Corporate Presentation

Solar Frontier K.K.

Company & Product Presentation

September 2011

Corporate Profile

Group Structure

Parent Company

Downstream oil refining & marketing company

Showa Shell Sekiyu K.K.

Saudi Aramco	Royal Dutch Shell	General Shareholders
15%	35%	50%

Basic Data FY 2009 - US$

Listed in Tokyo Stock Exchange Class 1

Turnover: $21.6 B

Total Assets: $12.5 B

Market Cap: $ 3 B

※Currency: $1 =¥93.6

※Stock price = ¥756

100% Subsidiary for Solar Business

Solar Frontier K.K.
Capital: US$ 191M

100%

Solar Frontier Europe, GmbH

100%

Solar Frontier Americas Inc.

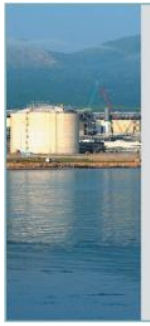
Showa Shell Sekiyu K.K.

Crude oil procurement and transport

Distribution

Refining

510,000bbl/day



Storage

Other manufacturing and blending

Oil Business

Main fuels sales business

- Sales of gasoline, gas oil, and automotive lubricants
- Sales of kerosene for home use
- Sales of fuels for industrial use

LP gas business

- Production and sales of Clean Propane used in homes and commercial stores
- Production and sales of Clean Auto for automobiles
- Production and sales of Clean Butane for industrial and consumer gas applications and as a raw material for chemical products
- Production and sales of Clean Mix, a mixture of propane and butane

Petrochemicals business (feedstocks)

- Production and sales of mixed xylene
- Production and sales of benzene
- Production and sales of propylene

Export and trading business

- Export of gas oil and other oil related products
- Cargo trade focusing on naphtha (this business has been leased to the Shell Group as of August 2007)

*The trading business is centered on overseas marine transactions.

Specialty products business (lubricants, bitumen, and international sales)

- Production and sales of lubricants and greases
- Production and sales of bitumen for road paving, compounds for civil engineering foundation work, and other road and construction material products
- Sales of fuel and lubricants for jets and tankers

Non-oil Business

CIS Solar Business
- Production and sales of CIS photovoltaic modules

Power Business
- Retail and wholesale of electric power

Other businesses
- Home security services
- House cleaning services

History

1970 — Arco Solar started research on PV

1978 — **Showa Shell started R&D work on PV**

1981 — Technical partnership with Arco Solar

1983 — Started c-Si production

1986 — Launched **Showa Arco Solar** JV with Arco Solar

1987 — Showa Shell & Kyocera co-founded JPEA (Japan Photovoltaic Energy Association)

1990 — Showa Arco Solar re-launched as **Showa Solar Energy**

1990 — Siemens Solar acquired Arco Solar

1992 — Installed PV for the first residential application

1993 — Started research on CIS funded by NEDO

1997 — ・Foundation of Shell Renewable
・Foundation of Shell Solar

2003 — Shell Solar acquired Siemens Solar

2004 — **Shell Solar Japan** established

2005 — Decision made on commercial production of CIS

2006 — **Showa Shell Solar** established

2006 — • Shell Solar sold crystalline PV business to SolarWorld
• Focus on CIS R&D, launched JV with Sant-Gobain

2007 — ・Commercial production in Miyazaki Plant 1

2008 — The JV, Avancis completed a 20MW CIS production facility
Shell sold share of Avancis to Saint-Gobain August 2009

2009 — Production at 2nd. plant started, Atsugi Research Centre opened Expanded capacity to 80MW/year

2010 — New Worldwide Name **Solar Frontier**

2011 — **Launching world's largest mass production plant TTL 1GW Scale**

R&D activities

crystalline-Si

amorphous-Si

CIS

1974, 1978 **Oil crisis**

Overseas (Shell)

Japan (Solar Frontier)

Mission

To create the most economical, ecological solar energy solutions on earth

Atsugi Research Center

R&D Strategy:
First Priority on Cost Reduction in Manufacturing.
- Higher Efficiency
- Simpler Product Structure
- Smaller Facility Footprint
- Higher Throughput
- Less Energy

R&D
Atsugi

Production
Miyazaki

Headquarters
Tokyo

CIS technology: R&D, Commercial Production

2011 The third plant has started commercial production

900MWp capacity

Land = 400,000 sqm
Bldg =190,000 sqm

2009 Atsugi Research Centre :
Next gen. production technology
Three key processes
Enlarged substrate size, higher throughput, higher efficiency

2009 Miyazaki Plant 2
60MW p.a. capacity
Land = 50,000 sqm
Building = 27,000 sqm
Capex = USD 150M
(JPY 15 Billion)

2007 Miyazaki Plant 1
20MW p.a. capacity
Land = 25,000 sqm
Bldg = 6,000 sqm
Capex = USD 50M

Laboratory - key technology development
world record of 16.03% efficiency was achieved.

MP3 – Electrical Parameter

Size:: 1,257 mm x 977 mm x 35 mm

Weight: 20 kg

Cmax Load: 2400 Pa

STC conditions: (25°C / AM 1,5 / 1.000 W/m²)		SF 140	SF145	SF150	SF155	SF160	SF165
P Pmax	W	140	145	150	155	160	165
Tollerance (on Pmax)		+10%/-5%					
Efficieency		11,4%	11,8%	12,2%	12,6%	13,0%	13,4%
Open circuit tension Voc	V	109	110	110	108	109	110
Short circuit current Isc	A	2,1	2,1	2,1	2,2	2,25	2,25
Vmpp	V	77	78	79	80	81	82
Impp	A	1,82	1,86	1,9	1,95	1,98	2,02
a Vsys	V DC	1.000					
Max reverse current Ir	A	7					
Parameters vs T							
α(Isc)	%/K	+0,01					
β(Voc)	%/K	-0,3					
δ(Pmax)	%/K	**-0,31**					

SF160/165: preliminary data

Quality and Safety（Certifications）

Quality	JET www.jet.or.jp	**IEC61646** ✓
	TÜV	**IEC61646** ✓
Safety	⧈	**Safety Class II** ✓
	CE	**IEC61646 + Safety Class Ⅱ** ✓
Quality + Safety	c UL us LISTED CEC Listed	**USA/CANADA** ✓
	JET www.jet.or.jp	**IEC61730** ✓

SOLAR FRONTIER

What is CIS?

Why CIS?

Road Map

What is CIS?

Cu: Copper

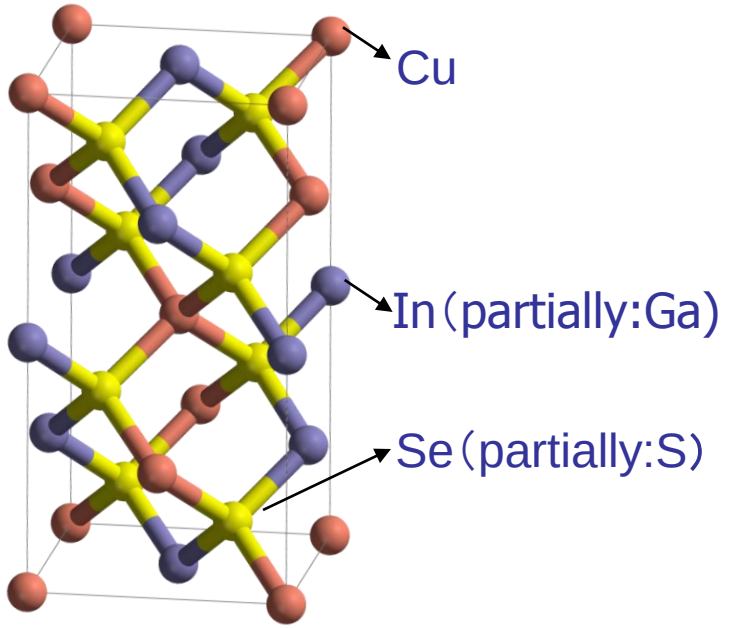
In: Indium

Se: Selenium

A thin-film "compound-semiconductor PV"

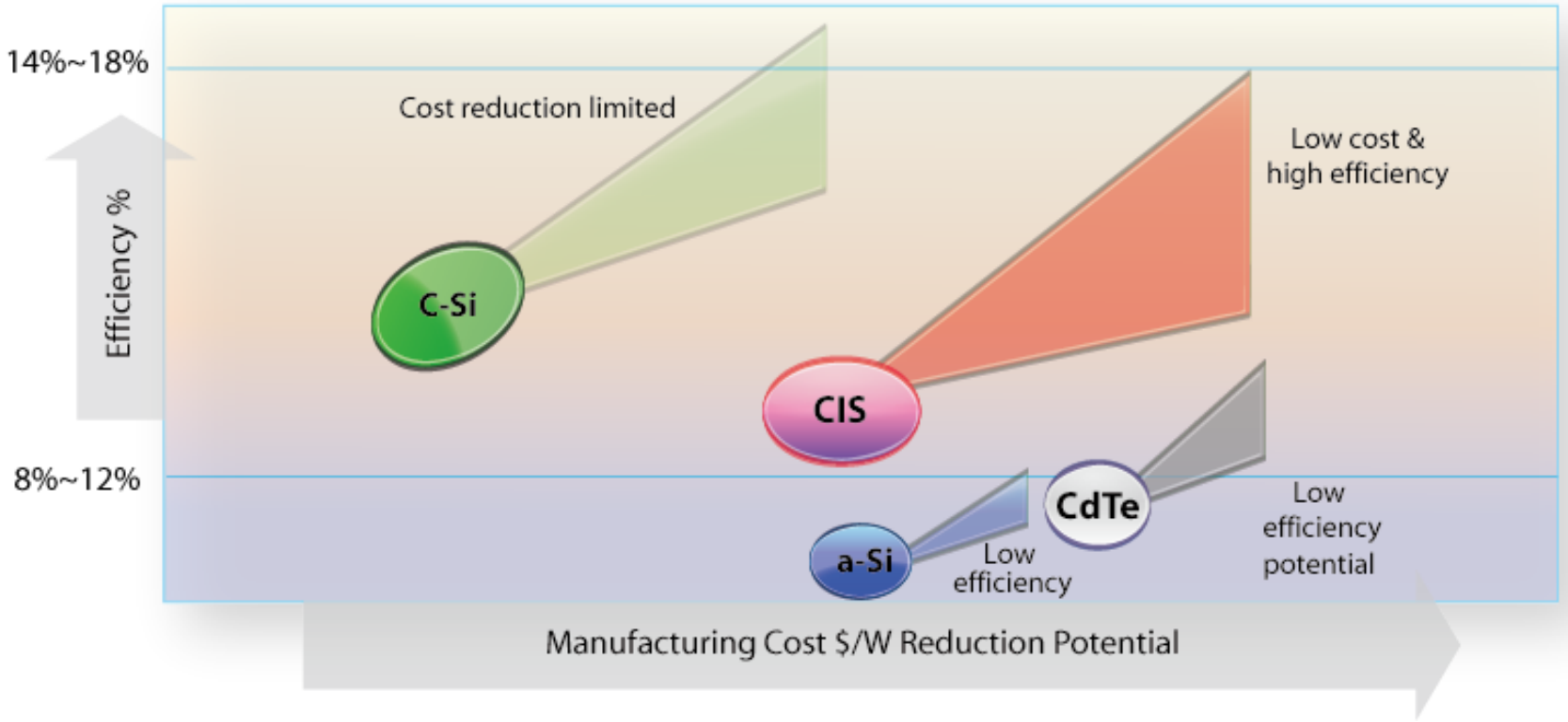
consisting of Three Major Elements

Crystal structure of CIS
(Chalcopyrite structure)



Sometimes called “CIGS” since portions of *In* are replaced by *Ga*

Potential of Efficiency Improvement & Cost Reduction



CIS

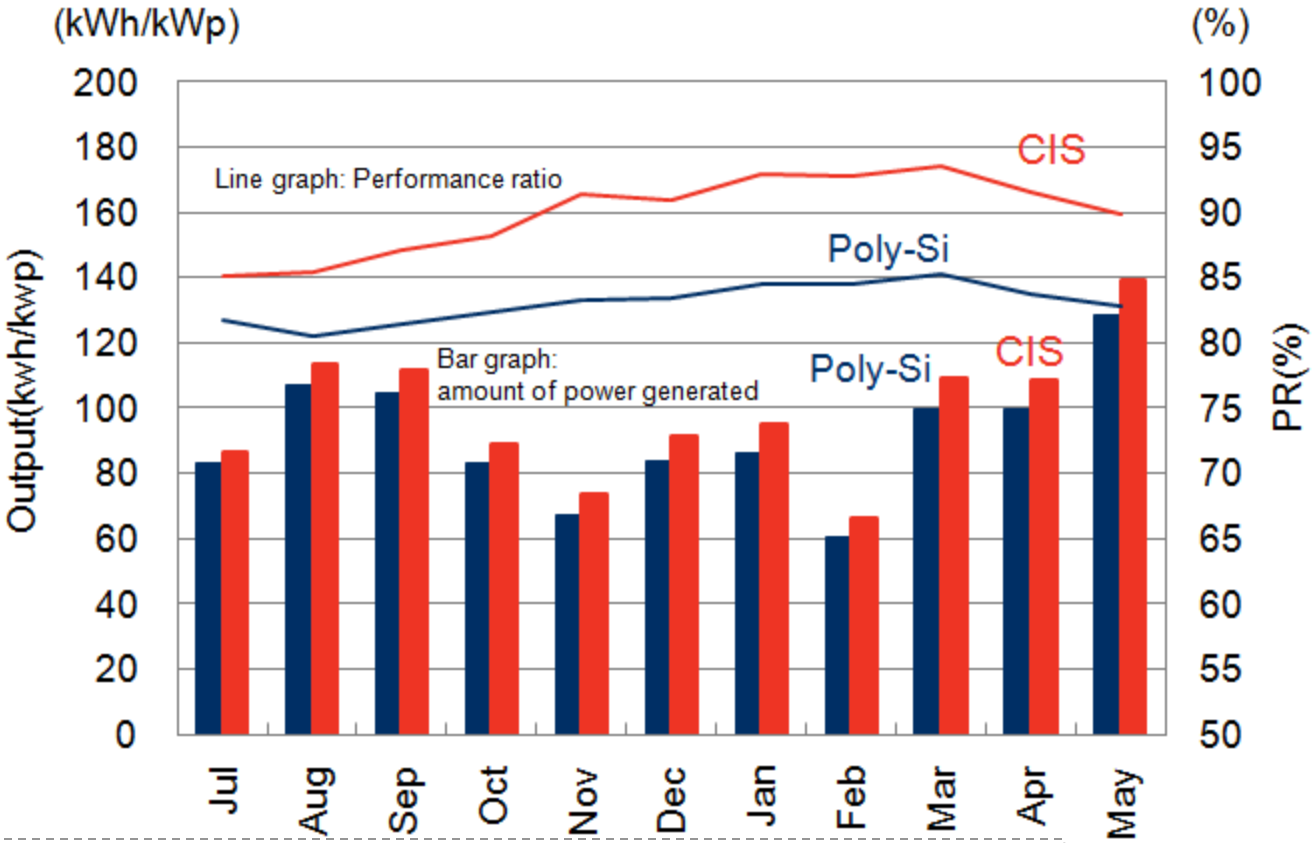
Most Economical System

Electric Power Comparison of CIS and p-Si

Data taken from our research center in Japan

1/7/2009~31/5/2010

CIS: 2.25 kW System
Poly-Si: 4.20 kW System
20°(South East) Tilt:20°
Inverter Eff.94.5%



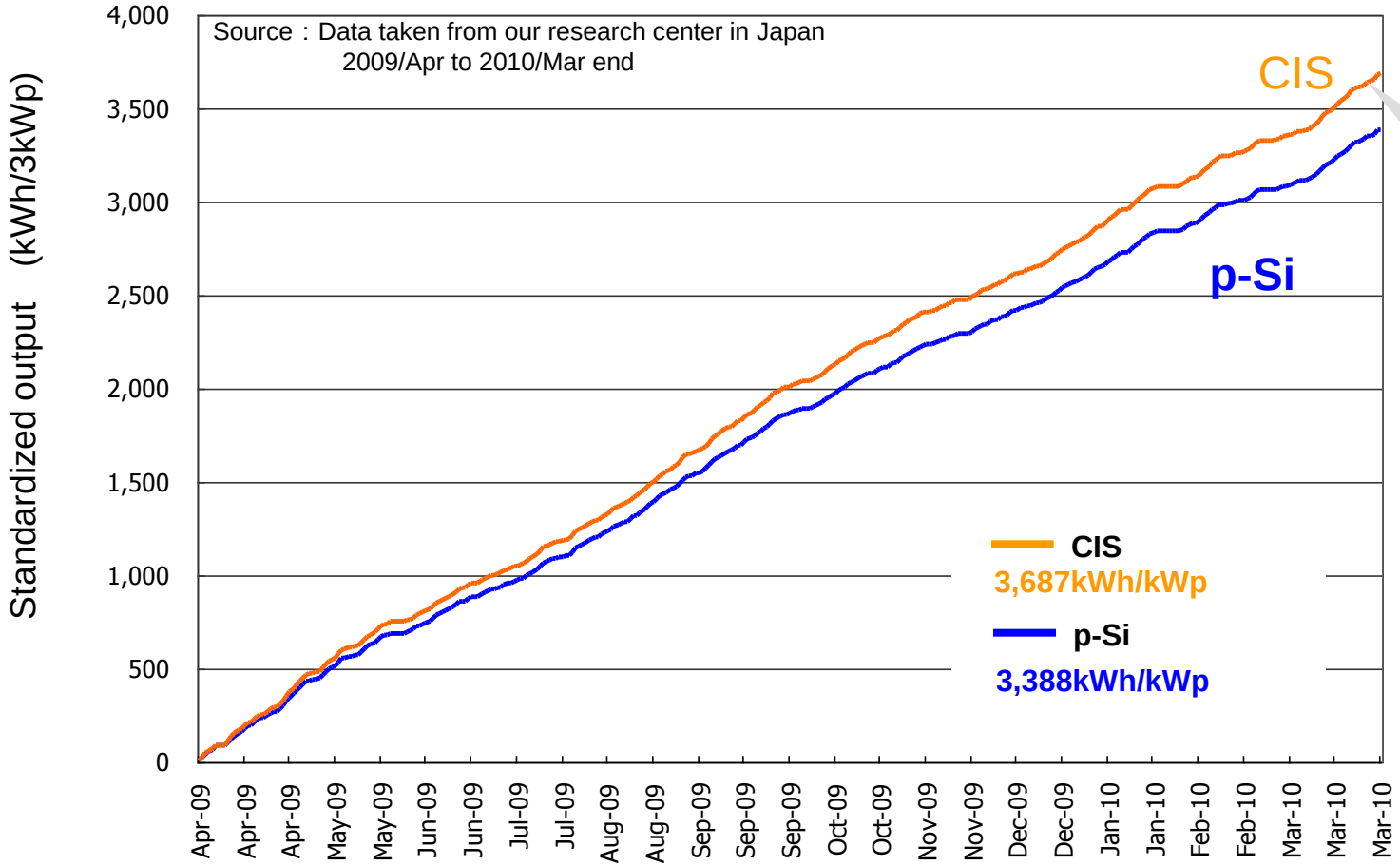
NOTE: Performance ratio PR (%)
Performance ratio means "the relationship between actual yield and target yield"

$$\frac{\text{Actual output (AC) from installed capacity (kWh)}}{\text{Installed Capacity (kW)} \times \dfrac{\text{Actual Radiation (kWh/m}^2\text{)}}{\text{1 sun (1kW/m}^2\text{)}}}$$

RAC10-0032_05

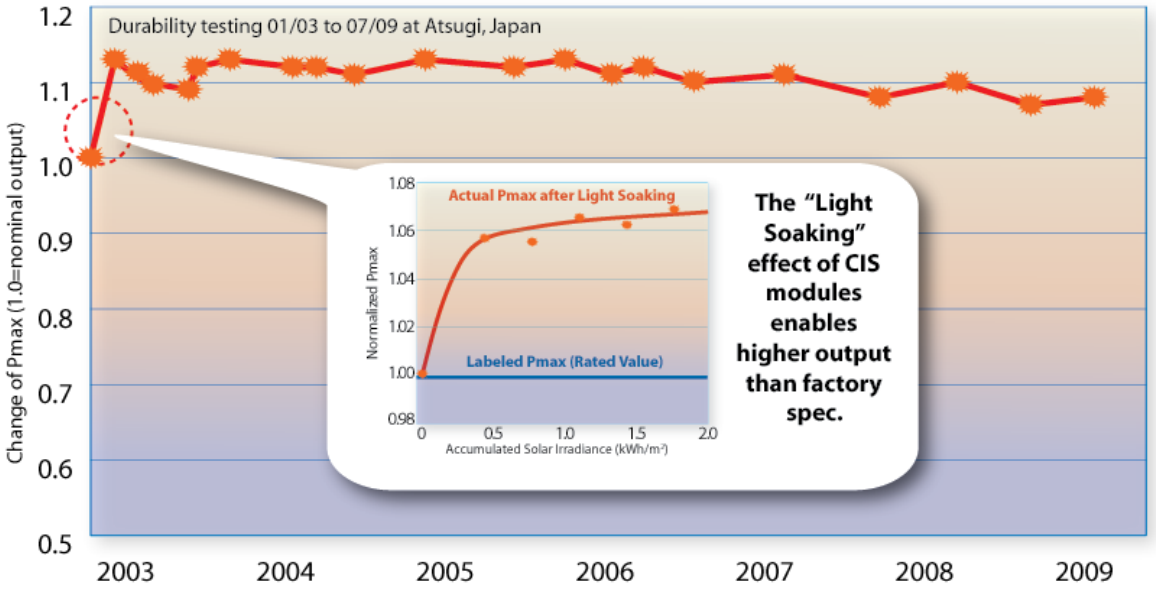
CIS- More Output from Installed Capacity

Comparison of Standardized Output



CIS generated almost 300kWh more electricity per 3kW capacity in a year. (8.8% more)

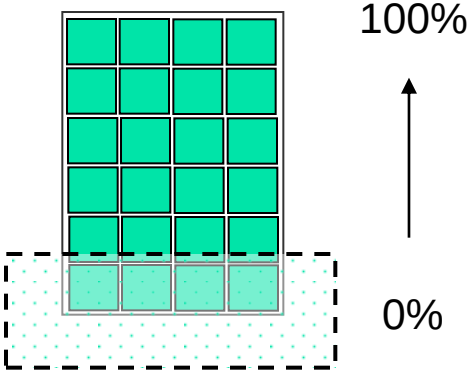
“Light Soaking” & Degradation



- **CIS Pmax consistently improves after light soaking**
- **Higher performance than rated value can be expected after installation**
- **Decrease in Pmax: 0.5 %/Year (10% in 20 years)**
- **No decrease in nominal capacity during this time.**
- **Ref. c-Si : 0.5-2.7 %/Year (10-54% in 20 years), p-Si : 0.3-1.3 %/Year (6-26% in 20 years)**
  Manuel V. and Ignacio R. *Progress in Photovoltaics, 16, 419 (2008)*

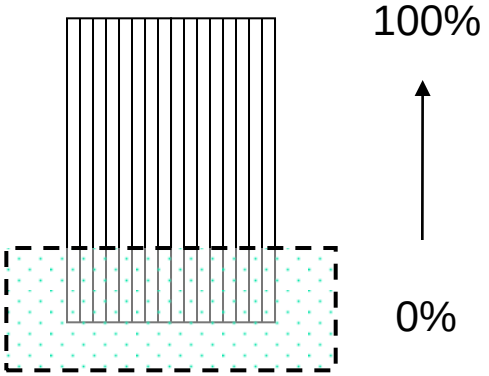
Shadowing

C-Si



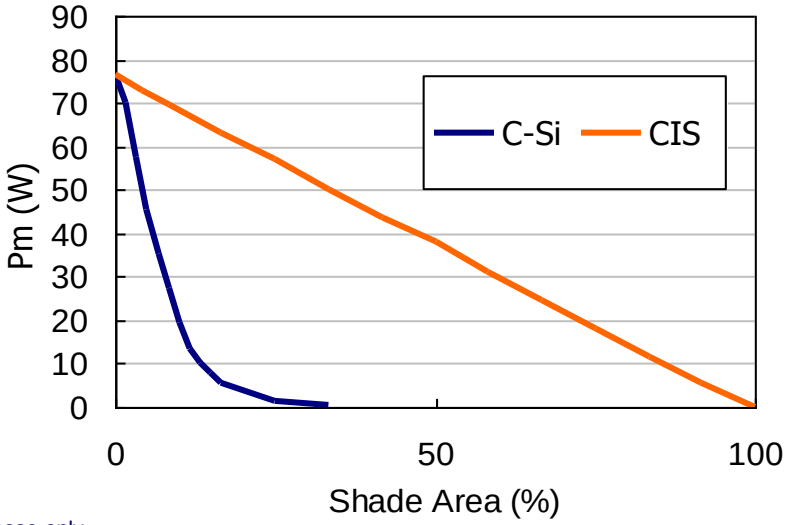
The module's output drops significantly under a partial shadow

CIS



There is only a partial loss but the overall effect is minimum

The unique patterning of CIS photovoltaic modules keeps the drop of output to minimum under partial shaded conditions

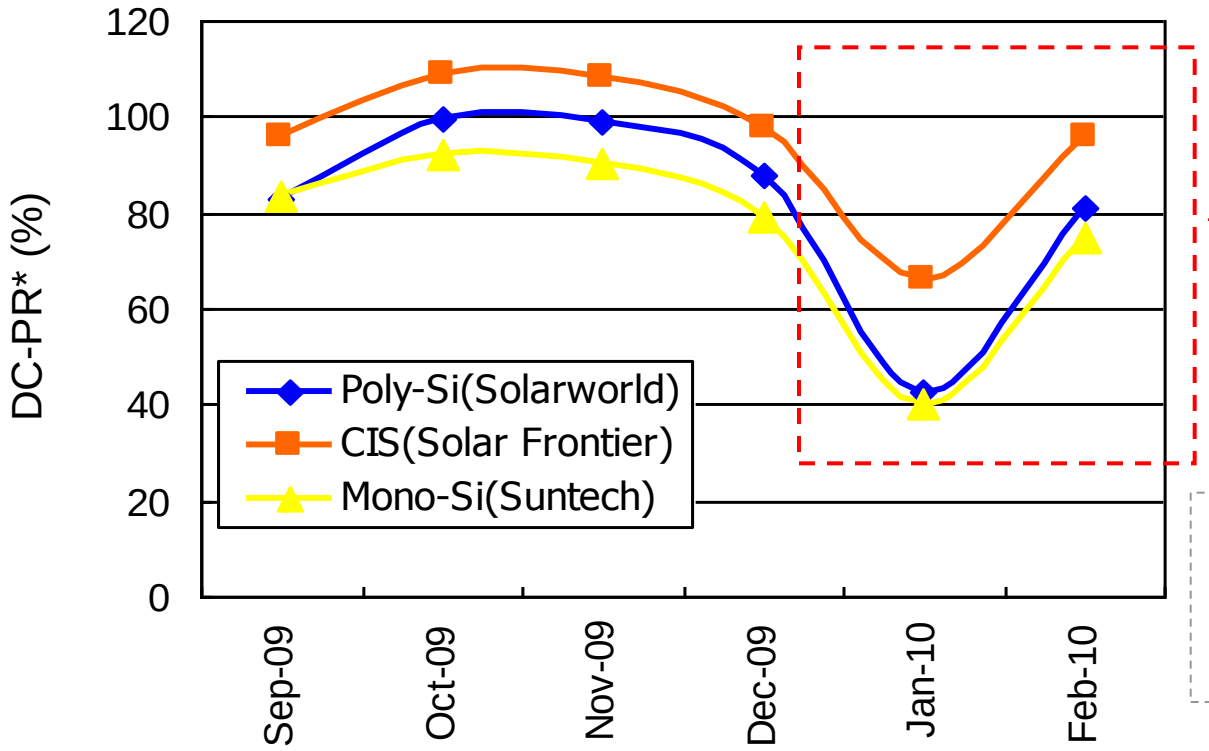


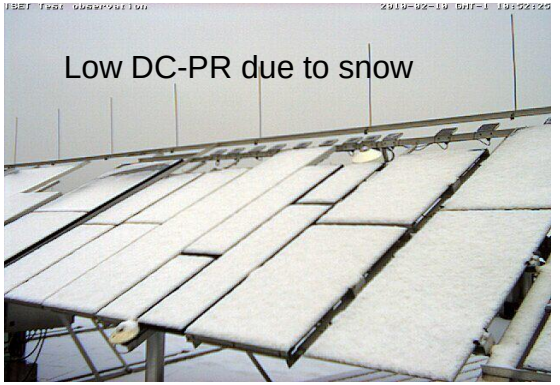
Leadership in Test Results

CIS has higher Performance Ratio due to two reasons.

1. Light soaking effect after installations.
2. More conservative labeling at the CIS factory.

(ex. Product classification is positive sorting. SF80-EX modules should have Pmax between 80.0-84.99W)





NOTE: Performance ratio PR (%)

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$$\frac{\text{Actual output from installed capacity (kWh)}}{\text{Installed Capacity (kW)} \times \frac{\text{Actual Radiation (kWh/m2)}}{\text{1 sun (1kW/m2)}}}$$

Modules : SW210-poly (Solarworld)、SC80-EX-A (Solar Frontier)、STP180S-24/Ac (Suntech)

(Source: ISET **I**nternational **S**olar **E**lectric **T**echnology field test data at Germany)

CIS Solar Frontier

Product Advantages

Product Benefits of SF CIS

- **"Light Soaking Effect"**
  - Increase of output power after stabilization under sunlight (intrinsic to CIS)
- **Low temperature coefficient**
  - Temperature coefficient of 0.31%/K* is about 30-50% lower than for crystalline

    *MP3 preliminary; 0.35%/K for MP1,2
- **Shadowing**
  - Linear relationship between shadowing and output power
- **Low-Light Behavior**
  - Reduction of efficiency only 3% (irradiance of 1000 W/m2 to 200 W/m2)*

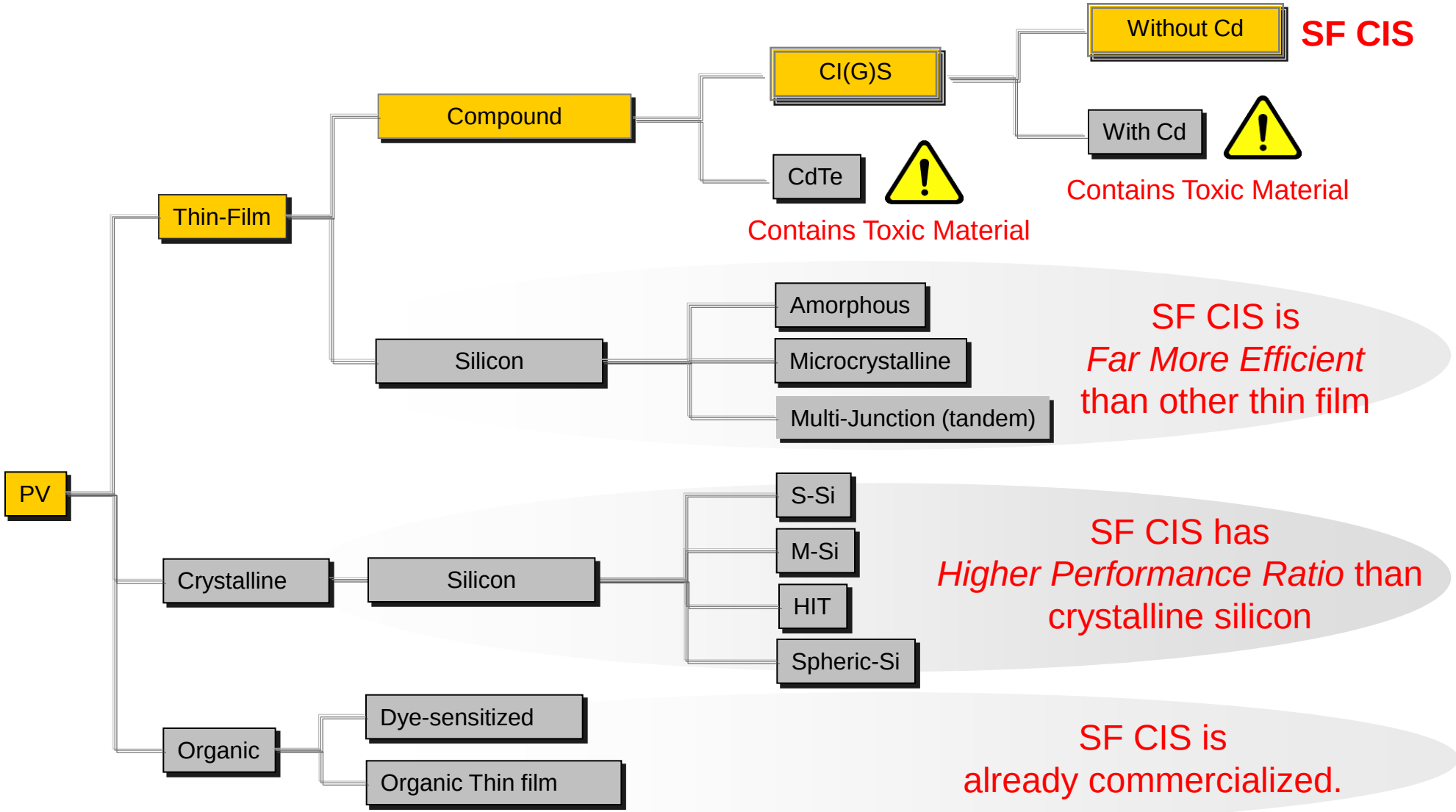
    *MP3 preliminary; 2% for MP1,2

Up to 10% extra kWh/kWp vs. c-Si

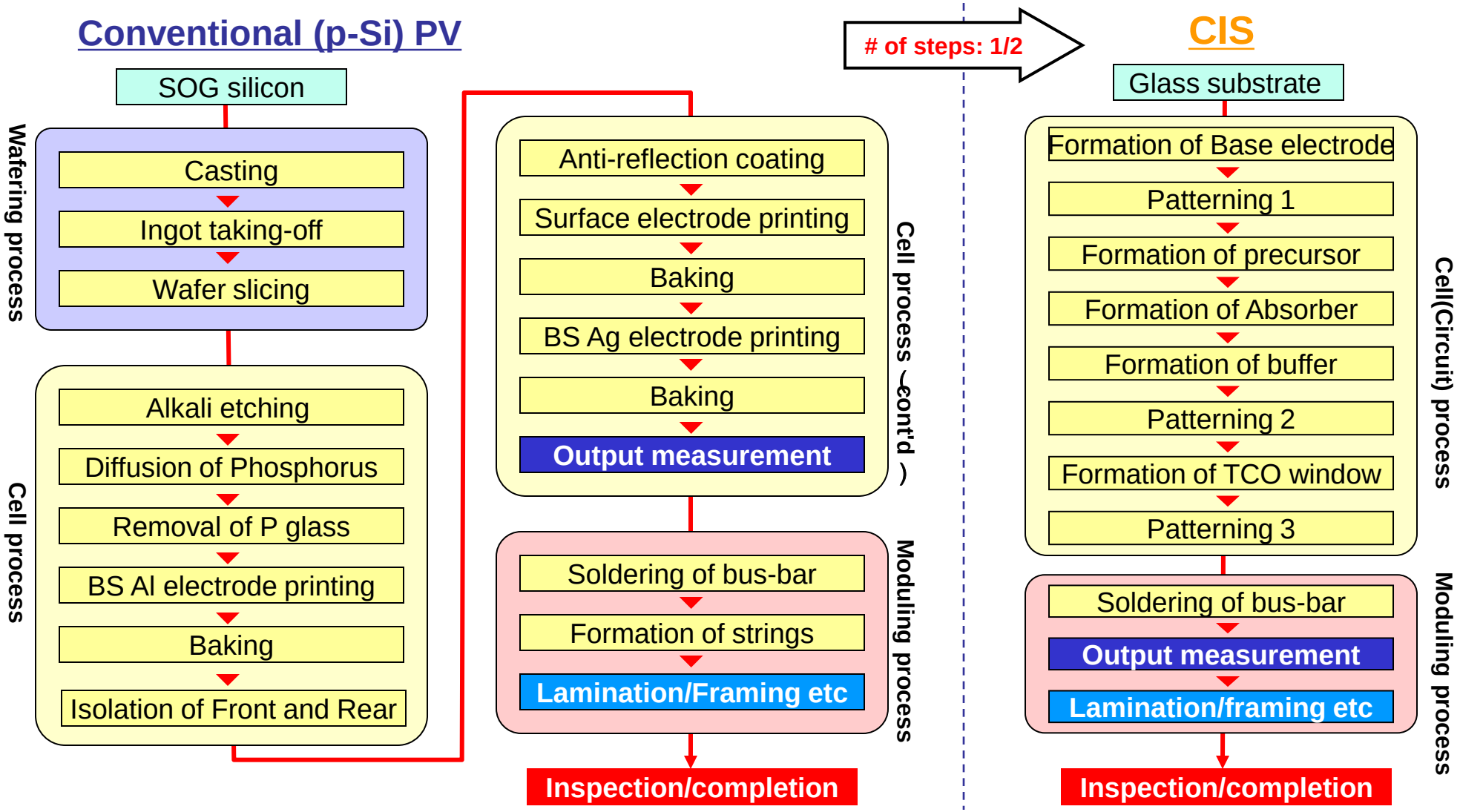
CIS

Most Ecological System

PV Categories and CIS Advantages

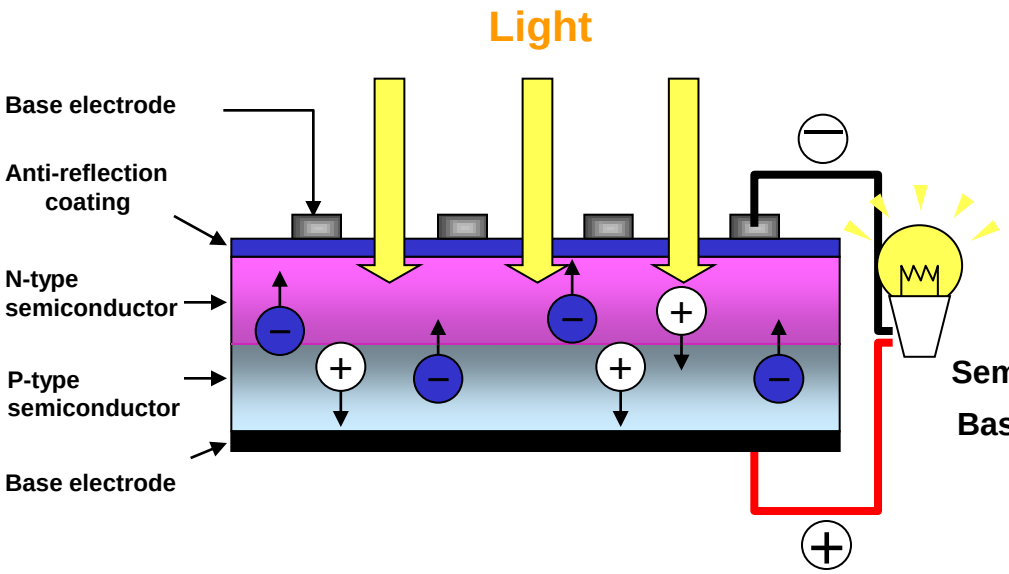


Comparison of Production Process



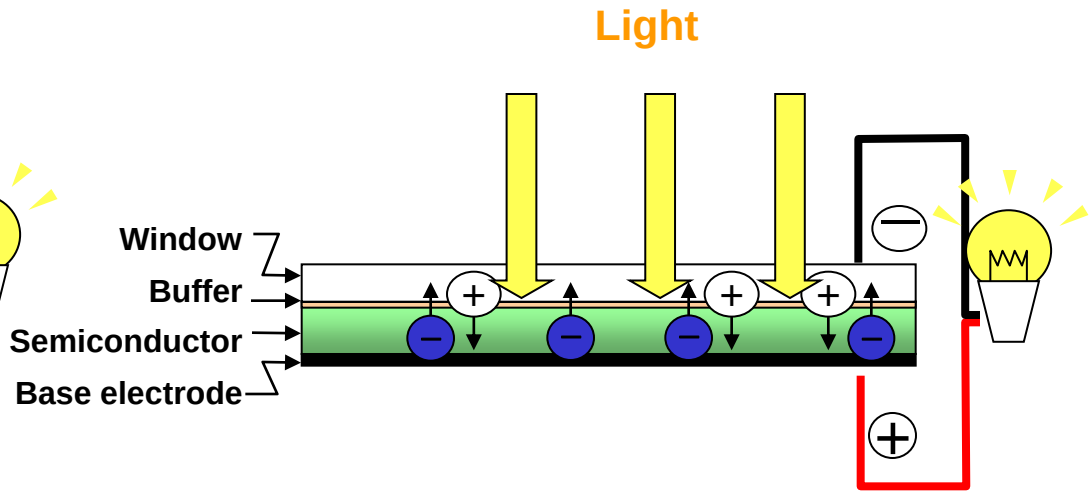
Shorter and “Green” Production Process

Crystalline-Si



Thickness 200～300μm

CIS



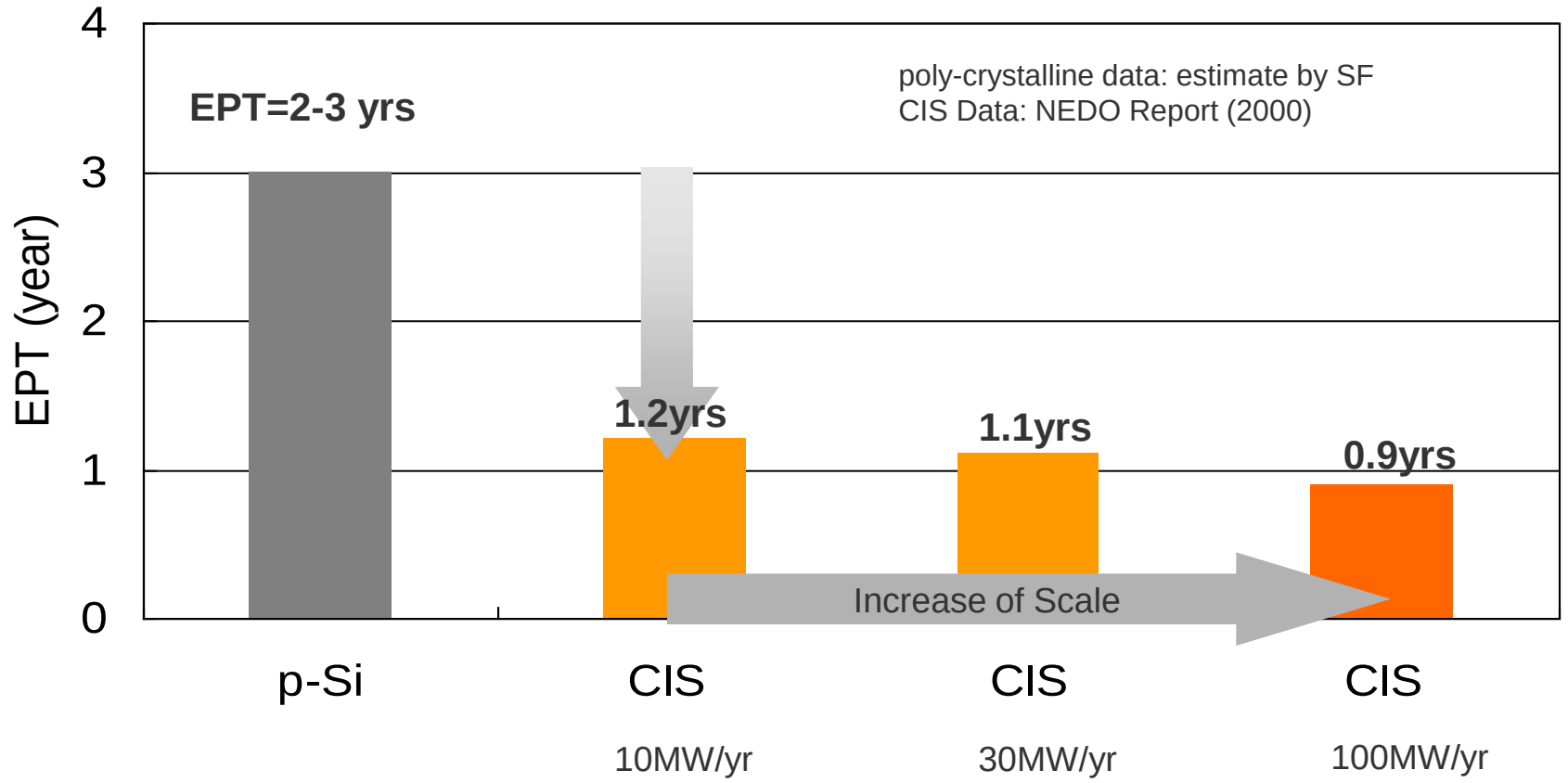
Thickness 2～3μm

1/100

Solar Frontier CIS technology enables large saving on resources and raw materials

Energy Payback Time of CIS and p-Si

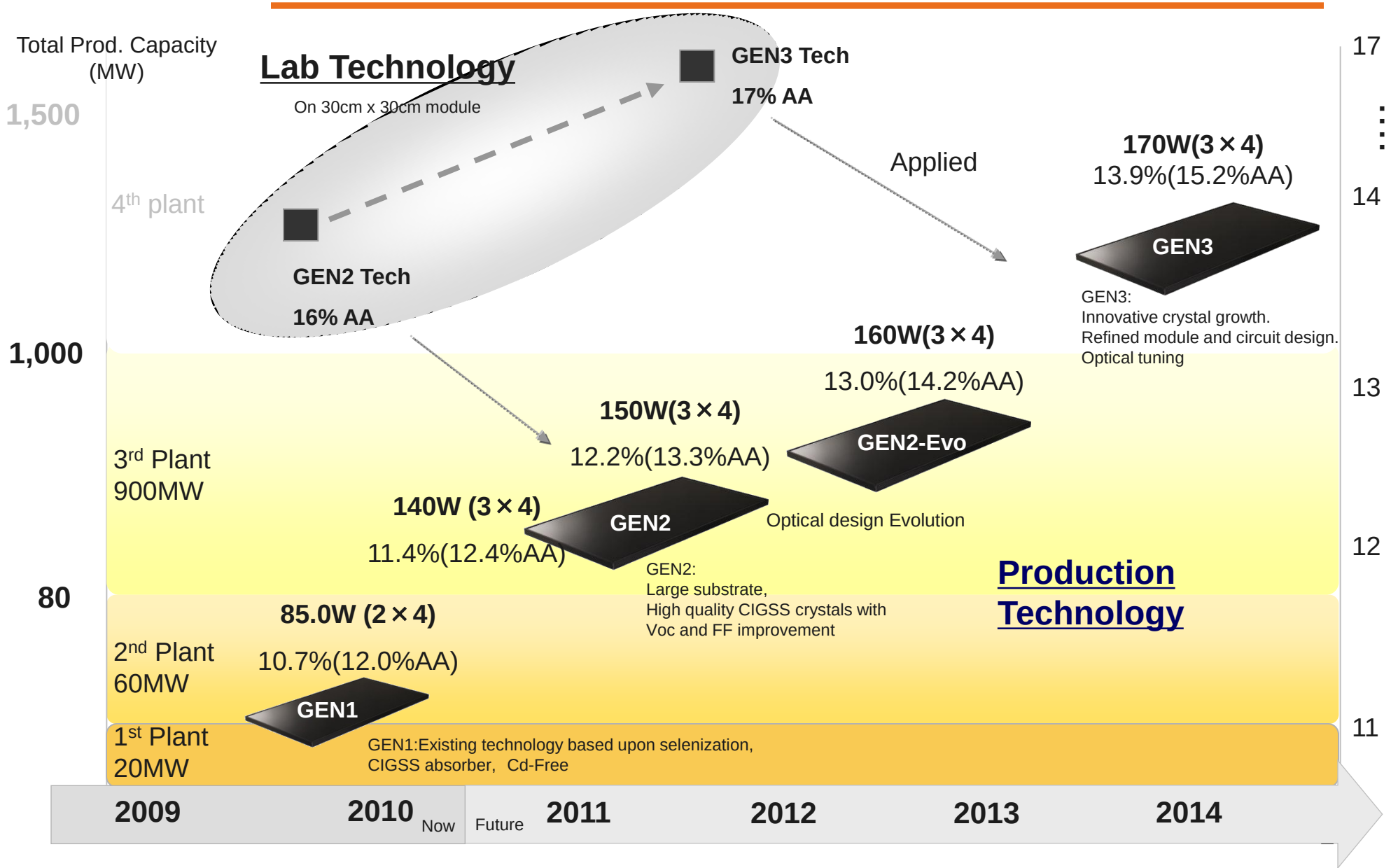
Energy payback time:
Period needed to delivery the equivalent energy consumed to produce PV modules.
The shorter the better for environment.



CIS

Roadmap

Product Development Roadmap



References

Roof-Top CIS-Systems

Ground-Mounted CIS-Systems

Solar Power Plants and Micro Grids

Completion: Apr. 2010

Size: 135 kWp

Location: Tokyo, Japan

Completion: Apr. 2010

Size: 10 kW

Location: Saudi Arabia

(Environmental test program for 10MW project in 2010)

Solar Power Plants

Completion: Sep. 2010

Size: 1.0 MWp

Location: Niigata, Japan

Completion: Sep. 2010

Size: 0.2 MWp (total: 1.2 MWp)

Location: Suria, Brunei

Large Scale Solar Power Plants

Completion: QI / 2011

Size: 10 MWp

Location: Dahran, Saudi Arabia

Completion: Feb. 2010

Size: 1.0 MWp (total: 10 MWp)

Location: Almeria, Spain

Own Solar Power Plants

Completion: early 2011

Size: 2.0 MWp

Location: MP3 Miyazaki, Japan

Completion: 2010

Size: 1.0 MWp

Location: MP2 Miyazaki, Japan

100 kWp – Modena – Marzo 2011

selected Rooftop Systems (1/2)

Residential Rooftop, Germany

Riding Hall Rooftop, Germany

Parking Lot Rooftop, (from above) Germany

Parking Lot Rooftop (from below), Germany

selected Rooftop Systems (2/2)

Commercial Rooftop, Japan

Commercial Rooftop, Japan

Residential Rooftop, Germany

Residential Rooftop, Germany

Power Plants and Microgrids

Power Plant, Germany

Megawatt Power Plant, Germany

Microgrid, Saudi Arabia

Megawatt Power Plant, Spain

Selected Reference Cases

MHH, Neudrossenfeld, Germany

Date onstream	May 2011
System Capacity	180kW
Panel type	130 W
Number of Panels	1,384
Panel tilt and orientation	diverse
Financing Bank	Sparkasse Kulmbach-Kronach

Belectric, Wildflecken, Germany

Date onstream	June 2011
System Capacity	0,55 MW
Panel type	130 W
Number of Panels	4,240
Panel tilt and orientation	20° , South 0°
Financing Bank	-

Mp-tec, Eberswalde, Germany

Date onstream	July 2011
System Capacity	5 MW
Panel type	130 W
Number of Panels	36,720
Panel tilt and orientation	-
Financing Bank	-

Baltic Solar, Scharbeutz, Germany

Date onstream	December 2010
Systemgröße	8.7kW
Panel type	87.5 W
Number of Panels	99
Panel tilt and orientation	45° , East 10°
Financing Bank	-

Selected Reference Cases

Almeria Megawatt Project, Spain

Date onstream	February 2010
System capacity	1 MW
Panel type	85 W
No. of panels	11,850
Panel angle & orientation	25° , South 0°
Estimated output	1,356,231 kWh/yr
Estimated CO_2 reduction	529 tonnes

Yukigunigata Megasolar, Niigata, Japan

Date onstream	September 2010
System capacity	1 MW
Panel type	80 W
No. of panels	12,528
Panel angle & orientation	20° & 30, South 0°
Output Sep.-Nov. 2010	376,586 kWh
CO_2 reduction	169 tonnes

Miyazaki Solar Park, Miyazaki, Japan

Date onstream	October 2010
System capacity	1MW
Panel type	85 W, 80 W, 75 W
No. of panels	12,584
Panel angle & orientation	Various
Estimated output	1,280,000 kWh/yr
Estimated CO_2 reduction	576 tonnes

Miyazaki Solar Way, Miyazaki, Japan

Date onstream	March 2011
System capacity	1 MW
Panel type	80 W
No. of panels	12,528
Panel angle & orientation	10° , South 15°
Estimated output	1,349,000 kWh/yr
Estimated CO_2 reduction	415 tonnes