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10 Trends in smart PV @2025

Oct 20-21

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Methodology

Forecasts based on market insights

Forecasts by international organizations

Forecasts by consulting companies

Forecasts by industry vendors

Huawei analysis

Customer and partner surveys and interviews

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Trend 1 Digitalization

Integration of digital and PV technologies enables simple, intelligent, and efficient O&M, production management, and asset management.

By 2025, 90% of global PV plants will be fully digitalized.

Trend 2 AI-driven Upgrades

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AI technologies will serve as future experts, enabling autonomous and collaborative optimization of systems and creating infinite possibilities.

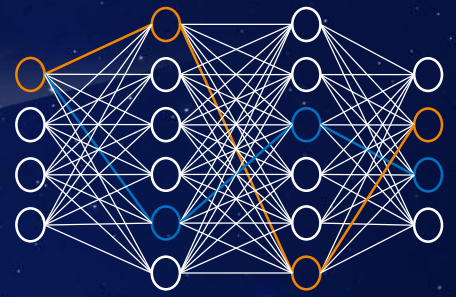
System design optimization
Optimized tracker design

Fault diagnosis
Proactive identification of root causes of device alarms

Solar + Storage

$G = f(x)$

AI computing is extending human capabilities.



By 2025, 70% of PV plants will adopt AI.

Algorithms

AI algorithms in specific fields have reached or exceeded human capacities (such as speech recognition and mathematical inference).

Computing power

Innovation of cloud-edge-device computing architecture brings dramatic growth of computing power.

Data

Each year, 1 GW PV plant generates 1000 GB data on average.

Trend 3 Unmanned PV Plants

Robots will account for massive O&M in PV plants, vastly improving the productivity and safety of PV plants.

By 2025, more than 80% of the work in PV plants will become unmanned.

Unmanned drone
Site inspection

Inspection robot
Patrol and remote operation

Cleaning robot
PV module cleaning

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Machine vision
Facial recognition for security

Smart glasses
Fault identification and intelligent operation

Biomorphic robot
Transportation and installation

Trend 4 Proactive Support for Power Grids

New energy penetration rate

In regional power grids across the world, the increasing new energy penetration rate will gradually edge out traditional generator sets.

For power grids, the use of new energy introduces more power electronic devices and does not provide synchronous short-circuit current capacity.

New transmission architecture

UHVDC transmission
AC transmission + series compensation

New transmission lines will become one of the main long-distance transmission modes of new energy in China.

Increase in renewable energy penetration rate will undermine power grid strength.

$$SCR = \frac{\text{Synchronous short-circuit capacity of a grid}}{\text{Installed capacity of a PV plant}}$$

~1.8	~1.5	~1.2	~1.2	*Northwest China @2025

To adapt to low SCR of grids, solar inverters must use more accurate algorithms for grid connection.

Over the next 5 years, PV plants will gradually shift from grid-following to grid-supporting.

Impedance reshaping	Harmonic suppression	Series compensation adaptation	Dynamic damping adjustment
Oscillation suppression	High and low voltage ride through	Fast frequency modulation	Islanding protection

Trend 5 Solar + Storage

The proportion of PV systems with energy storage is projected to exceed 30% by 2025.

Technology-driven

Lower costs

- Breakthroughs in the cell production
- Optimized battery heat dissipation technologies

Solar-Storage synergy

- EMS power plant energy management
- Interconnection between PV and storage system

Market-driven

Peak load and frequency regulation

- Increasing renewable energy penetration rate
- Lower cost in renewable energy generation than traditional solutions

Self-consumption

- Reduced residential PV feed-in tariffs
- Lower levelized cost in electricity (LCOE) than that of the mains.

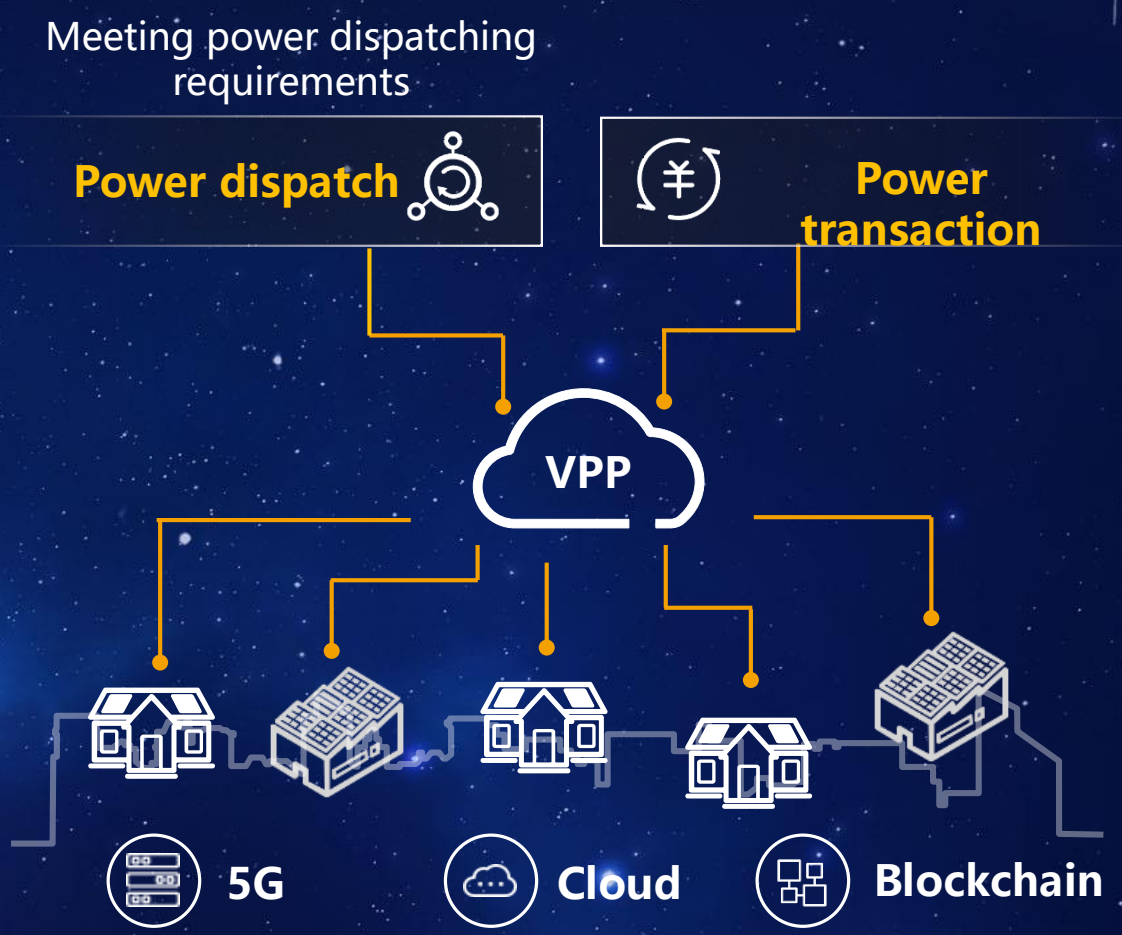
Trend 6 Virtual Power Plants

Virtual power plants (VPPs) are collaboratively managed. They will participate in power dispatching and transaction, serving as the new engine of growth for distributed PV.

By 2025, **80%** of residential PV systems will connect to VPP networks.

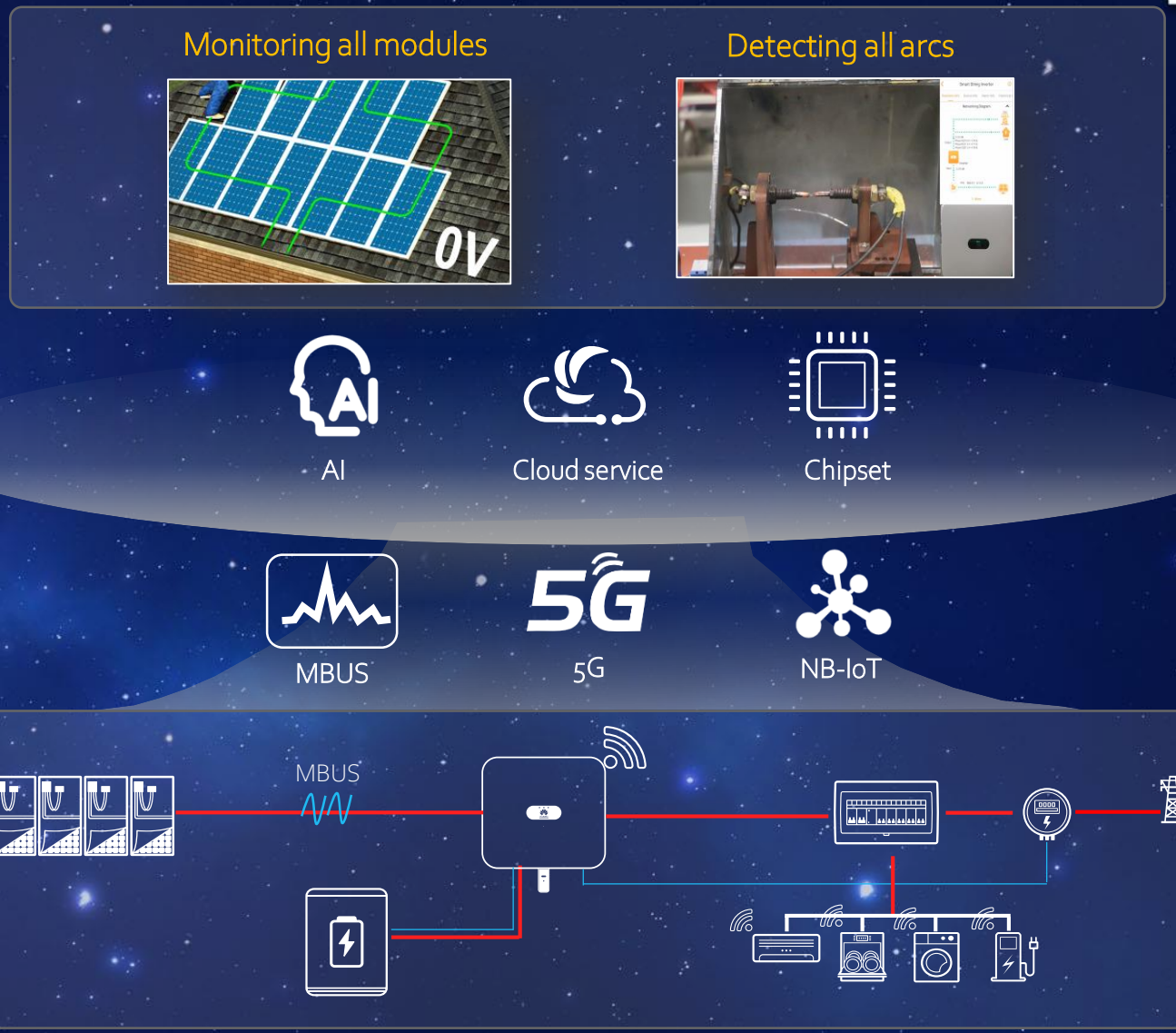
The application of VPPs will inspire **a new business model** and become as the **new engine of growth** for distributed PV.

Massive distributed PV plants can be **collaboratively managed as VPPs.**

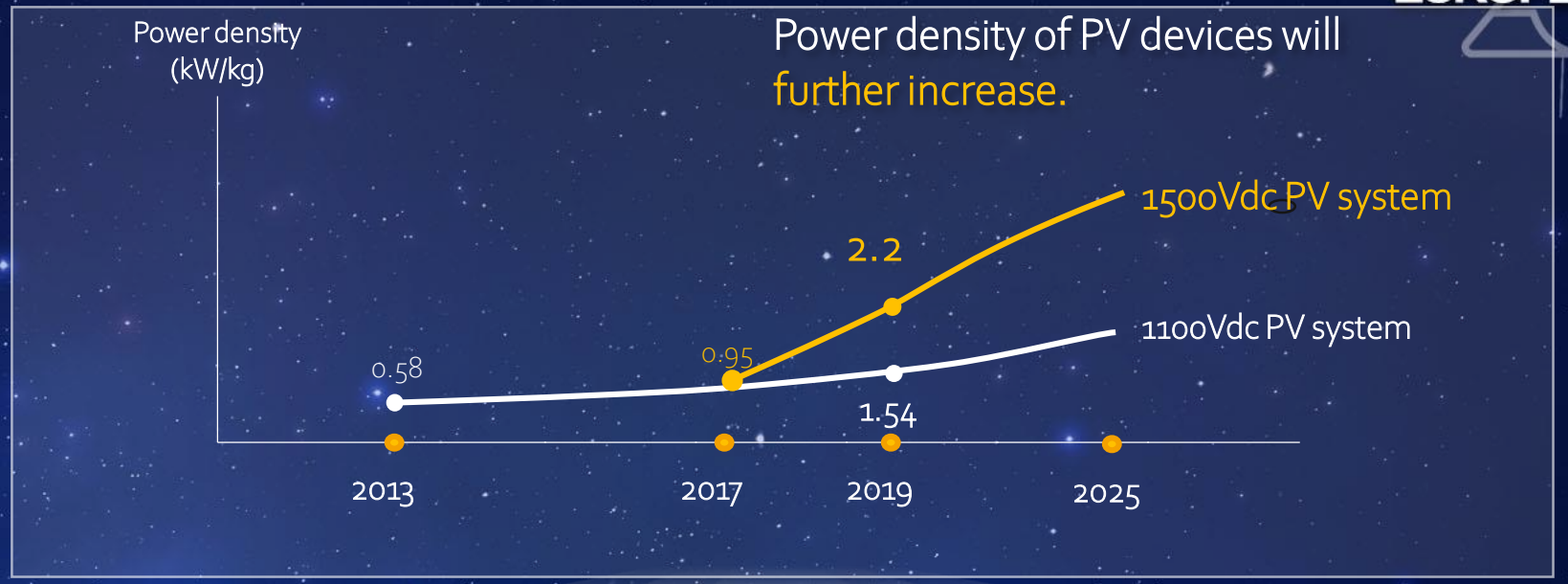


Trend 7 Active Safety

Arc-fault circuit interrupters (AFCI), the module monitoring and safety shutdown devices, will become must-have in C&I and residential PV plants and industry standards worldwide.



Trend 8 Higher Power Density



Development of materials, heat dissipation, and engineering technologies will increase the power density for lower LCOE.

By 2025, solar inverter power density will be improved by over 50%.

Materials science

- Silicon carbide components
- Gallium nitride components

Heat dissipation technologies

- Chip heat dissipation optimization
- Heat dissipation design optimization

Engineering technologies

- Component integration
- Control algorithm optimization

Trend 9 Modular Design

Components such as solar inverters, PCSs, and battery modules will adopt modular design for flexible deployment and multi-scenario application.

Multi-scenario application

Standard interfaces between devices enable easy interconnection in various scenarios without restrictions.

Flexible Deployment

Modularized subsystems feature high duplicability, facilitating service deployment for future expansion.

Expert-free maintenance

Modular components negate the need for expert onsite maintenance with hot swapping.

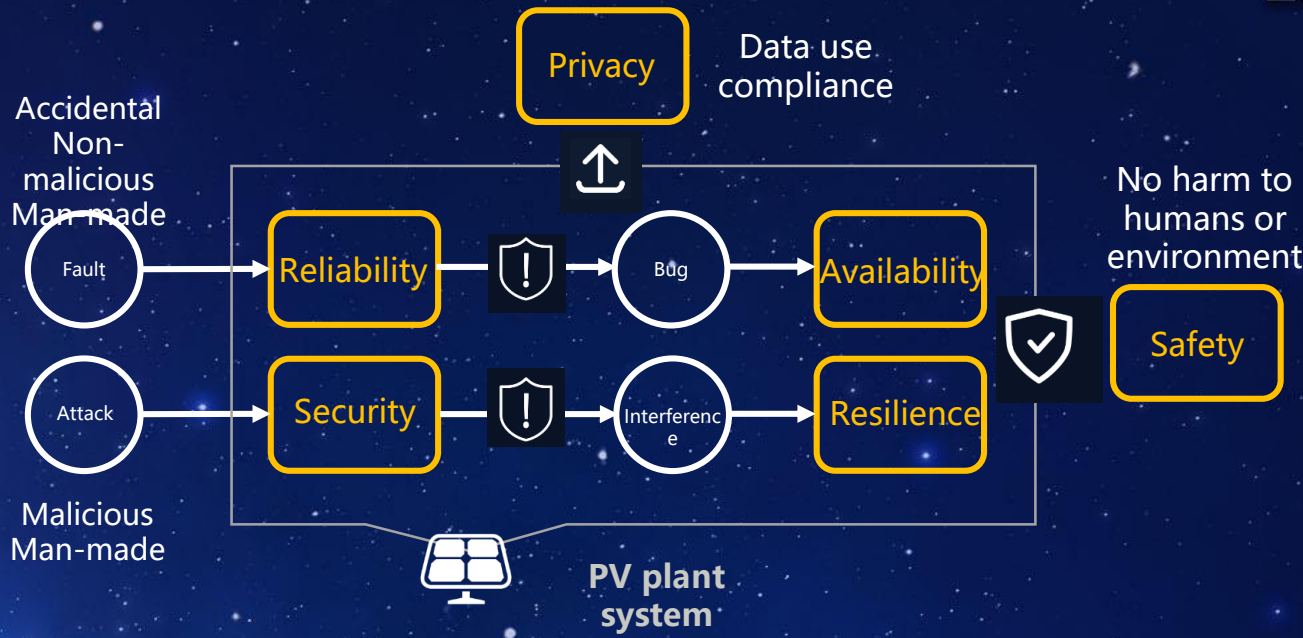
Solar inverter

Energy storage

PCS

Transformer

Trend 10 Security and Trustworthiness



PV system cyber security risks and user privacy security requirements will rise sharply.

By 2025, system **reliability, availability, security, safety, resilience, and privacy** will become essential requirements.

Technology, industry, and society collaboratively develop to build digital trust.

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Thank you.

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