CPV: Space Technology for Space Research

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Fabio Brunner,
Head of Sales EU and Latin America
Concentrix Solar GmbH

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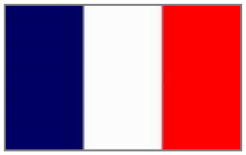
Soitec

Leading Provider of Concentrator Photovoltaic Systems (CPV)

Soitec



- French company, founded 1992 in Grenoble
- SmartCut™ Technology, Market leading provider of innovative Substrates (Integrated Circuits)
- Joint development in Research and Development with CEA Leti (France), the Fraunhofer Institute und with Corning (USA)
- € 209 Mio. Sales (2009); 1000 employees worldwide

Concentrix Solar

- German company, founded 2005 in Freiburg, Spin-off of the Fraunhofer Institute for Solar Energy Systems
- Concentrix CPV technology is the leading technology in terms of industrial production, efficiency and long term durability

In December 2009 Soitec buys the solar company Concentrix Solar

- In the future: production of the **SmartCut™** based on individual leading technologies
- **SmartCell™** will be the most efficient PV solar cell in the market
- there are **three pilot projects in Europe** und in the USA

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Outline

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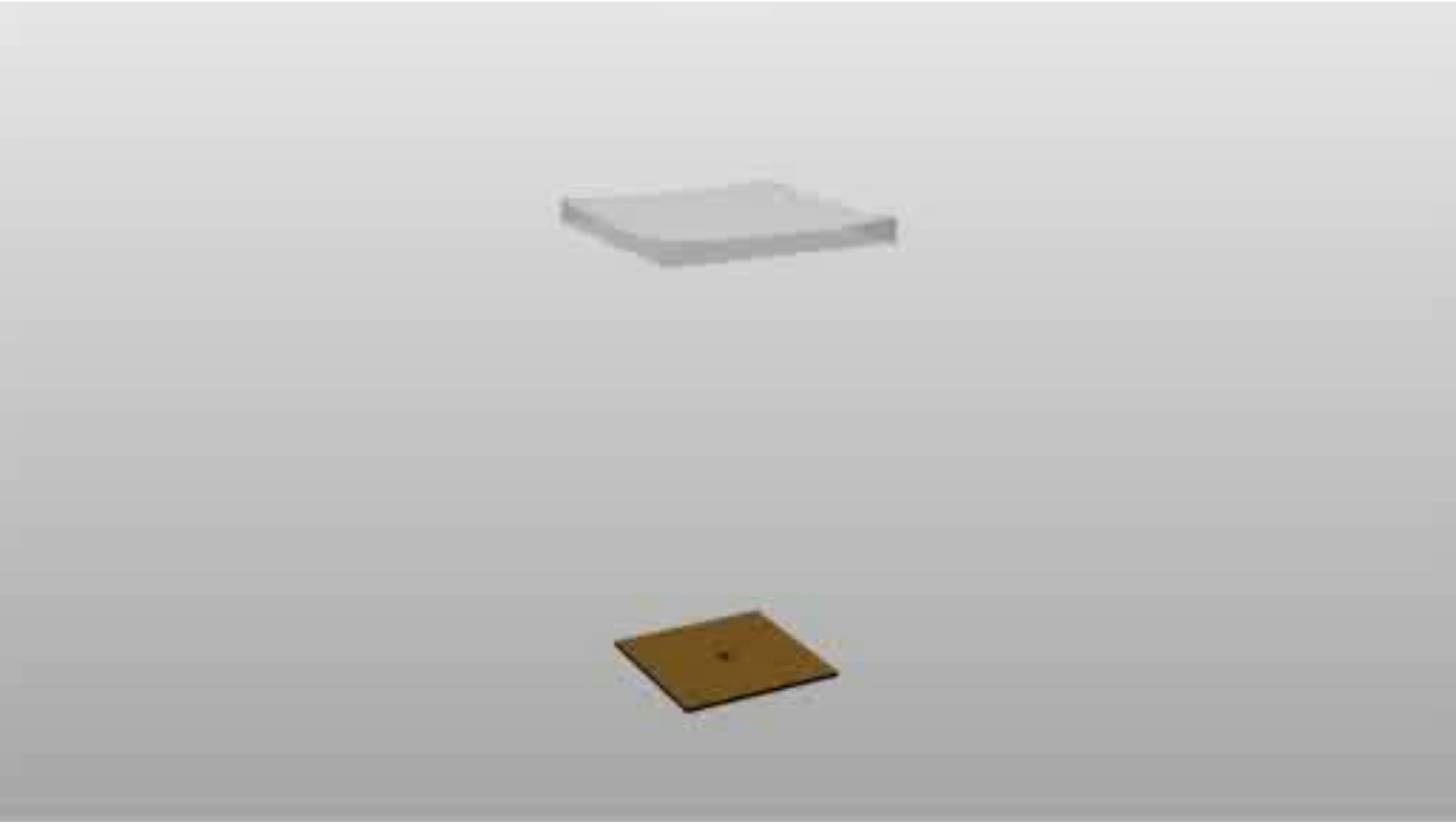
Principle of Concentrating Photovoltaics (CPV)

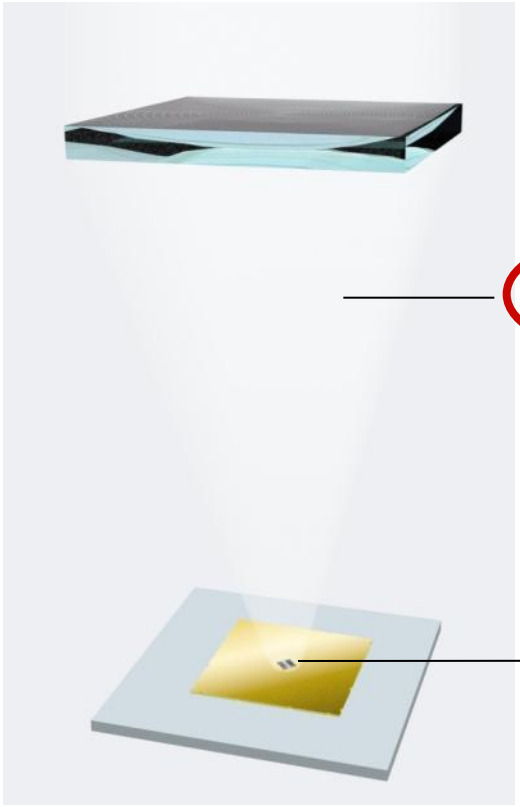


Principle of Concentrating Photovoltaics (CPV)

Efficiency is the key driver for cost reduction:

By reducing the area of the semiconductor to a pure fraction, one can afford the best solar cells available in the market and thus reach efficiency above 30%

Solar cells initially used for Space Applications enable high efficiency!



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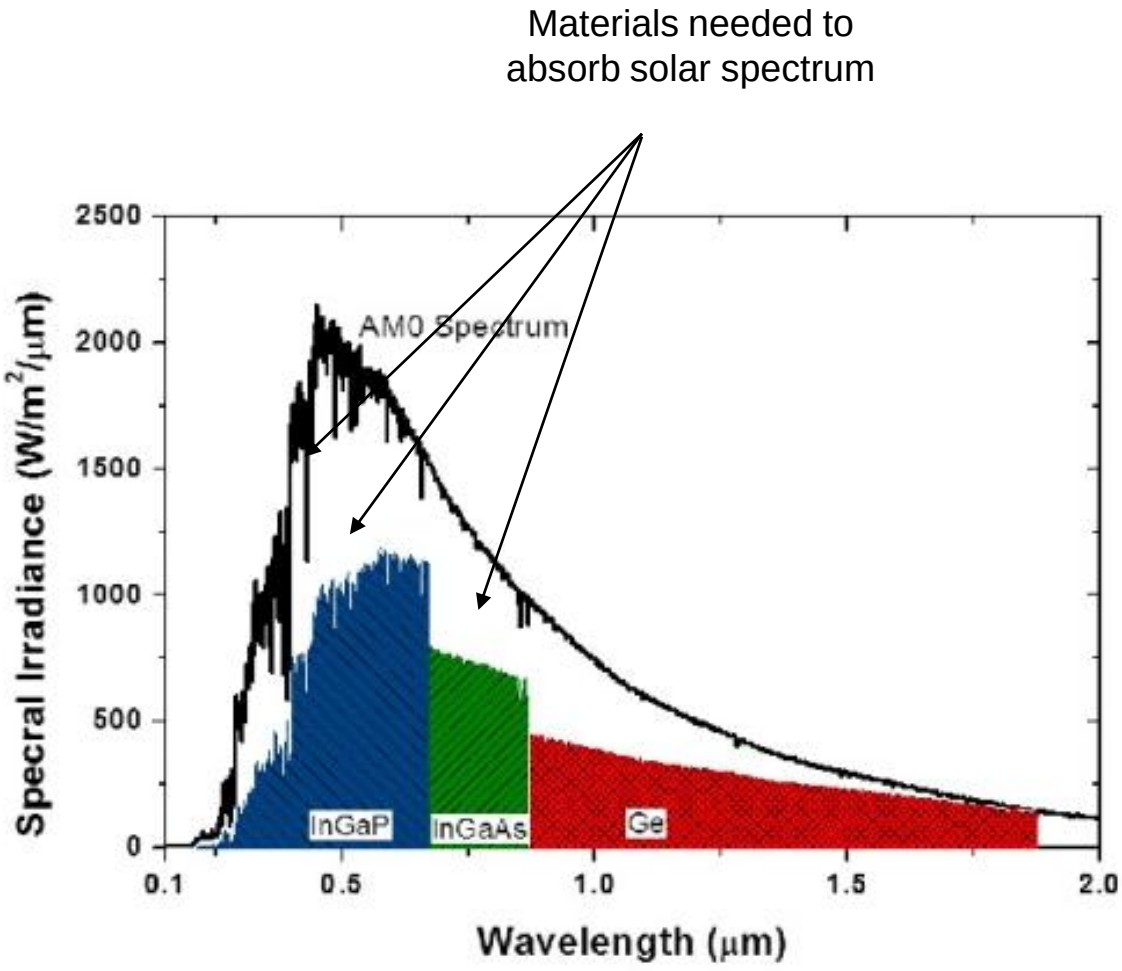
How to improve solar conversion efficiency?

Need to combine different materials in order to capture the widest part of solar spectrum, with two challenges:

- These materials can be rare and expensive
- These materials can't be made on the substrate



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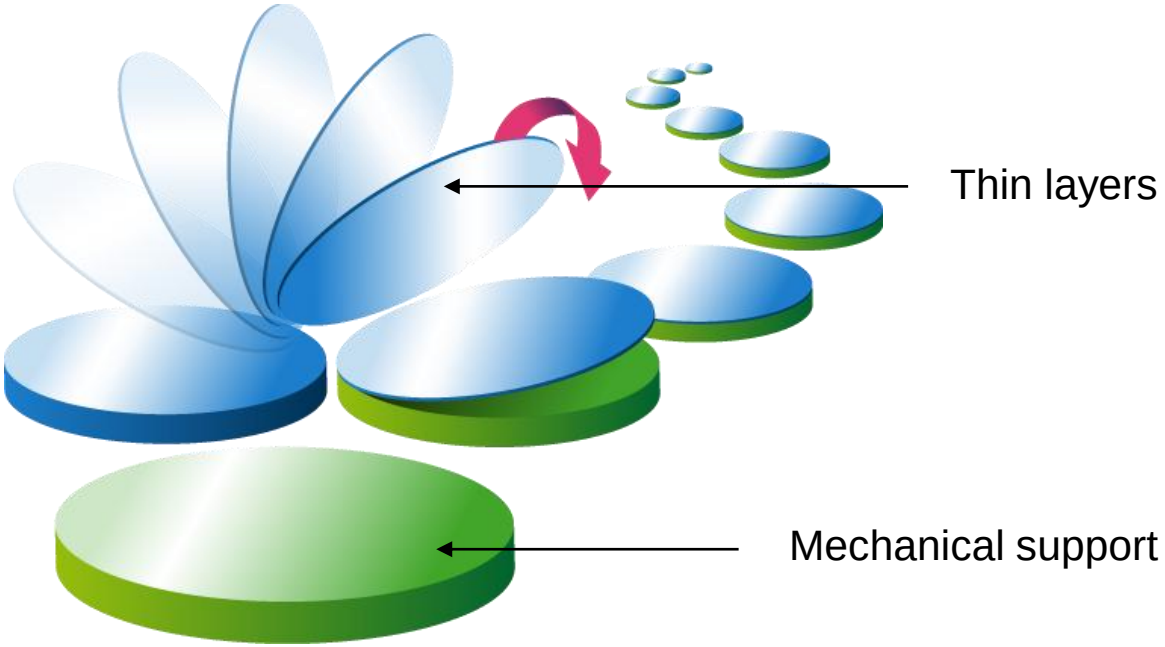
Soitec know-how to improve solar cells

- Thanks to Smart Cut™

  Optimization of rare and expensive III-V materials needed for the ultra-highly efficient solar cell (Gallium Arsenide, Germanium, …) by using thin layers transfer

- Thanks to Smart Stacking™

  Stacking of these materials to convert into electricity a wider part of the solar spectrum.



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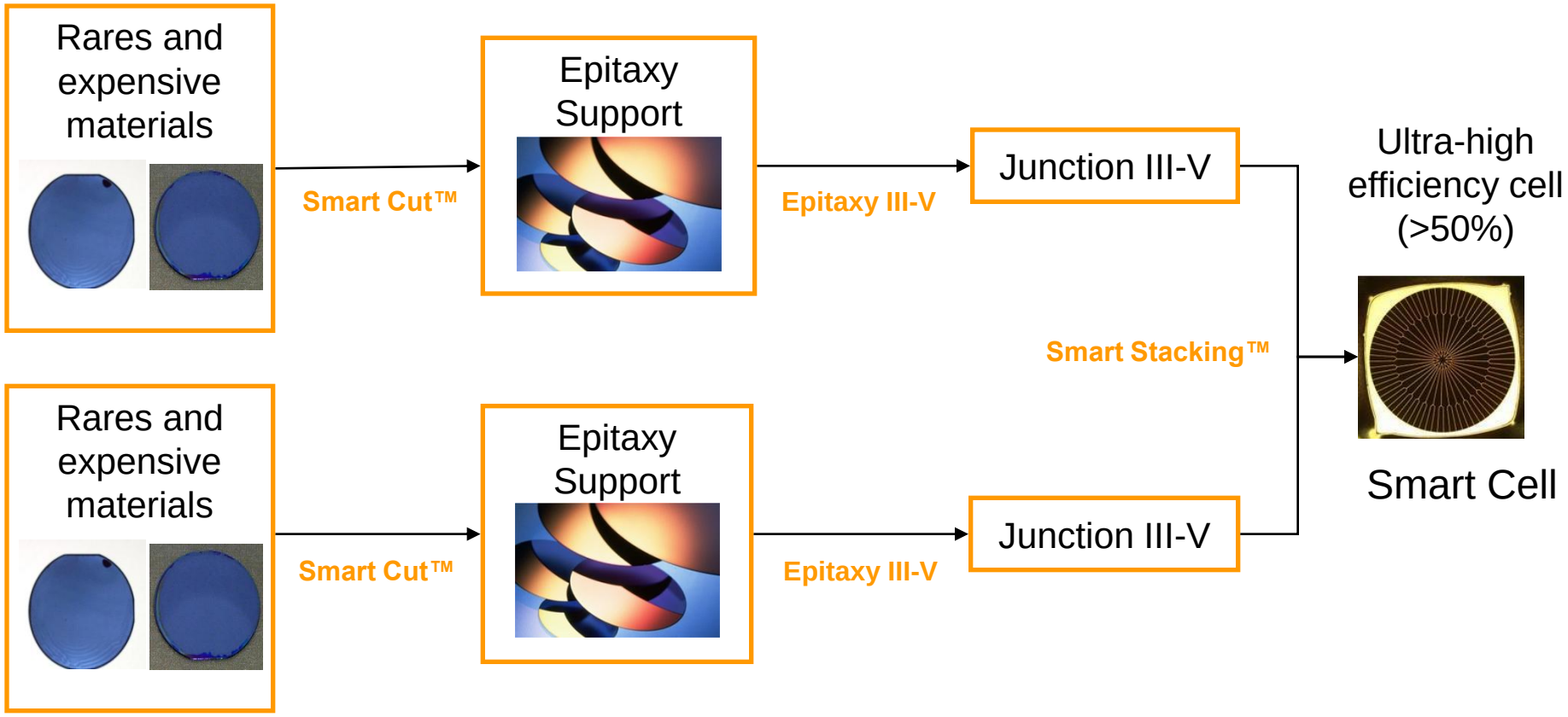
Typical process flow of ultra-high efficiency



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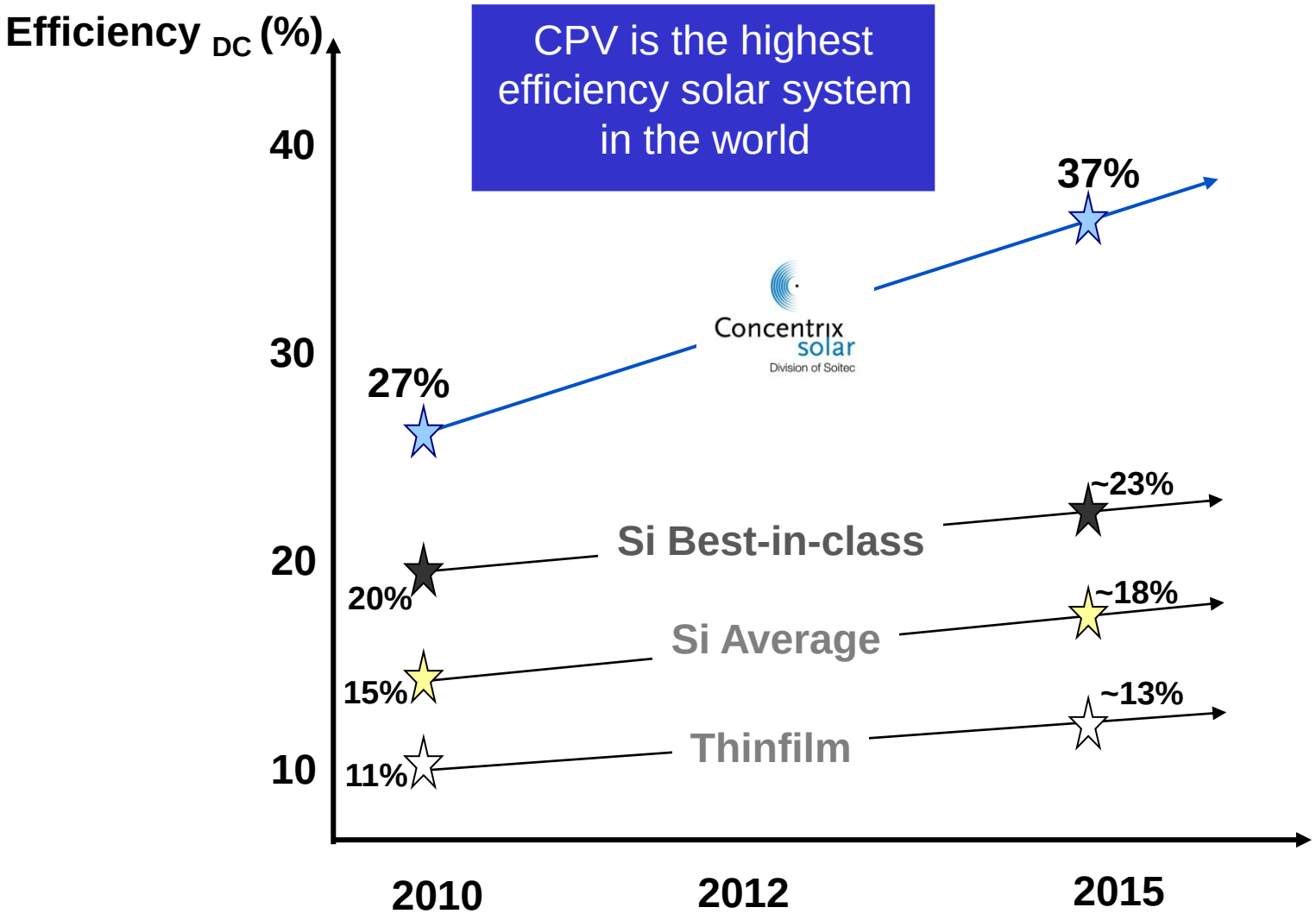
Conversion efficiencies benchmark



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Outline

1 Principle of Concentrating Photovoltaics

2 The choice for CPV

3 Industrial Manufacturing & Field Performance

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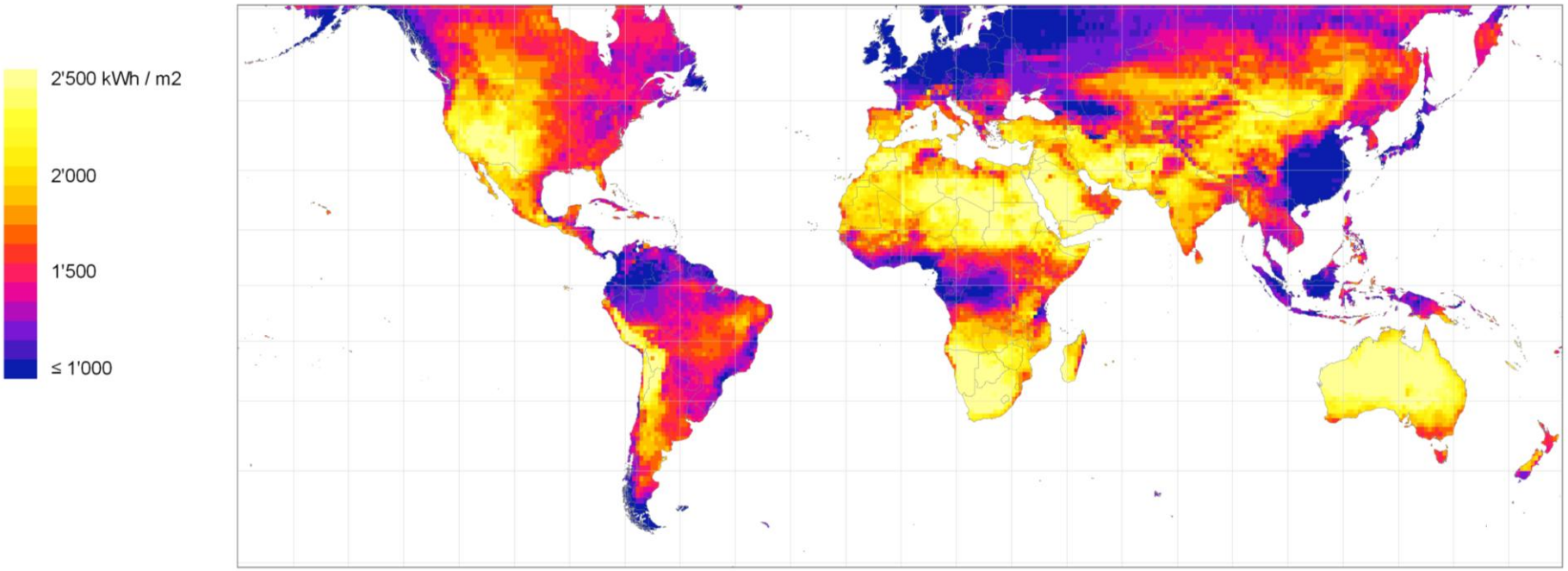
Regional focus for CPV market development



CPV targets at regions with
high direct irradiation (>1800 kWh/m²):

- Southern Europe
- Northern & Southern Africa
- the US South-West
- Middle East
- Australia

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Four major arguments for CPV

1. **Great performance in regions with high DNI**

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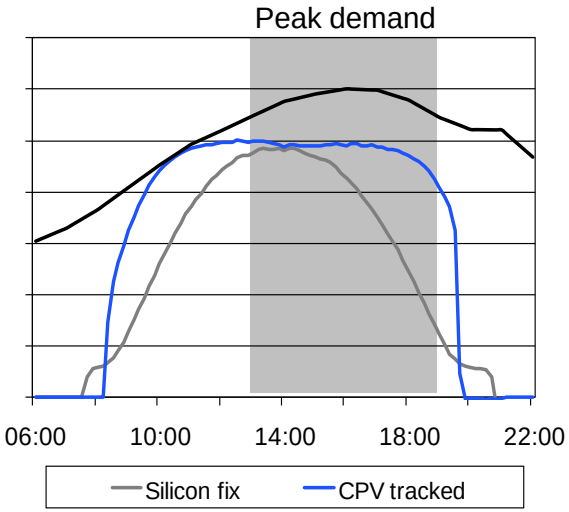
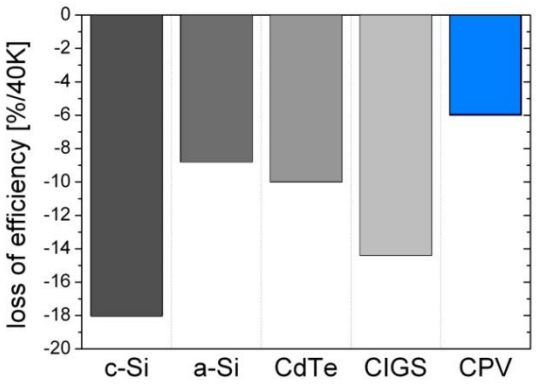
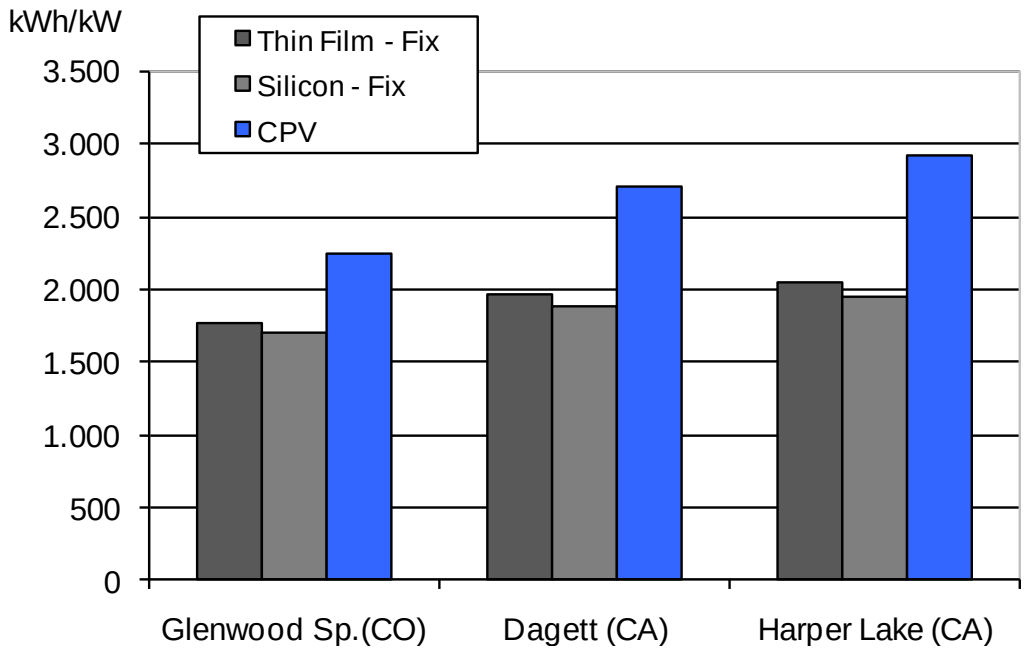
CPV provides very high electricity yields







CPV provides 40% up to 50% more kWh/kW than fix installations and provides energy when it is needed most

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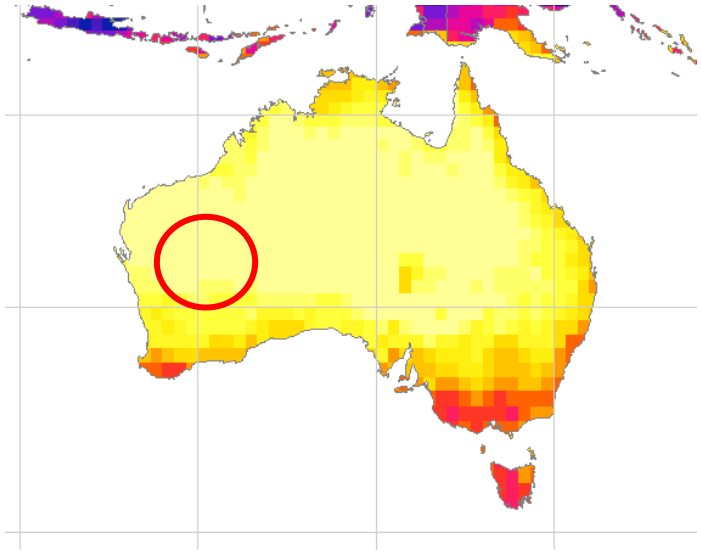
Example: Western Australia



	CPV	Fixed-Tilt Si PV
Efficiency	27%	14%
Resource	2670 kWh/m²a DNI	2255 kWh/m²a GHI
Energy Produced (MWh) by 1 MW AC in 1 year	2.861	1.740

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Four major arguments for CPV

1. Great performance in regions with high DNI

2. **Easy and flexible implementation in the field**

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Easy and flexible implementation in the field

- Flexible in size
  - Commercial installations from 1 MW to 100+ MW
  - Demos in the kW range feasible
- Commissioning in phases
- Criteria for site selection
  - Power plant size can be matched to grid capacity
  - No water availability/permits required
  - No grading of land required
- Simple installation
  - Installation basically with local workforce
  - Only a few specialists required

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Four major arguments for CPV

1. **Great performance in regions with high DNI**

2. **Easy and flexible implementation in the field**

3. **Clean energy with a light environmental footprint**

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CPV has the lowest optical and environmental impact on land

- Environmental Footprint
  - Low lifecycle CO2 intensity
  - High recyclability
  - Short energy payback time
- No Water Consumption
- Optimum Use of Land
  - No permanent shading
  - Preserved plant and wildlife ecosystems
  - Minimized erosion from runoff
  - Minimal land coverage/disruption
  - Dual use of land

Due to the light environmental footprint, CPV allows for smooth permitting

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Four major arguments for CPV

1. **Great performance in regions with high DNI**
2. **Easy and flexible implementation in the field**
3. **Clean energy with a light environmental footprint**
4. **Low Cost of Energy**

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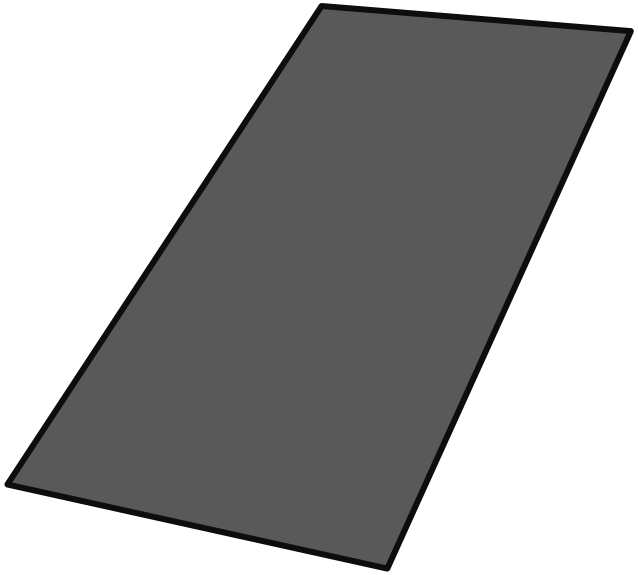
CPV modules will become the cheapest solar technology

- Highest Efficiency
  - About twice as efficient as state of the art PV technologies …
  - … which allows for most efficient use of materials

27% efficient CPV module



11% efficient thin film module

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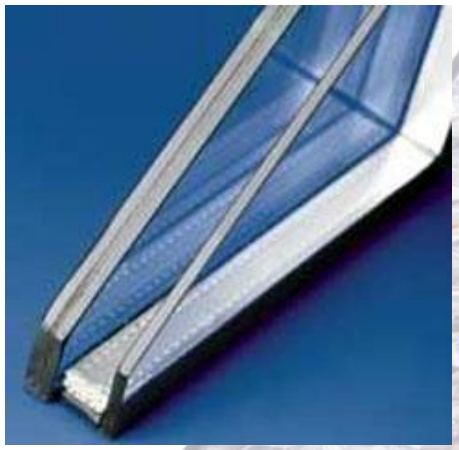
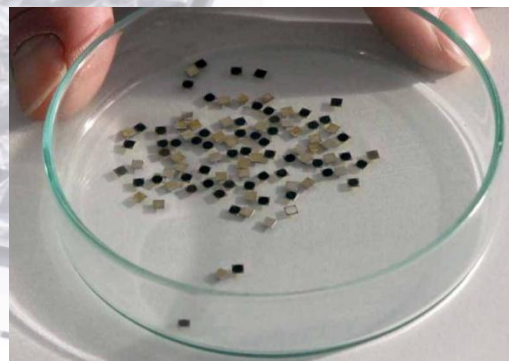
CPV modules will become the cheapest solar technology

- Highest Efficiency
  - About twice as efficient as state of the art PV technologies …
  - … which allows for most efficient use of materials
- Slim bill of materials
  - Semiconductor area is reduced to a fraction of the solar module size
  - Exclusively usage of low-cost material like glass, silicone



250 g metal for heat sink



70 ml of silicone

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Different technologies for different applications

Concentrating PV (CPV)

+ Further cost reduction
+ Low capax for production
+ Performance in high DNI regions
+ Environmental footprint
- Needs high DNI

Silicon PV

+ Low cost
+ Building integration
- Temperature coefficient
- Energy Payback Time

Thin-Film PV

+ Low cost
- Tracking not viable
- Land use

Concentrating Solar Power (CSP)

+ Storage
+ Hybrid concepts
- Cost reduction and innovation cycles
- Water consumption
- Needs high DNI

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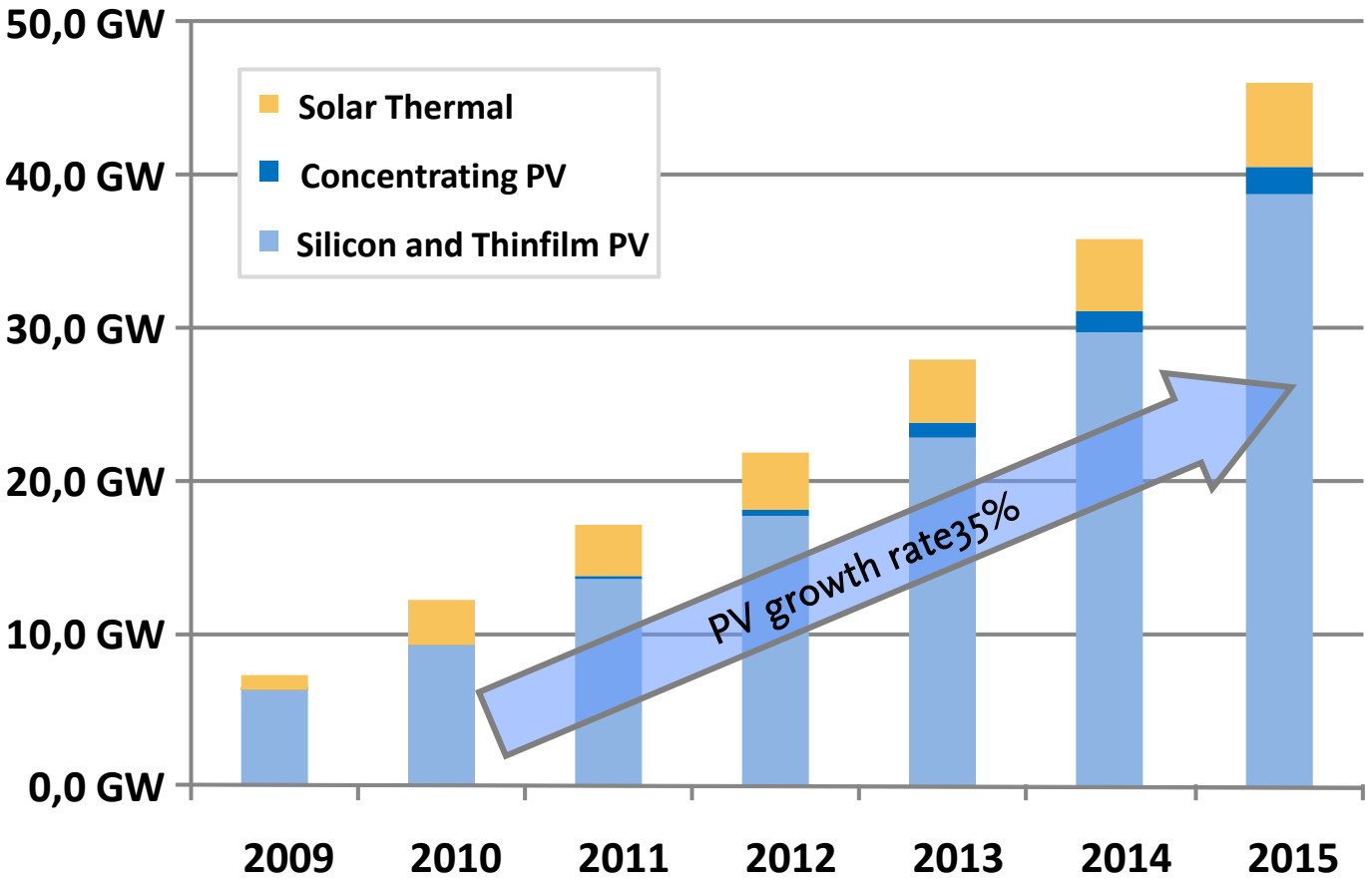
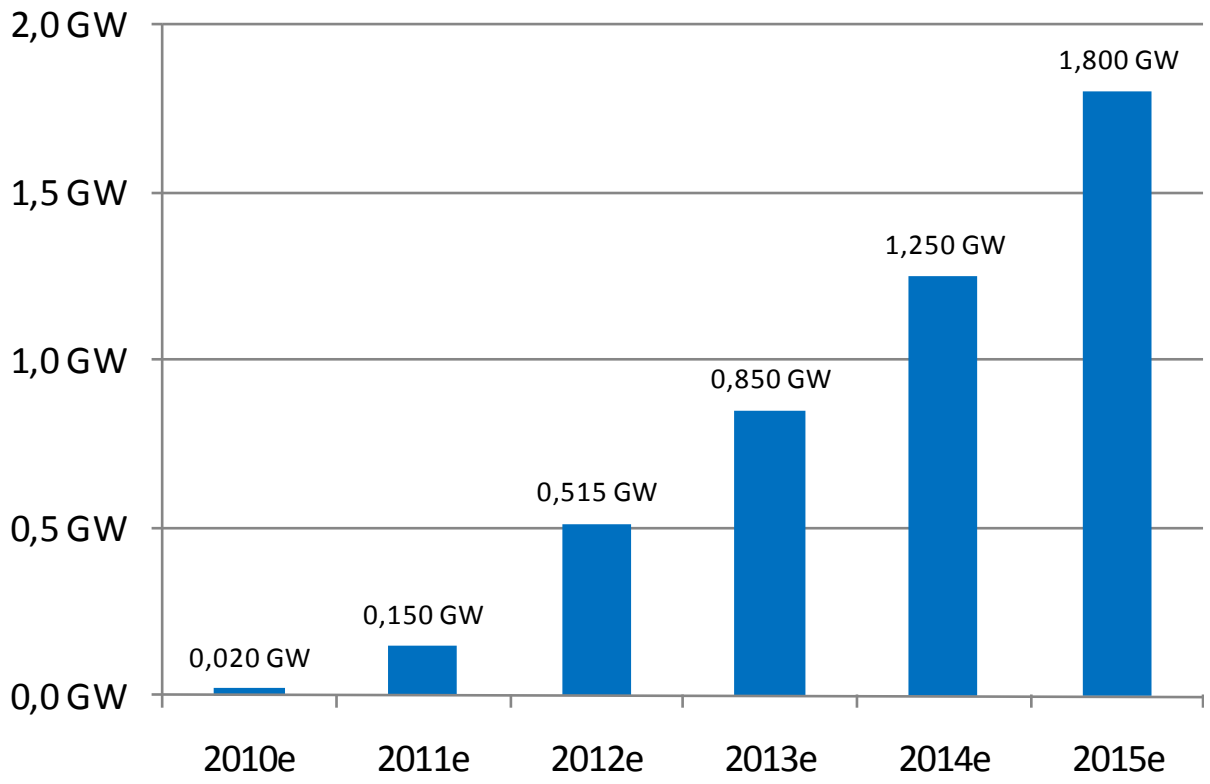
Market Projections – All Solar Technologies



Market development of Solar Technologies

Market Projections – CPV



Outline

1 Principle of Concentrating Photovoltaics

2 The choice for CPV

3 Industrial Manufacturing & Field Performance

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Industrial manufacturing is essential for a high quality product

- Capacity 25 MW/a
- 3 cells per second
- Fully automated positioning of cells assure for high accuracy and quality
- Unique quality assurance tools and processes

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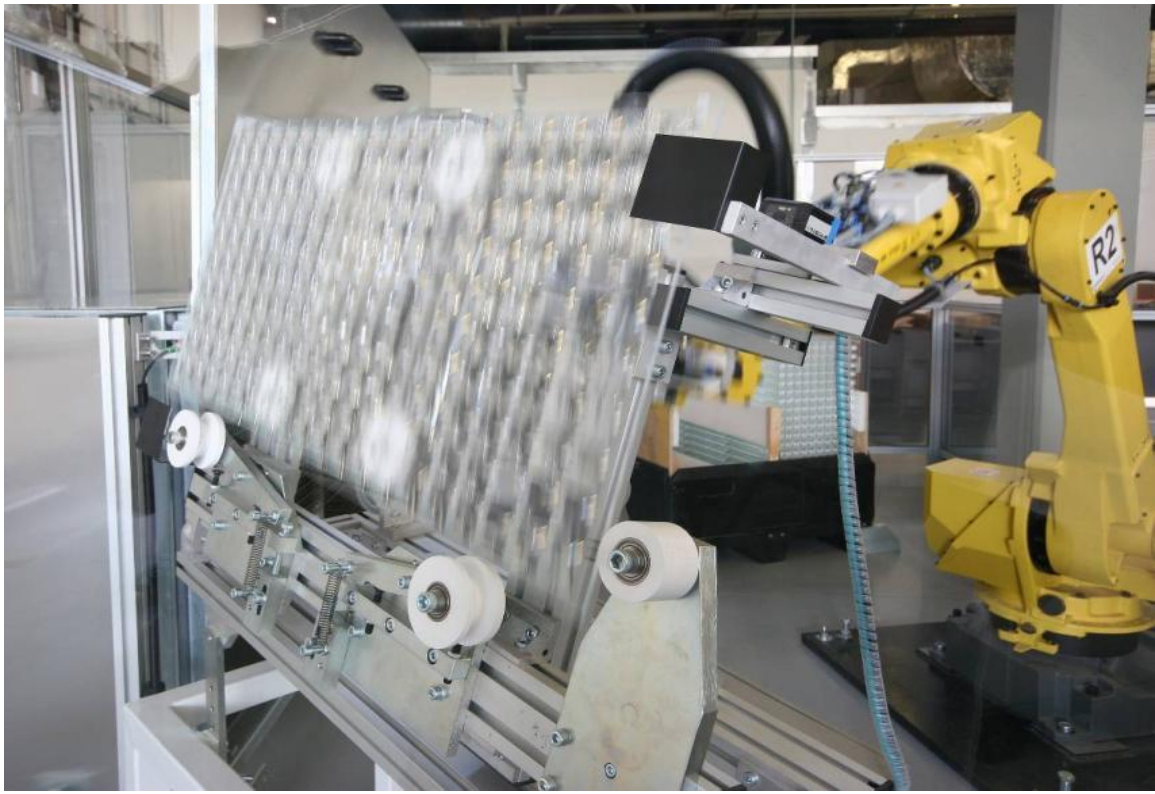
Industrial manufacturing is essential for a high quality product

- 50 modules per hour
- Fully automated module assembly assures for high
  quality and efficiency



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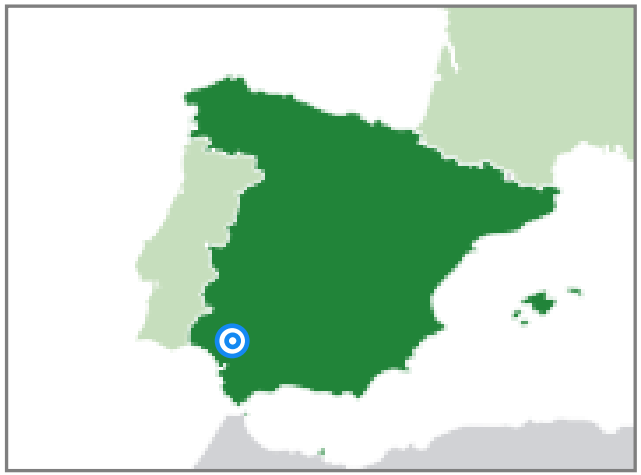
Power Plant Reference: Casaquemada (Spain)



Location:	Seville, Andalusia
Customer:	Abengoa
Size:	100 kW
Contract type:	CPV Turnkey Equipment
Concentrix Services:	Planning, Installation, Commissioning
Building phase:	June 2008 – July 2008
Grid connection:	28 September 2008

The power plant from Concentrix is part of a 2 MW combination power plant with both silicon flat plate modules and FLATCON® systems.

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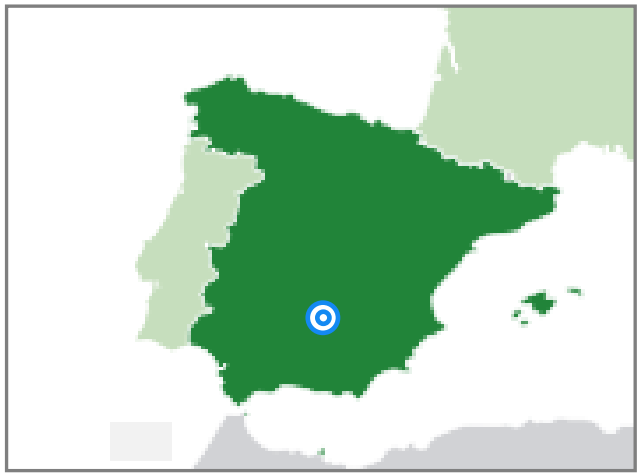
Power Plant Reference: Puertollano (Spain)



Location:	Puertollano, Castilla-La Mancha
Customer:	ISFOC
Size:	500 kW
Contract type:	CPV Turnkey
Concentrix Services:	Planning, Installation, Commissioning
Building phase:	Dec 2007 – Feb 2008 (1st phase) May 2008 – July 2008 (2nd phase) Oct 2008 – March 2009 (3rd phase)
Grid connection:	15 October 2008

The project is the first large solar power plant in Europe where highly efficient III-V multi-junction solar cells are used. The entire size of the power plant is 3 MW, of which 500 kW are delivered by Concentrix Solar.

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Power Plant Reference: Touwsrivier (South Africa)

Location:	Touwsrivier, South Africa
Customer:	PPA with Gamming Hotel Touwsrivier
Size:	60 kW
Contract type:	CPV Turnkey
Concentrix Services:	Planning, Installation, Commissioning
Building phase:	May 2010 – June 2010
Grid connection:	15 June 2010

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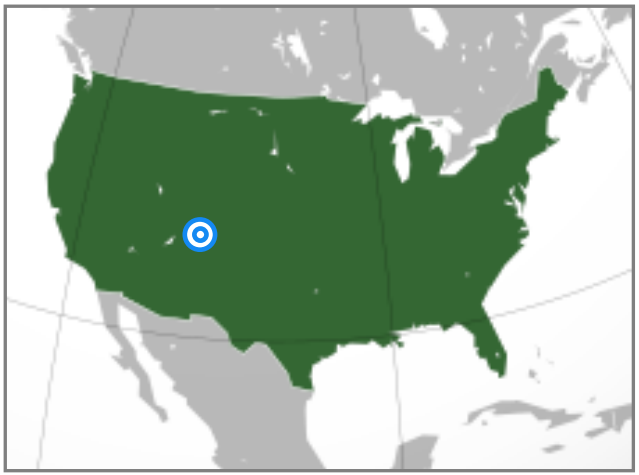
Power Plant Reference: Questa (USA)



Location:	Questa, New Mexico, USA
Customer:	Chevron
Size:	1000 kW
Contract type:	CPV Equipment
Concentrix Services:	Detail Engineering Support, Installation Support, Commissioning Support
Building phase:	2010, Q3/4

The power plant will be located on the mining tail, turning a brown field into a green field

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Summary of key messages

- CPV has entered the commercial & industrial stage
- The technology is bankable as it has proven reliable operation in the field and long term durability
- CPV has a number of strong advantages
  - Best performance in hot/sunny areas with high capacity factor
  - Lowest environmental footprint
- Highest cost reduction potential – lowest cost of electricity in sunny areas

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