



# Environmental profile of PV mass production: globalization




Mariska de Wild-Scholten

26<sup>th</sup> European Photovoltaic Solar Energy Conference, Hamburg  
8 September 2011



- Life Cycle Assessment

- Energy payback time  
 Carbon footprint

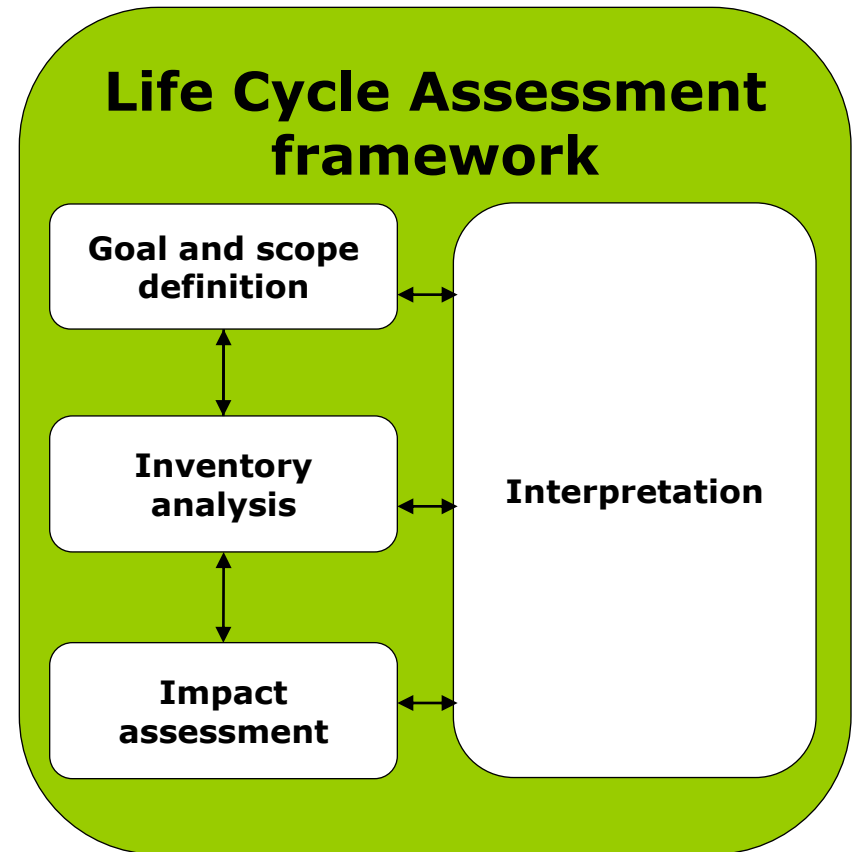
& Globalization  
of the PV industry

- Data request

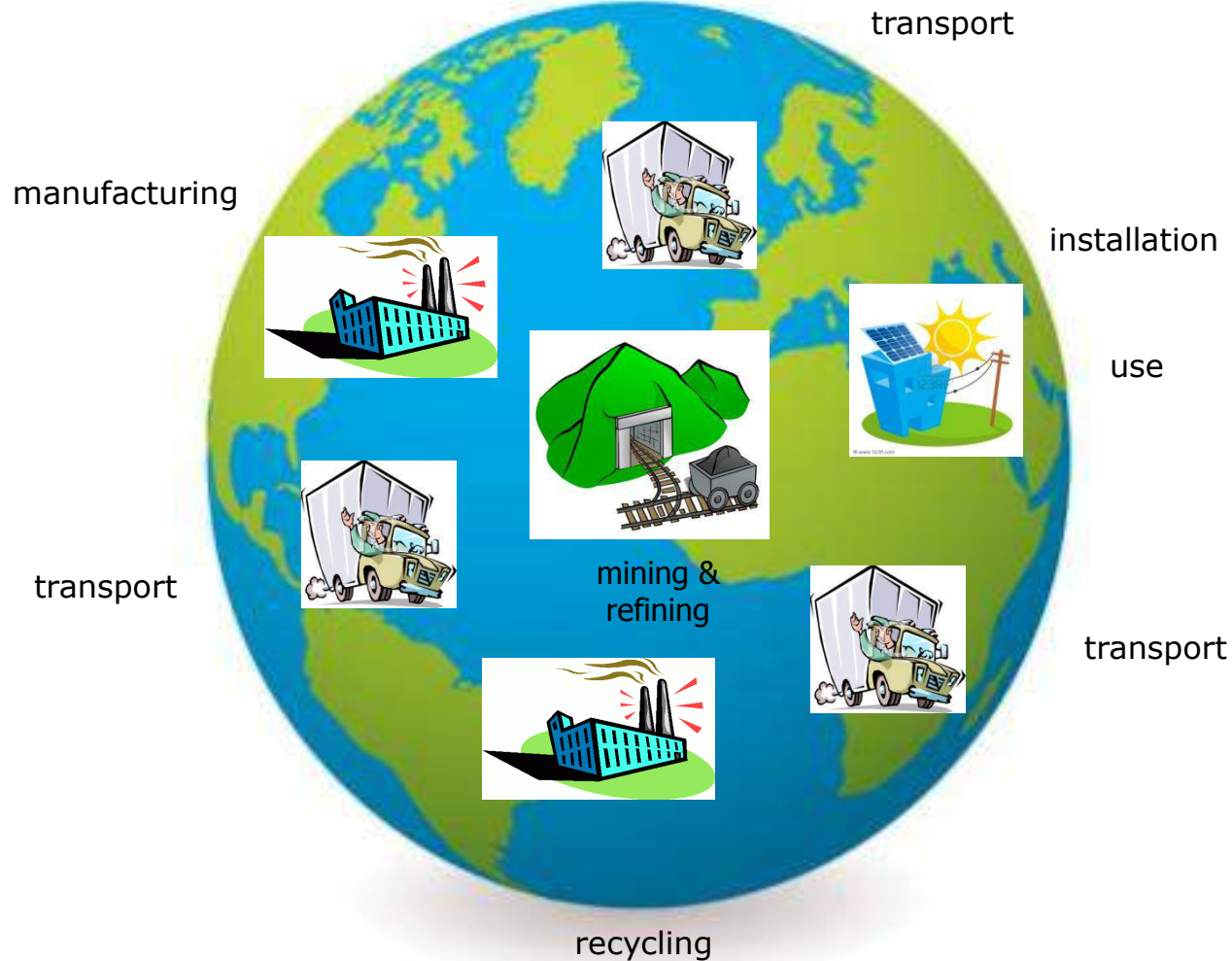
# Life Cycle Assessment

Determination of environmental impact of a product from cradle to grave/cradle

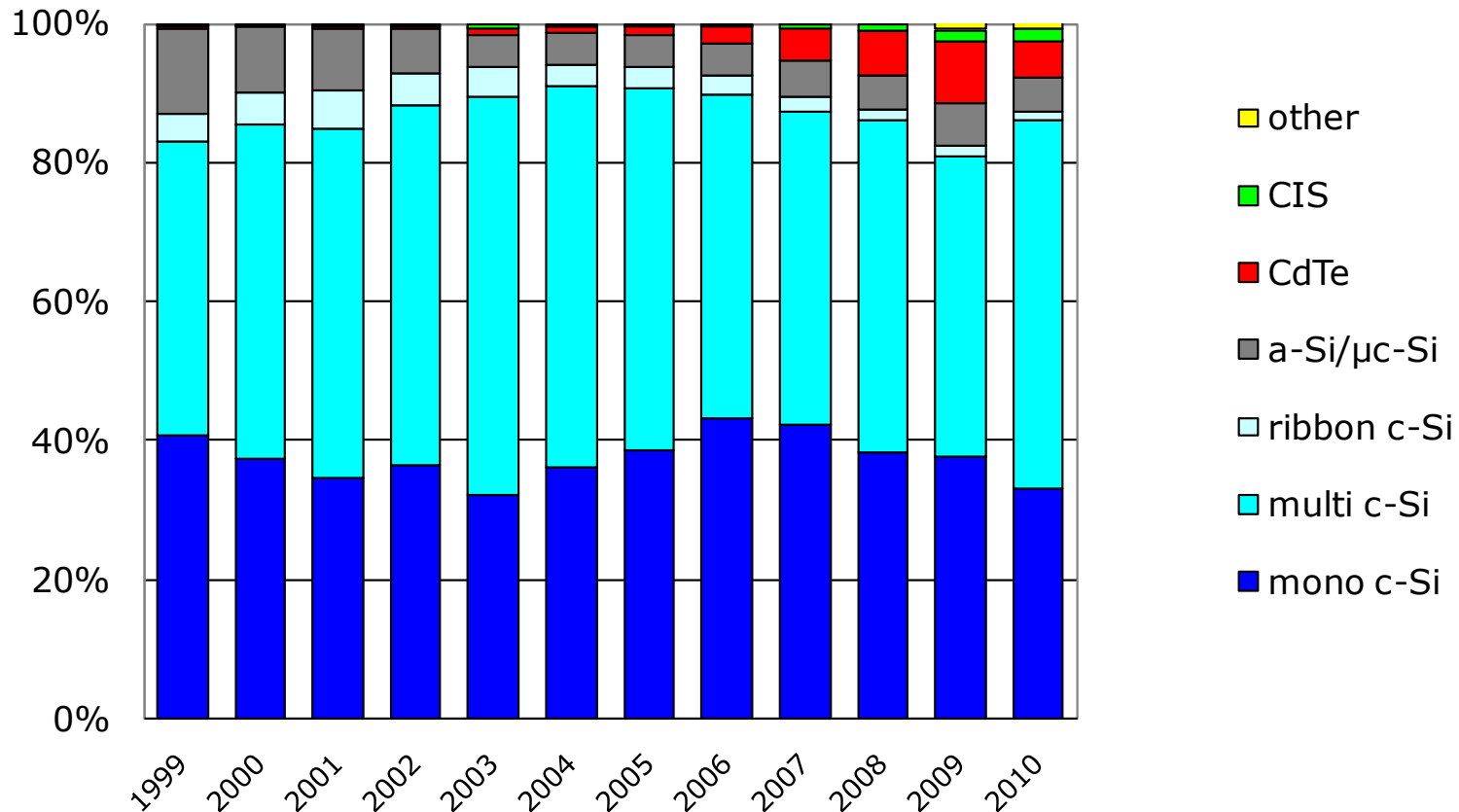
**ISO14040 series**



# Life Cycle

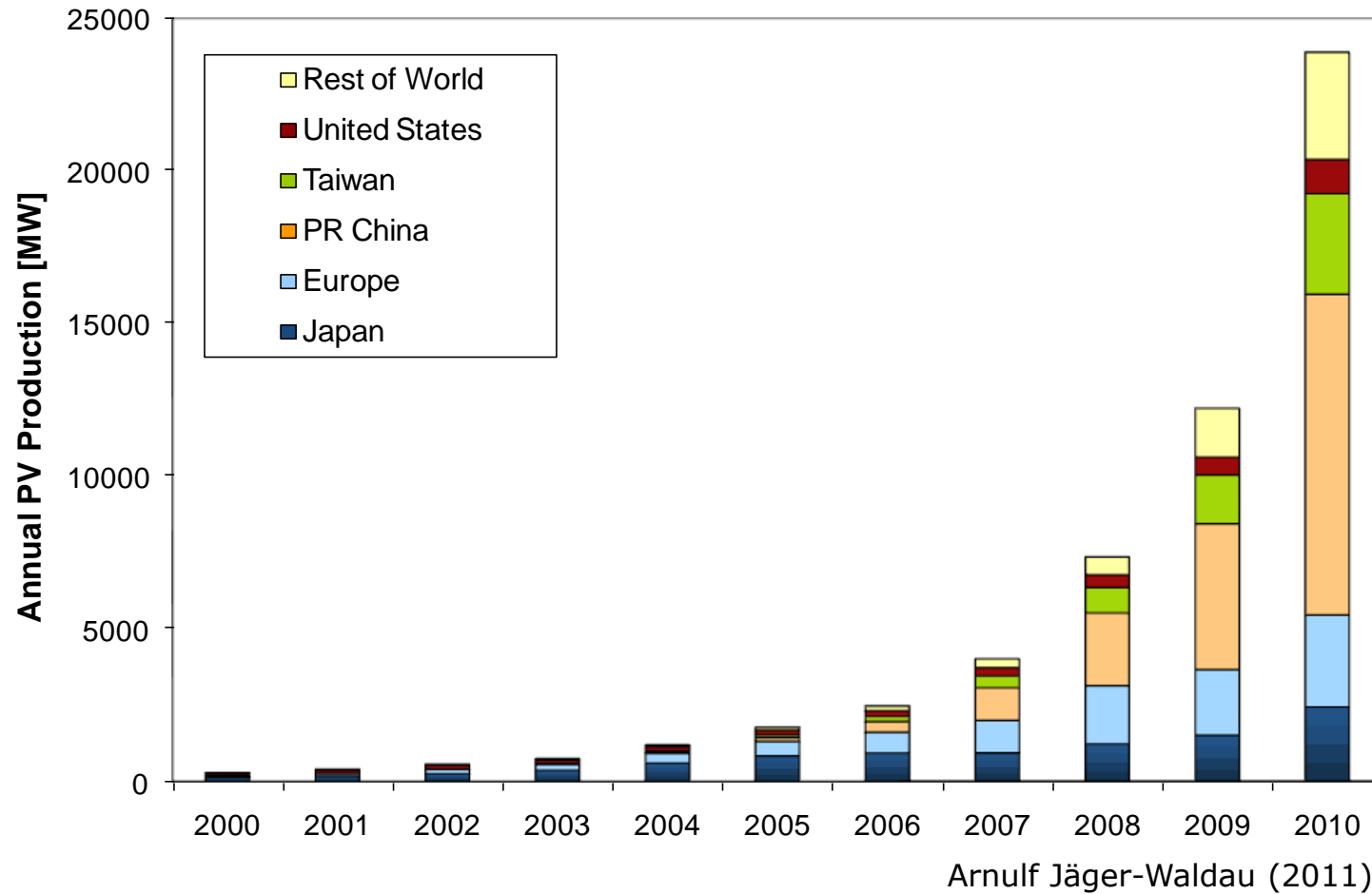


# Market share of cell technologies

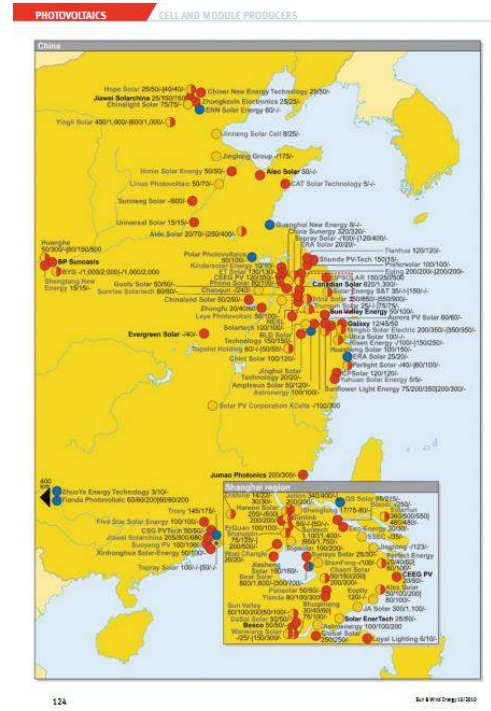
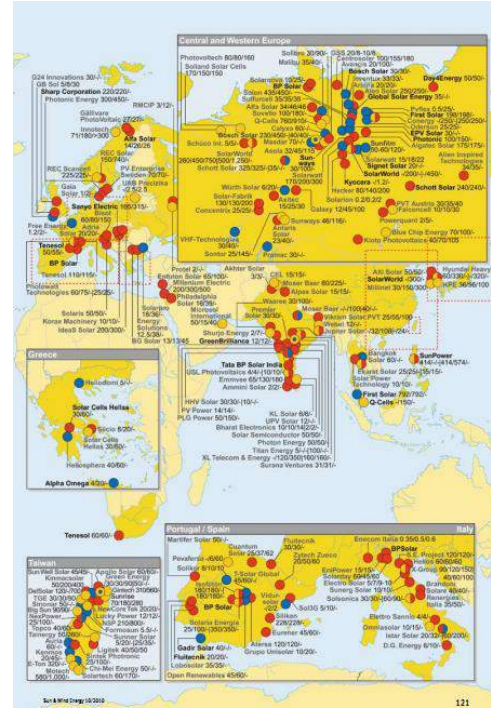
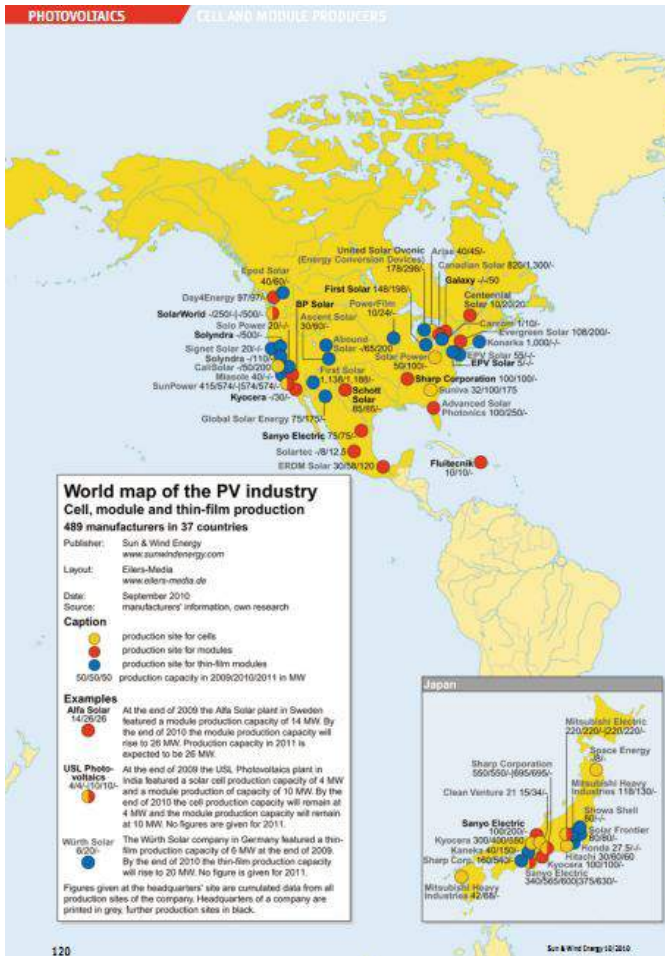


Photon International March 2011

# Global PV production

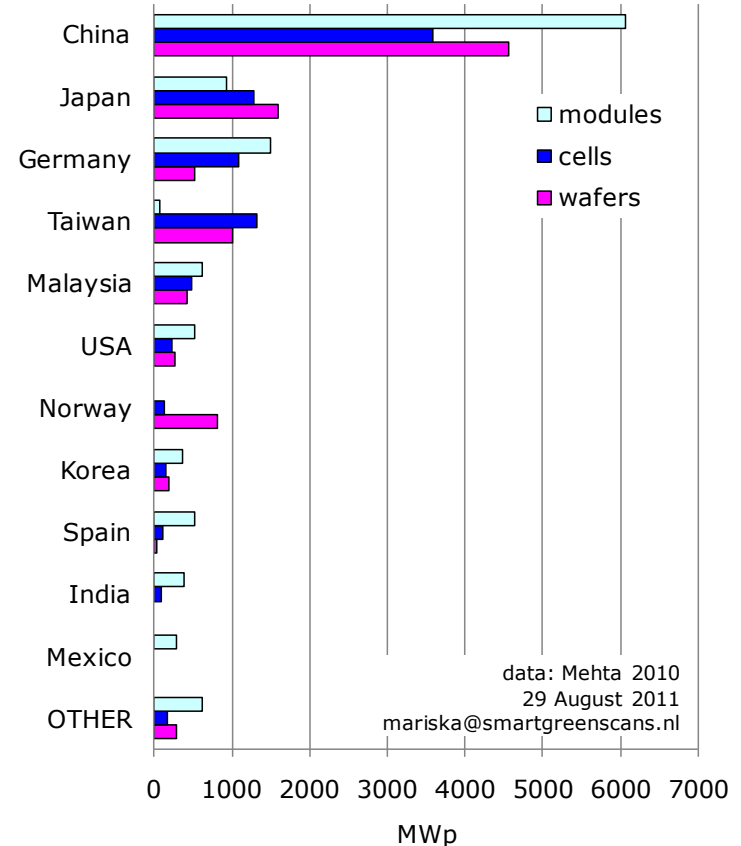
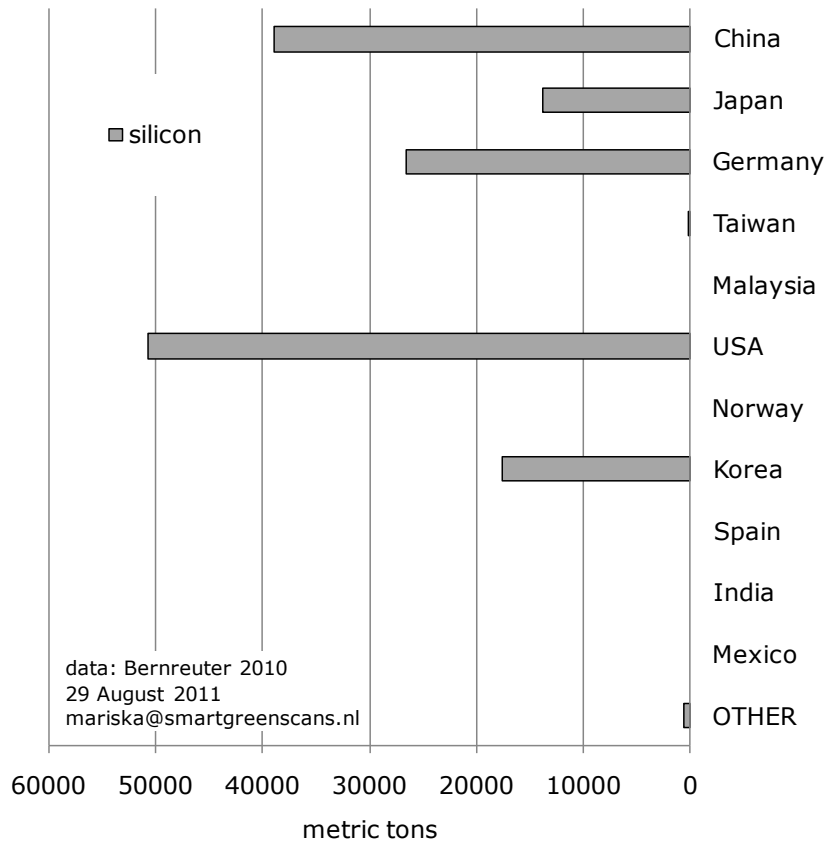


# Global PV production



## Raspe in Sun & Wind Energy 10/2010

# Global PV production

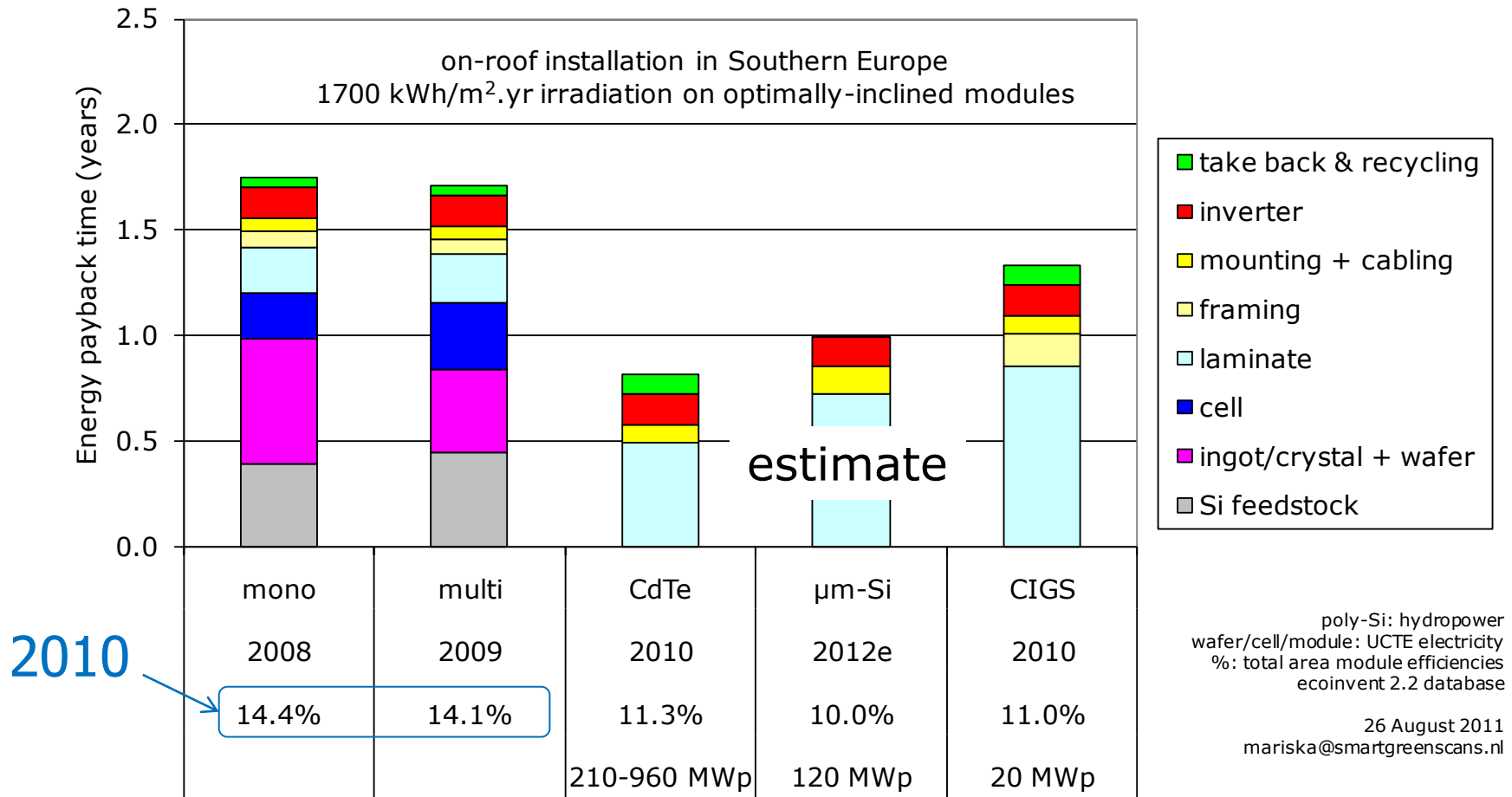


Poly-silicon production partly with local electricity (hydropower or CHP) instead of country mix

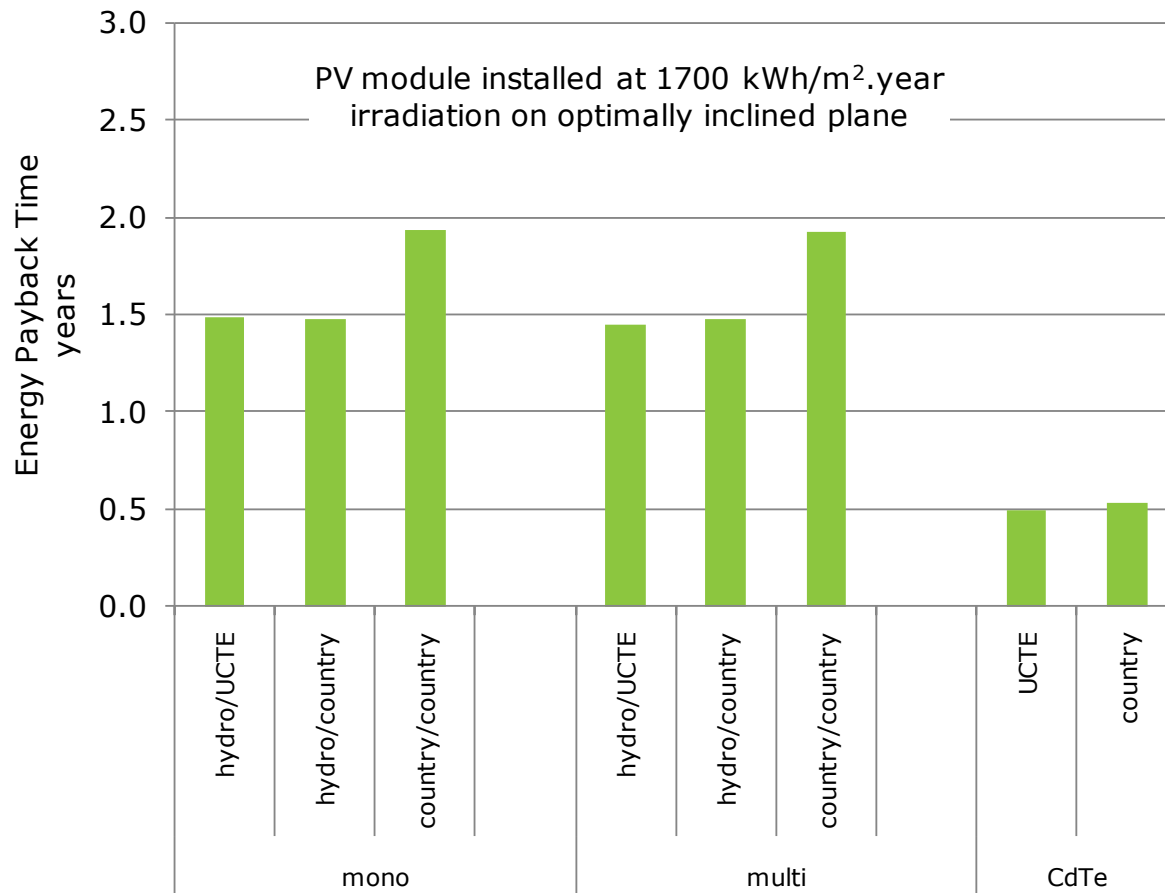


# Energy payback time

# Energy payback time



# Energy payback time



sensitivity  
to type of  
electricity  
for electricity  
consumption  
in poly-Si, wafer,  
cell and module  
production

poly-Si / wafer-cell-module

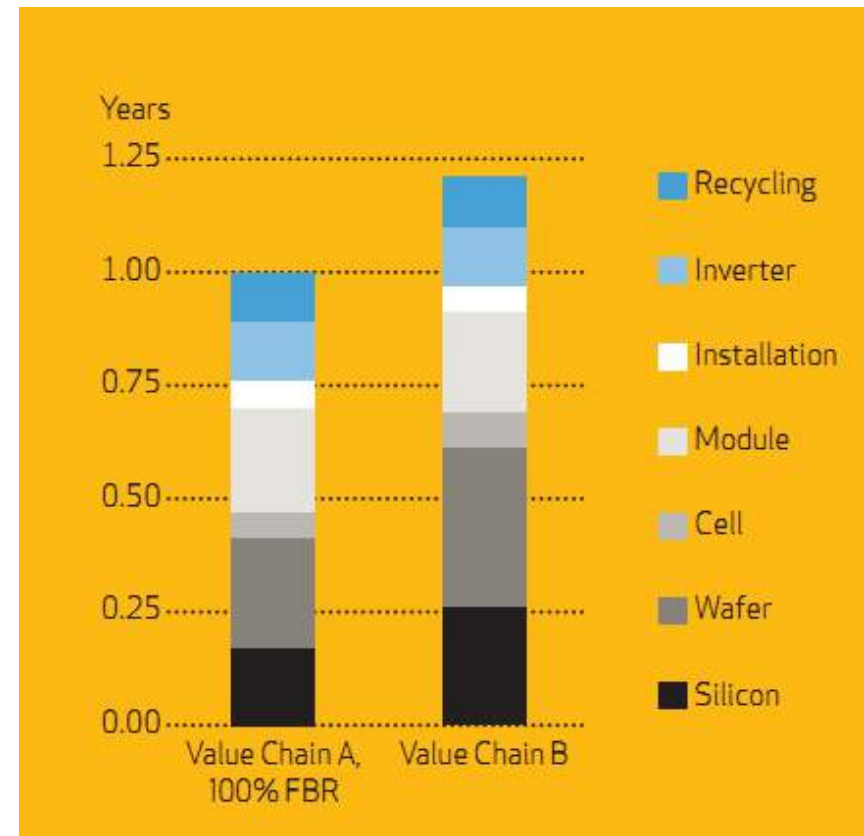
ecoinvent 2.2 database  
IEA Statistics Electricity 2008

29 August 2011  
mariska@smartgreenscans.nl

# Energy payback time

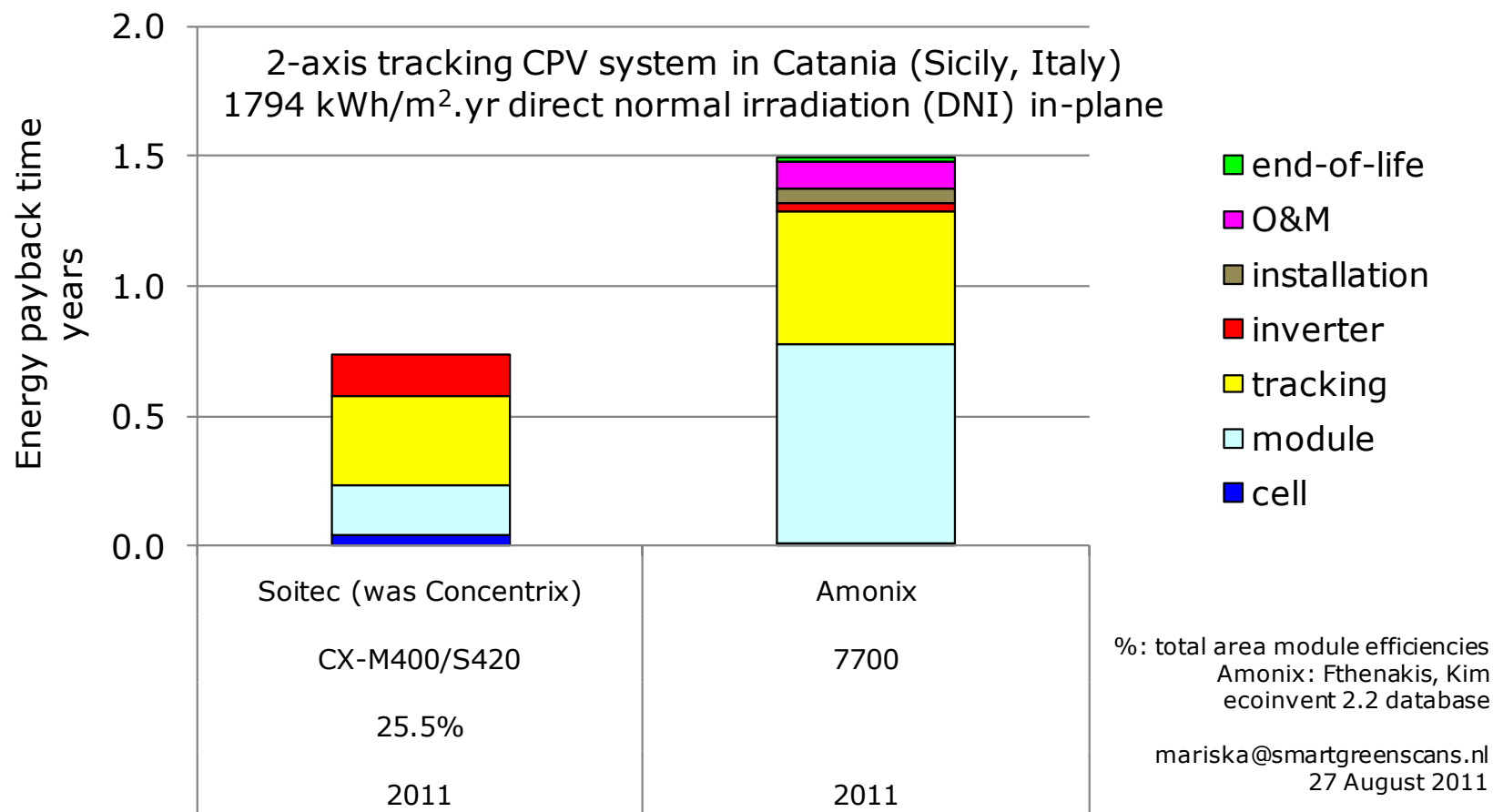
@ 1700 kWh/m<sup>2</sup>.year

- REC
- LCA by ECN
- Value chain A:
  - poly-Si: FBR, hydro
  - wafers/cells: Norway
  - modules: Singapore
- Value chain B:
  - poly-Si: Siemens/FBR, hydro
  - wafers, cells, modules: Singapore



<http://www.recgroup.com/en/sustainability/>

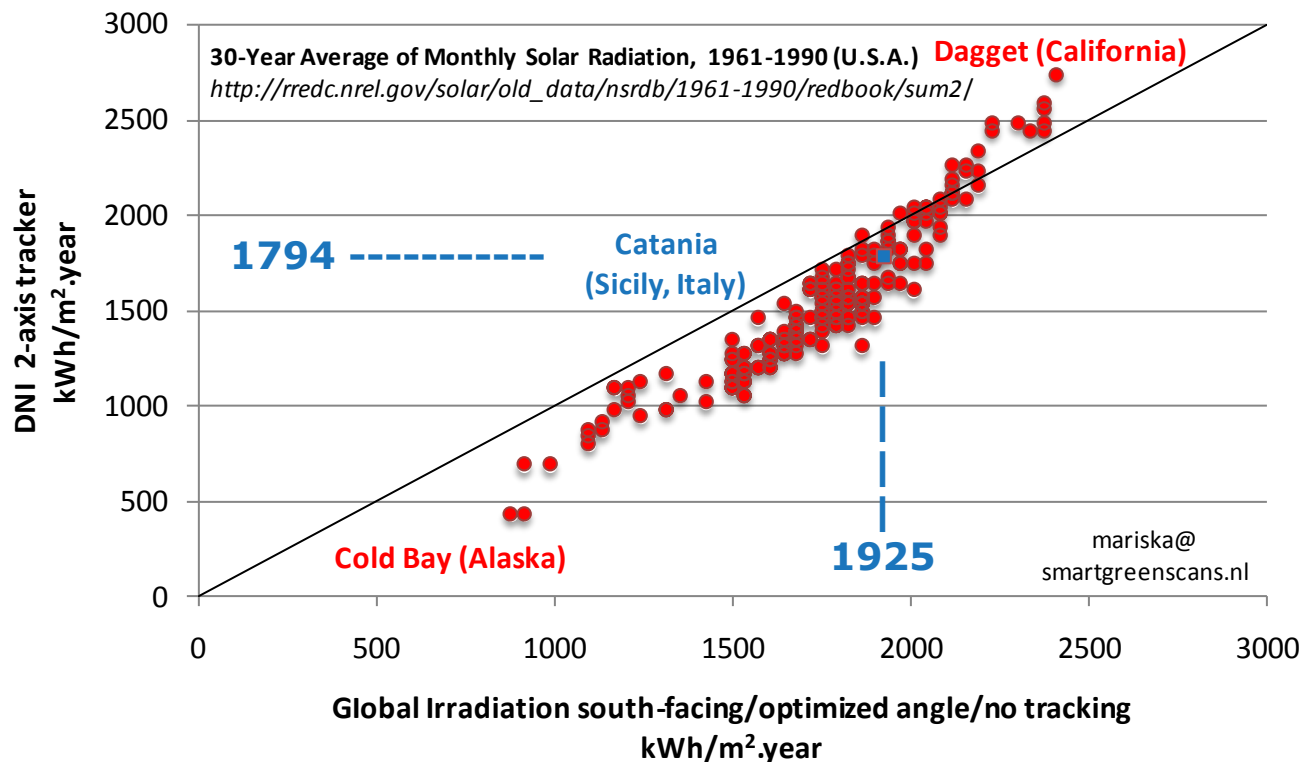
# Energy payback time



Global irradiation in Catania is 1925 kWh/m<sup>2</sup>.year

# DNI vs global irradiation

Compare CPV with flat plate PV only for one DNI-GI combination (location)!



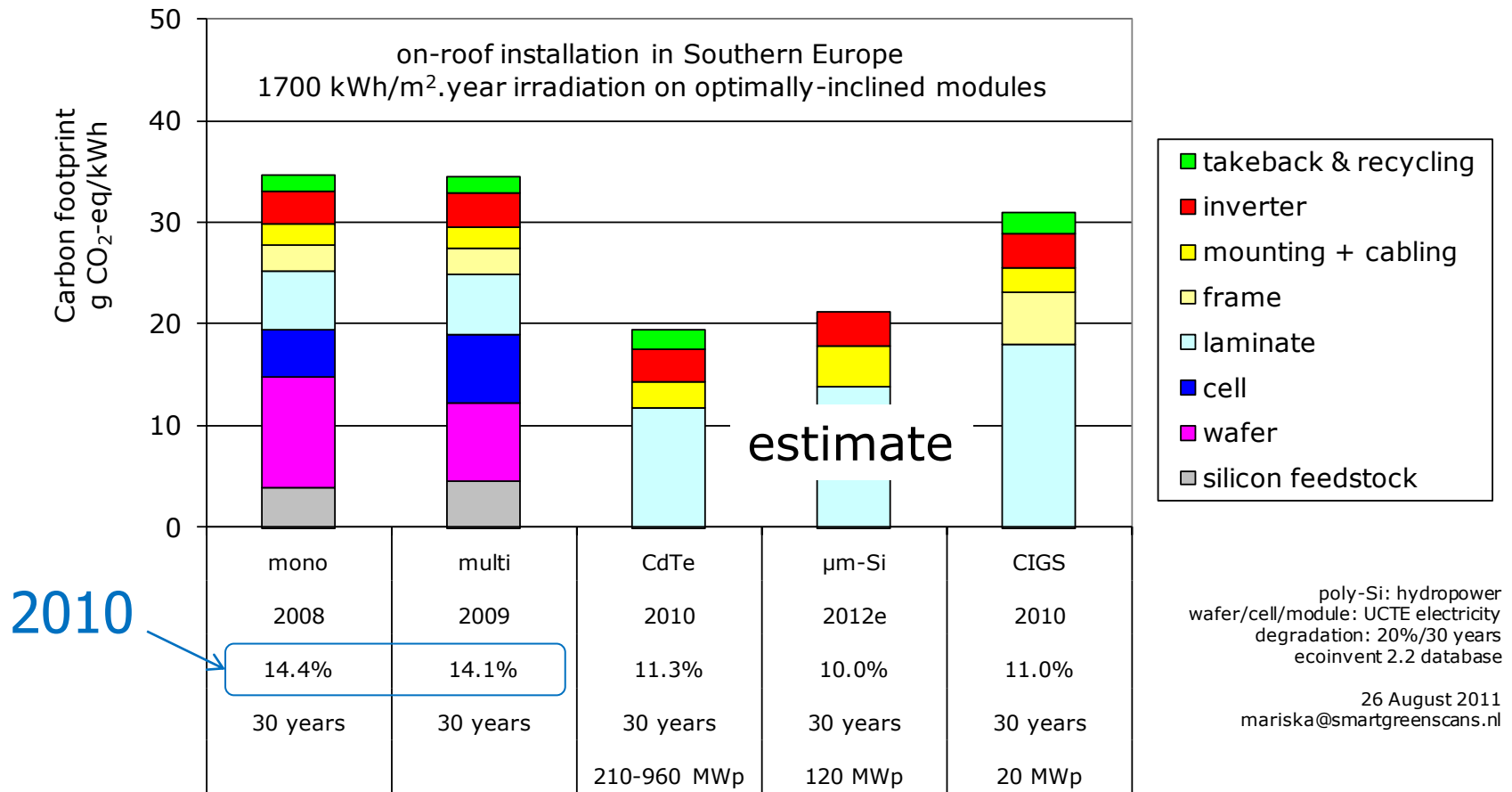


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Carbon footprint  
=  
life-cycle CO<sub>2</sub>-equivalent  
emissions

now with module degradation included: 20% / 30 years

# Carbon footprint

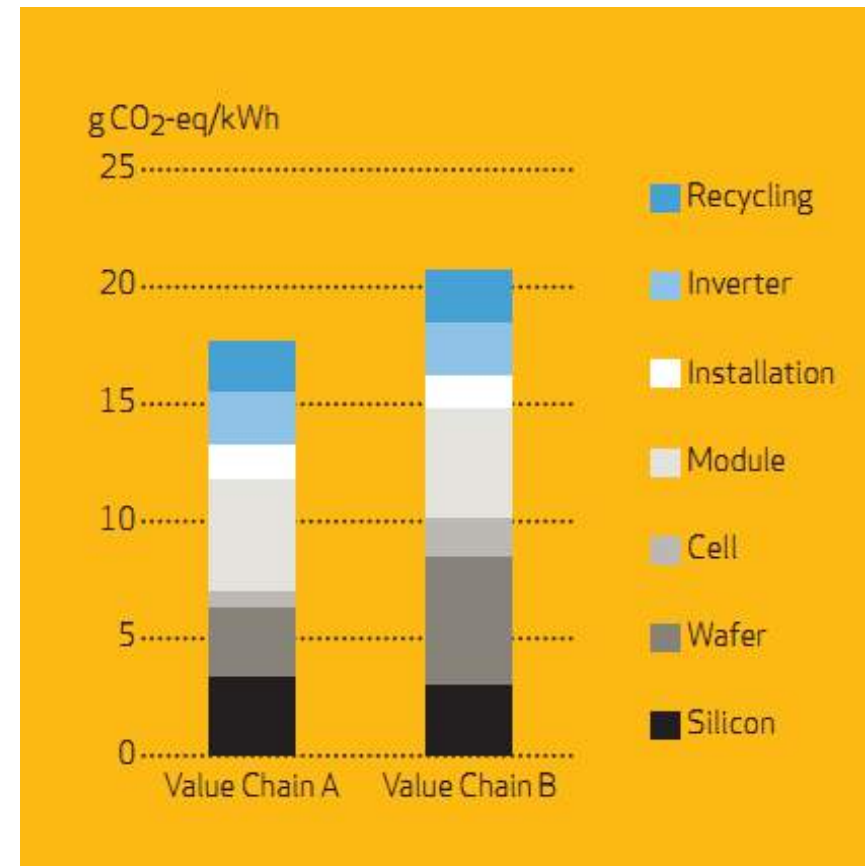




# Carbon Footprint

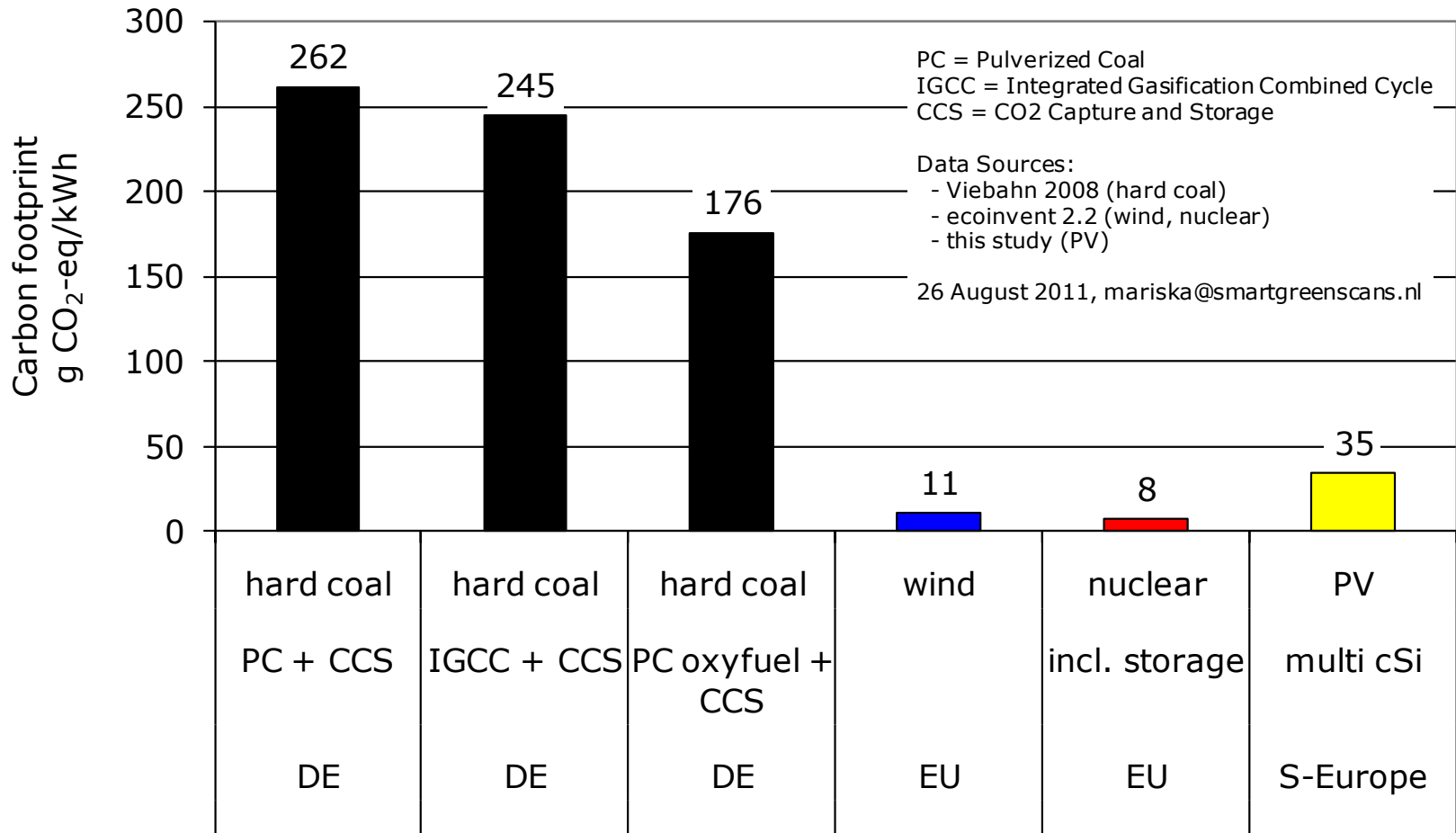
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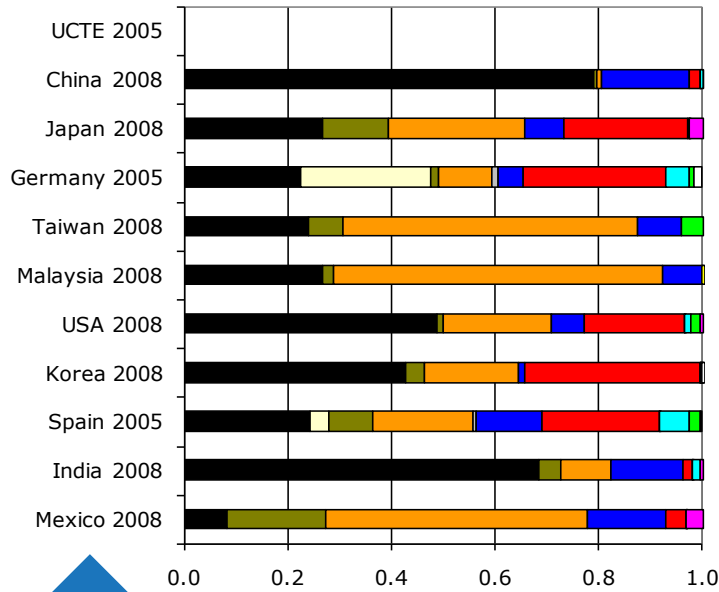


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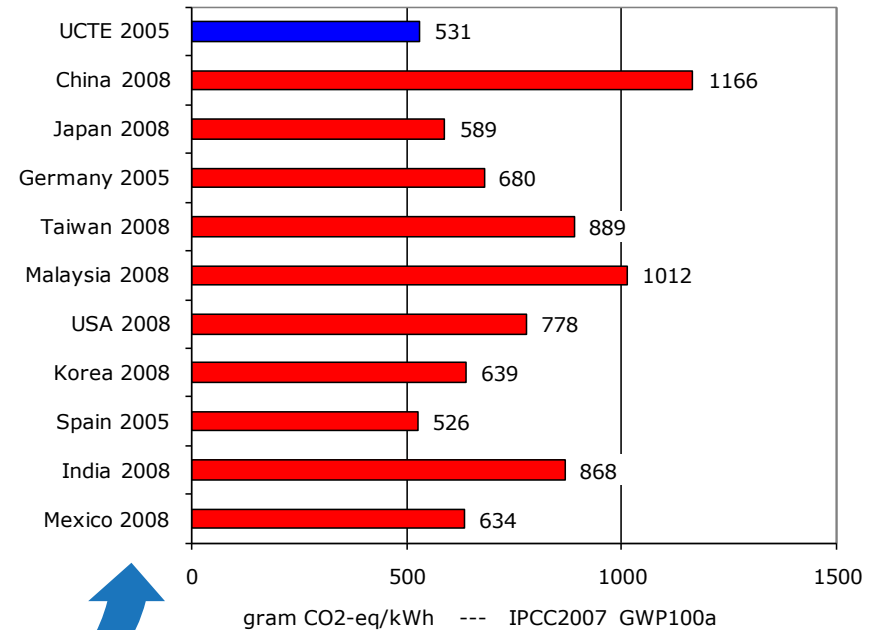
# Carbon footprint electricity



# Carbon footprint electricity

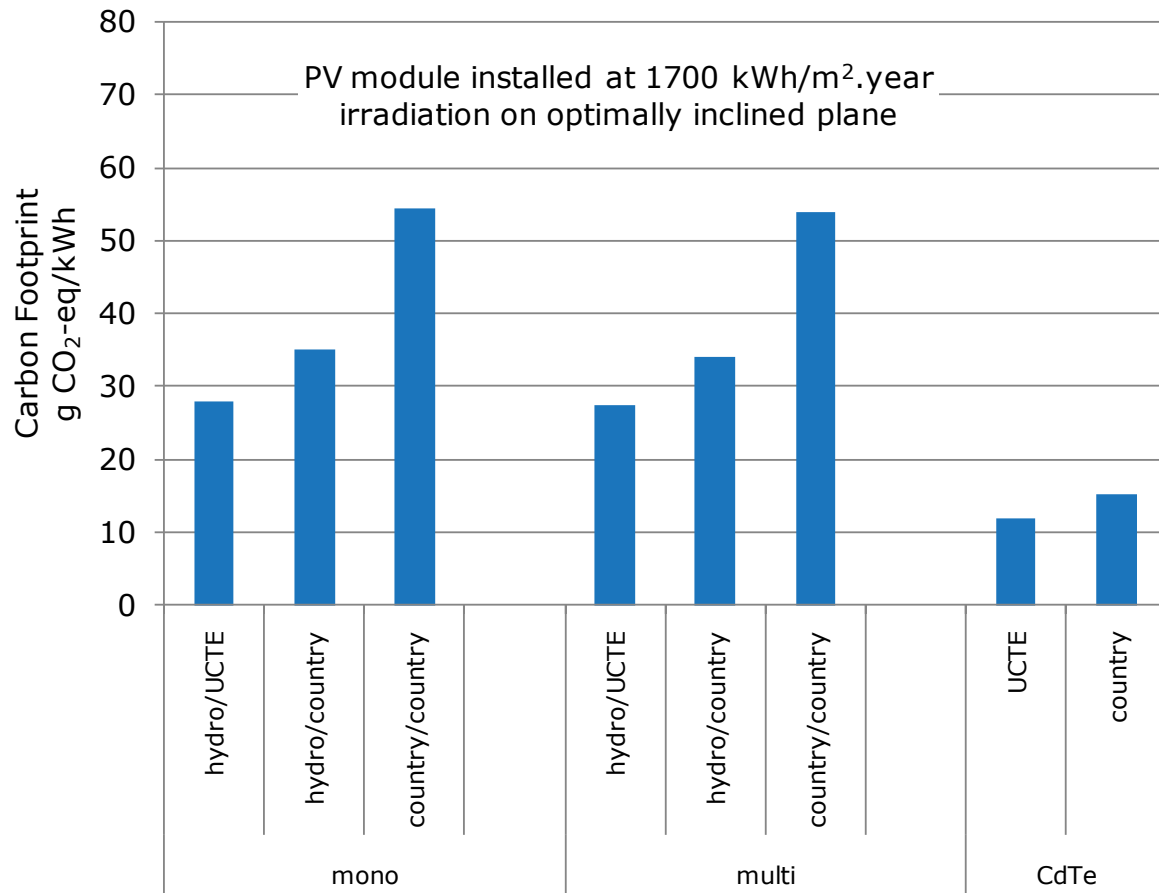


top production locations



high uncertainty

# Carbon footprint



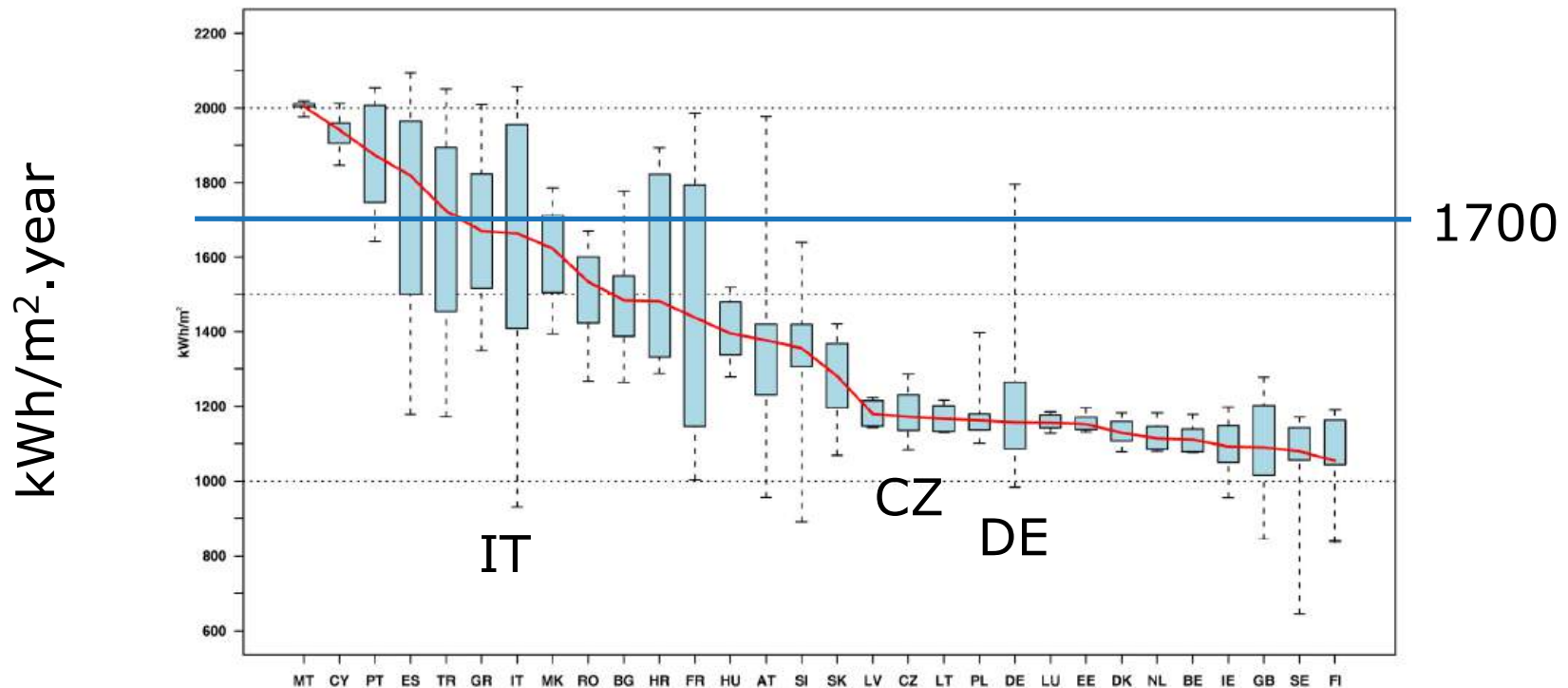
sensitivity  
to type of  
electricity  
consumption  
for electricity  
consumption  
in poly-Si, wafer,  
cell and module  
production

poly-Si / wafer-cell-module  
module degradation: 20%/30 years  
ecoinvent 2.2 database  
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# Installation location

Comparison of yearly global irradiation incident on optimally-inclined photovoltaic modules in 25 European Union member countries and 5 candidate countries

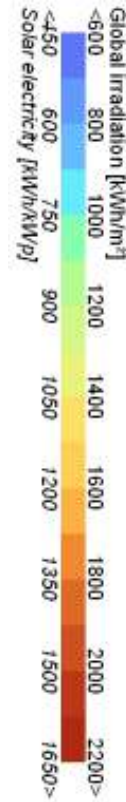
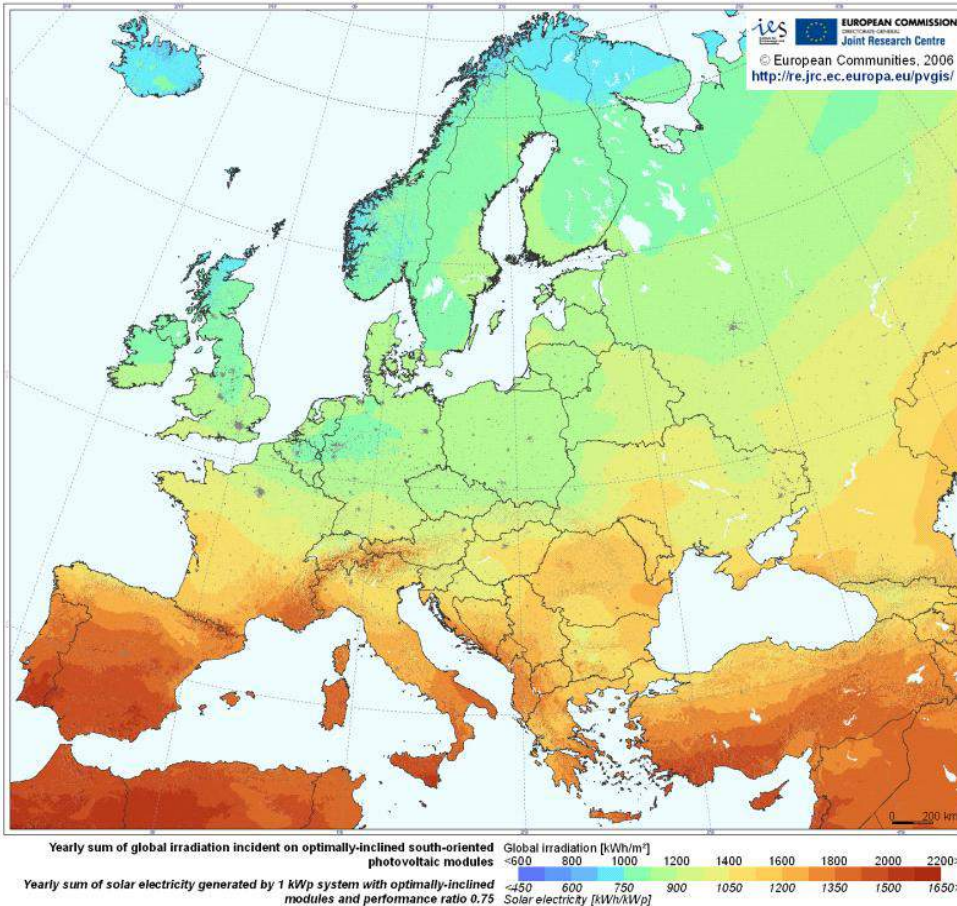


The country averages are connected by the red line. The minima/maxima in each country are shown as dashed lines, while the boxes show the range in which 90% of built-up areas in the country fit.

[http://re.jrc.ec.europa.eu/pvgis/cmeps/eu\\_opt/PVGIS-EuropeSolarPotential.pdf](http://re.jrc.ec.europa.eu/pvgis/cmeps/eu_opt/PVGIS-EuropeSolarPotential.pdf)

# “The” carbon footprint of multi c-Si PV system

Photovoltaic Solar Electricity Potential in European Countries



g CO<sub>2</sub>-eq/kWh

98  
73  
59  
49  
42  
37  
33  
29  
27

# Data & assumptions

	mono	multi	μm-Si	CdTe	CIS
<b>DATA SOURCES</b>					
poly-silicon	1	1			
ingot/wafer	1	3			
cell	Schottler2009	2 + Schottler2009			
module	same as multi	2	Oerlikon Solar THINFAB	First Solar DE, US, MY	DE
mounting	1	1	1	1	1
inverter	ecoinvent 2.2	ecoinvent 2.2	ecoinvent 2.2	ecoinvent 2.2	ecoinvent 2.2
<b>KEY PARAMETERS</b>					
wafer thickness	180 μm	180 μm			
cell size	156 mm x 156 mm	156 mm x 156 mm			
module size	6 x 10 cells	6 x 10 cells			
glass	single	single	double	double	double
EVA or PVB	EVA	EVA	EVA	EVA	PVB
frame	yes	yes	no	no	yes
mounting on -roof	Schletter	Schletter	fix	Schletter (cSi)	Schletter (cSi)
inverter	2.5 kW	2.5 kW	2.5 kW	2.5 kW	2.5 kW
module recycling	via glass recycler	via glass recycler		excl. filtercake recycling	same as CdTe
average total module eff	14.4%	14.1%	10.0%	11.3%	11.0%
degradation (%/year)	0.67	0.67	0.67	0.67	0.67
performance ratio	0.75	0.75	0.75	0.75	0.75

- Update renewable energy data in GEMIS:
  - Project financed by BMU (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
  - draft/final report ready 31 October/November 2011
- Updateecoinvent database:
  - deadline data delivery toecoinvent 31 December 2011
- Excel data template is available on request (english & chinese)



# Conclusions

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Energy payback time & environmental impacts / kWh produced depend on production and installation location.

For commercial roof-top PV system with Siemens poly-Si from hydropower and wafer/cell/module from UCTE electricity, installed in Southern Europe (1700 kWh/m<sup>2</sup>.year)

- Energy payback time ~0.8-1.7 years
- Carbon footprint ~19-34 g CO<sub>2</sub>-eq/kWh
- More data needed to reduce uncertainty in analysis & make it more representative



## Acknowledgements:

BMU

Certisolis

First Solar

## Further info:

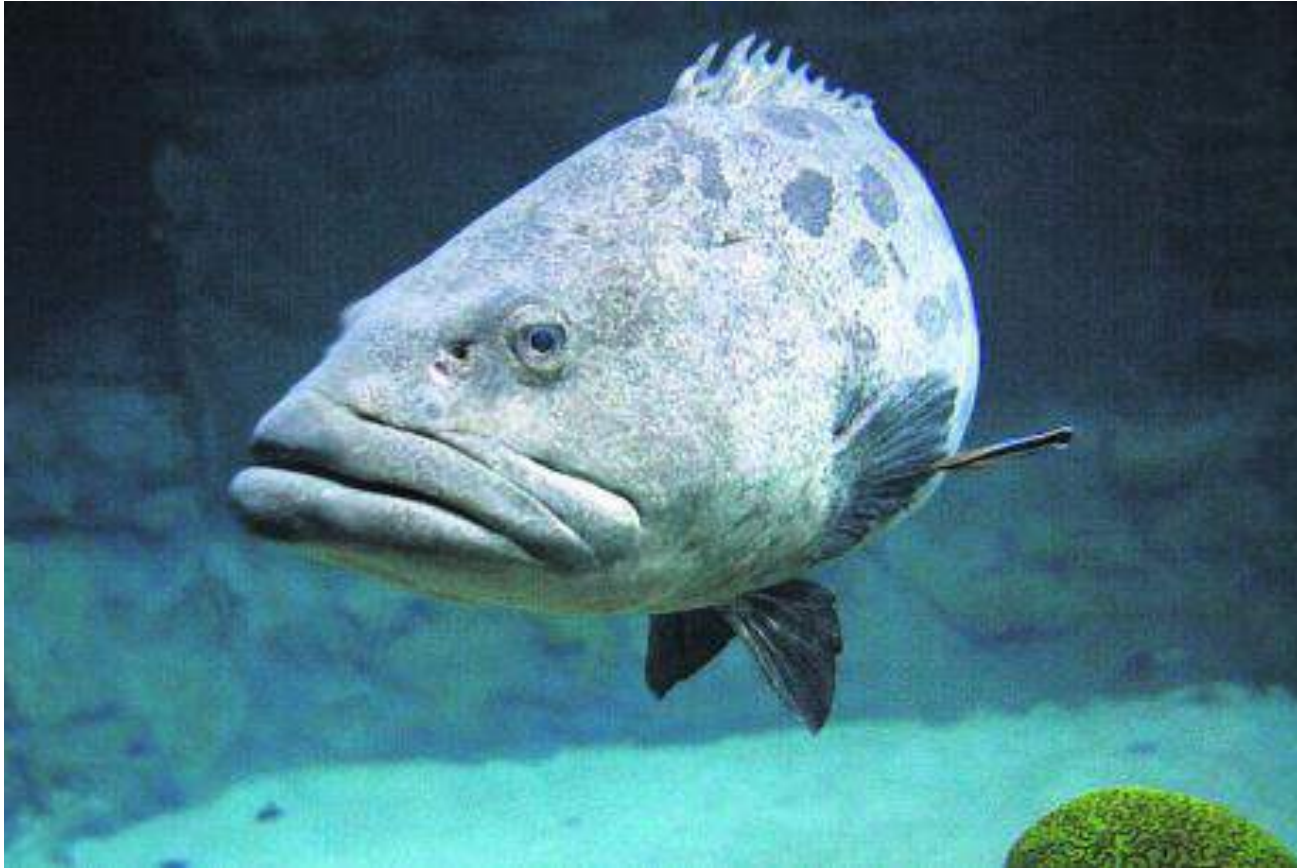
<http://smartgreenscans.nl/>

- download this presentation
- free energy payback time tool thin film PV module

IEA PVPS Task 12

EPIA Sustainability Working Group

# Thank you!



Tropical Aquarium Hagenbeck in Hamburg

