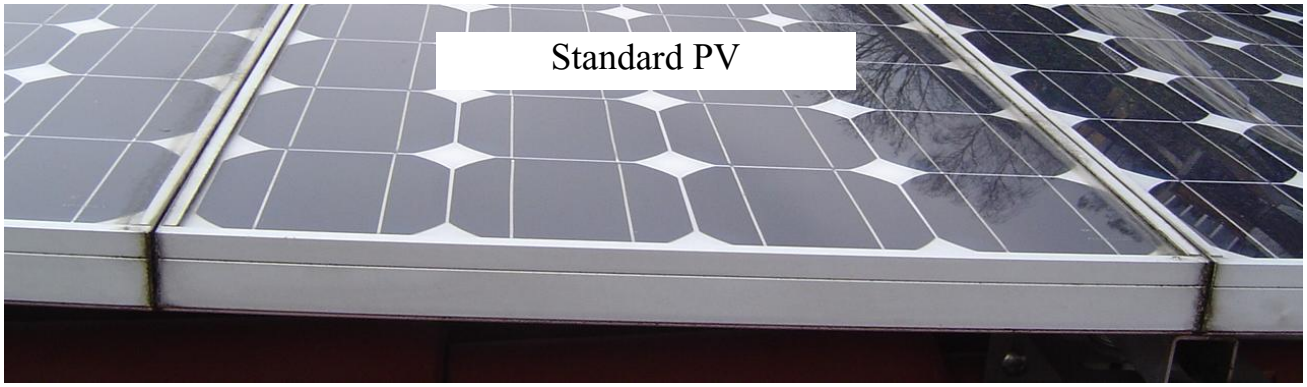
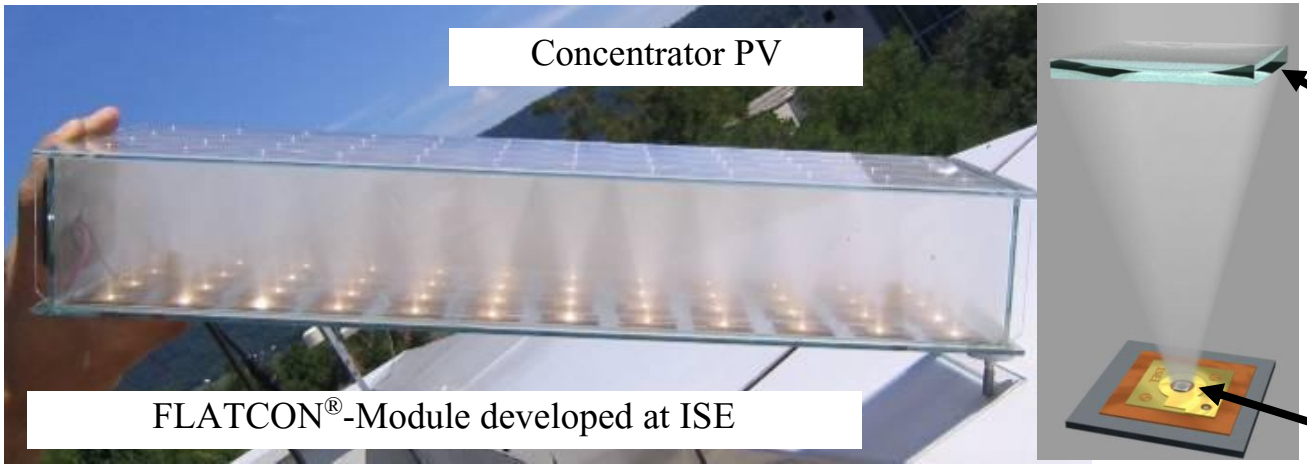
Photovoltaics

Standard PV and Concentrator PV



Light collection
and conversion
is one unit



Light collection
collection area

separated
from

Light conversion
cell area

Concentration Factor = collection / cell area

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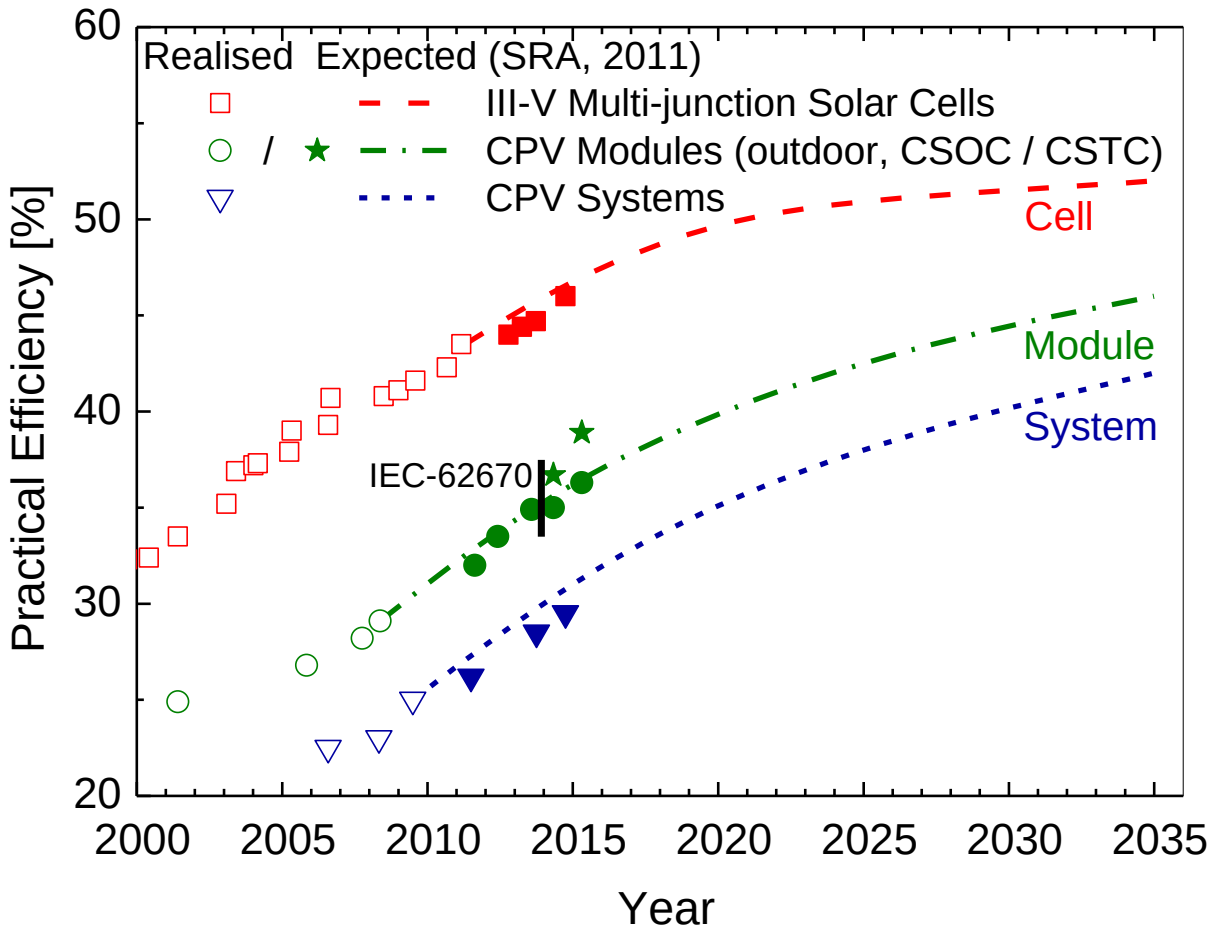
Progress of Efficiencies in CPV

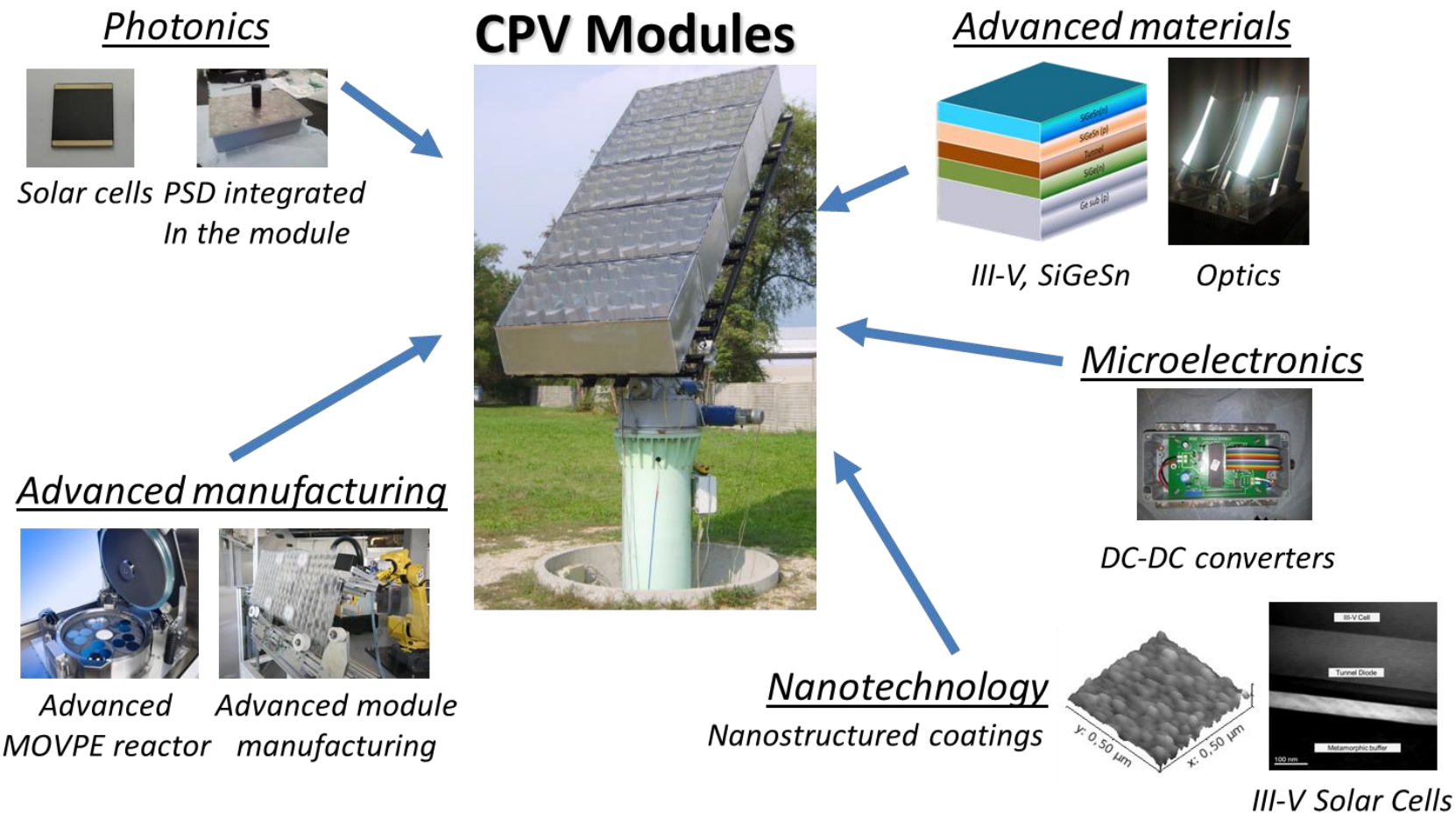


A Strategic Research Agenda for Photovoltaic Solar Energy Technology, Edition 2, 2011, W.Sinke, A.Bett et al, with update beyond 2012

Object of the CPVMatch Project

- The overall aim of the project is to **bring practical performance of HCPV modules closer to theoretical limits**.
- This should be achieved through:
  - novel **multi-junction solar cell** architectures using advanced materials and processes for better spectral matching
  - innovative **HCPV module concepts** with improved optical and interconnection designs, thus including novel light management approaches.
- The central objective of CPVMatch is to realise **HCPV solar cells and modules working at a concentration level ≥800x with an efficiency of 48% and 40%, respectively, with a low environmental impact.**

Key Enabling Technologies in CPVMatch



WP1: Cutting edge multi-junction solar cells

- 1 eV subcell for metamorphic concepts
- Wafer bond processing
- 4J metamorphic MJSC with 48% efficiency

Fraunhofer, RSE SPA, UPM, AZUR SPACE, ASSE

WP2: Frontier multi-junction solar cells

- New MOVPE growth chamber design for III-V and IV elements
- 1 eV subcell based on SiGeSn
- Lattice-matched dual-junction GaAs/SiGeSn
- Nanostructured coatings
- 4J solar cells with III-V and SiGeSn

Fraunhofer, RSE SPA, AIXTRON SE

WP3: Innovative Fresnel-lens-based HCPV modules

- Achromatic Fresnel lenses for improved light management
- Anti-reflective coatings

Fraunhofer, UPM, CEA, TECNALIA

WP4: Smart, mirror-based HCPV modules

- New mirror-optics
- Low-cost, reliable receivers
- DC/DC converters and PSD sensor to reduce power losses

Fraunhofer, RSE SPA, ASSE, TECNALIA

WP5: Characterization and Testing

- Analysis of advanced materials
- Characterization of MJSC and subcells
- Development of new characterization methods for CPV optics
- Indoor and outdoor testing of new HCPV modules

Fraunhofer, RSE SPA, UPM, ASSE, CEA

WP6: Life-cycle assessment

- Life-cycle and environmental assessment of new multi-junction cells and HCPV modules

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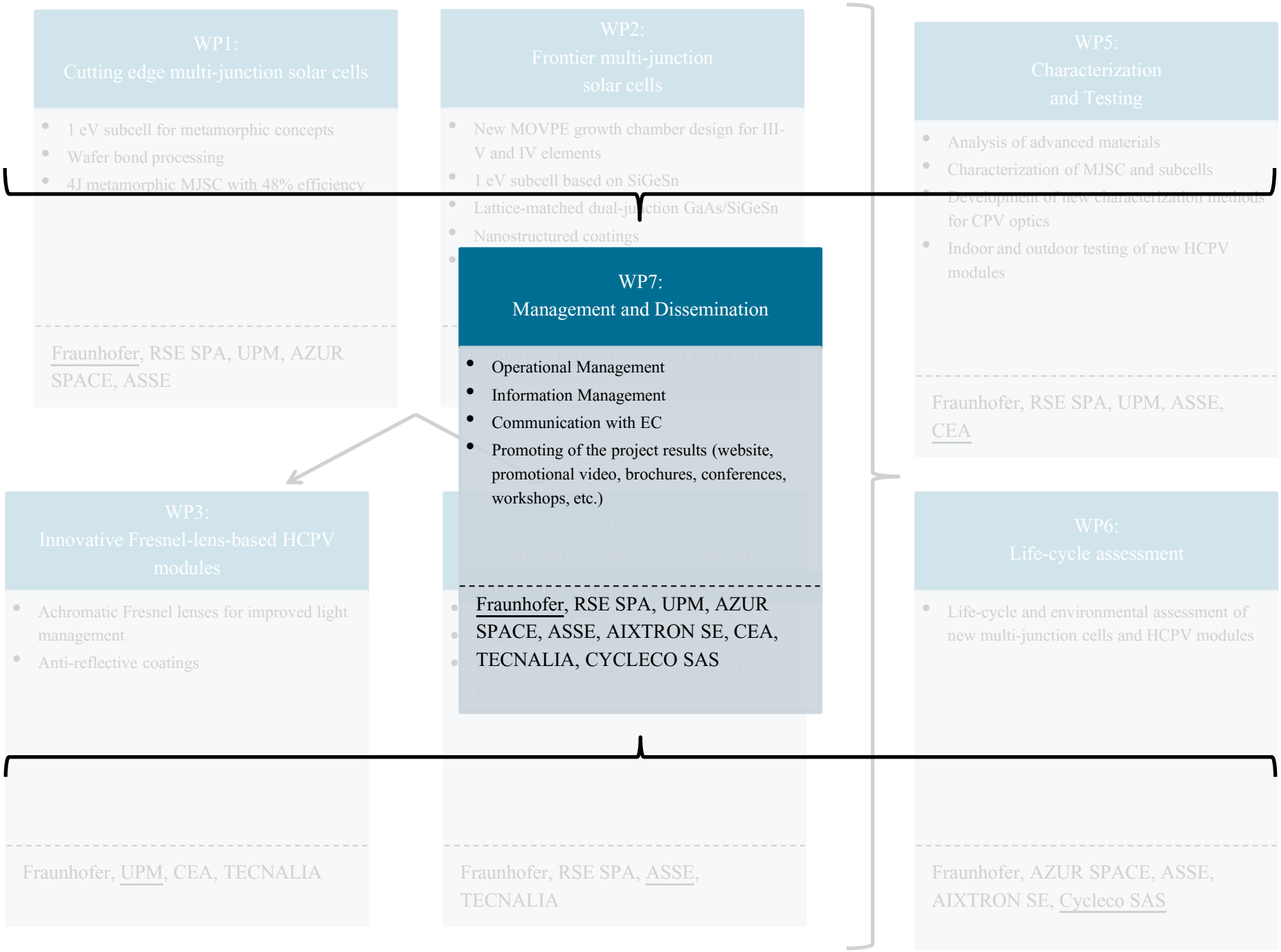
WP1:
Cutting edge multi-junction solar cells
1 eV subcell for metamorphic concepts
Wafer bond processing
4J metamorphic MJSC with 48% efficiency
Fraunhofer, RSE SPA, UPM, AZUR SPACE, ASSE
WP2:
Frontier multi-junction solar cells
New MOVPE growth chamber design for III-V and IV elements
1 eV subcell based on SiGeSn
Lattice-matched dual-junction GaAs/SiGeSn
Nanostructured coatings
WP5:
Characterization and Testing
Analysis of advanced materials
Characterization of MJSC and subcells
Development of new characterization methods for CPV optics
Indoor and outdoor testing of new HCPV modules
Fraunhofer, RSE SPA, UPM, ASSE, CEA
WP7:
Management and Dissemination
Operational Management
Information Management
Communication with EC
Promoting of the project results (website, promotional video, brochures, conferences, workshops, etc.)
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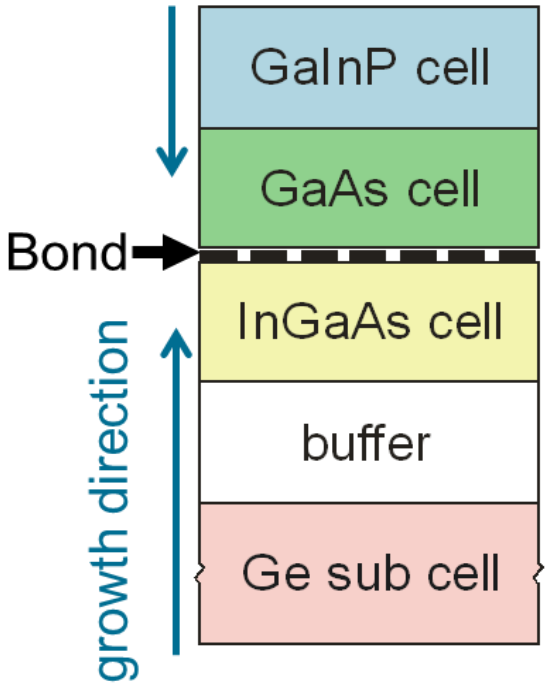
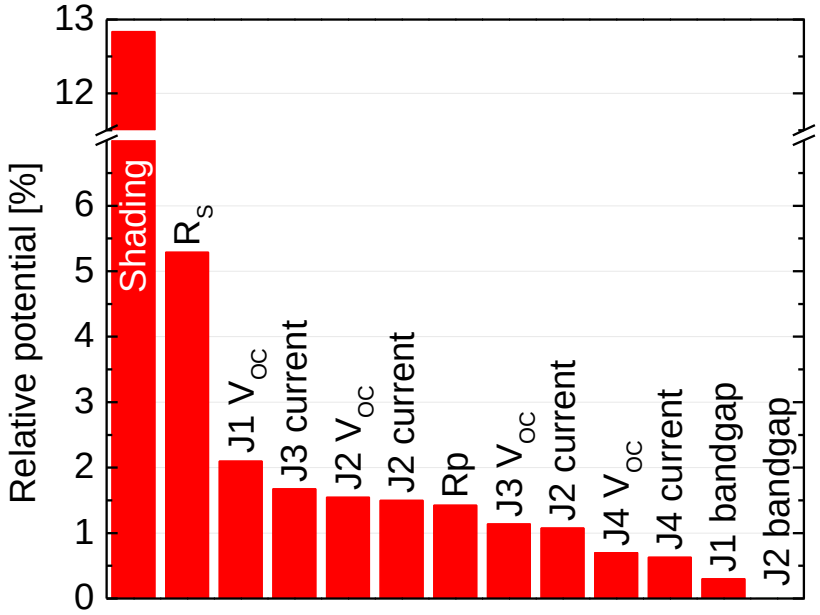
WP3:
Innovative Fresnel-lens-based HCPV modules
Achromatic Fresnel lenses for improved light management
Anti-reflective coatings
Fraunhofer, UPM, CEA, TECNALIA
WP4
Smart mirror-based HCPV modules
power losses
Fraunhofer, RSE SPA, ASSE, TECNALIA
WP6:
Life-cycle assessment
Life-cycle and environmental assessment of new multi-junction cells and HCPV modules
Fraunhofer, AZUR SPACE, ASSE, AIXTRON SE, Cycleco SAS

WP1: Cutting Edge Multi-Junction Solar Cells

Metamorphic Growth Combined with Wafer Bonding

- **Objective:** Development of a novel wafer bonded four-junction solar cell for better spectral matching with an efficiency of 48% using advanced materials and processes.





Efficiency improvement potential in realized structure with respect to target structure.

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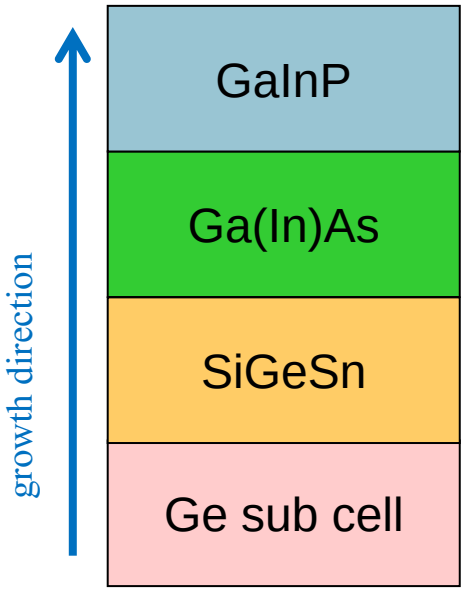
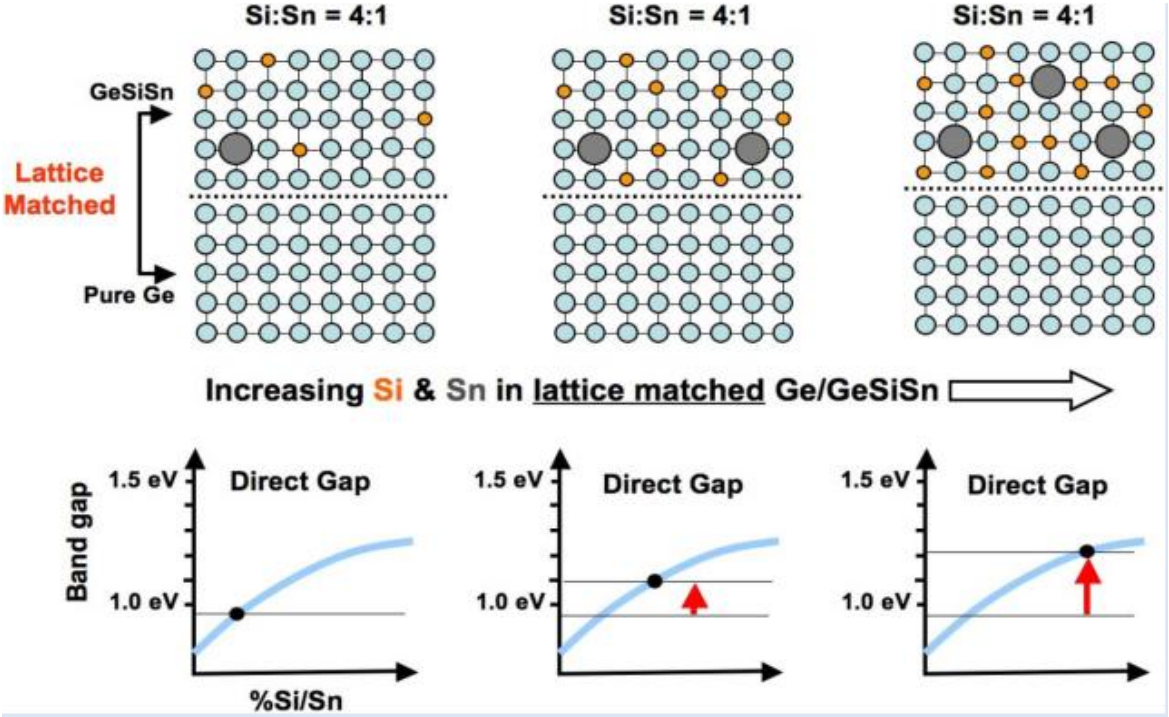
WP2: Frontier Multi-Junction Solar Cells
Technologies with Lattice-Matched Approach

- **Objective:** Development of a frontier lattice multi-junction solar cell with high efficiency potential and low process cost, comprising nanostructured coatings and innovative lattice-matched materials, obtained by combing III-V and IV elements.

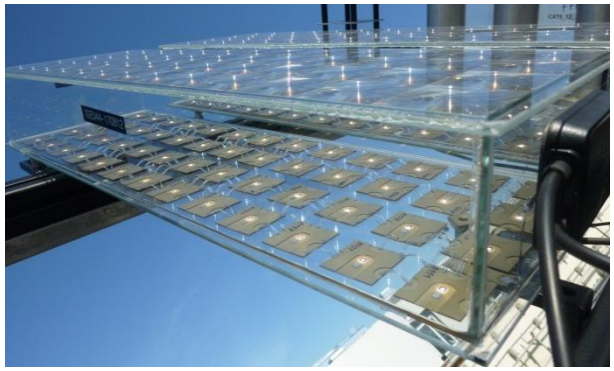


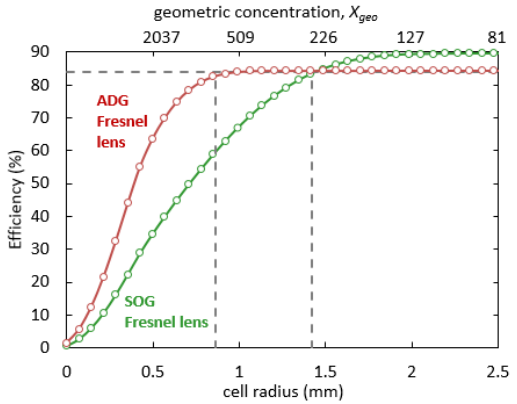


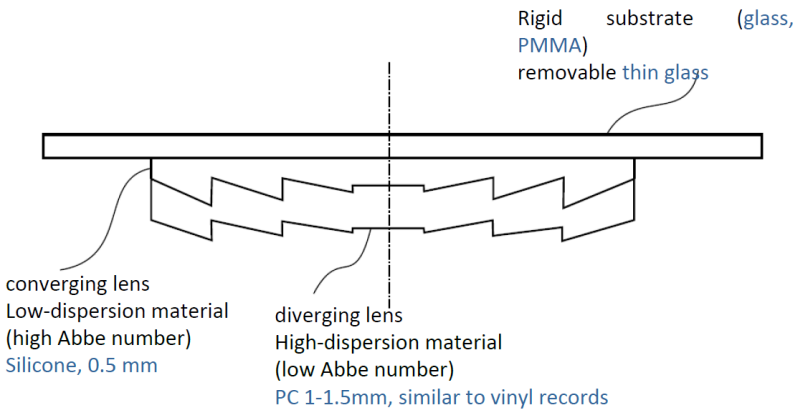
WP3: Innovative, Fresnel-Lens-Based HCPV Modules

The Fresnel Optics Concept

- **Objective**: Development of achromatic Fresnel lens-based HCPV modules



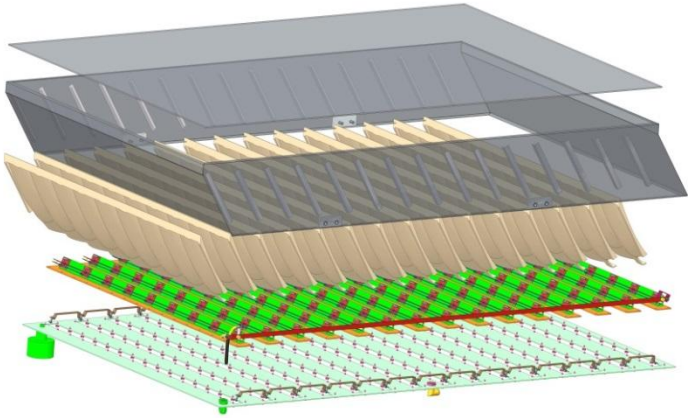


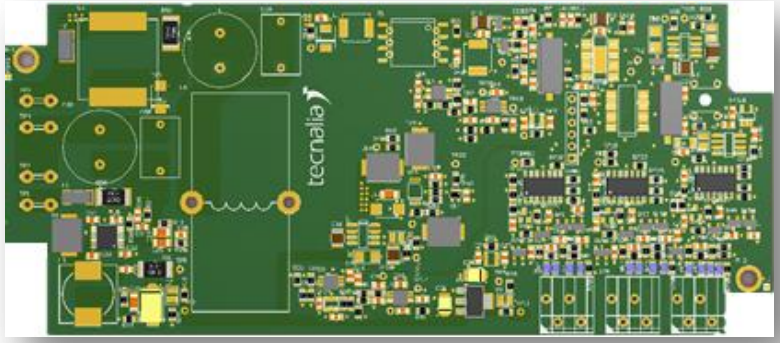


WP4: Smart, Mirror-Based HCPV Modules

The Mirror-Based Optics Concept

- **Objective:** Development of smart, mirror-based HCPV modules.





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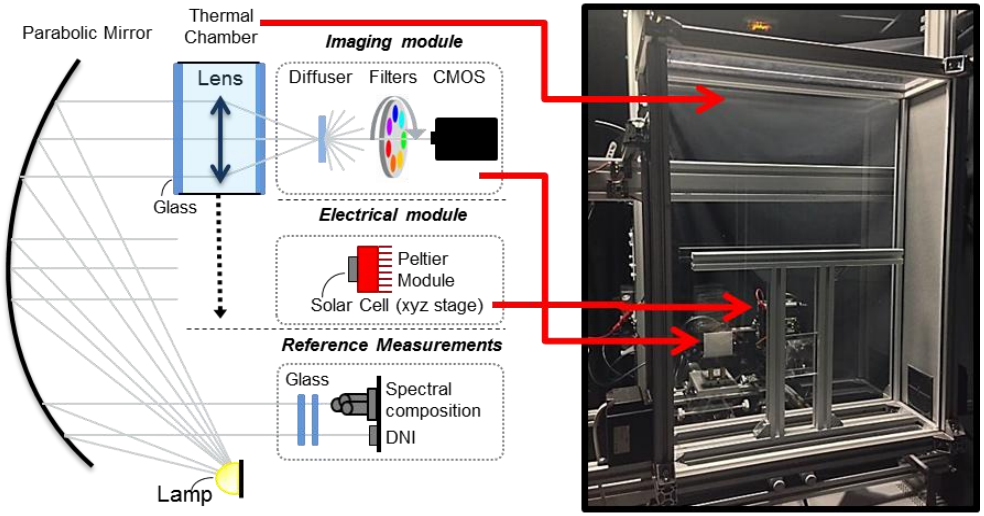
WP5: Characterization and Testing

Adapted Characterization Methods

- **Objective**: Assess the developments realized on solar cells and module by means of adapted characterization methods



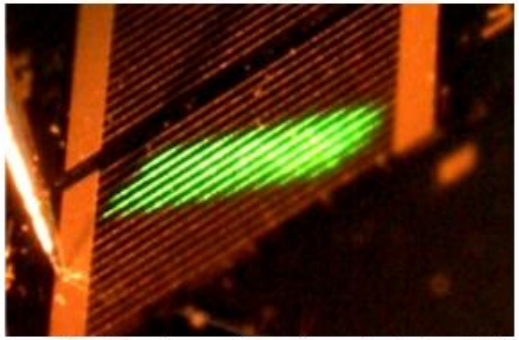
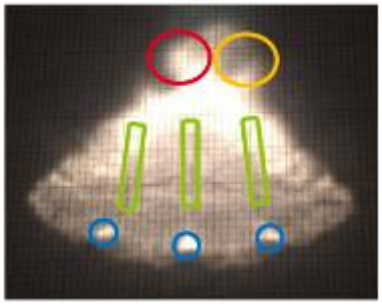
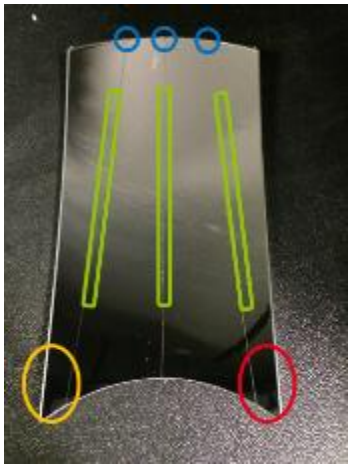


Figure 6: 4 junctions solar cells under test on EQE.





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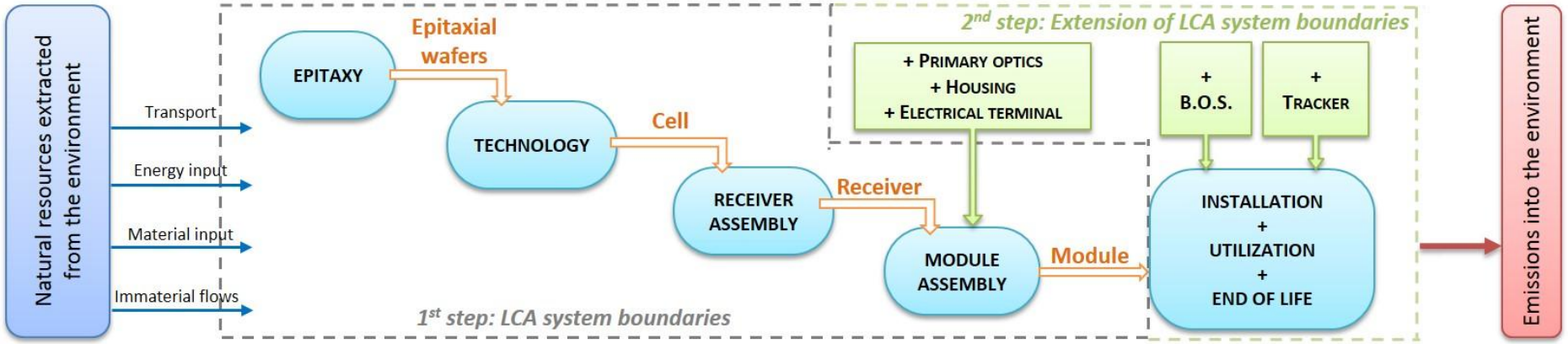
WP6: Life-Cycle Assessment
Flow-Chart and System Boundaries

- **Objective:** Life-cycle and environmental assessment of new multi-junction cells and HCPV modules.



Thank you for your attention!

Fraunhofer Institute for Solar Energy Systems ISE

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