Solar Frontier K.K. Corporate Presentation

September 2019

ソーラーフロンティア株式会社

1. Company Profile

Disclaimer:

The data presented in this document is the proprietary information of Solar Frontier K.K. and is intended for discussion purposes only.
Solar Frontier does not intend to warrant any data in this presentation document.

Our Vision:

Harnessing the power of the sun to provide a cleaner, more comfortable lifestyle for everyone

太陽による快適でクリーンな暮らしをすべての人に

Solar Frontier Company Overview

Solar Frontier is a leading CIS thin-film solar energy company in terms of production, sales and technology. Envisioning solar for all, we manufacture CIS thin-film modules as provide system solutions worldwide.

Established in 2006 as a subsidiary of Showa Shell Sekiyu K.K., Solar Frontier has played a core role in the group's Energy Solutions Business segment. In the wake of Showa Shell's integration with Idemitsu Kosan Co.,Ltd（TSE 1st:5019）in April 2019, Solar Frontier's operations are now strategically placed in the new company's Power and Renewable Energy Business segment.

Solar Frontier Company Overview

Shareholder:	Idemitsu Kosan Co.,Ltd (100%)
Employees:	1,100

Idemitsu Kosan Company Overview

Stock Exchange:	TSE 1st : 5019
Capital Stock:	JPY 168 billion
Financial Ratings:	A (R&I), A (JCR)
Employees:	13,000

As of April , 2019

Introduction of Solar Frontier

Technology

Value creation through CIS technology

- Improved conversion ratios
- Strengthened system competitiveness
- New product development
- Long history of R&D dating back to 1970s

Production

Sophisticated production and quality control

- Enhanced cost competitiveness
- 100% made in Japan
- Full commitment to quality control
- World-leading CIS thin-film production capacity

Solutions

Added value and solutions

- Integrated system sales
- After-sales maintenance
- Solutions development
- Business partnerships with major house builders

We Build on a Legacy of 40+ Years in Solar PV

Following the oil crises of the 1970s, our parent company began R&D in multiple PV technologies. We soon converted to CIS for its economical and environmental advantages.

SOLAR FRONTIER

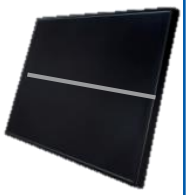
The Evolution of CIS Technology

2007

2009

2011

2016



2017

The Growth of Our Company

1970s
Began R&D in multiple solar technologies

1993
Committed to CIS

2006
Founded company (then called Showa Shell Solar)

2007
Commenced production in Japan

2009
Established state-of-the-art R&D facility

2011
Started Kunitomi Plant – the largest CIS factory worldwide

2016
Started Tohoku Plant

2017
Launched the PV system package SmaCIS (available only in Japan)

2018
Surpassed 5 GW in global shipments

We Are Led by Energy and Solar PV Pioneers

Solar Frontier's leaders bring together decades of experience in solar and energy innovation.

" We will continue to expand our leadership in the solar energy industry by advancing our proprietary CIS technology and implementing integrated, value-added solutions. "

Hiroshi WATANABE
Representative Director, CEO

Director
Executive Officer

Corporate Planning

Shigeto TSURU

Executive Officer

Manufacturing, R&D

Kazuki KAKEGAWA

Executive Officer

Sales, Marketing, Logistics

Hideki GAKUMAZAWA

2. Our Three Strategic Pillars of Value Creation

What It Takes to Win – Three Strategic Pillars of Value Creation

Solar Frontier is advancing solar energy worldwide on three strategic pillars of value creation:

Technology

Innovating in R&D:

- Increasing efficiency
- Reducing system cost
- Creating new products

Production

Challenging the limits of production:

- Cost Reduction
- Flexible production to meet demand
- Made-in-Japan quality

Solutions

Professional solutions:

- Residential
- Commercial
- Utility-scale

R&D to Achieve Our Strategic Goals

R&D is core to driving forward our leading status in technology, our scale and our solutions

Atsugi Research Center

Location: Kanagawa, Japan

Established: 2,009

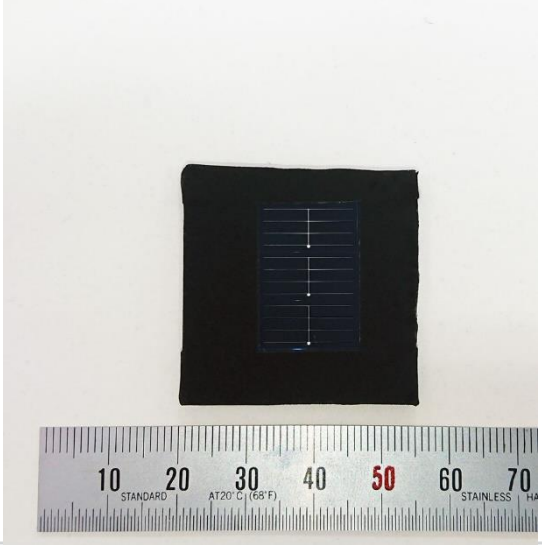
Mission:

1. Advance CIS module efficiency
2. Drive down total system cost
3. Create new products to open new markets
4. Develop proprietary mass production lines

World Record Thin-Film Solar Cell Efficiency of 23.35%

The technological development team that achieved the world record for conversion efficiency

Solar Frontier K.K. has set a new world record for thin-film solar cell efficiency. In joint research with the National Research and Development Agency's New Energy and Industrial Technology Development Organization (NEDO) of Japan, Solar Frontier achieved 23.35% conversion efficiency on a 1cm² cell using cadmium (Cd)-free CIS technology. The result was independently verified by the National Institute of Advanced Industrial Science and Technology (AIST) in November 2,018.

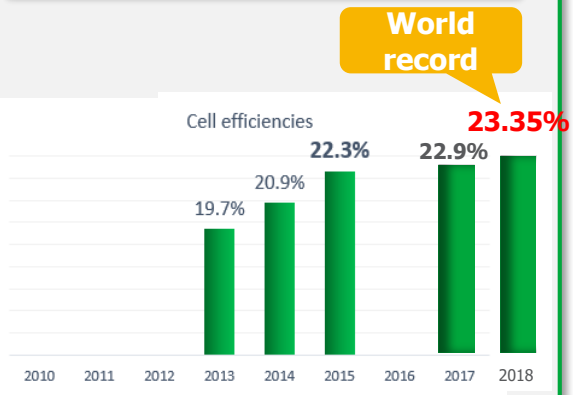


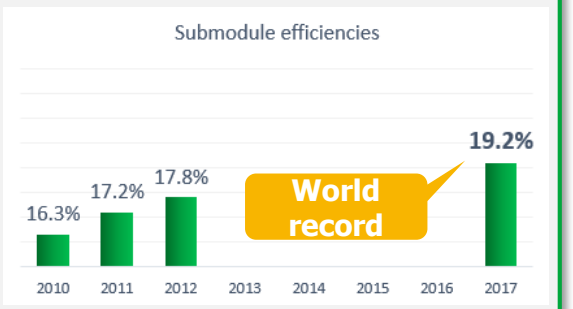
World record-setting Cd-free CIS thin-film solar cell (approx. 1cm²) with 23.35% conversion efficiency

Game-Changing Innovations

Solar Frontier continues to push the boundaries of CIS in new and unexplored directions:

Efficiency





Commercial Products

2013:

Lightweight module commercially introduced

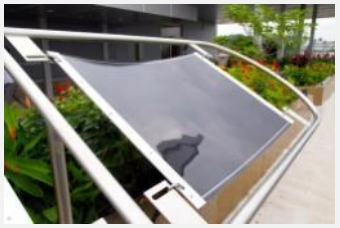
2017:

Rooftop PV system package SmaCIS introduced (Japan only)

Prototype Products

2015:

Bendable module installed in Singapore



System Cost

2017:

20% faster installation using SmaCIS rooftop mount

The World's Largest CIS Manufacturer

Kunitomi Plant

Online:	2,011
Capacity:	900 MW
Land:	400,000 m^2
Total floor area:	158,000 m^2
Location:	Miyazaki, Japan

Tohoku Plant

Online:	2,016
Development site for next-generation products	
Land:	70,000 m^2
Total floor area:	15,000 m^2
Location:	Miyagi, Japan

Development of Next-Generation Modules

Thin and durable ultra-lightweight modules slated for backend of 2019

The thin new ultra-lightweight modules will achieve greater durability by having the glass typically used in the substrate replaced with an aluminum currently under development.

Leveraging what we expect to be a success domestically, we intend to provide these modules in solution packages for the overseas market.

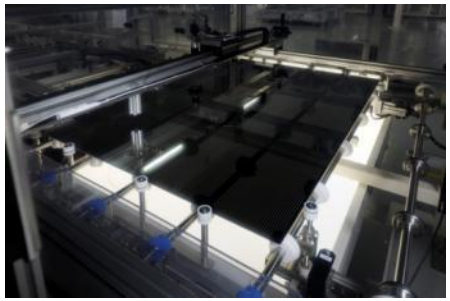
Manufacturing Excellence

Solar Frontier's proprietary lines are fully automated, proven in mass production and in producing modules at globally competitive cost levels.

Inspiring Trust

"What impressed us most…was the level and intensity of quality control."

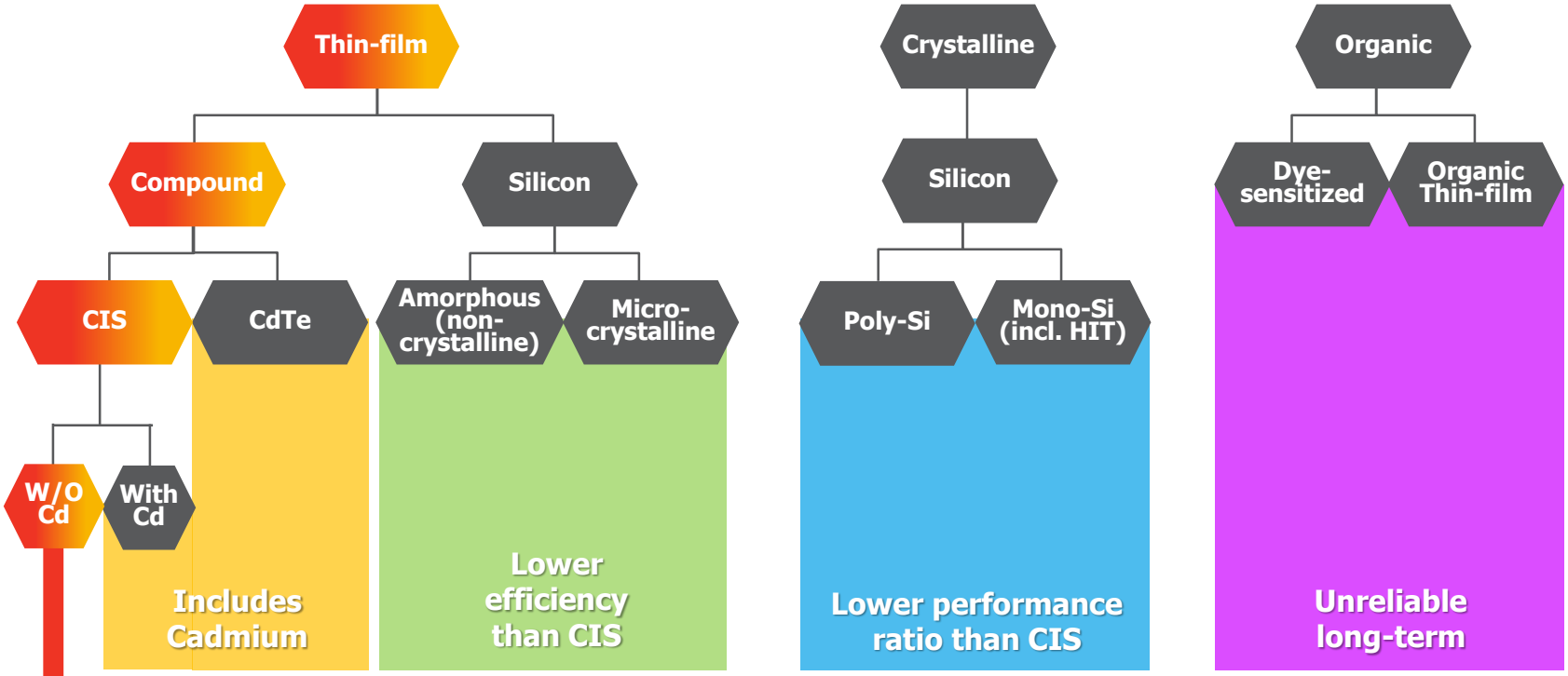
BNP Paribas Research



3. CIS Technology

What is CIS?

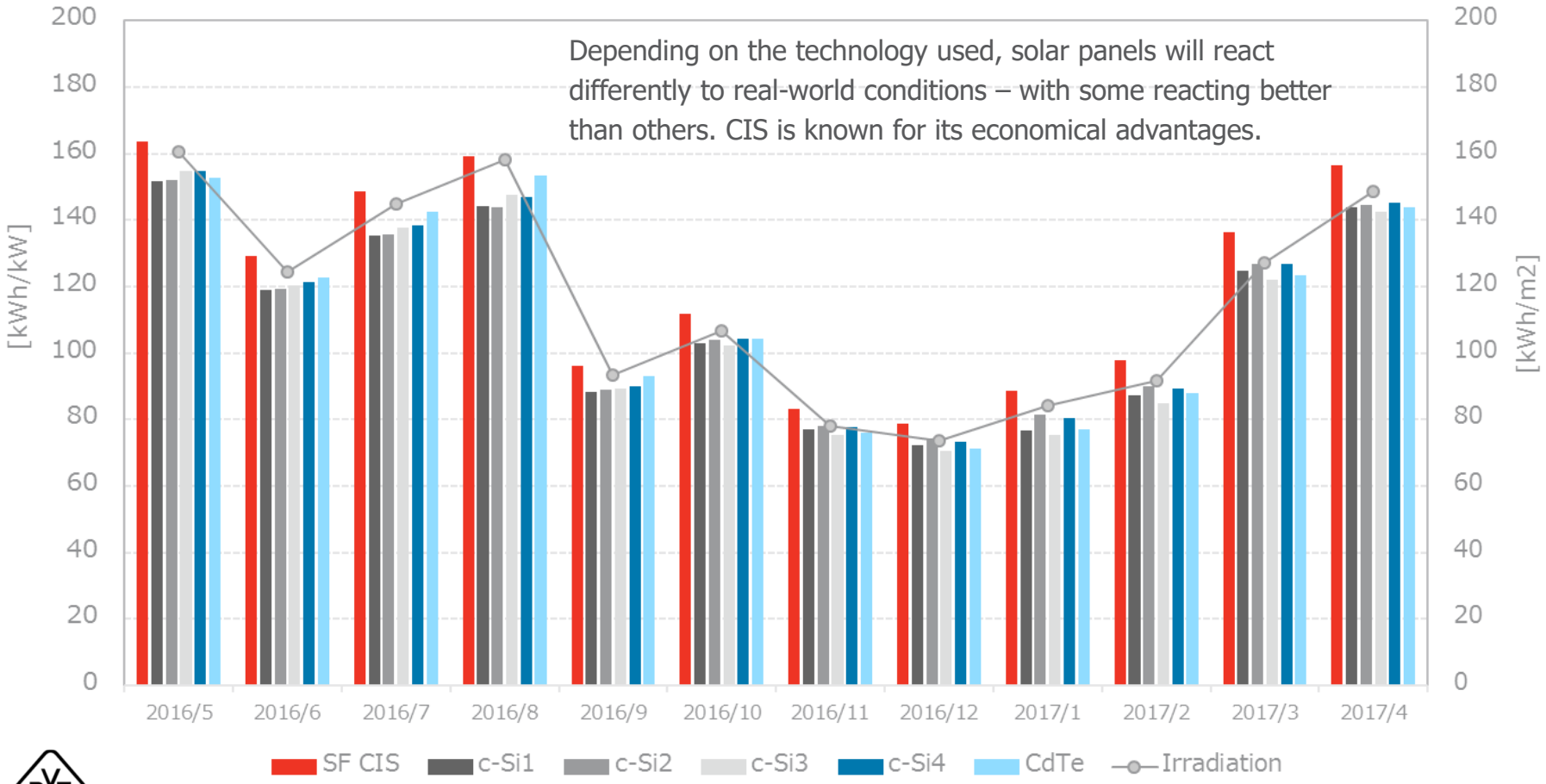
CIS is a thin-film technology using key ingredients copper (C), indium (I) and selenium (S).



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

More kWh Nationwide

CIS outperformed the module technologies of the six other major PV manufacturers at each Japanese site (Aomori, Miyagi, Fukuoka) throughout a full year.



※The validity of the system design and the impartiality in the measurement have been verified by the VDE Testing and Certification Institute, a neutral and internationally recognized certification body.

※Conditions: Facing south, 20 degrees (10 degrees in Fukuoka), 3kW

Four Reasons Why CIS Generates More Energy

Performance at **High Temperatures**

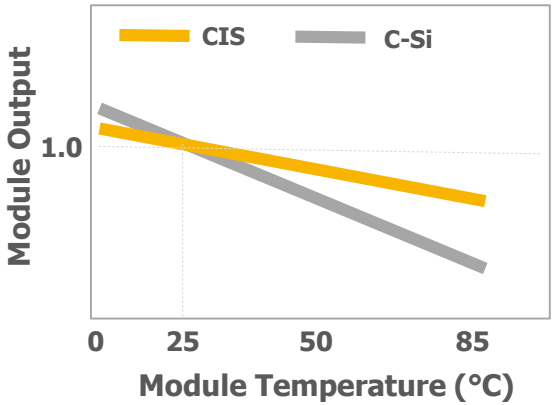
CIS modules' **Light-Soaking Effect**

Tolerance to **Partial Shading**

Superior quality for **Durability**

Performance at High Temperatures

- **CIS delivers high yields – even in desert heat**
- This is indicated by the lower temperature coefficient of CIS compared to crystalline silicon modules



The CIS "Light-Soaking Effect"

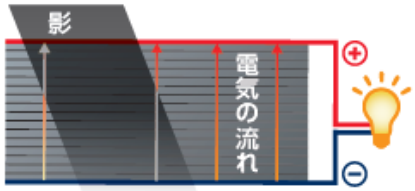
- **CIS modules increase in power output after exposure to light**
- In other words, the module has "warmed up" and is now operating at its full capacity, contributing to CIS' higher performance ratio

Tolerance to Partial Shading

- **Even under partial shading from neighboring objects, CIS continues to perform**
- Shadows cast perpendicular to the shorter end of the module will only affect the covered part

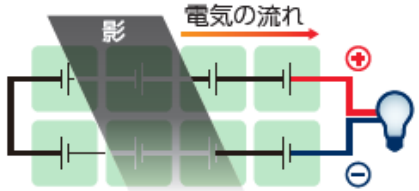
CIS

Shading does not affect unshaded areas



C-Si

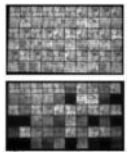
Shading on one cell affect the total output



A More Durable Technology

PID Resistant

- **Crystalline silicon:** susceptible due to insulation layers and thin N-layer
- **CIS:** resistant due to no insulation layer



C-Si: PID

No Microcracks

- **Crystalline silicon :** fragile cell material affected by micro-vibrations
- **CIS:** resistant to cracking because cell laid directly onto thick glass layer

c-Si: microcracks

Robust structure: glass/glass/backsheet

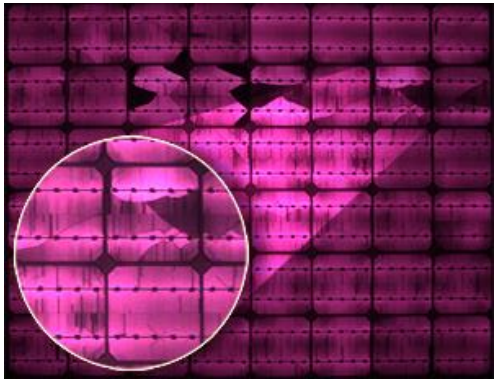
No hotspots

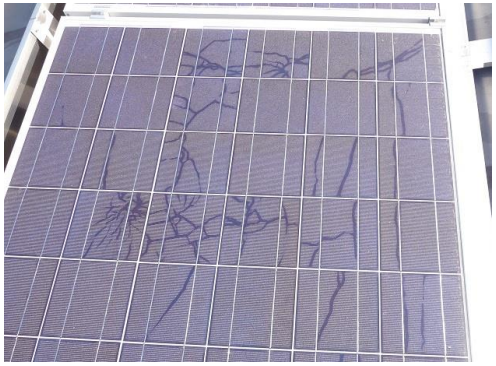
Resistance to salt mist corrosion

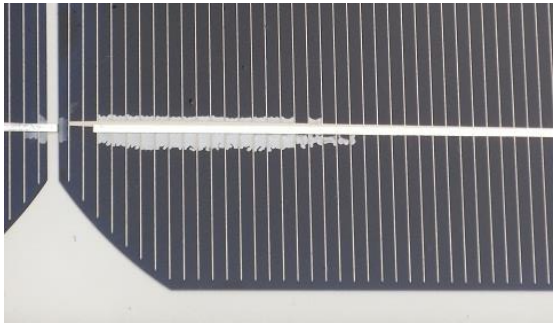
Resistance to ammonia corrosion

Superior Quality – Risk minimizing technology

Microcracks	Snail tracks	PID
/More critical for p-Si than m-Si /Caused by weight on modules	/Material defects, can be caused or boosted by microcracks	/Potential-Induced Degradation





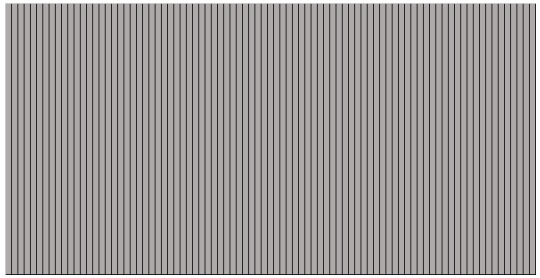


NO RISK

for Solar Frontier CIS modules, due to different technology!

Back to the future technology

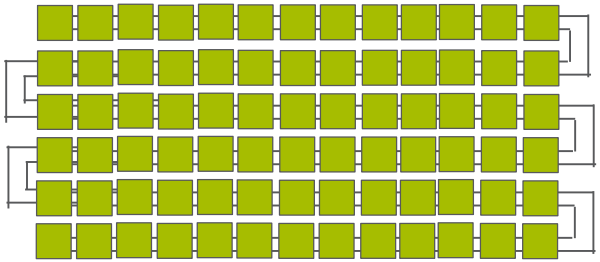
CIS Thin Film



One thin film containing strips of184 cells

vs.

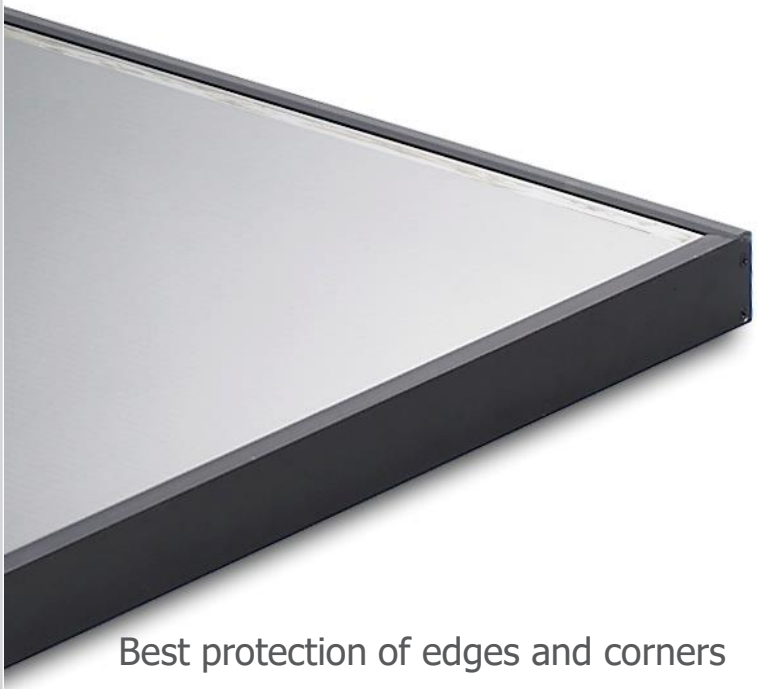
Crystalline silicon



Number of cells soldered in series

Mechanical stability - Framed Module

No chips or cracks in module edges



Best protection of edges and corners

Easy and safe transport

Widely Certified

Performance・Quality・Safety

- JET
- UL
- ISO9001

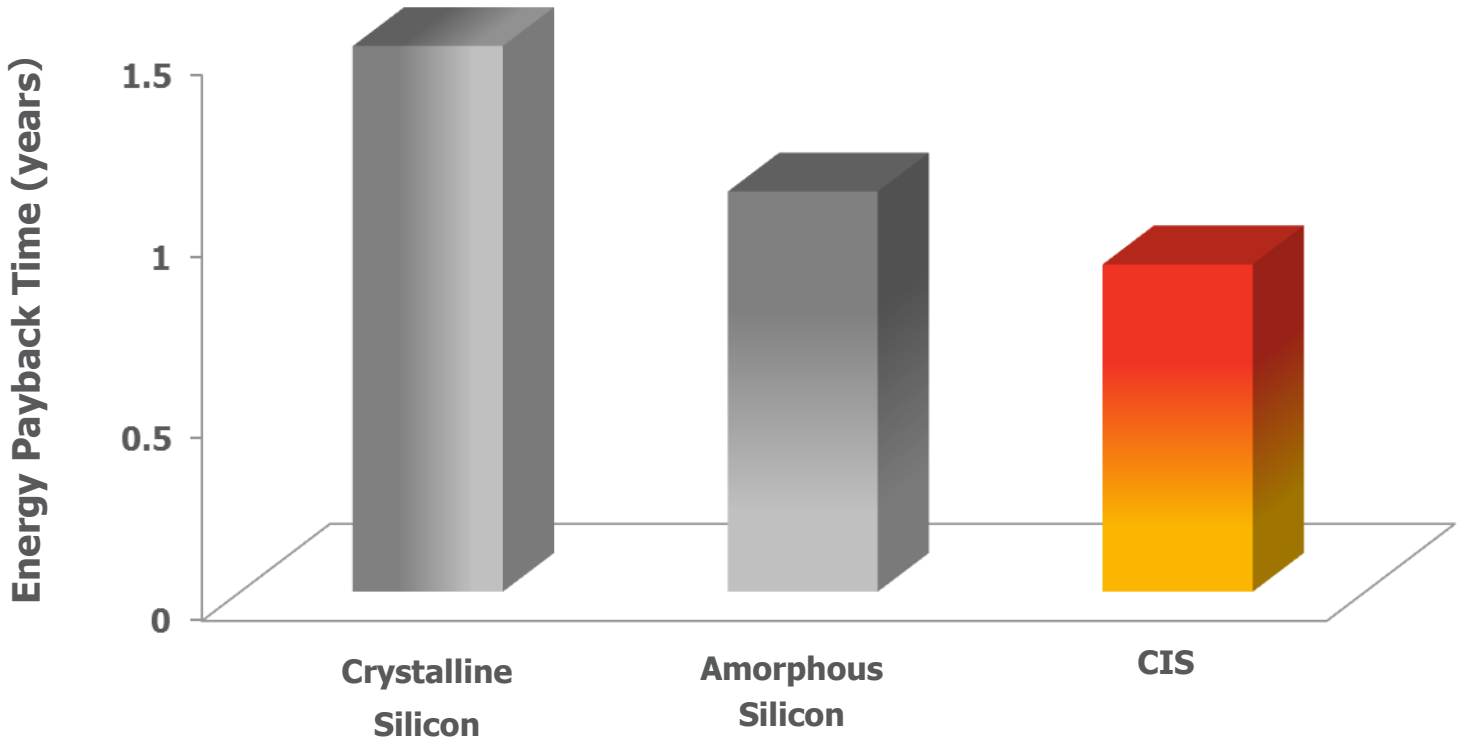
Environment

- ISO14001
- L2-Tech
- ISO18001

※Most certificates are obtained at Kunitomi Factory

Environmentally Friendly Production

Energy Payback Time (EPT) measures how long it takes for a module to generate the same amount of energy as required to manufacture it. CIS modules require 60% less time compared to that of crystalline silicon panels.



Note: EPT depends on the level of irradiation. This data was sourced from NEDO, Japan.

4．Case Studies

Solar Irradiation Distribution in Southeast Asian countries

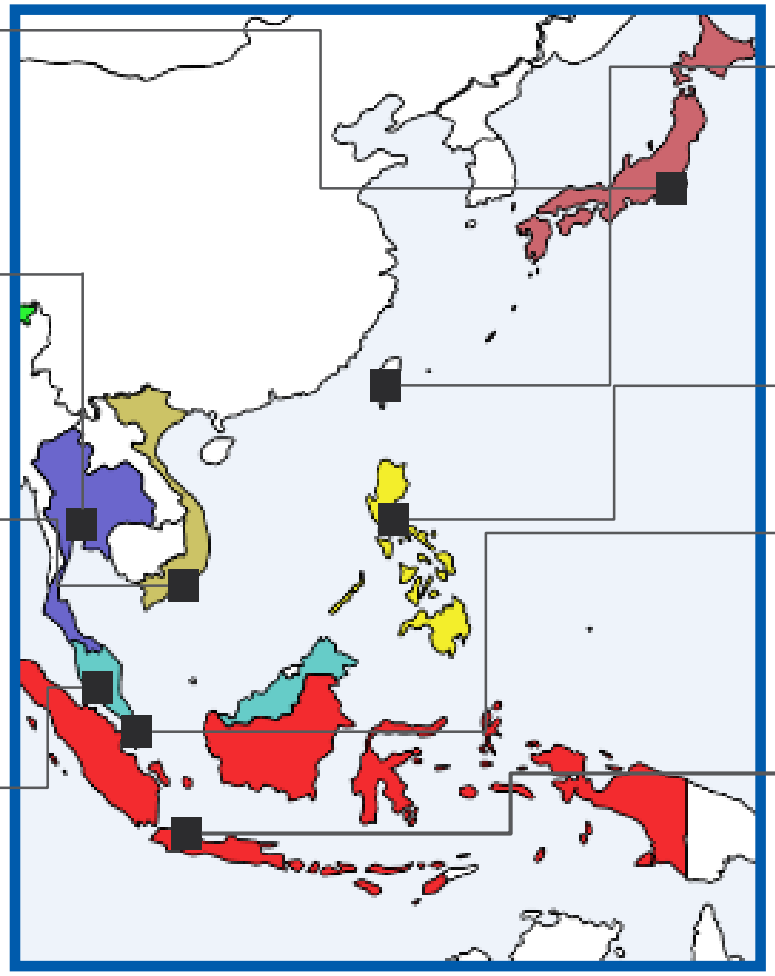
- The amount of solar irradiation in the South-east Asia countries are higher than Japan (economically superior)
- Reduction of CO2 emission by utilizing solar energy is higher in Malaysia and Indonesia

Tokyo：1.0 (Irradiance factor)
Irradiance = 1,236 kWh/㎡
kWh Yield = 1,093KWh/kWp
CO2 Emission = 556g/kWh

Bangkok1.5(compare with Tokyo)
Irradiance = 1,790 kWh/㎡
kWh Yield = 1,477KWh/kWp
CO2 Emission = 531g/kWh

Ho Chi Minh 1.4
(Compare with Tokyo)
Irradiance = 1,771 kWh/㎡
kWh Yield = 1,460Kwh/kWp
CO2 Emission = 355g/kWh

Kuala Lumpur 1.3
(Compare with Tokyo)
Irradiance = 1,597 kWh/㎡
kWh Yield = 1,307KWh/kWp
CO2 Emission = 666g/kWh



Kaohsiung 1.3
(compare with Tokyo)
Irradiance = 1,531.6 kWh/㎡
kWh Yield = 1,269Kwh/kWp
CO2 Emission = 581g/kWh

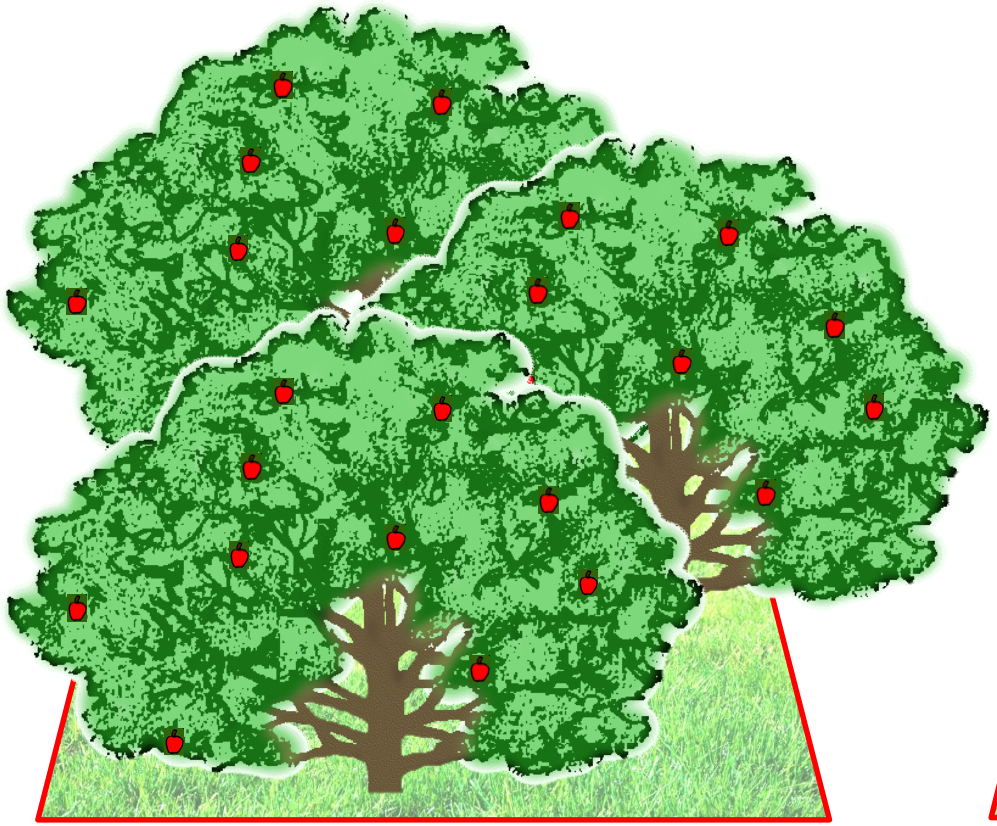
Manila1.4
(compare with Tokyo)
Irradiance = 1,779 kWh/㎡
kWh Yield = 1,468Kwh/kWp
CO2 Emission = 604g/kWh

Singapore1.3
(Compare with Tokyo)
Irradiance = 1,624 kWh/㎡
kWh Yield = 1,325KWh/kWp
CO2 Emission = 441g/kWh

Jakarta 1.3
(Compare with Tokyo)
Irradiance = 1,662 kWh/㎡
kWh Yield = 1,376Kwh/kWp
CO2 Emission = 736g/kWh

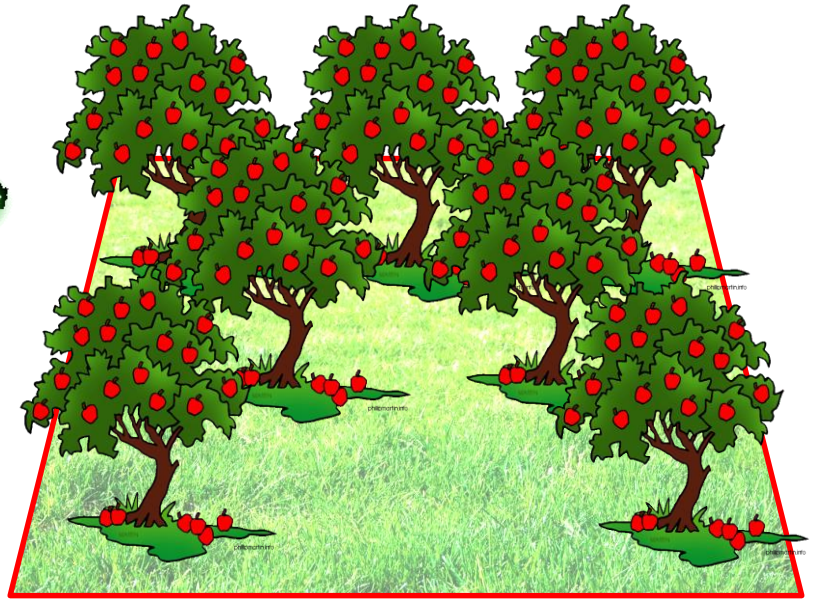
※Source: Irradiance : Meteonorm; kWh use : Pvsyst; CO2 Emission : IEA CO2 emissions from fuel combustion (2016 edit)

What is the real value for custmers?



Powerful modules?

kWp ?



… or best harvest?

kWh/kWp & kWh/ha

Example CIS vs. poly-Si PVSYST simulations, rooftop Italy

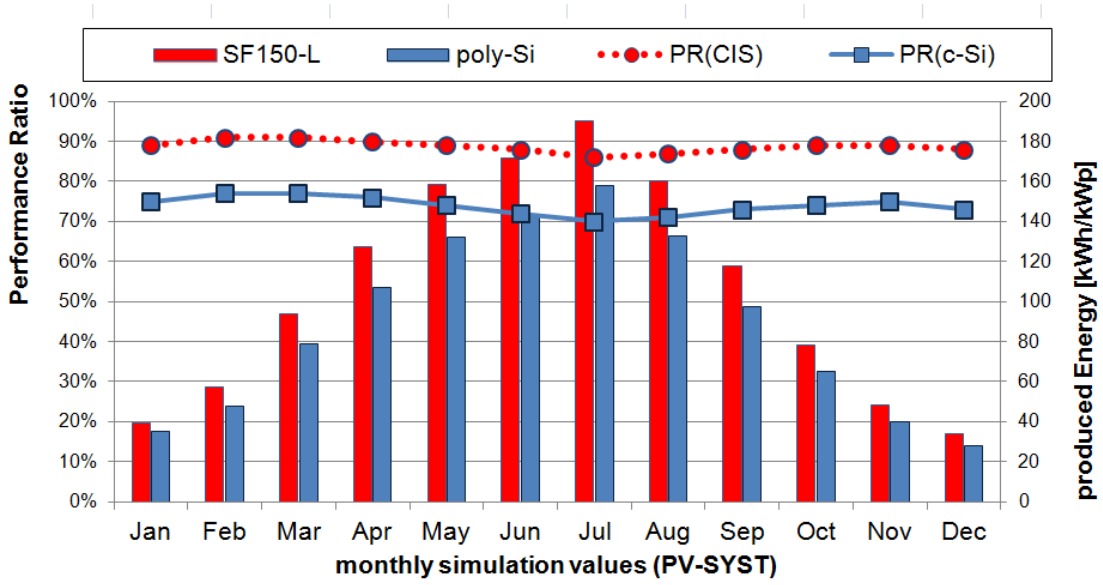
Industrial rooftop, Italy

Technical overview of poly-Si

System capacity	204 kWp
Panel power	275 W
Inverter	Solargate PV7L220
Installed panels	741 (on 1431 m²)
Panel angle, orientation	18°, 80°W
Yearly output	1,064 kWh/kWp

Technical overview of CIS (Solar Frontier)

System capacity	175 kWp
Panel type	SF150-L (150W)
Inverter	Solargate PV7L220
Installed panels	1165 (on 1431 m²)
Panel angle, orientation	18°, 80°W
Yearly output	1,277 kWh/kWp



- Same rooftop size, location, orientation, tilt; same inverter; same environmental conditions
- poly-Si: Higher module and system power
- CIS: More produced energy, better performance ratio

→ **CIS PV-solution is more efficient than poly-Si PV-solution**

1. CIS vs. Poly-Si, Atsugi Research Center, Japan

Monitoring Period: July 2009 – June 2013

Overview	Poly-Si	SF CIS
System Capacity	4.2kW	2.25kW
Module Power	175W	75W
Inverter	SPC4002 (95%)	
Average ACPR	**82.8%**	**87.5%**
AC Energy Yield	**4804** kWh/kWp	**4547** kWh/kWp

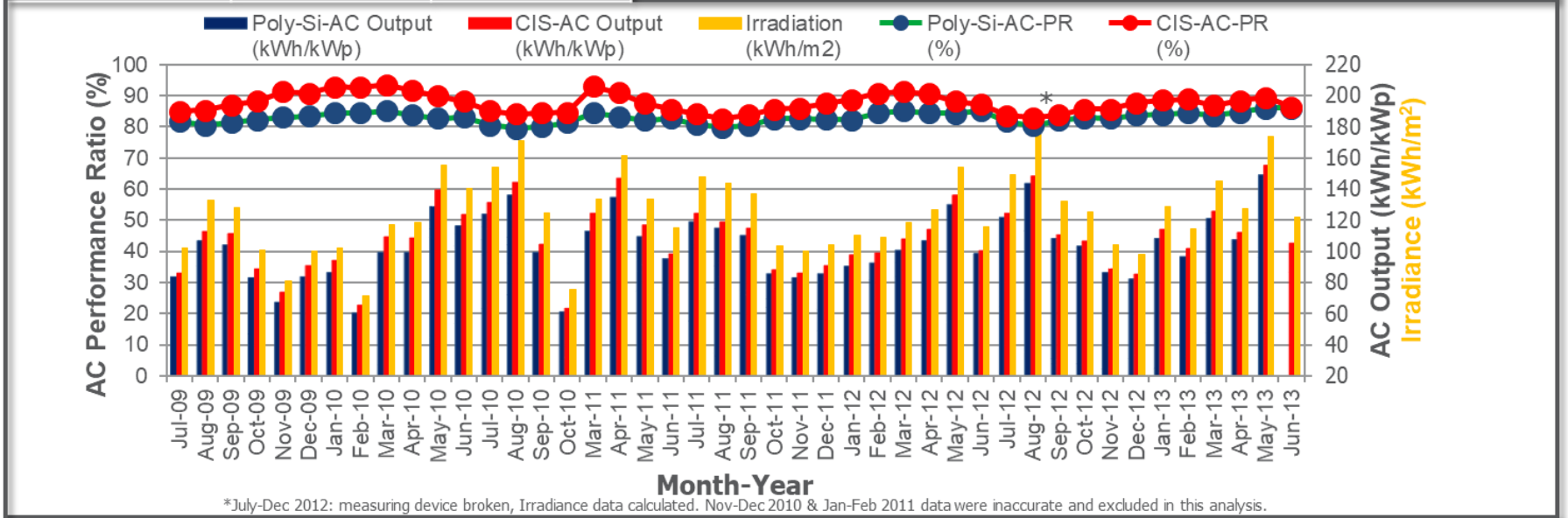
Location: Atsugi Kanagawa, Japan

Azimuth: 20° South East

Average Temp.: 14.6°C (58.3°F)

Average Irradiance: 1204.5kWh/m²/yr

Module Tilt angle: 20°



*July-Dec 2012: measuring device broken, Irradiance data calculated. Nov-Dec 2010 & Jan-Feb 2011 data were inaccurate and excluded in this analysis.

☀ **CIS modules constantly show better performance than Poly-Si modules over a period of 4 years at Atsugi Research Center in Japan!**

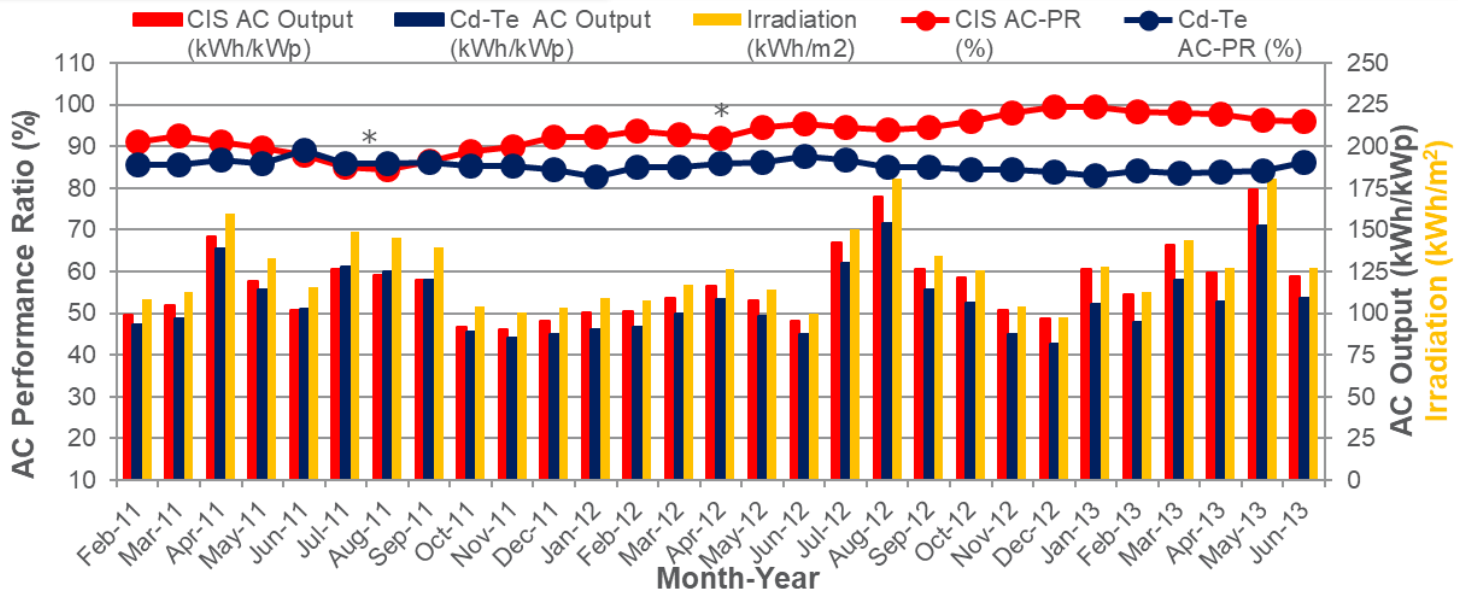
Unrestricted
RAC10-0082_12

2. CIS vs. CdTe, Atsugi Research Center, Japan

Monitoring Period: July 2011 – June 2013

Overview	CdTe	SF CIS
System Capacity	3.60 kWp	
Inverter	SPC4002 (95%)	
Average ACPR	**90.5%**	**98.3%**
Total AC Output	**3313** kWh/kWp	**3596** kWh/kWp

Location: Atsugi Kanagawa, Japan
Azimuth: 180°
Module Tilt angle: 20°
Average Temp.: 14.6°C (58.3°F)
Average Irradiance: 1204.5kWh/m²/yr



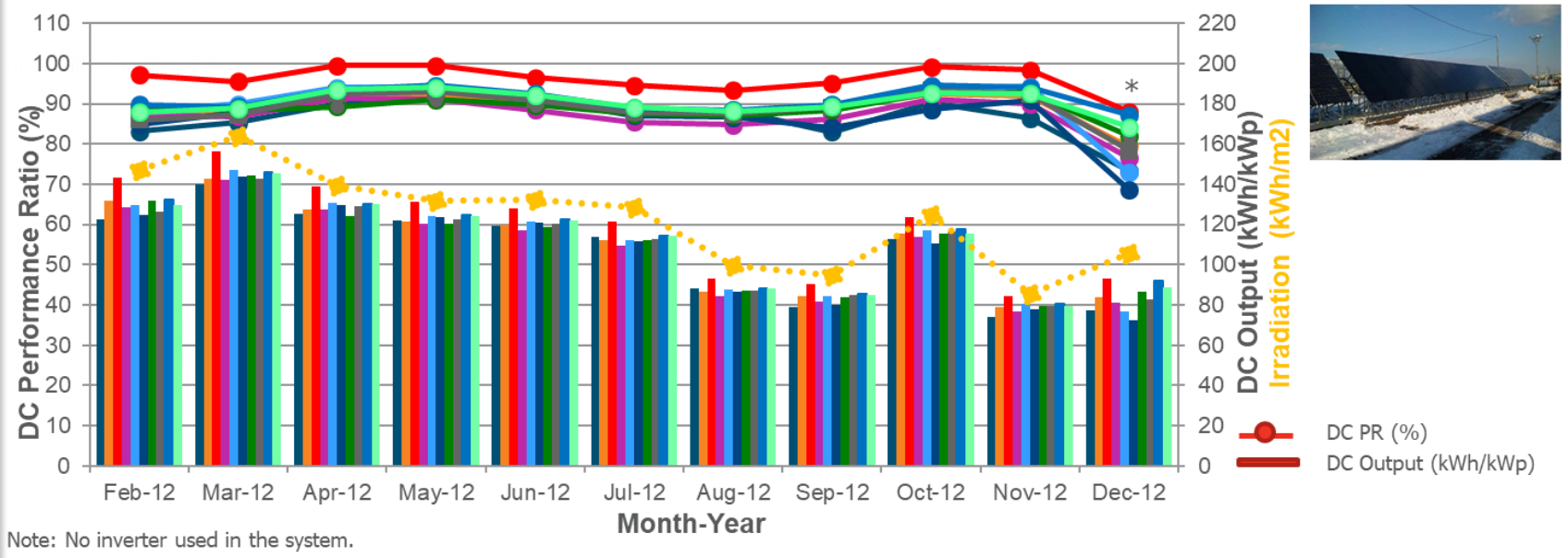
*April 2012: System maintenance,; Jul. & Aug. 2011: measuring device broken, PR & Output calculated.

☀ **Solar Frontier CIS modules shows better performance than CdTe modules for more than 2 years at Atsugi Research Center in Japan!**

3. Softbank Energy Test Site, Hokkaido Japan

Monitoring Period: February 2012 – December 2012
Average Irradiance: 2,388 kWh/m²/yr **Module Tilt Angle:** 40°

Overview	Kaneka Hybrid-Si	Panasonic Hybrid HIT	Solar Frontier CIS	Mitsubishi Mono-Si	Kyocera Poly-Si	Sharp Poly-Si	Itogumi Poly Si	Canadian Poly-Si	Suntech Poly-Si	Yingli Poly-Si
Capacity (kWp)	4.83	3.44	4.80	5.00	5.24	5.01	5.04	5.06	5.04	5.17
DC Energy Yield (kWh/kWp)	**1174**	**1205**	**1303**	**1183**	**1213**	**1183**	**1205**	**1205**	**1235**	**1223**
Average DC PR	**86.7%**	**89.0%**	**96.2%**	**87.4%**	**89.6%**	**87.3%**	**89.0%**	**89.0%**	**91.2%**	**90.3%**



Note: No inverter used in the system.

☀ **Solar Frontier CIS modules confirmed to be performing better compared to other module technologies!**

Unrestricted
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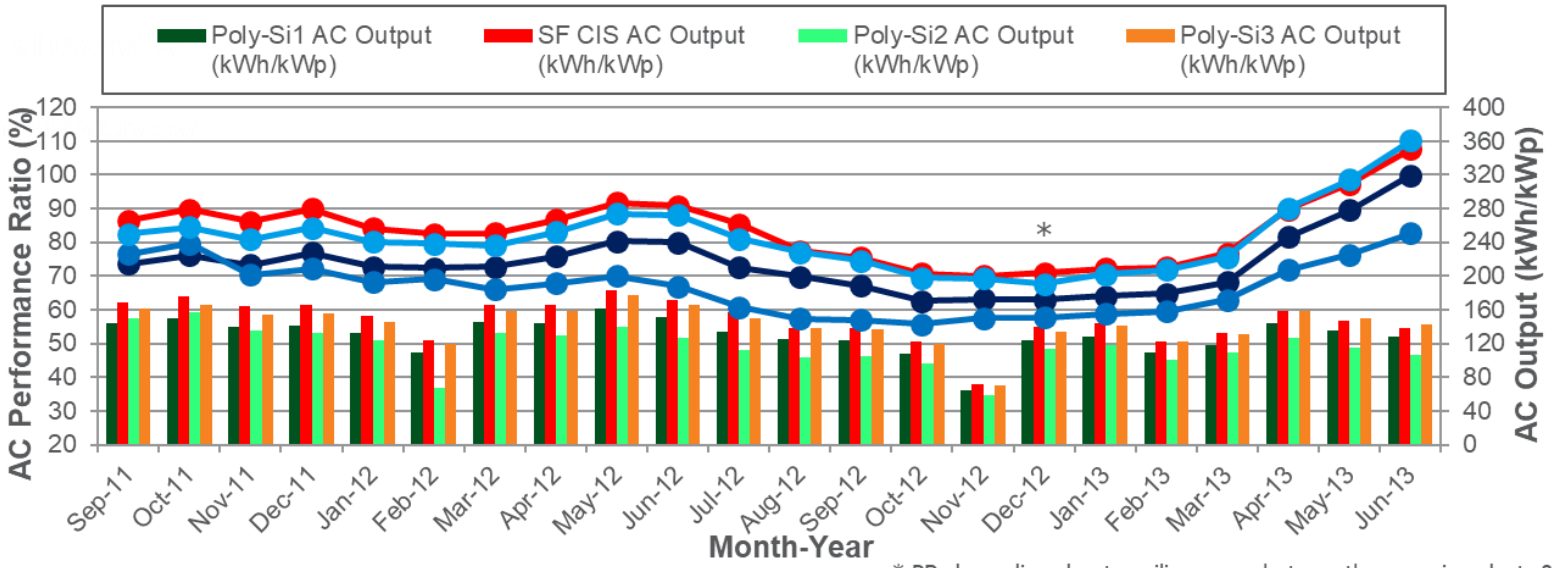
4. HopSol Test Site, Otjawarongo Namibia, Africa

Monitoring Period: September 2011 – July 2013

Overview	Poly-Si 1	SF CIS	Poly-Si 2	Poly-Si 3
System Capacity (kWp)	1.15	1.17	1.15	1.12
Inverter	SMA SB1200 (92.1%)			
Average ACPR	**73.4%**	**83.4%**	**65.7%**	**81.0%**
AC Energy Yield	**2860** kWh/kWp	**3251** kWh/kWp	**2558** kWh/kWp	**3155** kWh/kWp

Technical Info:

Azimuth: 0°
Module Tilt angle: 22°
Average Temp.: 22°C (71.6°F)
Average Irradiance: 2,388 kWh/m²/yr



* PR degrading due to soiling, very hot weather causing dust & bushfires.

☀ **Solar Frontier CIS module shows to have better performance compared to three different kinds of Poly-Si modules even in a very hot climate like Namibia!**

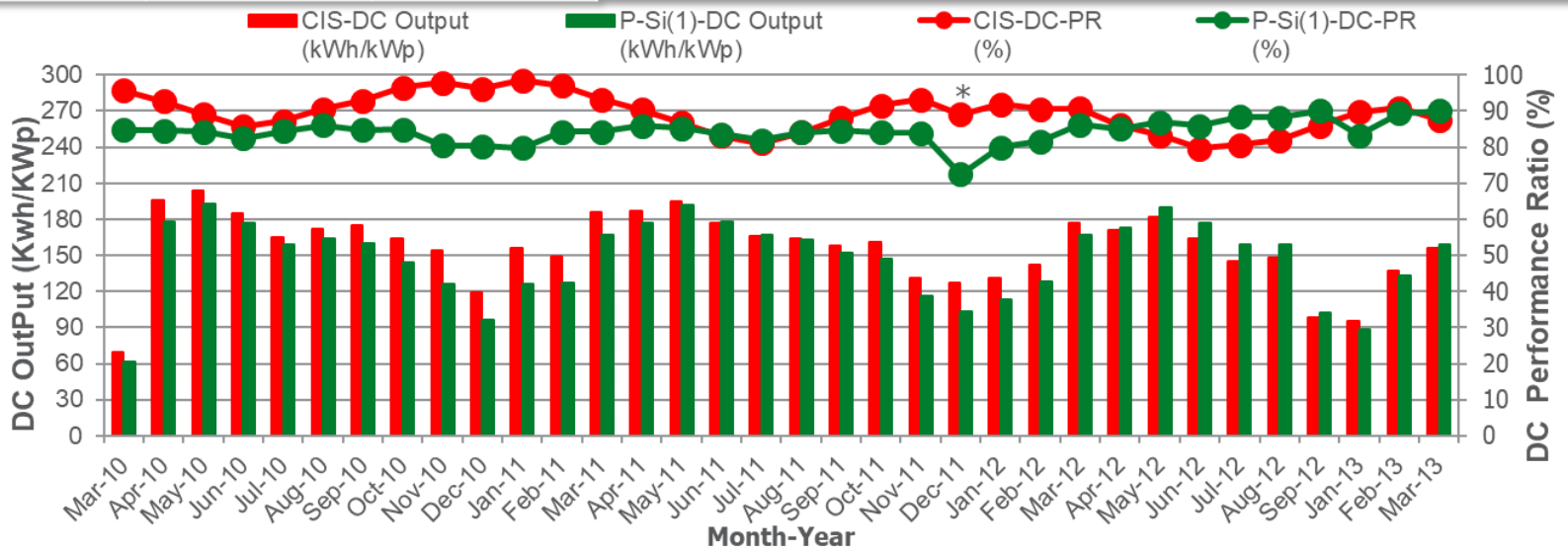
5. Wilson Electric Test Site, Tempe Arizona U.S.A.

Monitoring Period: : March 2010 – March 2013

Overview	Poly-Si	SF CIS
System Capacity	12.8 kWp	9.36 kWp
Module Power	200W	80W
Inverter	Fronius IG Plus (96.2%)	
Average ACPR	**86%**	**90%**
AC Energy Yield	**5026** kWh/kWp	**5310** kWh/kWp

Location: Tempe, Arizona, U.S.A.

Azimuth: 180°
Average Temp.: 22°C (71.6°F)
Average Irradiance: 1893 kWh/m²/yr



*Dec 2011: monitoring was stopped for 18 days; Oct-Dec2012: inaccurate data due to monitoring upgrade , thus excluded in this analysis.

☀ **CIS modules shows better performance than Poly-Si modules for 3 years at Wilson Electric Test Site in Arizona!**

Unrestricted
RAC10-0082_12

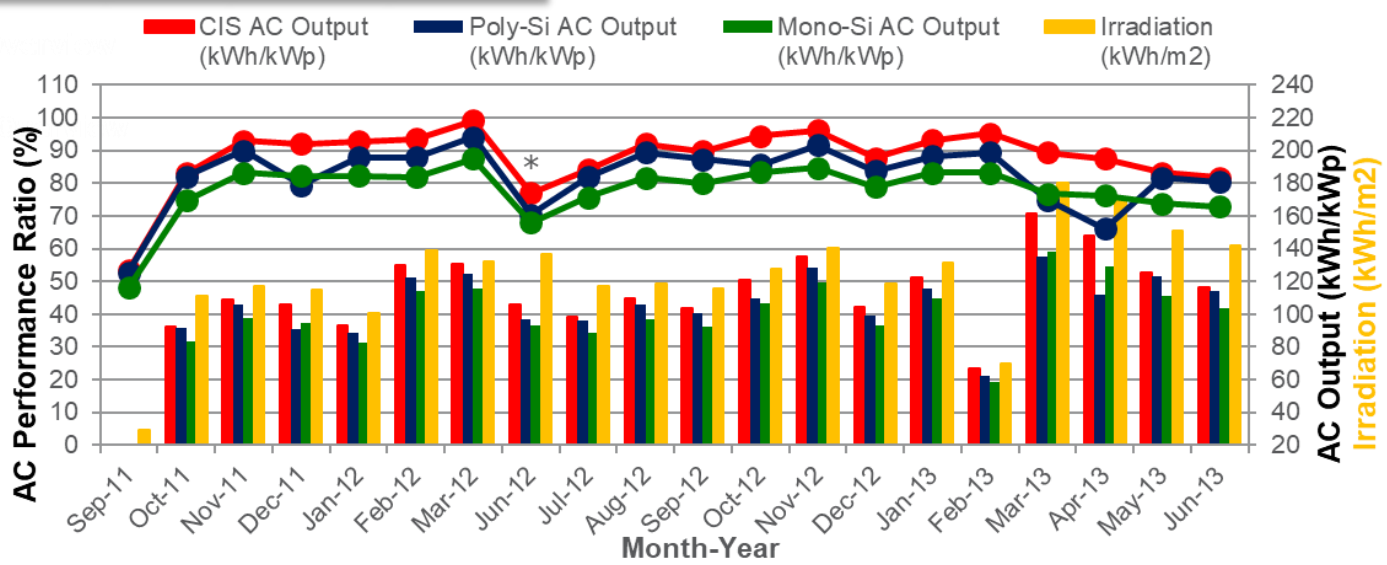
6. Phoenix Solar Calamba Test Site, Philippines

Monitoring Period: : 22nd September 2011 – June 2013

Overview	SF CIS	Poly-Si	Mono-Si
System Capacity (kWp)	13.4	13.5	13.9
Inverter	Sunny Mini Central 7000HV-11 (92.1%)		
Average ACPR	**89.1%**	**82.8%**	**78.8%**
AC Energy Yield	**2194** kWh/kWp	**2039** kWh/kWp	**1942** kWh/kWp

Technical Info:

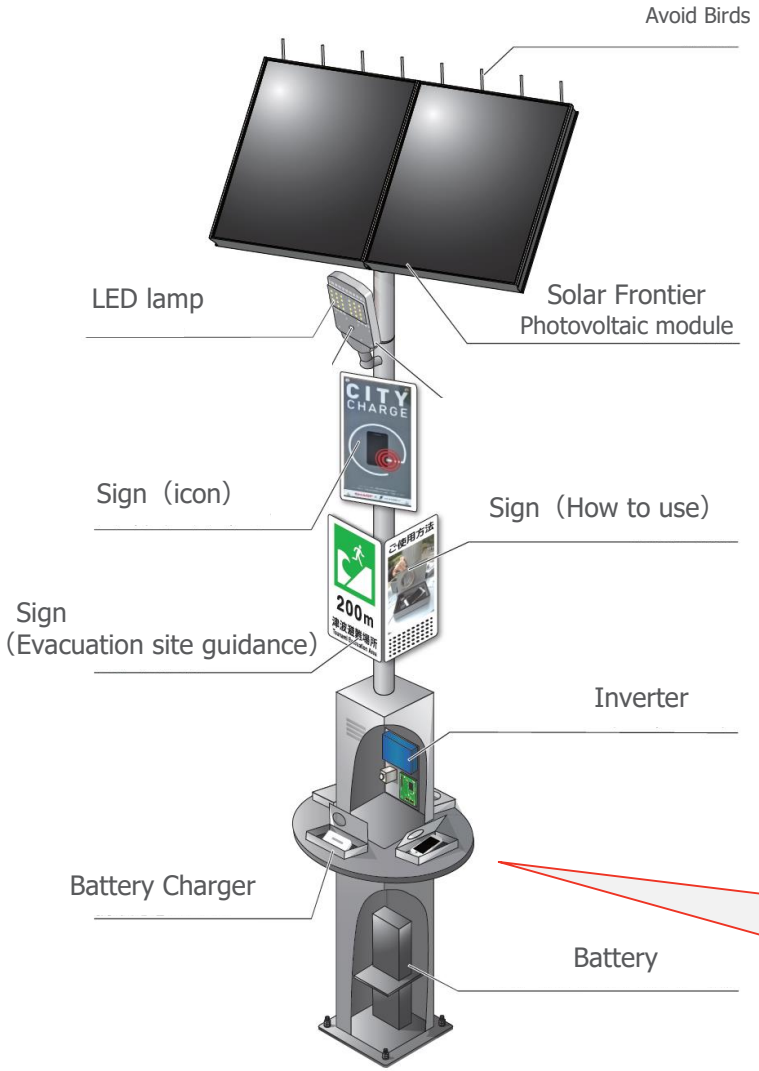
Azimuth: 31°
Module Tilt angle: 10°
Average Temp.: 22°C (71.6°F)
Average Irradiance: 1,664 kWh/m²/yr



* June 2012:rainy season; April-May 2012:system down and data not included in this analysis.

☀ **Solar Frontier CIS module shows to have better performance compared to silicon-type modules even in tropical areas like the Philippines!**

CIS Solar Street Light



Technical specification of Solar Street Lighting Systems

【definition】

A stand alone solar photovoltaic street lighting system is an outdoor lighting unit used for illuminating a street or an open area. It consist of a photovoltaic module, compact LED lamp, Lithium-ion batteries or lead acid batteries, control electronics , inter-connecting wires/cables, module mounting Pole including hardware and battery box. Compact LED lamp is fixed inside a luminaire which is mounted on the pole. The module is mounted facing south , so that it receives solar radiation throughout the day , without any shadow falling on it. Electricity generated by the photovoltaic module will charge the battery during the day time. This system operates from dusk to down.

【Technical Specifications & General Specifications】

1) operating time
   The system should automatically switch is ON at dusk , operate throughout the night (14hours/day) and automatically switch is OFF at the dawn.
2) PV module
   Solar Panel made by Solar Frontier
3) Battery
   Lithium-ion battery (240Wh・20Ah) × 2pcs
4) Lamp
   The Lamp should be 650lm/5Watt (Power Consumption) compact LED lamp.
   The lamp should be housed in an assembly suitable for outdoor use.
5) Charger
   The charging function for Smartphones or Tablets
   Battery is available for charging your smartphone（15min*10times/day）.

Green Investment Tax Allowance (GITA) reviewed by MGTC/ approved by MIDA

MIDA: Malaysian Investment Development Authority

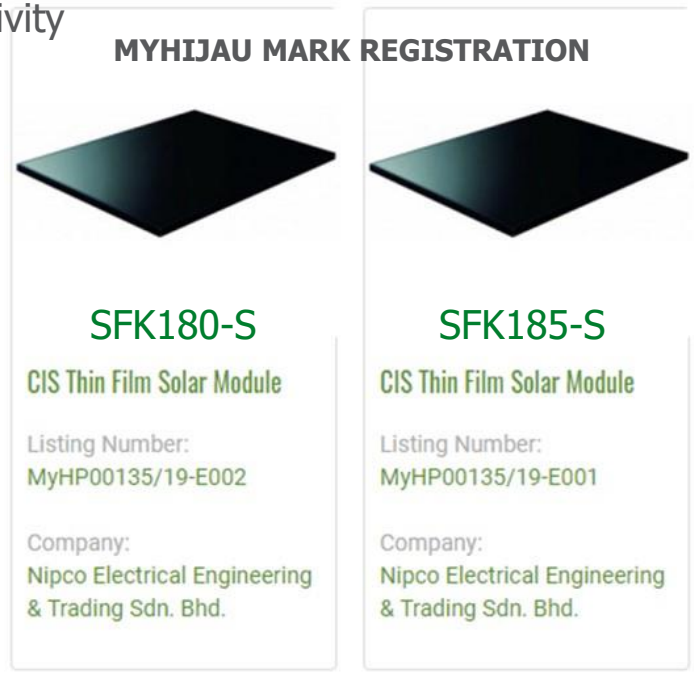
A company which undertakes investment in a specific project that promotes sustainability and green environment is eligible for Investment Tax Allowance (ITA) of 100% of qualifying capital expenditure (QCE) incurred from the date of application received by MIDA until 31 December 2020.

The ITA can be utilized to offset against 70% of statutory income.

Promoted projects for ITA are Renewable Energy (RE), Energy Efficiency (EE) , Green Building, Green Data Centre and Integrated Waste Management Activity

MGTC: Malaysian Green Technology Corporation (Greentech Malaysia)

Equipment/assets in the GITA projects must be owned by the company.
60% of main equipment/assets in the GITA Project must be recognized and registered under the MyHIJAU Mark or have product certification that is recognized and accepted by Greentech Malaysia.



ITA computation sampled made by MIDA

Tax Computation 'With' & 'Without' Tax Incentive

Example: Assumption: ITA: RM10 million

	WITHOUT TAX INCENTIVE (RM)	WITH TAX INCENTIVE (RM)	
Profit Before Tax add/less Tax Adjustments	15,000,000 2,000,000	15,000,000 2,000,000	
Adjusted Income Less: Capital Allowances	17,000,000 (5,000,000)	17,000,000 (5,000,000)	
Statutory Income	**12,000,000**	**12,000,000**	
Percentage (%)		*70%	30%
		8,400,000	3,600,000
(-) ITA	Nil	**10,000,000	-
		0	3,600,000
Chargeable Income	12,000,000	3,600,000	
Tax Liability @ 24%	2,880,000	864,000	
Balance to be carried forward to next year of assessment		1,600,000	

* Offset against 70% of statutory income

** Only RM8.4 million will be utilised.

Solar Frontier at IMGE2019 upcoming October

"NIPCO Electrical Engineering & Trading Sdn Bhd" becoming an official agent in Malaysia for only 100% made in Japan Solar module manufacturer "Solar Frontier K.K." committed to CIS thin film technology.
The product is officially registered "MyHIJAU" and would be exhibited in upcoming IGEM2019 as "CIS Thin Film Solar Module...here we come in Malaysia"

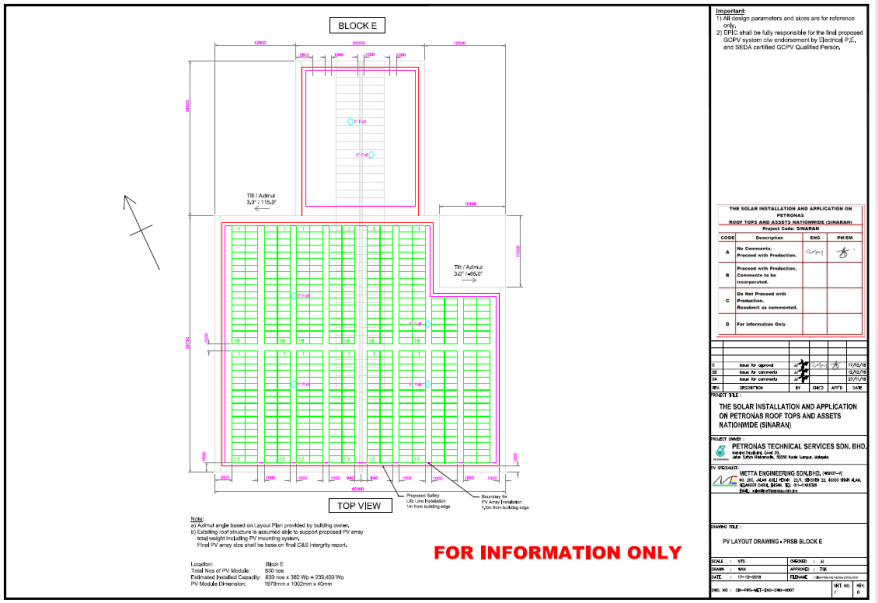
マレーシア　ペトロナス国営石油公社案件概要

PETRONAS

発注元　　：ペトロナスリサーチ社
　　（マレーシア国営石油公社ペトロナスの100%子会社）
担当者　　：Mr.Norhasnizam Hasan
　　：PD＆T（プロジェクト開発 兼 技術チーム）
販売代理店：NIPCO Electrical Engineering＆Trading Sdn Bhd
EPC　　：Mattan Engineering Sdn Bhd
稼働日　　：2019年6月
設置面積　：40m×45m （E区画）

■設置場所
PETRONAS Research Sdn Bhd
Off, Jalan Ayer Itam, Kawasan Institusi Bangi, 43000 Bandar Baru Bangi, Selangor, マレーシア

■設置容量
76.5kW　（SFK180-S　425枚）



Lay out

Solar Frontier's Product Date Sheet

Electrical Characteristics

Electrical Performance at Standard Test Conditions (STC) *1

Maximum Power (Pmax)	185 W
Tolerance of Pmax	+10% / - 5%
Open Circuit Voltage (Voc)	121 V
Short Circuit Current (Isc)	2.19 A
Maximum Power Voltage (Vmpp)	95.0 V
Maximum Power Current (Impp)	1.95 A

Note*1 Standard Test Conditions (STC) : 1,000 W/m² irradiance, cell temperature 25 ℃ and a spectral distribution of irradiance according to air mass 1.5. Isc and Voc are within ±10% tolerance of the rated values at STC.

Electrical Performance at Nominal Operating Cell Temperature (NOCT) Conditions*2

Maximum Power (Pmax)	144 W
Open Circuit Voltage (Voc)	115 V
Short Circuit Current (Isc)	1.75 A
Maximum Power Voltage (Vmpp)	93.2 V
Maximum Power Current (Impp)	1.54 A

Note*2 Nominal Operating Cell Temperature Conditions: Module operating temperature at 800 W/m² irradiance, ambient temperature 20 °C, wind speed 1m/s and open circuit condition.

Performance at Low Irradiance*3

Note*3 Efficiency reduction of maximum power from an irradiance of 1,000 W/m² to 200 W/ m² at 25 °C is typically2.0%.

Characteristics for System Design

Maximum system Voltage (Vsys)	1,500 V DC
Limiting Reverse Current (Ir)	7 A
Maximum Series Fuse Rating (Isf)	4 A

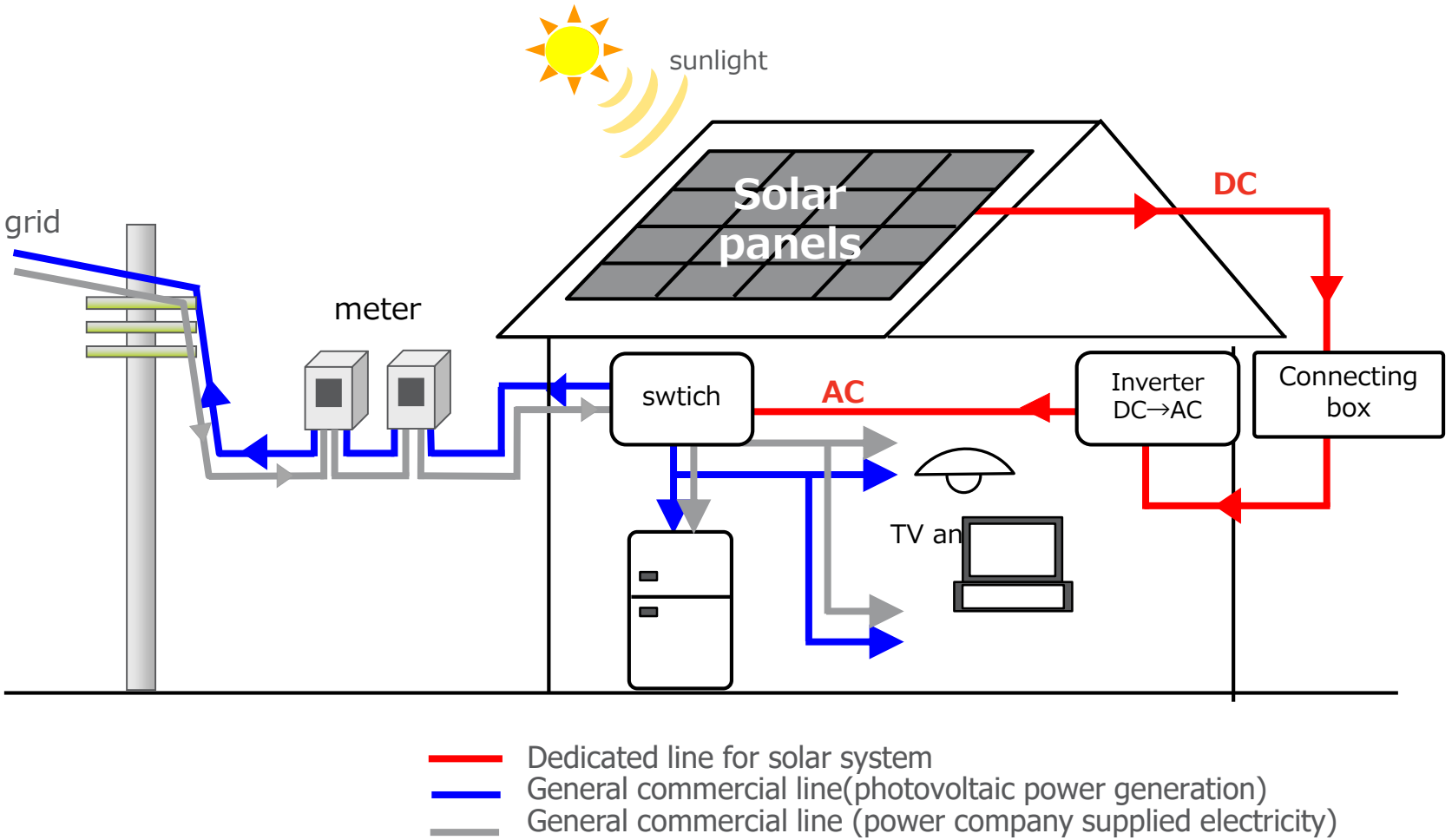
Mechanical Characteristics

Dimensions (L x W x H)	1,257 x 977 x 35 mm (49.5 x 38.5 x 1.4 inch)
Weight	18.5 kg (40.8 lbs)
Snow Load*4	2,400 Pa (IEC61646 Ed 2.0)
(to the front of the module)	1,600 Pa design load (UL1703)
Wind Load	2,400 Pa (IEC61646 Ed 2.0)
(to the back of the module)	1,600 Pa design load (UL1703)
Module Operating Temperature	- 40 °C ～ 85 °C
Application Class on IEC61730 Ed 1.0	Class A
Fire Safety Class on IEC61730 Ed 1.0	Class C
Safety Class on IEC61140	II
Module Fire Performance	Type 1
Cell Type	CIS substrate glass (Cadmium free)
Front Glass	Tempered anti-reflective glass
Encapsulant	EVA
Back Sheet	Weatherproof plastic film
Frame	Anodized aluminum alloy (Color: black)
Junction Box	Protection rating: IP67 (With bypass diode)
Output Cables (Conductor)	2.5 mm²/14 AWG (Halogen free)
Cable Lengths (Symmetrical)	1,200 mm (47.2 inch)
Connectors	Hosiden, HSC2013 (Male) / HSC2014 (Female)

Note*4 UL:1.5 times design load is applied to the module. Accordingly, 2,400 Pa (50.1 lbs / ft²) is loaded to test the 1,600 Pa (33.4 lbs / ft²) UL design load

Home Solar Electric System

・Grid-tied systems are the most common type. They connect to the electric grid. When power demand is higher than the solar panels can provide, such as at night or rainy day, electricity from the utility supplements the solar system. Conversely, when the solar panels are generating more electricity than its need, it sends the excess power to the utility grid.



Estimate Your Solar Electricity Needs

・Review electricity bills to determine annual electricity needs. Your usage will be shown in kilowatt-hours(kWh).
・Review each month of the year; you may use more electricity in some months than others (e.g., air conditioner in summer) .
・Consider any planned changes. If you will be purchasing an electric vehicle or are planning a home addition , your electricity needs may increase.

■ Standard electricity consumption by Household size in Japan

Household size	Electricity consumption (spring or autumn)
1	6.1kWh/day・185kWh/month
2	10.5kWh/day・320kWh/month
3	12.2kWh/day・370kWh/month
4	13.1kWh/day・400kWh/month
5	14.8kWh/day・450kWh/month
6～	18.4kWh/day・560kWh/month

400 kWh/month * 12 month/year
= **4,800 kWh/year**

■The average JAPAN household uses 400kWh power per month. For 30 days per month we get 30kWh per day, and for an average day you might get between 6 and 10 hours of effective sunlight. The solar system capacity is 4kW per hour.
■In summer +10%, In winter +35%
■Gus user
■Rated power consumption per unit
/Air conditioner 750～1100W /refrigerator 250～300W /TV 125～155W /all lighting 300～780W
And, Rice cooker, electric kettle, microwave oven, oven toaster, IH cooking heater, exhaust fan, dishwasher, washing machine, washing dryer, bathroom dryer, vacuum cleaner, iron, eco-cute, DVD, Blu-ray, router, dryer, air purifier , Fire alarm, intercom, tropical fish tank, etc. (e.g., 40W appliance in domestic use that will be used for 2hours per day. The daily energy consumption for it would be 40*2=80kWh.)

※The calculations done this way will not be accurate. There are other factors affecting the generation of solar energy. The daily production might fluctuate greatly on a daily basis.
※Based on a household survey by the Statistics Bureau, Ministry of Internal Affairs and Communications in Japan.

Required capacity of Solar Electric System

Required capacity of home solar electric system is 4.1kW.

■ Recommend the capacity as below;

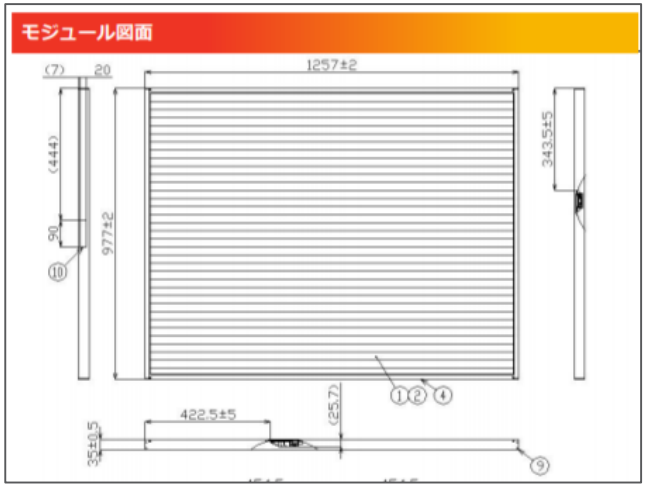
Estimated Power generation in Tokyo,Japan

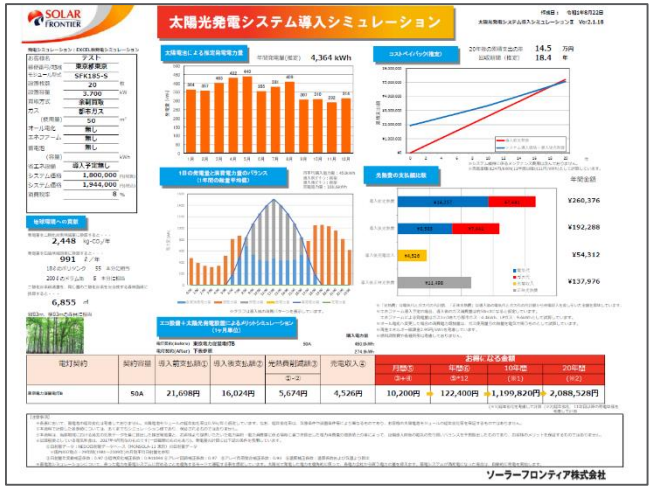
4,800 kWh/year ÷ 1,178 kWh/kW・year = **4.1kW** (≒ **185 W * 22 pieces**)

■ Calculate the roof's usable area

・The roof size available for setting up the solar panel would need to be ascertained in square feet.
・The size available needs to be divided by the size of the solar panel that is going to be used.

1.23 m^2/piece (1,257 mm * 977 mm) * 22 pieces = 27.06 m





An Off Grid System

・An off grid system is independent of the electric grid. Because of this, it has to be able to meet the user's full electricity demand. To store excess power for use at night or when the system isn't able to be 100% efficient, a battery is connected, often supported by a back-up generator or other energy source. Due to the complexity and reduced flexibility of off-grid system, they are most commonly used for remote locations ,or to power buildings or equipment a consistent energy need that is safely within the maximum output of the panels.

Solar panel installation guide: how to install solar panels in 5 steps

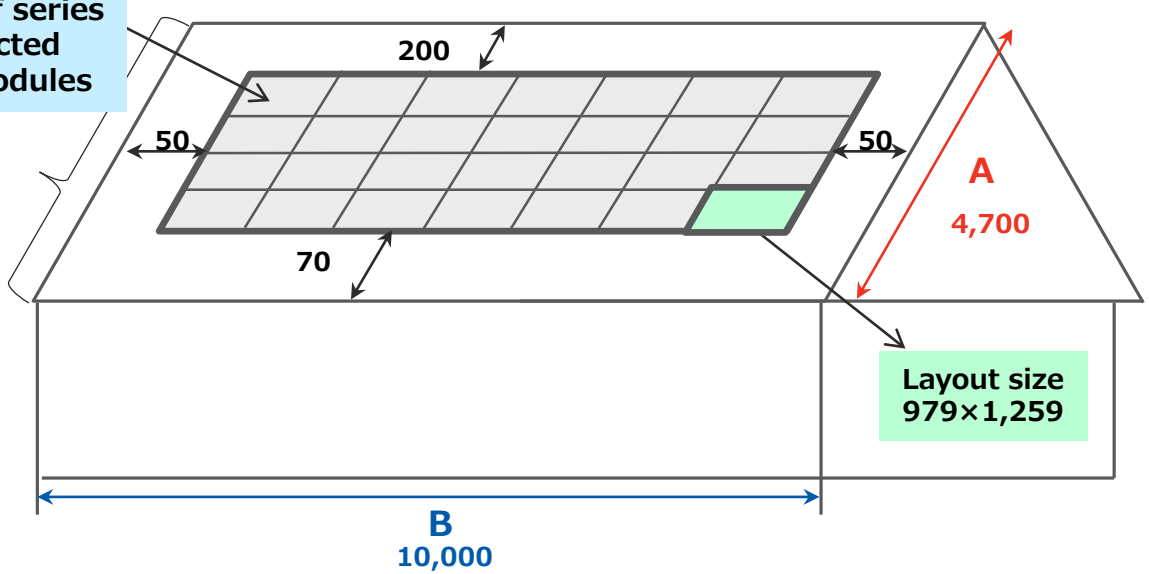
we've outlined a simple five-step guide for the typical solar installation process.

How to install solar panels: five main steps

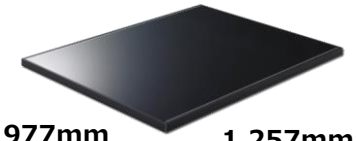
There are five major steps to a solar installation that your chosen solar company will generally follow:
Engineering site visit
Permits and documentation
Ordering equipment
Solar panel installation
Approval and interconnection

How to layout CIS Modules ~typical example~

Array:
Layout of series connected Solar modules



CIS Module



Size 1257mm×977 mm

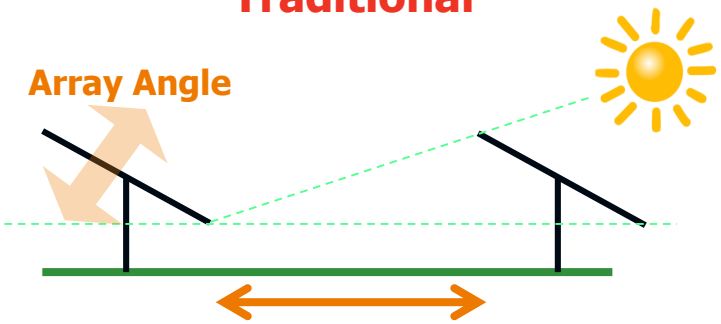
A : {4,700 − (70+200)} ÷ 979 = 4.52••• ⇒ 4 line

B : {10,000 − (50+50)} ÷ 1,259 = 7.86••• ⇒ 7 law

	SFK180-K			
Quantity(modules)	12modules	15modules	18modules	24modules
Capacity(kW)	2.16	2.70	3.24	4.32
Array area	5,640mm×3,500mm	6,900mm×3,500mm	8,160mm×3,500mm	10,680mm×3,500mm

Standard Layout on Ground

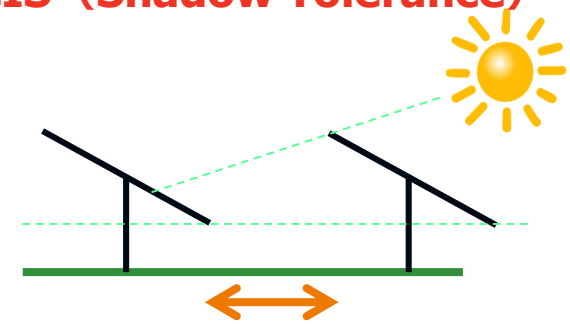
Traditional



Standard Layout
■ Completely avoid of shadow on modules and keep enough distance between arrays

✓Less output per m2
✓Need more area

CIS（Shadow Tolerance）



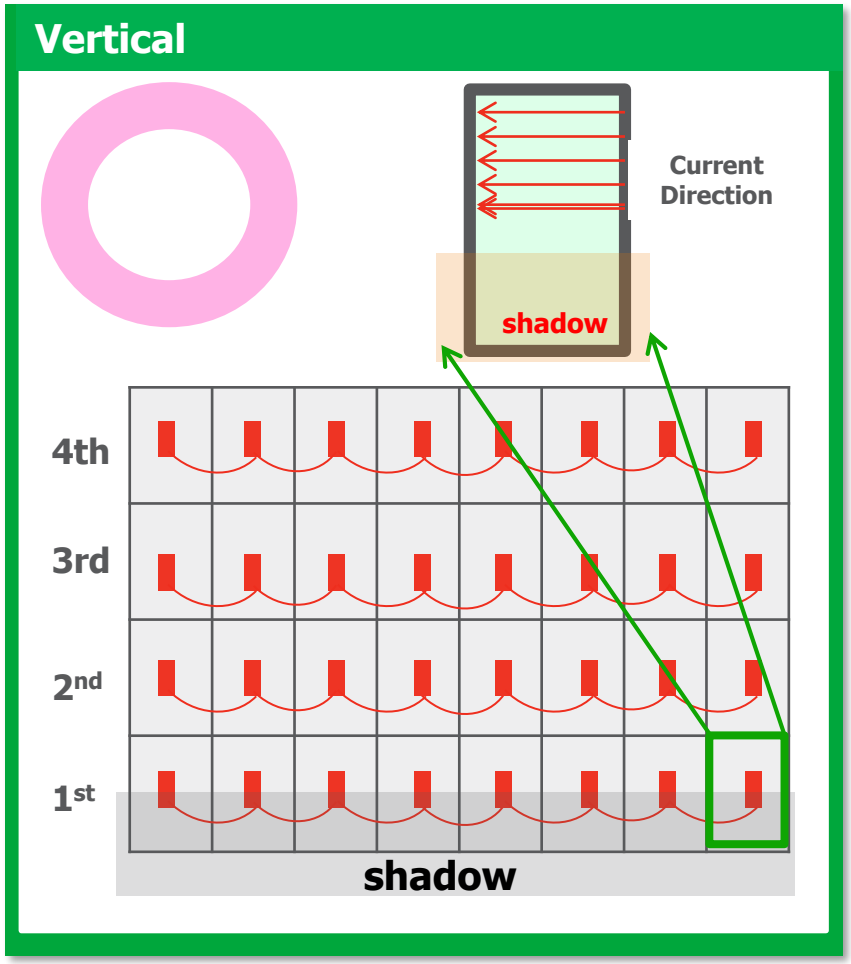
CIS Layout
■ Narrow array distance as much as possible even partially covered by shadow on the first row
■ Shadow tolerance enables this layout

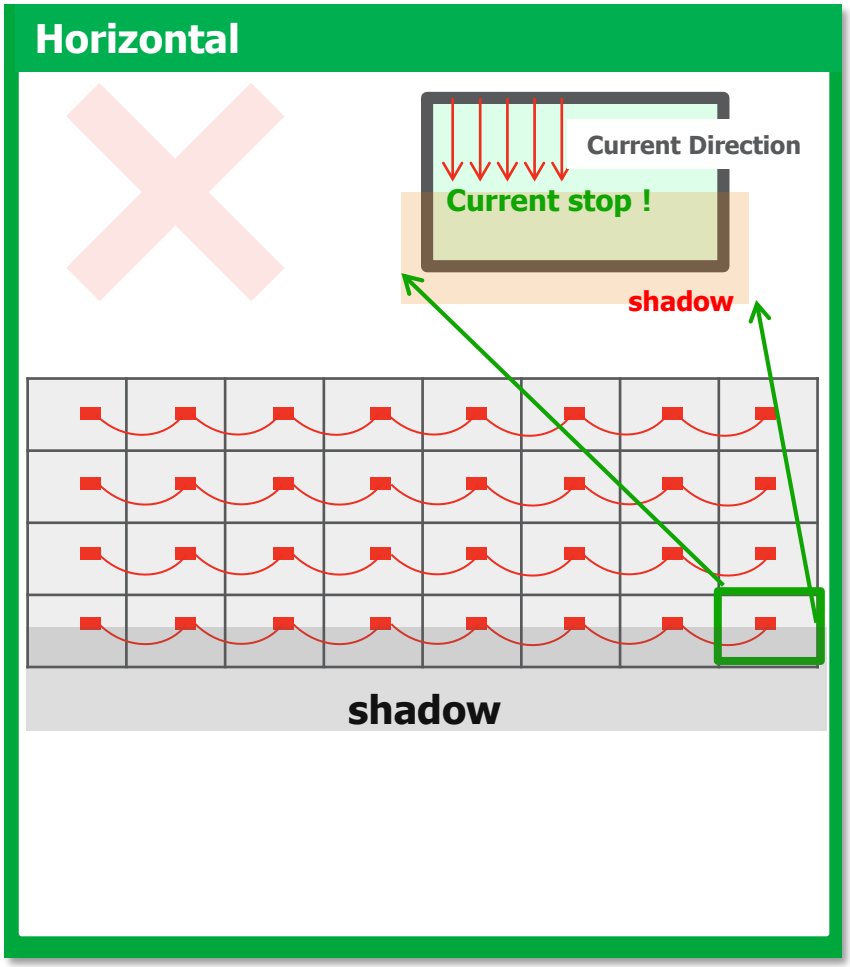
✓More output per m2
✓Less area needed

SOLAR FRONTIER

Layout on Ground

Vertical Installation is recommended to maximize CIS advantages.





Layout capacity for roof top

Maximum system voltage:
Vsys = 450 V

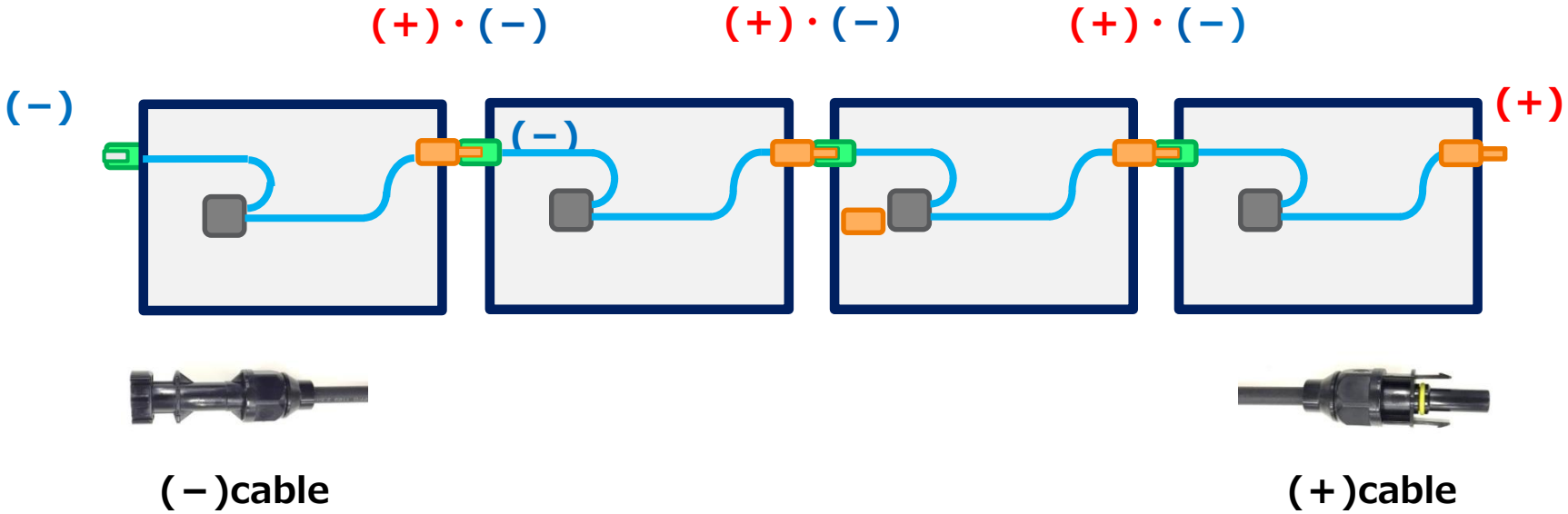
Power conditioner		KPK3 series		KPM series	
	Power conditioner capacity	4.0 kW	5.5 kW	4.4 kW	5.5 kW
SFK180-S	series	2~3	2~3	2~3	2~3
	parallel	14	19	13	16
	Capacity	27	36	30	36
DC		4.86 kW	6.48 kW	5.4 kW	6.48kW

Number of series	Open circuit voltage		OK or not
2series	120 × 2series = 240V		◎
3series	120 × 3series = 360V		◎
4series	120 × 4series = 480V		✕

※over voltage

Illustrations of typical string wiring connections

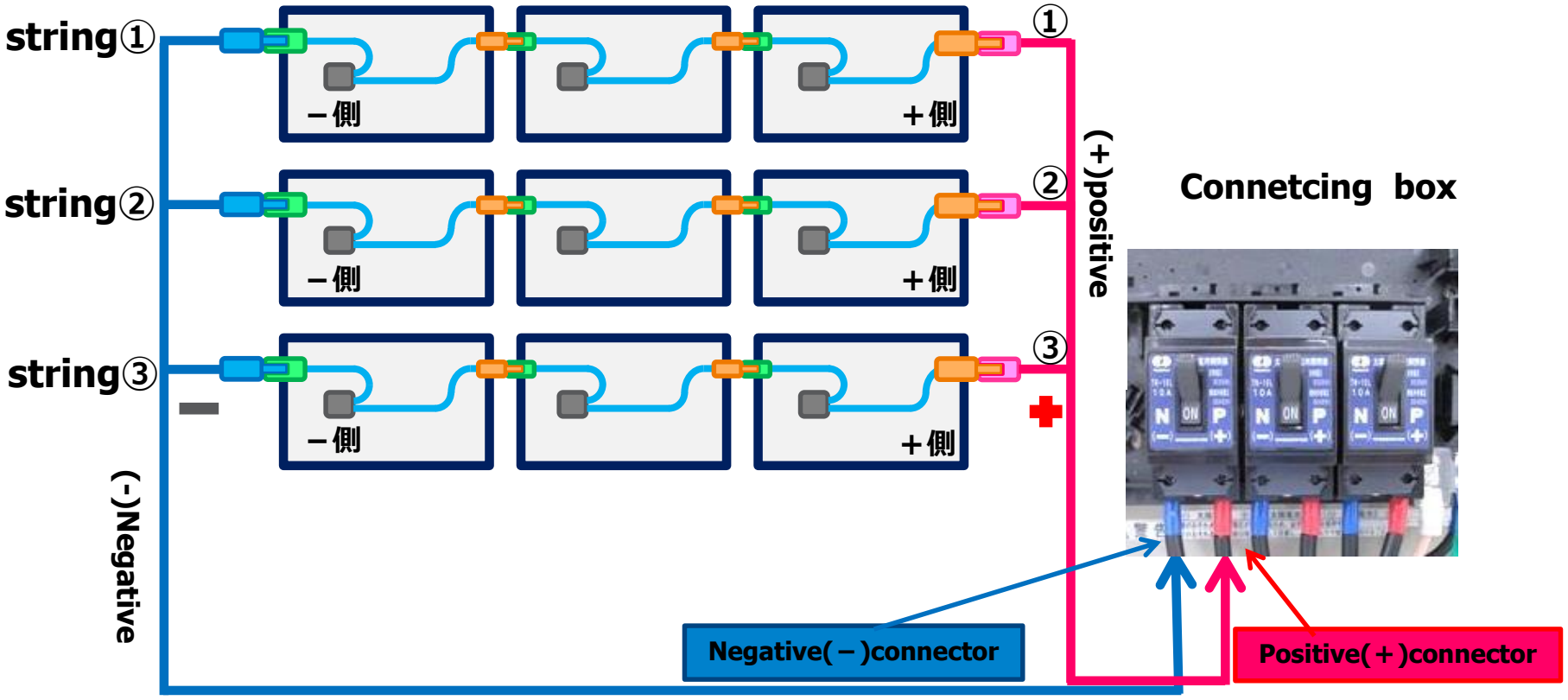
String 1



(−)cable

(+)cable

Collecting parallels into one cable



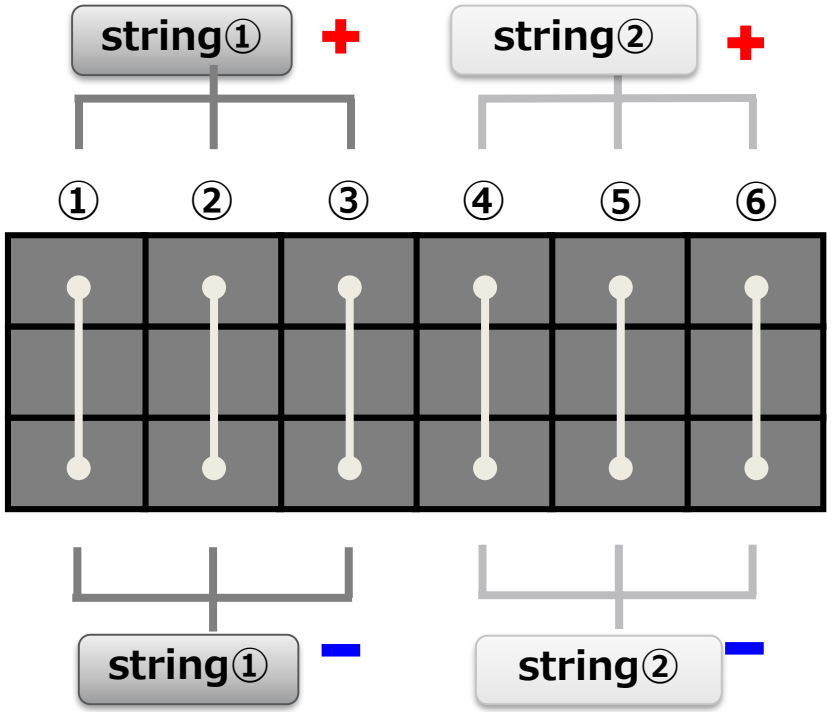
Connecting BOX

- **Advantage**: Reducing the number of cables from panels to junction boxes or inverters

SFK180-S × 18枚 = 3.24kW
3series 3pallales × 2strings

item	specification
power（Pm）	180W
series	2～3series

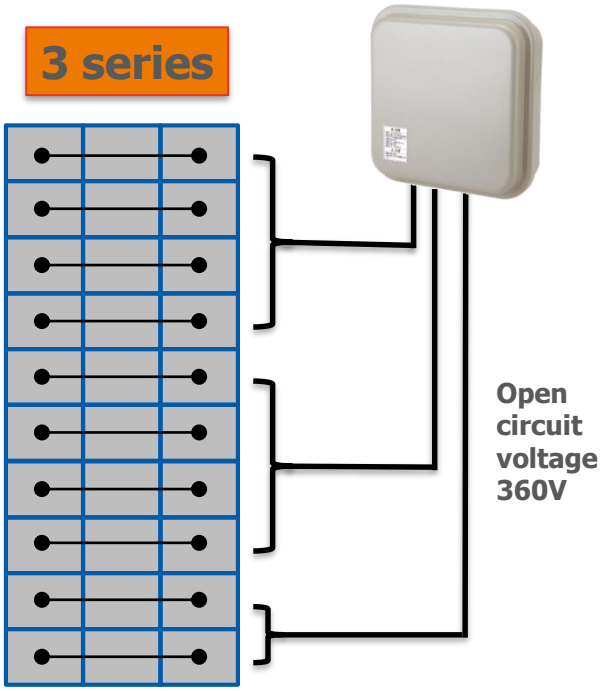
Model	SCO-03A10001	SCO-04A10001	SCO-06A10001
Number of circuits	3circuit	4circuit	6circuit
voltage	DC 0～450V		
Flat-rate input current （1circuit）	10A		
	metal(SPCE)		
Mm / W × H × D	280×280×100		350×250×100
weight	2.7kg	2.8kg	4.7kg



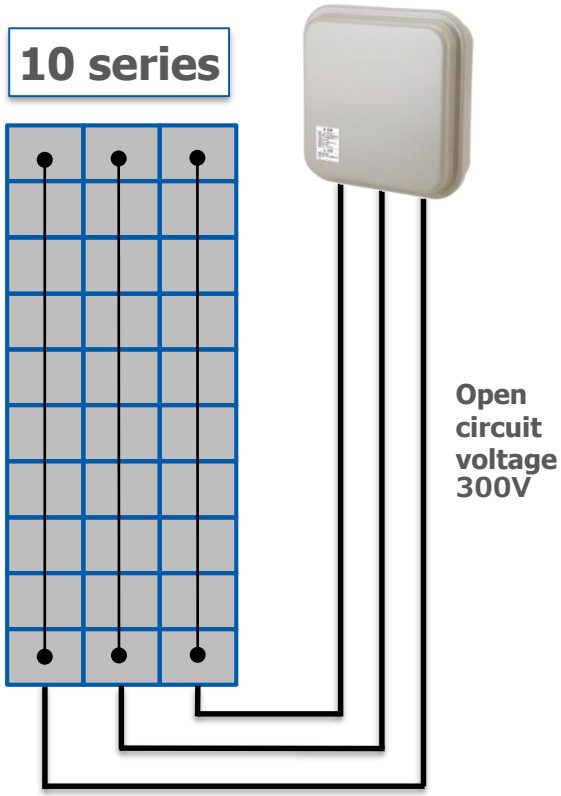
Warning of open circuit voltage

In case of CIS, it is necessary to suppress the number of series because the open circuit voltage is **high.**

【 CIS example 】
Open circuit voltage : **120V**

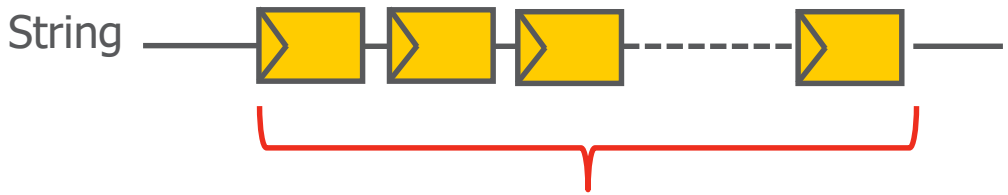


【c-Si example】
Open circuit voltage : 30V



Maximum Number of Modules in One String

How to Connect CIS modules



Maximum system voltage: Vsys = 1,500 V

$N_{modules} \leq N_{max} =$ **X**

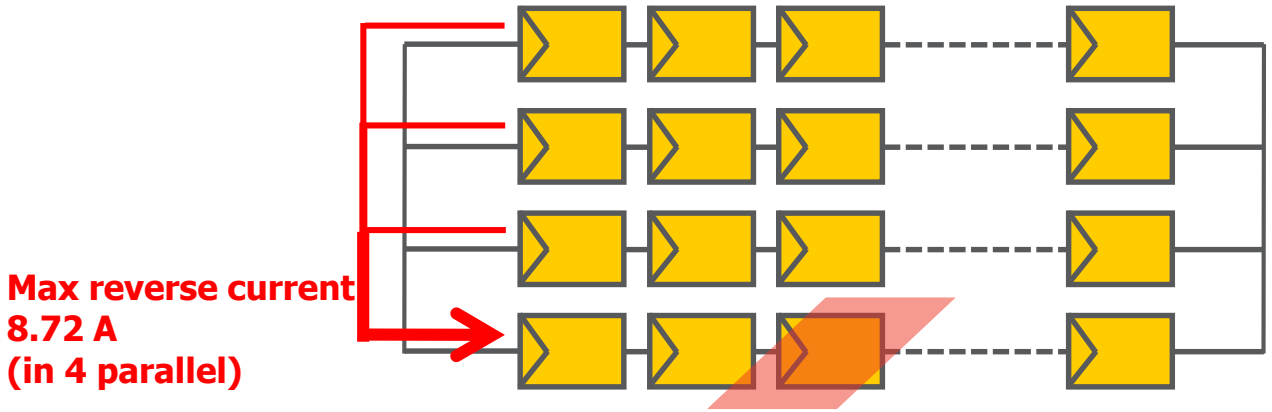
X see the Open Circuit V Table on sperate sheet

- **String voltage $V_{string} = N_{modules} \times V_{module}$**

- **Considerations for design of the maximum number of modules in one string:**
  - $V_{string} <$ Vsys
  - V_{module} = Voc (±10 % tolerance)
  - Temperature coefficient of Voc (β_{Voc})
  - Possible module temperature range (typical: -40° C / 85° C)
- **Depending on installation location, alternative temperature ranges may be possible.**

Parallel Connection of SF CIS modules

4 or less parallel connections without blocking diode (or fuse) in each string are 100% secure for Solar Frontier modules.



If a panel was broken or shaded, reverse current from the next strings flow into the string where the panel was broken or shaded.

Reverse current for SF PV module is limited up to 7A:
Max reverse current with SFK185-S in **3 parallel** connection is:
2.18A (Isc for SF185) * 3 (strings) = **6.54A** < 7A OK

Type of Collecting cable

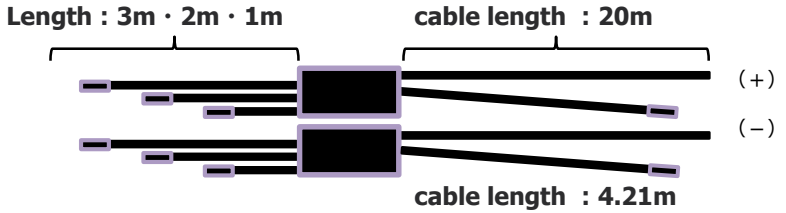
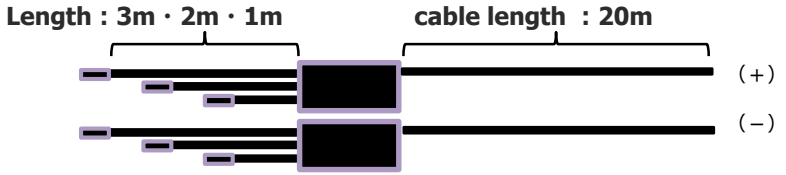
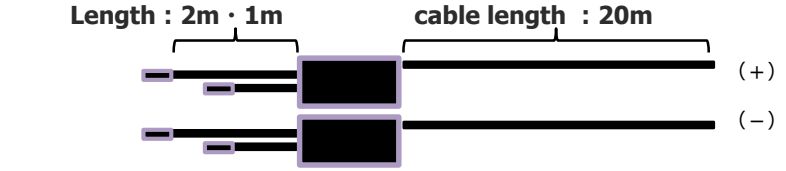
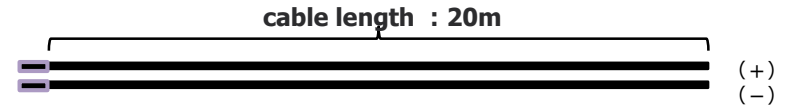
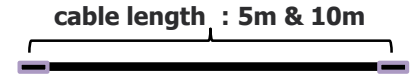
Solar Frontier have 6 types of Collecting parallels into one cable

■ connector

(+)Positive cables

(-)Negative cables

■ type

4Collecting parallels + ・ − set	
3Collecting parallels + ・ − set	
2Collecting parallels + ・ − set	
1Collecting parallels + ・ − set	
Connecting cables (5m/10m)	

Type of Collecting cable

Solar Frontier have 6 types of Collecting parallels into one cable

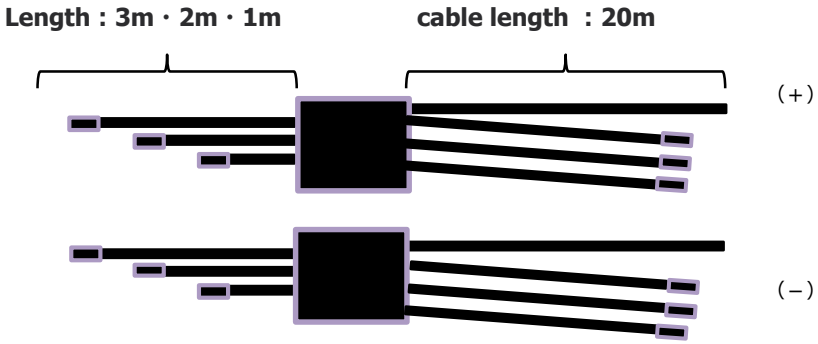
■ **connector**

(+)Positive cables

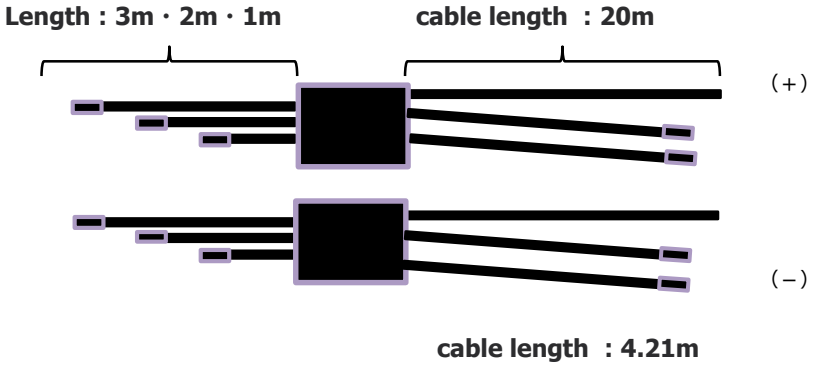
(-)Negative cables

■ **type**

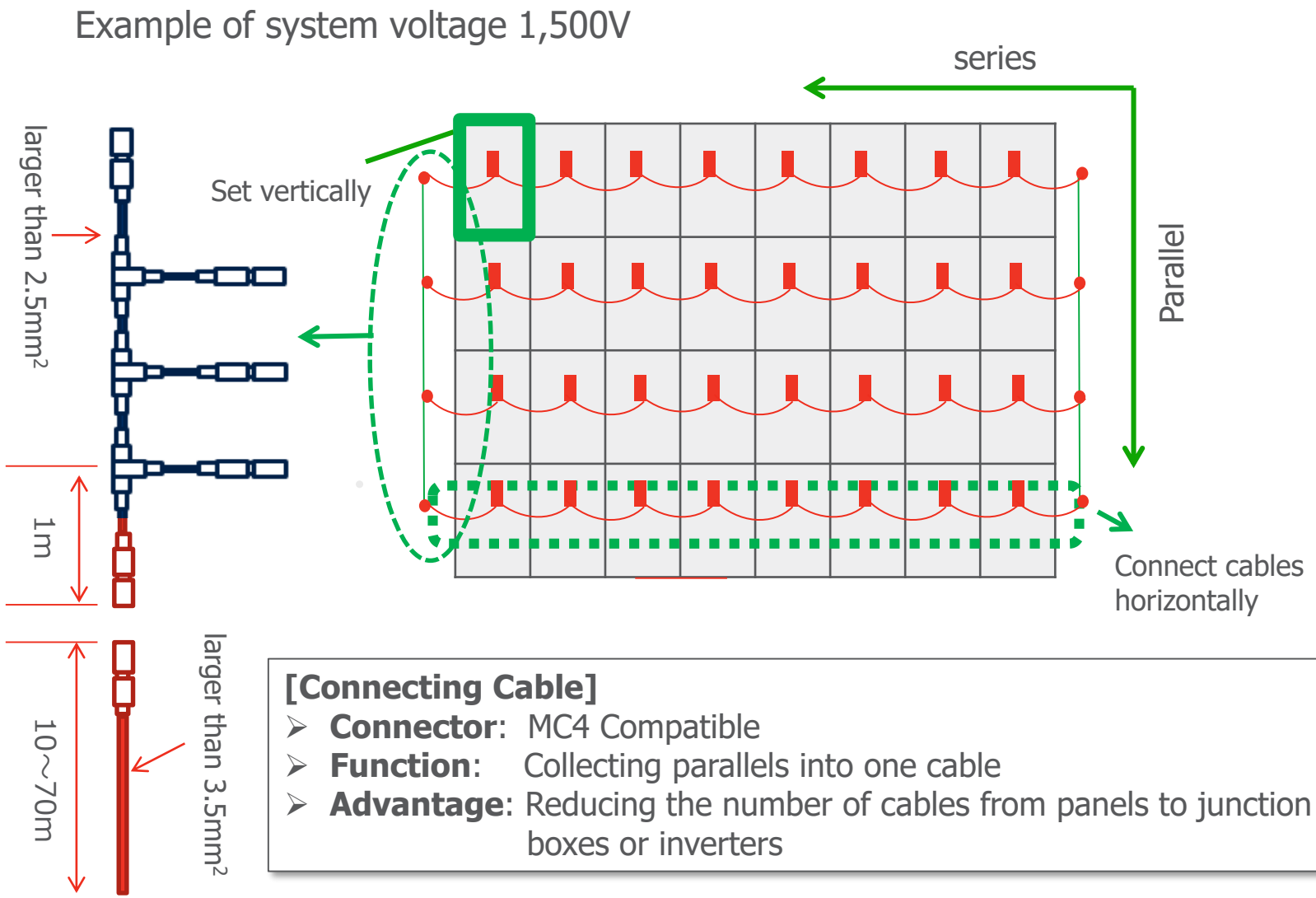
6Collecting parallels
+ ・ − set



5Collecting parallels
+ ・ − set



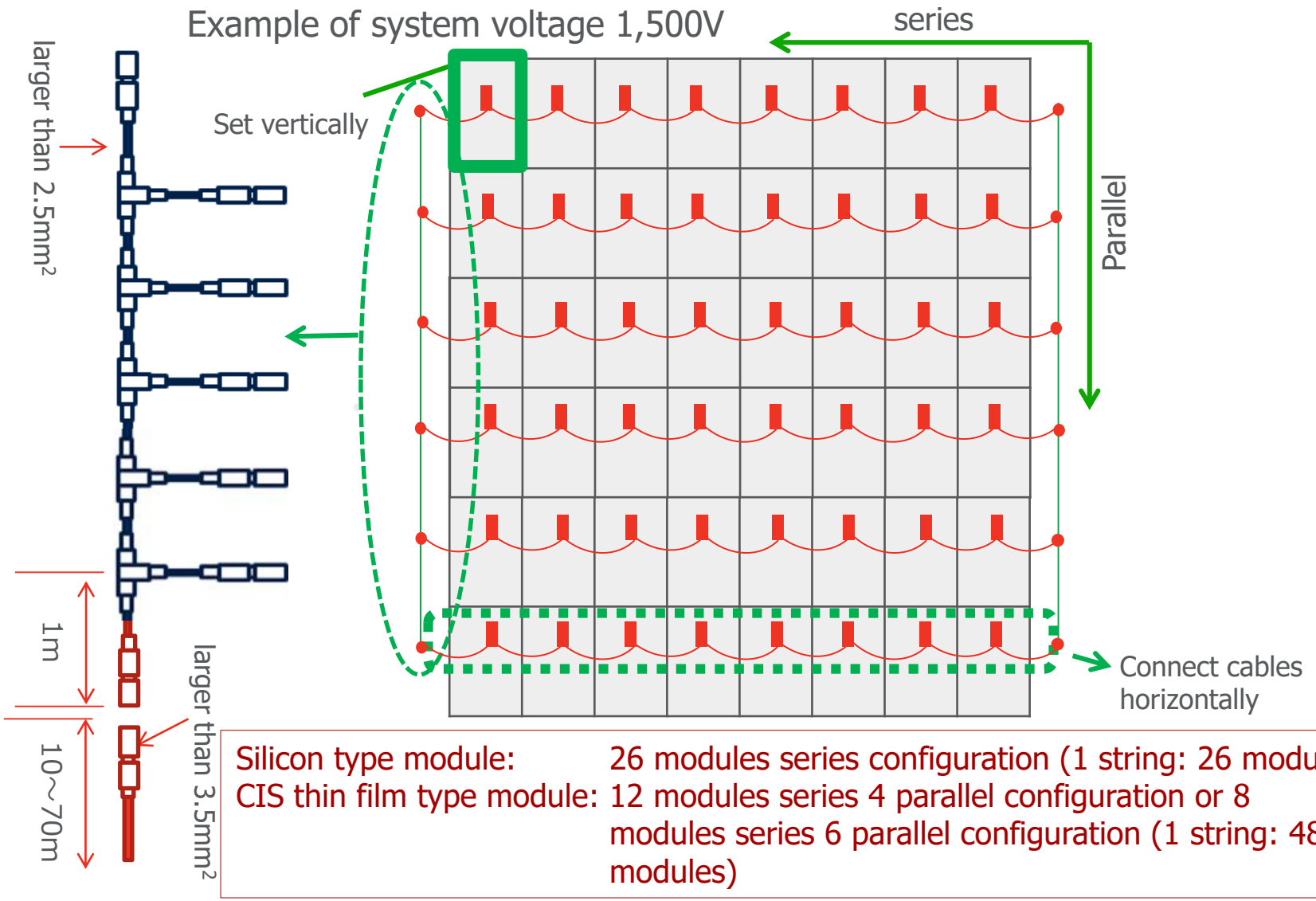
Parallel Connection and Connecting Cable (8 series 4 parallels)



[Connecting Cable]

- **Connector**: MC4 Compatible
- **Function**: Collecting parallels into one cable
- **Advantage**: Reducing the number of cables from panels to junction boxes or inverters

Parallel Connection and Connecting Cable (8 series 6 parallels)

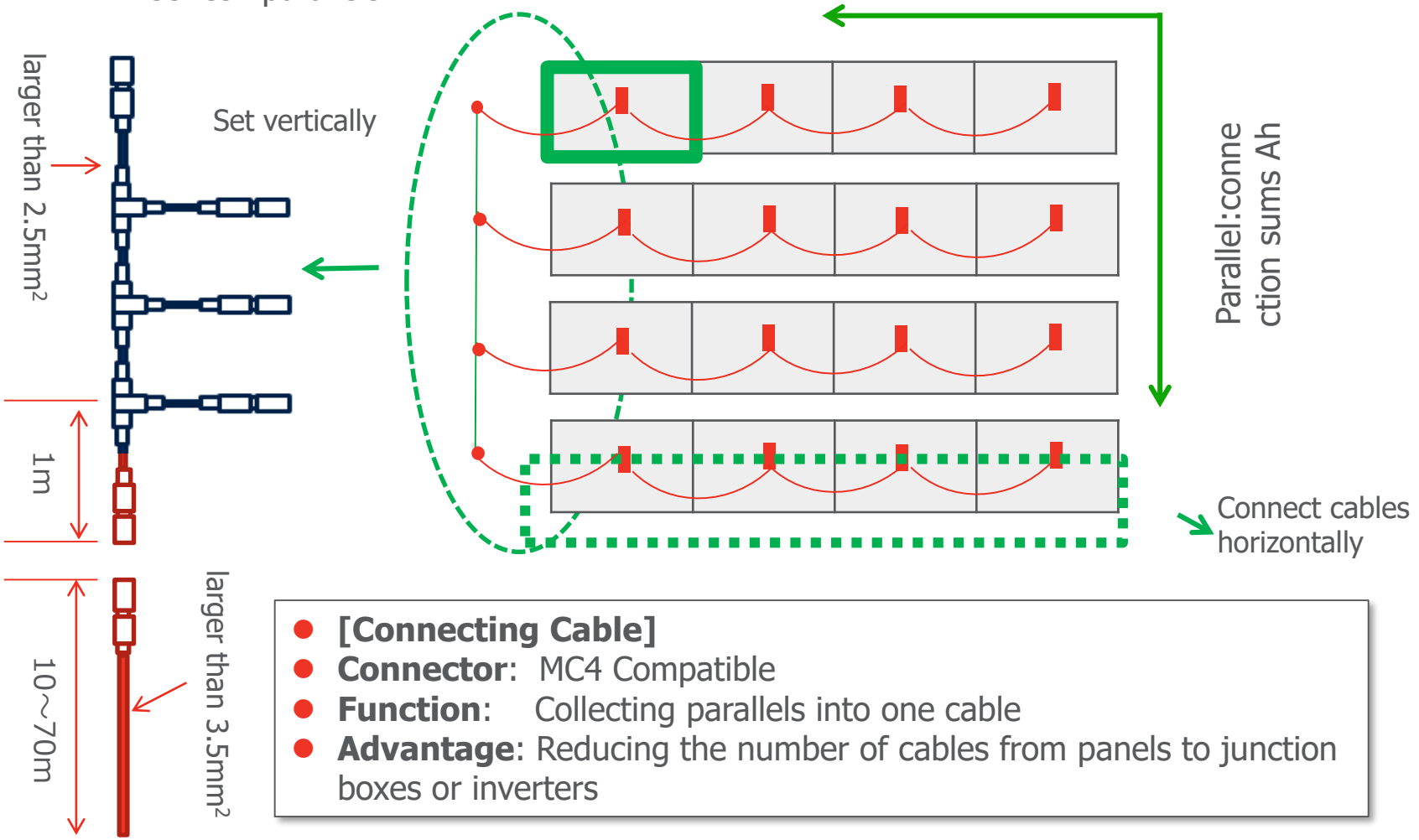


Silicon type module: 26 modules series configuration (1 string: 26 modules)
CIS thin film type module: 12 modules series 4 parallel configuration or 8 modules series 6 parallel configuration (1 string: 48 modules)

Parallel Connection and Connecting Cable (in case of Roof Top)

Example of system voltage 1,500V

- 4series 4parallels

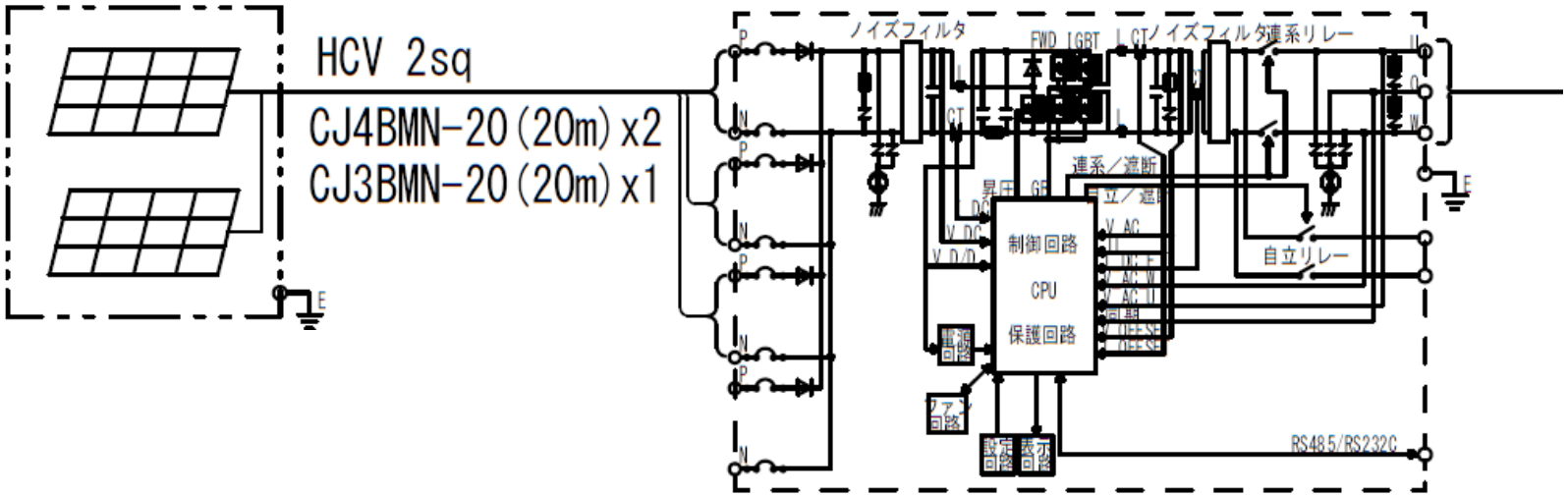


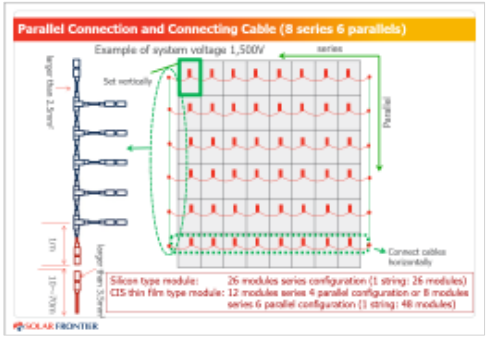
- **[Connecting Cable]**
- **Connector**: MC4 Compatible
- **Function**: Collecting parallels into one cable
- **Advantage**: Reducing the number of cables from panels to junction boxes or inverters

Sample Layout

Solar Module Array (5.61 kW)

Single phase Power conditioner (5.5 kW)





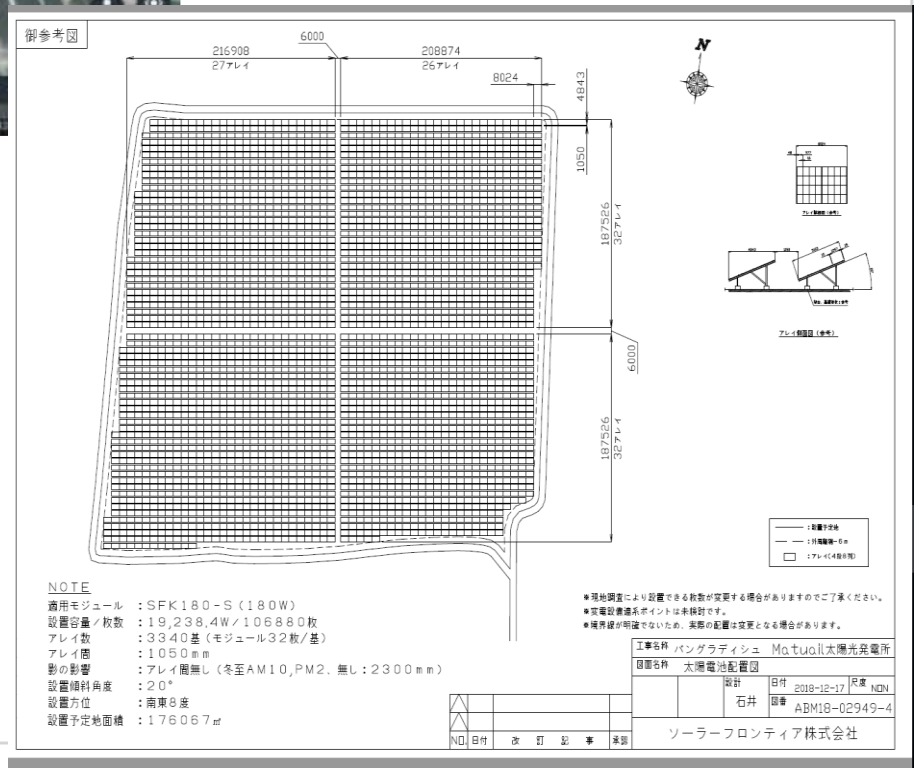
The cable can be connected up to 6 parallel lines collecting current 15 A - 20 A.
If the power conditioner of SMA has the capacity to receive up to 15 A - 20 A, it is feasible to design 6 parallel configuration.

Sample Layout from Google Map

- **Approximately 176,000㎡ required for 19 MW module space**

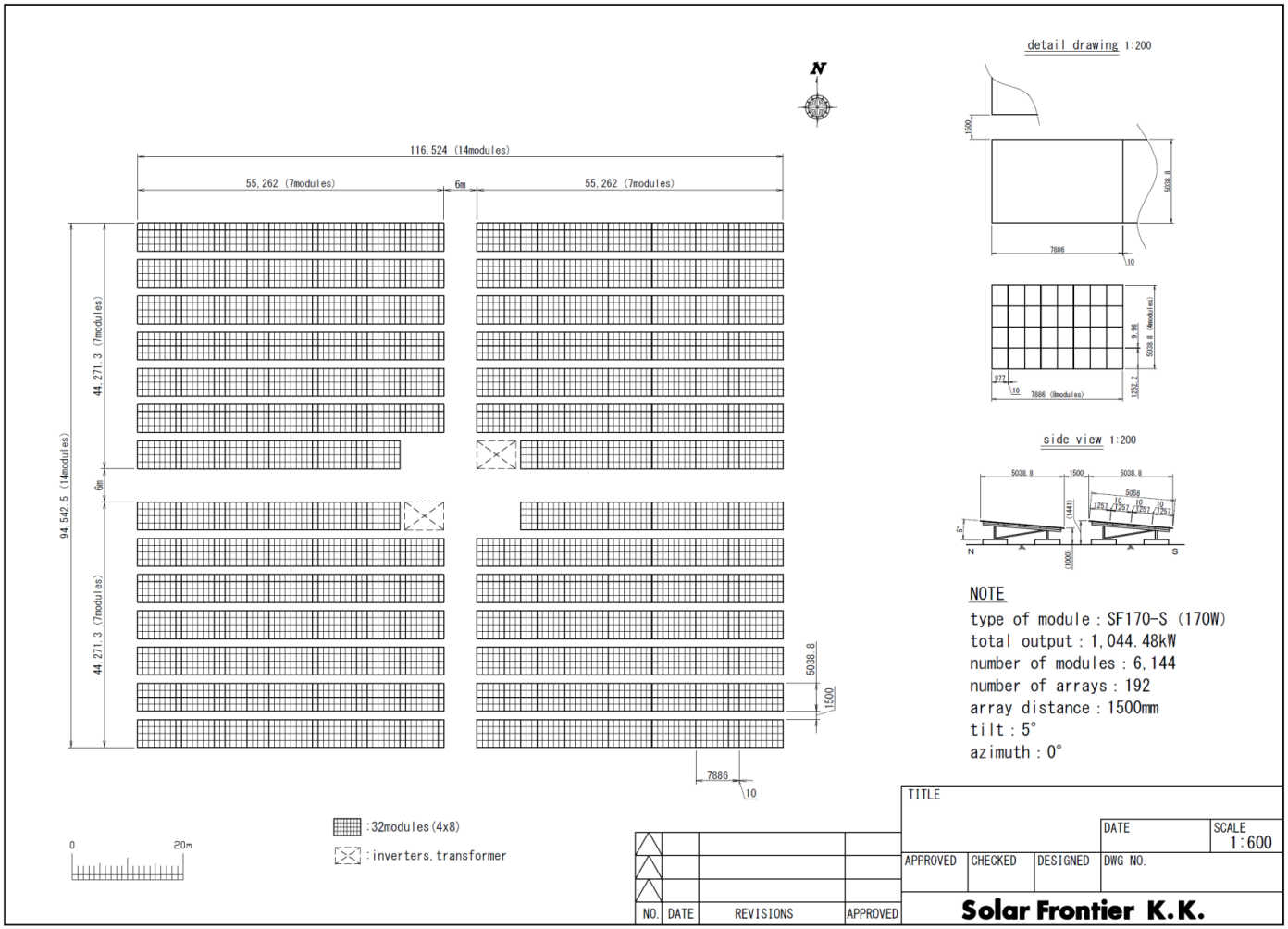
Search from Google Map

Estimated:
type of module:SFK180-S
Total output:19,238.4kW
Number of modules:106,880
Number of arrays:3340
Array distance :1,050mm
Tilt:20°
Azimuth: South East8°



Sample Layout for 1MW for illustration

- Approximately 10,000㎡ required for 1000 kW module space



Pallet Components

MP3 Panels X 25 units
Panel unit weight: 18.5 kg
Panel dimensions: 1,257 x 977 x 35 mm

Cardboard X 1

Corner Pieces X 100 (4 X 25)

Resin & Steel Pallet X 1

Pallet is shrink-wrapped and strapped

L = 132.5 cm
W = 110 cm
H = 117 cm

Total panel weight
462 kg

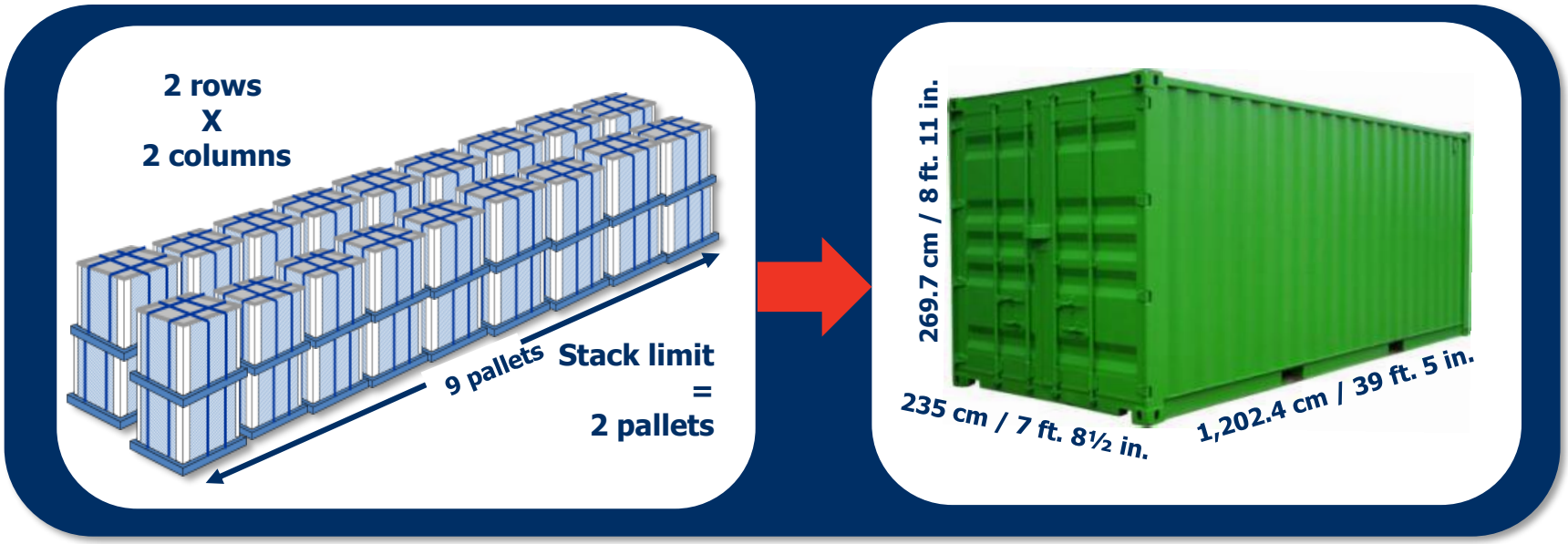
+

Packaging weight
33 kg

=

Total weight
495 kg

40FT HC Container Loading



2 rows
x
2 columns
x
9 pallets
=
36 pallets

36 pallets
x
25 units
=
900 panels

900 panels
+
packaging material
=
19.4 tons

900 panels
x
185 W per panel
=
166.5 kW
(6 containers per MW)

Solar Frontier's Warranty

Solar Frontier issues an official warranty letter as an appendix to the sales agreement after evaluating the actual site location. The foundation is: 1) A limited product (Materials and Workmanship) warranty; and 2) A limited linear power output warranty.

Direct Shippment for Asian countries

Solar Frontier is the only CIS company to have achieved production and sales at gigawatt-scale volume. We have more than 5GW cumulative sales worldwide.

India

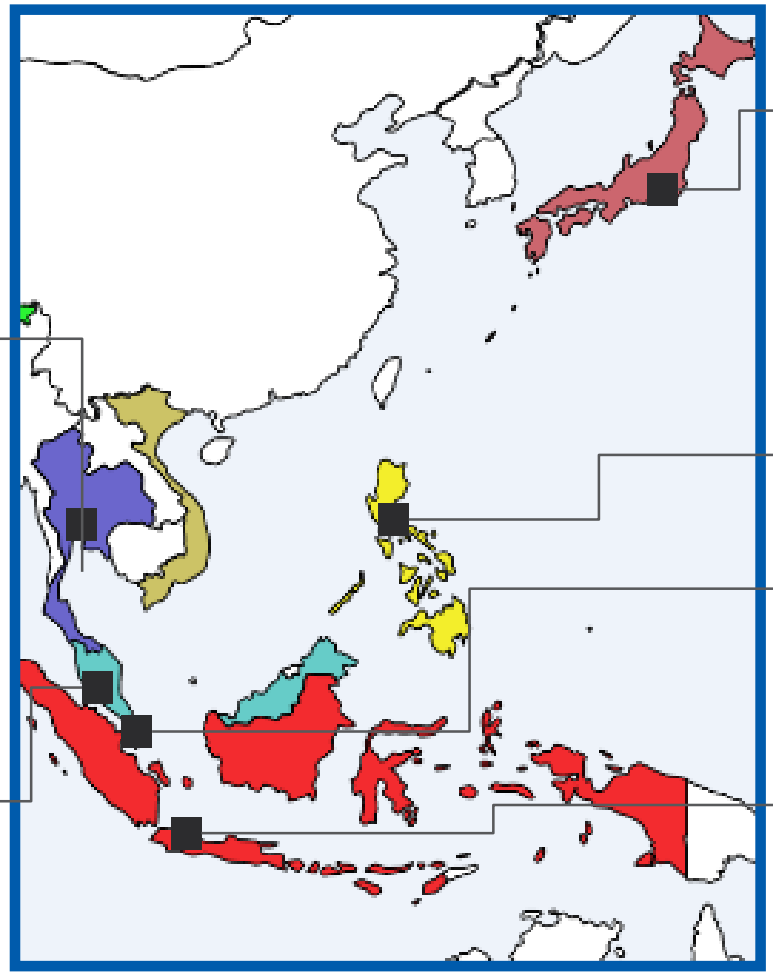
Cumulative Sales are
220MW

Thailand

Cumulative Sales are
45MW
Experiences
- Shell Thailand
- Delta Electronics
- AEON MaxValue

Malaysia

Cumulative Sales are
1MW
Experiences
- petronas



Japan

Cumulative Sales are
+3.5GW

Philippines

Cumulative Sales are
90MW

Singapore

Cumulative Sales are
10MW

Indonesia

Cumulative Sales are
1MW

Thank you

Harnessing the power of the sun to provide a cleaner, more comfortable lifestyle for everyone