FusionSolar 8.0 Smart PV Solution

SUN2000-330KTL-H2

SOLAR.HUAWEI.COM

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01 PV technology evolution and trends

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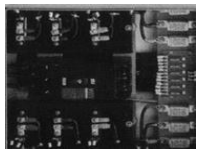
Inverter Roadmap and Evolution: Functional Machines to Smart Machines

linear power

phase-controlled power



String INV

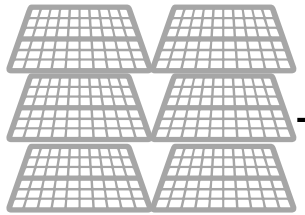
Smart String PV Inverter

V1.0: 28KW

V2.2: 36KW

V3.0: 60KW

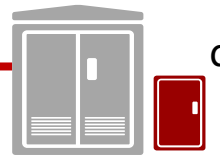
HAV3.0: 175KW/196K



Battery assembly and support system

PV string INV

MBUS



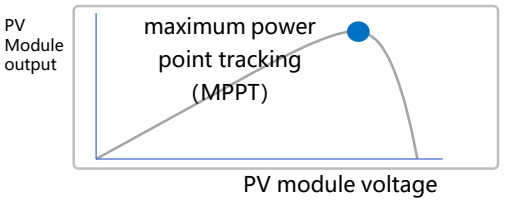
STS & SACU

data flow

Cloud Operation Center

Internet

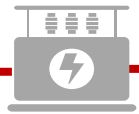
Station-level management system



combiner box

Central INV

Electricity flow



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Inverter Architecture Evolution

Central INV

SUN2000-V1.1

- Number of input strings: 6
- AC voltage: 380/400 V AC
- Rated power: 8–20 kW

SUN2000-V2.1

- Number of input strings: 6
- AC voltage: 480 V AC
- Rated power: 30–36 kW

SUN2000-V2.2
SUN2000HA-V1.1

1100 V input
- Number of input strings: 8
- AC voltage: 500 V AC
- Rated power: 50 kW

1500 V input
- Number of input strings: 8
- AC voltage: 800 V AC
- Rated power: 60 kW

SUN2000-V3.1
SUN2000HA-V2.1

1100 V input
- Number of input strings: 12
- AC voltage: 500 V AC
- Rated power: 70 kW

1500 V input
- Number of input strings: 12
- AC voltage: 800 V AC
- Rated power: 100 kW

SUN2000HA-V3.1
SUN2000-V5.1

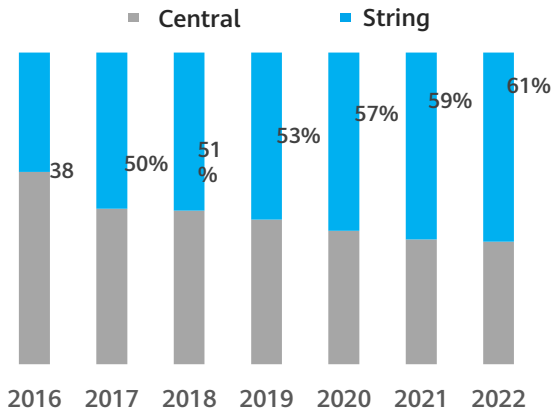
1100 V input
- Number of input strings: 20
- AC voltage: 380 V AC/500 V AC
- Rated power: 100 kW/136 kW

1500 V input
- Number of input strings: 18
- AC voltage: 800 V AC
- Rated power: 185 kW

Smart DC System
Grid-friendly support
Smart IV 4.0

HAV5 (MPPT+INV)

+1500V input, 330KTL
- Number of input strings: 28
- AC voltage: 800 V AC
- Rated power: 330 kW



➢ The development of all science and technology routes follows the direction of system efficiency improvement and cost reduction.

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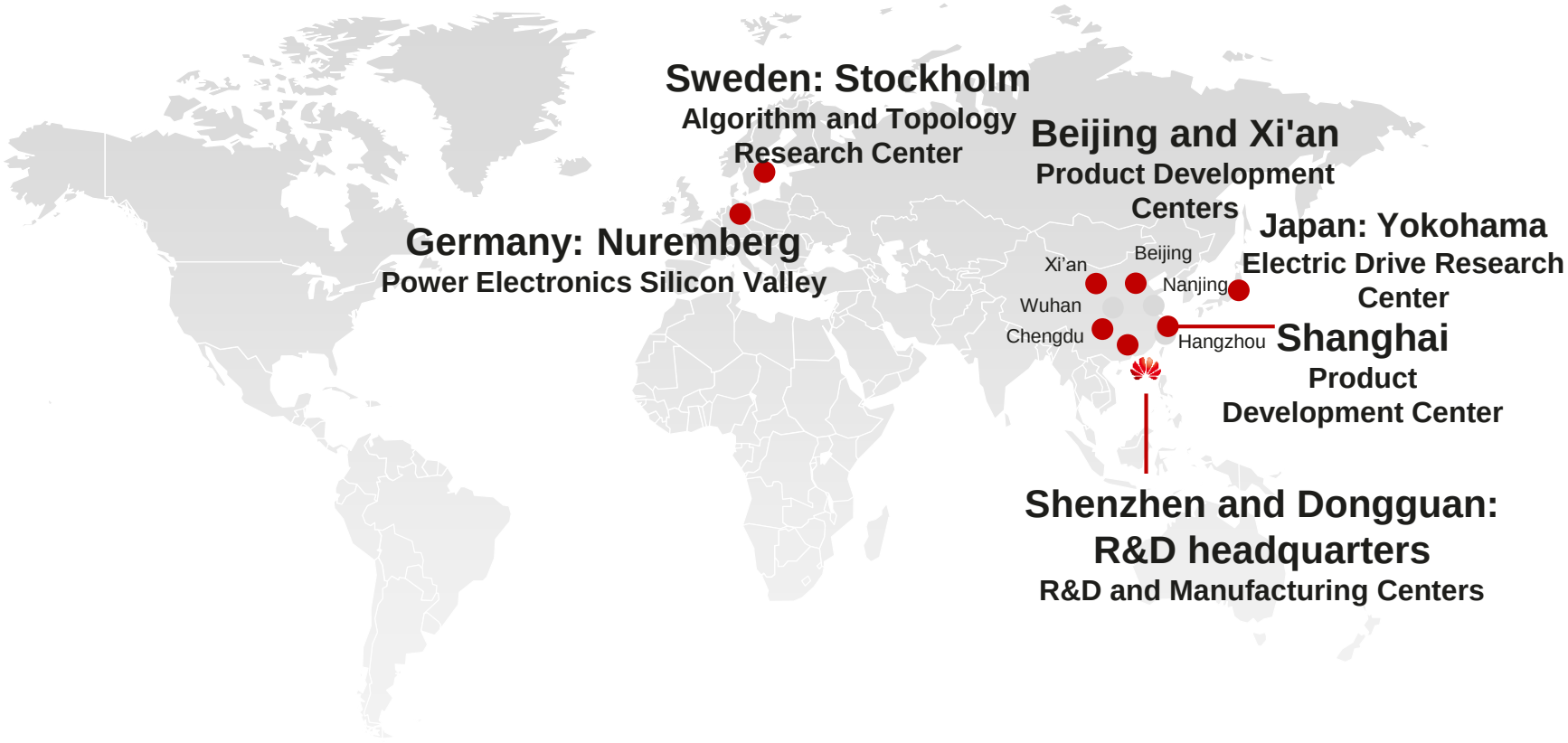
Global R&D teams and technology platforms: Leveraging the domain specific advantages globally to keep leading

- 6000+ employees
  60% R&D
- 12 R&D centers
- 10%+ R&D investment
- 1300+ patents



Smart PV: All-scenario PV & storage solution, accelerating the shift to zero carbon generation

PV & storage Utility solution

Challenges: High PV LCOE and weak grid problem

Trend: **PV & storage coordinated solution,creating the smart PV generator and accelerating the shift to zero carbon generation**

C&I solution

Challenges: High electricity cost and low system safety

Trend: **Green C&I power solution with integrated PV & storage architecture, entering thousands of C&I fields and adapting to different scenarios**

Residential solution

Challenges: High safety risks and low system safety

Trend: **"1+3+X" architecture, increasing the self-consumption ratio and reducing the electricity cost**

Microgrid solution

Challenges: High diesel generators cost and pollution

Trend: **Comprehensive off-grid fuel removal PV & storage solution, helping bridge the energy divide**

Utility-scale PV plant

The largest single-site PV project, Qinghai, 2.2 GW

Commercial & industrial PV rooftop

Longyang road metro station PV project, Shanghai, 3.66MW

Residential PV rooftop

X

Family green power PV & ESS project, Dongguan, 30kW

Island off-grid PV power station

Maritime bureau PV & off-grid energy supply project, Zhuhai, 24kW

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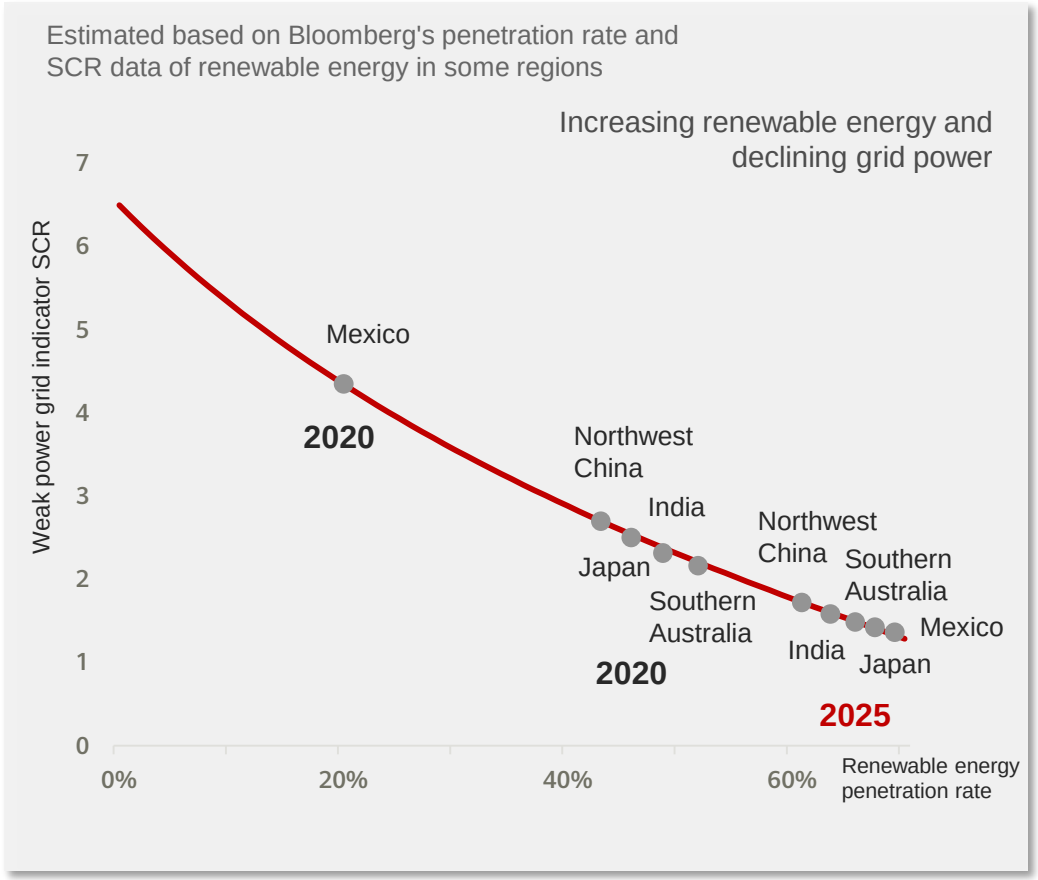
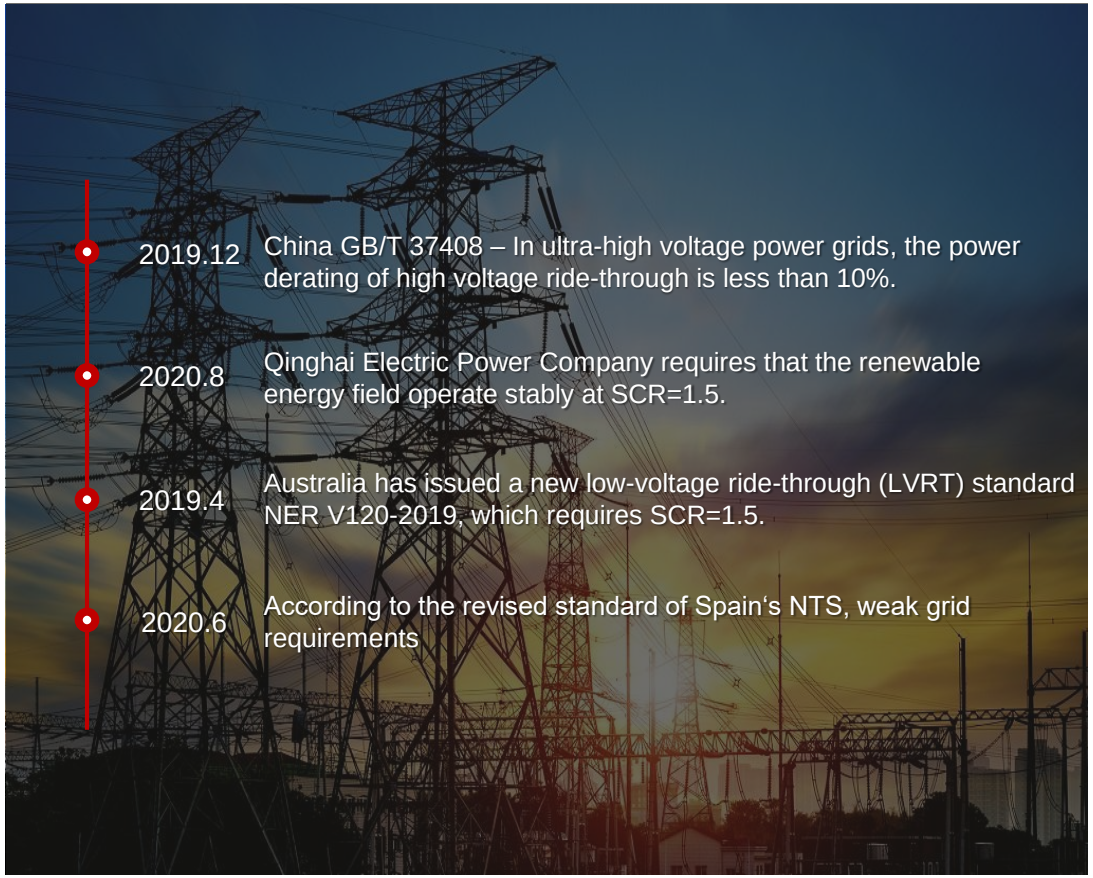
Renewable energy penetration rate increases, power grid declines, and requirements for power grid friendliness increase rapidly

In the next five years, half of global power grids will be declining.



The power grid declines rapidly, and the stability problem becomes more and more serious.
The requirement for power grid friendliness is rapidly increased.



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02 Introduction of Huawei PV Solution

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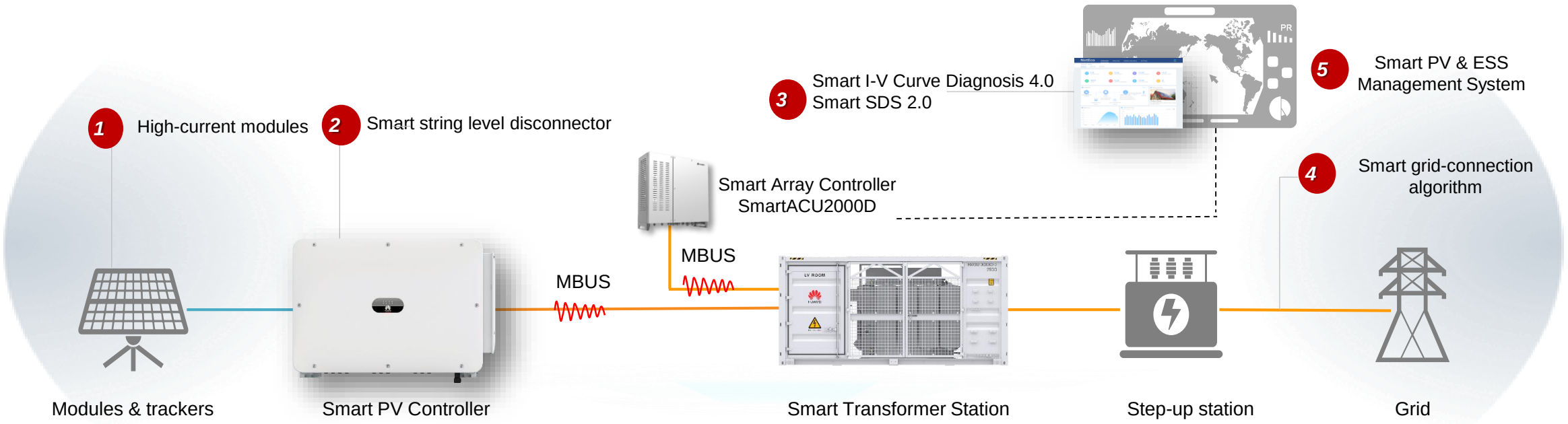
FusionSolar : Higher Yields, Safe and Reliable, Smart O&M, and Grid Forming



Higher Yields

- Perfectly match high-current modules, especially 210mm
- Smart SDS, yields increased by 1%

Smart O&M

- Smart I-V Diagnosis 4.0
- Smart PV & ESS management system

Safe and Reliable

- DC safety: Smart string level disconnector
- IP66 fully sealed

Grid Forming

- Full power operation even SCR low to 1.1 (full output)
- THDi ≤ 1%, SCCR supported to 0.7

US$0.031-0.046/kWh

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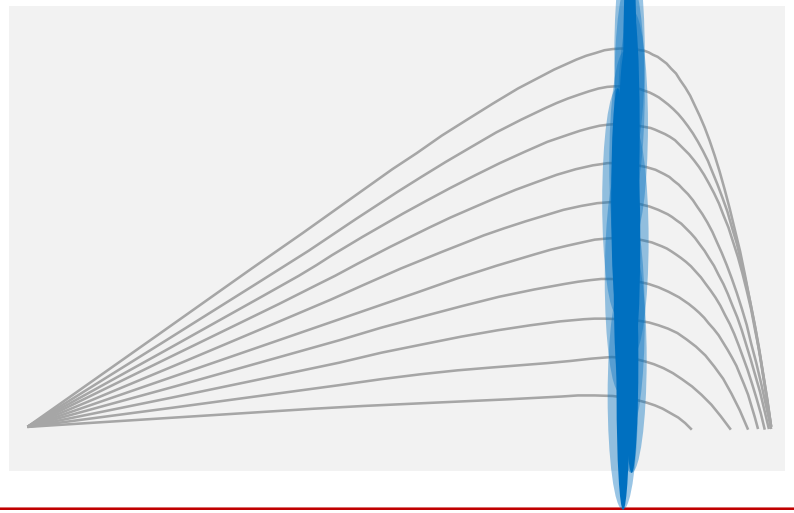
Industrial-leading Dynamic MPPT Efficiency

Better Ability to Capture Max. Power Point in Actual Operation

Huawei Smart PV Inverter

Dynamic MPPT Efficiency 99.839%

Find max power point at the highest speed when irradiation changes

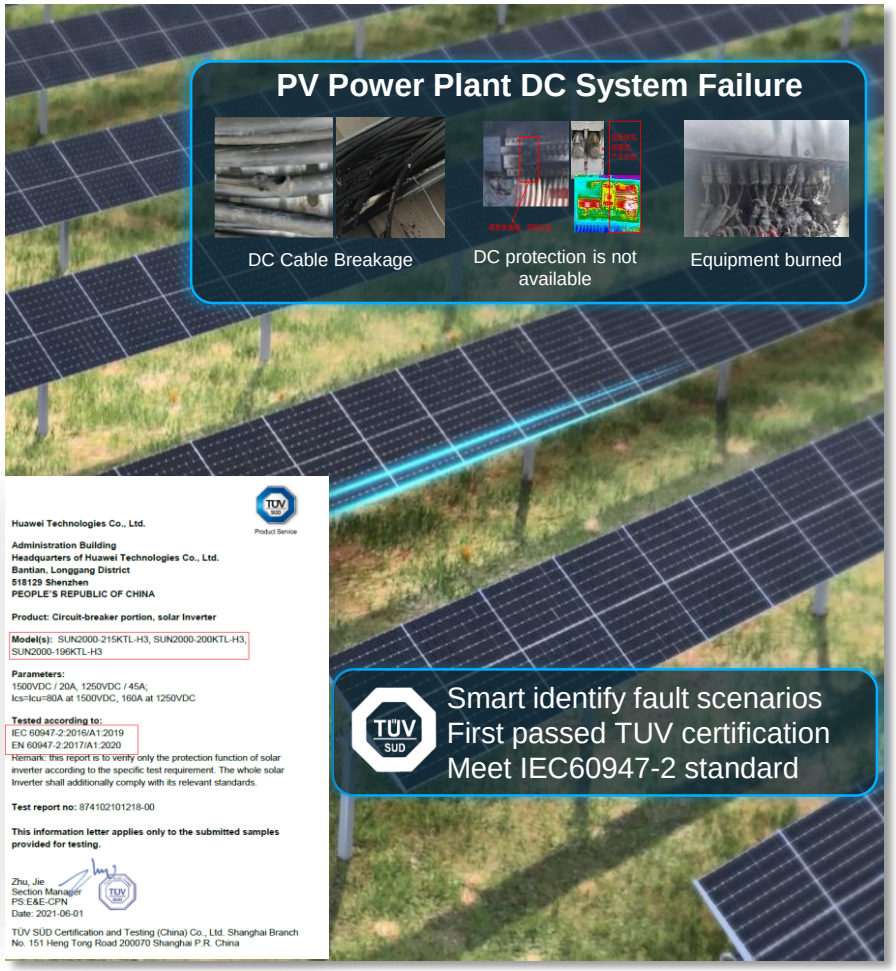


	Huawei Smart PV Inverter	Other String Inverter	Huawei Advantage
1500V Dynamic MPPT Efficiency	99.828%	99.637%	0.191%
1100V Dynamic MPPT Efficiency	99.839%	99.35%	0.489%

*Total dynamic efficiency = arithmetic mean of the piecewise dynamic efficiency of all the total test period——HAV3 series

Smart string level disconnector: Precise fault detection, rapidly disconnect DC system faults

Smart String-Level Disconnector



Huawei Technologies Co., Ltd.

Administration Building
Headquarters of Huawei Technologies Co., Ltd.
Bantian, Longgang District
518129 Shenzhen
PEOPLE'S REPUBLIC OF CHINA

Product: Circuit-breaker portion, solar Inverter

Model(s): SUN2000-215KTL-H3, SUN2000-200KTL-H3, SUN2000-196KTL-H3

Parameters:
1500VDC / 20A, 1250VDC / 45A;
Ics=Icu=80A at 1500VDC, 160A at 1250VDC

Tested according to:
IEC 60947-2:2016/A1:2019
EN 60947-2:2017/A1:2020

Remark: this report is to verify only the protection function of solar inverter according to the specific test requirement. The whole solar Inverter shall additionally comply with its relevant standards.

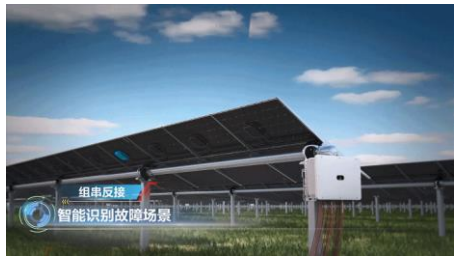
Test report no: 874102101218-00

This information letter applies only to the submitted samples provided for testing.

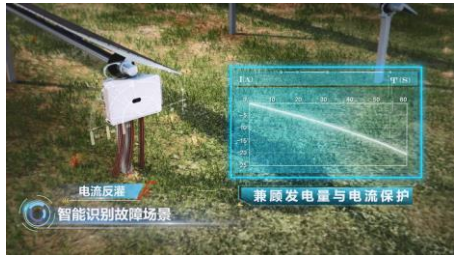
Zhu, Jie
Section Manager
PS:E&E-CPN
Date: 2021-06-01

TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch
No. 151 Heng Tong Road 200070 Shanghai P.R. China

15ms Automatic Disconnect



Scenario 1：String fault connection



Scenario 2：DC input current reverse-flow

Scenario 3：inverter internal short circuit

Success Case

CSI Brazil
100MW

Solaria Spain
50MW

Hebei China
50MW

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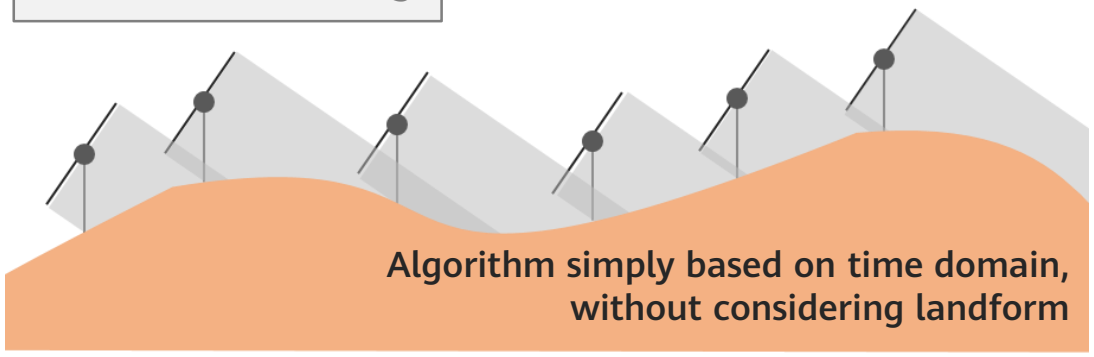
AI BOOST Optimizes Tracker Control Tracking Algorithm

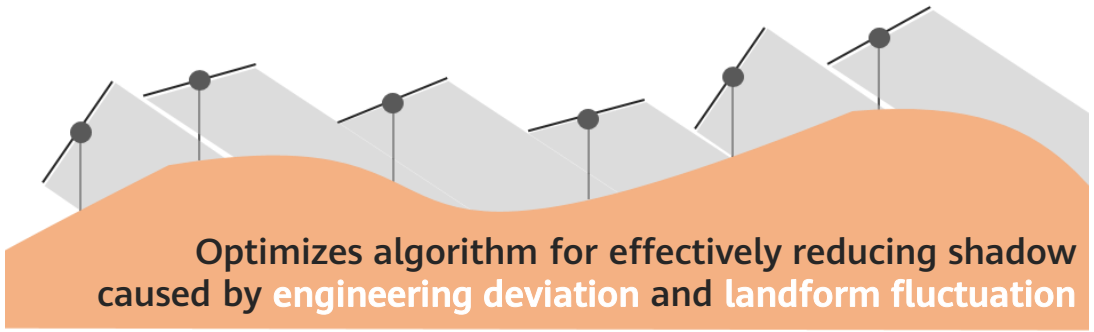
Traditional Tracking



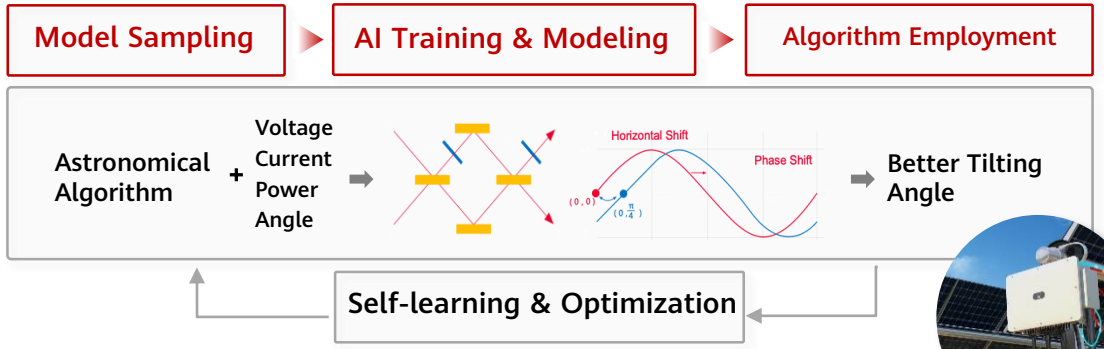
Algorithm simply based on time domain, without considering landform

Smart PV Solution

Optimizes algorithm for more capturing more irradiances during **rainy or cloudy** days



Optimizes algorithm for effectively reducing shadow caused by **engineering deviation** and **landform fluctuation**



Brief Description of deploying Smart DC System

Tracker Type	Flat single axis tracker
Data Analysis	Control and calculation based on power value of PV strings collected by smart string inverters
Comm. Solution	Tracker controller connected to the inverter via RS485) **Tracker controller ->RS485-> inverter -> SmartLogger.**
Quantity Limitation	Quantity of controller supported by a single inverter **≤16**
Cooperated vendors	Arctech Solar, TK NEW ENERGY, MOKUN, Clenergy

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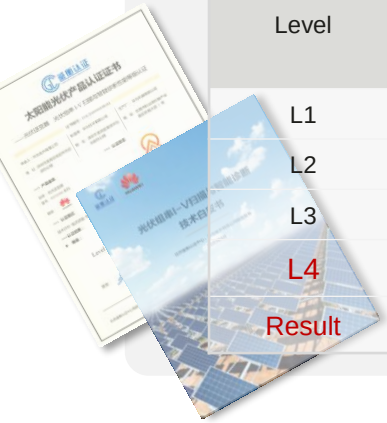
Smart IV Curve Diagnosis 4.0: Online and Full diagnosis, Reducing O&M Costs

Recall ratio, consistency, accuracy >95%

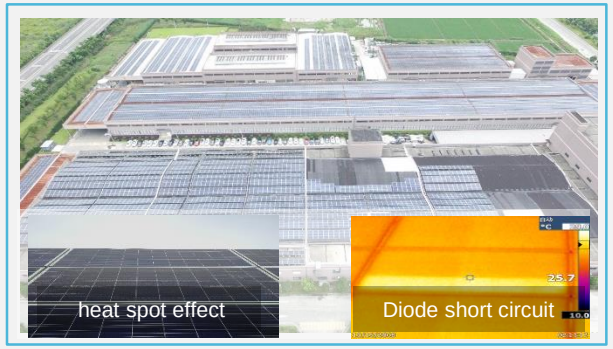
L4 Highest Level in the Industry



Level	Exception identification		Fault Diagnosis
	Recall rate[1]	Recurrence rate[2]	accuracy[3]
L1	≥75%	≥70%	≥70%
L2	≥85%	≥80%	≥80%
L3	≥90%	≥85%	≥85%
L4	≥95%	≥90%	≥90%
Result	100%	96.23%	96.8%

Worldwide Application >15GW, improving O&M efficiency

Project：XX Rooftop PV Plant, Ningbo, Zhejiang



528 Total String | **62** Faulty String | **11.7%** Failure Rate

Project：XX PV Plant, Yangquan, Shanxi

3960 Total String | **188** Faulty String | **4.7%** Failure Rate

Smart IV Curve Diagnosis

Better adaptability

- large-scale ground & mountain scenarios；
- Compatible with mainstream components such as half-chip, tile, 166, 182, and 210

Loss assessment

- Quantifying the power generation loss of a faulty string
- Plant O&M Guide

Scheduled scanning

- Periodic diagnosis and email results for a good experience

Integrated by ISVs

- Open API (Restful)
- Integrated by ISVs (2021Q4)

Fine-grained data

- The inverter automatically obtains radiation.
- String-level parameter configuration

Higher availability

- overview report, diagnosis curve report, and fault O&M report.
- Provide raw data for customer self-development.

Smart I-V Curve Diagnosis 4.0: Online and Full diagnosis, Reducing O&M Costs

Traditional I-V Testing VS Smart I-V Curve Diagnosis

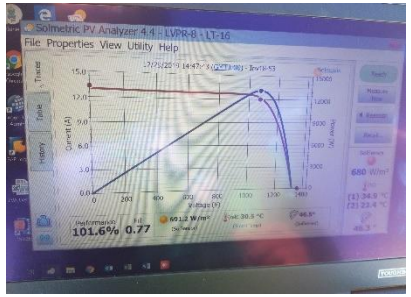
	Traditional I-V Testing	Huawei Smart I-V Curve Diagnosis
Tools Cost	Four sets of instruments & Software $46,200	Only Software
Time(300MW Inspection)	30 Days	30 Minutes
Yields Loss	Inverter Off When Testing $4,886	Almost Zero
Labor Cost	12 Professionals $24,000	No professionals required, just O&M staff is sufficient
Total	**$75,086**	-

I-V Test for Twice per Year

Traditional OPEX 500 $/MW per Year

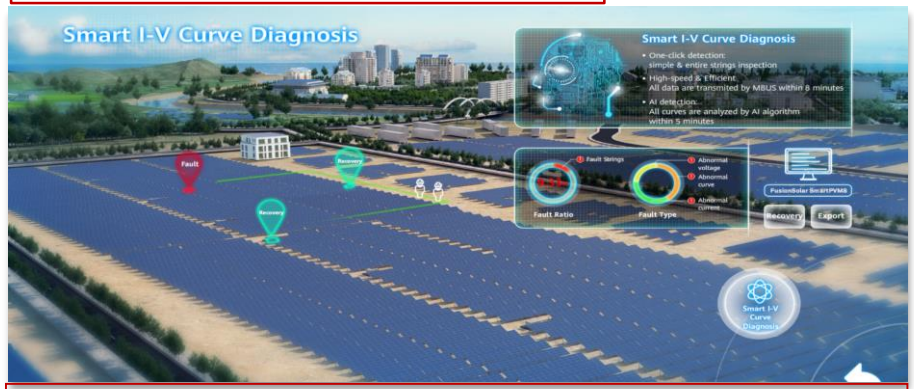
Data sourced from SAKAKA 300MW projects

Traditional I-V Testing



Onsite inspection | **Loss** of Yields | **Manual** Analysis & Reporting

Smart I-V Curve Diagnosis



Online inspection | **No Loss** of Yields | **Auto** Reporting

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Malaysia Asia Meranti LSSPV Plant 30MW

ASIA MERANTI SDN. BHD. (493243-M)
Lot 6298, Jalan Taiping, 34200 Parit Buntar, Perak, Malaysia.
Tel: 05-717 6331, 717 6332 Fax: 05-717 6099
Email: asiameranti@gmail.com

Date : 10th Feb 2021

Dear Huawei Team,

Commendations for Exceptional Service and Outstanding Product Capability

- LSSPV Plant of 10MWac at Daerah Larut & Matang, Perak
- LSSPV Plant of 10MWac at Daerah Kampar, Perak
- LSSPV Plant of 10MWac at Daerah Kinta, Perak

We thank you for your service and great support in the implementation our LSS plants.

Since the commissioning of our 3 facilities in 2019Q4, the Huawei Inverters installed in our facilities have been running smoothly.

The Smart I-V Curve function has also helped us tremendously in maintaining the efficiency of our facilities. The ability to perform diagnostics on PV module arrays at the string level remotely have saved us more than 2000 man-hours in O&M activities. On top of that, being able to identify and attend to the underperforming PV arrays early have allowed us to recover more than RM7,400.00 in potential revenue loss across all 3 facilities.

We also would like to express our gratitude to Mr. James Lee and Mr. Farhan b. Zainu[illegible] professionalism and continuous assistance in providing us with technical support[illegible]bout the installation and operation of our facilities.

Sincerely,
For and on behalf of
Asia Meranti Sdn Bhd

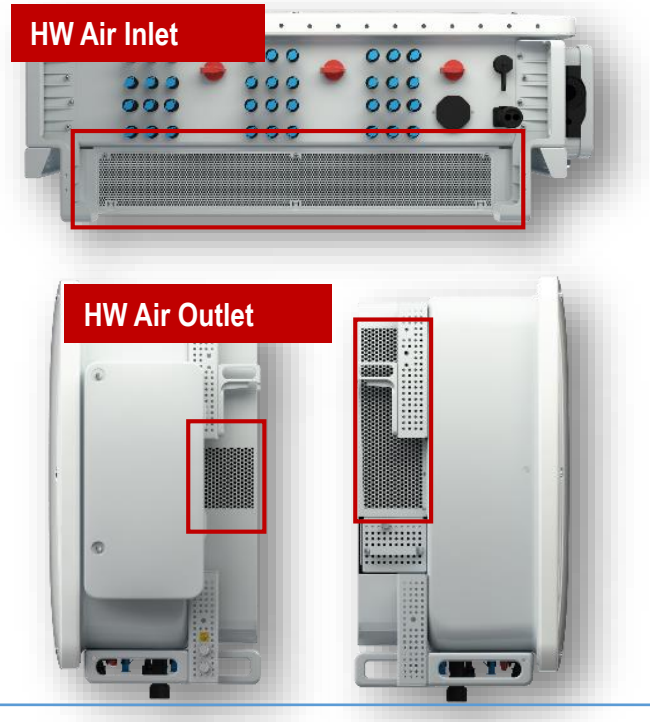
Zack Yong
Director

The **Smart I-V Curve function** helped us tremendously in **maintaining the efficiency** of our facilities. The ability to perform diagnostics on PV module arrays at the string level remotely **have saved us more than 2000 man-hours in O&M activities.** On top of that, being able to **identify and attend** to the **underperforming PV arrays** early have allowed us to **recover** more than **RM7,400.00** yearly in potential **revenue loss** across all 3 facilities.

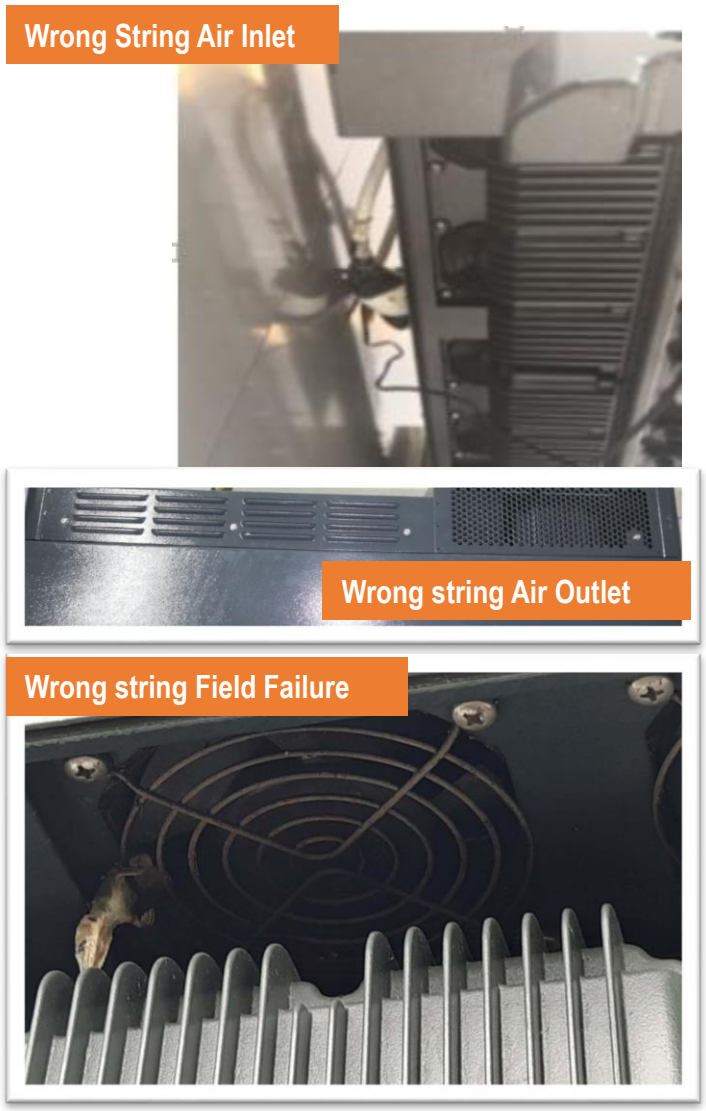
Huawei Components *SUN2000-185KTL-H1; STS-6000K-H1; SACU2000B; FusionSolar Smart PV Management System; Smart I-V Curve Diagnosis*

Total Capacity of 30MW commissioned in Y2019

The Design of string Inverter Cooling System Has Defects



HW	others	Comments
4 pcs fans	6 pcs fans	Others： more fans, higher power consumption
High-density Ventilation board	No filter	Others： foreign matters cause fans failure
Side air outlet	Top-to-Bottom Straight air outlet	Others： Rainwater enters and causes corrosion
Self-clean function	No	HW： self-clean after power-on



Other string site testing：
Noise decibel 83dB (1m distance)

Hazard Analysis：

- High fan speed, mechanical vibration affects the reliability of inverter components;
- It shows that the other solution has high power loss and heat generation, and the long-term reliability of the product is doubtful;
- 6 fans consume over 200W power;
- Noise pollution, endangering human health

Smart Grid-connection supporting stable operation in all-scenario grid scenarios

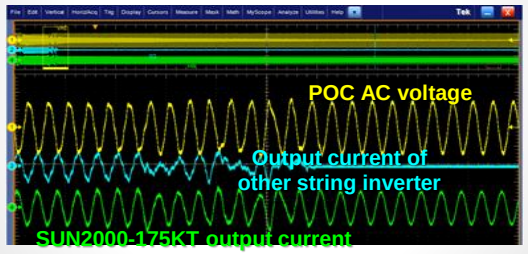
Robust Operation under All Grid Scenario

Accurate Grid Sensing + **Advanced Control**

Support Weak Grid SCR=1.1 (full output)

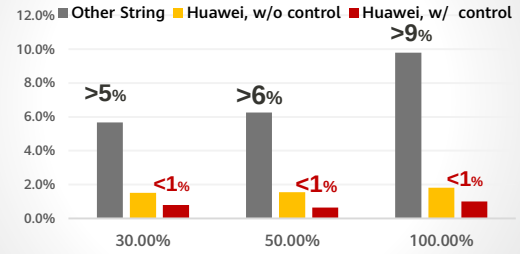
Operation Stability in weak grid

Smart PV Controller maintains stable operation,
Other inverter **shuts down for protection due to oscillation**



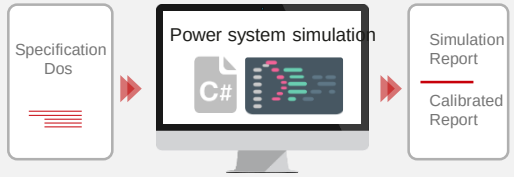
Active THD inhibition THDi<1%

Harmonic injection in weak grid



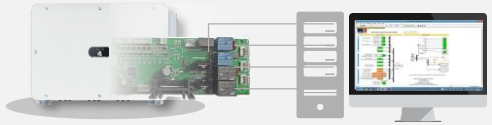
Digital Simulation

Grid code simulation modeling



Semi-physical Simulation

'Hardware in the Loop'



DSP control circuits

Real Testing

Grid simulation test in the lab, Onsite testing

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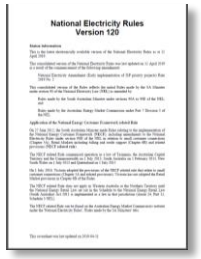
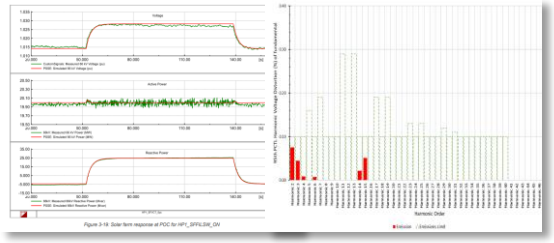
Success Case: Huawei Smart PV Fully Compliance with World's Strictest Grid Code

Huawei Smart PV: Unique string solution fully compliance with Australian new strict grid code





New Grid Code Launched in Australia

2019.02

New Australian grid code

- Strictest grid code for HVRT/LVRT

GPS Simulation

2019.08

Fully compliance with new code

- First approval letters compliance with new code within half year

R1 Simulation & Construction

2020

Successfully pass strict model audits

- Fully compliance with new Australian dynamic models
- SCR low to 1.5

R2 Testing & Commissioning

2021.04~08

300+ onsite tests, **100%** fully grid-connected

- Onsite results fully overlay with simulation
- Superior power quality: THD_u < 0.37%
- Better communication: 40 ms instruction cycles and < 10 ms time delay

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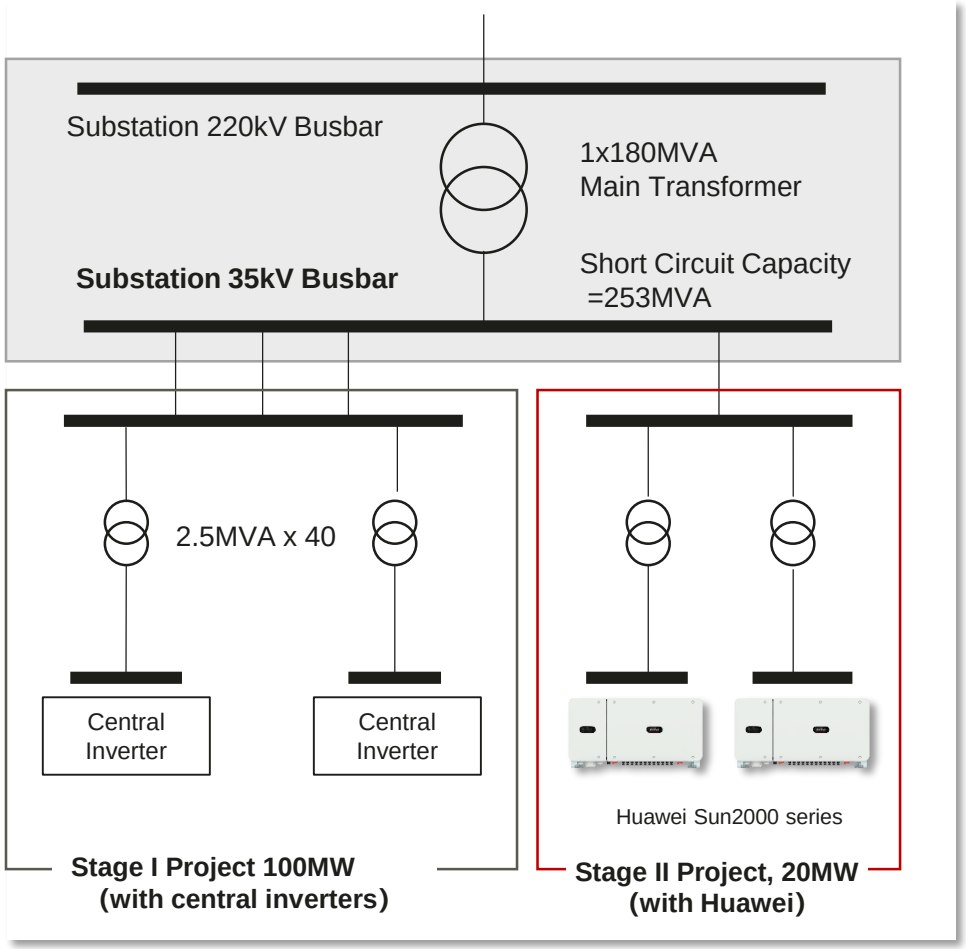
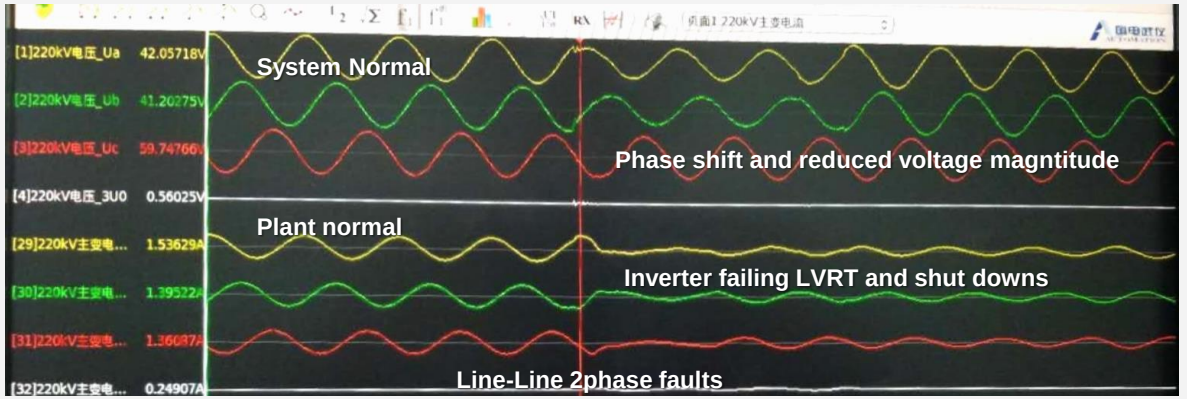
Success Case: Huawei Smart PV stable operation in weak grid

ChangDe solar farm, HeiLongJiang Province



Apr 4th 2020, 09:32:26, Massive shutdown.

Stage I 100MW project contingency event recording…

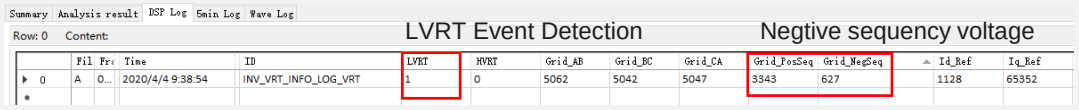


- 35 out of 140 inverters shutdown and damaged.
- Whole plant shuts down for 2 weeks (3% yield loss) ..
- Replacement of control PCB of all inverters … does not guarantee no recurring.

VS

Meanwhile..

Huawei inverter log:
Detected the fault accurately and rode through the fault.



	Fil	Fre	Time	ID	LVRT	HVRT	Grid_AB	Grid_BC	Grid_CA	Grid_PosSeq	Grid_NegSeq	Id_Ref	Iq_Ref
0	A	0...	2020/4/4 9:38:54	INV_VRT_INFO_LOG_VRT	1	0	5062	5042	5047	3343	627	1128	65352

HUAWEI

Reliability is Huawei DNA, strictly tested by GCTC above industry level

Huawei Global Compliance & Testing Center (GCTC) is recognized by international authoritative organizations.

Huawei GCTC


K3 Lab in Shenzhen

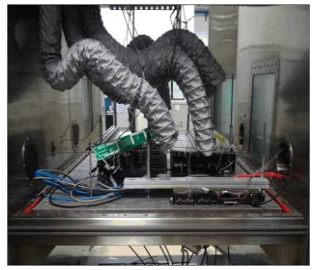

GCTC in Shanghai


GCTC in Shenzhen


K3 Lab in Shenzhen


THB Test
85℃
Humidity: 85%-90%


High Temperature
Resistance Test
Waterproof Test


HALT
-60 ℃ ~ 110 ℃
5-time Cycle Test


Dustproof Test
24-Hour/Dirt Retention
48-Hour/Humidity

Salt Mist
Reliability Test
Corrosion resistance


Rocket triggered Lightning at Guangdong

1400+ *Test Cases*

21 *Specific Tests*

HUAWEI

Automatic production line Guaranteed unified and long-term product reliability

Fully-automatic Product Line

Product Line Overview

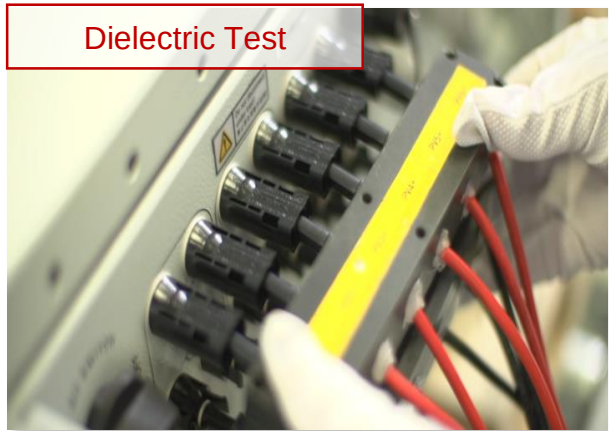
Largest in Asia
2nd largest in the world

Logistics Center

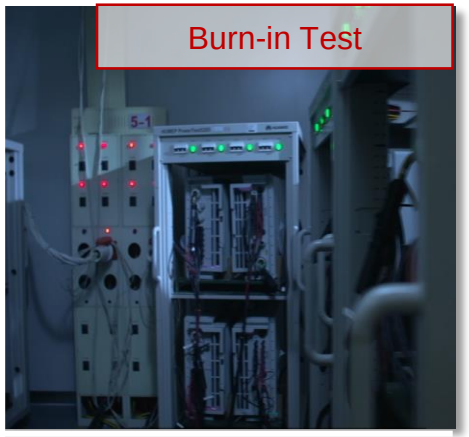
Assembly Line

Strict Online Quality Check

Dielectric Test



Burn-in Test



Gas Leakage Test

Barcode Check

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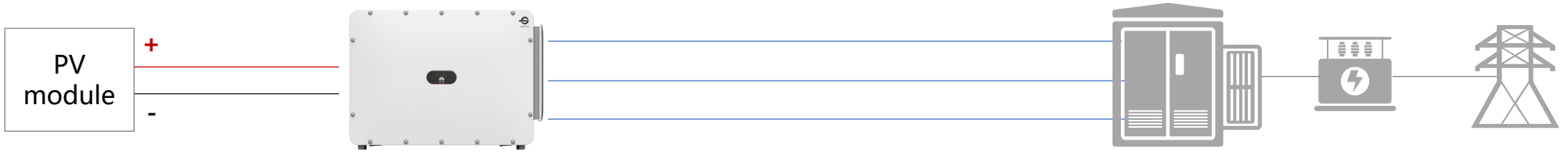
03 SUN2000 330KTL Block Design

HUAWEI

Bill of material



SUN2000-330KTL-H1/H2

Jupiter-9000KTL-H0

	Equipment	Type	number
1	**Inverter**	SUN2000-330KTL-H2	30
2	**STS**	Jupiter-9000KTL-H0	1
3	**SACU**	SACU2000D	1

SUN2000 330KTL H2

Rated output power @ 50: 275 kVA

Maximum output power: 330 kVA (30°C)

Output voltage: 800 V AC

Input operating voltage range: 500 - 1500 V

No. of MPPT: 6 Nos

Maximum input current: 65A per MPPT

Efficiency: 99.0% maximum

Weight: <108 kg

Dimensions: 1048 x 732 x 395 mm

SACU2000D Parameters

Integrated with data acquisition unit：SmartLogger3000

Operating temperature：-40℃ ~ +60℃

Operating Voltage（AC）：100 V ~ 240 V, L / N (L)+ PE

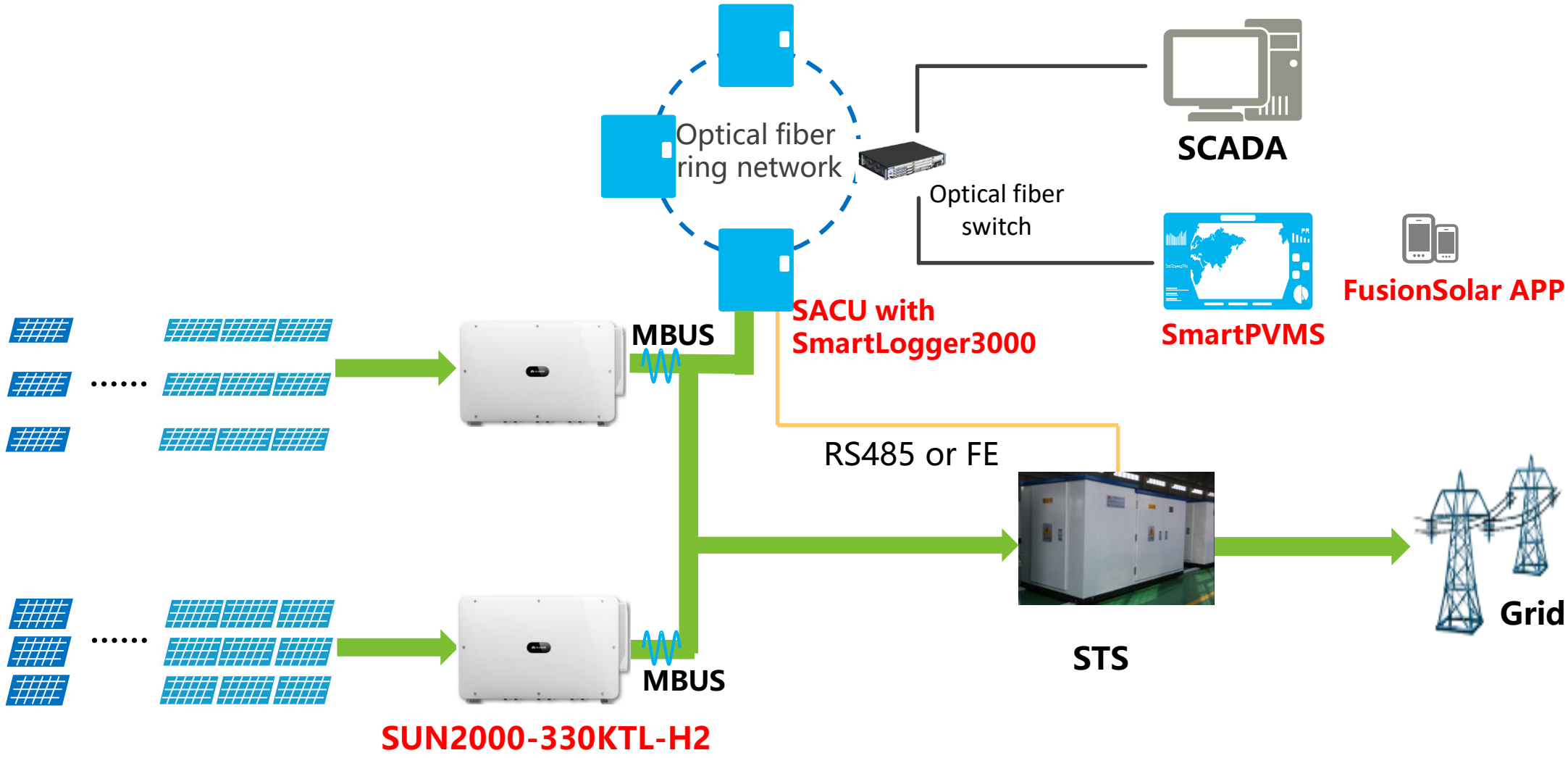
Dimension：640 x 770 x 315 mm

Weight：27.6 kg

installation：Brackets, Holding bars, Wall hanging

Detailed info please refer to user manual and quick guide

Communication and monitoring system network



- One SACU/SmartLogger3000 can manage up to 80 inverters
- The optical ring network formed by the SmartLogger can connect to a maximum of 15 SACUs/SmartLogger.
- Check whether the interfaces and protocols match when the SmartLogger connects to other third party devices in the southbound direction.

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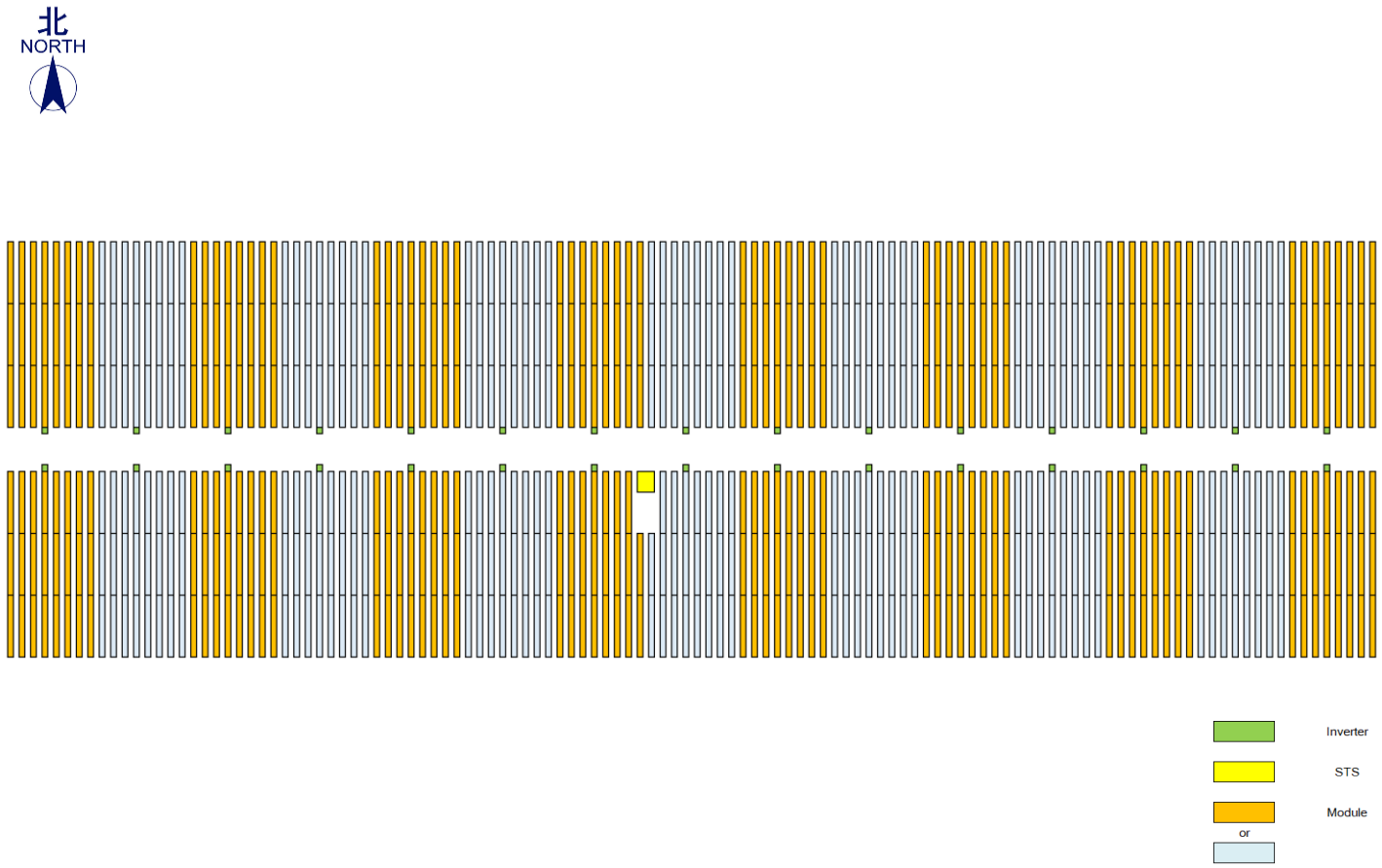
2P Fixed Tilt MMS + Bifacial Module: Sample block

Inverter model	SUN2000-330KTL-H2
PV module power (Wp)	545
#Module in series	29
Inverter nominal power (kW)	275
String per inverter	21
#Inverter	30
DC capacity (kWp)	9957
AC capacity (kWac)	8250
DC/AC ratio	1.21
Pitch （m）	10

HUAWEI

1P Horizontal Single-axis Tracker + Bifacial Module: Sample block layout



Inverter model	SUN2000-330KTL-H2
PV module power (Wp)	545
#Module in series	29
Inverter nominal power (kW)	275
String per inverter	21
#Inverter	30
DC capacity (kWp)	9957
AC capacity (kWac)	8250
DC/AC ratio	1.21
Pitch（m）	5

HUAWEI

Qinghai Santara utility-scale PV project

Huawei smart PV solution

Contributes to successful grid connection of the world's largest single-site PV station

The total AC capacity is **2.2 GW**, including 1.6 GW AC from Huawei smart string inverters.

Smart O&M – Smart I-V curve diagnosis 4.0, taking only 20 mins to scan a 100MW PV plant

Grid forming – Weak grid support (SCR down to 1.2), supporting stable operation in all-scenario grid scenarios

Safe & reliable – TUV verified: Cumulative failure rate < 0.6‰

Inverter SUN2000-175KTL-H0, Grid connection time: September 30, 2020

* The world's first ultra-high voltage power line that delivers 100% renewable energy over long distances
* The world's largest single-site renewable energy project with the shortest construction time