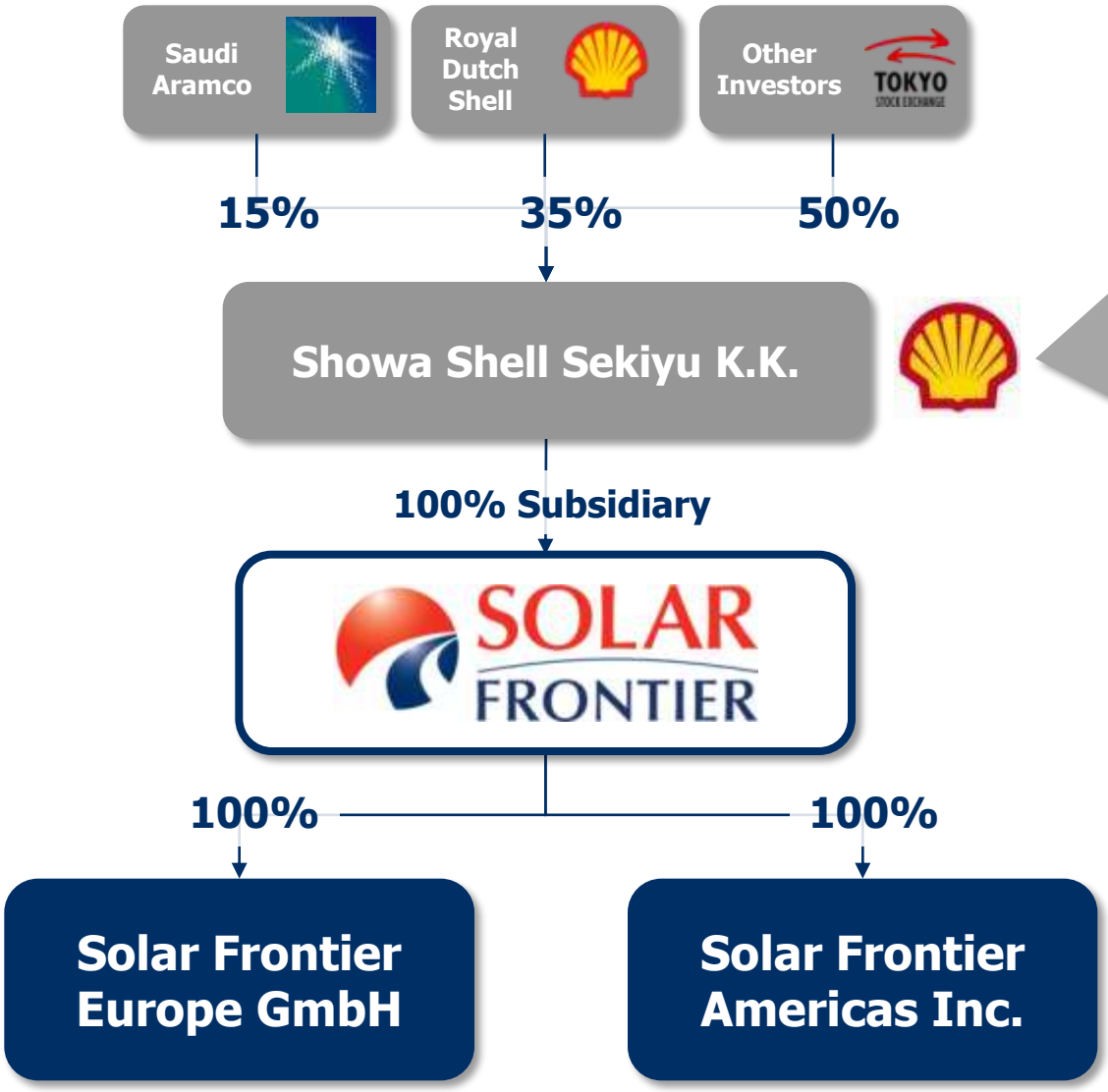
CIS Photovoltaic Business in the World

May 2012

SOLAR FRONTIER

Group Structure



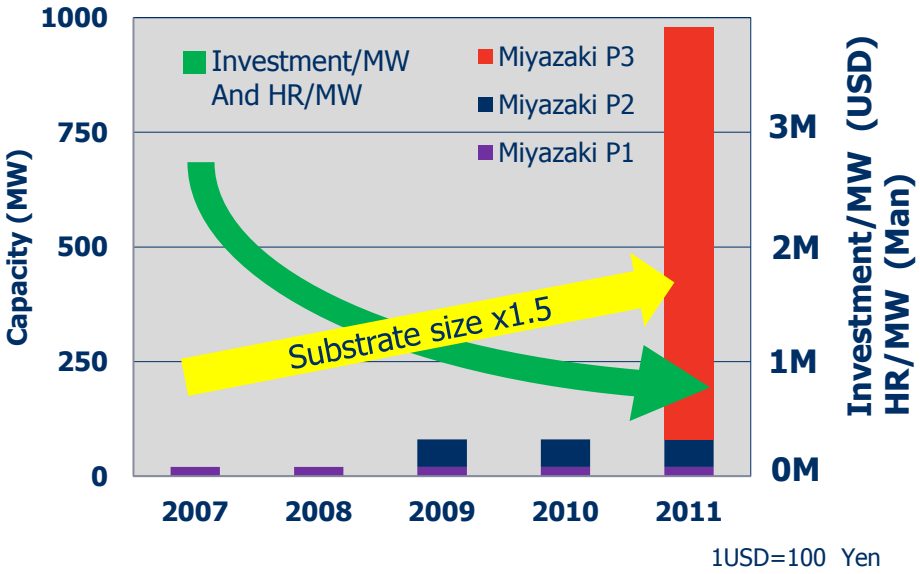
Showa Shell Sekiyu

Downstream oil refining & marketing company

Basic Data FY 2010	(US$)*
Tokyo Stock Exchange Class 1	
Turnover	$28 B
Total Assets	$14 B

*FOREX USD-JPY exchange rate - December 2010

Production Facilities



1USD=100 Yen

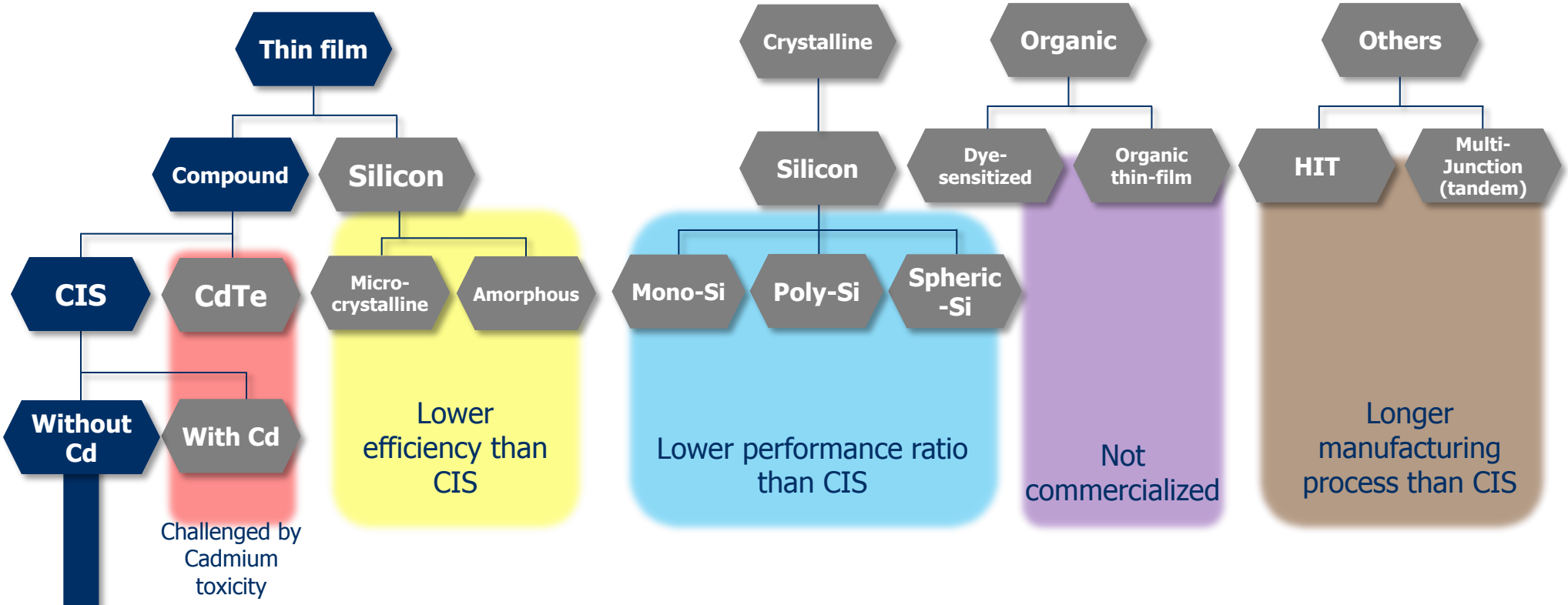
- **100% subsidiary of Showa Shell Sekiyu**
  - **110 years experience in energy**
  - **30+ years experience in solar**
- **1,500+ employees**
- **Tokyo, Munich, Santa Clara & Al Khobar**
- **Approximately 1GW of capacity**

Miyazaki Plant 1
20 MW p.a. capacity
Land = 25,000 m^2
Building = 6,000 m^2
Capex = USD 50M
(JPY 5 billion)

Miyazaki Plant 2
60 MW p.a. capacity
Land = 50,000 m^2
Building = 27,000 m^2
Capex = USD 150M
(JPY 15 billion)

Miyazaki Plant 3
900 MW p.a. capacity
Land = 400,000 m^2
Building = 158,000 m^2
Capex = USD 1 bn
(JPY 100 billion)

The Photovoltaic Landscape



Solar Frontier's CIS modules do not contain cadmium or lead

RoHS compliant

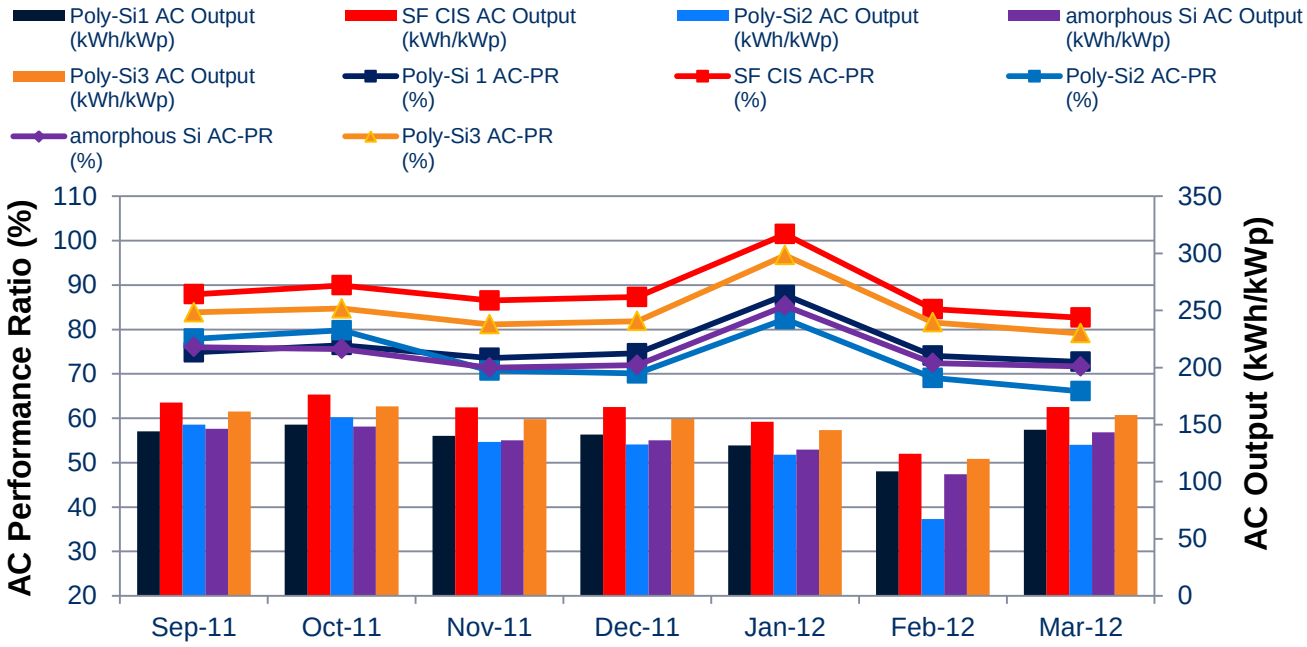
RAC10-0042_01

CIS vs Other Technologies

Site Overview

HopSol

Location:
Namibia, Africa
Coordinates:
22.6°S, 17.1°E
Average Irradiance:
2,363 kWh/m²/yr
Average Temp.:
20.5°C, 68.9 °F



	System Capacity	Azimuth	Tilt Angle	Inverter	Output(kWh/kWP) (Sep.11 – Mar.12)
Poly-Si 1	1.15 kW	180° N	22°	SMA SB1200	961
Solar Frontier (SF-130-L)	1.17 kW	180° N	22°	SMA SB1200	1118
Poly-Si 2	1.15 kW	180° N	22°	SMA SB1200	897
Amorphous Si	1.20 kW	180° N	22°	SMA SB1200	945
Poly-Si 3	1.12 kW	180° N	22°	SMA SB1200	1061

Value ADD:
System Optimisation

CIS Solar Business

- **First Step: the Product**
  - Advantages: Light Soaking, Shading Resistance, Low Light Behaviour, Temperature Coefficient, RoHS Compatibility, …
- **Second Step: The System**
  - Customer cost advantages by
  - intelligently utilising the product advantages
- **Third Step: The Solution**
  - Customer business advantages because of
  - Optimal balance of costs,
  - Optimal surface utilization, and
  - technical / technological advantages

Economical system output optimization

Characteristics of Solar Frontier CIS Modules

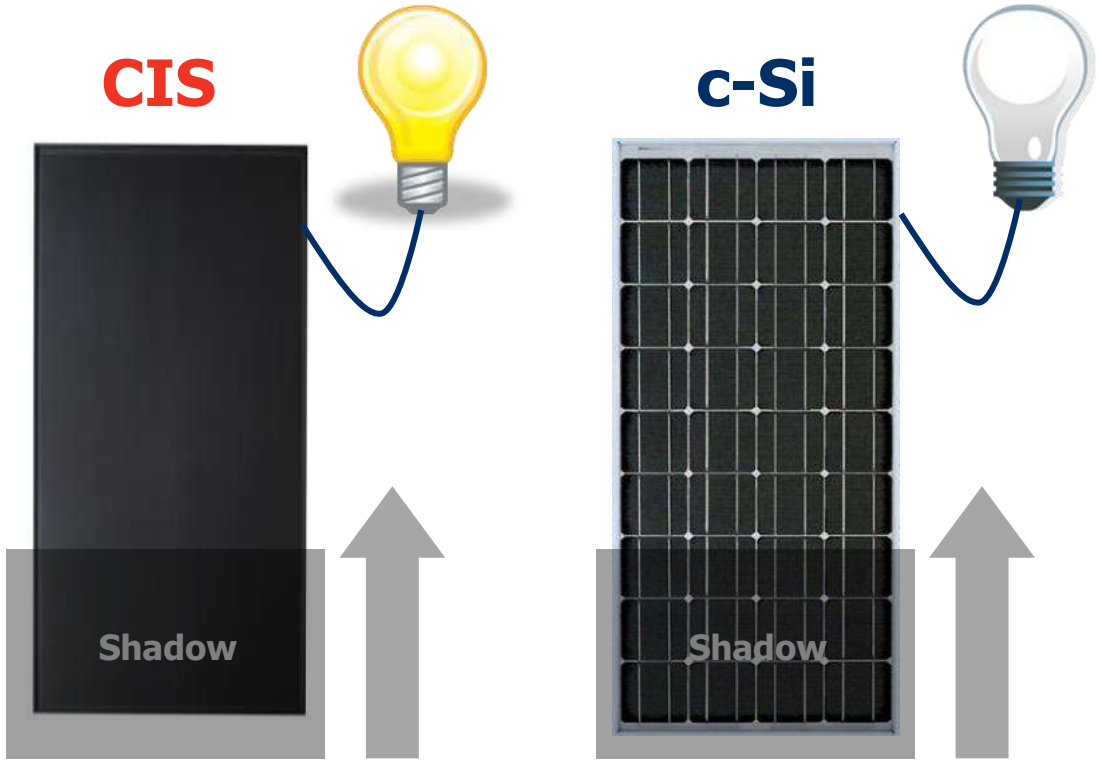
1. Contains neither lead nor cadmium (RoHS compliant)
2. Resistance against Ammonia / Salt corrosion (TÜV-Cert.)
3. No module grounding, no inverter restrictions
4. **High shadow resistance**
5. **Best low light behaviour**
6. **Good performance also for low angle irradiation**
7. **Light Soaking effect**
8. **Low temperature co-efficient**
9. Superior appearance

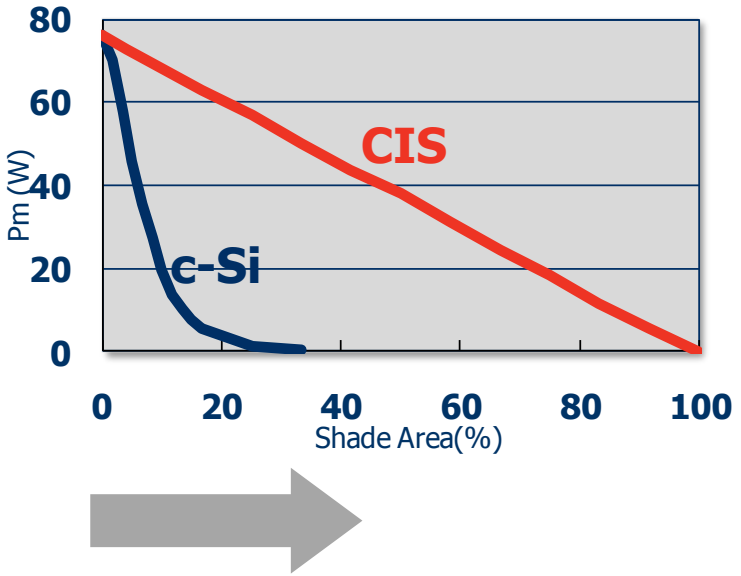
The PV Module best optimized for real life conditions

The highest output even under toughest conditions!

4. High Shadow Resistance

- **Under partially shaded conditions, the unique patterning of CIS modules, combined with optimal installation, keeps the drop of output to a minimum**



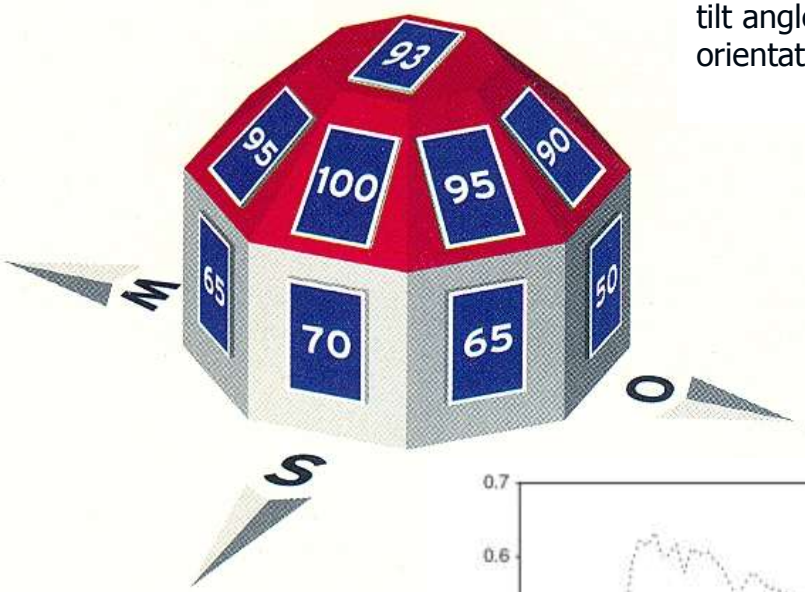


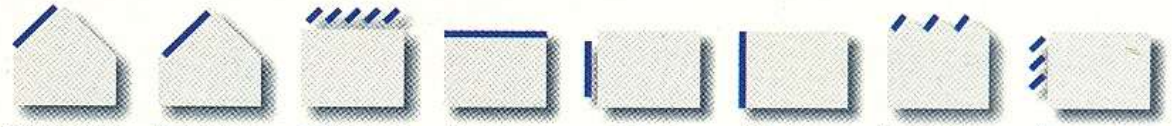
There is a partial loss of output but the overall effect is minimum

The module's output drops significantly under partial shadow

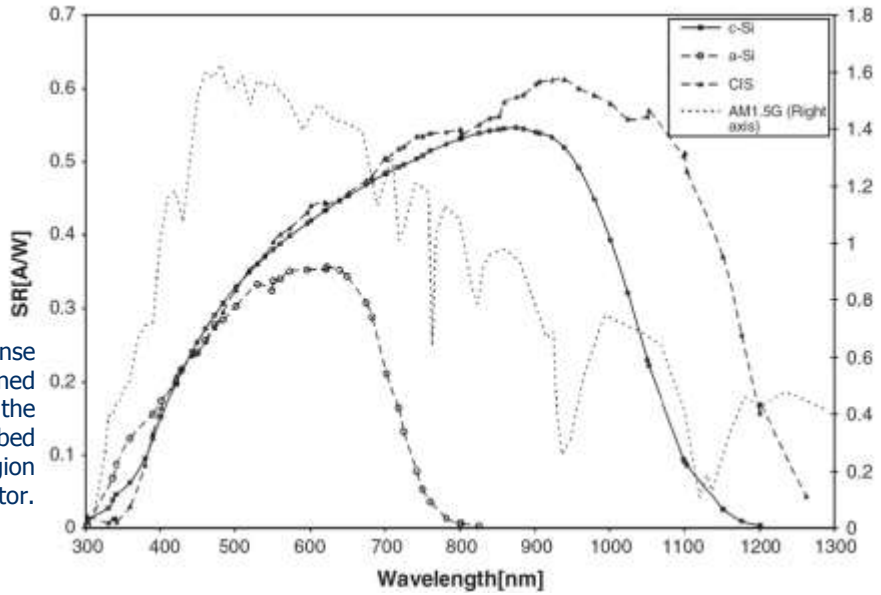
5. Best Low Light Behaviour
6. Low Angle Irradiation

Best energy yields are achieved with the PV system facing south and a tilt angle of 30% (values for Germany). Deviations from these orientation result in less power harvest.





Graphics: Solarpraxis AG



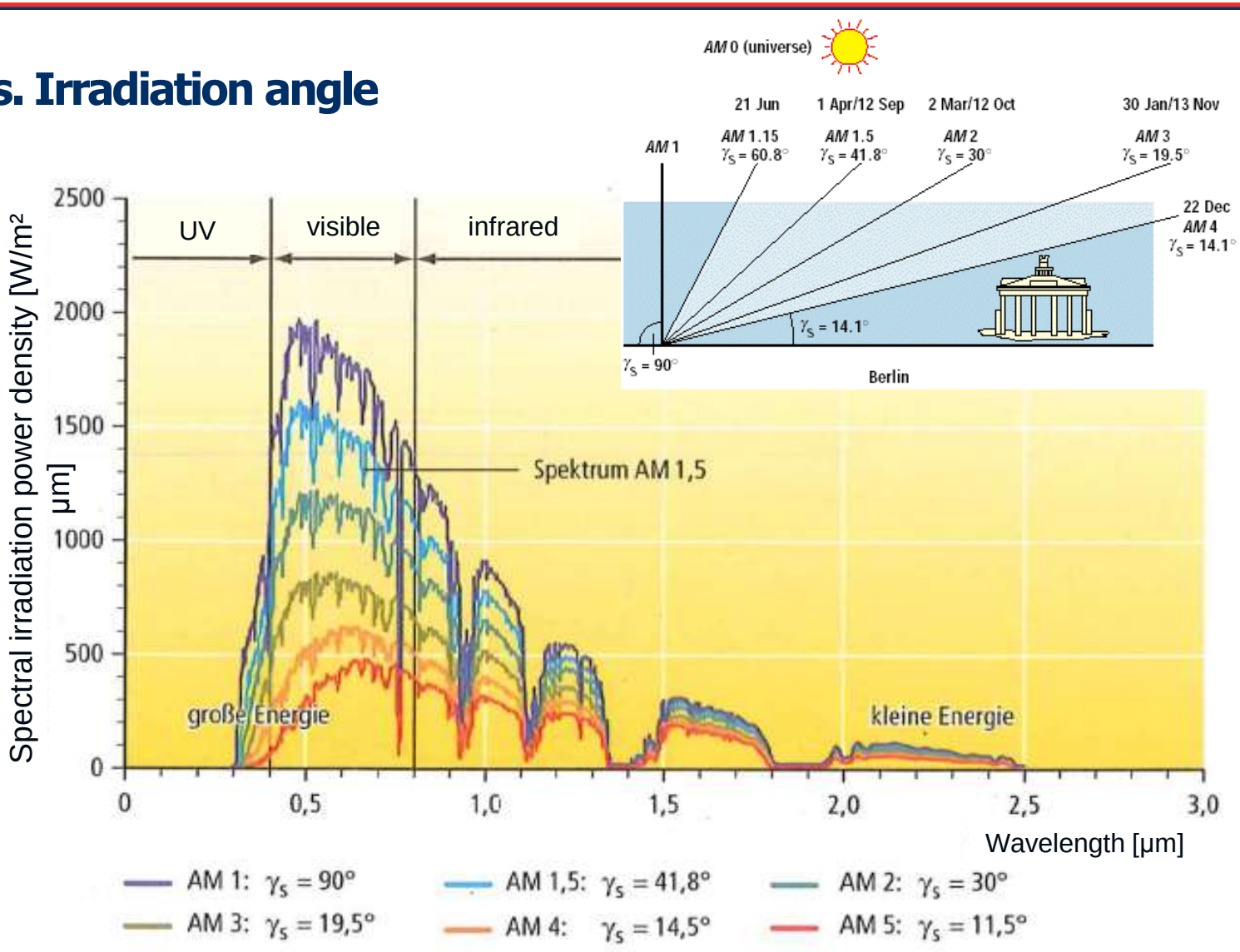
The Spectral Response (SR or QE) is governed by the ability of the photons to be absorbed in the Depletion Region of the detector.

Source: 23rd European Photovoltaic Solar Energy Conference, Valencia, Spain, 1–5 September 2008

5. Best Low Light Behaviour
6. Low Angle Irradiation

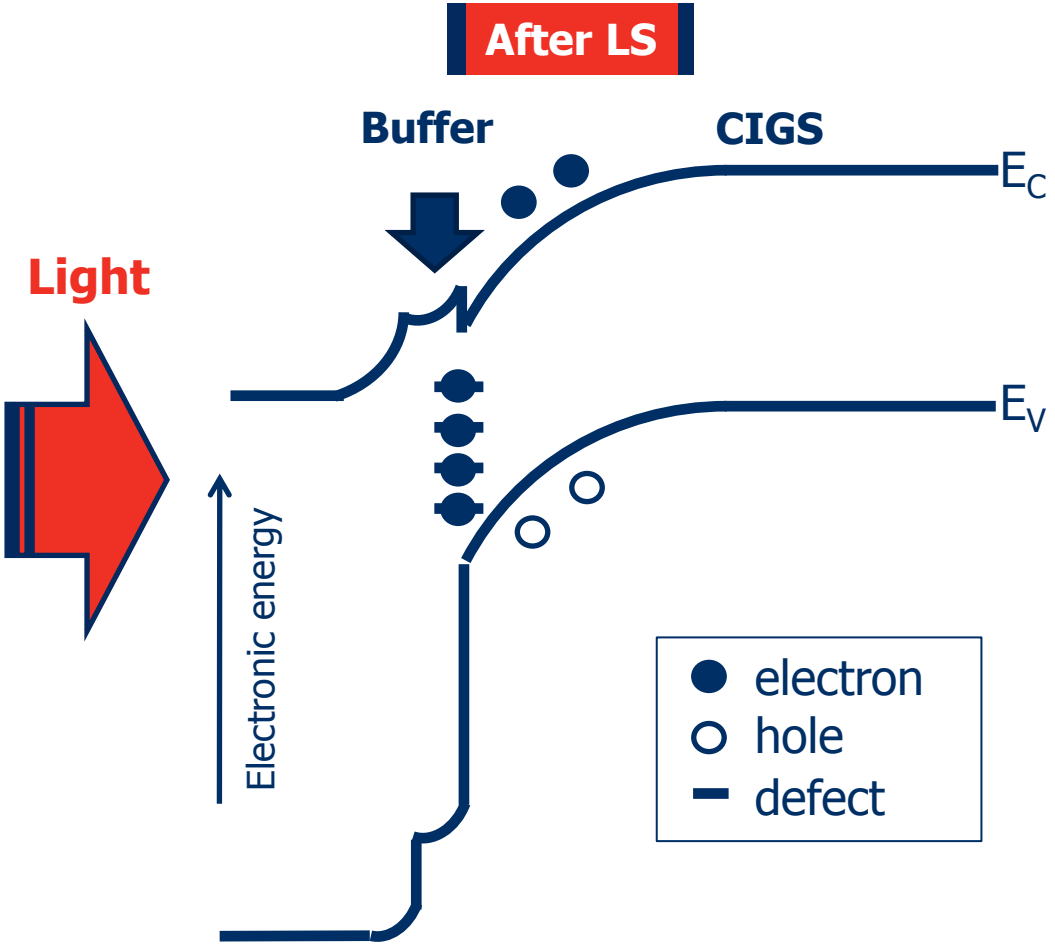
Sunlight spectrum vs. Irradiation angle

- **Big Airmass values**
- **Low irradiation angles**
- **Relative shift of spectral composition of sunlight to infrared (longer wavelengths)**
- **Matching of optimized CIS spectral response curve**
- **Better low light behaviour!**



Sunlight spectrum at different irradiation angles

7. Light Soaking Effect Model (Animation)



Light soaking effect Model

Light is absorbed in the cell

- **Electrons are trapped at defect**
- **Barrier height of buffer layer decreases**
- **Electrons become easy to flow**

Series resistance decrease

Improvement of power!

*Precise physical and chemical mechanism of the light soaking effect has not been identified yet. However, following illustration shows the most likely mechanism for the effect suggested by Dr. Lany and Dr. Zunger , *Journal of Applied Physcis*, **100**, 113725 (2006).

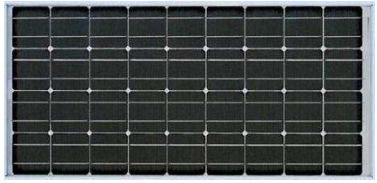
8. Low Temperature Co-efficient

Temperature-Coefficient Solar Frontier-CIS

Temperature Coefficient		
I_{SC}	0.00 (A/°C)	**0.01 (%/°C)**
V_{OC}	-0.34 (V/°C)	**-0.31(%/°C)**
P_{max}	-0.45 (W/°C)	**-0.30 (%/°C)**

Temperature-Coefficient c-Si (example)

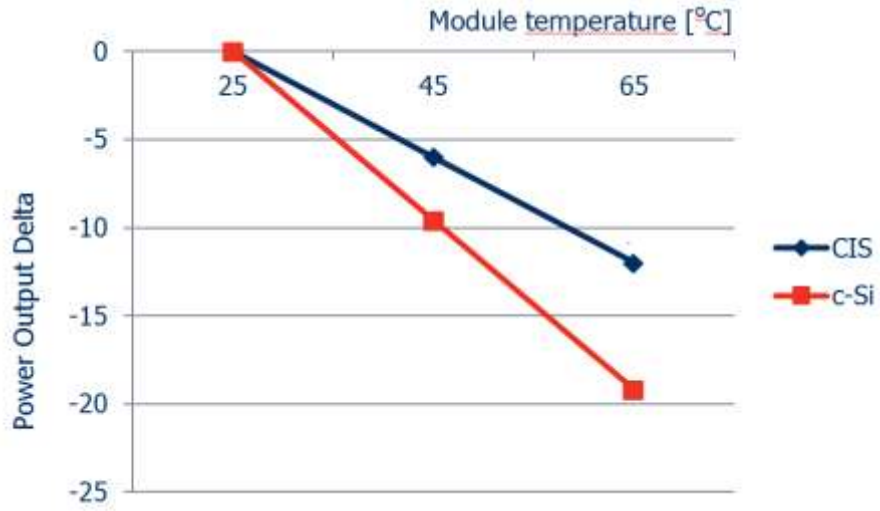
Temperature Coefficient		
I_{SC}		**0.034 (%/°C)**
V_{OC}		**-0.34(%/°C)**
P_{max}		**-0.48 (%/°C)**



This means:

Less power reduction in case of high module temperatures

Example: 65 °C module temp.:
SF-CIS module: -12%
c-Si-module: -19.2%
> Delta: 7,2%



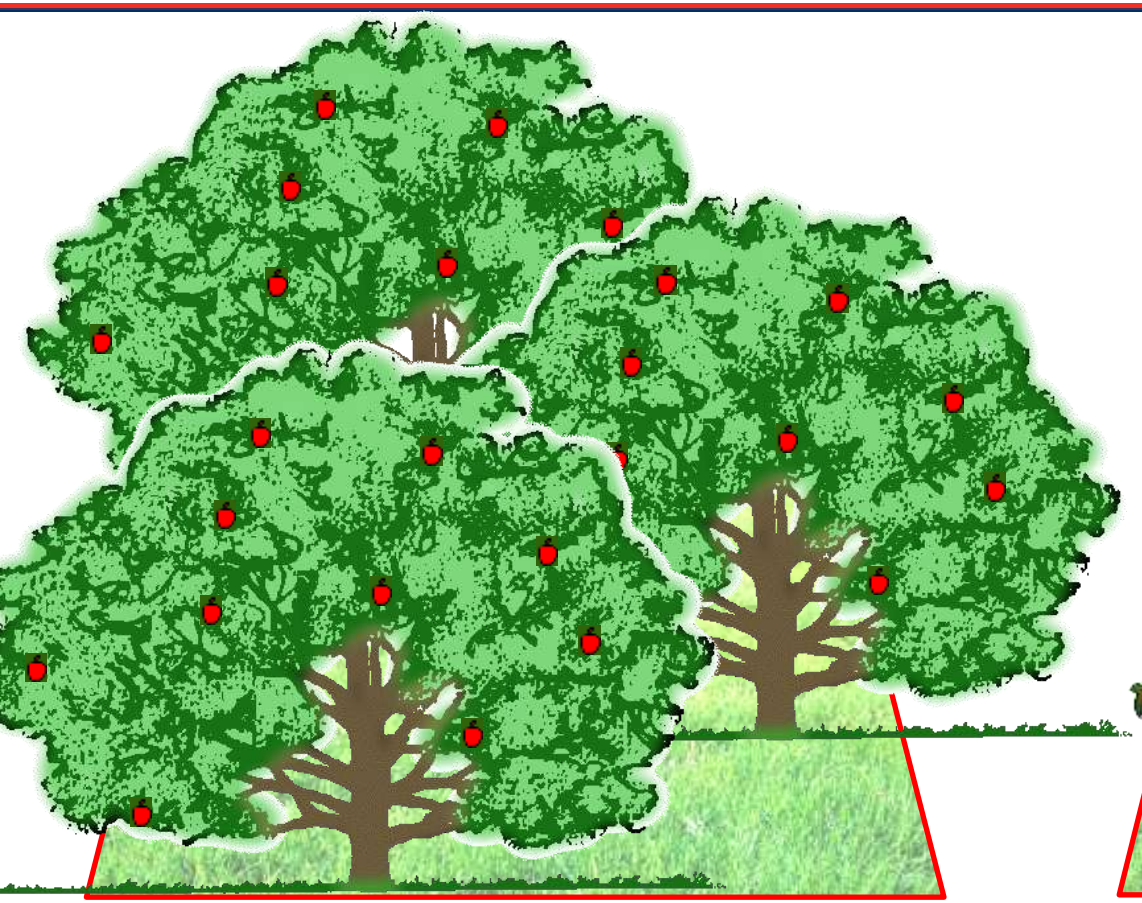
Technical Training Result

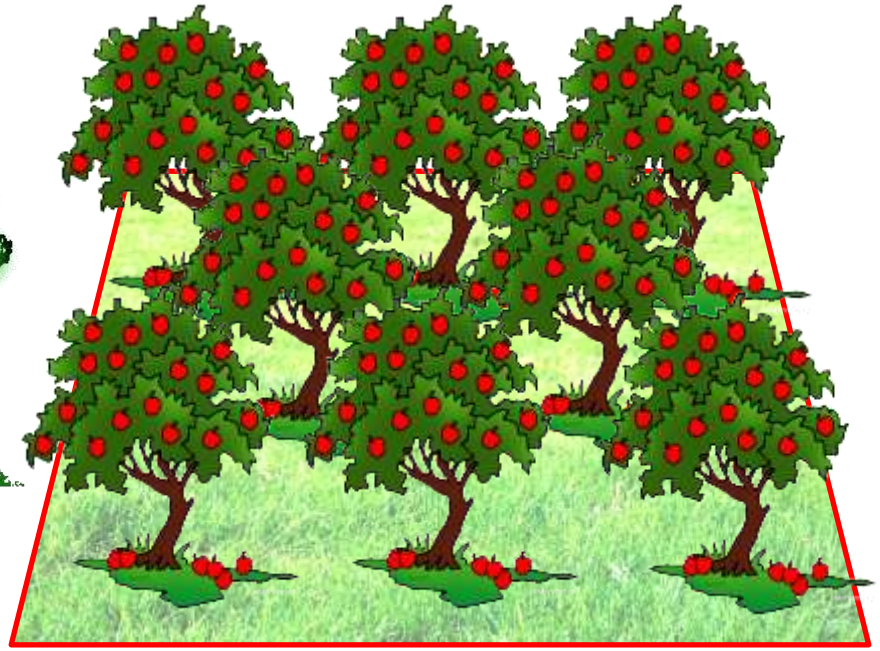
The customer knows
why our product is superior

BUT STILL NOT

Which advantages he achieves when utilising it!

What is the Real Value?



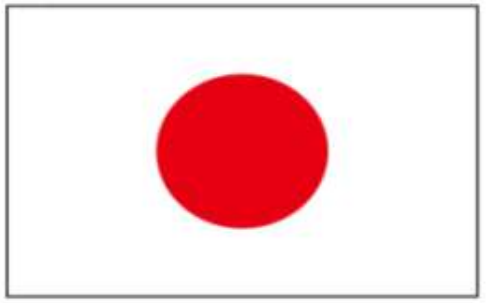


Powerful modules?

kWp ?

… or best harvest?

kWh/kWp & kWh/ha



Japanese Flagship Solar (PV) Power Plant Demonstration Project at Ouarzazate

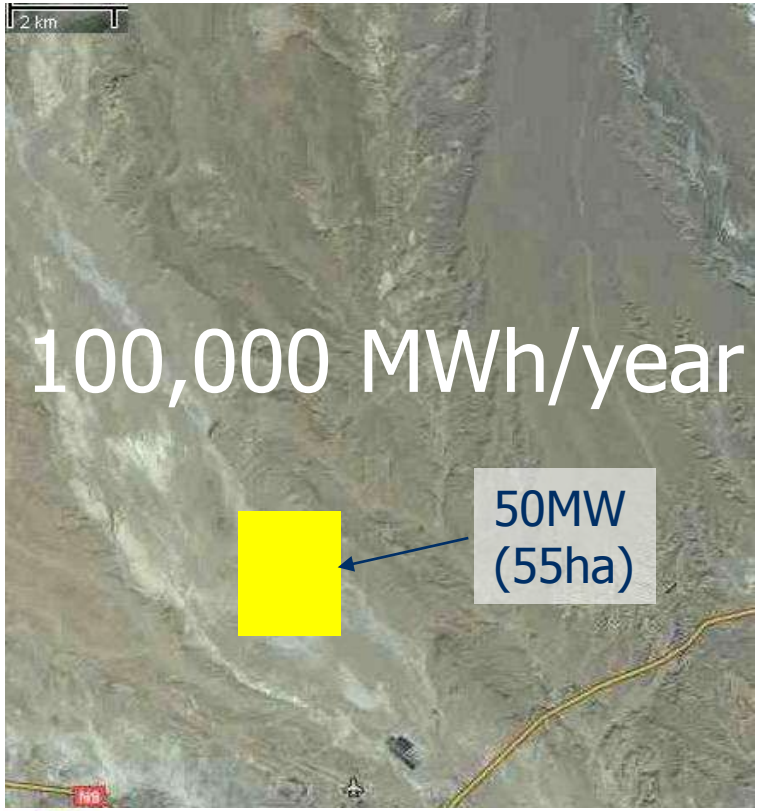
Photovoltaic Power WG

Japanese Business Alliance for Smart Energy – Worldwide

Japanese Business Alliance for Smart Energy Worldwide

50MW Solar Power Plant Project

- Footprint: Approximately 55 ha (2.7km X 2km) of land is required to build 50MW PV power plant.



Thank you for your Attention!

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