

FusionSolar Smart String Energy Storage System Solution

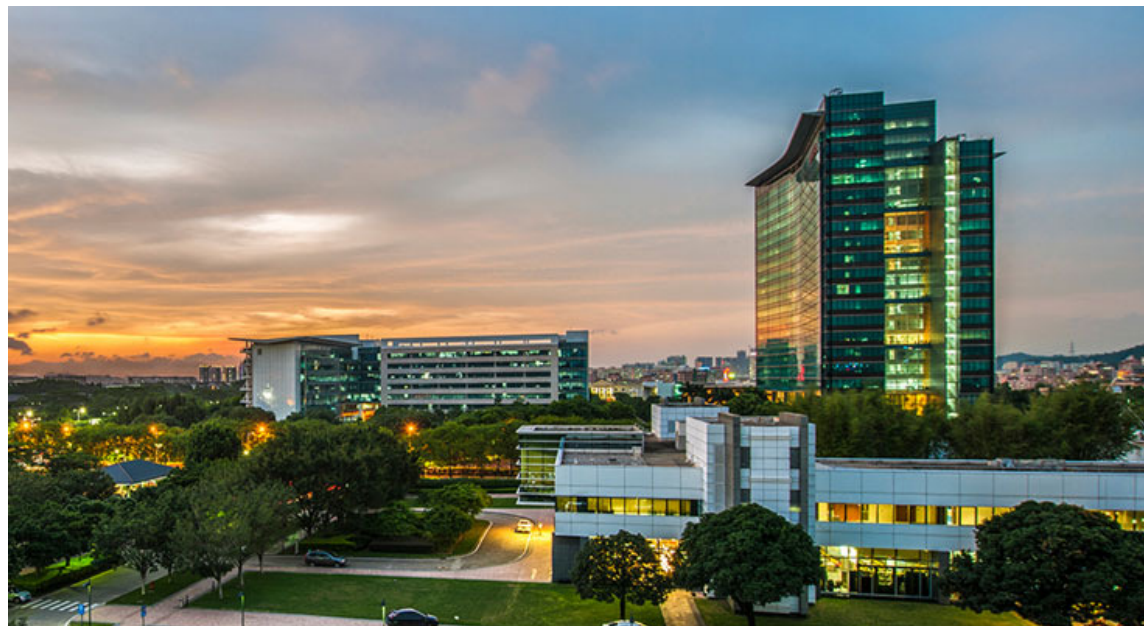
Pioneering innovation of digital and power electronics
Enabling smart renewable energy and accelerating carbon neutrality



01

Huawei Overview

Huawei: Leading provider of ICT infrastructure and smart devices



Vision & mission

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

195,000

employees

170+

countries and regions

No. 44

on Fortune Global 500

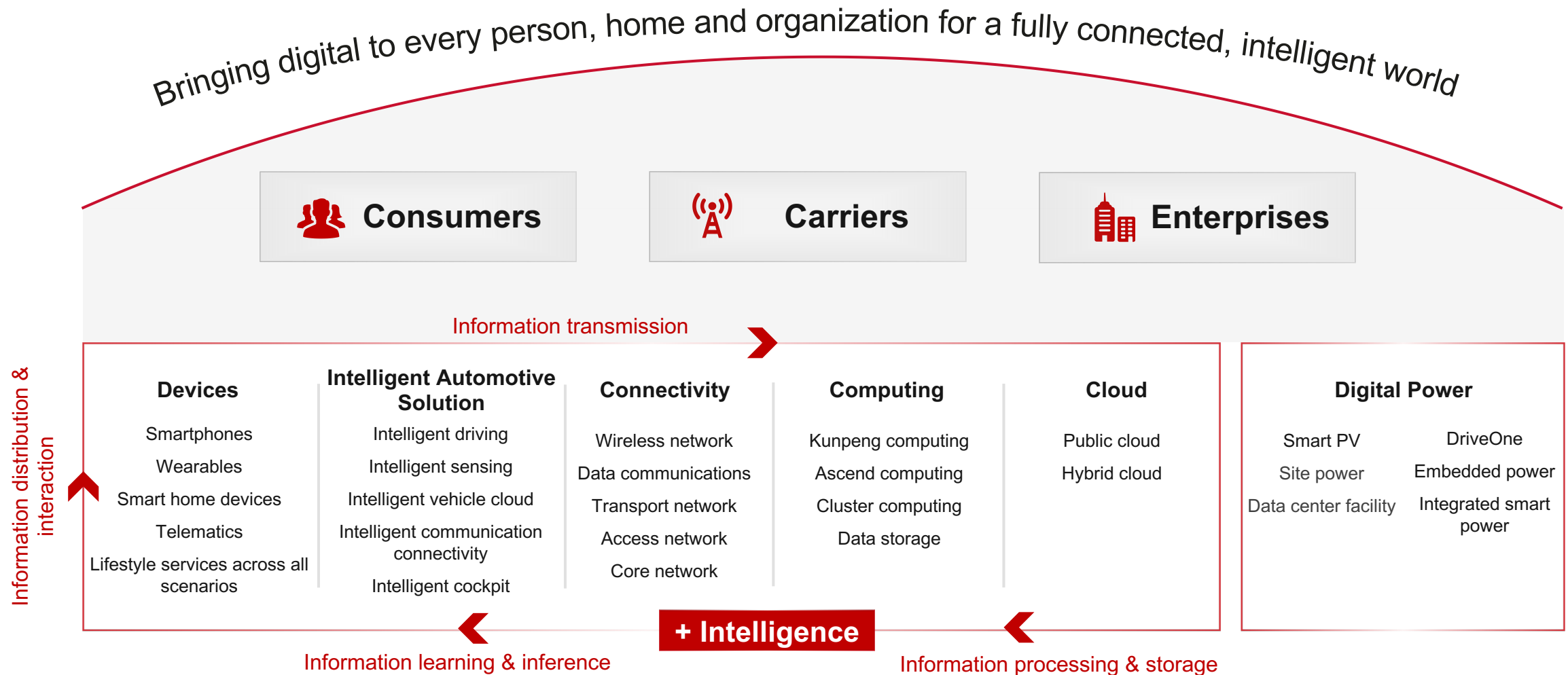
No. 2

in R&D investment

54.8%

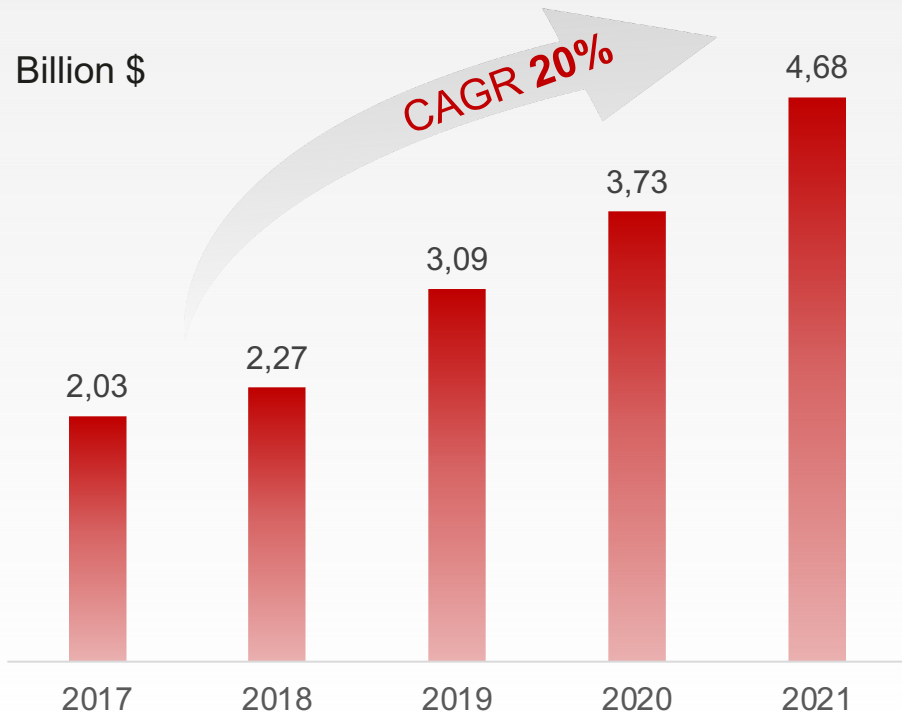
of employees are in R&D

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



Digital power business maintains rapid growth

Sales Revenue in Digital Power Business



* The data of 2021 unaudited

Applicable To 170+ Countries and Regions Serving 1/3 of the World's Population

Smart PV



No. 1 Shipments in the world for 6 years

Source1

Data Center Facility



Prefabricated modular DC
No.1 global market share for 7 years

Source2

Site Power



340+ Telecoms & TowerCos
NO.1, 35.6% global market share

Source3

DriveONE



15 OEMs, **40+** vehicles choose DriveONE

Embedded Power



809 million PCS delivered

Source1: IHS Markit & Wood Mackenzie

Source2: Omdia

Source3: Frost & Sullivan

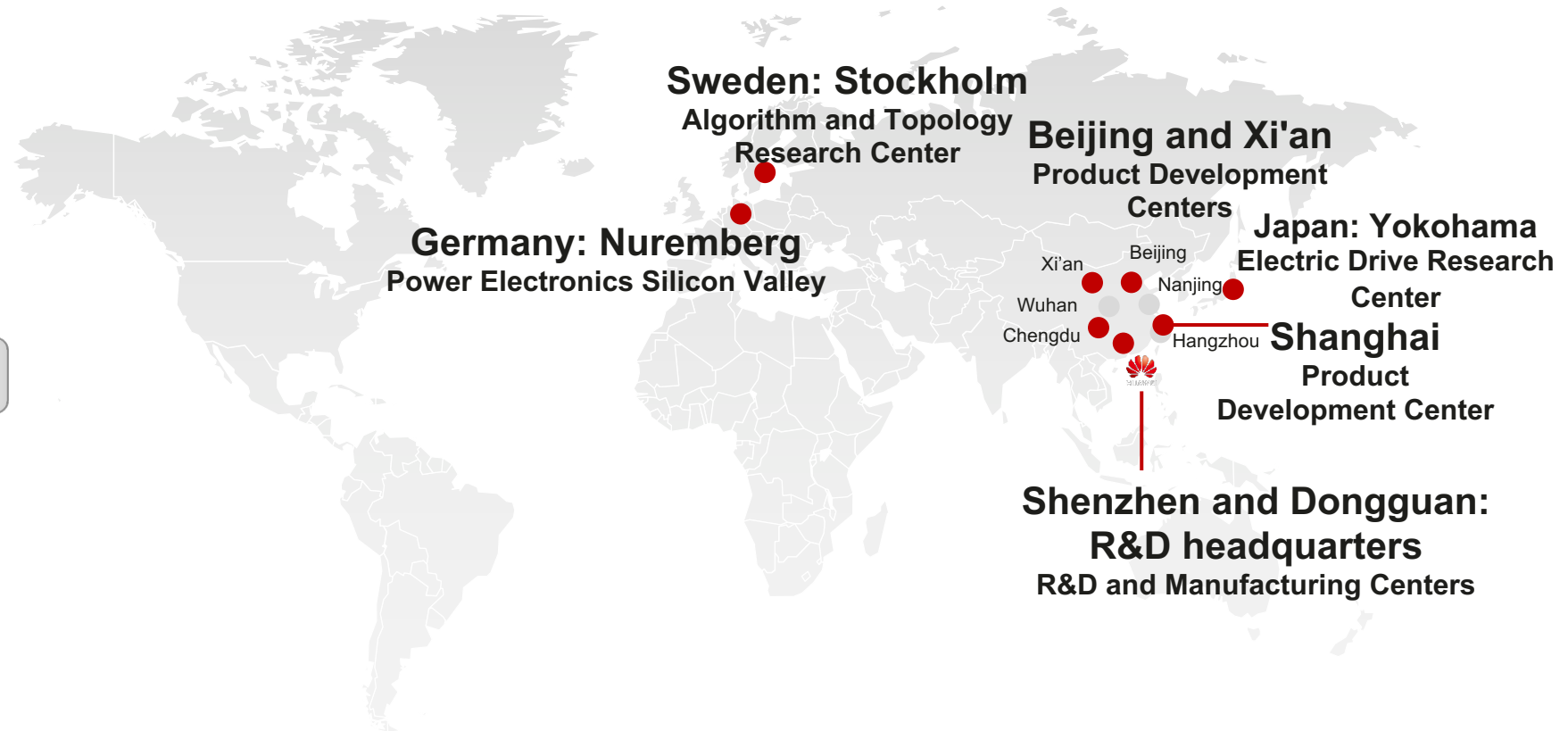
Global R&D teams and technology platforms: Leveraging the domain specific advantages globally to keep leading

 6000+ employees
60% R&D

 12 R&D centers

 10%+ R&D investment

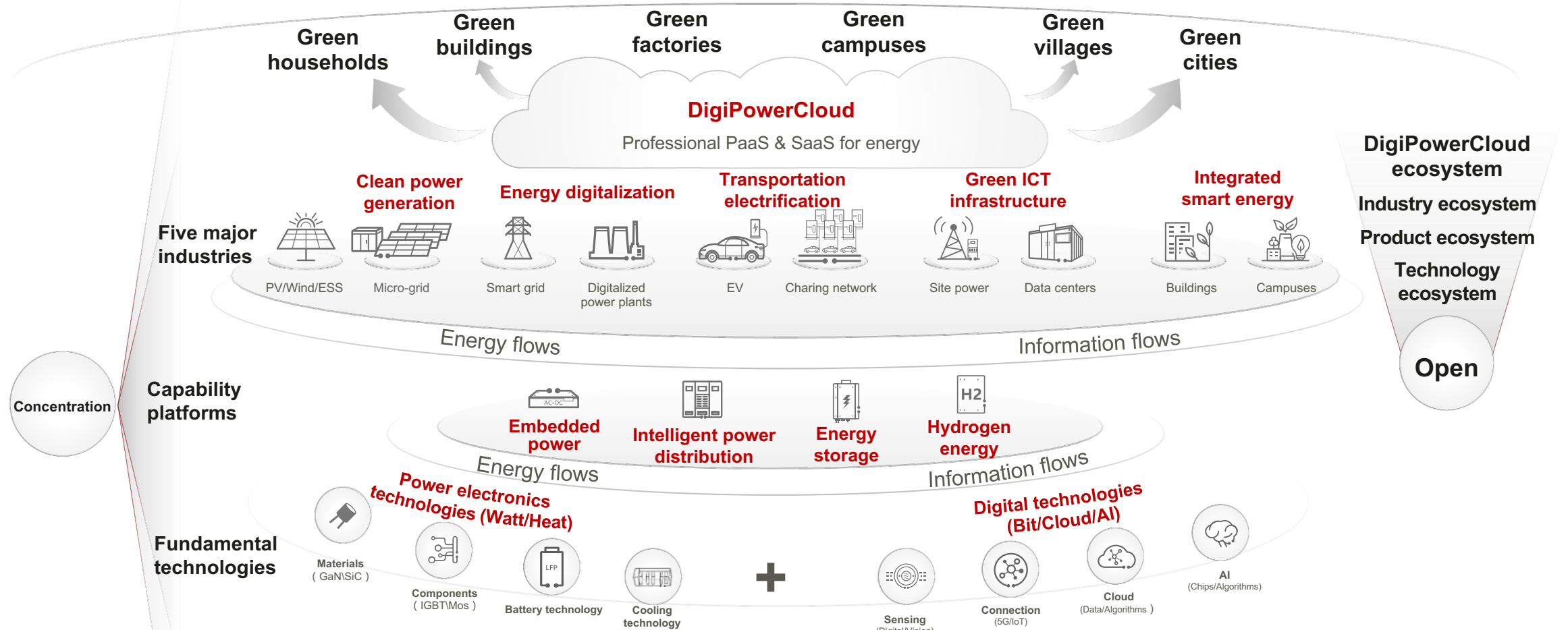
 1300+ patents



Digital Power Strategic Vision Overview

Developing clean energy, promoting the digitalization of traditional energy, integrating digital and power electronics technologies, and converging information and energy flows to drive energy revolution for a better, greener future

Evolve society from low carbon to zero carbon



Huawei Digital Power has accumulated 10+ years of experience in energy storage R&D and application

10+ years
R&D experience

500+
R&D team

6 GWh
Annual ESS capacity

From cell to system,
end-to-end verification



Cell & Pack

Long-term cycle charge
and discharge
Fast life test...



Energy storage

System Safety fire test
Field verification...

Accumulated shipments of ESS **>8 GWh**,
long-term stability verified in extreme conditions globally



Site ESS
200,000+ sets



Data Center
64,000+ sets



-40°C
Helps 5G summits
Mount Everest



50°C
Guarantee stable
Power supply at high
temperature



Resi ESS
11,000+ sets



Micro-grid ESS
2000+ sets



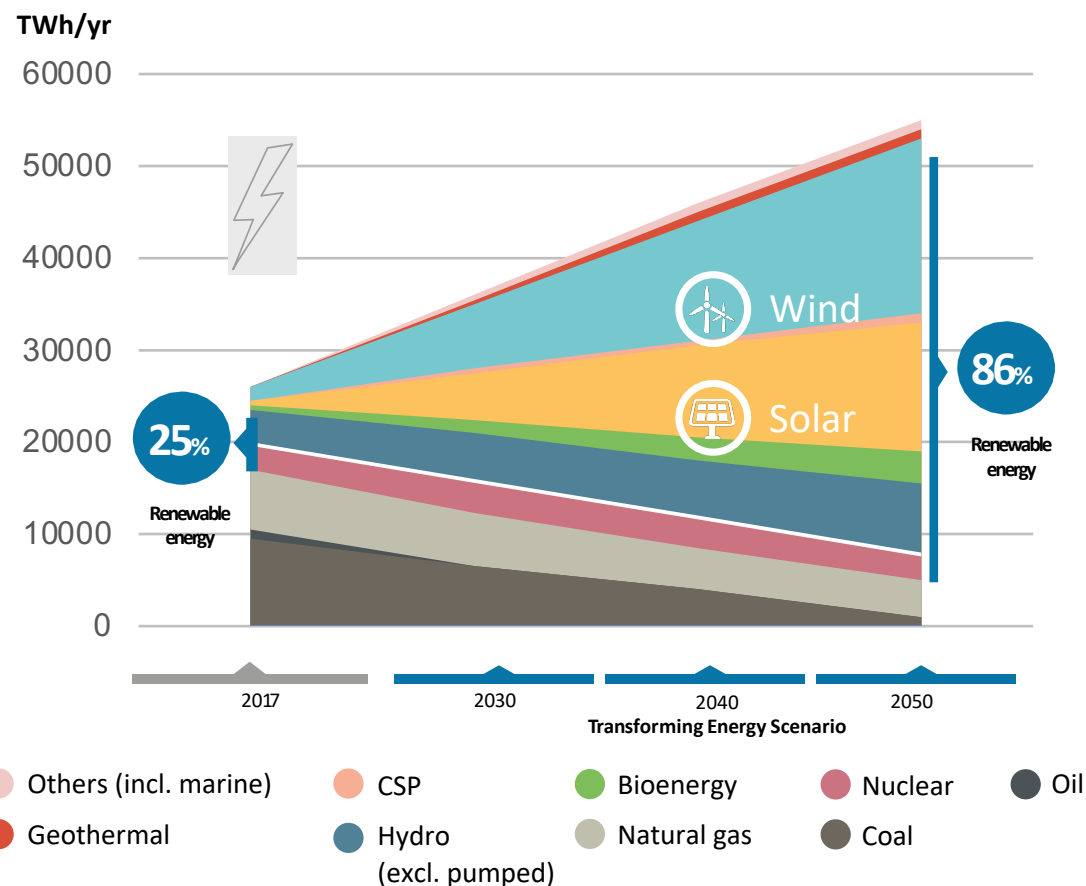
**High humidity and
high salt fog**
Resistant to salt and
corrosion, guarantee a
15-year lifespan

02

Trends & Challenges

Energy Strategy Transformation: Promoting solar & wind to become the major energy

PV: the major energy supply for power plant installation



Governments & corporations specify low-carbon targets



China

Carbon neutral realized **in 2060**

Peak value **by 2030**, 20% renewable energy



EU

Carbon neutral realized **in 2050**

GHG emission -60% **by 2030**, 32% renewable energy

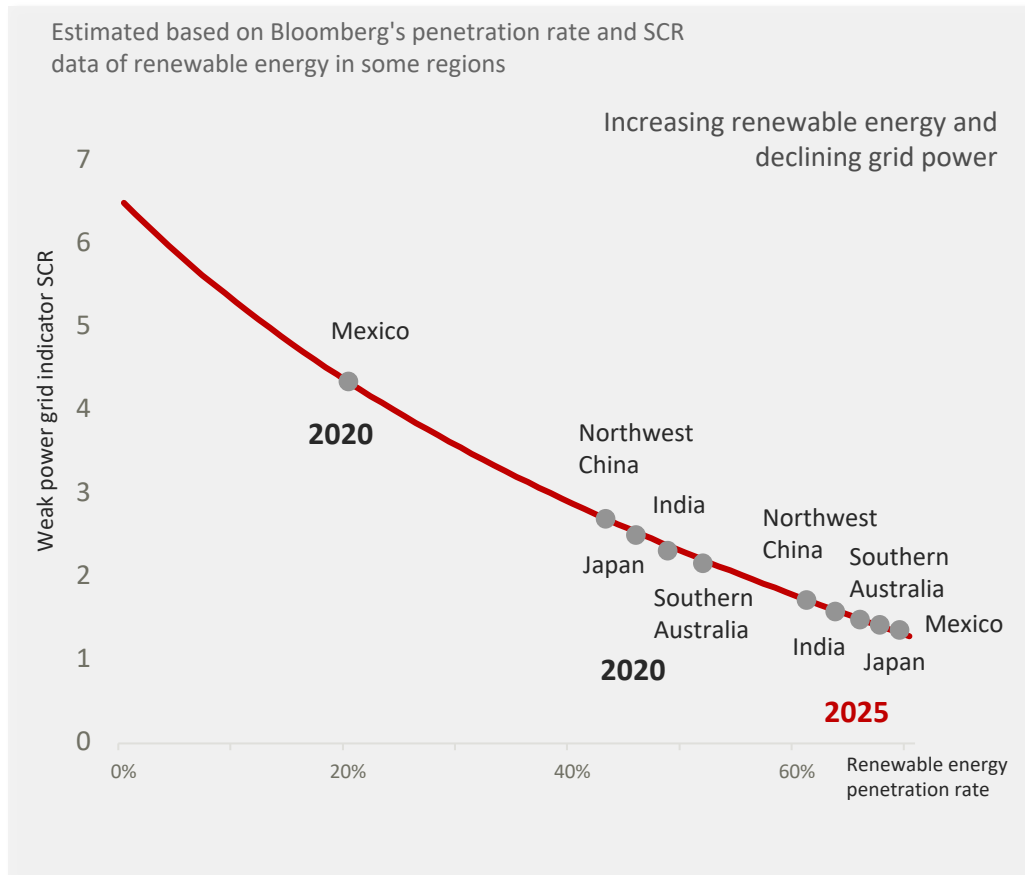
Strategic transformation of energy
giants accelerate Carbon Neutral

Various Power consumption companies join
RE100 & promise to achieve 100% renewable
energy power consumption

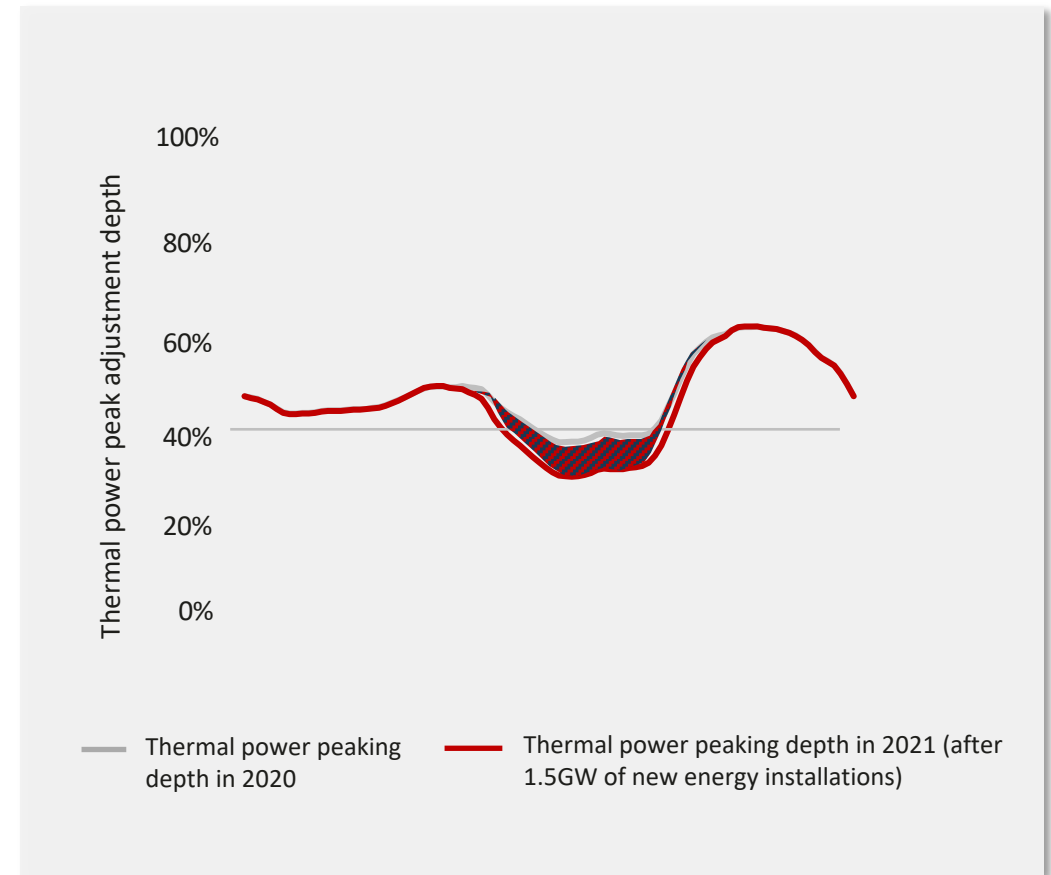


Power grid stability declines, Energy Storage has emerged as a flexible grid-balancing tool

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



Thermal power peaking capacity is nearing its limit, Sharp increase of power grid peak shaving requirements



Challenges in Battery Energy Storage System Industry

Low Available Capacity



Complex O&M



Short Lifespan



Fire Risks



- Series & Parallel mismatch due to inconsistency between battery cells, which leads to lower available capacity according to Cannikin Law

- On-site battery installation wiring & commissioning
- Regular SOC calibration by professional staff

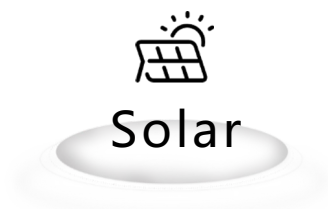
- Unbalanced temperature control design, resulting in a temperature difference of $>10^{\circ}\text{C}$ inside the container and a 25% reduction in battery lifespan

- Battery cell over-charge, over-discharge, or other faults
- Key components (circuit boards, contactors, etc.) failure cause sparking and arcing

03

Smart String Energy Storage System Solution

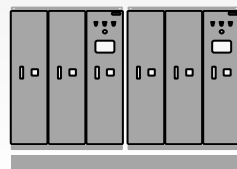
Concept STRING becomes the mainstream from PV to PV+ESS industry



Solar

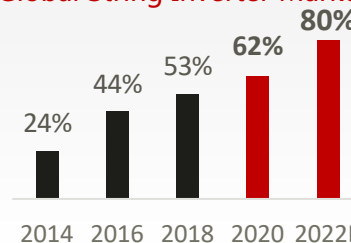
Central Inverter

2000+ PV Modules / MW, 1MPPT Centralized Management

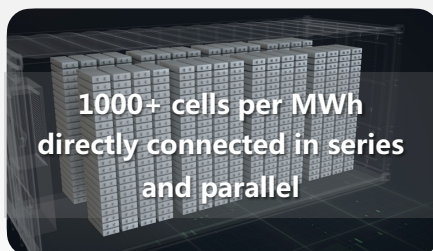


Smart String Inverter

Global String Inverter Market Share



Central ESS



- Cell mismatch causes severe loss



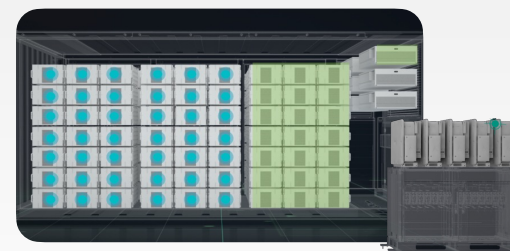
- Periodic manual O&M



- Difficult to identify failures
- Lack of linkage protection



Smart String ESS



- Independent control of battery packs & racks



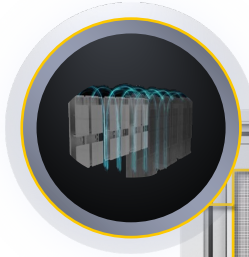
- No need of SOC calibration



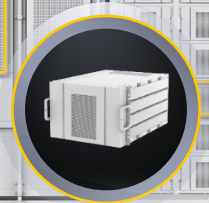
- System quadruple security protection

Smart String ESS: Optimal LCOS, Proactive Safety Protection

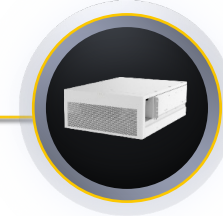
Distributed Cooling



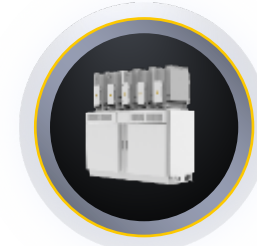
Pack-level Optimization
Pack Optimizer



Rack-level Optimization
Smart Rack Controller



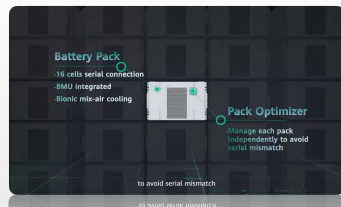
All Modular Design
Smart PCS



More Energy

Increase discharging energy by 15%

Pack-level Optimization
Rack-level Optimization



* Calculated base on 100MW/200MWh project

Optimal Investment

Initial configuration reduced by 30%

Battery augmentation supporting



Simple O&M

Saving EUR 1.7 million/year*

No need for periodic balancing
No need for experts to visit sites



Safety & Reliability

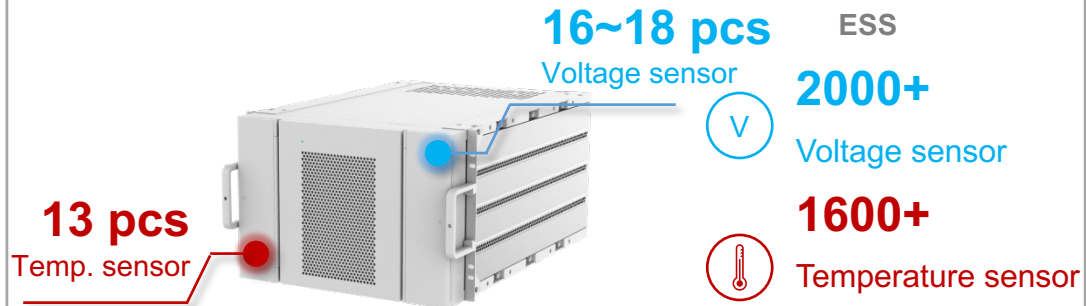
Proactive Protection

Cell to system safety protection
Avoid thermal runaway



More Energy: Higher Usable Capacity with Refined Energy Management

Pack-level Monitoring

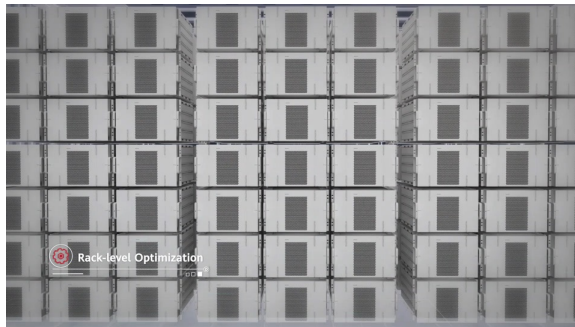


Battery Pack Optimizer



- **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

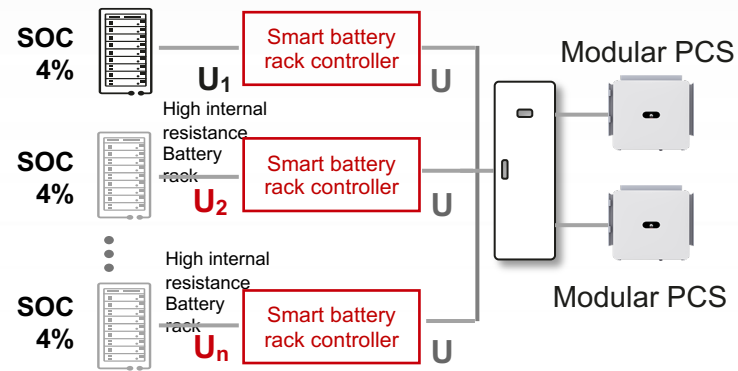
Distributed Temperature Control



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

Optimal Investment: Smart Rack Controller Enables Battery Augmentation

New and old batteries can be mixed



*The discharge capacity within 10 years is not less than 100 MWh.
DOD: 90%, charge and discharge twice a day

No AC-Side device is required

	Traditional Augmentation Solution	Huawei Battery Augmentation Solution
Total	156 MWh battery + 140 MW PCS & transformer	156 MWh battery + 100 MW PCS & transformer
Initial configuration	116 MWh battery + 100 MW PCS & transformer	116 MWh battery + 100 MW PCS & transformer
Early in the third year	10 MWh battery + 10 MWh PCS & transformer	10 MWh battery
Early in the fifth year	10 MWh battery + 10 MWh PCS & transformer	10 MWh battery
Early in the seventh year	10 MWh battery + 10 MWh PCS & transformer	10 MWh battery
Early in the ninth year	10 MWh battery + 10 MWh PCS & transformer	10 MWh battery

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

Central Solution

Routine O&M

SOC calibration
every 6 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: Proactive alarm, Active safety

Proactive Alarm

- **Smart internal short circuit diagnosis:**
Pre-alert & bypass the faulty cells
- **Fire risk point monitoring:**
Massive sensors monitor system exception
- **Live insulation monitoring:**
ISO/IMD pre-alert short circuit risks

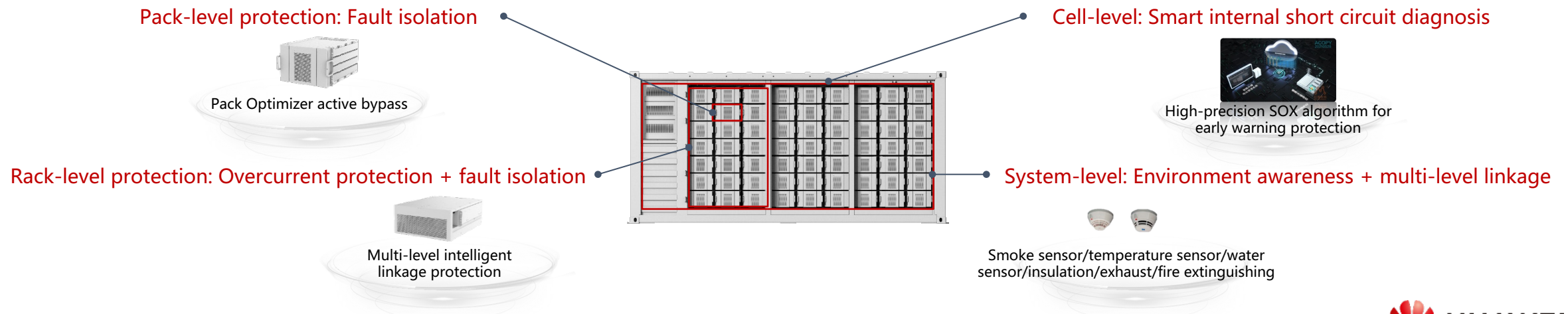
Active Safety

- **Multi-level shutdown & protection :**
Faulty packs & racks are disconnected & isolated
- **Rapid System disconnection :**
One click shutdown while identify thermal runaway

Active Safety

- **Active Gas release:**
Actively exhaust combustible gas to avoid explosion
- **Quick fire extinguishing:**
Fast fire extinguishing within 10s

Smart String ESS: Active Alarm, System quadruple safety protection



04

Smart Energy Storage System Solution

Flexible Adaption in Different Business Scenarios

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

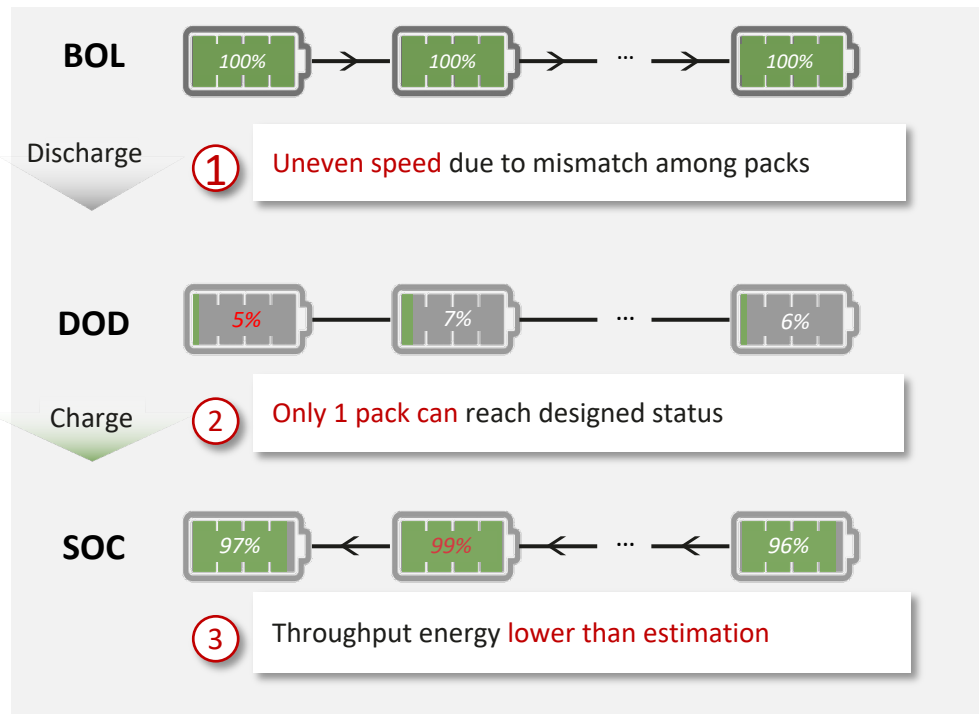
Frequency Regulation

Rack-level Refined Energy Management

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

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

Capacity loss due to series/parallel mismatch



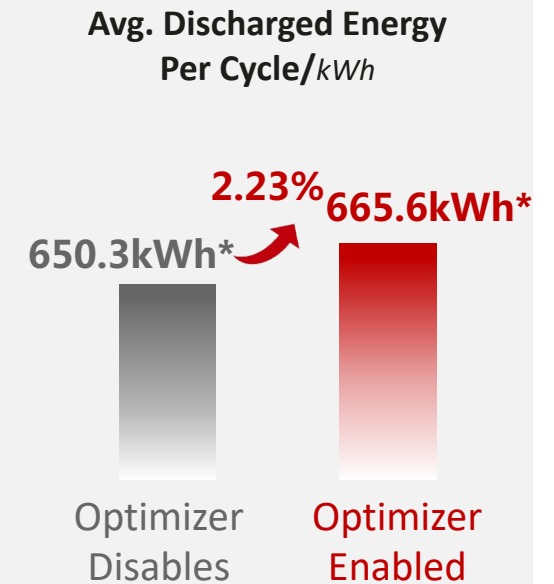
Case Analysis: 1MW/2MWh project in Tangshan, China



COD: 2021.11

Application: Peak-valley shifting

Test Period: 2022.01.11 -2022.01.19



Note: * testing sample – 2 battery racks, rated capacity 688 kWh

Simple O&M: No Experts On-site Visit, Spare Parts “Plug and Play”

Central Solution



- Peak shaving plant always in a large scale
- Complicated O&M
- Higher O&M cost



Expert
On-site visit



Pack SOC
detection in one rack



Spare pack SOC
adjustment



Backup pack
replacement

30+ times/year, Once every 2-3 days
\$ 1300/person/time

Smart String ESS Solution



- No experts on-site visit
- Pack optimizer enabled spare parts “Plug and Play”



On-site O&M
personnel



Backup pack
replacement

No Expert Required
\$ 0 , Once every 0.5 day

Frequency Regulation: Smart rack controller enables constant power output for longer period

Traditional Solution: Discharging Power Derating



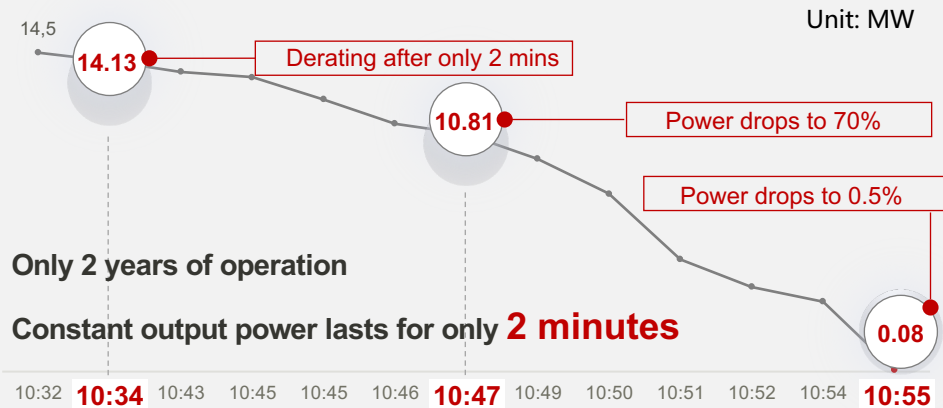
Battery inconsistency leads to current bias between battery racks



Output capability depends on the worst performing battery



Key Indicator: The constant power output cannot be satisfied



* Based on a survey of a BESS plant in Guangdong, China

Huawei Solution: Rack-level Refined Energy Management



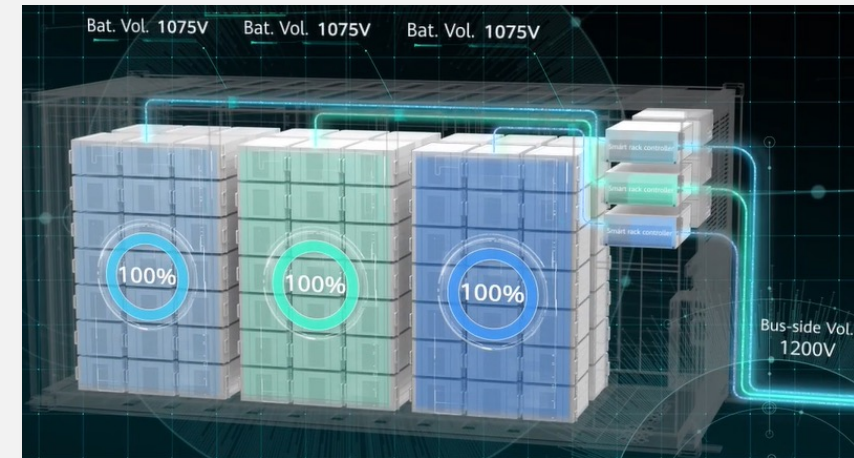
Independent running between battery racks



Rack-level optimization, avoiding current bias



Enabling constant power output for longer period



Frequency Regulation: Automatic SOC calibration helps BESS plants operate more sustainably, saves O&M cost ~\$ 2.52 Million per year*

Traditional Solution: High SOC Deviation



Inaccurate SOC Estimation : High number of shallow-cycles, battery cannot be calibrated in normal operation



High SOC Deviation : SOC deviation is >10% after 3 months, SOC deviation is >50% after 1 year

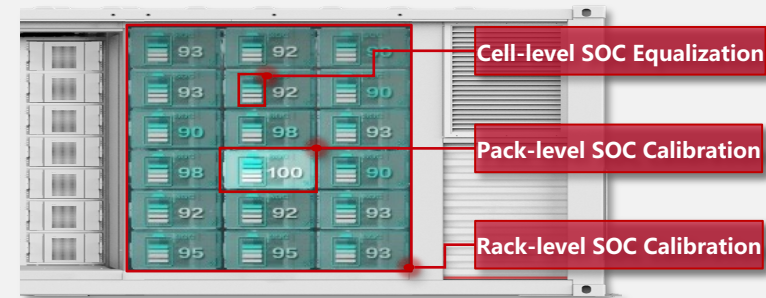
*Reference: China electric power research institute



A BESS project in Shanxi, China

After 3 months of operation, the SOC deviation between battery racks exceeds 10%

Huawei Solution: Automatic SOC Calibration



*Routine Inspection only
No SOC Calibration*

- **BMS Automatic Determination:** When the number of cycles of a battery pack reaches the default value, the **rack automatic calibration logic** is started.
- **Power Automatic Allocation:** Smart rack controller **allocates more power** to the battery rack that needs SOC calibration.

Saving SOC Calibration Cost ~\$2.52 M/year^[1]

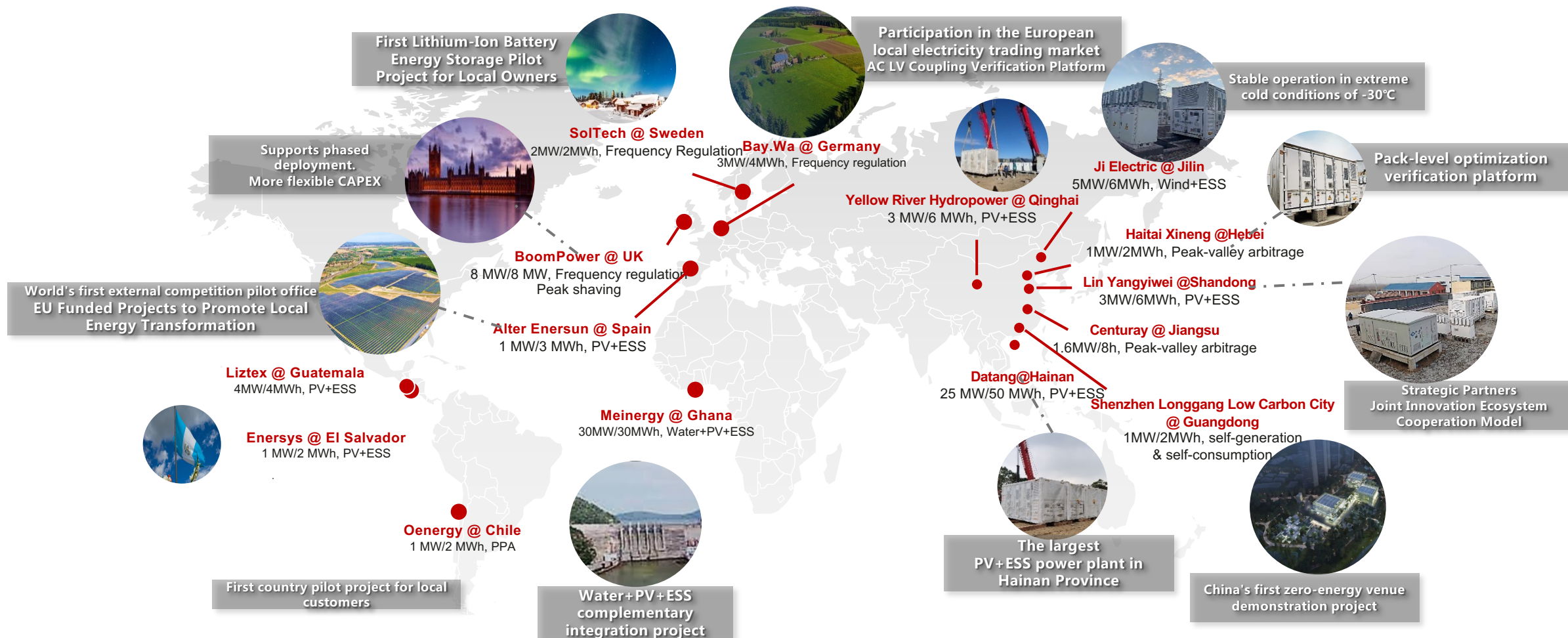
*Calculation based on 200MWh BESS plant ,

1. SOC calibration saving: 6 times/year * 600 person*day * \$700 day/person ≈ \$2.52 M/year

05

Application Cases

Smart String Energy Storage System Solution has been applied globally



Smart String ESS pilot projects cover five regions: China, Europe, LATAM, MEA, and Africa, promoting the smart string ESS solution with optimal LCOS globally.



China Datang Corporation Ltd.

Plant Scale: 25MW/50MWh

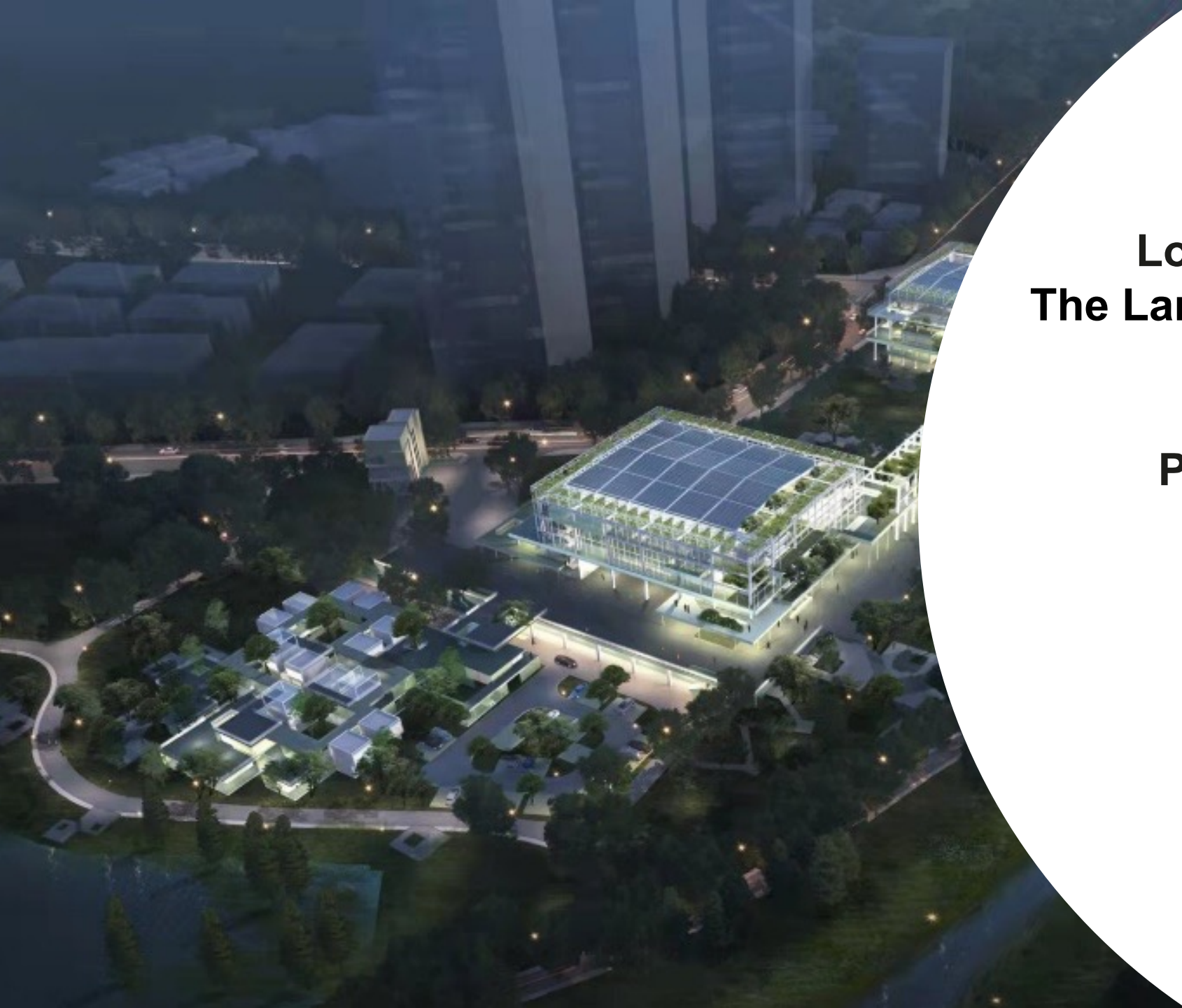
COD: 2022.05



Jilin Electric

Plant Scale: 5MW/6MWh

COD: 2022.05

An aerial night-time photograph of the LongGang Low Carbon Town. The central focus is a large, modern building with a glass facade and a flat roof covered in solar panels. The building is illuminated from within, and its lights reflect on the surrounding area. To the left of the main building is a cluster of smaller, more traditional-looking houses with dark roofs. The entire development is surrounded by lush green trees and landscaping. In the background, several tall, modern skyscrapers of a city skyline are visible against the dark night sky. A curved white line, likely a road or a design element, runs through the lower left portion of the image.

LongGang Low Carbon Town The Largest Zero-Carbon Building in China

Plant Scale: **1MW/2MWh**

COD: 2021.12



Centuray

Plant Scale: 1.6MW/8MWh

COD: 2022.03



LinYang

Plant Scale: 3MW/6MWh

COD: 2021.12

Digital Power: Your Best Partner for a Better, Greener Future

By June 30, 2021, Digital Power has helped customers

generate green power

save power

reduce carbon emissions

equivalent to planting

403.4 billion kWh

12.4 billion kWh

200 million tons

270 million trees



Conversion note:

Note 1: Conversion coefficient of electricity carbon emissions – 1 kWh electricity is equivalent to 475 g CO₂ (global average).

Source: International Energy Agency (IEA) Global Energy & CO₂ Status Report 2018

Note 2: Lifetime CO₂ absorption of trees (equivalent number of planted trees) – A tree absorbs 18.3 kg of CO₂ a year, and each tree has a 40-year lifespan.

Source: Open data of the North Carolina State University website

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.

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