White Paper on Top 10 Site Power Trends

Help Build Green and Fully-Connected Networks,
Enable Industry Digitalization, and Bridge the Energy Divide

Preface

The world's major economies have set carbon neutrality goals to cope with global climate changes. European Commission announced that EU will achieve carbon neutrality by 2050 and released the Green Deal. The UK, Japan, South Korea, and Canada have announced that they will achieve carbon neutrality by 2050. China has promised to meet its targets by 2060. Driven by carbon neutrality goals, the proportion of low-carbon clean energy such as wind, solar, and water is expected to increase from 26% in 2020 to 60% in 2050. The energy structure will transform from fossil energy to renewable energy at faster speed.

Meanwhile, emerging technologies such as Internet of Things (IoT), cloud computing, and intelligence are rapidly commercialized. The New Infrastructure Construction and digital transformation in various industries are getting prospering. Diversified intelligent applications are popularized, and the digital economy is vitalizing.

From drilling wood for fire, coal, oil and gas, to new energy, human history has witnessed three energy revolutions. A new round of energy revolution featured with renewable energy and intelligent technologies is hoped to bring new momentum to the increasingly digital world.

In January 2021, multiple experts and scholars from the site power field jointly released the White Paper on Top 10 Site Power Trends based on the discussion about green and digital transformation of energy. The white paper provides insight into the future trends and analyzes the future directions, and is a strategic reference for site power transformation and upgrade.

Contents

Trend 1

Power Digitalization

From watt to watt + bit, bit manages watt. Digital and power technologies are integrated to implement digital management of power networks.

The traditional watt power link does not support coordination. After digitalization, bits are used to manage watts. The power network will evolve from watts to watt+bit collaboration, and the full power link from power generation, conversion, storage, distribution, to use will be digitalized and intelligent. Power digitalization at sites, chains, and networks will be realized. In addition, digital technologies such as intelligence, big data, and IoT[1] will be integrated with power electronics technologies to implement visualized, manageable, controllable, and optimizable systems.

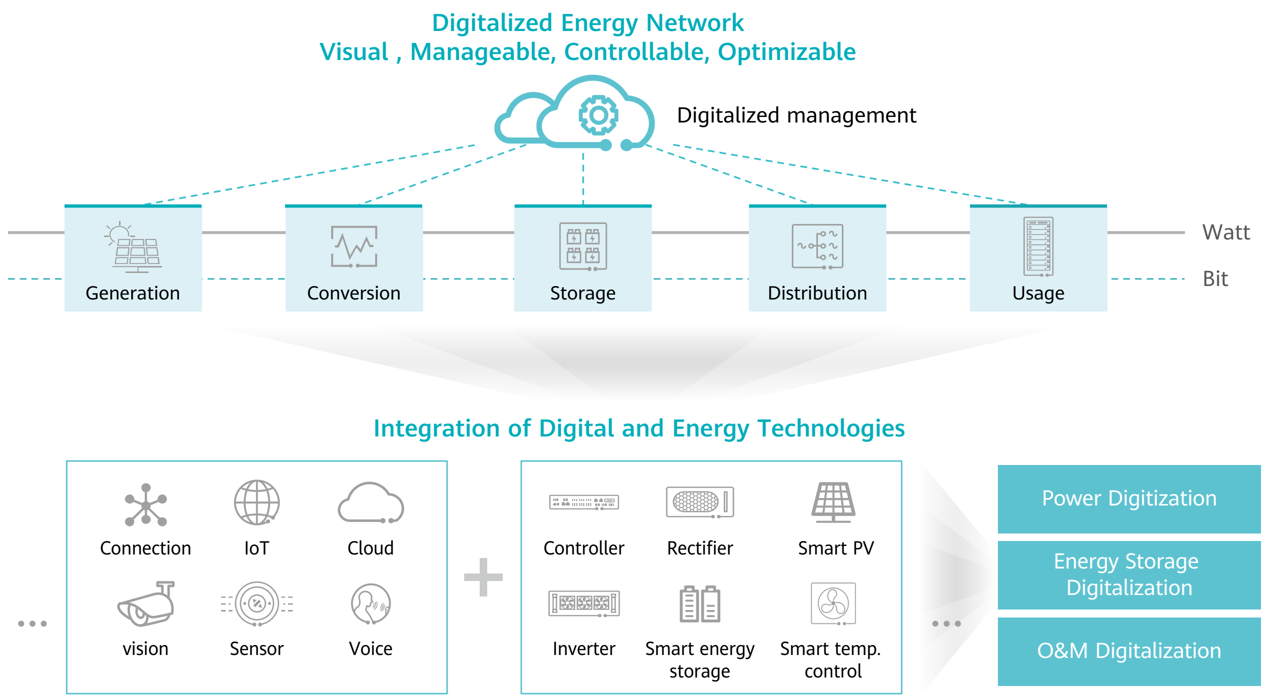


Figure 1: Power digitalization and intelligence

Trend 2

"Zero-Carbon" Network

Clean energy application and energy saving have become the mainstream

Green and sustainable development is a global campaign. Carbon neutrality has become the most pressing mission in the world today. Top carriers around the globe have proposed carbon emission reduction strategies and will achieve 100% renewable energy power supply in 2025 to 2040. In addition, with the rapid development of new energy technologies, the cost of new energy power generation is greatly reduced. Solar power has entered the grid-parity era, and wind power will reach grid-parity soon.

High energy consumption erodes profits

According to statistics, there are still 600,000 diesel generators (DGs) worldwide that require long-term O&M. The fuel cost is high, and about 20 million tons of carbon emissions are generated each year. In addition, the network SEE[2] of many enterprises is less than 60%, and the electricity fee is high. Building a green and efficient "zero-carbon" network can decrease power consumption costs. It is also an act of shouldering social responsibilities.

The rapid development of digital, core, and high-efficiency technologies makes "zero-carbon" networks possible. Energy-related OPEX will not increase for carrier network evolution, greatly reducing CAPEX.

Digital technologies enable a "zero-carbon" network and help achieve "zero-carbon" management throughout the lifecycle

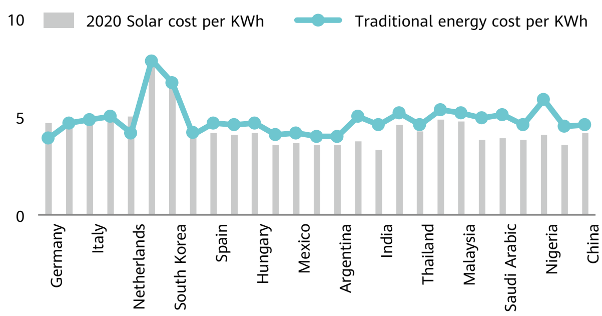


Figure 2: Comparison between the levelized cost of electricity (LCOE) of PV power and the benchmark price of coal power in major countries in 2020 (source: digital power industry think tank)

The integration of digital technologies and power electronics technologies makes network carbon neutrality feasible. A "zero carbon" network needs to rely on the "zero carbon" planning throughout the lifecycle of the network, and reduce carbon emissions in network construction, operation, and O&M phases.
In the network construction phase, cabinets and poles are used to implement simplified deployment to reduce carbon emissions, save site locations, avoid engineering reconstruction, and reduce the use of air conditioners in equipment rooms. In this way, network CAPEX[3] and OPEX[4] are reduced. Zero carbon emission for new construction, capacity expansion, reconstruction, and optimization is achieved.

In the operation phase, zero carbon design is implemented at the four nodes (power generation, conversion, storage, and use) to achieve green and efficient operation of the entire link. On the power generation side, use clean energy, increase the use of renewable resources such as solar power and wind power in site

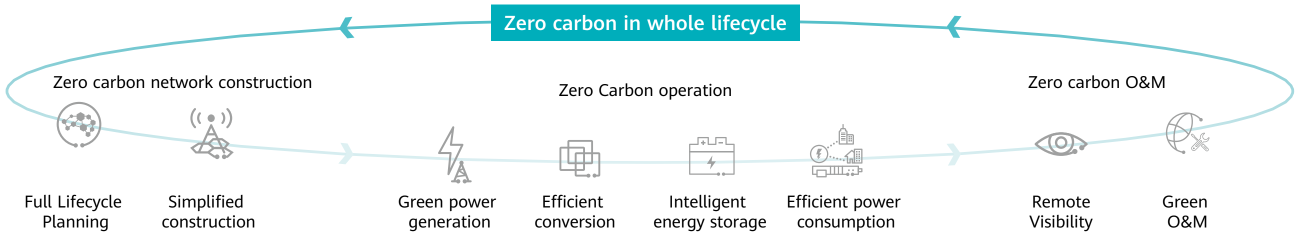


Figure 3: Zero carbon in the entire lifecycle

and equipment room scenarios, and use the PV+storage solution to remove diesel generators and save power. On the power conversion side, a system with high-efficiency modules is used to replace traditional low-efficiency modules and multiple power systems. On the power use side, the intelligent power consumption management unit implements accurate measurement for each tenant, mode, and route loads and on-demand backup power supply. On the power storage side, cloud-based intelligent lithium batteries are used to provide backup power precisely through collaboration with power supplies and loads.

In the O&M phase, site digitalization ensures intelligent power and O&M. intelligence and IoT technologies are used to implement intelligent collaboration of all links, including power generation, conversion, storage, distribution, and use. Remote intelligent O&M replaces traditional manual site visits. Remote inspection and risk prediction reduces site breakdown risks and maintenance costs. In emergency scenarios, mobile lithium batteries are used to replace DGs, ensuring low carbon emissions. In addition, the refined energy efficiency management function continuously filters out low-efficiency network devices and sites, and the system automatically outputs reconstruction suggestions and iterative optimization solutions based on the situation. With these measures and functions, "zero carbon" planning and practice of network construction, operation, and O&M can be realized, thus achieving "zero carbon" in the entire network lifecycle.

Core technologies enable green power

New power technologies emerge. Smart PV and generation-grid-load self-adaptation technologies are used in the power generation phase. The new generation of wide-band-gap devices and intelligent power distribution technologies are used in the power conversion and distribution phases. Refined energy efficiency management technologies, including heat consumption management, are used in the power use phase. Bionic structures are used to implement natural heat dissipation. These technologies help implement energy saving for all nodes at a site.

High-efficiency technologies enable low-carbon networks

A large amount of data is applied to energy networks to implement efficient energy efficiency management from components to sites and then to networks, and reduce electricity fees and energy consumption throughout the lifecycle from sites to networks.

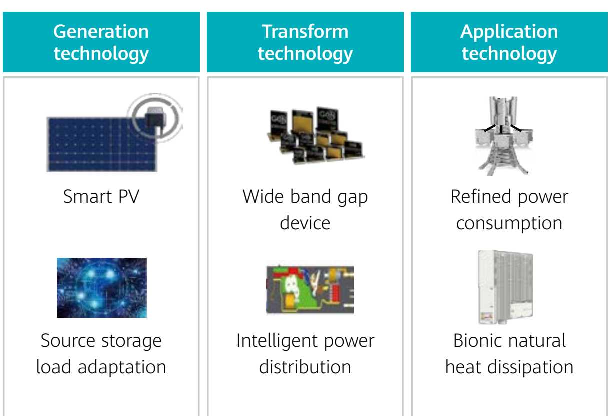


Figure 4: Energy conservation enabled by the core technologies

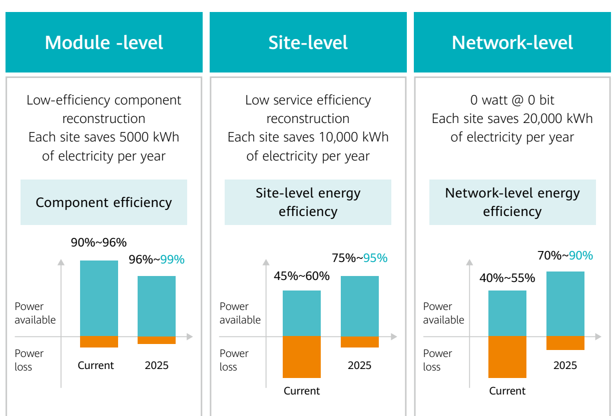


Figure 5: Network-wide low carbon enabled by high-efficiency technologies

By adding PV modules to sites, a Greek carrier reduces the use of mains electricity by 51.2% and saves up to 14,500 kWh of electricity in a year. In Pakistan, the application of PV and intelligent technologies greatly reduces the DG runtime and reduces the OPEX by 81% in a year.

Figure 6: Site solar access,
saving 14,500 kWh power/year in Greece

Figure 7: DG-removal by adding PV,
reducing OPEX by 81%/year in Pakistan

Trend 3

Lithium for All

Lithium batteries replace lead-acid batteries in large-scale application across various industries around the world

With the rapid development of network, the site power consumption surges, which requires an energy storage system with higher energy density. Traditional lead-acid batteries are challenged by large size, heavy weight, short service life, and difficult maintenance. Lithium batteries are advantageous in terms of the cost of ownership, service life, and security throughout the lifecycle. The rapid development of electric vehicles greatly lowers the cost of lithium batteries. Currently, lithium batteries have been widely used in various industries.

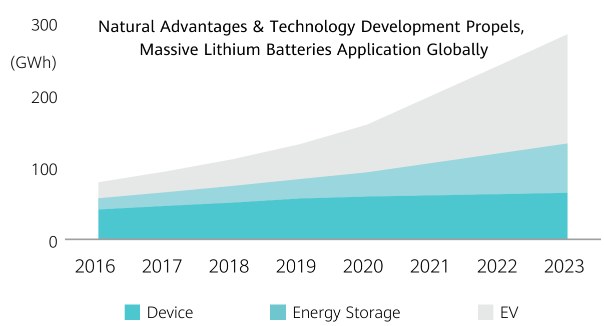


Figure 8: Wide application of lithium batteries in various industries around the world

Common lithium batteries gradually evolve to cloud-based intelligent energy storage systems, maximizing the value of site energy storage

Batteries that solely serve as emergency backup power can no longer meet diversified requirements in various scenarios. They are hoped to become a comprehensive energy supply. Although common lithium batteries have the features of lithium batteries, they are simple combinations of electrochemical cells and mechanical parts and can provide only simple backup power functions and are isolated from each other. Issues such as inefficient management, resource waste, high evolution costs, and difficult O&M still exist. A new architecture needs to be built for the site energy storage system, and a cloud-based intelligent energy storage system emerges accordingly.

The cloud-based intelligent energy storage system integrates power electronics, intelligence, big data, IoT, with energy storage technologies. The local BMS[5] works with the cloud BMS to implement distributed energy storage and cloud-based comprehensive management. The IoT connection technology is used to implement simplified cloud-based maintenance of the energy storage system in all scenarios. The site-network-cloud synergy implements cloud-based voltage boosting, peak shaving, peak staggering, hybrid use, and anti-theft. The refined intelligence configuration achieves efficient investment. Cloud-based status monitoring, risk prediction, life prediction, fault locating, and multiple anti-theft measures are used to implement comprehensive asset security management. Evolving from a single component to a cloud-based smart energy storage system, lithium batteries will be safer, applicable to more scenarios, and ensures more efficient O&M to maximize the value of site energy storage.

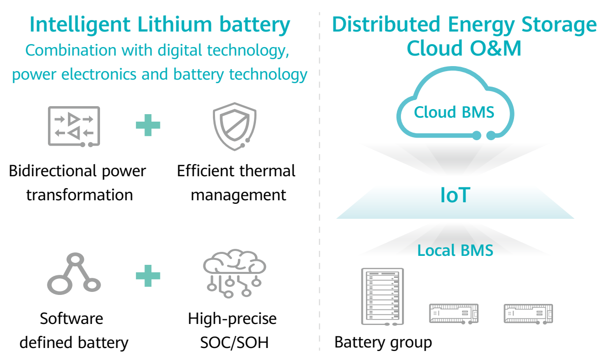


Figure 9: Cloud-based intelligent energy storage system

Trend 4

Telecom Site to Social Site

ICT[6] convergence has become a trend, and a large number of digital sites are emerging in various industries

Digital transformation in various industries is accelerating. A large number of sites are becoming ICT convergence sites to meet the digital application requirements. How to maximize the values of the existing sites has become a focus. Traditional site infrastructure with a single function will transform to one providing comprehensive services, enriching the social values of the sites.

The socialization of site resources maximizes the site value

Power of the telecom sites will be gradually shared with the society, such as power for emergency, commercial advertisements, meteorological and environmental monitoring, and video surveillance. Besides communications equipment, the site power infrastructure can also provide industrial and commercial power supply, charging, and battery trade-in services. In some areas where the mains supply is poor or unavailable, site power infrastructure can provide power supply for local production and people's livelihood, maximizing site values.

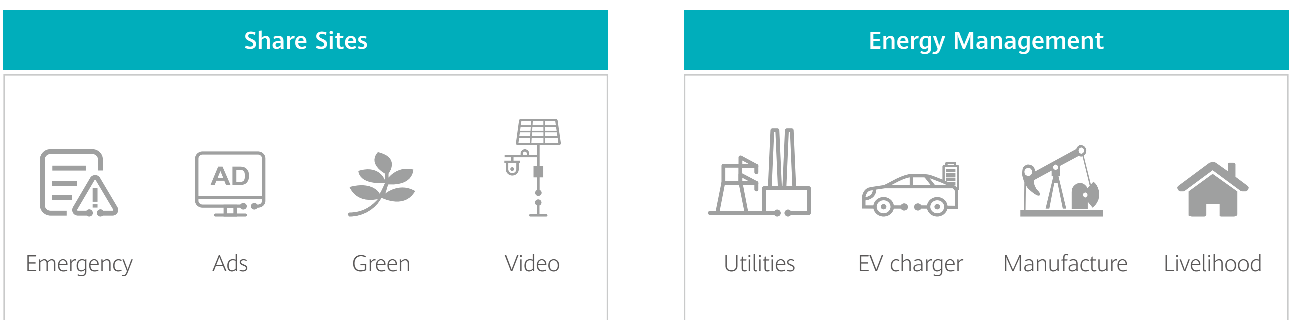


Figure 10: Social application scenarios of communication sites

Trend 5

Energy Supply Diversification

Diverse power sources

Traditional sites are mainly powered by mains or DGs. In the future, there will be more diversified energy sources. New energy, especially solar energy, will gradually shift from supplementary to primary. In addition, more power supply solutions with optimal configurations will be available thanks to the combination of new energy with mains and energy storage system.

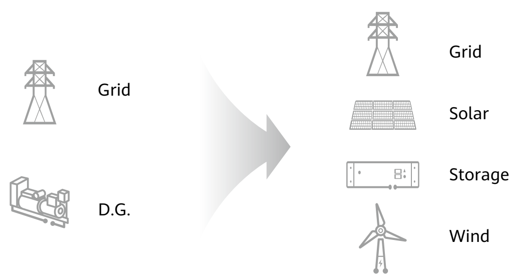


Figure 11: Evolution of power sources

Diverse application scenarios

Site power serves not only IT or CT equipment. Instead, it will be used in ICT convergence, livelihood, and production scenarios.

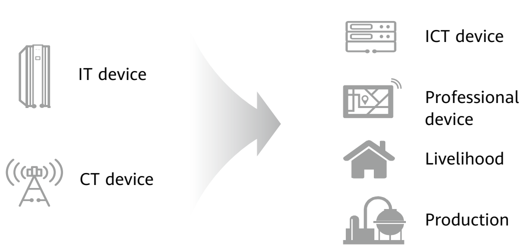


Figure 12 Application scenario evolution

With abundant sites and flexible power supply architecture, high-quality power can conveniently reach surrounding households and shops. Site power supplies power to site devices and can also provide value-added services.

Diverse deployment modes

Different deployment modes such as green power supply introduction from centralized large solar power plants, power supply deployed in campuses and small-sized microgrids, distributed power supply, and residential PV system are available to meet different application requirements.

In Zhuhai, China, the green solar access distributed deployment solution is used to replace the original "DG+UPS+lead-acid battery" solution through multi-energy scheduling of the solar energy power generation system and intelligent lithium battery energy storage system. The fuel cost is reduced by about CNY100,000 per year, hereby lowering carbon emissions by 25 tons/year. In Nigeria, the advanced hybrid power technology saves 12.26 million liters of fuel and US$20,000 per site, and reduces carbon emissions by 26.2 tons per site.

Figure 13: Smart Island@Zhuhai, China

Figure 14: Smart Hospital@Nigeria

Trend 6

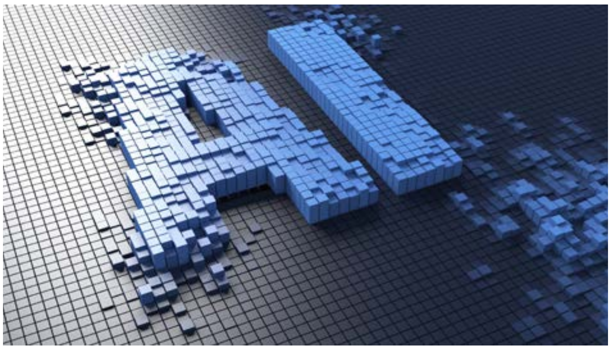
Full Link Intelligence

Intelligent and software-defined full-link power

The power link consists of power generation, conversion, storage, distribution, and use. The traditional power featured with a siloed architecture and isolated management of energy subsystems will evolve towards full-link integrated smart power.

Integrated smart power uses digital technologies to centrally manage power generation, conversion, transmission, distribution, and use, and implements full-link intelligence through digitization and software definition of all power supply subsystems.

For example, in the power generation phase, PV modules integrate optimizers to implement software-defined PV module output. Intelligent power distribution and circuit breakers are used to implement software-defined capacity protection and power-on and power-off strategies, greatly improving power utilization efficiency and reducing energy costs. In the intelligent power consumption phase, the power slicing technology enabled by the intelligent load management features supports intelligent features such as software-defined circuit breaker, branch control, branch power-off, branch measurement, and power consumption inspection, achieving refined intelligent management of site loads and clear power consumption.



Intelligent technologies boosts the value of power

Intelligent optimization, intelligent peak shaving, intelligent peak staggering, and intelligent prediction optimize performance of a power system. For example, intelligent modeling and power collaborative optimization are used to achieve optimal efficiency of a power link. Through load power consumption prediction and battery high-precision SOC[7]/SOH[8] prediction, the optimal mains staggering is achieved, thereby saving electricity fees. In Zhejiang, China, the intelligent peak staggering function helps save 17.1% electricity fees every year.

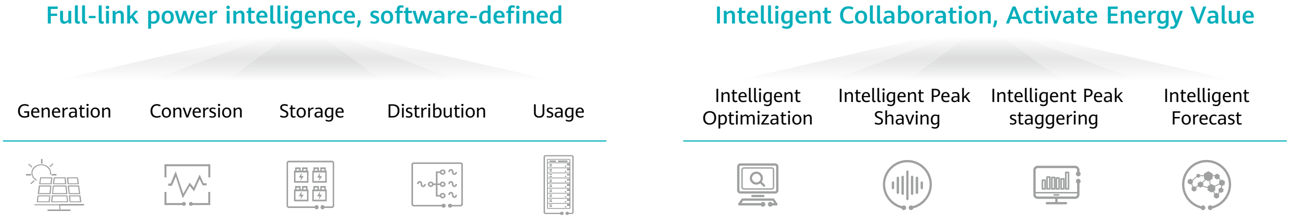


Figure 15: Full-link power intelligence

Figure 16: Intelligence values

Trend 7

Simple and Convergent

As a large number of sites will be deployed, wireless, transmission, and IT services are further integrated at one site. Traditional site construction depends on equipment rooms. Multiple sets of power supplies and batteries are combined, resulting in high costs, poor reliability, disordered management, and difficult evolution. Low carbon emission throughout the entire network and simplified power supply during the lifecycle will be achieved, realizing faster delivery, and lower energy consumption and TCO.

Service convergence

In the past, multiple power systems were used to supply power to equipment of multiple voltage standards. In the future, one power system will be used to supply power in multiple scenarios. This enables site power to support wireless, transmission, and IT equipment at the same time, simplifies construction, and saves space and rents.

Simplified form

Sites will evolve from equipment rooms, cabinets, to blade power supplies, greatly reducing the footprint and power consumption loss. For a tower company in Guizhou, China, one cabinet is used to replace three cabinets, reducing the rent and electricity fee by CNY4400 per month and cutting O&M costs by 75%. In Langfang, Beijing, the SEE of a site is increased to 96%, the temperature control loss is reduced by 700 kWh per year, and the line loss is reduced by 50% through simplified deployment of blade power supplies.

Simplified power supply

Integrated AC and DC power supplies support multiple output modes. Linkage between the power devices and energy storage system further simplifies power supply.

Figure 17: Simplified site @ Guizhou, China

Figure 18: Simplified blade site @ Beijing, China

Simplified management

The unified energy management platform intelligently controls the power supply and energy storage, greatly simplifying O&M. The prefabricated design not only shortens the delivery period, but also enables centralized management through the remote network management system (NMS). In this way, preventive maintenance can be performed without site visits, reducing O&M costs.

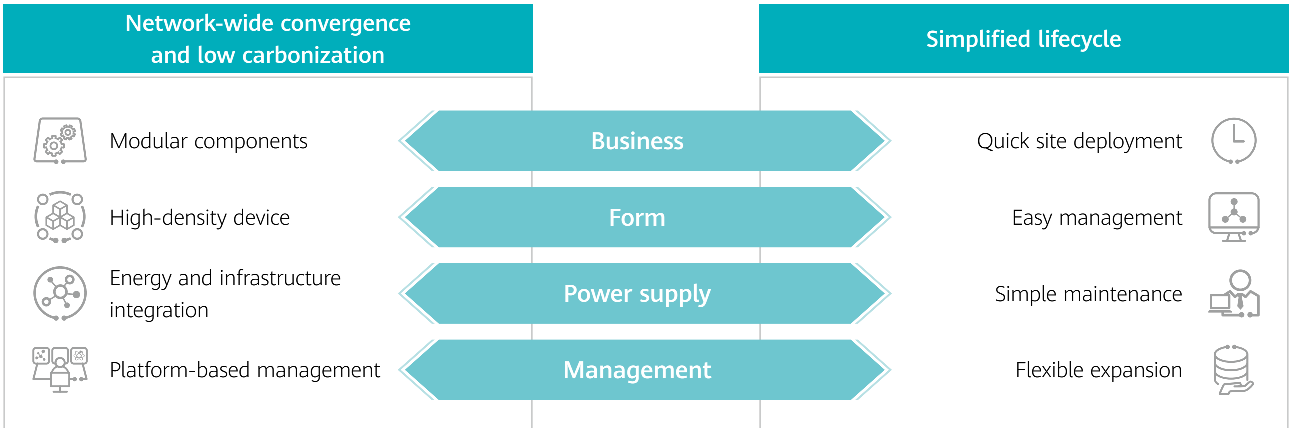
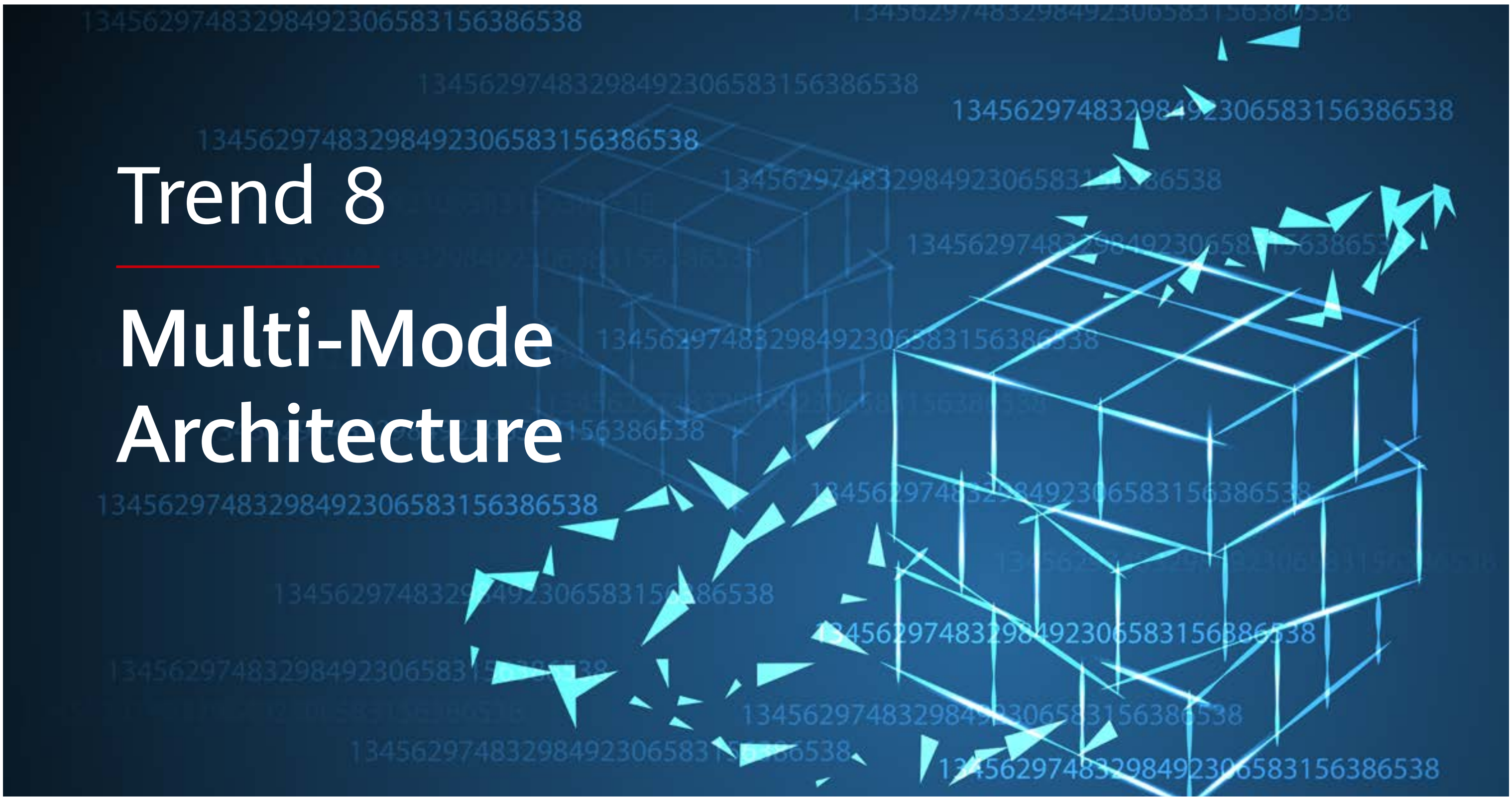


Figure 19: Simplified convergence of energy devices



Trend 8

Multi-Mode Architecture

Multiple energy + Multiple modes, meeting the requirements of multi-service convergence sites

"Multi-mode" is reflected in multiple aspects. First, the technical architecture of the power supply supports multi-energy input and multi-mode output. Traditional power only supports the input of a single energy source and the output of a single mode. In converged application scenarios, multiple power supply systems of different types are stacked, which occupies a large area and is difficult to manage. In the future, a power platform that supports multiple energy inputs (such as solar energy, mains, diesel generator, and energy storage) and AC and DC outputs will be developed to meet the energy supply requirements in all scenarios.

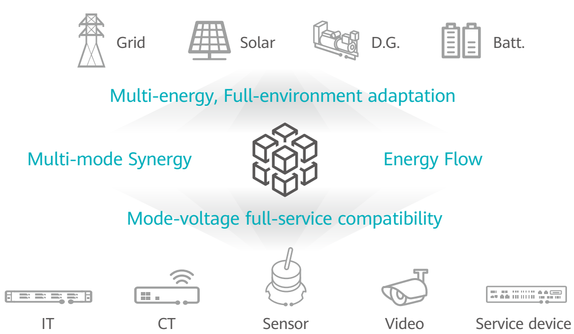


Figure 20: Multi-mode coordination

Modular expansion of hardware and software, multi-mode scheduling, control, and management

The modular design facilitates modular capacity expansion of hardware and software. The architecture of the entire system can be flexibly expanded.

Collaboration of multiple service systems and application in multiple scenarios

The power system collaborates with the power grid to implement peak adjustment, frequency regulation, and staggering and works with the energy storage system to implement multi-scenario application and convergence of different services. For example, service collaboration can be used to implement "zero bit and zero watt" deep hibernation management, achieving the optimal network energy saving effect.

Multi-mode coordinated architecture is used to implement diversified power supply modes.

For example, free flow control enables multi-directional power flow, achieving free switching between off-grid power consumption and grid-tied power generation. In this way, sites can be switched to distributed virtual power plants (VPPs).

Trend 9

Autonomous Driving

The new era calls for intelligent autonomous networks

Differentiated services and complex scenarios at a large number of sites pose higher O&M requirements. Traditional network O&M is just monitoring and alarm reporting. In addition, energy devices are maintained manually, requiring a large number of repeated and complex operations and causing high labor cost. According to the Intelligent in Network Use Cases in China released by GSMA[9] in September 2019, autonomous driving is used throughout the network planning, construction, maintenance, optimization, and operation phases, and intelligent autonomous networks are gradually required.

Energy network O&M is moving towards autonomous driving

With the development and application of Intelligent technologies, the entire energy network will implement intelligent O&M, sensing, and connection, simplifying O&M. The intelligent IoT technology will change the original "dumb device" management to digital management. Various types of digital sensors and intelligent management platform will be used to implement intelligent sensing and connection of energy networks.

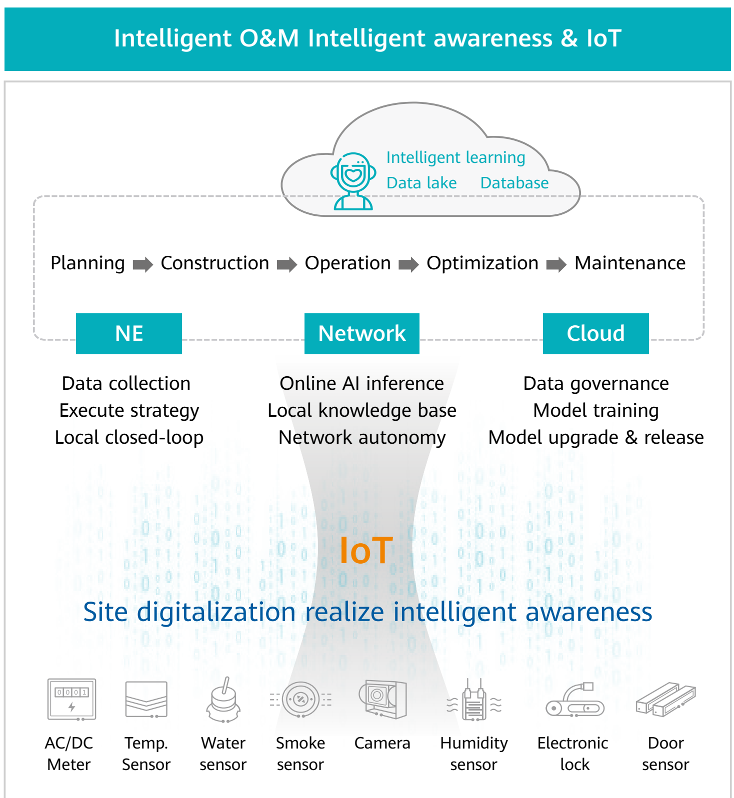


Figure 21: Intelligent O&M of the energy network

Trend 10

Safe and Reliable

Power is the foundation. The use of digital and intelligent technologies spurs the network, digital, and intelligent transformation of the site power. It is a must to enhance the reliability, security, privacy, resilience, and scalability of hardware and software.

Enhance the security and reliability design of software and hardware

In addition to high-reliability design and manufacturing, predictive maintenance will be enhanced to consolidate the foundation and ensure hardware trustworthiness. As for software, layered defense and layered control will be implemented, making software and the power industry more secure and reliable.

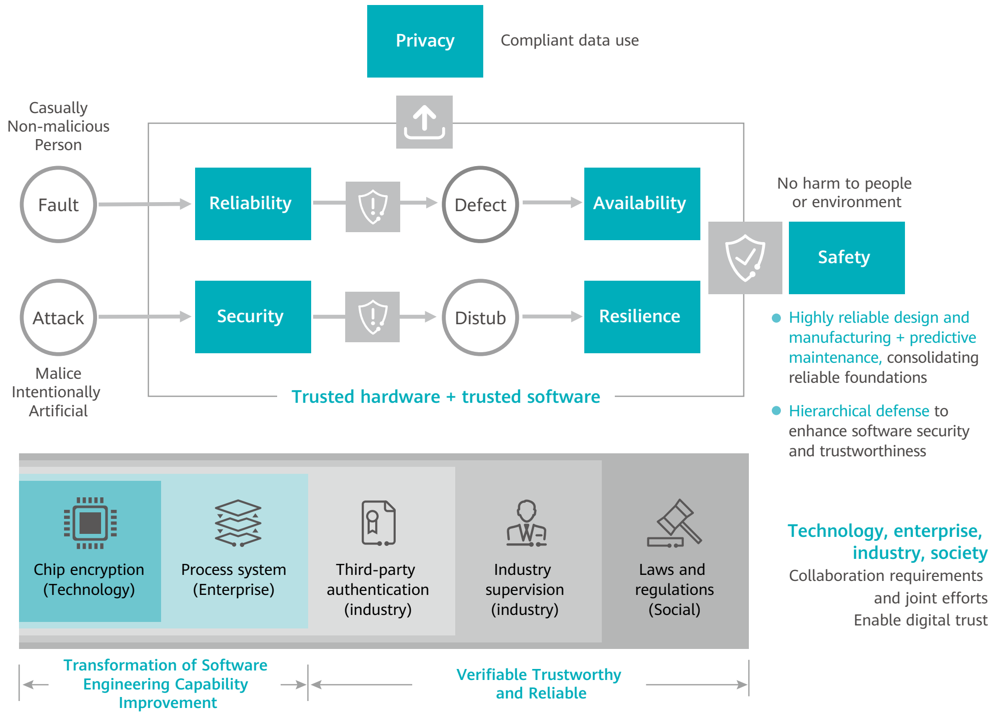


Figure 22 System-level design to ensure security and trustworthiness

Acronym or Abbreviation

Number	Acronym and Abbreviation	Expansion
1	IoT	Internet of Things
2	SEE	Site Energy Efficiency
3	CAPEX	Capital Expenditure
4	OPEX	Operating Expense
5	BMS	Battery Management System
6	ICT	Information and Communications Technology
7	SOC	State of charge
8	SOH	State of health
9	GSMA	Global System for Mobile Communications Association