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From solar module reliability to bifacial solar module production lines

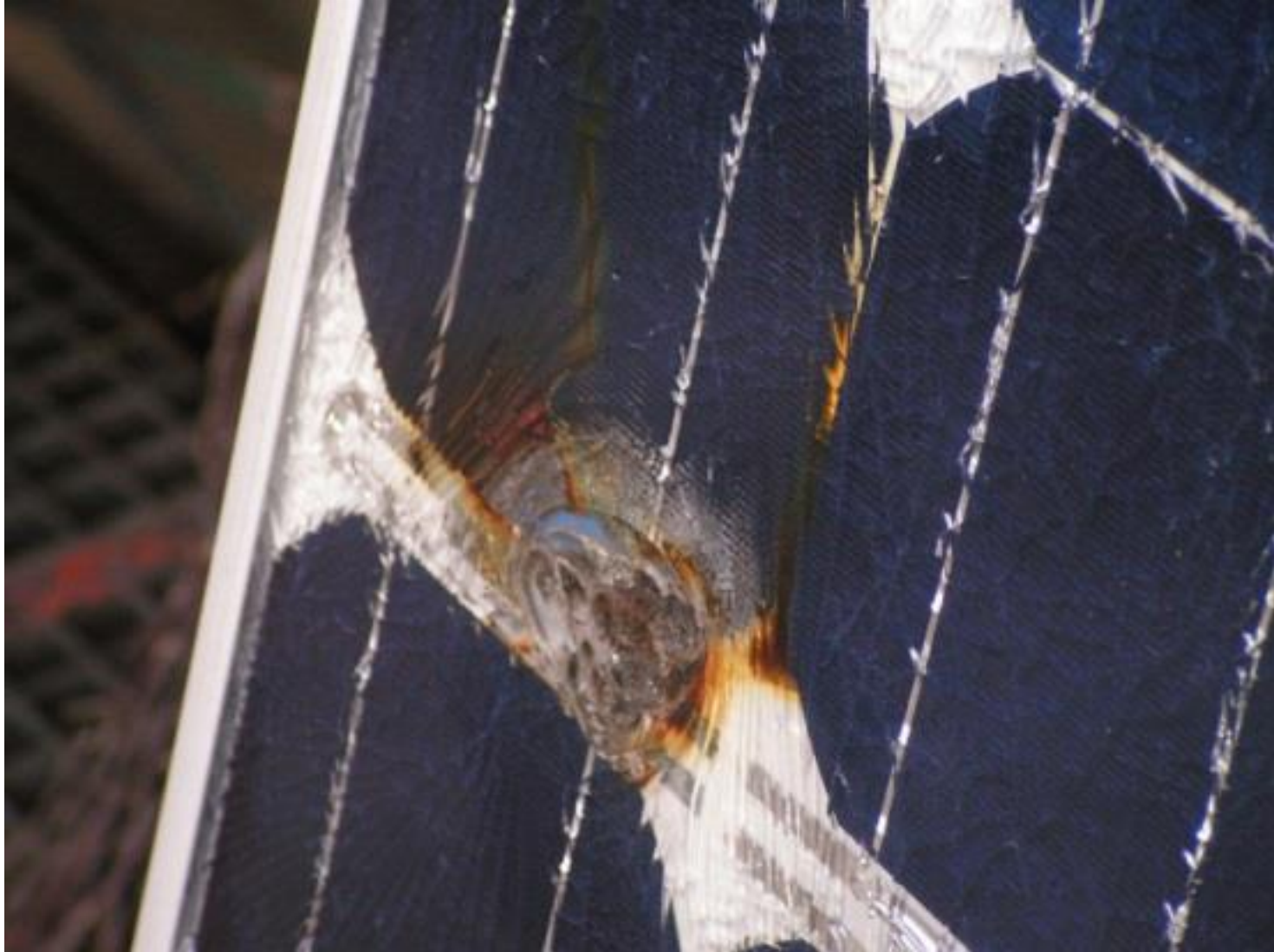
Thomas Söderström Head of TPI-M department at Meyer Burger AG, Switzerland
September 2015



Hot Spots



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Wind, Snow Loads



Fire



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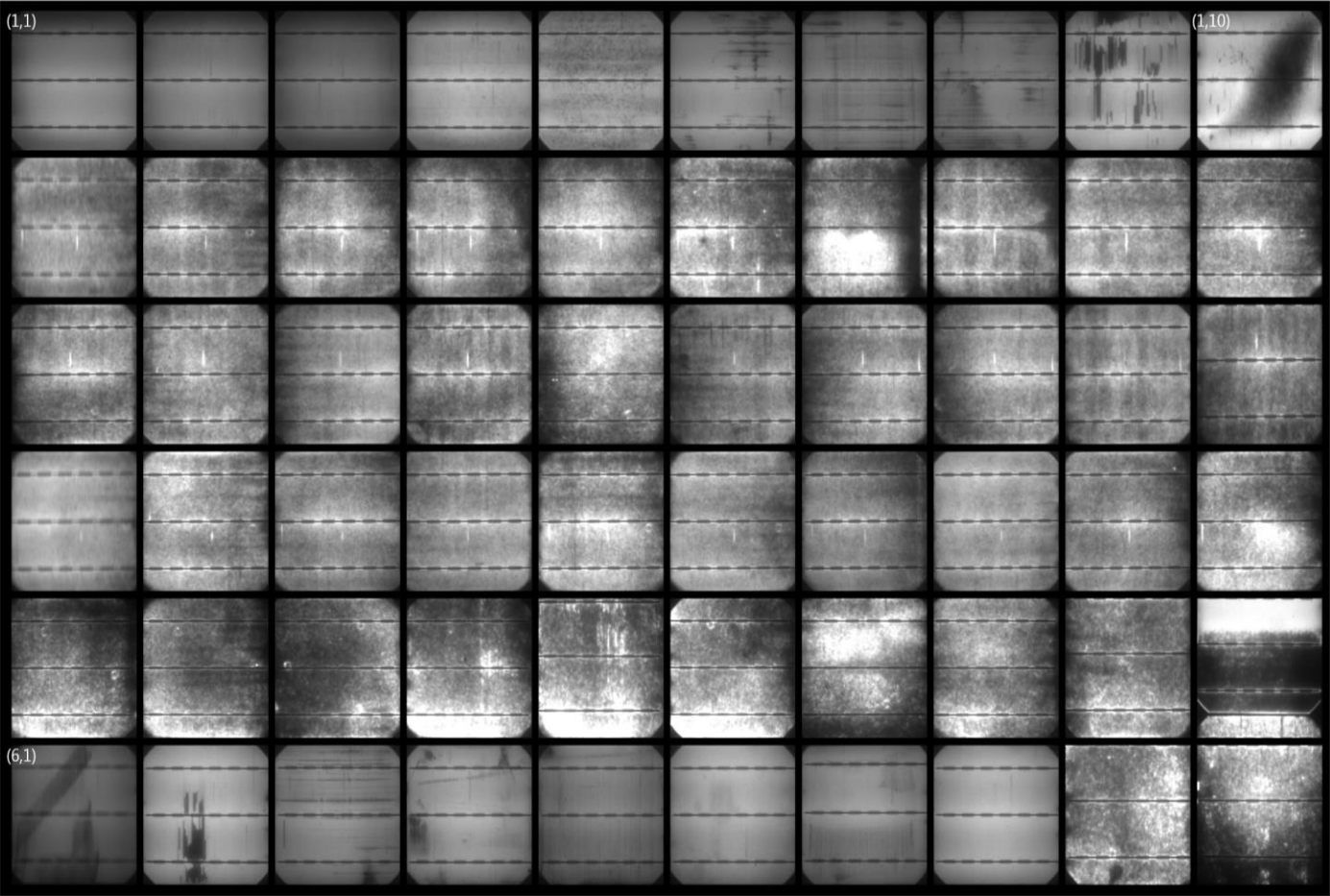
Creep



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Solar cell quality



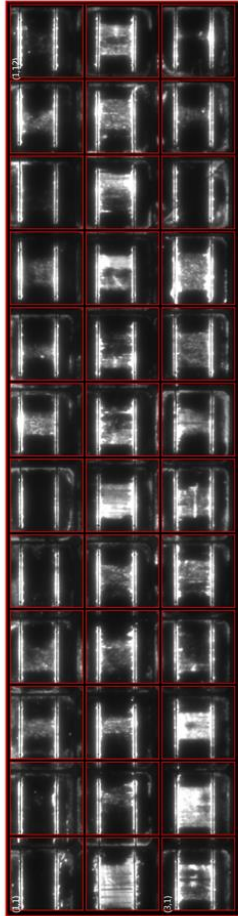
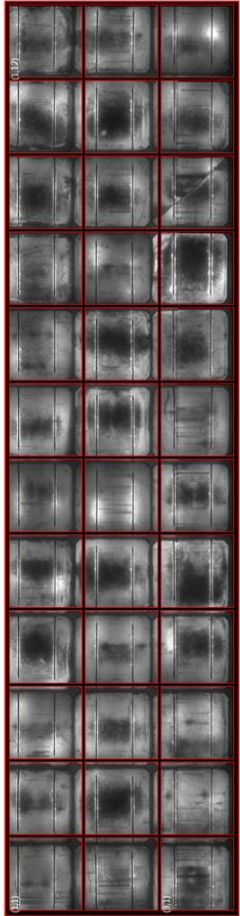
22 years modules in CH



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0h

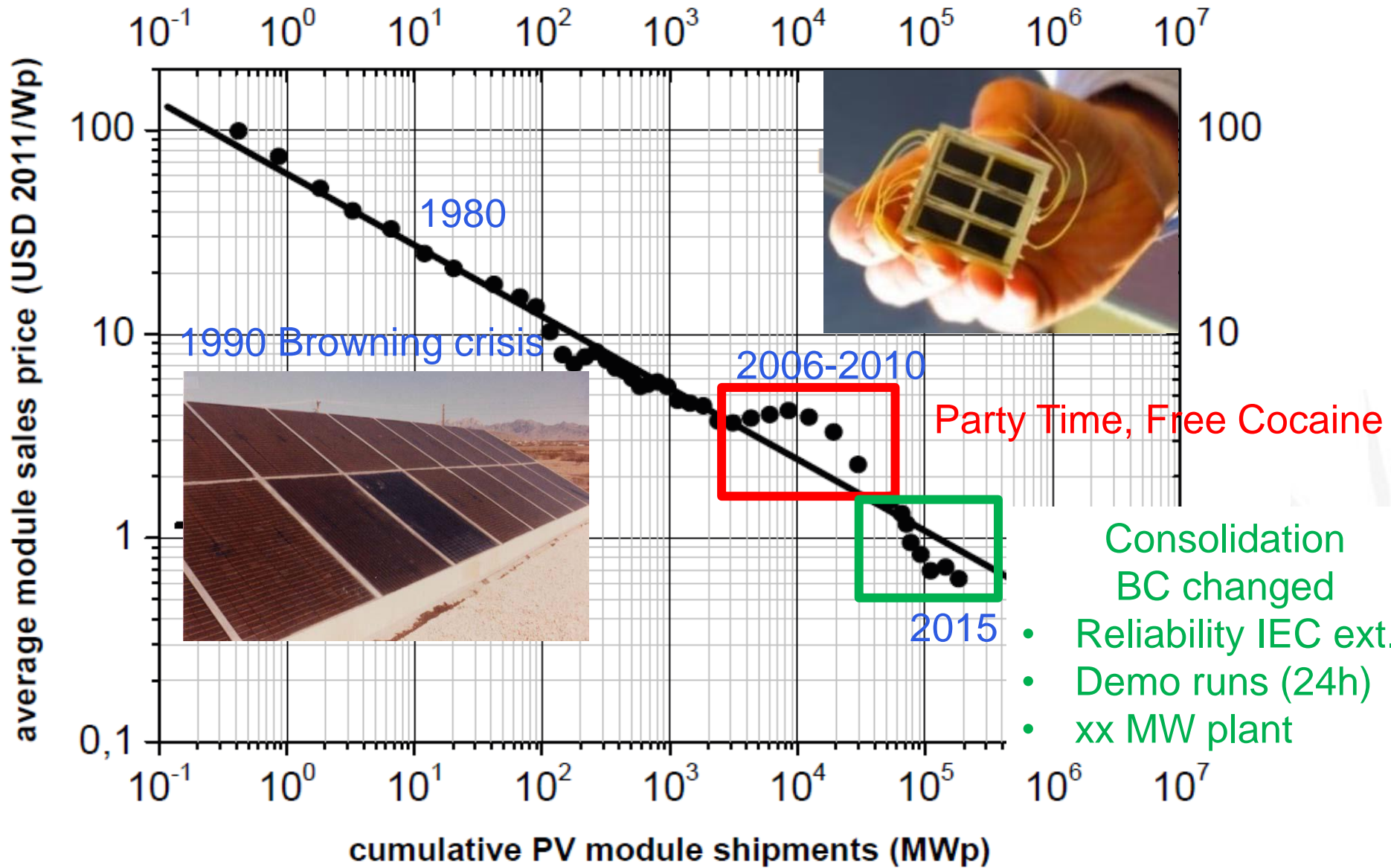
1000h



-15 % loss after 20 years

1000 h in DH => -60% loss

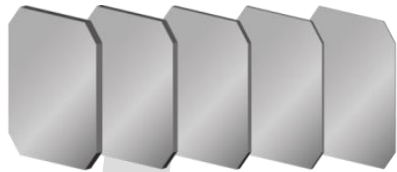
Our PV Story



A Diamond Wire Sawing

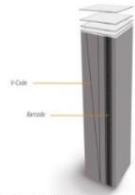
Thinner wafer, reduced kerf loss → Lower costs

180 μm 160 μm 140 μm 120 μm 100 μm

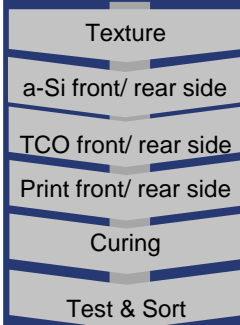


B Single Wafer Tracking

Quality & performance control



Heterojunction (HJT)



High efficiency

- Lower system cost (BOS)
- Independent of wafer thickness

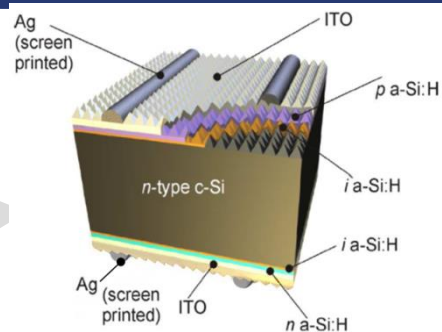
Only 6 process steps

- Low COO

Higher energy yield

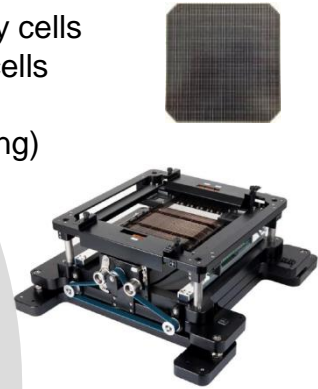
- Low temp. coefficient
- Bifacial

C



D Adapted test metrology

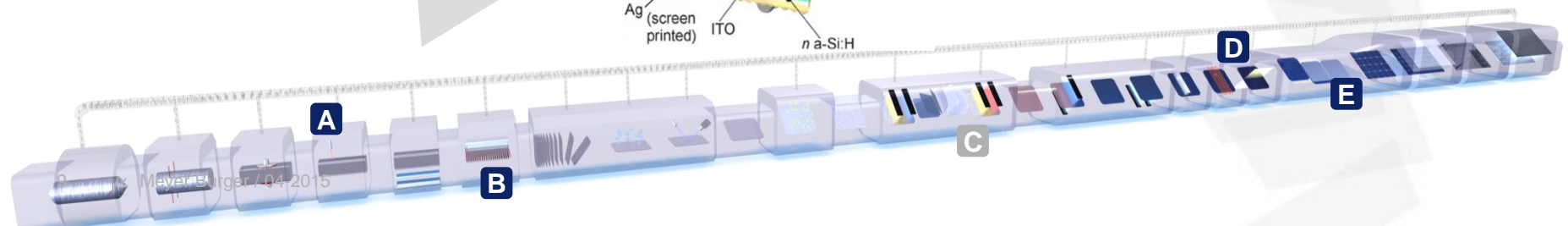
- High capacity cells
- Busbarless cells
- DragonBack
- PED (Chipping)



E SmartWire Connection (SWCT)

TCO layer and wafer thickness suitable for SmartWire

- 80% less silver
- Higher energy yield
- Higher efficiency
- Longevity and micro-crack resistant



Bifacial solar cells and modules



HJT cell	22-23%
HJT module	290-310W
Record	525W (100 cells)

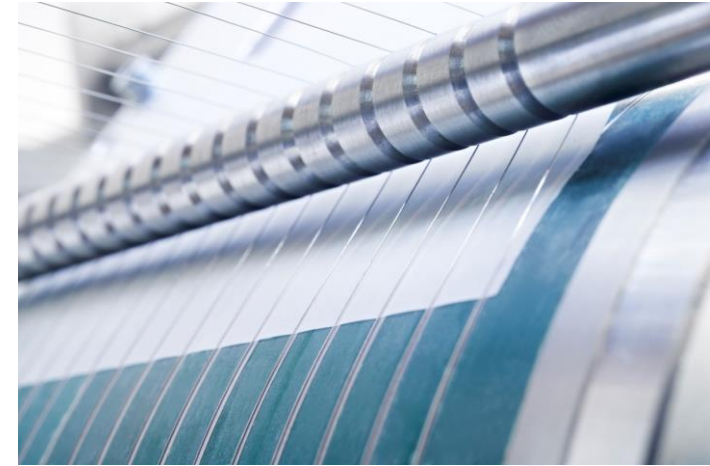


Bifacial solar cell and modules lines



HELIA Tools: Hohenstein-Ernstthal

SWCT Tools: Thun

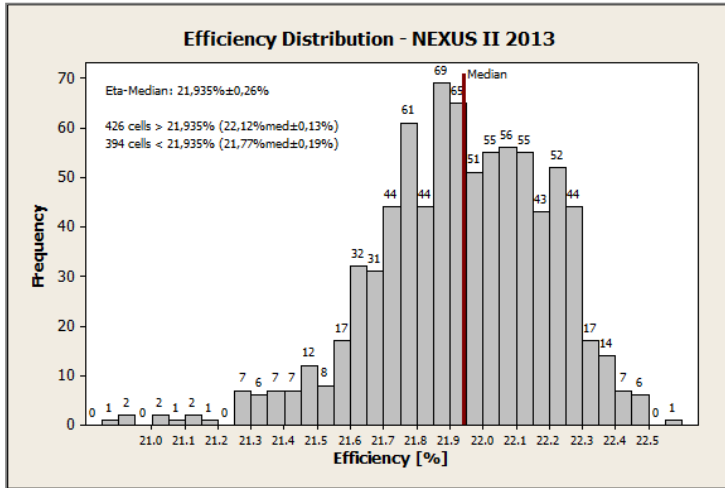


Cell and module lines are in ramp up phase



HJT Line Performance

Cell efficiency distribution



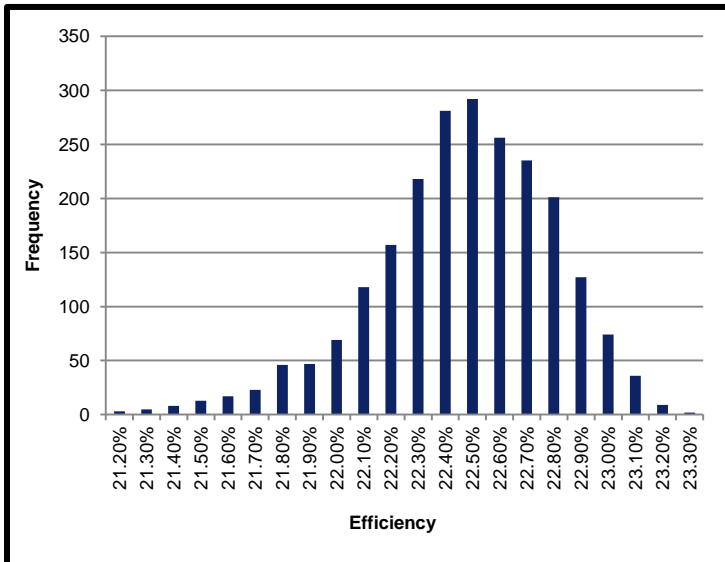
N-type CZ, 6 inch mono wafer

December 2013

- ~1000 cells
- Median: 21.94% ($\pm 0.26\%$)

March 2015

- ~2350 cells
- Median: 22.51%
- Record bifacial cell

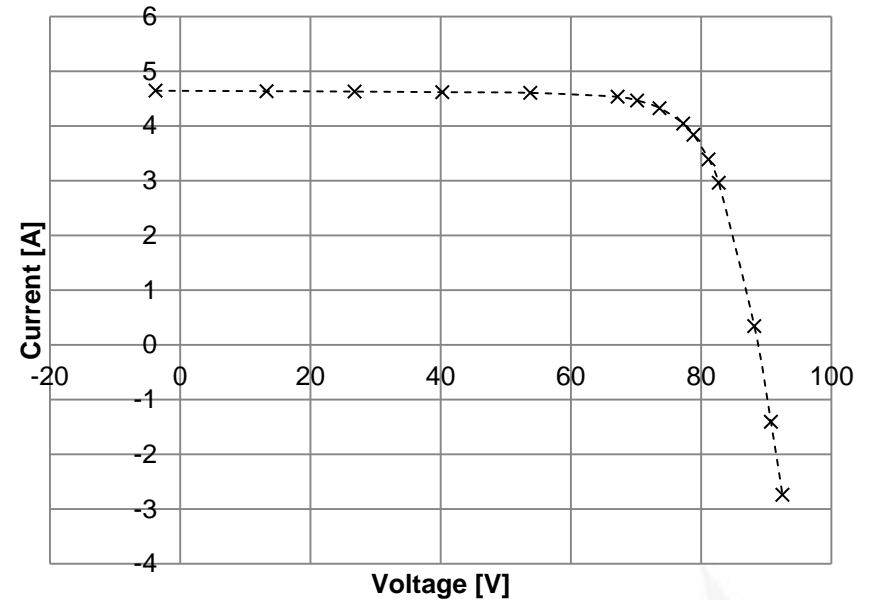
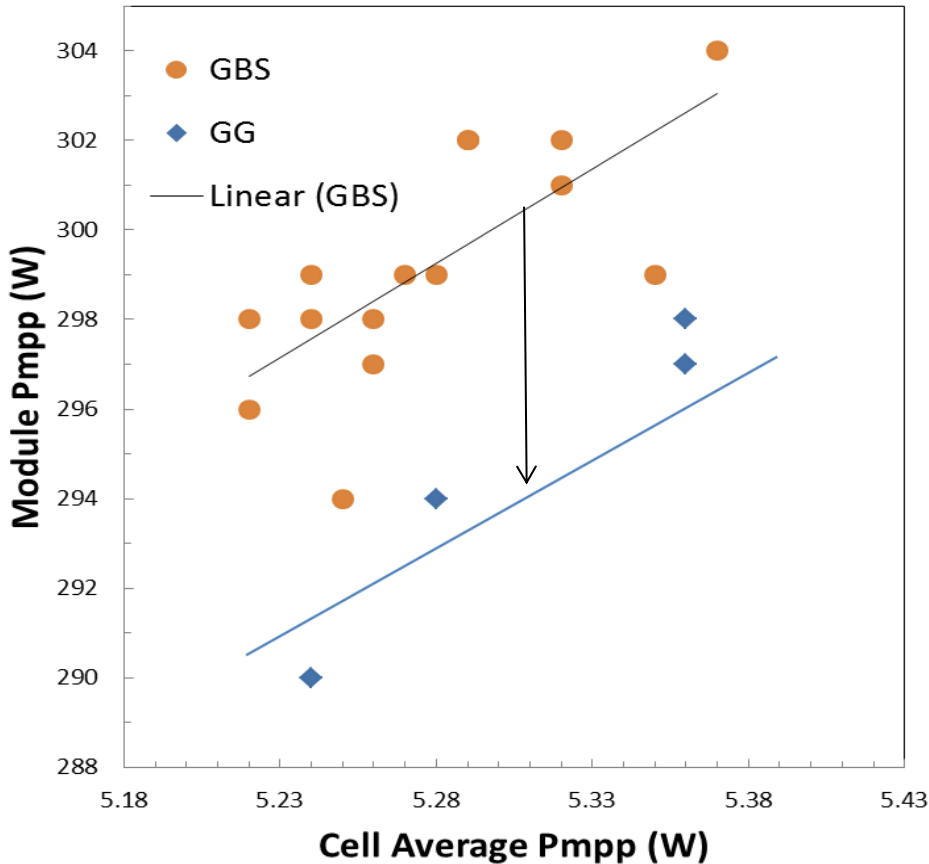


Eta	Jsc (mA/cm ²)	Voc (mV)	FF
23.32%	39.06	739.3	80.75%



Module Line Performance

Power distribution



	Pmax [W]	Voc [V]	Isc [A]	FF [%]
Full cells 300 mu wires	316	44.4	9.3	76.2
Half cells 200 mu wires	319	88.7	4.6	77.4

Module power between 295-305W => Record 319 W (PSQ M0)

Glass-Glass enables bifacial => 6-7W lower at flasher but...

\$/kWh

HJT SWCT GG

Higher energy yield (kWh/Wp and kWh/m²)



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Location: Lugano, Switzerland

Moderate Climate, average air temp. 20.8 °C

Period: 22.07.2014-03.09.2014

Measured independently by SUPSI

kWh/Wp	c-Si multi	HJT competitor	CdTe	CIGS	MB GG
Power [Wp]	262	244	79	169	288
Summer 2014	reference	+ 1.3%	+ 6.8%	+ 6.9%	+ 14.0%
Clear days	reference	+ 1.6%	+ 7.0%	+ 7.1%	+ 13.6%
Cloudy days	reference	- 0.2%	+ 4.9%	+ 5.1%	+ 16.7%
kWh/m ²	c-Si multi	HJT competitor	CdTe	CIGS	MB GG
Summer 2014	reference	+22.6%	-27.0%	-7.9%	+25.3%



MB GG Bifacial

- ✓ Excellent low light
 - ✓ Low temp.
Coeffi: -0.25%/K
 - ✓ No LID, No PID
- 288 Wp GG => 328 Wp equivalent**

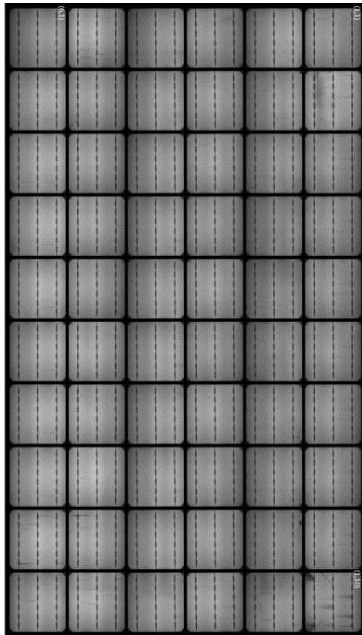


SWCT Module Reliability

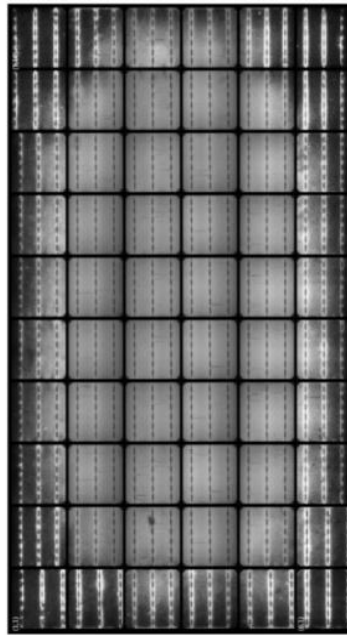


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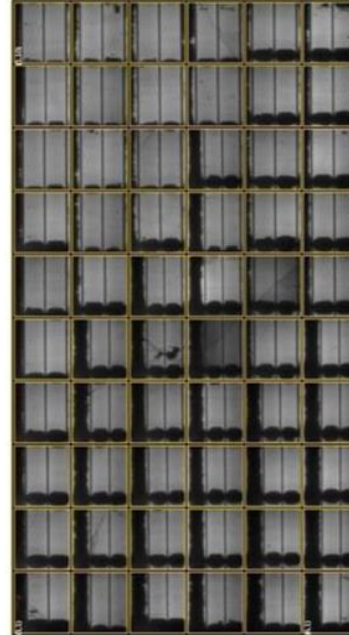
**Modules
after 7000h DH**



GG SWCT/TPO



GG 3BB/EVA



GBS 3BB/EVA

GG SWCT/TPO	<2% deg.
GG 3BB/EVA	20% deg.
GBS 3BB/EVA	40% deg.

Encapsulant	Water absorption (%)	WVTR (g/m ² /day)
EVA	0.2-0.3	10-30
TPO	<0.1	<5
PVB	0.4-0.5	25
Ionomer	<0.1	
Silicone	<0.1	>35

Polyolefin encapsulant material

GG module with TPO encapsulant has excellent performance in damp heat condition and therefore reduce furthermore the degradation rate



Module Reliability



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Damp heat testing

- Stable modules without power losses (> 4000 h)

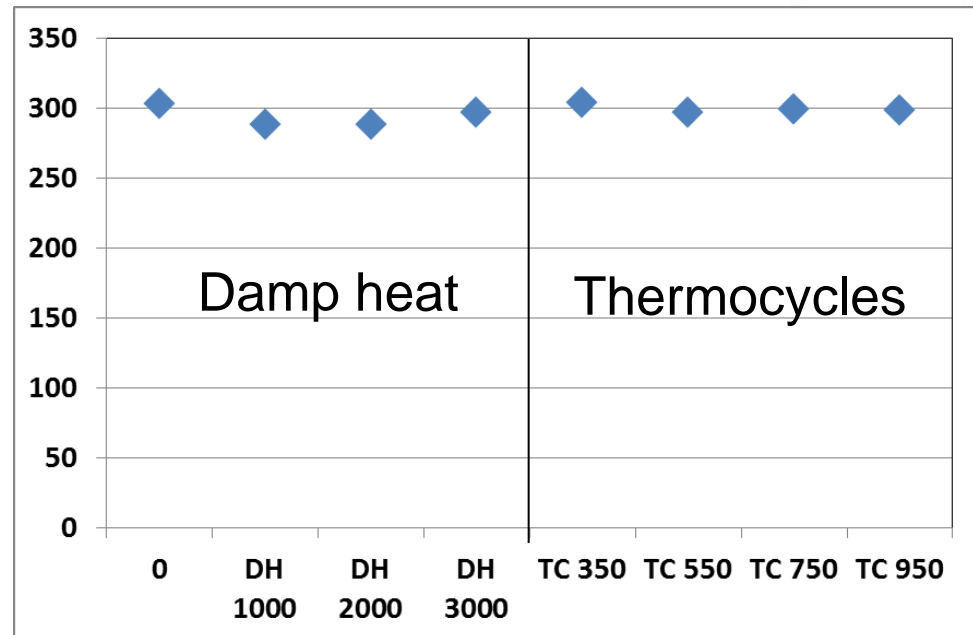
Thermal cycling testing

- Stable modules after 600 cycles

DH then TC

- Stable module after 3000h of DH and 950 TC

	DH Initial	DH 4000h	TC initial	TC 600 cycles
Power [W]	308	305	299	296
Loss [%]		1.0		0.9





Low degradation rate



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Busbar Technology

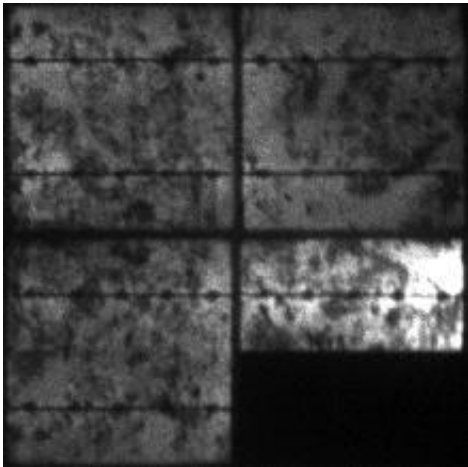
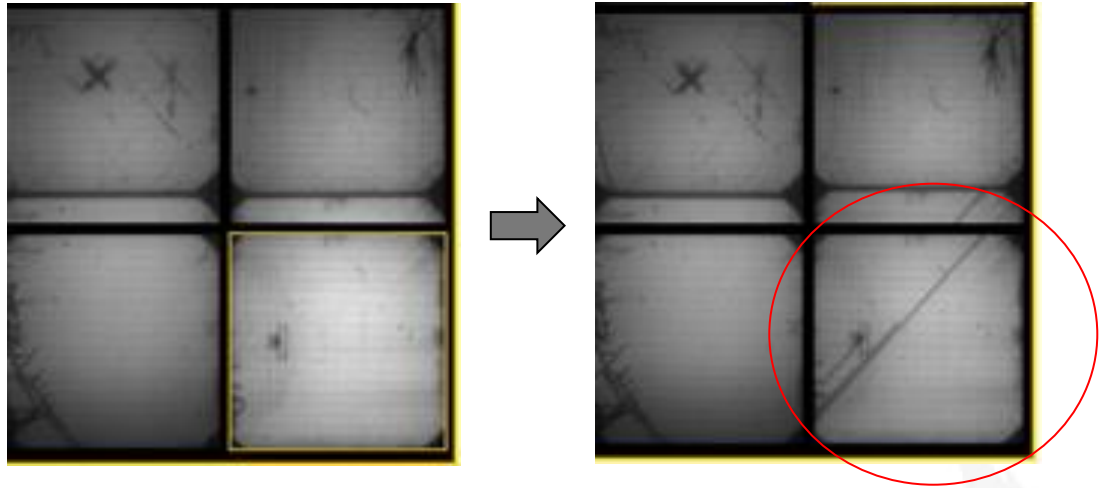


Image from: ISFH

Inactive cell area due to crack

SWCT Technology



Full cell area is active after crack

Dense SWCT contact matrix

- No negative impact of micro cracks → less degradation over module life time

IEC + UL certificates



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Certificate

Registration No.: PV 60102364 **Page 1** **Report No.:** 21228790.001

<p>License Holder: Meyer Burger AG Schorenstrasse 39 3645 Gwatt (Thun) Switzerland</p> <p>Manufacturing Plant: Meyer Burger AG Schorenstrasse 39 3645 Gwatt (Thun) Switzerland</p>	<p>Product: PV Module Type: with 6" heterojunction (c-Si/a-Si) solar cells: Sky SmartWire XXX Abalone SmartWire XXX (XXX represents output power, output power range: 265 Wp - 325 Wp)</p> <p>with 6" monocrystalline (c-Si) solar cells: Sky SmartWire XXX Abalone SmartWire XXX (XXX represents output power, output power range: 255 Wp - 315 Wp)</p>
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Basis:

- IEC 61215:2005
EN 61215:2005
"Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval"
- Factory Inspection**
To document the consistent quality of the product factory inspections are performed periodically.



www.tuv.com
ID 000044263

Remarks:
- Valid in conjunction with TÜV Rheinland certificate based on IEC EN 61730.

Conditions:
The product test is voluntarily according to technical regulations. Any change of the design, materials, components or processing may require the repetition of some of the qualification tests in order to retain type approval.
The certificate has a validity of 5 years counting from date of issue.



Certification body
Dipl.-Ing. M. Adrian

Cologne, 16 June 2015

TÜV Rheinland LGA Products GmbH, Tillystrasse 2, 90431 Nürnberg, Germany / Contact: + 49 221 806 2477 email: eneratest@de.tuv.com




Certificate

Registration No.: PV 60102365 **Page 1** **Report No.:** 21228791.001

<p>License Holder: Meyer Burger AG Schorenstrasse 39 3645 Gwatt (Thun) Switzerland</p> <p>Manufacturing Plant: Meyer Burger AG Schorenstrasse 39 3645 Gwatt (Thun) Switzerland</p>	<p>Product: PV Module Type: with 6" heterojunction (c-Si/a-Si) solar cells: Sky SmartWire XXX Abalone SmartWire XXX (XXX represents output power, output power range: 265 Wp - 325 Wp)</p> <p>with 6" monocrystalline (c-Si) solar cells: Sky SmartWire XXX Abalone SmartWire XXX (XXX represents output power, output power range: 255 Wp - 315 Wp)</p>
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Basis:


- IEC 61730-1:2004+A1+A2
IEC 61730-2:2004+A1
EN 61730-1:2007+A1+A2+A11
EN 61730-2:2007+A1
"Photovoltaic (PV) module safety qualification"
- Factory Inspection**
To document the consistent quality of the product factory inspections are performed periodically.



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ID 000044263

Remarks:
- Valid in conjunction with TÜV Rheinland certificate based on IEC EN 61215.
- The above listed PV modules fulfil the requirements of Application Class A (Class II acc. to IEC 61140). They may be used in PV plants at a maximum system voltage (Voc at STC) of up to 1000 VDC.
- The above listed PV modules fulfil the requirements of fire rating class C.

Conditions:
The product test is voluntarily according to technical regulations. Any change of the design, materials, components or processing may require the repetition of some of the qualification tests in order to retain type approval.
The certificate has a validity of 5 years counting from date of issue.



Certification body
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2 TPOs, 2 Backsheet (with & without Al), PERC, HJT, Integrated diode



- 1) **Certificate**
- 2) **Extensive reliability testing**
- 3) **Excellent COO 0.5\$/Wp**
- 4) **High module power => Low BOS**
- 5) **Demo runs on going**

Is that enough to invest for 1 GW?

Where is the reference plant?

HJT-SWCT @ CSEM



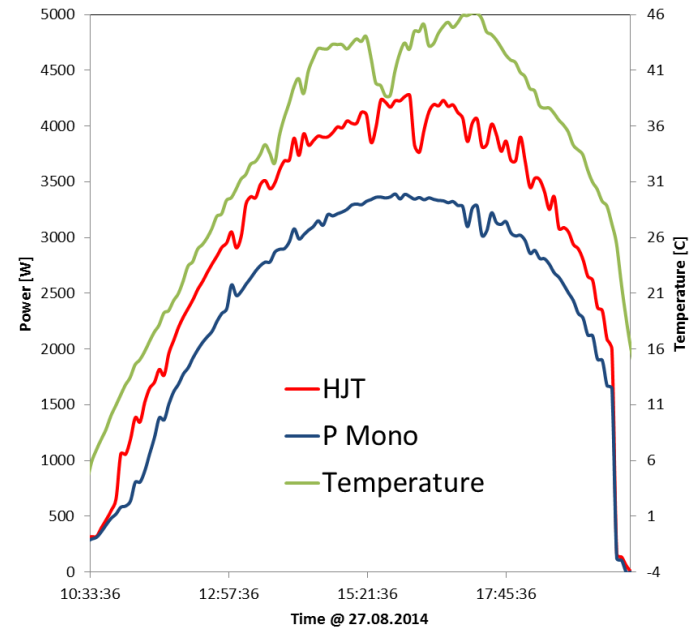
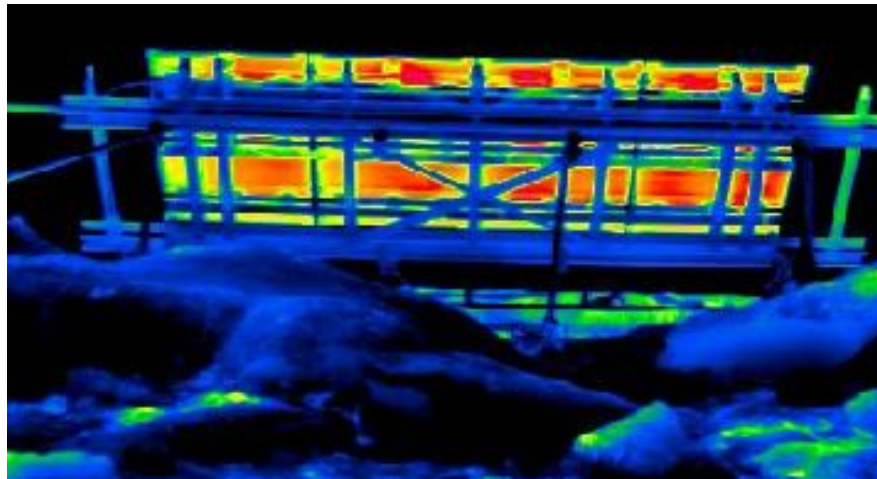
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HJT-SWCT @ Monterosa 3500m



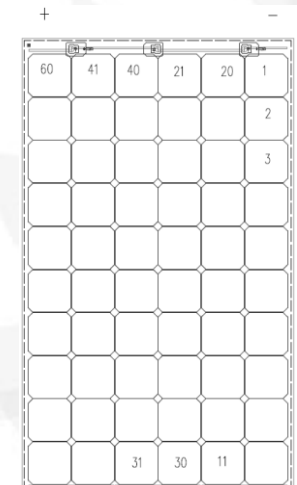
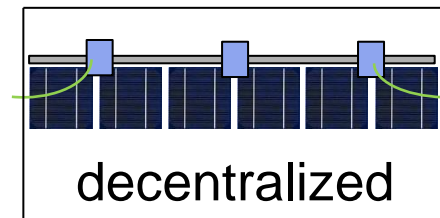
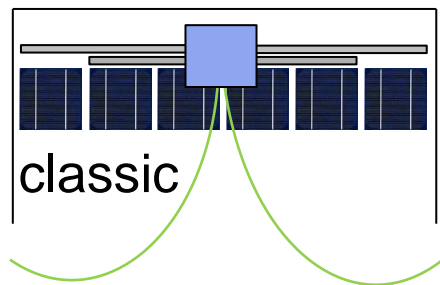
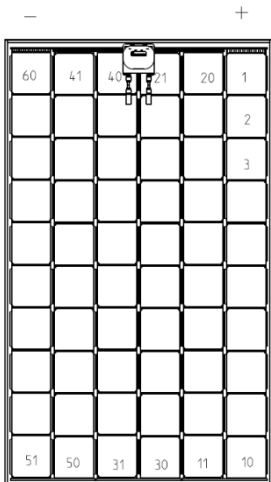
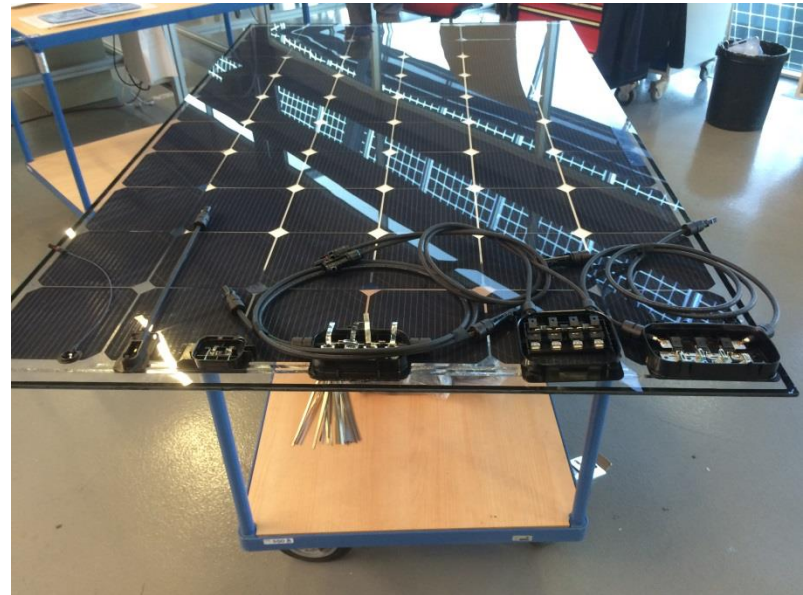
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Bifacial ↔ Module design



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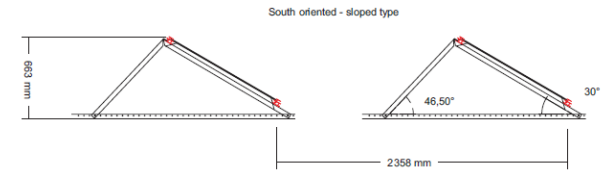
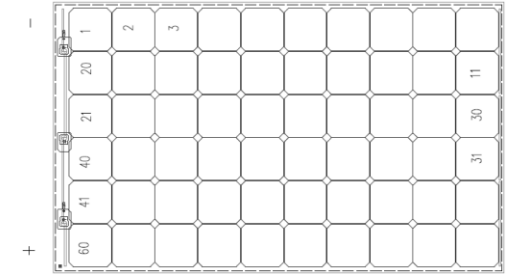
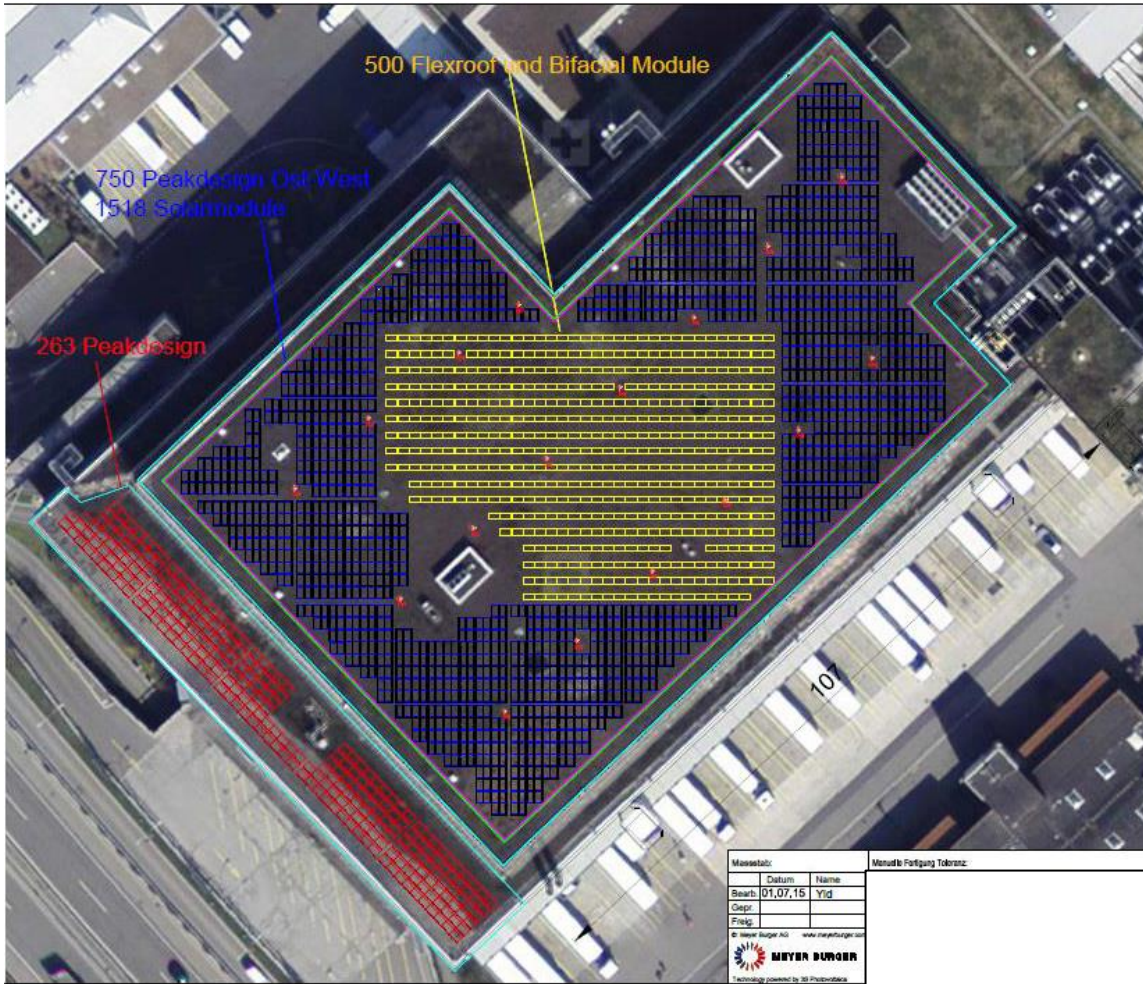
Lower cost, lower area loss
Lower back side shading

HJT SWCT in CH

-2000 SWCT PERC Monofacial & 500 SWCT HJT Bifacial



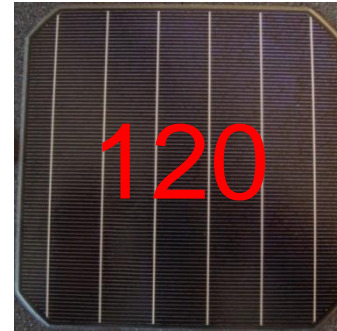
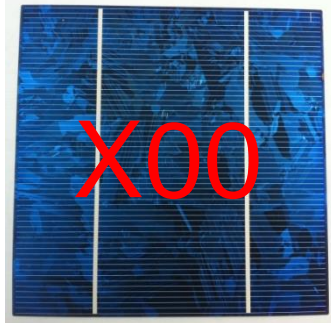
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Our MB PV Evolution



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- Low cost Bifacial Technology: 50-60\$cts/Wp @300Wp
- Extended durability: >2 * IEC passed + >1400 contact points per cell
- Medium scale coming to proof the HJT-SWCT-GG
- Potential improvement: Half cells, squared modules, standard





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High-end solutions for high-tech industries



University of Applied Sciences and Arts of Southern Switzerland
Department for Environment Constructions and Design
Institute for Applied Sustainability to the Built Environment

SUPSI