



**More Self Consumption through PowerMax®**

**September 2013**

- 1 The CIS-technology
- 2 PowerMax<sup>®</sup>, CIS-photovoltaik module
- 3 PowerMax<sup>®</sup> product advantages
- 4 More output with PowerMax<sup>®</sup>
- 5 PowerMax<sup>®</sup>, part of a autarchic house

**1** The CIS-technology

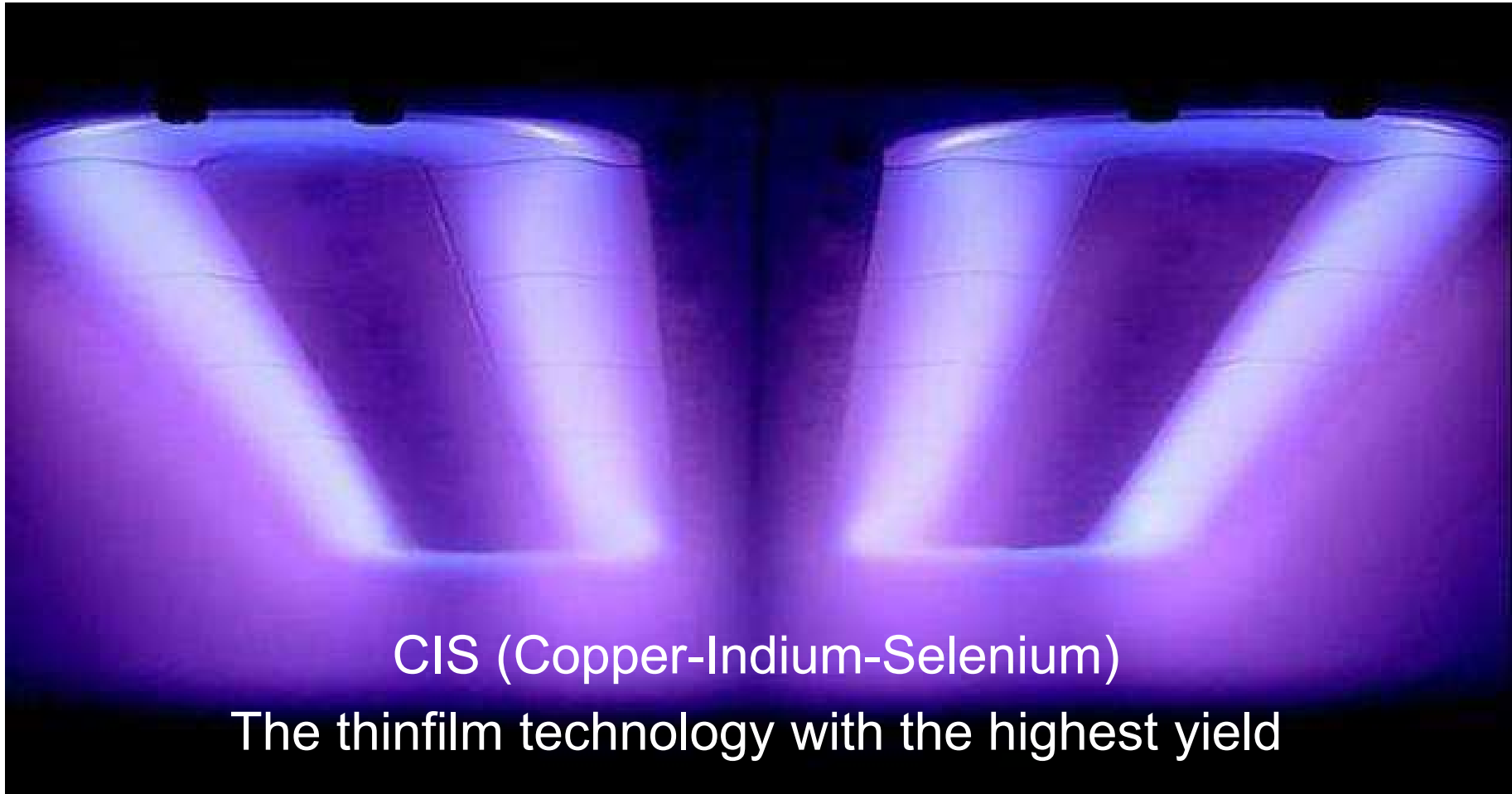
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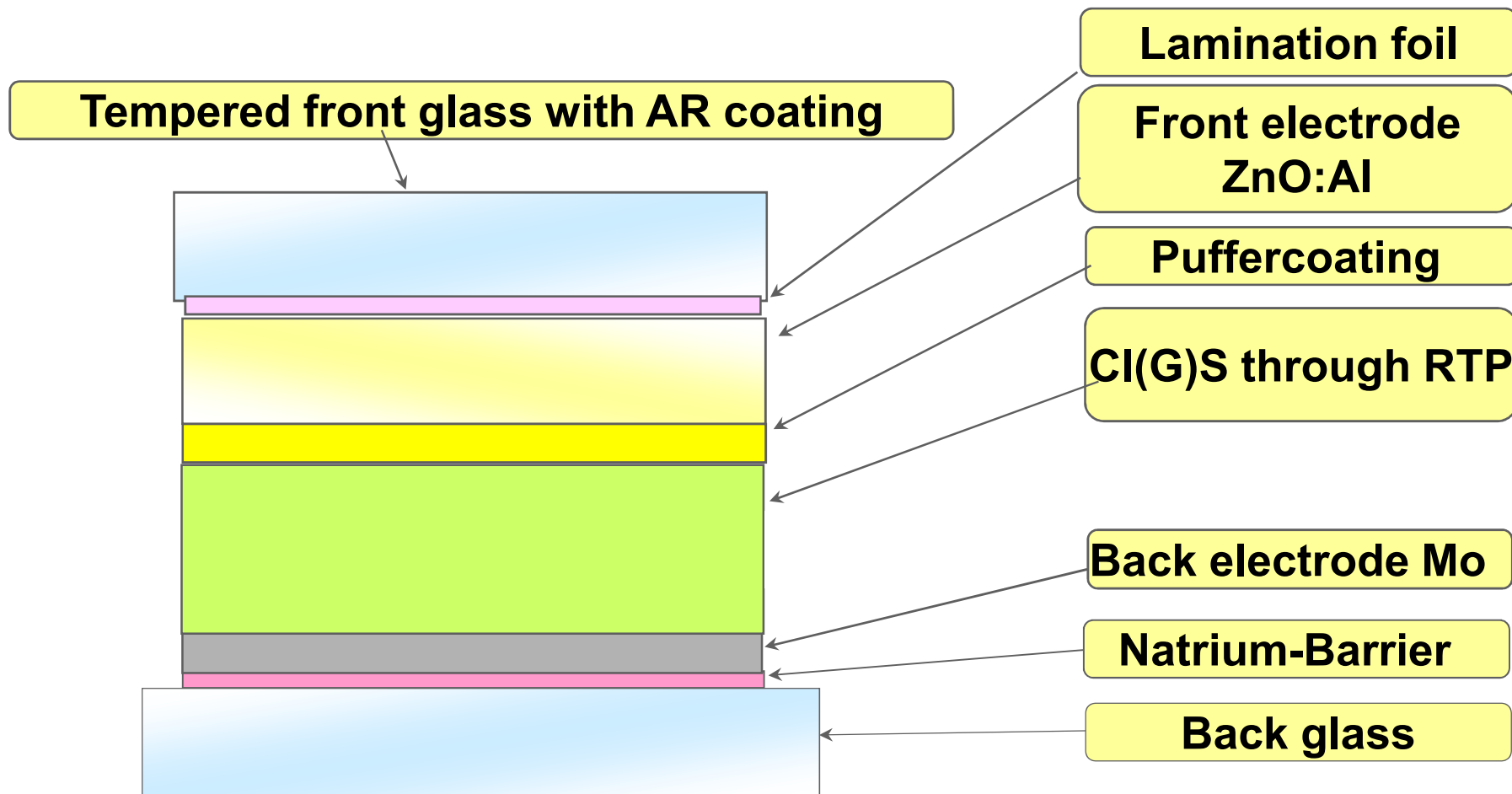
### Sputtering



# CIS-Technology: a patented production process

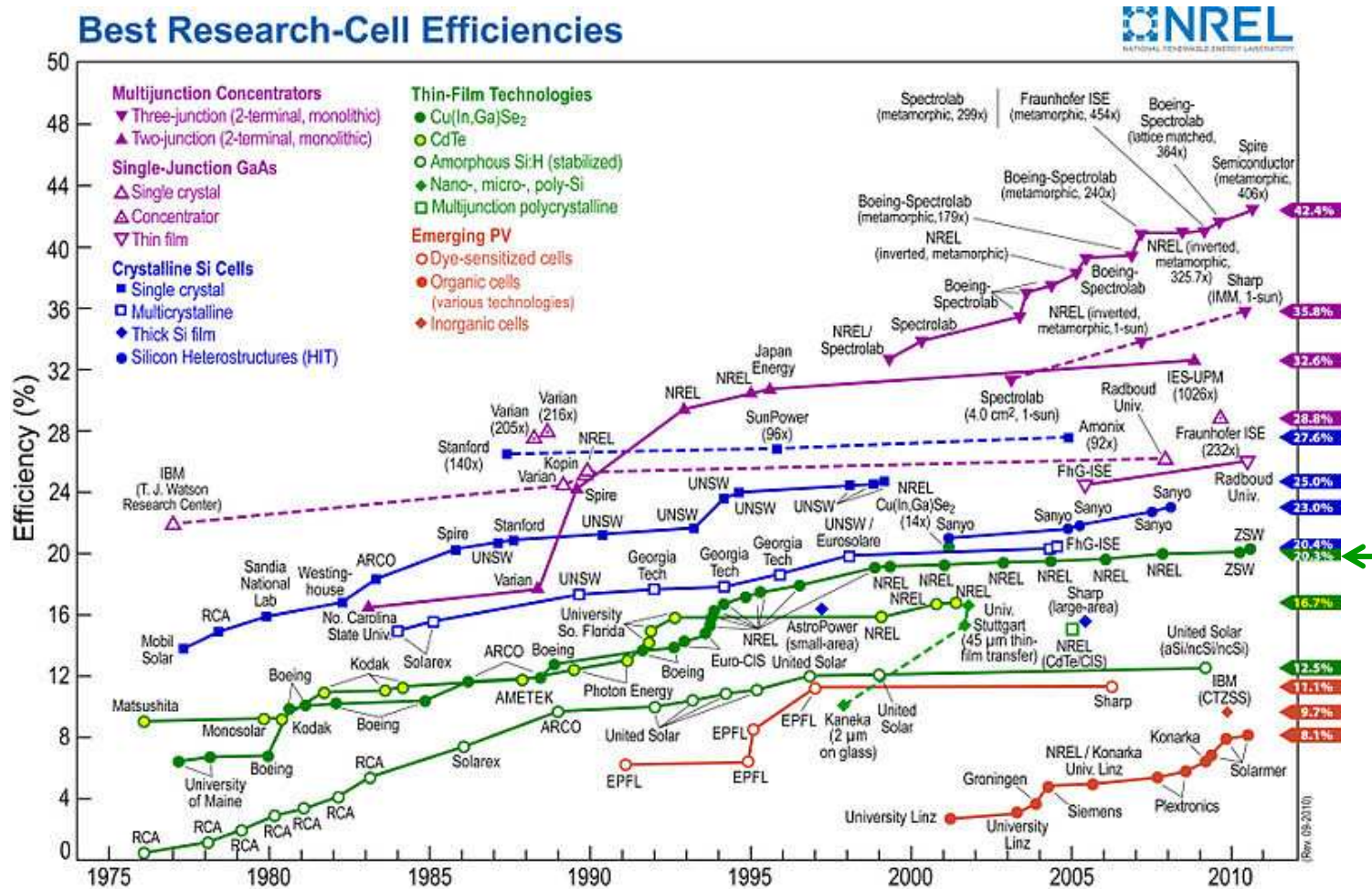


CIS stands for **Copper (Cu), Indium (In), Selenium (Se)**



# CIS-Technology: the biggest Potential

- Cell efficiency: CIGS closed the gap with poly-Si
- CIGS worldwide cell record produced by ZSW Stuttgart: 20,3%



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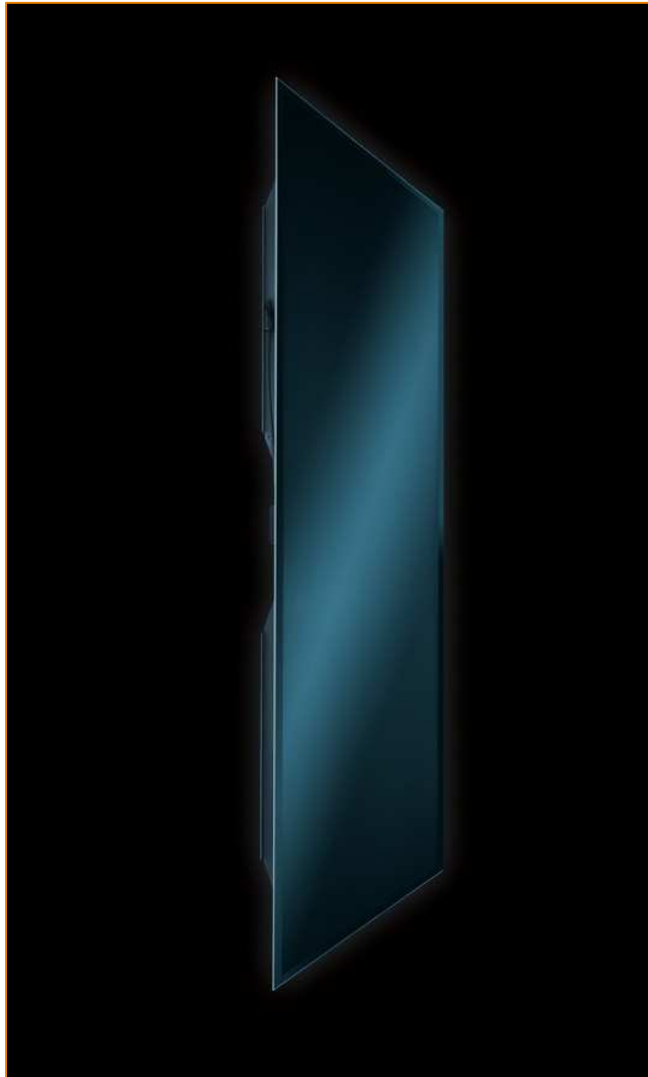
**5** PowerMax<sup>®</sup>, part of a autarchic house



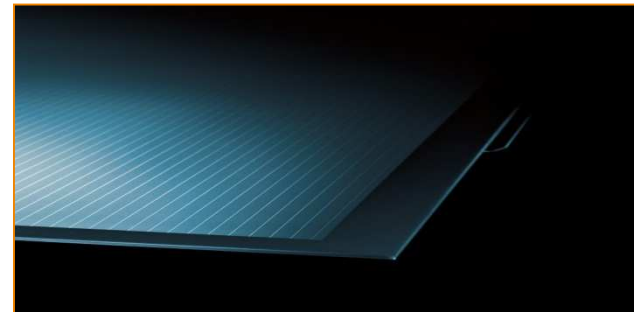
PowerMax<sup>®</sup> is made in Germany



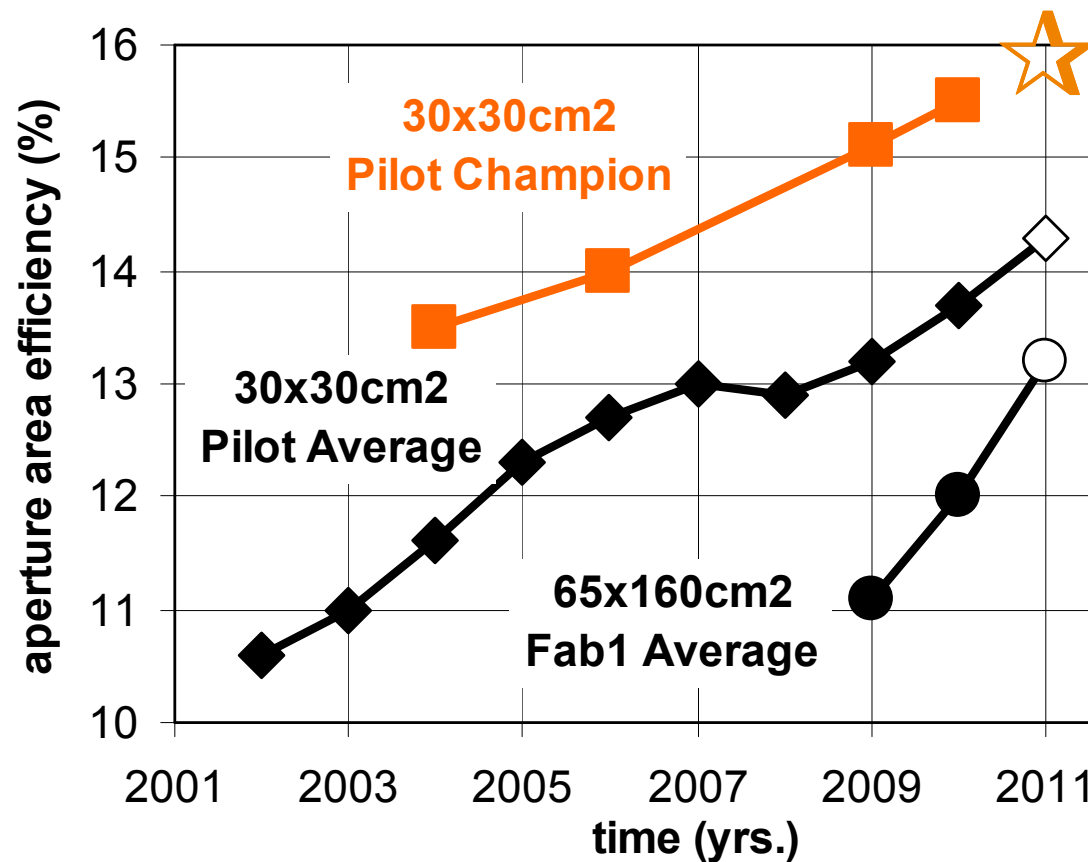
## PowerMax® SMART: the new PowerMax® generation



- Frameless module design
- Backrail mounting system (fast & easy mounting)
- Junction Box IP68
- Only 16kg Weight with 1,07m<sup>2</sup> module surface
- Starting 2014:
  - Compatible with trafo-less inverters and Solar Edge
  - Structural tempered front glass with AR-coating



# AVANCIS efficiency road map

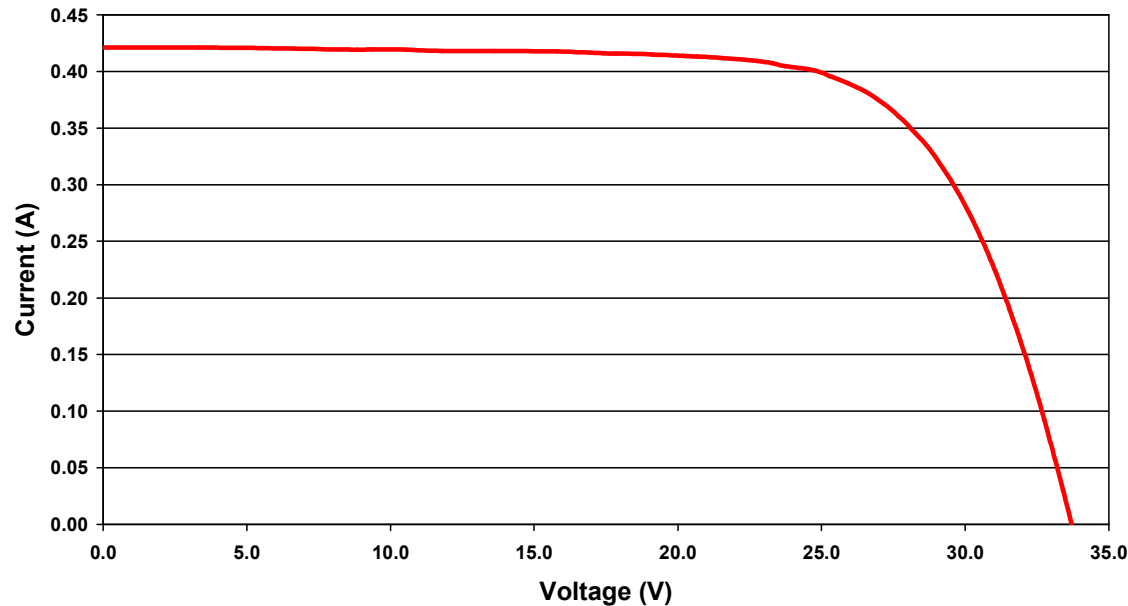


- Continuous efficiency improvement
- Short timing between pilot line and industrial production
- Positive improvement despite product design changes

Data: TÜV certified

## Current AVANCIS highest module record

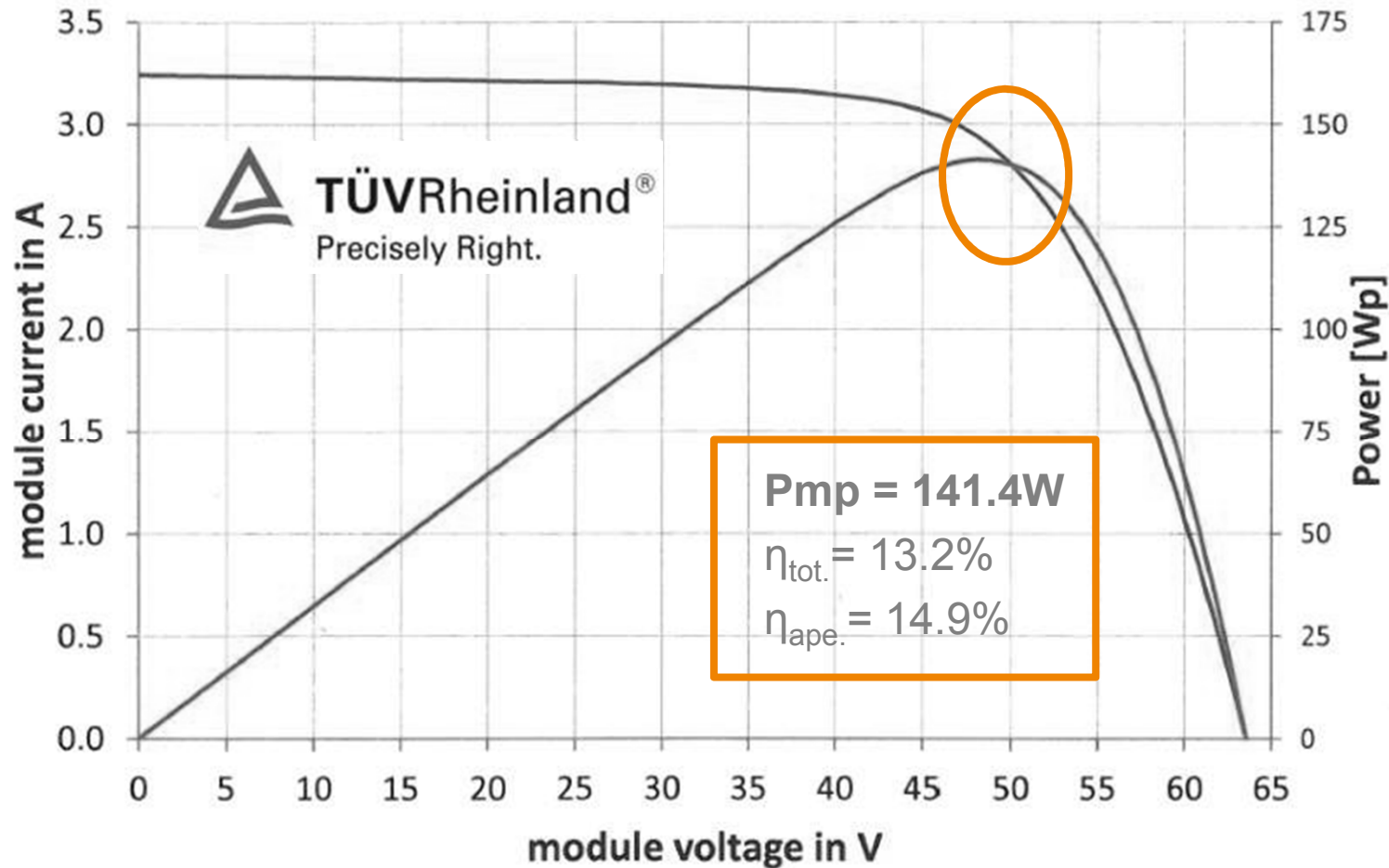
Certified STC I-V curve (TÜV Rheinland)



- Certified aperture efficiency of 15,8% (640,05cm<sup>2</sup>) from TÜV Rheinland
- International Module Champion for all Thin film Technologies\*\*

\*\* according to „Solar cell efficiency tables“  
Vers. 38, Prog. Photovoltaics 19 (2011) 565

Industrial record: 14,9% efficiency with PowerMax® (1,06 m<sup>2</sup>)



Pictured I,P(V) curve

Characteristic curve for record product at Standard Test Conditions

( $\eta_{tot.}$ =total-area\_efficiency,  $\eta_{ape.}$ =aperture-area\_efficiency,  $P_{mp}$ =maximum\_power)

## PowerMax® market segments



Private household –off roof-



Industrial roof



Facade



Power plants

- Private household Roof Germany



- A Family House Germany



- Warehouse Germany





- Farmer House Germany



- Industrial Roof Italy



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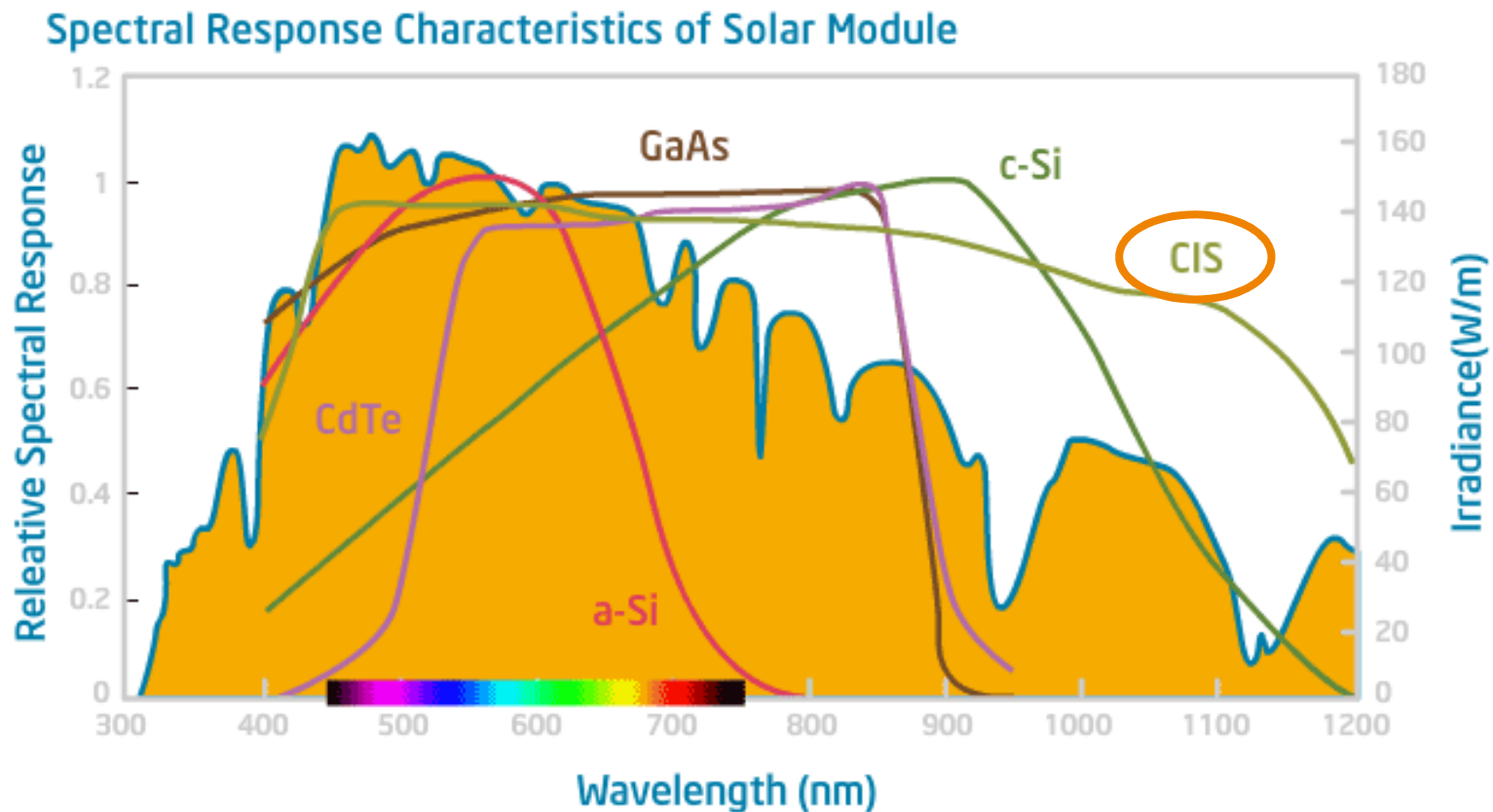
- „CIS-modules are giving output already very early in the morning and are efficient much more longer in the evening than crystalline module. They are more robust by **shadowing** and **diffuse light or low light**.“

Wolfgang Lange,  
Solar Frontier Europe Managing Director

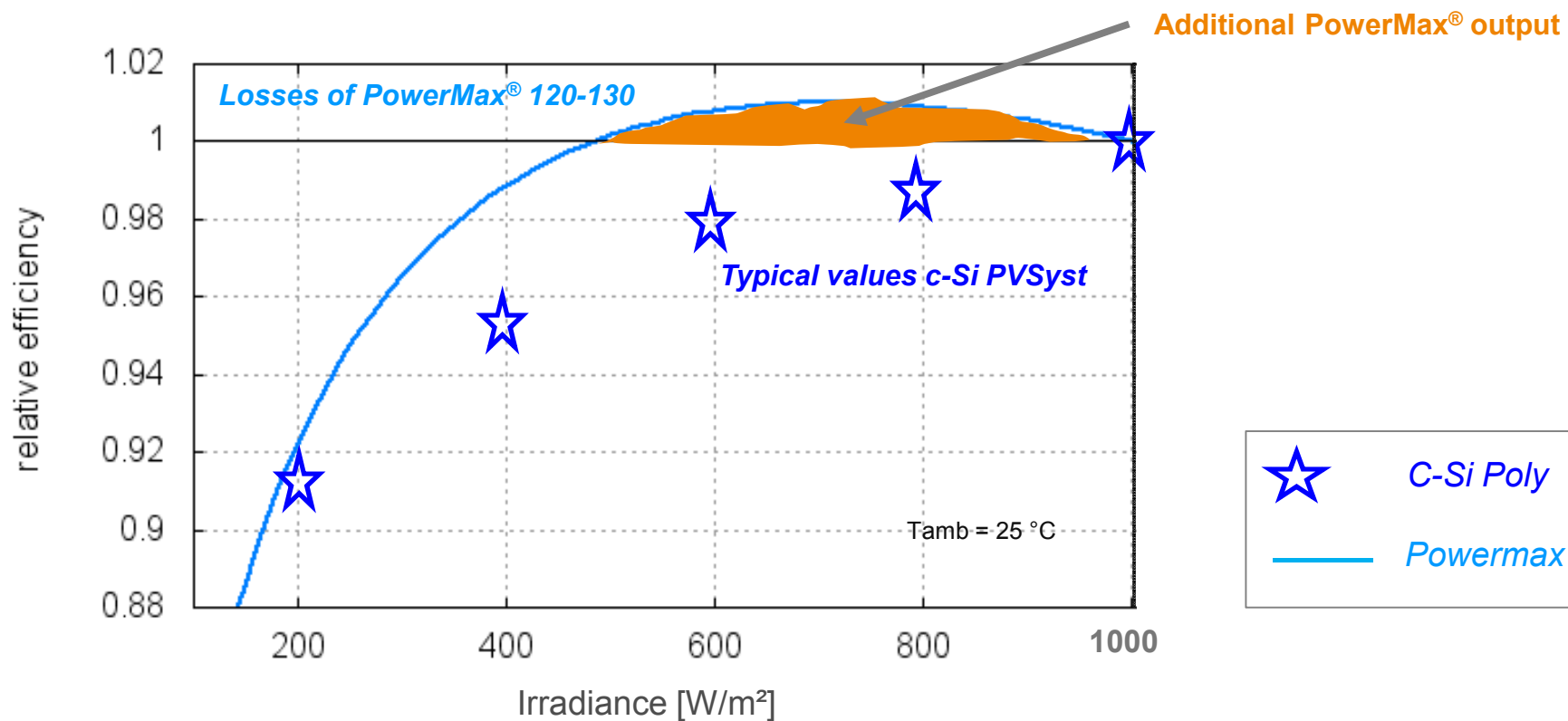
- **PowerMax® Spectral response**

CIS has the highest spectral resonance than all other PV-Technologies

Excellent output, thanks to broader spectral behavior, especially by diffuse light

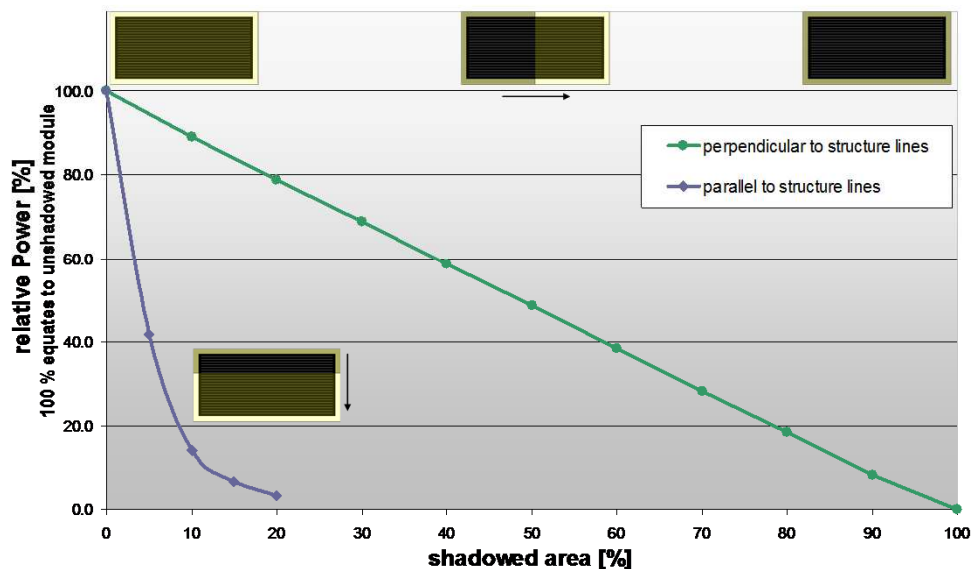


## ■ PowerMax<sup>®</sup> a unique low light behavior



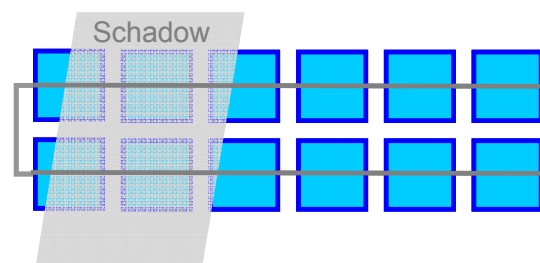
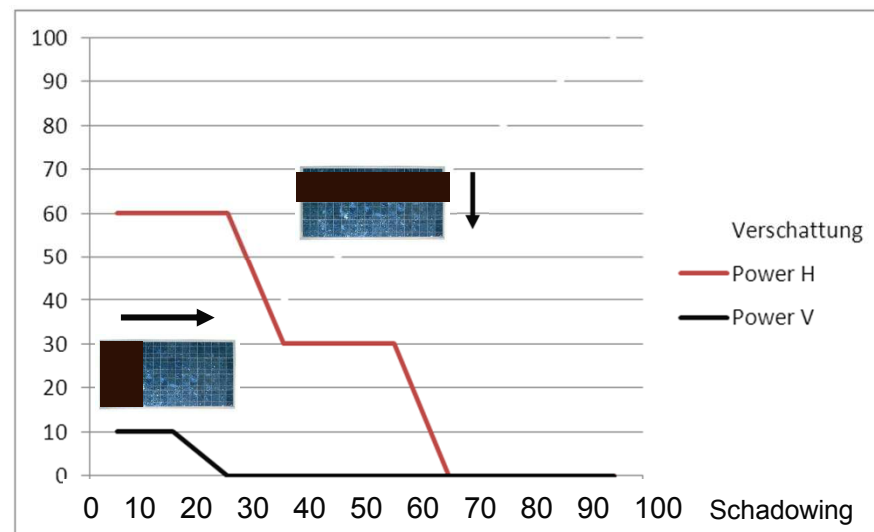
# PowerMax® excellent shadowing behavior

shadowing effects - Powermax®



With **PowerMax®** Bypass diodes could be switched easily and fast.

Efficiency



With **crystalline module**, no current is produced as soon as a module string is partially shadowed

- Proportional efficiency behavior in comparison too other technologies

	CIS	CIS	CdTe	c-Si
	<p>POWERMAX® NOCT = 40°C TC = -0,39 %/°C</p>	<p>SOLAR FRONTIER NOCT = 47°C TC = -0,31 %/°C</p>	<p>First Solar. NOCT = 45°C TC = -0,25 %/°C</p>	<p>Suneka NOCT = 45°C TC = -0,40 %/°C</p>
<b>SUNNY</b> Tamb = 30°C Irragg = 1000 W/m2	TCELL = 55 °C <b>ΔPm = -11,70 %</b>	TCELL = 63,8 °C <b>ΔPm = -12,03 %</b>	TCELL = 61,3 °C <b>ΔPm = -9,06 %</b>	TCELL = 61,3 °C <b>ΔPm = -14,50 %</b>
<b>FOGGY</b> Tamb = 5°C Irragg = 600 W/m2	TCELL = 20 °C <b>ΔPm = +1,95 %</b>	TCELL = 25,3 °C <b>ΔPm = -0,08 %</b>	TCELL = 23,8 °C <b>ΔPm = +0,31 %</b>	TCELL = 23,8 °C <b>ΔPm = +0,50 %</b>
<b>CLOUDY</b> Tamb = 10°C Irragg = 500 W/m2	TCELL = 22,5 °C <b>ΔPm = +0,98 %</b>	TCELL = 25,6 °C <b>ΔPm = -0,58 %</b>	TCELL = 25,6 °C <b>ΔPm = -0,16 %</b>	TCELL = 25,6 °C <b>ΔPm = -0,25 %</b>

2012 product data sheets



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## PowerMax<sup>®</sup> test reference by AVANCIS in Munich

- 2x12,65m<sup>2</sup> (Avancis and c-Si)
- Efficiency:
  - 1,32kWp for PM
  - 1,53kWp for c-Si
- DC Data
- *Azimuth: 0° South*
- *Angle: 30°*
- *Free land (no roof PV syst.)*
- *Almost no shadowing*
- *Almost flat und low Horizon*



## PowerMax<sup>®</sup> test reference by AVANCIS in Munich



- System comparison

	2010	Unit	PowerMax	c-Si	
$\div P_{nom}$ $\div irradiation$	Total Output	kWh	1441	1618	- 10.9%
	Output/kWp	kWh/kWp	1091	1055	+3.4%
	PR	%	90.7	87.7	+3.4%

- 2-Jahres-Vergleich

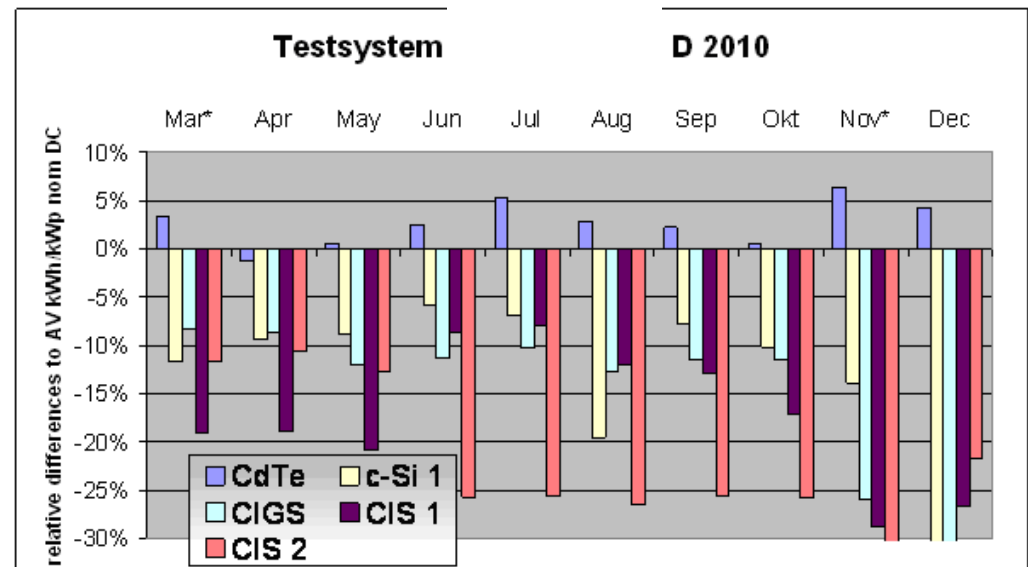
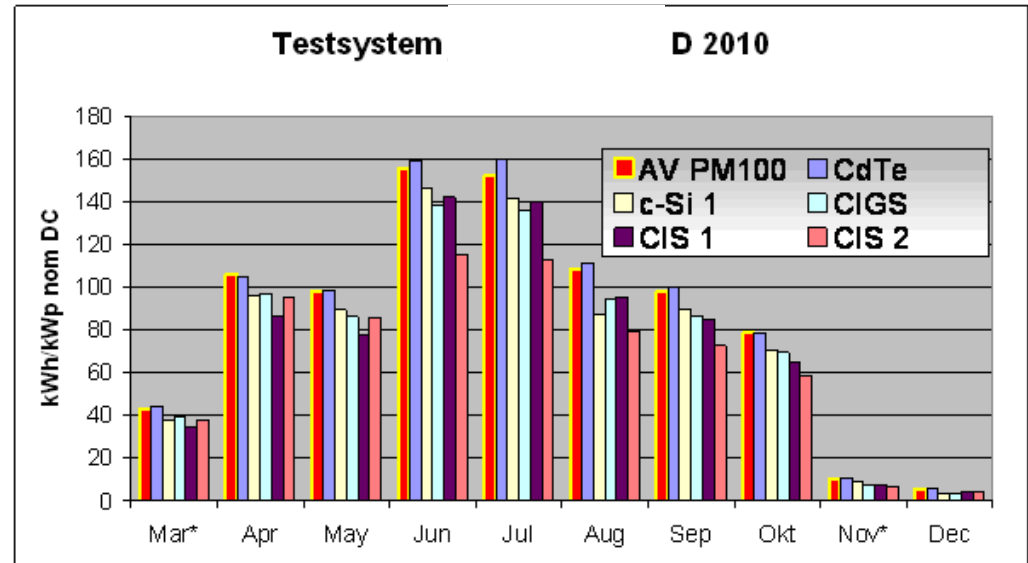
PowerMax	Unit	2010	2011	
Total Output	kWh	1441	1742	+20.8%
Output/kWp	kWh/kWp	1091	1303	+20.8%
Performance Ratio	%	90.7	91.8	+1.2%
Irradiance	kWh/m <sup>2</sup>	1203	1437	+19.5%

# 1,8 kWp PowerMax® 100 test field in Germany



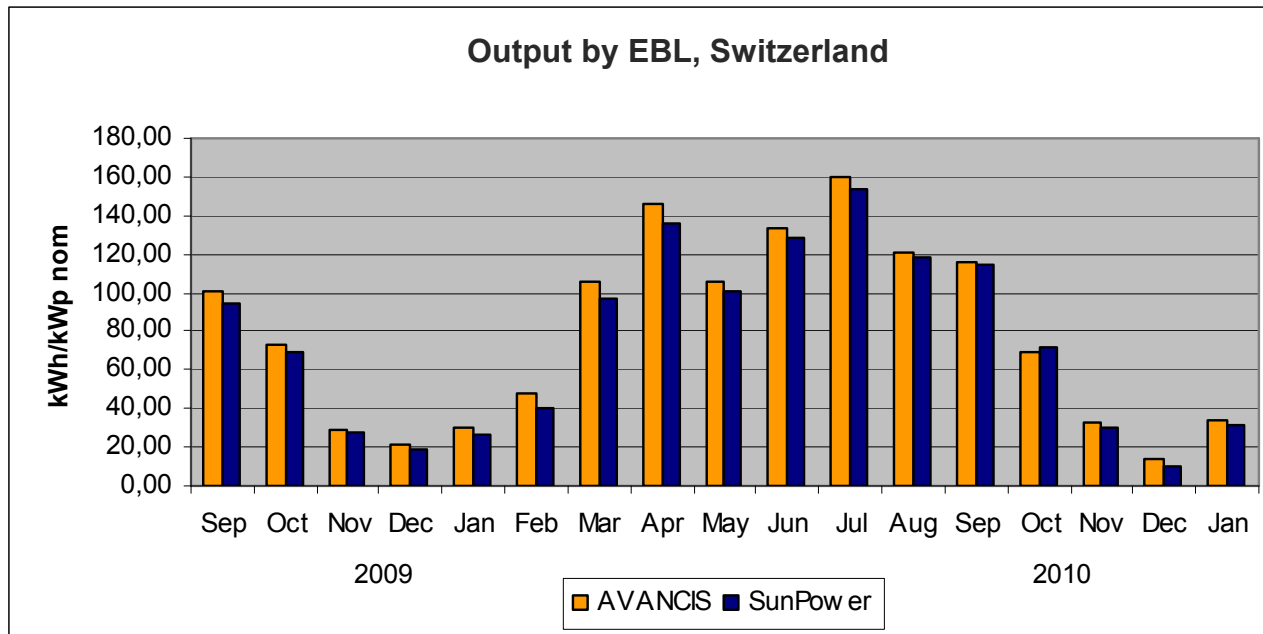
- Location: Germany
- PV-System:
  - 3x6 PowerMax 100
  - Other technologies
- Period: 12.3. – 31.12.2010

Module	kWh/kWp nom DC	Real Gap
AV PM100	854	
CdTe	873	2%
c-Si 1	770	-10%
CIGS	757	-11%
CIS 1	736	-14%
CIS 2	668	-22%



\* No data fr

-> PowerMax® is the modul with teh highest output



- AVANCIS modules have an higher output (kWh/kWp) than Mono c-Si modules.

Quelle: [http://www.fronius.com/cps/rde/xchg/SID-C7932663-31367C9F/fronius\\_international/hs.xsl/83\\_ENG\\_HTML.htm#](http://www.fronius.com/cps/rde/xchg/SID-C7932663-31367C9F/fronius_international/hs.xsl/83_ENG_HTML.htm#)

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- **ELF Plus-Energie House *eQUEST***

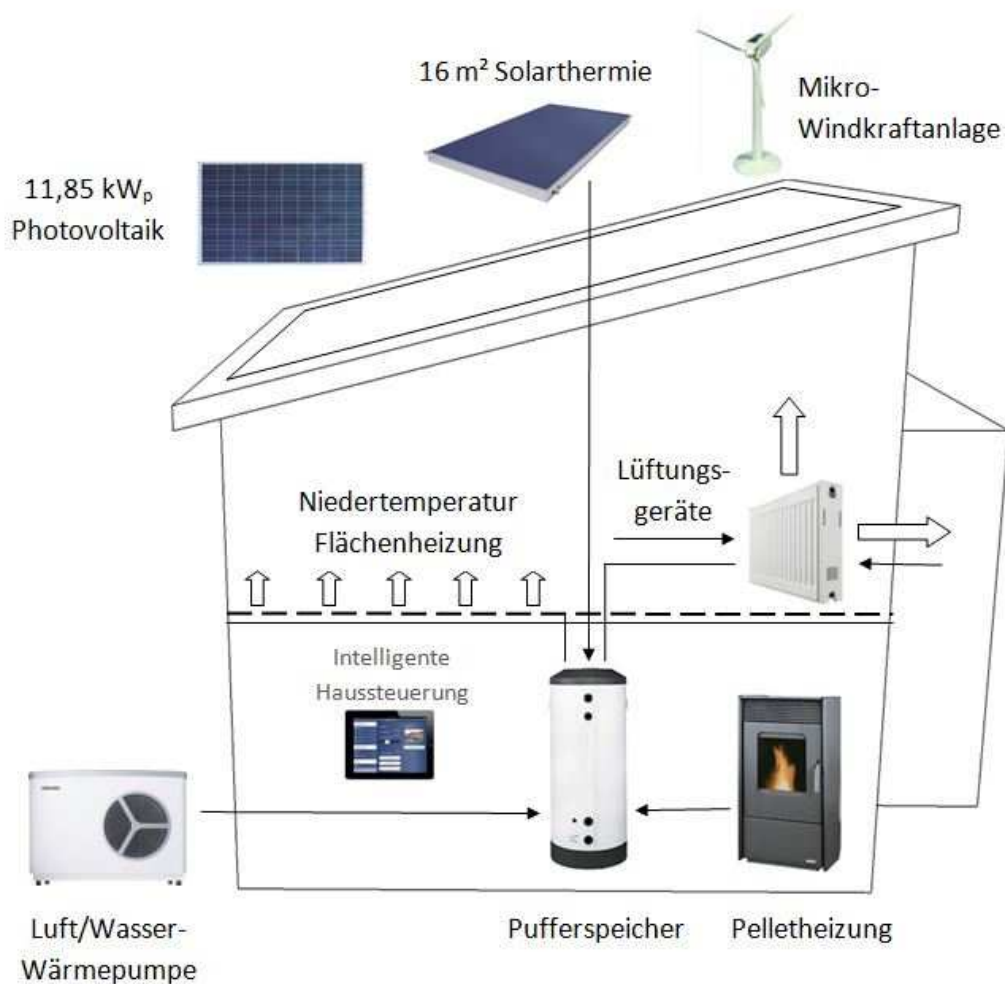


- **160 m<sup>2</sup> living space**
- **KfW-Efficiency house 40**
- **EnEV 2009 Norms**

- **Monthly energy costs: 70 €**
- **Monthly FIT: 150 €**
- ***Bottom-line costs: PLUS 80 €***



- Energy system concept





- LEITEC headquarters



## PowerMax<sup>®</sup> part of a autarchic house



- 117 kWp, 906 PowerMax<sup>®</sup> STRONG



## PowerMax<sup>®</sup> part of a autarchic house



- **Module are cooled during summer time**
- **In winter, Modules are de-iced**

- **80 t ice cellar for air conditioning and heating**
- **Underground ice cellar**
  - Heating is stocked in winter
  - Cold is used for air conditioning in summer
- **Heating / AC through ventilation**



- **Ideal for East-West Installations**

- During day time, much more production time for self consumption and storage

**=> Sooner Regeneration of Energy Storage System**

- **Loading current in all installation angles**

- Thanks to excellent shadowing behavior, more often loading current situations for storage systems

**=> More often Energy Storage Regeneration**

- **Frameless Module Design**

- Very good module cooling, much less dirt and easier snow sliding

**=> More Output**



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**Thank very much for your attention!**