

FusionSolar PV+ ESS

Huawei Solution



Huawei Overview

Huawei: A trusted long-term partner



Vision & mission

Bring digital to every person, home and organization for a fully connected, intelligent world

170+
countries and regions

207,000
employees

55.4%
of employees work in R&D

No. 4
in global R&D investment

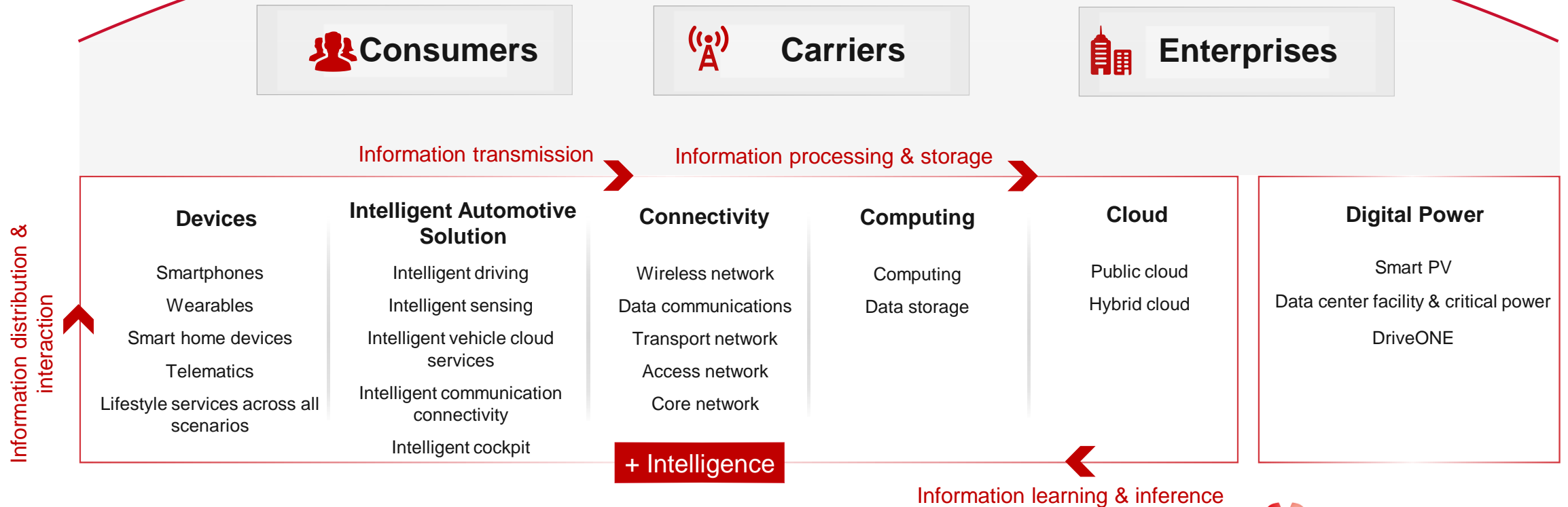
120,000+
active patents held globally

(*Huawei has one of the world's largest patent portfolios.)



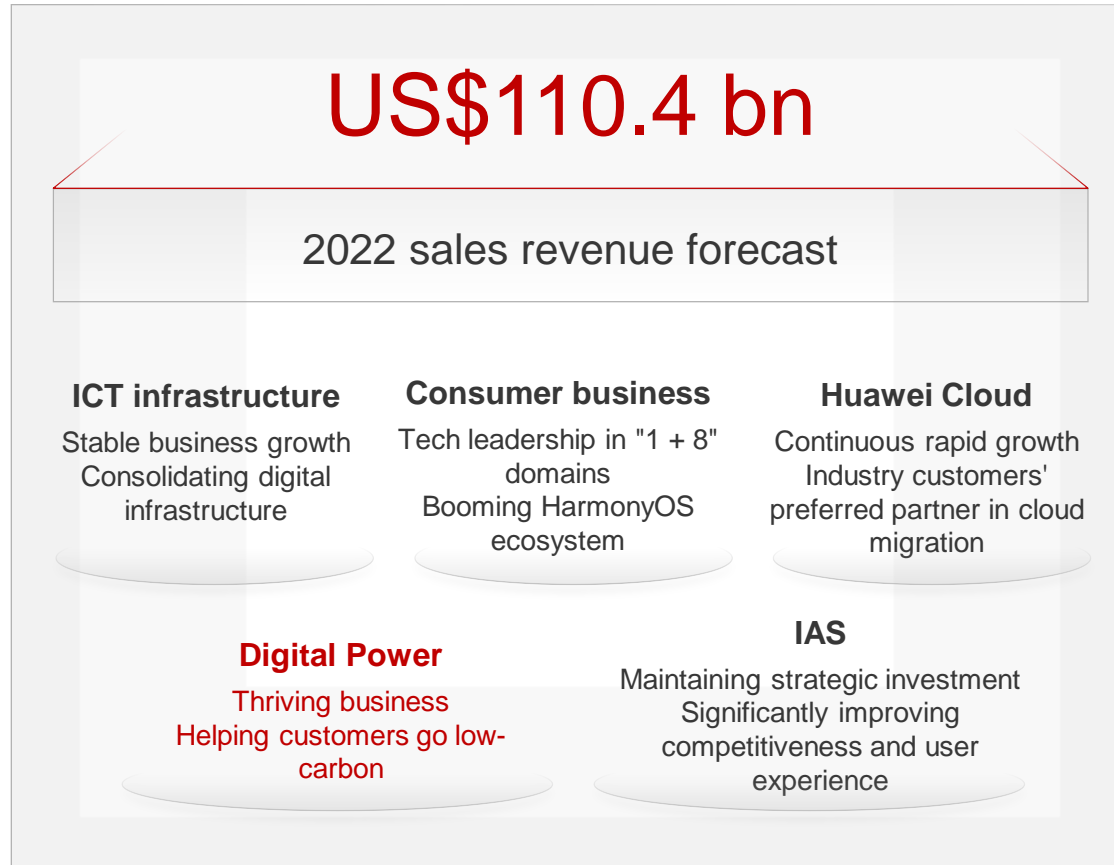
Focusing on ICT to provide products, solutions, and services to three customer groups

Bring digital to every person, home and organization for a fully connected, intelligent world

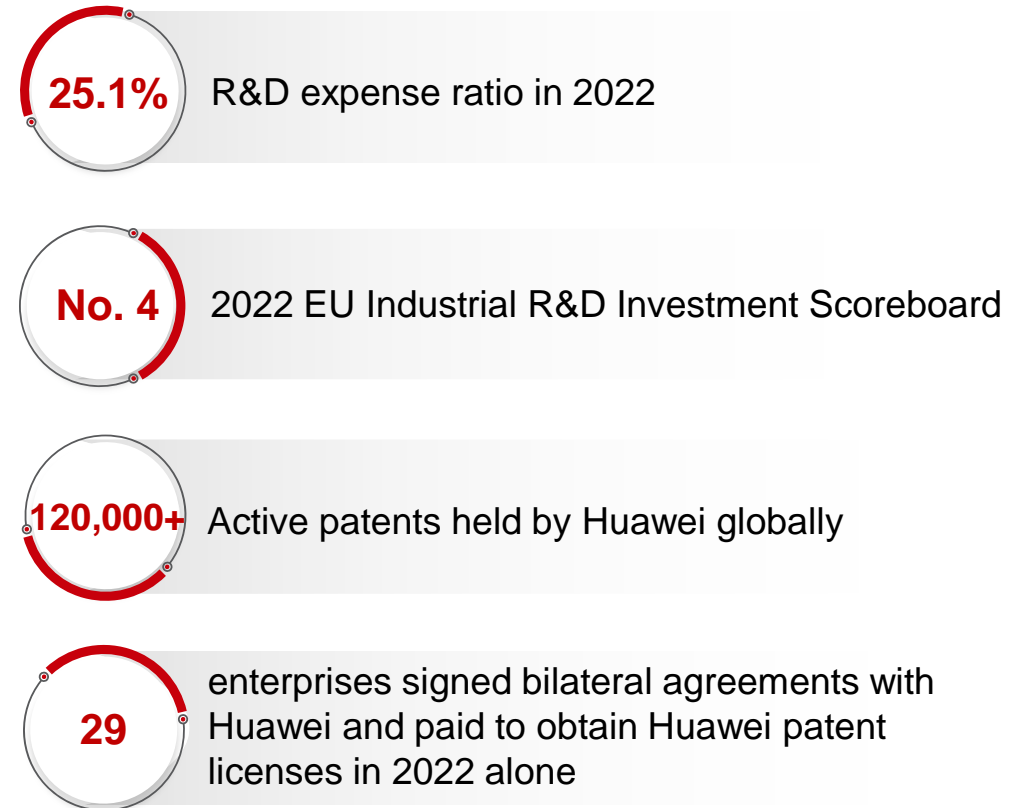


2022 business results aligned with expectations

The company's operations in 2022 aligned with expectations



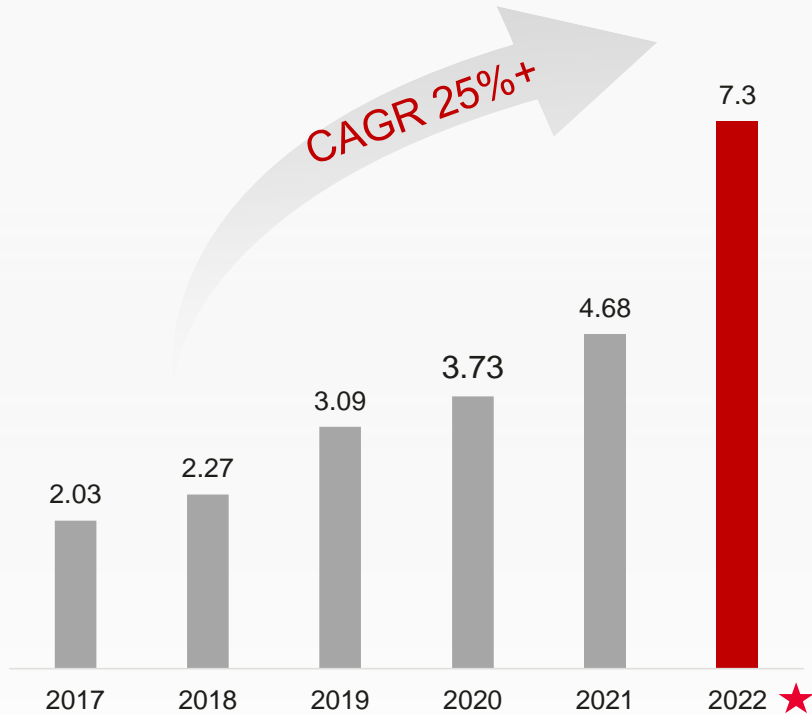
We maintained heavy R&D investment to drive future development through innovation



Digital Power: Solid operations and worldwide recognition

Stable business growth

US\$ billion



Integrating digital and power electronics technologies to promote green and low-carbon transformation in the energy industry

Smart PV

- Combine PV and energy storage and **make the green PV a main energy source** for every home and business; build a new power system based on renewable energy.

Data Center Facility & Critical Power

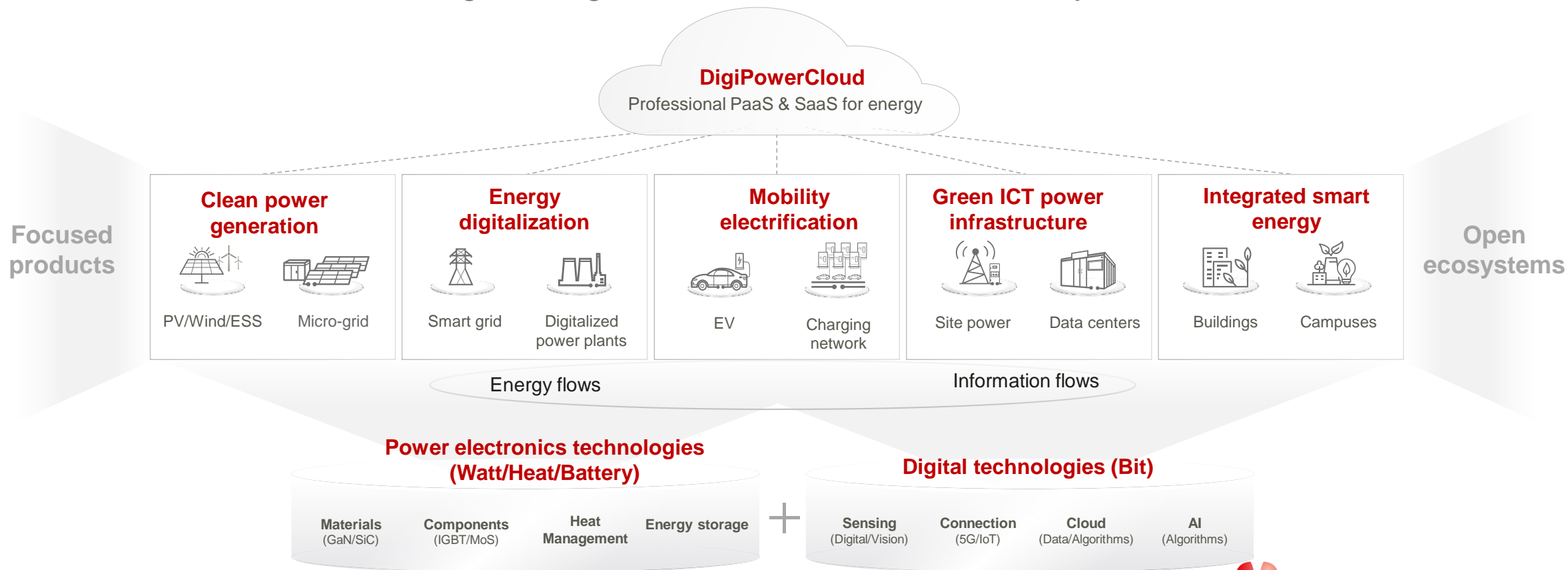
- Data Center Facility: Pursue continuous innovation in power, cooling, management, and architectural design to spearhead evolution toward **green, simple, smart, and reliable data centers**.
- Site Power Facility: Optimize construction, operations, and O&M to help carriers build all-scenario and full-lifecycle **low-carbon networks** based on the green site power target network; serving one third of the world's population.

DriveONE

- Work with industry partners to build DriveONE **full-stack eMobility solutions** that feature convergence & simplicity, safety & reliability, excellent experience, and cloud-based AI through technological innovations.

Digital Power: Integrating digital and power electronics technologies, developing clean power, and enabling energy digitalization to drive energy revolution for a better, greener future

Evolving from high carbon to low carbon, and finally to net-zero carbon



FusionSolar: Continuous innovation & Industry leading

Smart PV Era

Promoting string solutions to be mainstream solution

Smart PV & ESS Era

Promoting string PV & ESS solutions to be mainstream solution

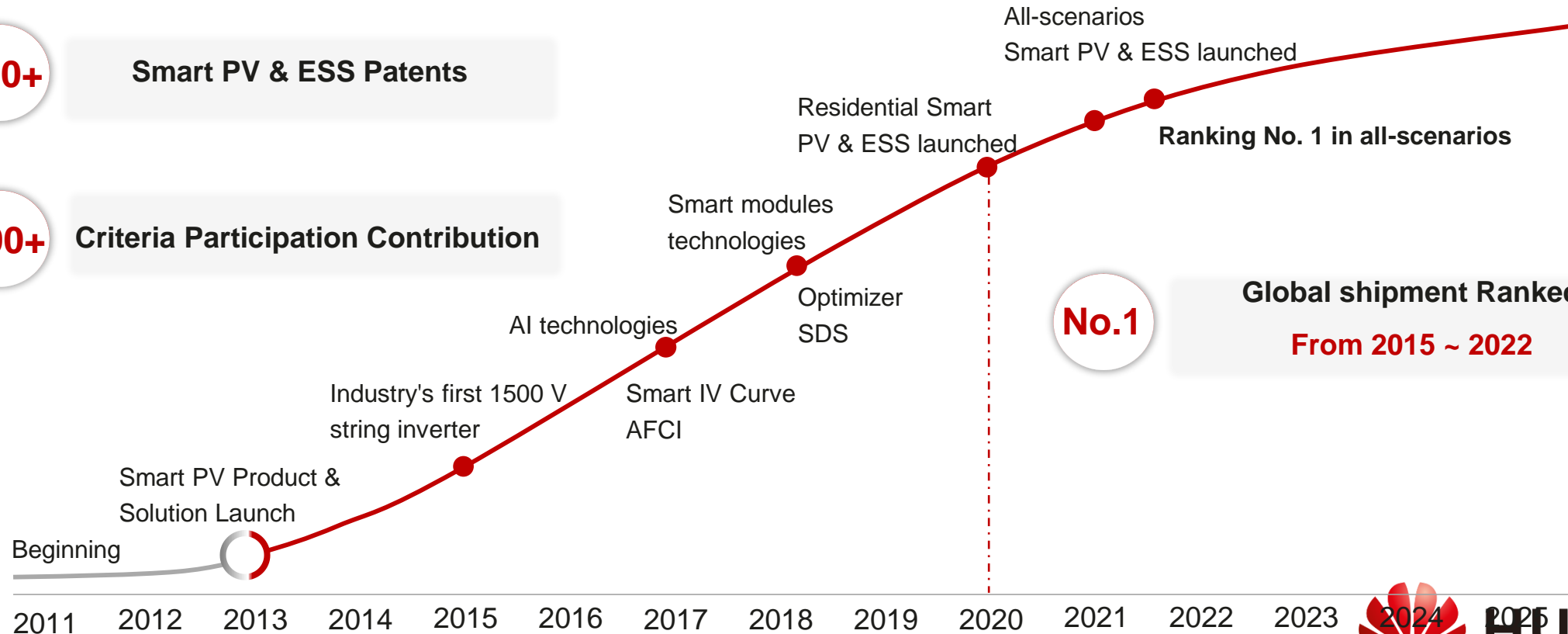


440+

Smart PV & ESS Patents

600+

Criteria Participation Contribution



HUAWEI

315 MW JEMSE Jujuy, Argentina

4020 Meter above sea level

660 GWH annual PV yield

90,000 families' electricity, 70% electricity of the province

\$60 Million Income, 7.3% of the province revenue

1500 Direct jobs, 15000 indirect jobs

Low failure rate

- Model: SUN2000-50KTL-C1
- COD: Q3, 2019



Colombia

Bosques Solares de los Llanos 4 & 5

Performance Ratio 4% higher than Design

- Trina Solar
- 137 MWp
- 121 pcs * SUN2000-215KTL-H3
- 4 pcs * STS-6000K-H1

The project has very tight delivery plan. Huawei service expert supported on-site to solve low performance ratio issue, and finish site acceptance test **within 1 month**



Republic of Guatemala Liztex Project

Capacity: **21MW** PV + **4MW / 4MWh** BESS


BESS helps **local grid frequency regulation**

When power frequency fluctuation occurs, no instantaneous purchase of third-party power is required

ROI less than 2 years

COD: 2022.Q1



An aerial photograph showing a large solar farm in the foreground, with rows of solar panels stretching across a cleared area. In the background, there is a village with several buildings, some under construction, and a dense forest. A wide river is visible in the distance. A large blue semi-circle is overlaid on the right side of the image, containing white and yellow text.

Peru rural micro-grid project

Lighting up villages by Amazon River

2.5 MW PV **+1 MW /2MWh** BESS

Serving green & resilient power supply for **20,000** people

Parallel operation of PV + ESS + Diesel Generation

Reducing **1** tons of diesel per day

Mar Rojo, Arabia Saudita

(Micro-red sea)

The Biggest Microgrid in the world

Capacity: **400 MW / 1,3 GWh**

Grid Forming:

Thanks to black bootability
100% Renewable PV + Storage project
serving more than 1 million people in
the new Red Sea city

Peru Poderosa Mine 4MW/8MWh BESS Plant

The **1st** **BESS** Plant in Peru Mine

ROI ~ **4 Years**

Diesel Saving **1M** USD/Y

Battery Lifespan **+50%** with Optimizer

WE ARE PART OF THE
GROWTH
WHAT HE
LEADS **COUNTRY**



- Smart String ESS Container : LUNA2000-2.0MWH (4 units)
- Smart String PCS: LUNA2000-200KTL (20 units)
- Communication Controller : SACU2000D (1 unit)
- Monitoring System: Smart PV Management System (1 unit)



Saudi Arabia Red Sea Project
World's Largest 100% PV + ESS Microgrid Project

400 MW PV + **1.3 GWh** BESS

Serving 100% PV + ESS power supply for 1 million
people in Red Sea new city
Grid Forming enabling 100% PV & ESS grid

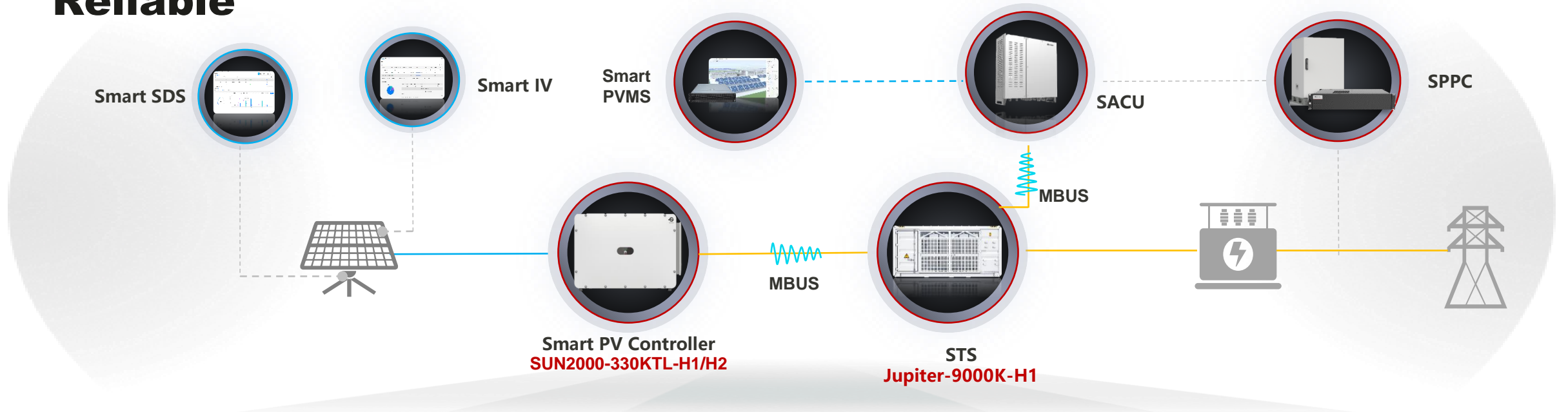
COD: 400MWh ready around Dec. 2022,
others shall be ready around middle of 2023



FusionSolar8.0

Smart PV Solution

FusionSolar 8.0: Optimal BOS, Higher Yields, Smart O&M, Safe & Reliable



Optimal BOS

- Supporting 9MW and Tracking Bracket saves **0.39 ¢ /W**
- One inverter fits mainstream modules

Higher Yields

- High efficiency & Low failure yields increased **by 1%**
- Stable power generation without derating
- SDS, yields increased by 1%
- STS: Smart closed-loop control, yields increased 0.35 cents/W·25years

Smart O&M

- SSCF-TECH without manual O&M
- STS: Distributed measurement and control
- Smart PVMS: Enables four-level refined detection, IV and CV Diagnosis, achieves precise, fast, and efficient O&M

Safety & Reliable

- DC triple safety: **SSLD + SCLD + MPPT-level** insulation detection
- High availability **99.999%**
- MBUS: Communication distance up to **1000m**
- STS: AC dual safety design
- SmartIMD function for continuous DC & AC insulation detection

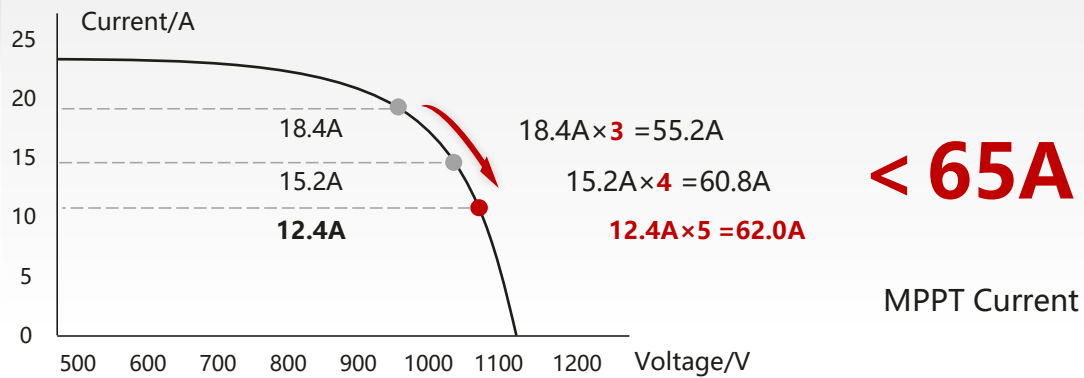
Grid Supporting

- Comprehensive Advantages of Five Grid-connected Indicators :
SCR = **1.1** (100% operation)
- / SCCR = **0.7** / THDi ≤ **1%** / DCI < **0.5%** / HVRT without derating

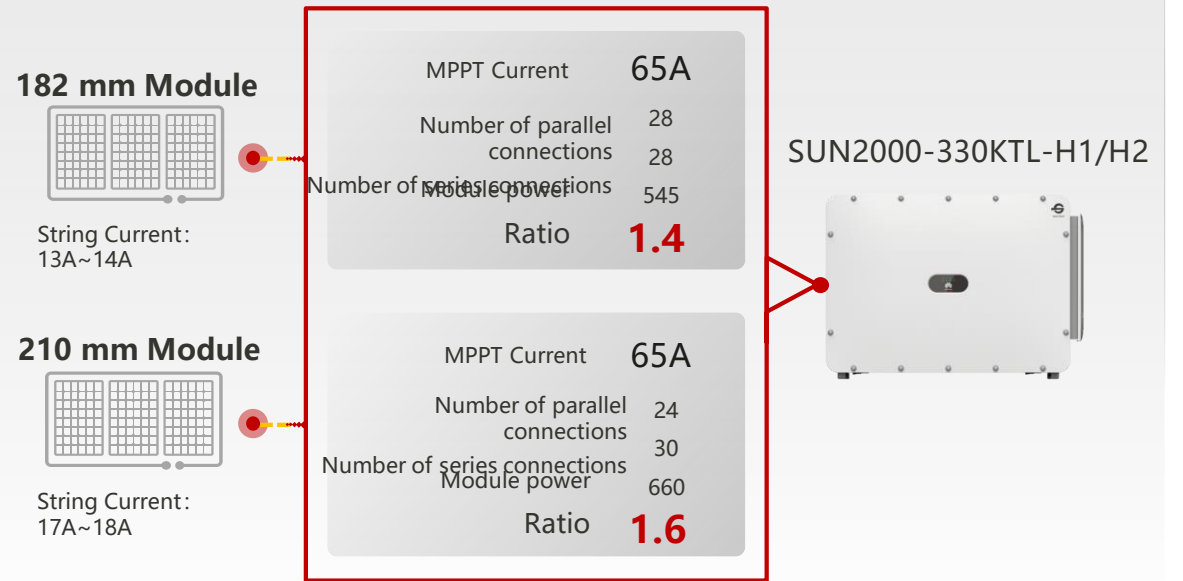
The first inverter adapts to mainstream PV modules, better MPPT input current design

Better MPPT input current design, simpler design

- Capacity ratio improved, input power of the inverter increased ↑
- Output power of the inverter exceeds the AC limit ↑
- Maximum power point offset, output current of the PV string decreases ↓
- Input power of the inverter decreases ↓
- Inverter maintains full output power ★



The first inverter adapts to mainstream components

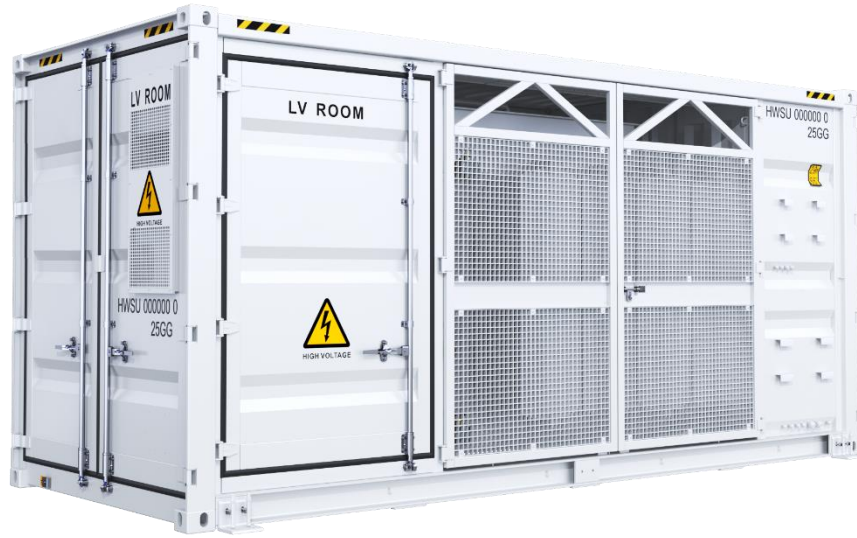


More flexible tactics for PV Module procurement



Easier management of Spare parts

Smart Transformer Station: JUPITER-3000K/6000K/9000K-H1



JUPITER-9000K-H1

JUPITER-6000K-H1

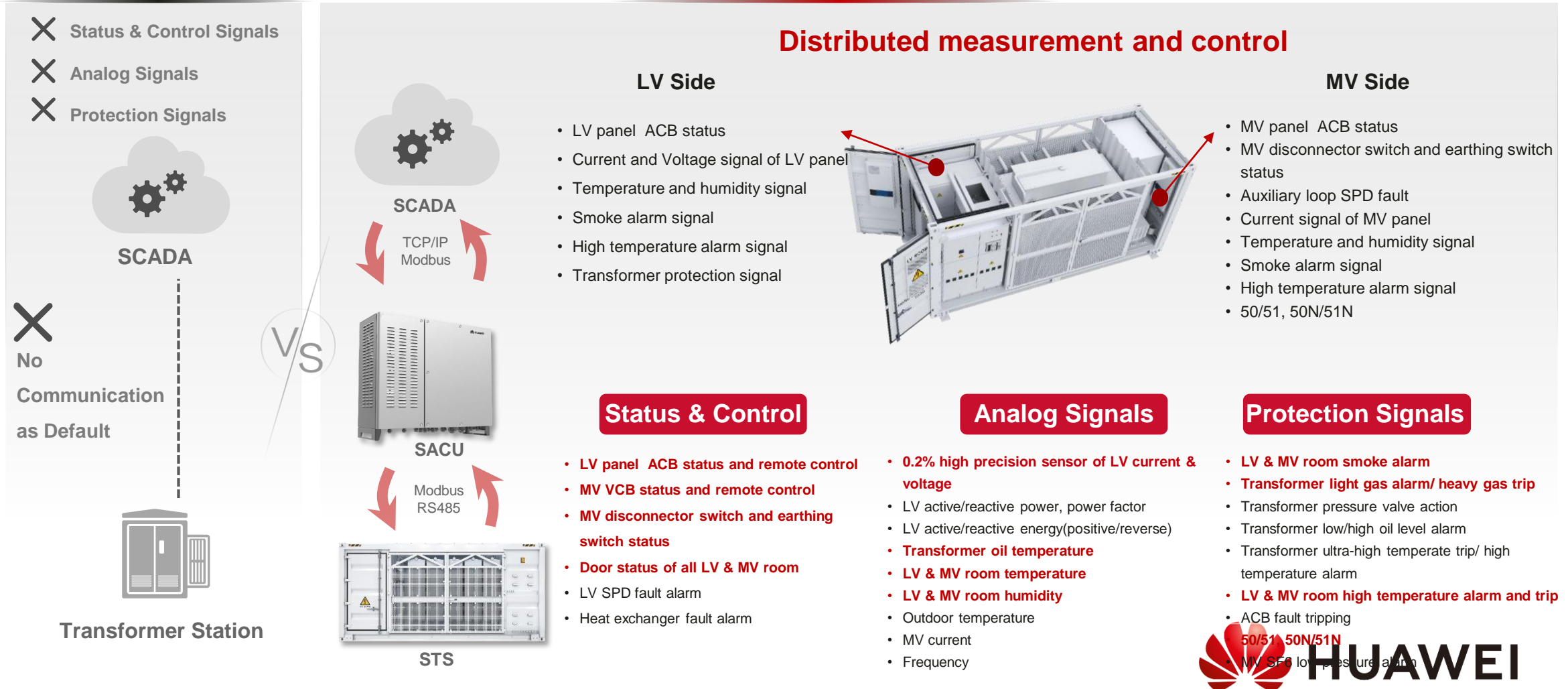
JUPITER-3000K-H1

Item	JUPITER-6000-H1	JUPITER-3000K-H1	JUPITER-9000K-H1
Available Inverters	SUN2000-330KTL-H1/H2		
AC Power	6,600 kVA @40°C	3,300 kVA @40°C	9,000 kVA @40°C
Max. LV MCCB	22	11	30
Rated Input Voltage	800 V		
Rated Output Voltage	20 kV/22 kV/30 kV/33 kV/34.5 kV/35 kV		
Transformer Type	Oil-immersed, Conservator Type		
Transformer Tappings	± 2 x 2.5%		
Transformer Oil Type	Mineral Oil		
Transformer Vector Group	Dy11-y11	Dy11	Dy11-y11
RMU Type	SF6 Gas Insulated, 3 Feeders		
Auxiliary Transformer	5 kVA, Dyn11, Ratio Varies according to Customization		
Protection Degree of MV & LV Room	IP 54		
Internal Arcing Fault of STS	IAC A 20 kA 1s		
LV Overvoltage Protection	Type I + II		
Dimensions (W x H x D)	6,058 x 2,896 x 2,438 mm (20' HC Container)		
Weight	< 22 t	< 15 t	< 28 t
Operating Temperature Range	-25°C ~ 60°C ² (-13°F ~ 140°F)		
Relative Humidity	0% ~ 95%		
Standards Compliance	IEC 60076, IEC 62271-200, IEC 62271-202, EN 50588-1, IEC 61439-1		

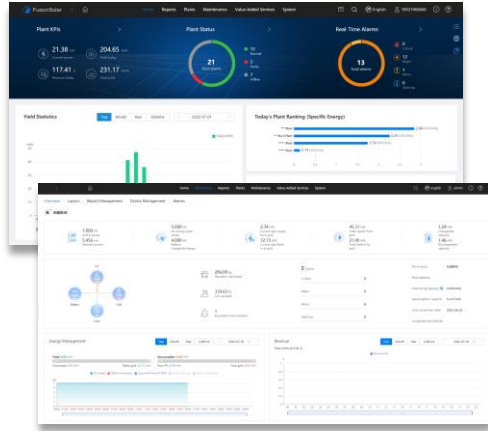
Comprehensive smart design, refined, manageable, controllable, and pre-configured, reducing > 50% O&M

Traditional Solution

Smart PV Solution: Simplified Deployment, Smart Maintenance, Ultimate Experience



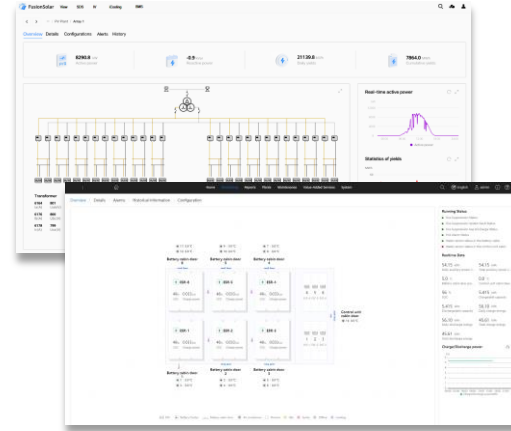
Multi-level Management and Comprehensive detection of Plant Status



Plant-level detection

Visibility into the operation status of the plant

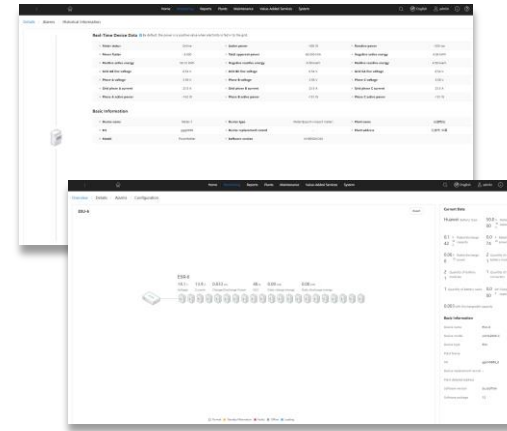
- Alarm visualization
- KPI visualization
- Energy statistics analysis
- Revenue statistics analysis



Array detection

Visibility into the PV array status

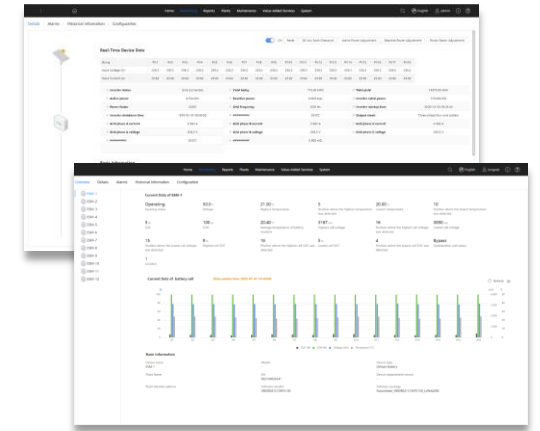
- Topology visualization
- Physical layout visualization
- Real-time data visualization
- Running status visualization



Device-level detection

Identification of device faults

- Real-time data visualization of devices
- charge/discharge data visualization




String-level detection

Real-time display of string data

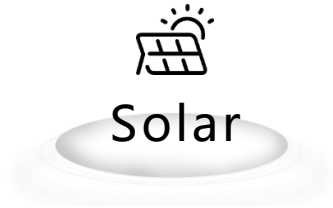
- Real-time data visualization of devices
- Graphic display of the voltage and temperature

Four-level detection, shifting from large-granularity management to refined management

An aerial photograph of a solar farm, showing rows of solar panels stretching across a landscape. A white grid pattern is overlaid on the image, suggesting a network or data flow. The sky is filled with soft, white clouds. A thin vertical line is positioned to the left of the main text.

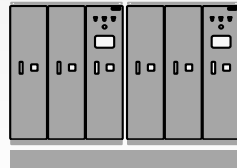
Smart String Energy Storage System Solution

Concept STRING becomes the mainstream from PV to PV+ESS industry



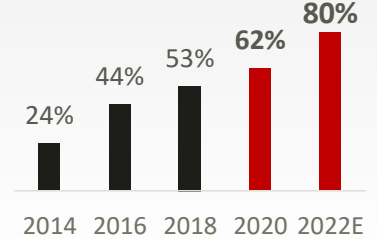
Central Inverter

2000+ PV Modules / MW, 1MPPT Centralized Management

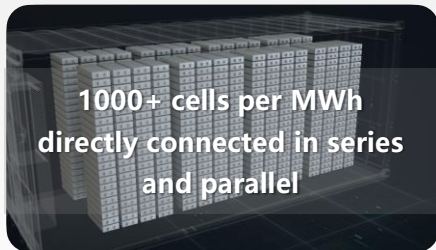


Smart String Inverter

Global String Inverter Market Share

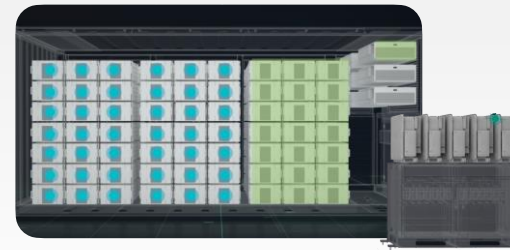


Central ESS



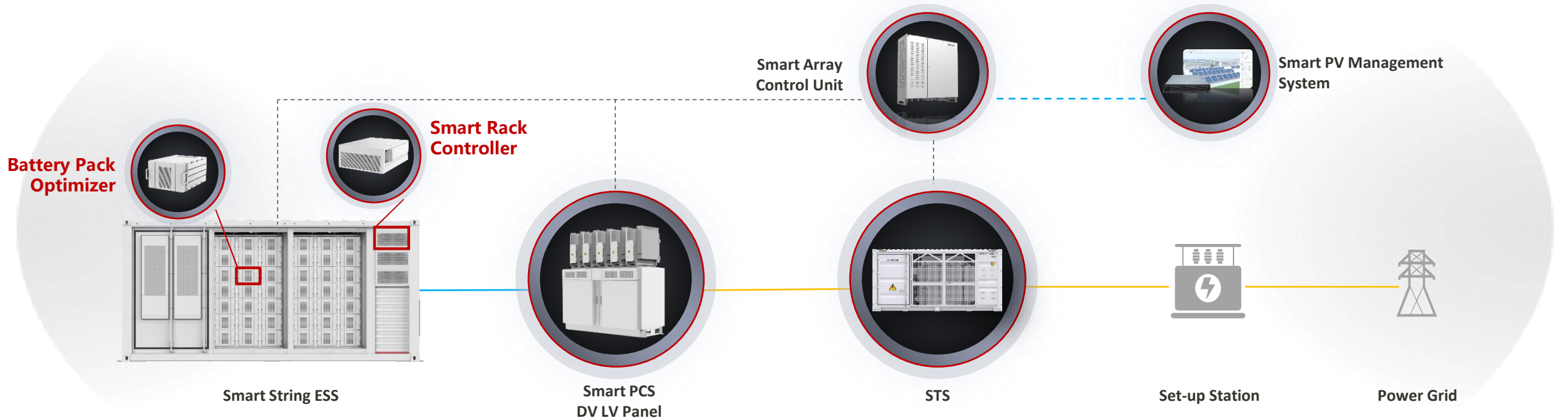
- Cell mismatch causes severe loss
- Periodic manual O&M
- Difficult to identify failures
- Lack of linkage protection

Smart String ESS



- Independent control of battery packs & racks
- No need of SOC calibration
- System quadruple security protection

Smart String ESS: Optimal LCOS, Proactive Safety Protection



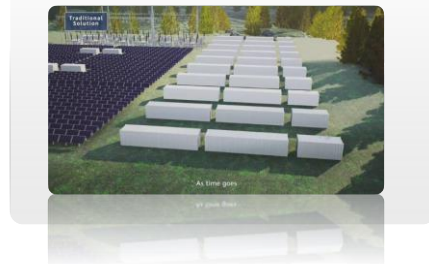
More Energy

Increase discharging energy by 15%
 Pack-level Optimization
 Rack-level Optimization



Optimal Investment

Flexible Adaption in Different Business Models
 More Energy Throughput, More Revenue



Simple O&M

Saving EUR 2.52 million/year*
 No need for periodic balancing
 No need for experts to visit sites



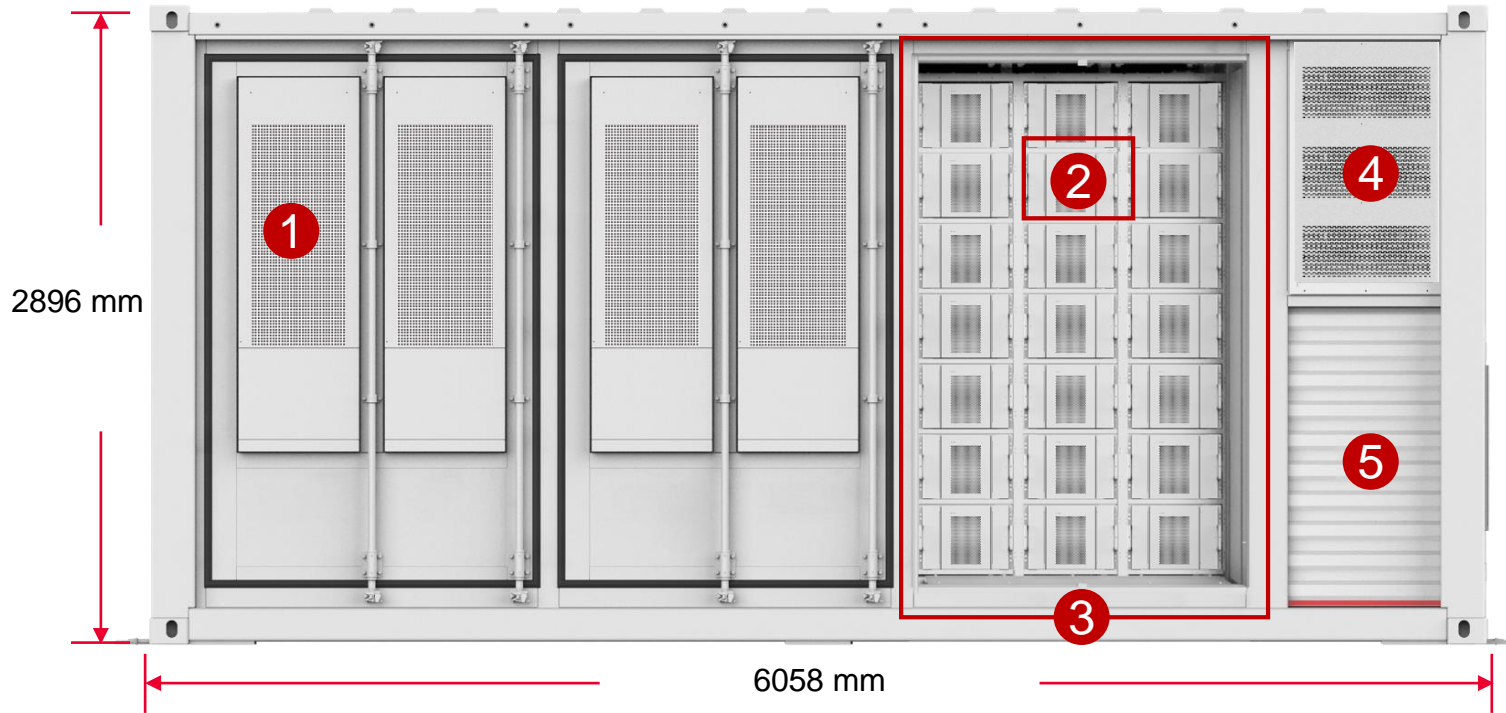
Safety & Reliability

Proactive Protection
 Cell to system safety protection
 Avoid thermal runaway



* Calculated base on 100MW/200MWh project

Smart String ESS



20 ft ESS container

LFP battery

Capacity: 2032 kWh

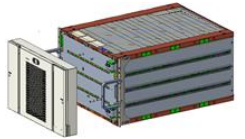
Weight: < 30 t

1. Door-mounted distributed air conditioner

6 in LUNA2000-2.0MWH-1H1
4 in LUNA2000-2.0MWH-2H1
3 in LUNA2000-1.0MWH-1H1
2 in LUNA2000-2.0MWH-4H1

2. Battery pack + optimizer

18 x 280 Ah cells per pack
Built-in battery pack optimizer

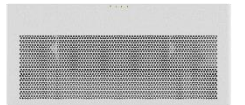


3. Battery rack

21 battery packs per rack
6 racks in 2.0MWH ESS
3 racks in 1.0MWH ESS

4. Smart Rack Controller

Each battery rack connects to one DC/DC module.(1C)
Two battery racks connects to one DC/DC module.(0.5C/0.25C)



5. Control unit cabin

Power distribution + fire suppression system

More Energy: Higher Usable Capacity with Refined Energy Management

Pack-level Monitoring

13 pcs
Temp. sensor

16~18 pcs
Voltage sensor

ESS

2000+
Voltage sensor

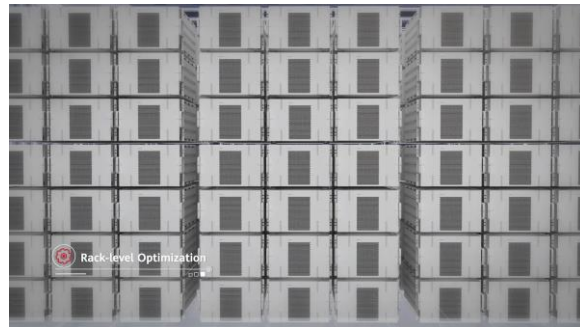
1600+
Temperature sensor

Battery Pack Optimizer



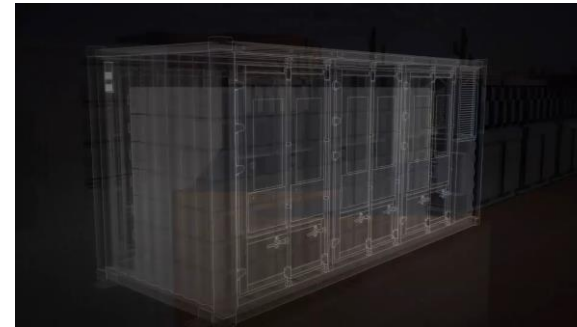
- **High available capacity:**
Avoiding series mismatch
- **High availability:**
A faulty pack is isolated actively
- **High safety:**
Battery Pack Port voltage is 0V

Smart Rack Controller



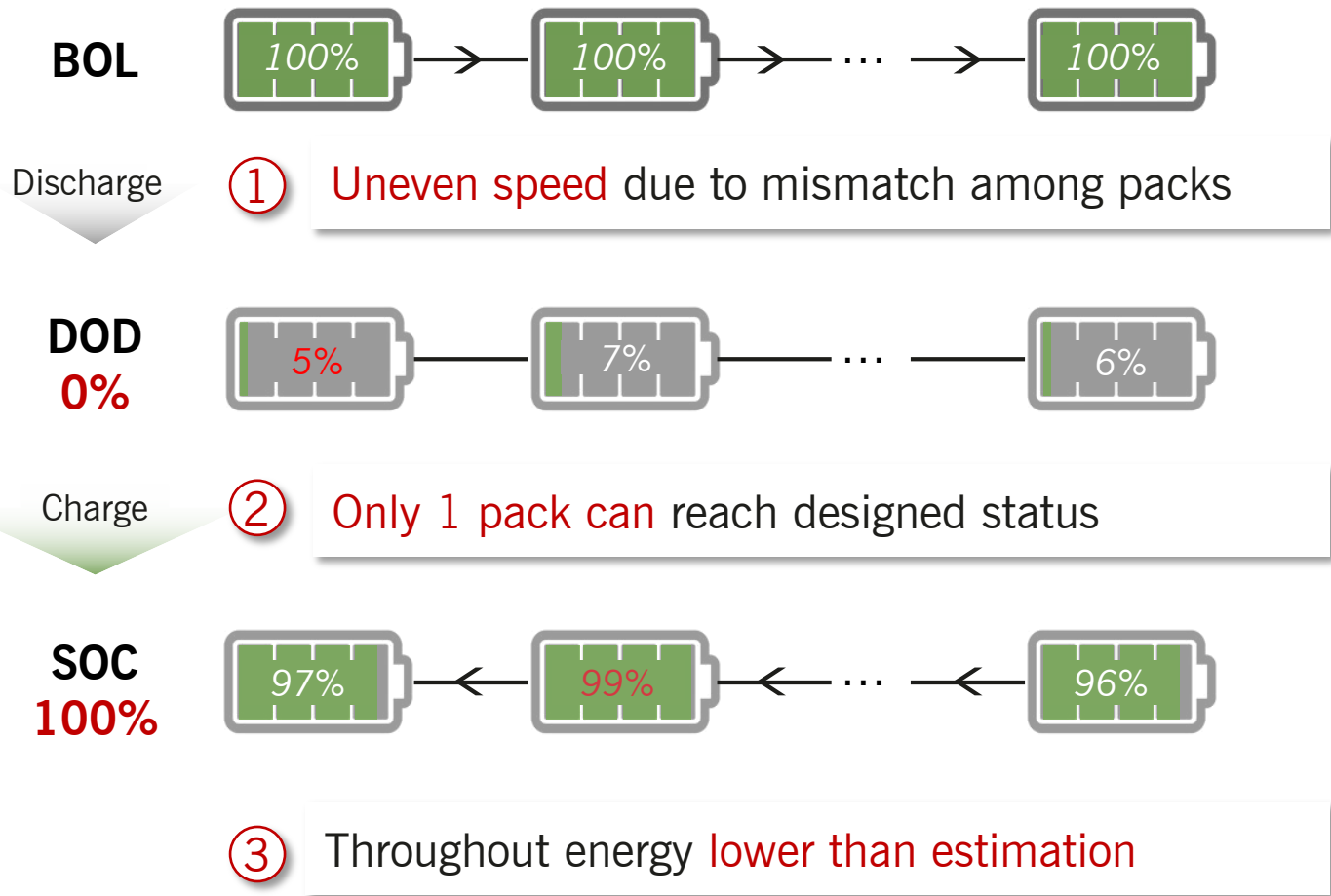
- **Charging/discharging each rack independently :**
Rack-level Optimization, fully charged/discharged
- **No bias current among racks :**
Independent running between racks with no bias

Distributed Temperature Control

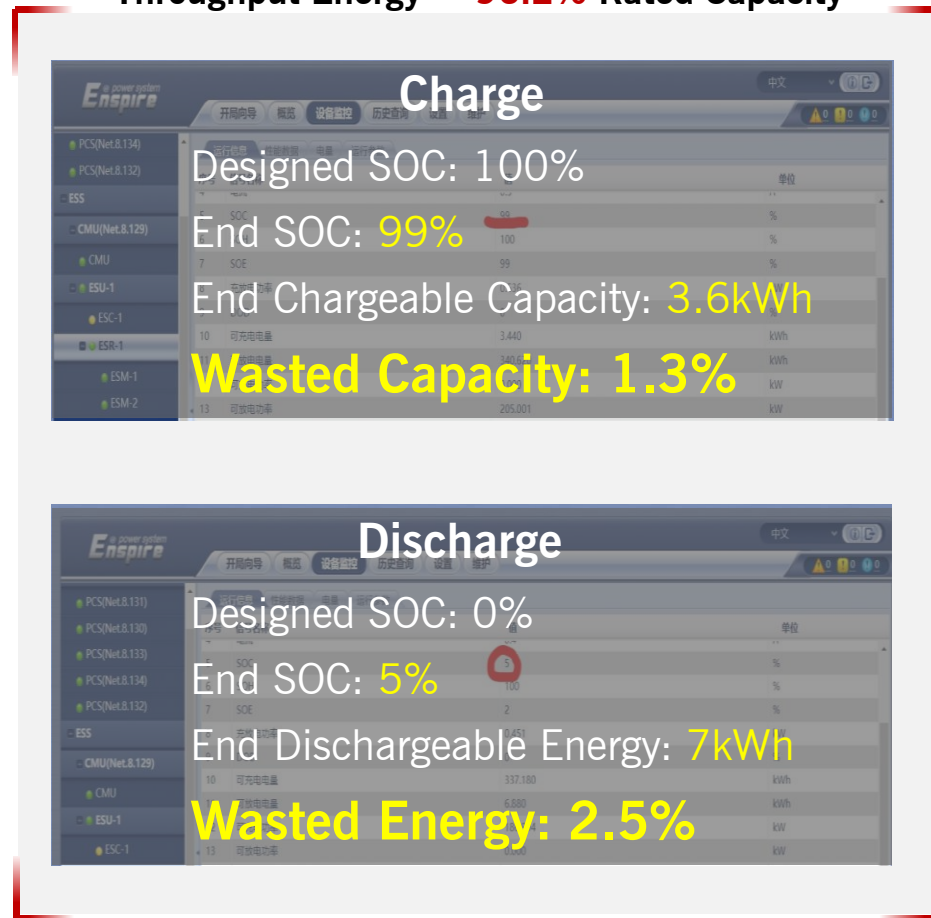


- **Rack-level distributed HVAC**
Averaged heat dissipation in each rack
- **Battery Pack Biomimetic mixed air duct**
Equalization of cooling capacity per battery cell

Pack-level unbalance: ~2.5% of energy cannot discharged even in the beginning of life



Case Analysis – Tangshan China Throughput Energy = 96.2% Rated Capacity



Pack Optimizer: Ensure every bit of energy can be discharged, increasing throughput energy



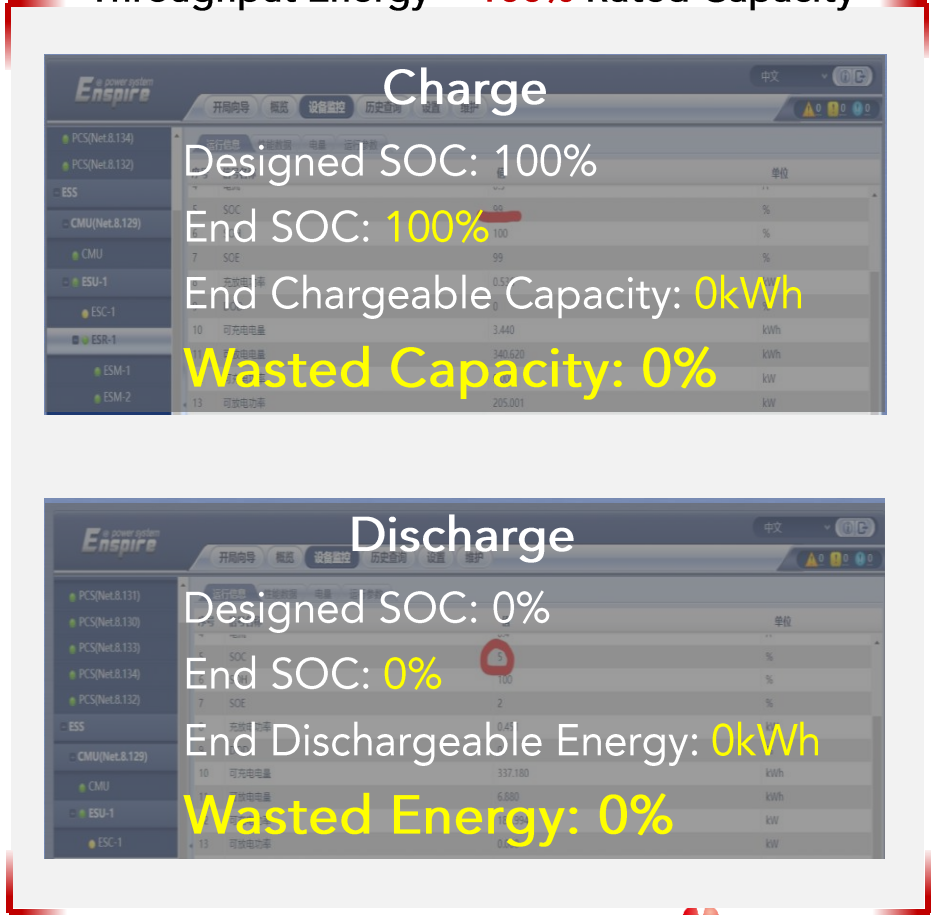
Independent

If a pack is fully discharged, optimizer will cut it off to avoid affecting other packs

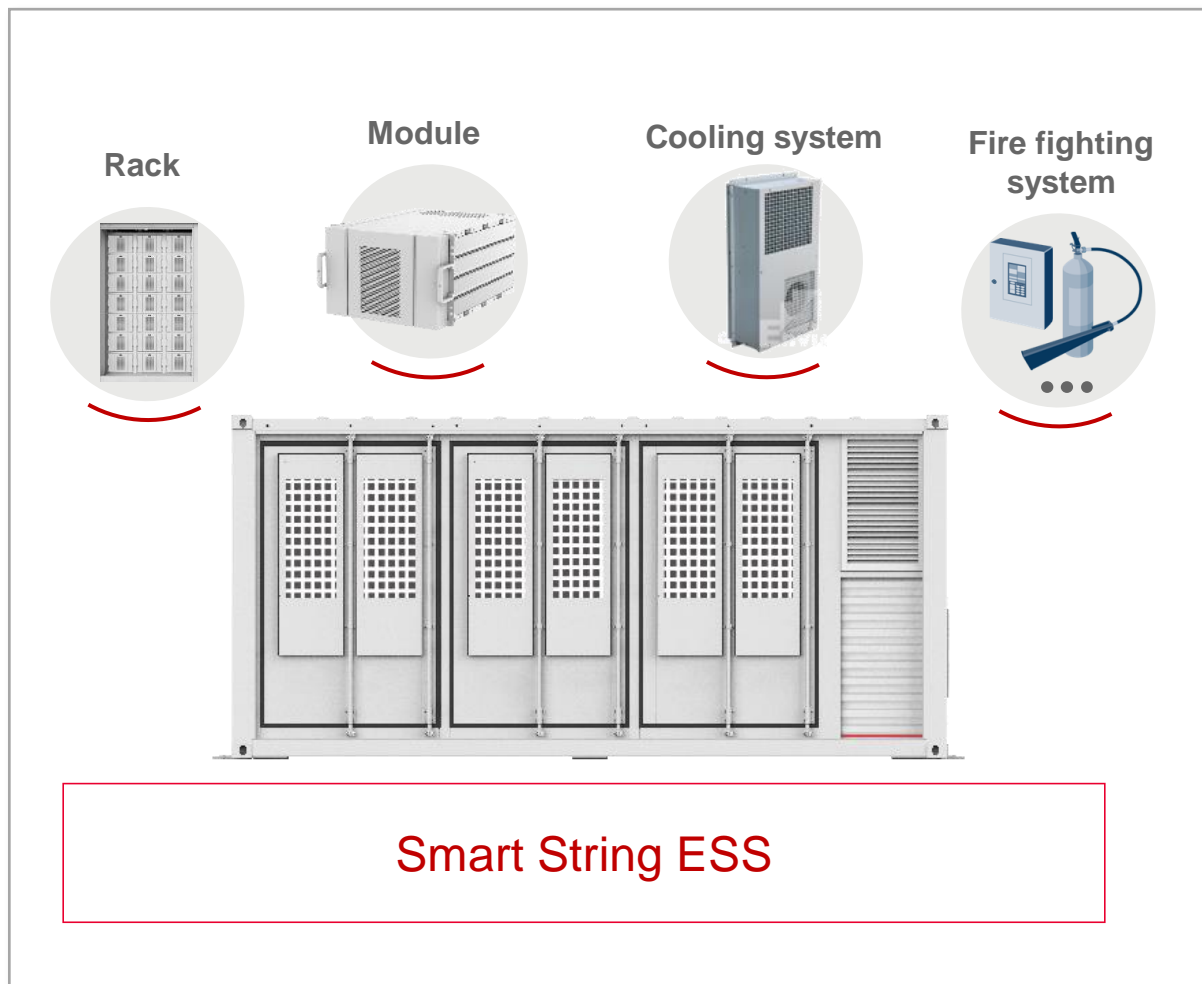
Highly Reliable

Optimizer will cut off packs with problems so that other packs can still work

Case Analysis – Tangshan China
With optimizer
Throughput Energy = **100%** Rated Capacity



Optimal Investment: 20ft HQ standard container, easy to transport, saving cost by 40%



High energy density design

- Transportation solution: 20-foot HQ standard container, easy transportation, no need to return the container.
- Equipment hoisting: weight < 30 tons, Common crane can be operated



Prefabricated installation

- Battery packs pre-assembled on the factory line
- Only simple construction such as wiring is required on site
- Save on battery pack installation manpower(15 packs/person/day)

Simple O&M: No Routine SOC Calibration, No Experts On-site Visit

Central Solution

Routine O&M

SOC calibration every 3 months

O&M cost for SOC calibration 100MWh during lifespan

> 1.7 M€



Failure Recovery

Experts onsite visit



Expert site visit failure analysis

5 - 7 days



Manual inspection of SOC of battery packs in the same rack

20-30 mins



Manual adjustment of spare battery pack SOC

1 hours



Replacing batteries

2 hours

Smart String ESS Solution

Routine O&M

Routine inspection only no SOC calibration

O&M cost for SOC calibration 100MWh during lifespan

~ 0 M€



Failure Recovery

O&M personnel ONLY, Plug & play



O&M personnel site visit

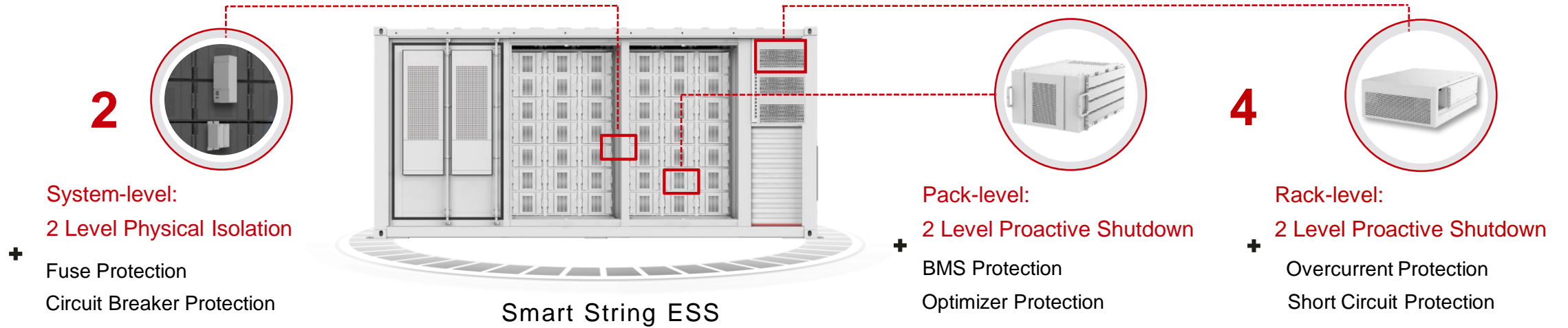
< 3 hours



Replacing batteries

2 hours

Safety & Reliability : '2 + 4' Multiple-level Protection



Hardware Safety Design

Software Safety Design

'2+4' Multiple-level Protection

Four-level proactive shutdown
two-level passive isolation

High Reliability in Structure

Isolation design ensures high system safety

Battery Cabin

Smart Rack Controller Cabin

Control unit cabin

Smart Internal Short Circuit Detection

Fault identification
Quick alarm

Cycle curve of severe short circuit

Plateau curve

Marked curve

Transient fluctuation in the charge and discharge curves of the battery is not real.

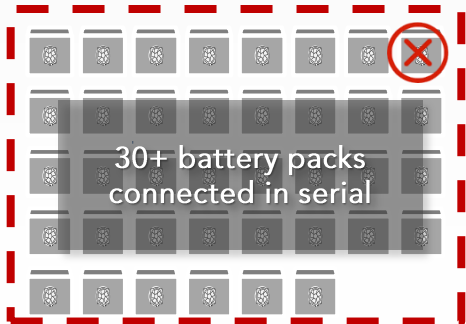
Cloud BMS

Warning of battery thermal runaway risks in advance

Safety & Reliability : Modular Design

Central Solution

If one pack is faulty, the entire rack will be unavailable.



10+ battery racks
(Direct Parallel Connection)

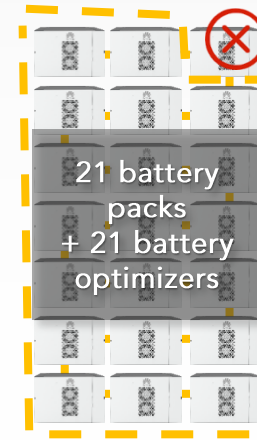
If one PCS is faulty, the entire system fails to work.



1 x 3450KTL
Centralized PCS

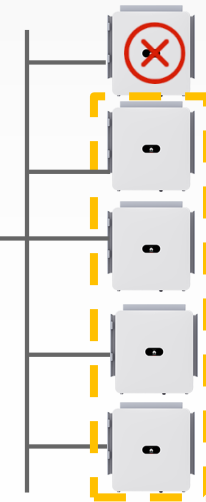
Smart String ESS Solution

If one pack is faulty, the other packs are not affected.



6 x racks+
6 x smart rack controllers

Modular PCS design minimizes the impact of PCS faults.



Smart String ESS: Flexible Adaption in Different Business Models



Peak Shaving

More Energy Throughput, More Revenue

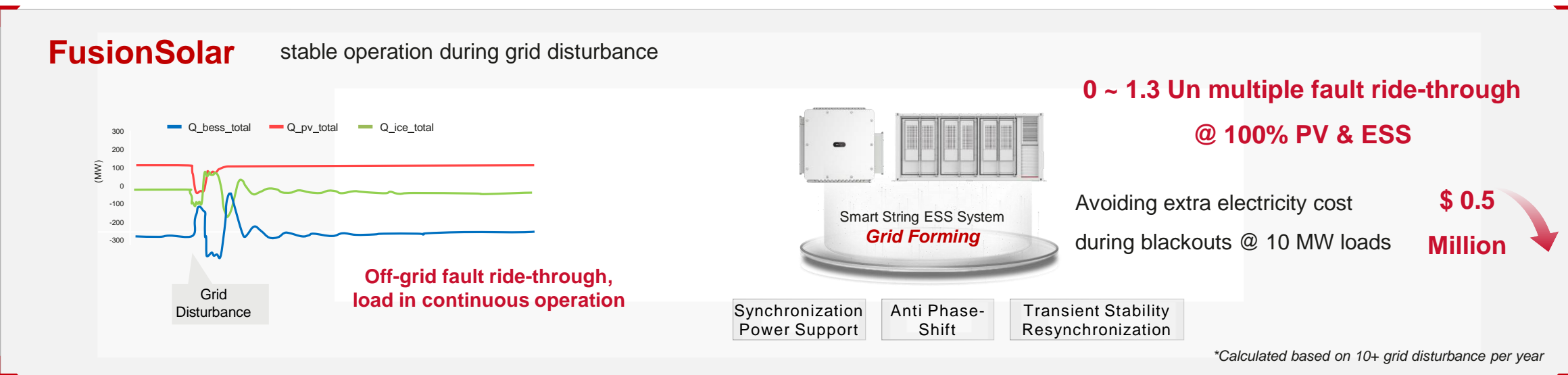
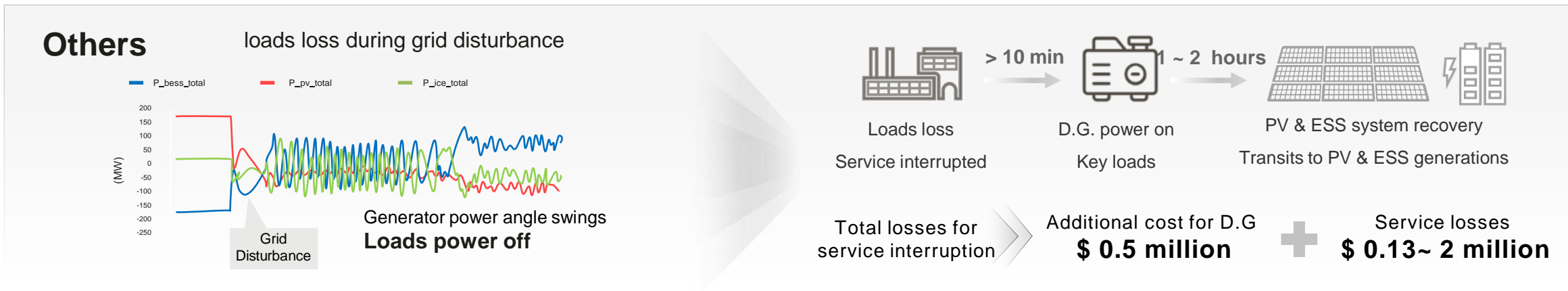
- Pack-level Refined Energy Management
- No Expert On-site Visit for Failure Recovery

Frequency Regulation

Rack-level Refined Energy Management

- Rack-level Refined Energy Management
- Automatic SOC Calibration
- High Availability

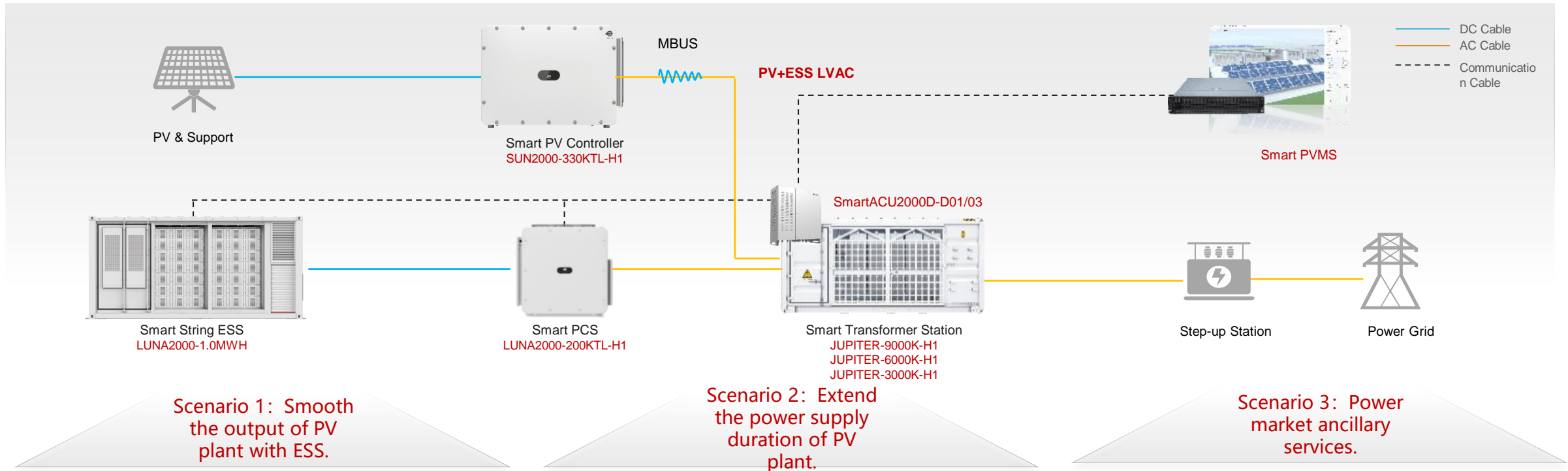
0 ~ 1.3 U_n multiple micro-grid fault ride-through @ 100% renewables enabling continuous service operation



Application Scenario

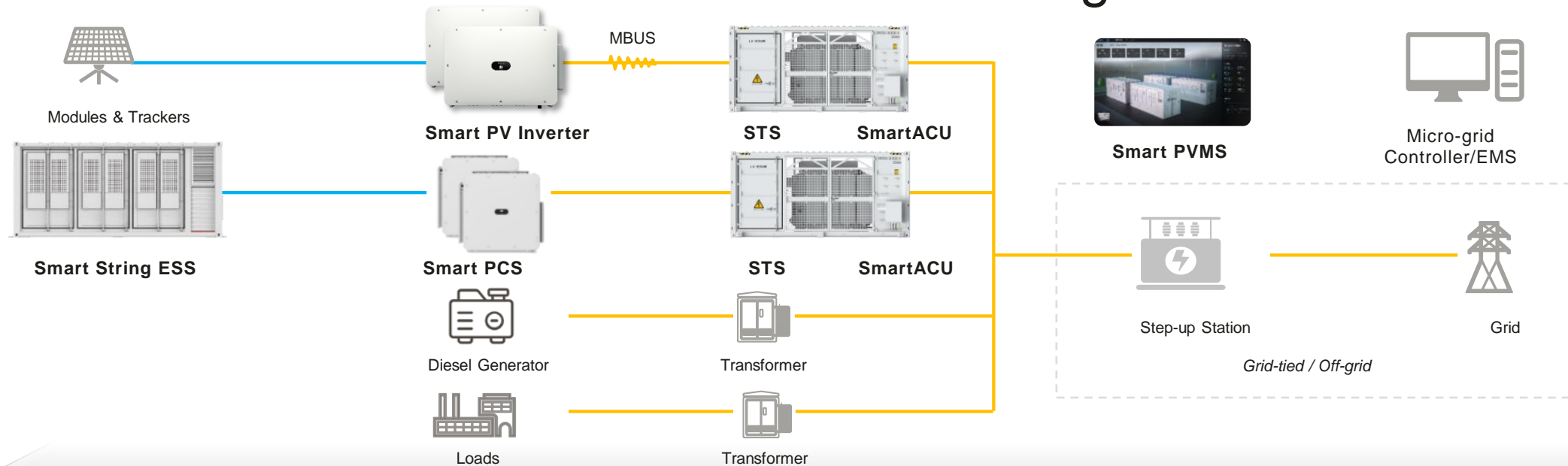
The LVAC coupling solution is used in scenarios where the energy storage ratio is not high in the PV plant, for example, large-scale PV plant and small or medium-sized PV plant.

- Compared with the MVAC coupling solution, the solution reduces the CAPEX, improves the energy storage and charging efficiency, and reduces the dependency on the EMS.
- Compared with the DC coupling solution, the DC coupling solution can narrow the gap between CAPEX and system efficiency. It does not have the safety problem of DC power distribution and has higher system availability.



Smart Micro-grid Solution: FusionSolar for Green & Resilient Power

First 100MW+ level 100% PV & ESS Micro-grid Solution



Higher Resilience

- Off-grid fault ride through, avoiding blackout loss **\$ 0.5 Million / 10 MW**
- Whole grid black start, enabling minutes level power recovery
- Online transition of off-/on-grid, avoiding blackout loss

Optimal LCOE

- LCOE reduced by **50% +**, compared with diesel generation
- 2:1 PV / BESS ratio in micro-grid, raising renewable energy proportion by 30%

Proactive Safety

- Smart String-level Disconnect, higher PV system safety
- Smart String ESS: Active Alarm, System quadruple safety protection

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home and
organization for a fully connected,
intelligent world.

**Copyright©2018 Huawei Technologies Co., Ltd.
All Rights Reserved.**

The information in this document may contain predictive statements including, without limitation, statements regarding the future financial and operating results, future product portfolio, new technology, etc. There are a number of factors that could cause actual results and developments to differ materially from those expressed or implied in the predictive statements. Therefore, such information is provided for reference purpose only and constitutes neither an offer nor an acceptance. Huawei may change the information at any time without notice.

