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Bankability:
Choosing right materials on module level

28.09.2016, André Richter, Meyer Burger Technology AG

Value Chain

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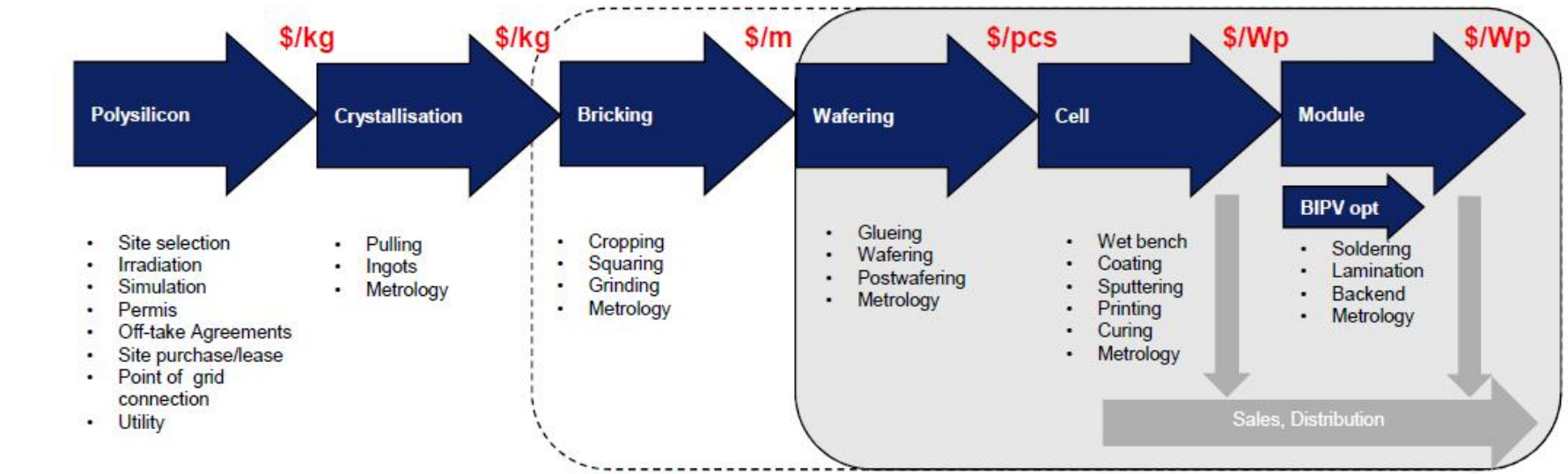

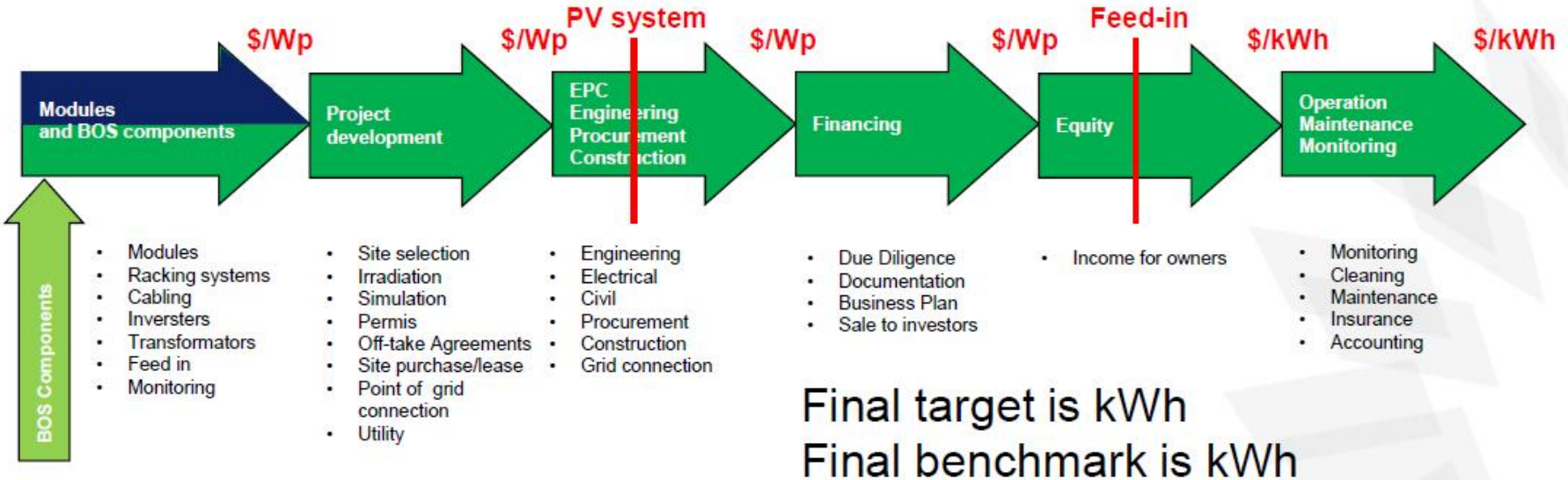

Final target is kWh
Final benchmark is kWh
Inside value chain different measures

Bankability

What is the specification for a good product?

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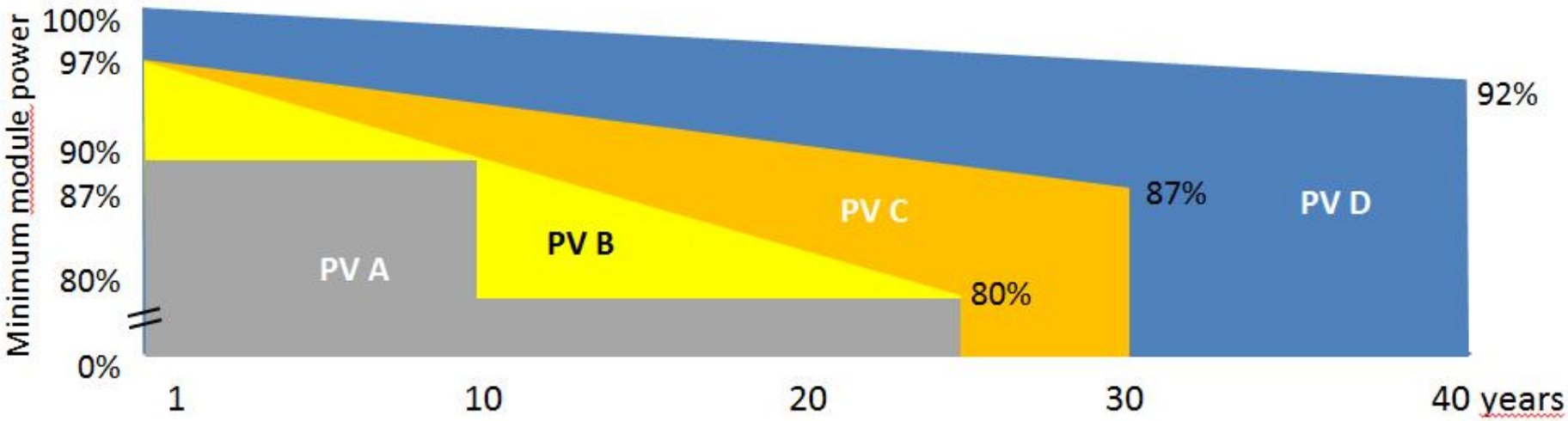
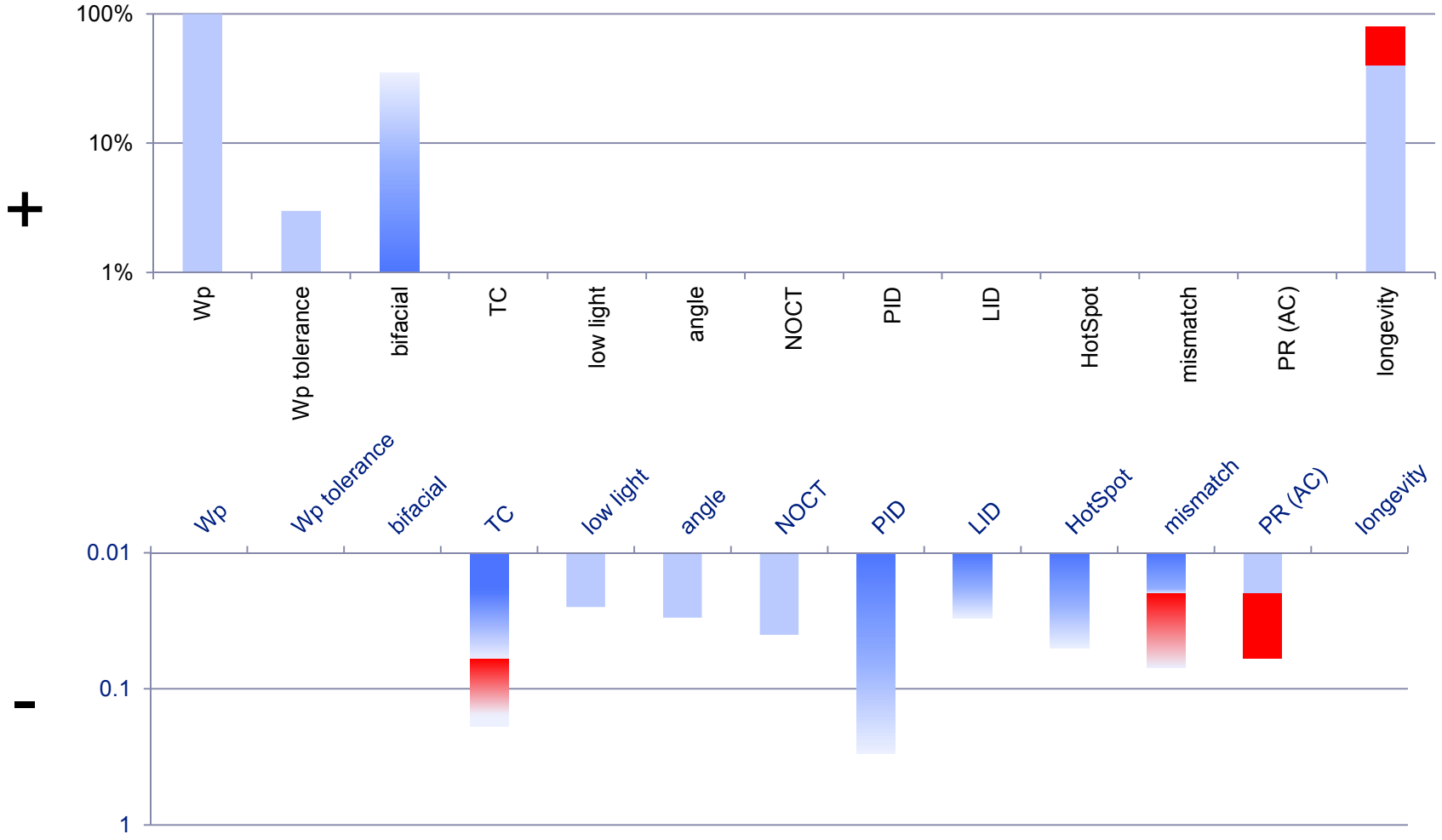
Guaranteed module power over lifetime



Real life you have reduce this value by:

- 3% to 5% module tolerance
- 2% for measurement tolerance
- Costs for measurement, decommissioning, energy yield loss, shipment etc.
- Some degradation mechanism is related to system (hot spots, failure of diodes)

Influences of different effects on energy yield



Technical property – economical impact

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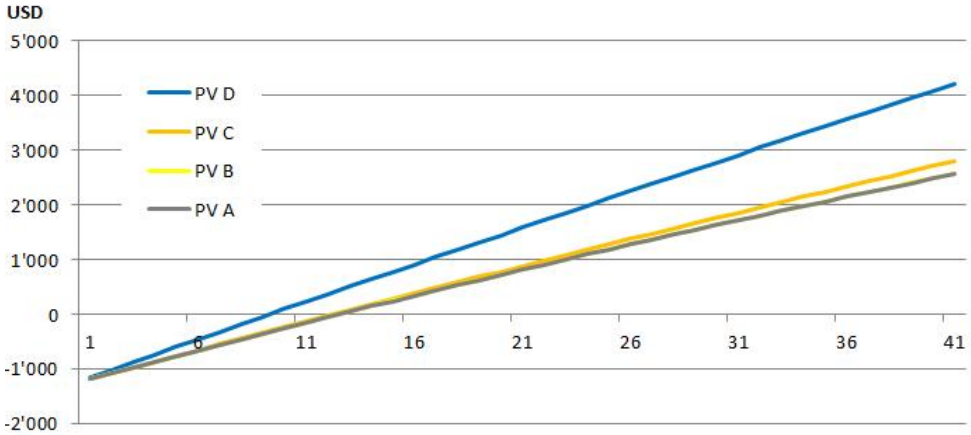
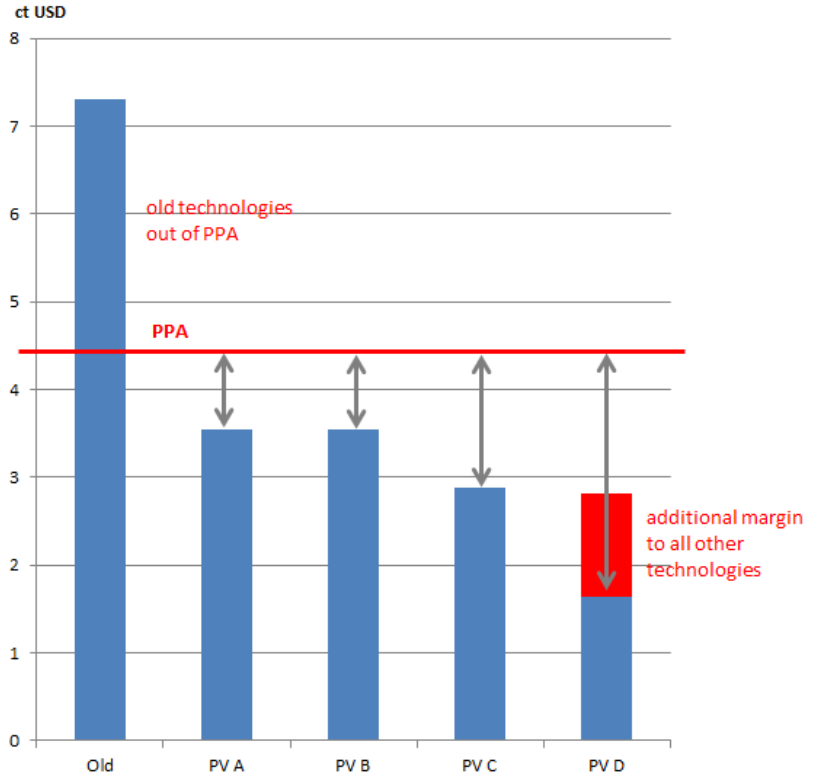
Cash-flow analysis



Conditions:

1800kWh/kWp/a
System costs 1300USD/kWp
PPA: 7ct$/kWh
no inflation, interests and maintenance
PV A: 3% initial, 90% 10 years, 80% until year 25
PV B: 3% initial, 10% until year 25
PV C: 3% linear, 10.25% 30 years
PV D: only 0.2% pa, better TC, 20% bifacial

Final economic effect



Faster payback > less risk of investment

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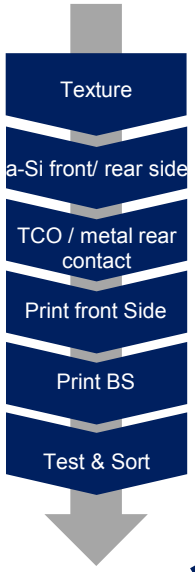
1 High efficiency cell
- lower system cost (BOS)
- Thin > high efficiency

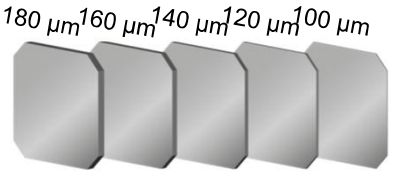
Only 6 process steps
- low COO

Temperature coefficient
- higher energy yiel
- Bifacial -> higher energy Yield

High upside potential
- In future technology will follows improvement path of PV

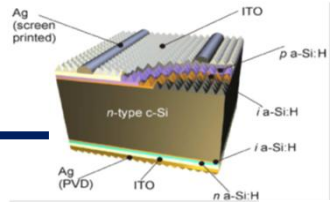


2 Diamond wire wafering
- thinner wafer -> lower costs



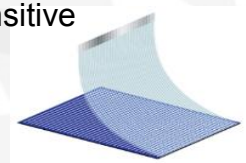
Mono wafers

7 PV-System:
- High performante
- Lower Capex
- High stability



thin cells (thin wafers)

3 TCO layer and wafer thickness suitable for SmartWire
- 80% less silver,
- higher energy yield
- higher efficiency
- longevity
- microcrack resistent
- less sand / dust sensitive

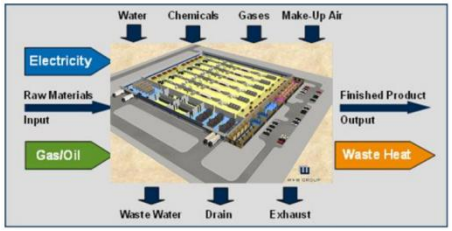


Improved facility

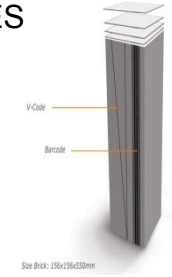
Quality & perfromance control

High capacity, busbarless measurement

6 Low energy consumption opens door for new facility concepts, layouts logistics



5 Material quality and Tracking, MES



4 Adapted test metrology
- high cap cells
- BB0
- DragonBack
- PED (Chipping)

n-type crystal inspection:
R-τ limite

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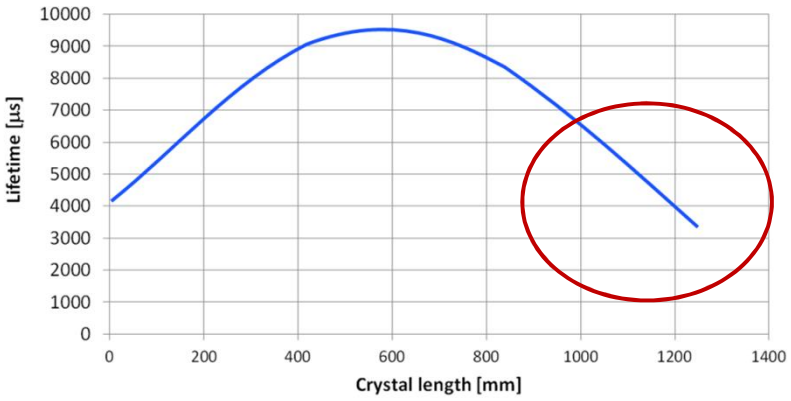
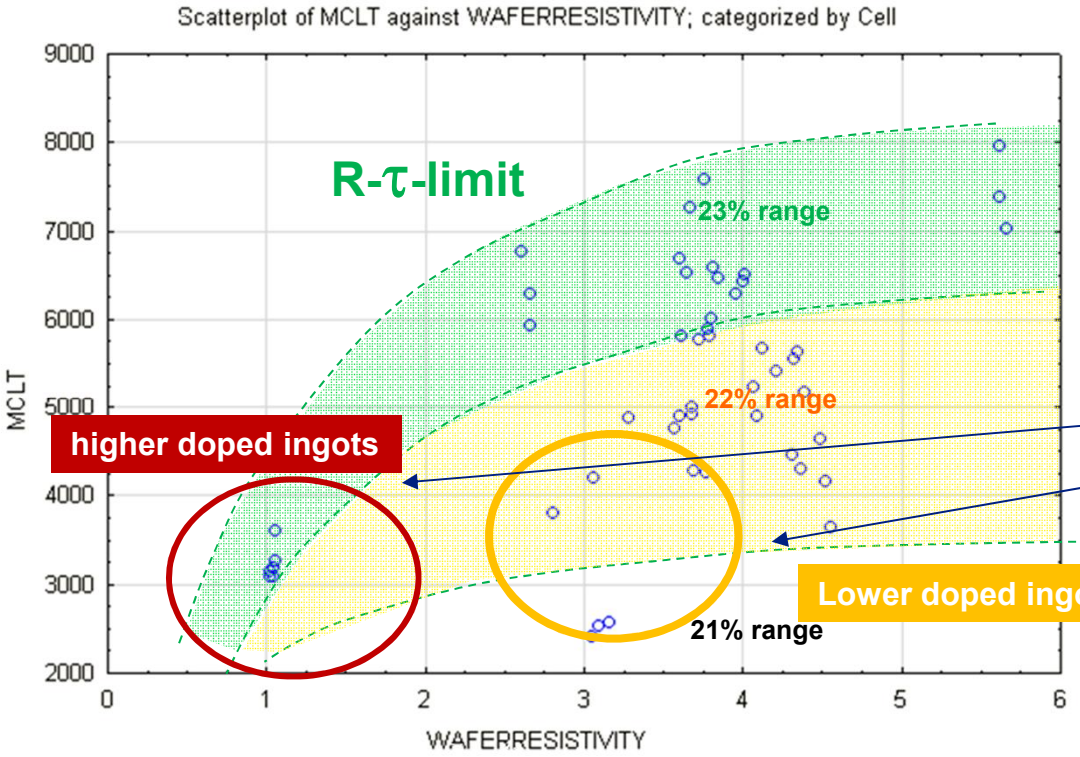
Typical distribution





Doping determines effective life time that can be yielded: R-tau-limit
Implied Voc is independent of life time when material operates at R-tau-limit

Interaction of process – tool - material

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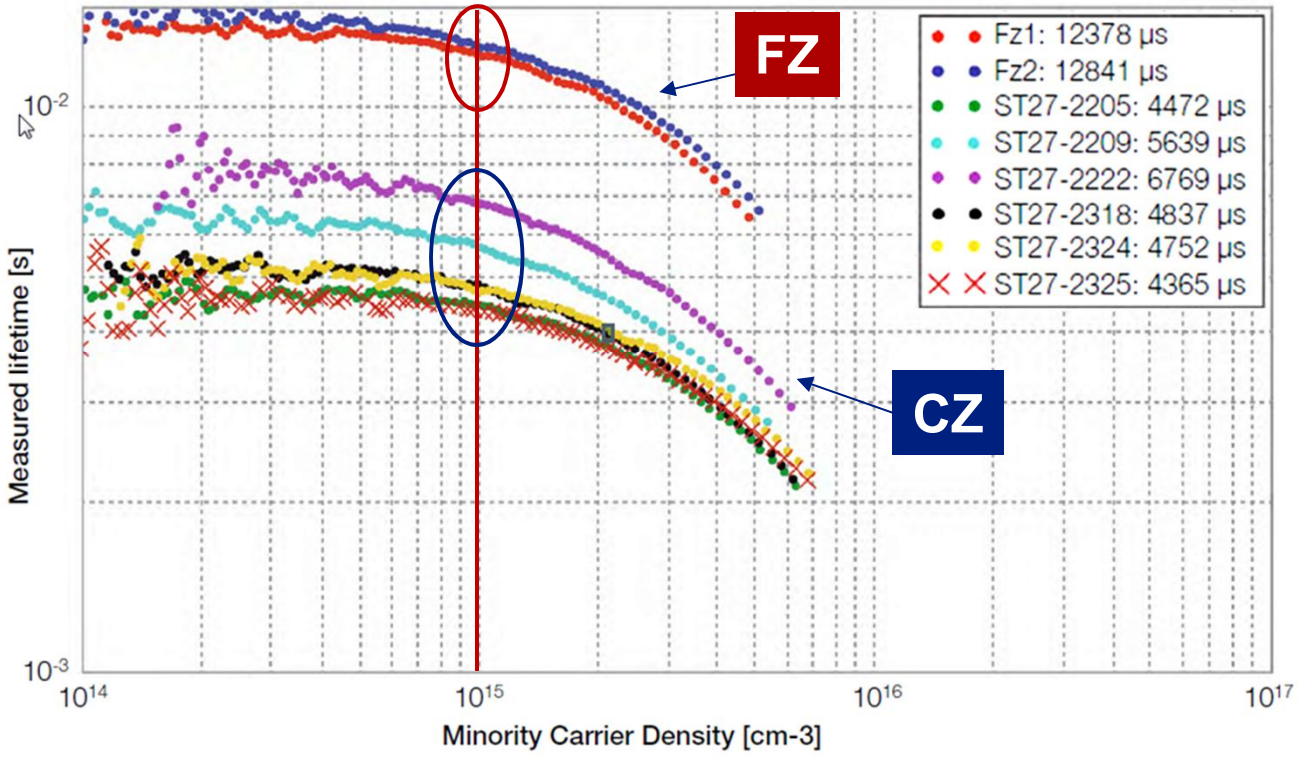
HELiA PECVD

- Excellent a-Si passivation quality
- Key process for high efficiencies

Sinton lifetime data a_i-Si passivated Cz and Fz wafer.



PL Monitoring

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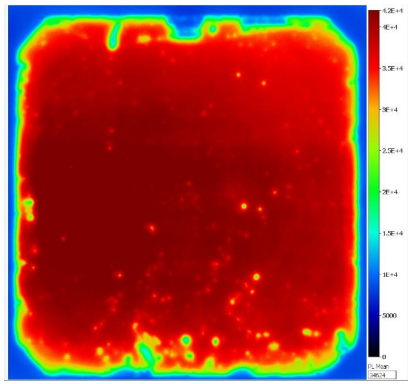
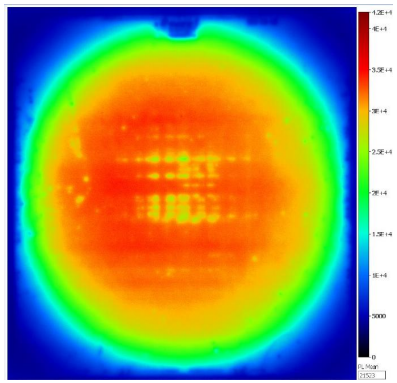
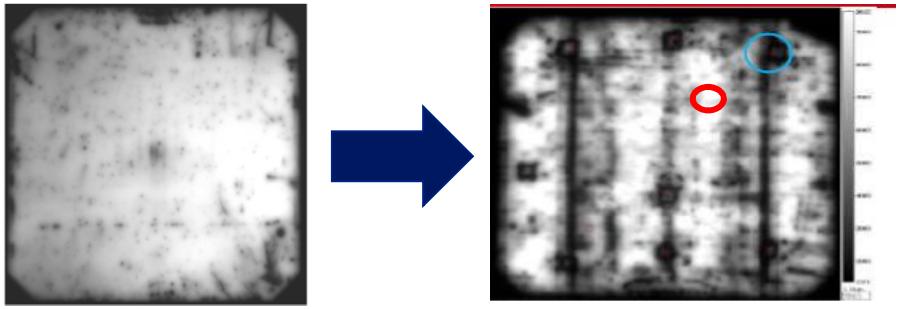


Standard crystal growth
4.1ms (center)



Low grade crystal growth (tail)
1.9ms (center)

PL Monitoring optimum inspection technology for production and quality control



Source: Hennecke wafer inspection system

Different climates – different solution

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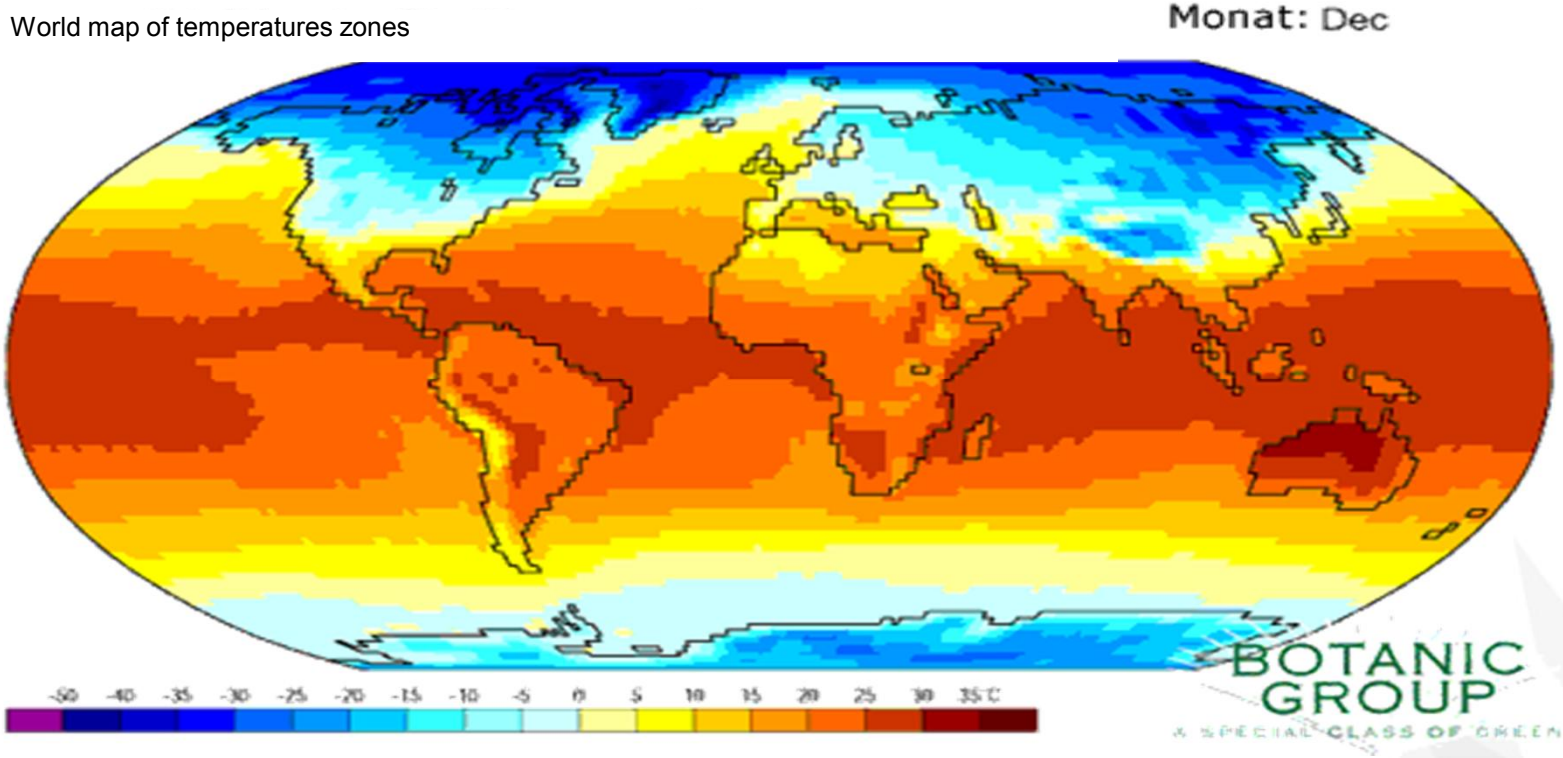
World map of temperatures zones



Source: http://www.botanicgroup.com/Klimazonen:_:14.html

ambient Celsius (celsius)		5	10	15	20	25	30	35
Irradiation (W/m2)		1000	1100	1200	1300	1400	1500	1600
expected cell temp. (celsius)		35	43	51	59	67	75	83
Technology	**%/K**	**MPP power due to temperature**						
STD	-0,43	96%	92%	89%	85%	82%	79%	75%
PERC	-0,38	96%	93%	90%	87%	84%	81%	78%
HIT	-0,28	97%	95%	93%	90%	88%	86%	84%
HJT	-0,25	98%	96%	94%	92%	90%	88%	86%
CIGS	-0,22	98%	96%	94%	93%	91%	89%	87%
CdTe	-0,26	97%	95%	93%	91%	89%	87%	85%
difference max-min		**2%**	**4%**	**5%**	**7%**	**9%**	**11%**	**12%**

Up to 12% difference

SWCT optimization
sunny side

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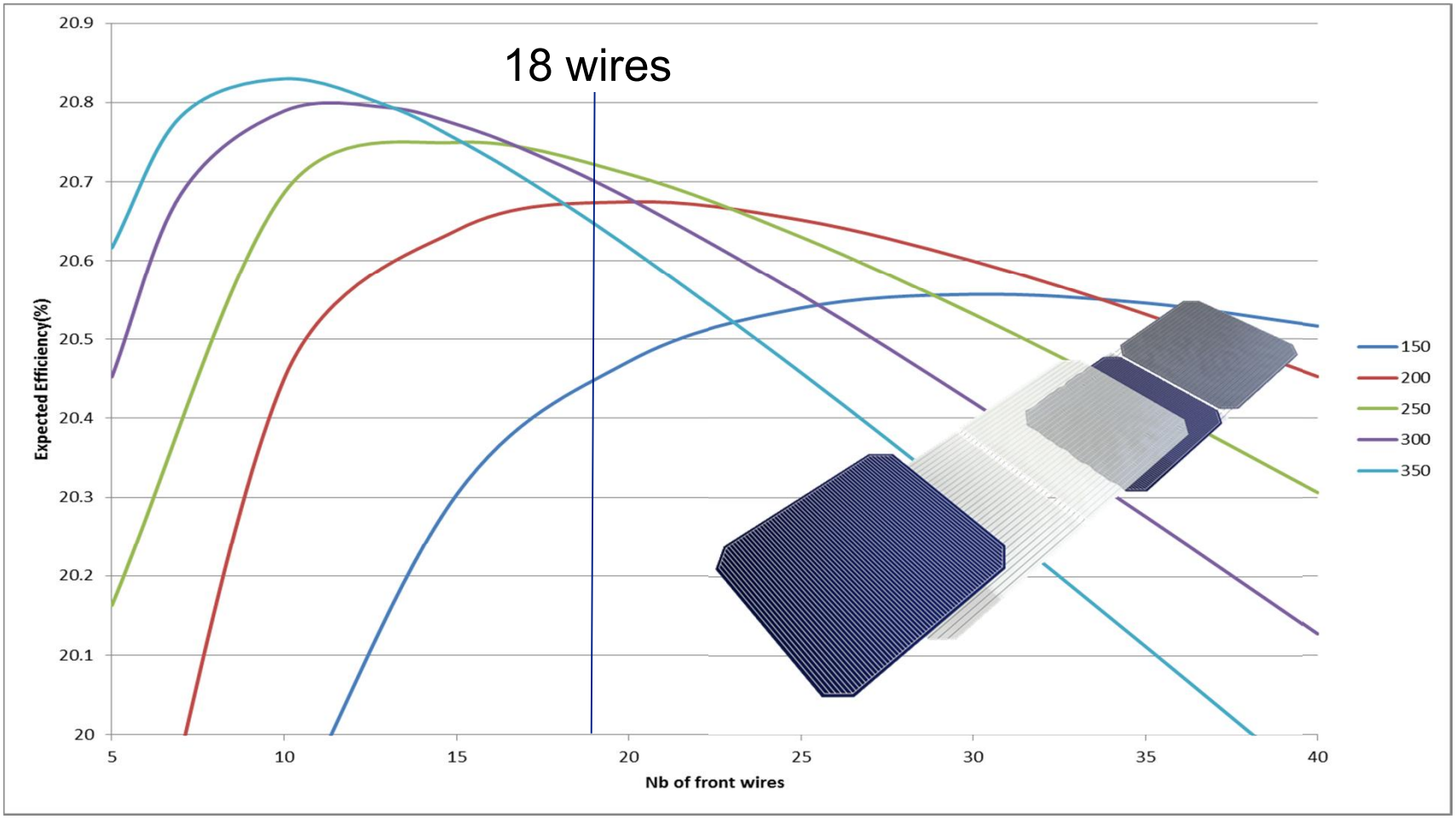
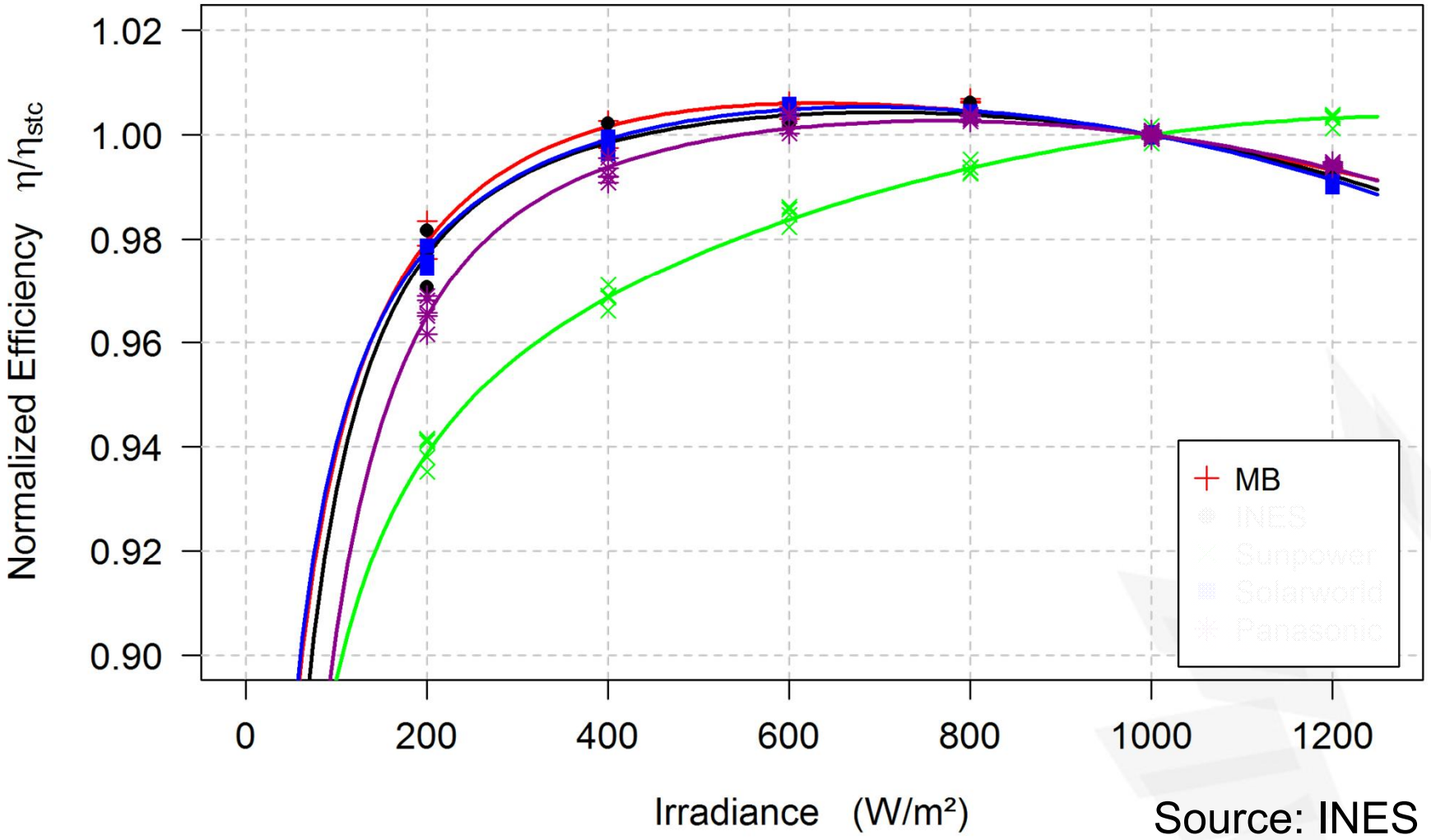
SWCT efficiency impact depends on the specific cell design and boundary conditions.

This simulation shows one example for the sunny side:



Function of light in relation to STC



Source: INES

$/kWh

HJT SWCT GG

Higher energy yield (kWh/Wp)

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Location: Lugano, Switzerland
Moderate Climate, average air temp. 11 °C, module working 22°C, max 40°C
Module temperature average working 31°C, max 64°C
Period: 01.06.2014-31.12.2014
Measured independently by SUPSI

kWh/Wp	c-Si multi	HJT competitor	CdTe	CIGS	MB GG
Power [Wp]	262	244	79	175	288
Sum	reference	+ 2.9%	+ 5.6%	+ 4.1%	+ 13.7%
Overcast	reference	+ 0.1%	+ 1.9%	+ 0.5%	+ 15.4 %

MB GG Bifacial

- ✓ Excellent low light
- ✓ Low temp. Coeffi: -0.26%/K
- ✓ No LID, No PID

300 W <=> 342W$_{eq(equivalent)}$

SUPSI zh aw

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Thank you