



# BenQ Solar Back-Contact PM3 I8B0I Introduction

*Highest Efficient PV Module*

Oct., 2013

BenQ  
Solar

A division of AU Optronics



# Product Features

# High Efficiency Solar Cells



- AUO SunPower, a joint venture of AU Optronics and SunPower, began manufacturing high-efficiency solar cells in Malaysia in 2010.
- AUO SunPower cells deliver record-breaking conversion efficiency rates of more than 22.5%.



# BenQ Solar PV Module Product by Application

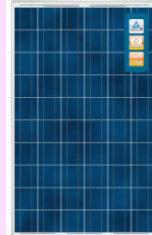


Limited space  
Non-consistent construction  
Delicate looking  
Light (in weight)

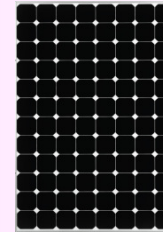
## Residential



Green Triplex  
245W series



SunForte  
PM318B01



Green Triplex  
250W series



AC PV  
255W

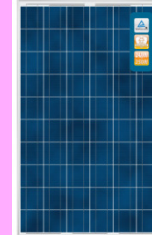


High power output  
Light in weight  
Resist to snow and  
wind Load

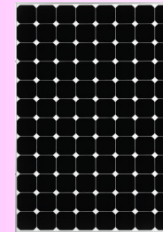
## Commercial



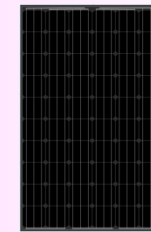
Green Triplex  
245W series



SunForte  
PM318B01



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AC PV  
255W

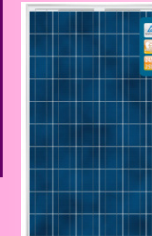


High power output  
Resist to snow and  
wind Load  
Stable Electricity  
generation

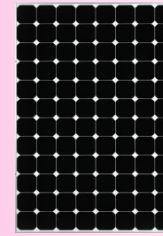
## Utility



Green Triplex  
245W series



SunForte  
PM318B01



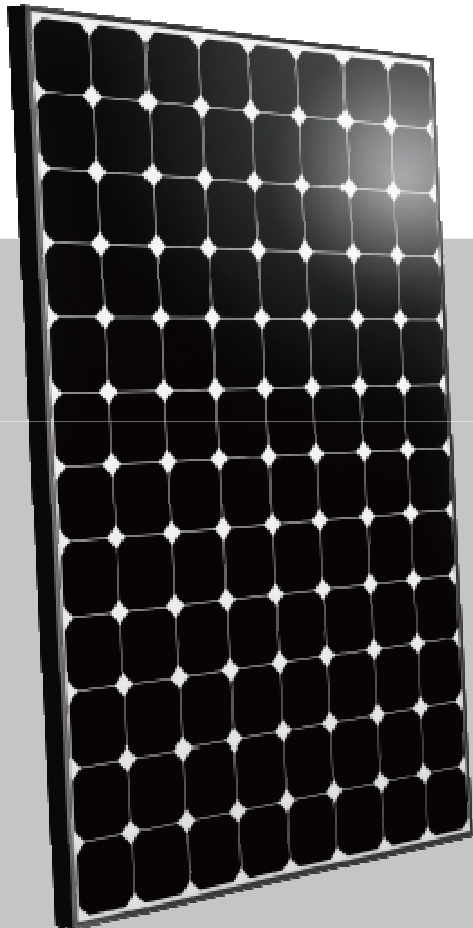
Green Triplex  
250W series



AC PV  
255W



# High Efficiency Module Provides Powerful Output



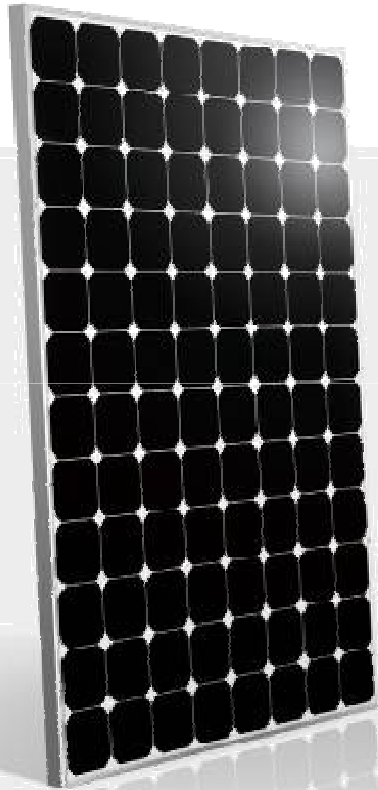
SunForte  
PM3 I8B0 I



- Module conversion efficiency over 20%
- Back Contact cell design

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# Back Contact V.S. Conventional Module



*SunForte PM318B01*

## Higher Efficient

PM096B00 module conversion efficiency is up to **20.1%** with power output up to 327W

## Better Energy Yield

PM096B00 has **better Temp. coefficients** than conventional c-Si modules. **AR glass** has better energy yield than non-AR modules

## Reliable Performance

PM096B00 is designed base on mature BC technology with 25 years history. **No LID effect.** Pass salt mist test.



*Conventional Module*

# Back Contact V.S. Conventional Cell



**Ingot**



High Quality N-Mono Wafer  
no LID effect

**Wafer**



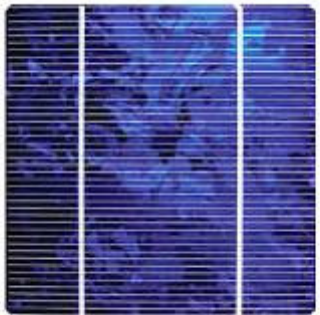
More than 20 Processes  
Elegant Appearance

**Cell**

**P-Multi Wafer**

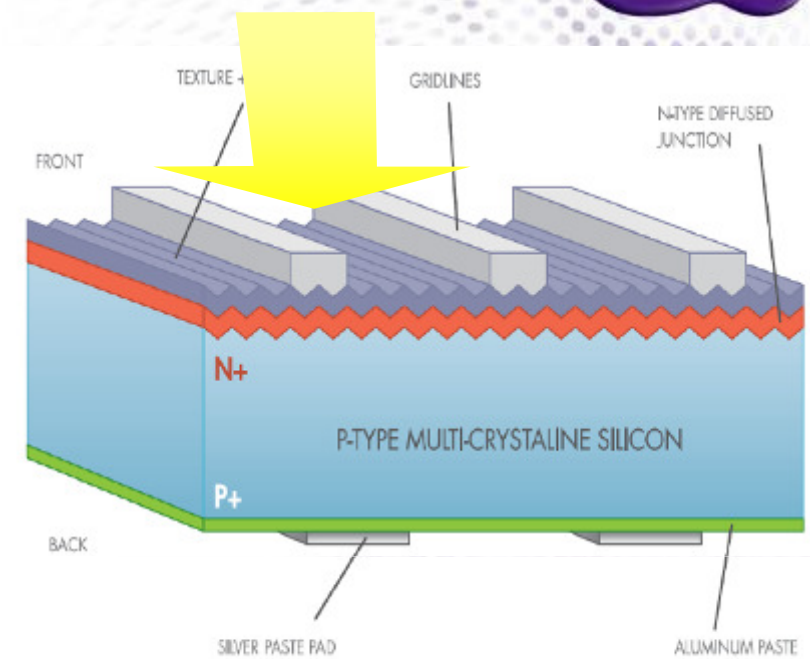
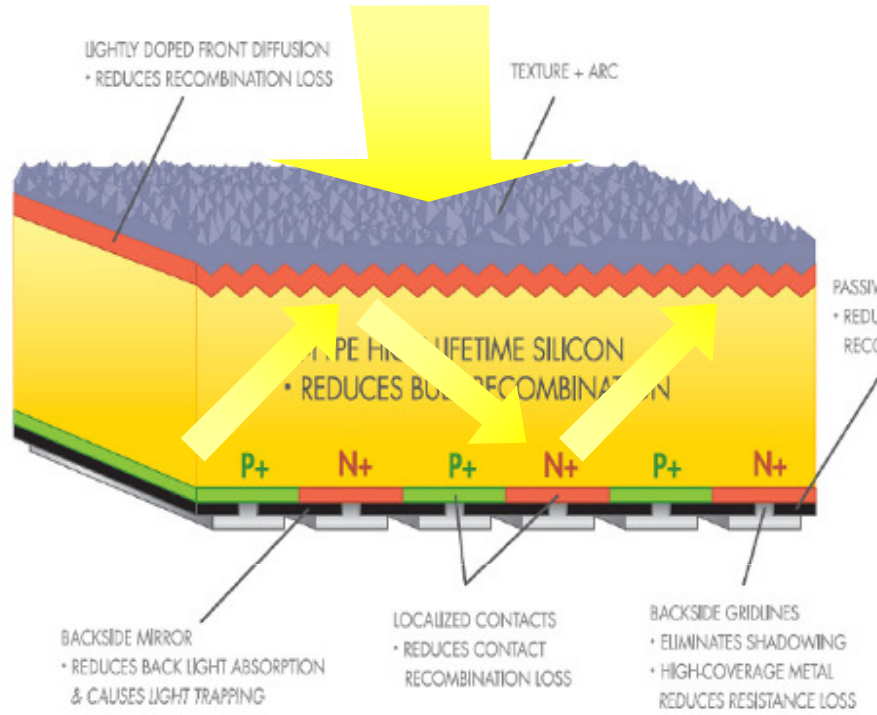


**ONLY 6 Process**



Note: LID (light-induced degradation)

# Back Contact V.S. Conventional Cell



## 1. Maximum Light Capture

- More sunlight transmit on front surface

## 2. Strong Metal Contacts

- Conduct more current
- High Rsh/ Rs ratio

## 3. Minimum Recombination Loss

- Passivated Silicon dioxide on front and back of cell

## 4. Reflects More Light

- Back-side mirror structure

Note: Rs: series resistance ; Rsh: shunt resistance



# Better Temperature coefficients



- Traditional c-Si and mc-Si
  - $T_{\text{coef,power}} = -0.47\%/C$
- AUO SunPower back-contact
  - $T_{\text{coef,power}} = -0.38\%/C$
- For a warm location with an energy-weighted average T of 45°C
  - Loss of energy from temp. for traditional Si cell: **9.4%**
  - Loss of energy from temp. for AUO SunPower cell: **7.6%**



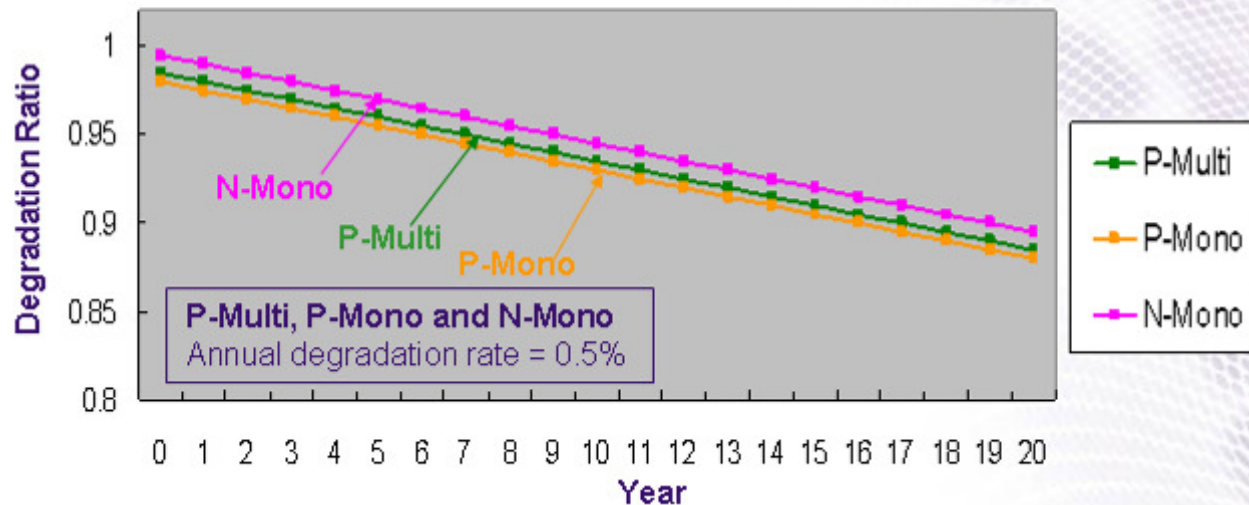
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# Degradation

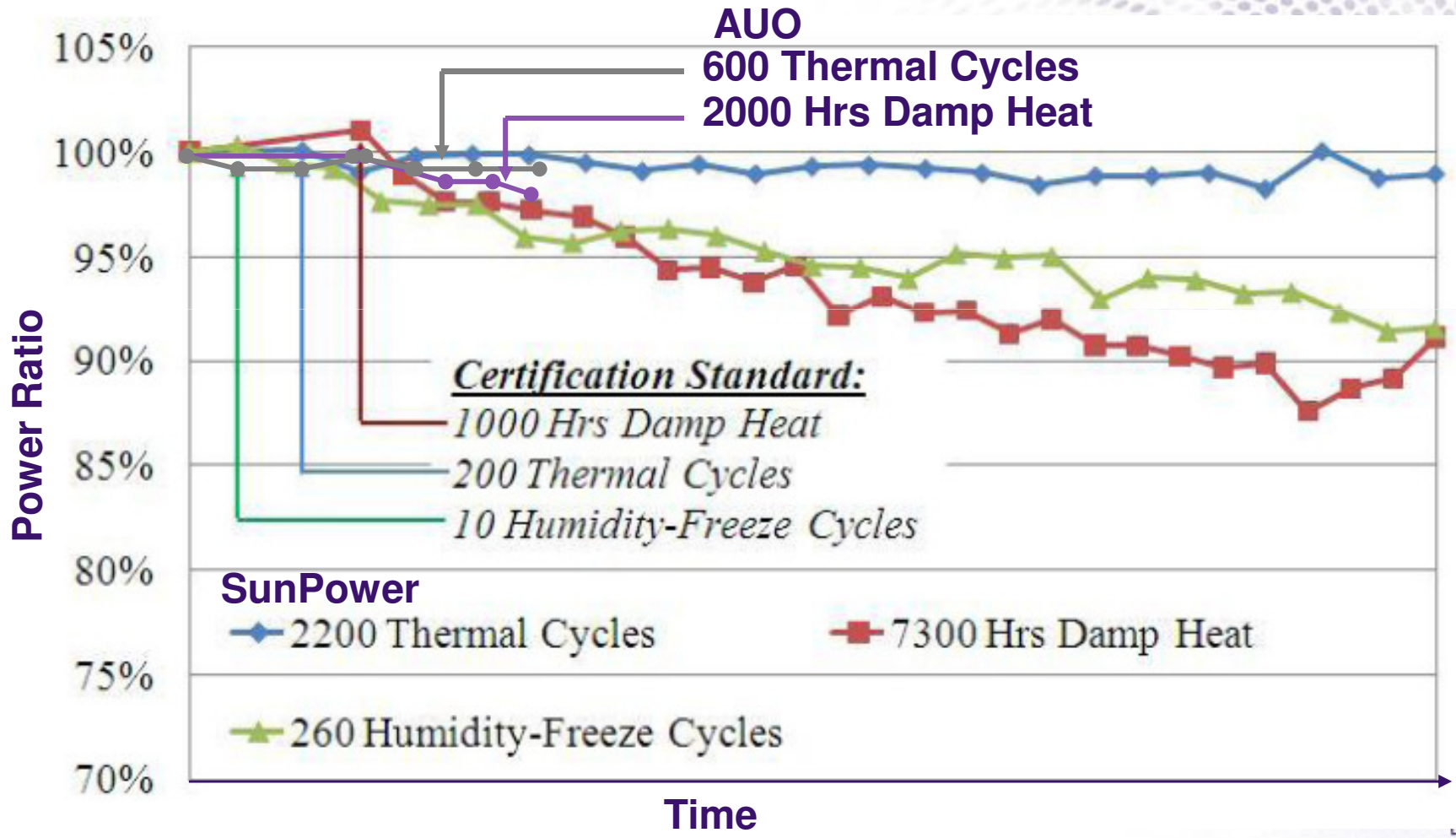


- Light-induced degradation (LID)
  - Back contact cell uses n-type Si, so no LID
  - “Average” c-Si LID is ~1.5% (previously, some low-quality modules had LID around 3~5%)

PV Technology	P-Multi	P-Mono	N-Mono
LID (%)	1.5%	2%	0%



# Back-contact-cell modules: long-term testing example



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# Better LCOE



*Confidence in the energy production and O&M estimates very strongly affects selling price and financing rates*

$$\text{LCOE} = \frac{\text{NPV [Total System Installed Costs + O\&M Costs]}}{\text{NPV [Energy produced]}}$$

High Efficiency

Energy / rated W

- Environmental conditions
- Mounting (tracking, tilt,...)
- System design
- Module type

System availability (uptime)

System Quality and Reliability

- System Lifetime
- Degradation rates
- Failure rates

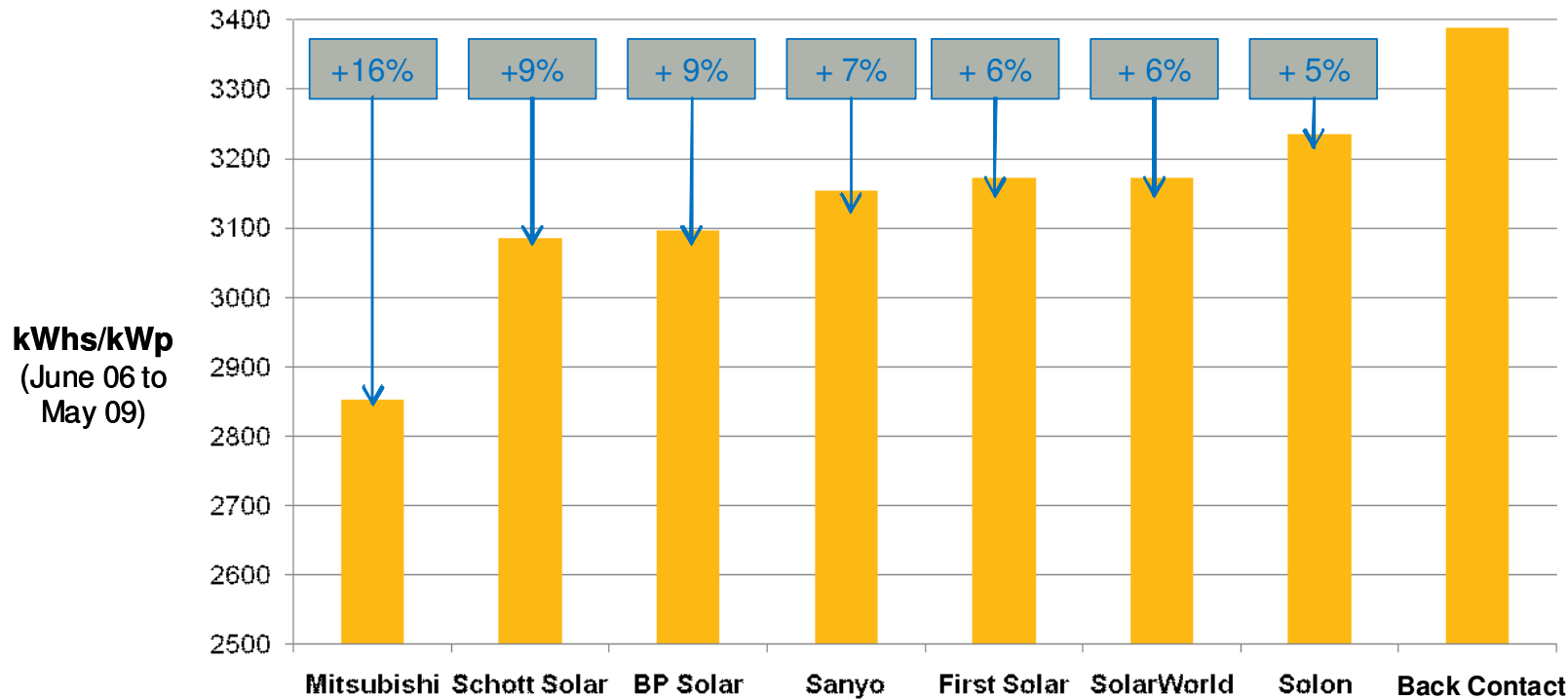
LCOE ≡ Levelized Cost of Energy  
NPV ≡ Net Present Value  
Total system costs includes cash flow impact of financing  
O&M ≡ Operation and Maintenance



# BenQ Solar PM3 I8 performances- Academic Reports

# PM318 – Back Contact cell proven performance

Stuttgart university



Technology: (a-Si thin film) (poly-Si) (mono-Si) (HIT-Si) (CdTe thin film) (poly-Si) (poly-Si) (back contact mono-Si)

Cumulative kWh yield (kWh ac / kWp rated) from June 2006 to May 2009 – Stuttgart, Germany

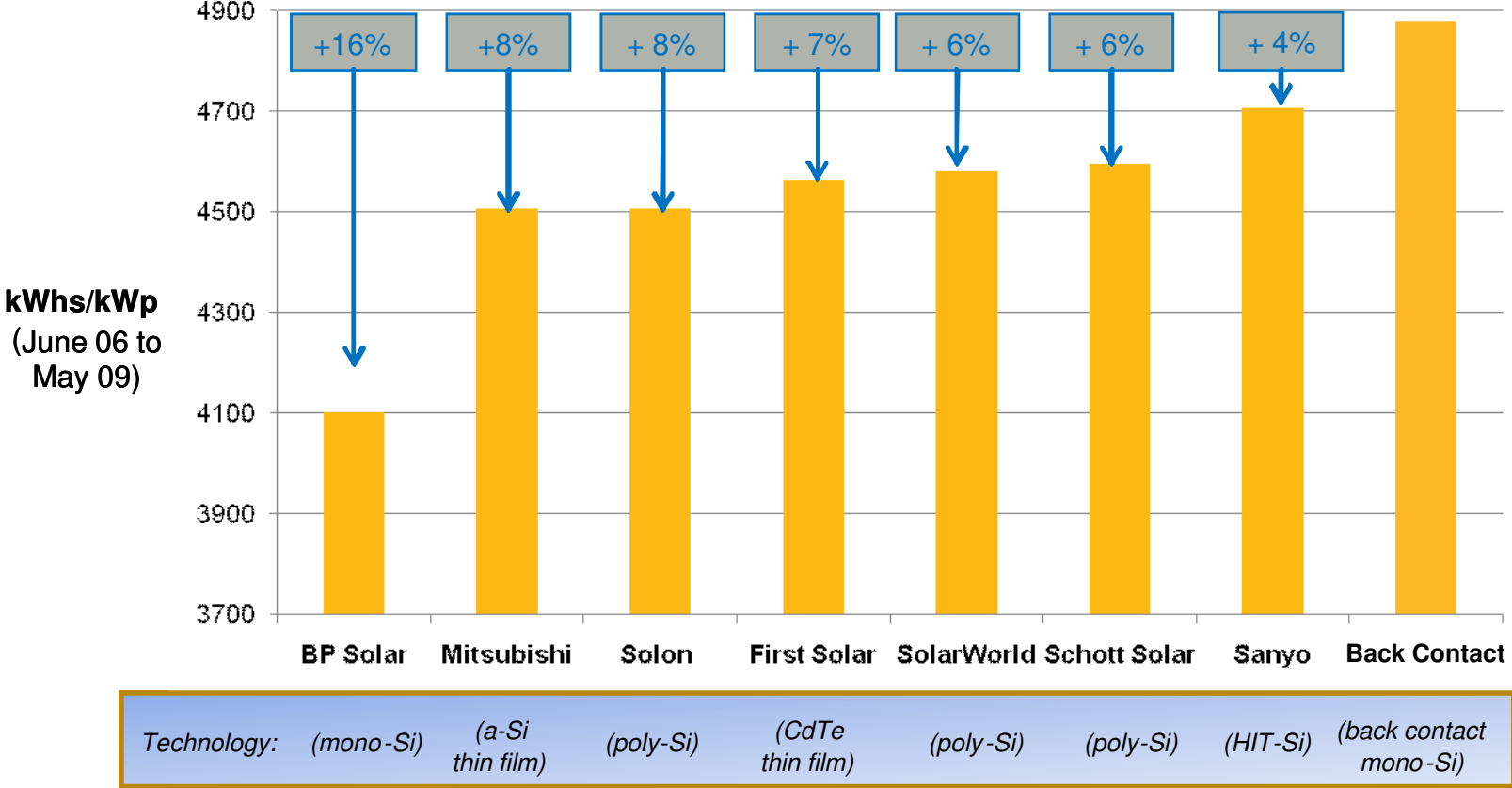
**Source:** Institut für Physikalische Elektronik (*ipe*) University of Stuttgart, Germany. Testing started in June 2006 and is on-going - Webpage: <http://www.ipe.uni-stuttgart.de/index.php?lang=ger&pullDownList=12&ebene2ID=44>.

<http://www.ipv.uni-stuttgart.de/forschung/pvsystem/index.en.html>



# PM3 I8 – Back Contact cell proven performance

University of Cyprus



Cumulative kWh yield (kWh ac / kWp rated) from June 2006 to May 2009 – Stuttgart, Germany

**Source:** Department of Electrical and Computer Engineering - University of Cyprus in Nicosia. Testing started in June 2006 and is on-going - Webpage: <http://www.ipe.uni-stuttgart.de/index.php?lang=en&pullDownList=12&ebene2ID=44>

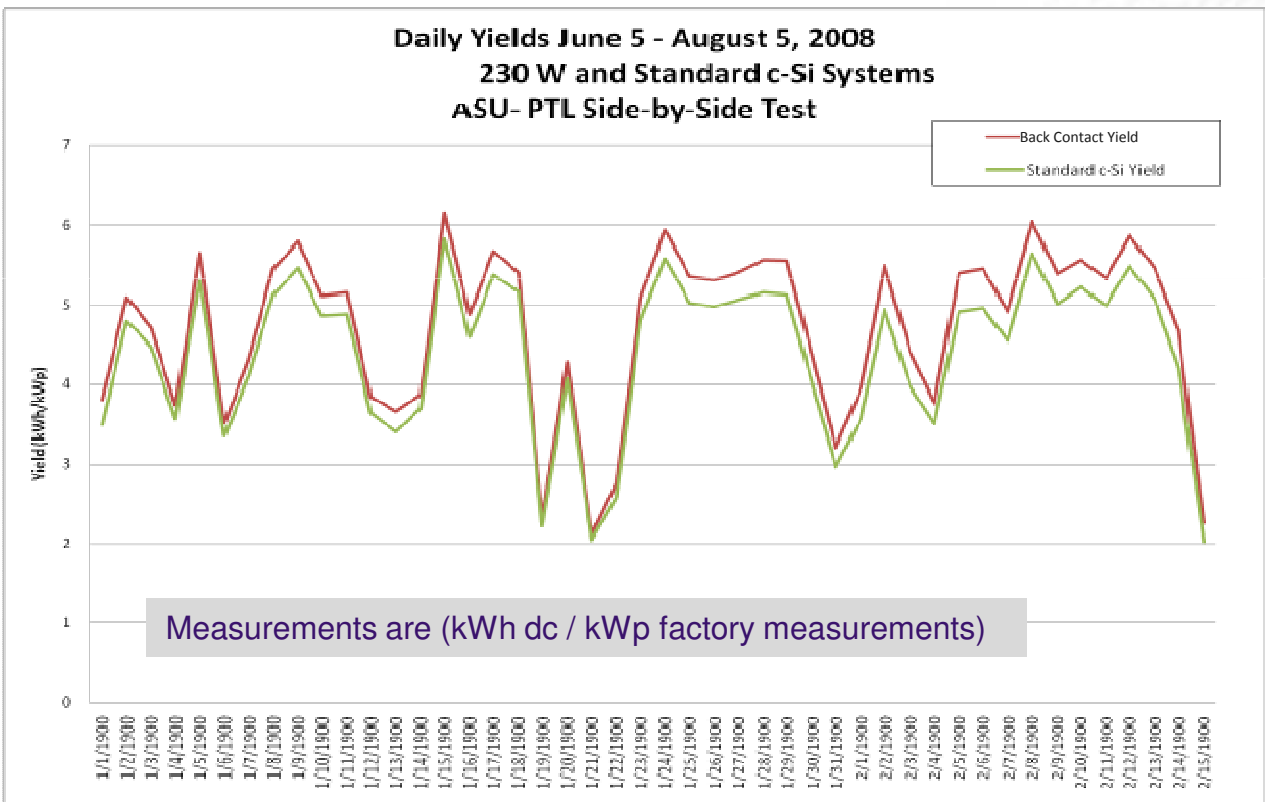


# PM318 – Back Contact cell proven performance

High Temperature test



7.2% higher energy yield than standard c-Si panels



Objective of ASU site monitoring:  
*Measure and quantify differences in performance between Back Contact modules and Standard crystalline silicon (c-Si) modules using independently verifiable data at a high temperature site*

Module Type	Modules	Capacity (Wp)
Back Contact 225W	7	1555
Std c-Si 208 W	9	1871

ASU – Arizona State University is a well known independent lab in the US that specializes in PV testing and monitoring





# Certifications of PM3 I8B01



Items	Certificate	Brand	PM3 I8B01
IEC	IEC (Intertek) P01	BenQ	ready
MCS	MCS P01	BenQ	ready
CEC	Australian CEC List	BenQ	ready
Ammonia	Ammonia (by Intertek)	BenQ	ready
Fire test (UL 790 class C)	Fire test UL790 (by Intertek)	BenQ	ready
Fire test (EN 13501 class E)	Fire test EN13501 (by Intertek)	BenQ	ready
PV cycle	PV cycle	BenQ	ready
Carbon footprint	Carbon footprint (PAS 2050)	BenQ	ready
ISO 9001	P01	BenQ	ready

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# Successful Project References

# Successful Project - 2011 Worldwide



**1st**

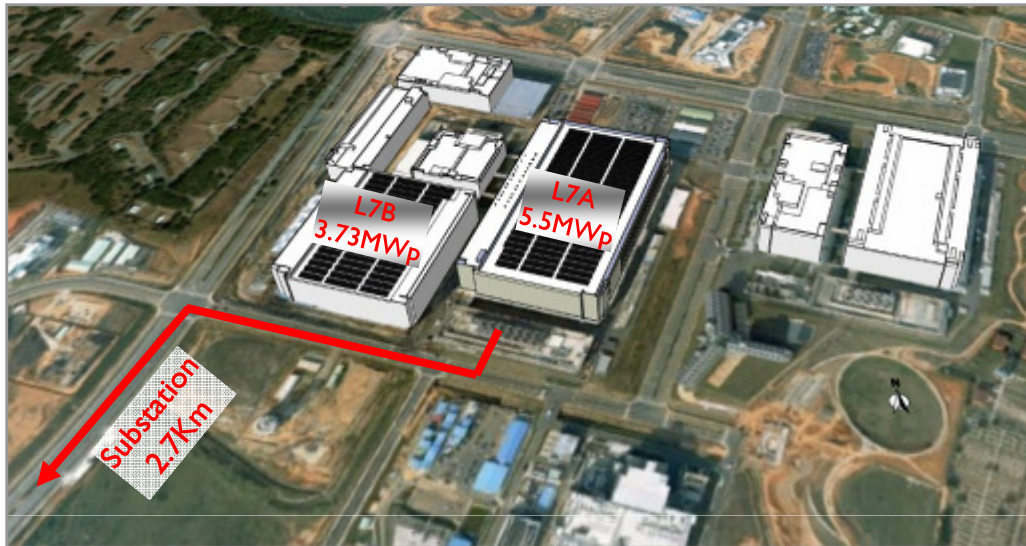
1st project with PM318B00 B/C modules in Taiwan



**1st**

Footprint to South Africa, Kendal  
1.2MW Tracking System + Ground-Mounted

# Mega Commercial Rooftop (AUO)



Site	Installed Capacity
No.1	5.5MWp ( PM318P00 )
No.2	3.23MWp ( PM318P00 ) ( PM250M00 )
TTL	9.23MWp

• Grid on Dec./21 / 2012



# Small Commercial Roofs



Kaohsiung  
499KWp



Pingtung  
51KWp



Kaohsiung  
499KWp



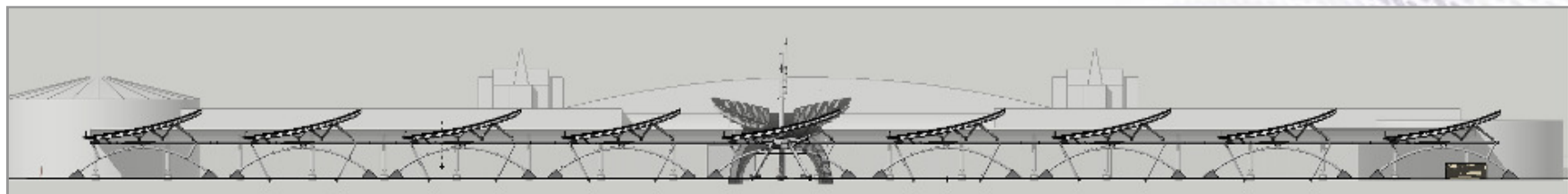
Kaohsiung  
499KWp



# Peng-Hu International Airport BIPV Project



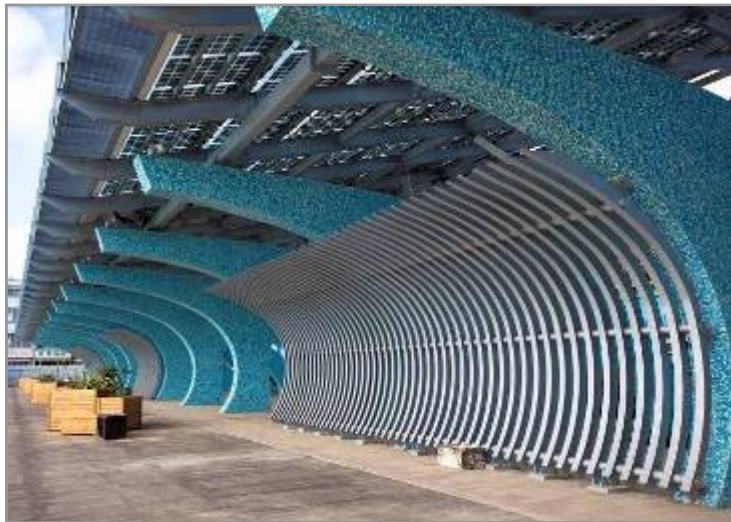
- 2012/12/21 on grid
- 500Kw BIPV+PM318
- Car port
- EV auto-bike power charger



# MaKon Fish Port BIPV Project



- 2012/12/21 on grid
- 300Kw BIPV + PM318
- Fish port ice maker
- Leisure area



# Hybrid Mini-Grid System at Dong-Gi (2)







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