

5G Power Whitepaper

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Changes in the 5G Era

1.1 Network

The 5G era is an all-mobile and all-connected intelligent era. In 2025, the number of global connections is estimated to exceed 100 billion. With that connection and communication between people and things are expected to become ever more common.

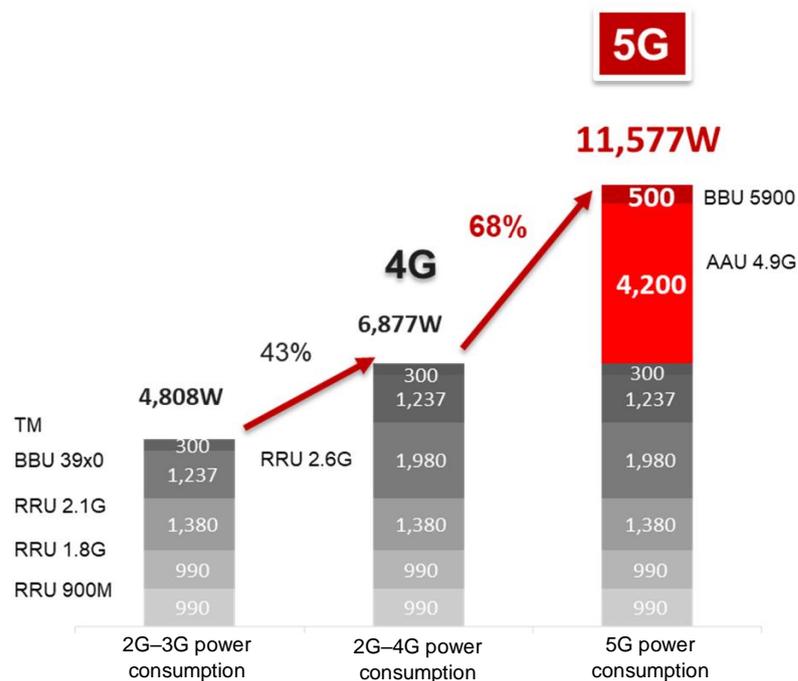
The service requirements of 5G network would become more diversified. There are three distinct 5G scenarios as defined by 3GPP; enhanced mobile broadband (eMBB, 10 Gbit/s); Ultra reliable and low latency communications (uRRLC, 1ms); and massive machine type communications (mMTC, 1 million/km²).

1.2 Power Consumption

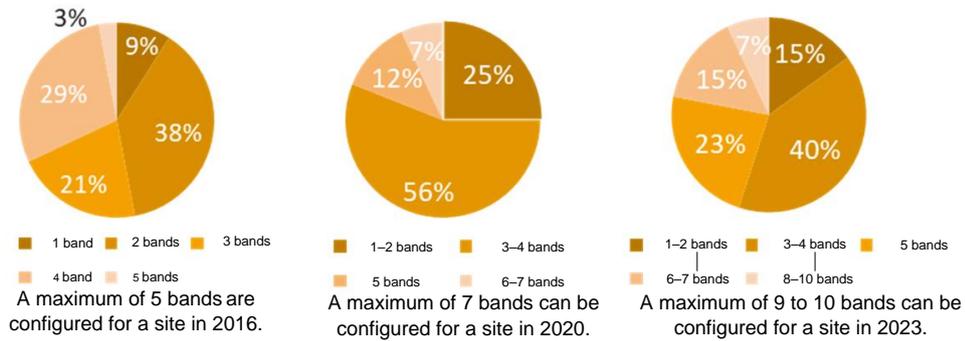
The power consumption per unit of traffic (Watt/bit) is greatly decreased, but the power consumption of 5G increases greatly compared to that of 4G. Noticeably, in the 5G era, the maximum power consumption of a 64T64R AAU is 1000–1400 W, and that of a BBU is about 2000 W.

Multiple bands in one site will be the typical configuration in the 5G era. The proportion of sites with more than five bands will increase from 3% in 2016 to 45% in 2023. As a result, the maximum power consumption of a site will be higher than 10 kW, in a site where there is more than 10 bands, the power consumption will exceed 20 kW. In the multi-carrier sharing scenarios, this figure will be doubled.

Typical maximum power consumption of a 5G site



Evolution of the frequency band proportion of a 5G site



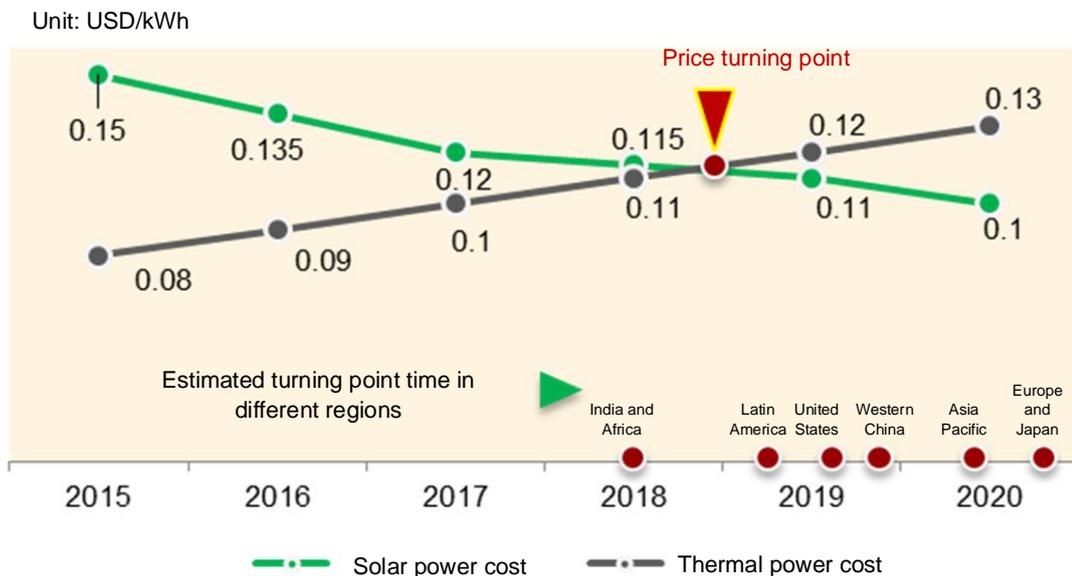
In the 5G network, low-frequency and high-frequency bands will be deployed together. To meet the service requirements of increasing network capacity, a large number of end sites will be deployed. The number of network sites will increase greatly, and the power consumption of the entire network will increase exponentially.

1.3 Energy Industry

- The Solar Photovoltaic (PV) Industry

The global solar energy yield will increase from 391 GW in 2015 to 600 GW in 2020. In 2020, the global solar power price will be the same as that of the thermal power. The figure below shows the projected changes of cost in solar and thermal power from 2015 to 2020.

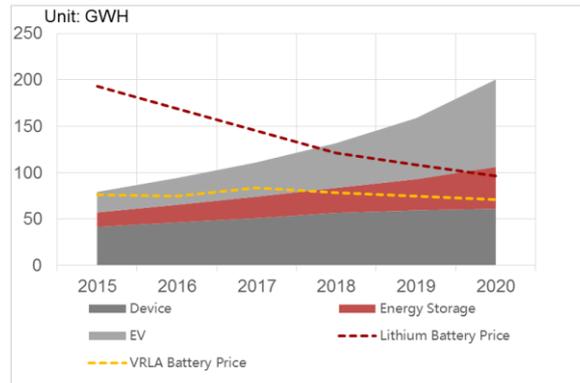
Comparison between solar power and thermal power costs



- Lithium Battery Industry

As the electric vehicle industry is growing vigorously around the world, it is estimated that the global lithium battery demand will reach 3000 GWh in 2030. Therefore, the cost of lithium battery will decrease rapidly. The cost of lithium batteries and lead-acid batteries is expected to be the same in 2021 (see figure 1-4).

Comparison between lithium battery and lead-acid battery costs



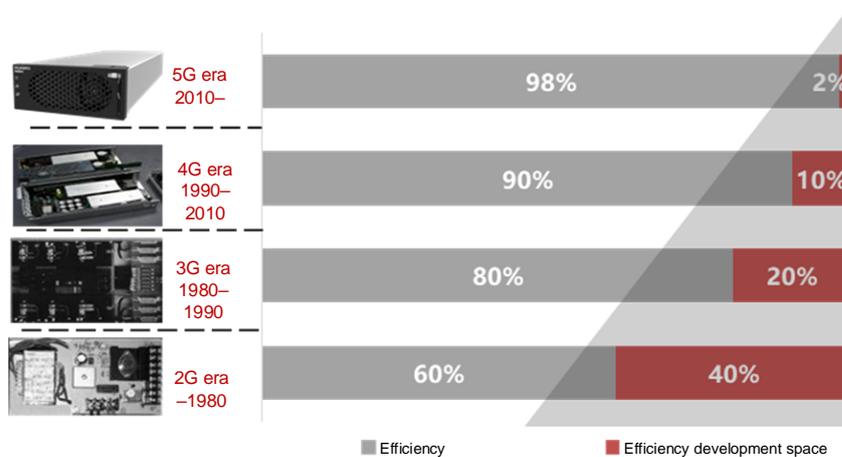
Data source: CBIA, CAAM, Huawei Search

The improved performance and expected cost reduction in the PV and lithium battery industries are bound to transform the telecom energy industry in making site power more cost-efficient and environment-friendly.

1.4 Power Supply Industry

The conversion efficiency of rectifier in the telecom industry has reached 98%, and there is not much development space left. However, the efficiency of the entire site is still low. To achieve the lowest energy consumption of sites and the entire network in the 5G era, not only do we need to pay attention to the efficiency of individual components, but also the entire link and the whole site.

Rectifier efficiency evolution



Challenges Posed by the 5G Network Evolution

2.1 Challenges to Site Power Construction and Reconstruction

Mains Reconstruction Challenges

As the power consumption of 5G sites increases, the mains capacity of existing sites may not meet the requirements of 5G deployment. Therefore, capacity expansion is required. The cost of mains capacity expansion is high, and the period of expansion is long, which greatly increases the duration and cost of 5G deployment.

For example, over 30% of sites in China need mains modernization; the reconstruction period of the mains capacity expansion in South Africa is about 12 months, and that in Germany is about 10 months; the reconstruction cost in the Philippines is about 3000 USD per site.

Power Distribution Challenges

The 5G single-band power distribution requires at least two 100 A inputs (or four 32 A & three 63 A inputs). For example, over 75% DC circuit breakers of a carrier in China are 63 A or smaller. This does not meet the operational requirements of 5G networks.

In a high-power remote AAU scenario, the voltage level drop in cables is too high, leading to large line loss. The input voltage of AAU is lower than the working voltage, as a result, the AAU cannot work.

Backup Power Challenges

As the power consumption of 5G sites increases, the traditional backup power strategies, systems and carriers will also need to be revamped. In addition, while the density of the traditional lead-acid battery is low, they are heavy and large in size. Some sites may have difficulty in accommodating the large weight and size of the lead-acid battery.

Cooling Challenges

As the power consumption of 5G sites expected to be doubled, the heat consumption of sites is also expected to go up in parallel. The heat dissipation capability of some sites cannot meet the requirements of 5G. The cost of modernizing a site cooling is high and the time required to complete the process is long, representing another barrier in accelerating the deployment of 5G.

Equipment Room and Cabinet Space Challenges

The remaining space in some existing cabinets is limited, which makes it difficult to accommodate 5G devices. Adding new cabinets needs more space. However, the space in some sites is limited.

2.2 O&M Challenges

Higher Electricity Fees

The current electricity fee accounts for 1%–8% of the carrier's revenue. In the 5G era, with doubled power consumption and the increasing electricity price, carriers are facing a higher electricity fee. Energy saving will be one of the core requirements of carriers.

More Complex Maintenance

Diversified 5G services pose more requirements on energy assurance, which will increase the complexity of site maintenance. More bands with higher frequency mean there are more devices on sites. Hence, maintenance would become more difficult, requiring more manpower and financial investment. Therefore, the site maintenance cost will increase greatly.

Higher Lease Costs

More physical spaces are required to accommodate for the new power supplies, batteries, and cabinets of 5G. Carriers will have to rent new rooms to store and install new devices, causing more lease costs.

5G Power Requirements and Design Concepts

3.1 The General Requirements for 5G Power

To deal with the power challenges of 5G deployment and improve carriers' investment efficiency, 5G power solutions need to meet the following requirements: low cost, fast construction, less energy, smooth evolution, and simple O&M.

Low Cost

In terms of engineering construction, new cabinets are not added, mains is not changed, and power distribution is not changed (including thick lines). These are the rules for 5G power solutions to save costs. Existing cabinets or old cabinets are reused, and no additional cabinet is required. Therefore, there is no need to rent new rooms. That mains is not changed means there is no mains transformation (including transformer, power cables, and upstream circuit breakers transformation). This avoids the high cost of mains modernization. The power supply capability of cables is improved by means of technical innovation, and power distribution is not changed (including thick lines). In this way, the tower load-bearing and high cost problems can be resolved.

Fast Construction

5G power needs to be flexibly and quickly deployed. For the existing sites, the power systems footprints and appearances are not changed. Therefore, the time and cost of renegotiation can be saved. For new sites, the minimum footprints and the simplest and fastest installation are supported.

Less Energy

5G power solutions need to achieve all-link energy saving. Saving energy in a single component is not enough. Saving energy at the entire site and the entire network is what we are trying to do.

Smooth Evolution

Subsystems of the site power system can evolve to 5G smoothly with the same or even less initial investment as 4G construction.

Simple O&M

The high cost of operating and maintaining 5G is unaffordable for carriers if the traditional O&M is performed. Thus the O&M mode of 5G power solutions needs to be more efficient and simpler.

3.2 5G Power Concepts

Traditional power solution provides only basic power supply and backup functionalities. They cannot support the deployment requirements of 5G. Therefore, new design concepts are required to drive 5G power solutions. Based on a deep understanding of 5G networks, Huawei proposes three principles for 5G Power design; be simple; intelligent; and efficient.

Simple

5G power solutions need to be simple. That means the devices require less space, the installation is simple, the deployment is fast, and O&M is easy.

Intelligent

Based on the concept of Bit Manages Watt, 5G power solutions use AI and Cloud technologies to implement multi-level intelligent collaboration between power supply and site devices, as well as power supply and network devices. Functional power supplies develop into intelligent ones, which

greatly reduce the CAPEX and OPEX of sites. At the same time, the traditional manual O&M needs to evolve into a more efficient and intelligent one.

Efficient

Different from the traditional single-component energy-saving design, 5G powering system requires end-to-end full-link energy-saving design from the aspects of power supply, conversion, power backup, power distribution, cooling, and load. In the power supply phase, various types of new energy access are supported to save energy and achieve the goal of 0 bits at 0 watts.

5G Power Detailed Scenarios and Product Features

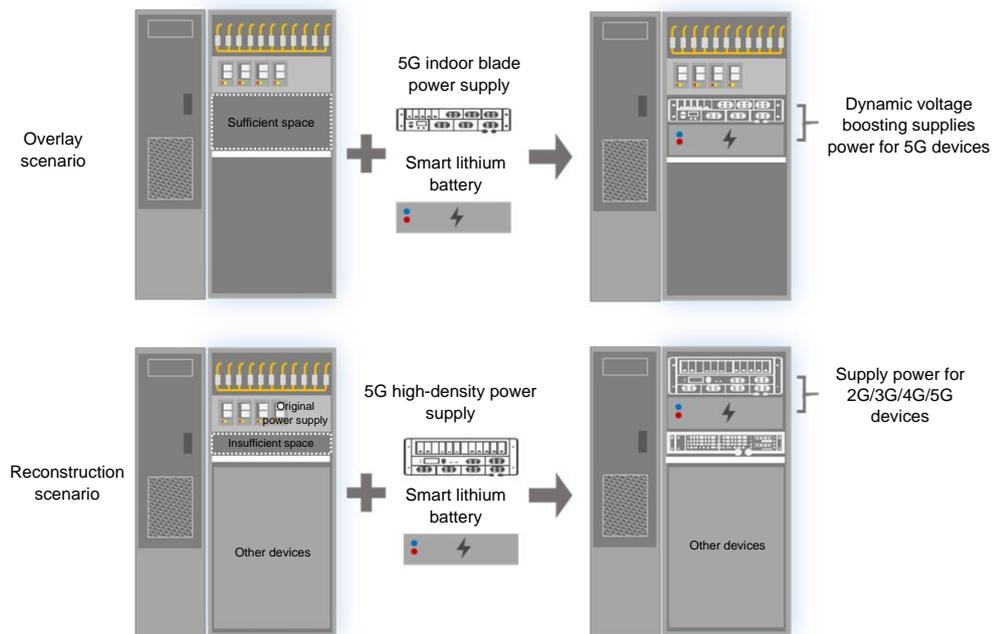
To address customers' challenges and meet their requirements, multiple 5G deployment scenarios can be divided such as upgrade and reconstruction of existing sites, site migration, new site building, overlay scenario, and micro sites. Based on the concept of simple, intelligent, and efficient, we proposed an optimal solution for different scenarios.

4.1 Reconstruction Scenario and Overlay Scenario

- Indoor Reconstruction or Overlay Scenarios

One Band One Blade and One Blade Reconstructs One Site are the optimal 5G power solutions in indoor scenarios.

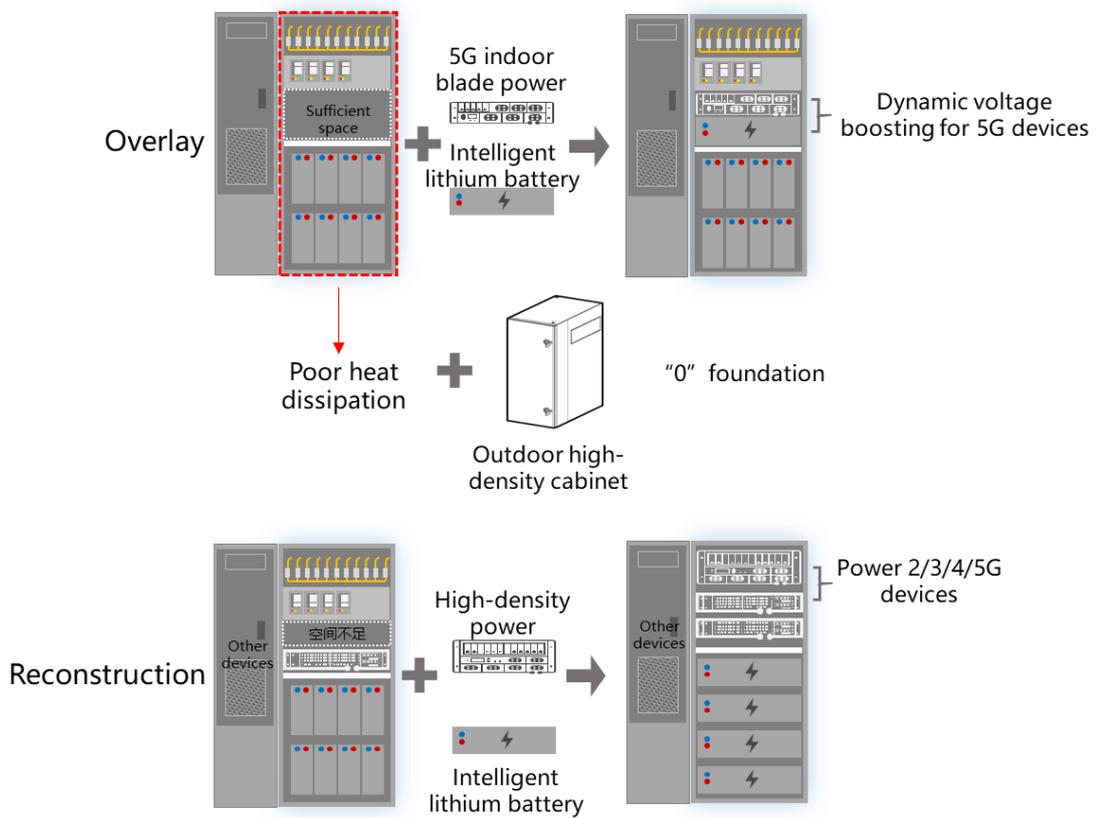
5G indoor blade power supply supporting simple deployment



- Outdoor Macro Site Reconstruction or Overlay Scenarios

Outdoor macro sites are confronted with problems such as insufficient power supply capacity, backup power, cooling, and foundation. The high-density power sub rack is used to replace the original power supply, and the high-density lithium battery to replace the lead-acid battery to implement the simple reconstruction of 5G deployment. The outdoor high-density heat dissipation DEU is used to implement the 5G BBU without adding cabinets or civil work.

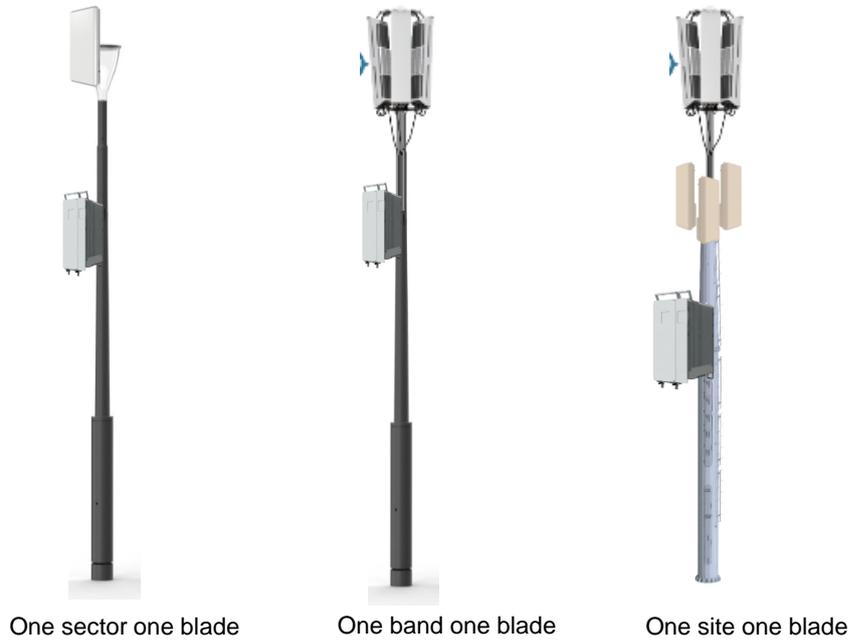
High-density power supplies, high-density lithium batteries, and high-density cooling devices simple reconstruction and overlay



- Outdoor AAU Overlay Scenario

In the 5G AAU remote scenario, only the AAU power supply and backup power are considered. Full series of outdoor blade power supplies with high protection level can be used in the same scenario with the AAU and support zero footprint deployment.

Full series of outdoor blade power supplies supporting simple AAU installation



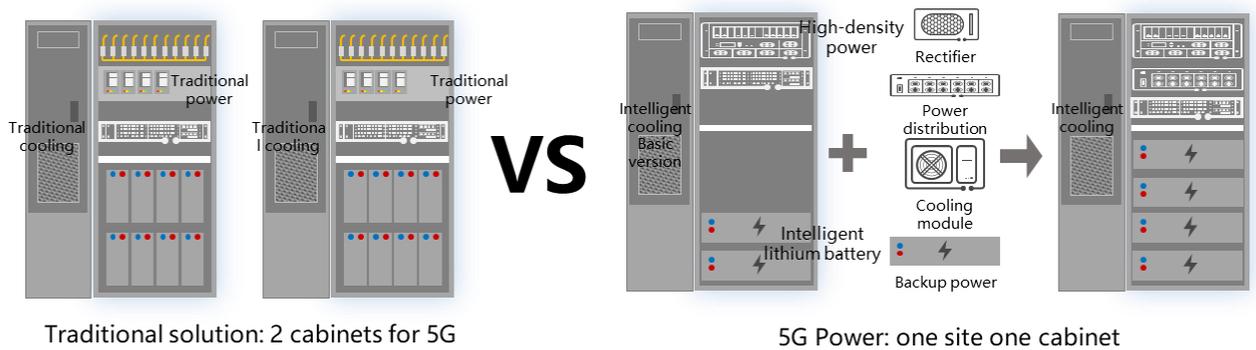
4.2 New Sites or Swapped Sites

For new sites or swapped sites, smooth evolution from 2G/3G/4G to 5G is required. One Site One Cabinet is ideal for new sites or swapped sites in all scenarios.

- Outdoor Scenarios

One Site One Cabinet is compatible with 2G/3G/4G and supports smooth evolution to 5G in terms of power, power distribution, backup power, and cooling.

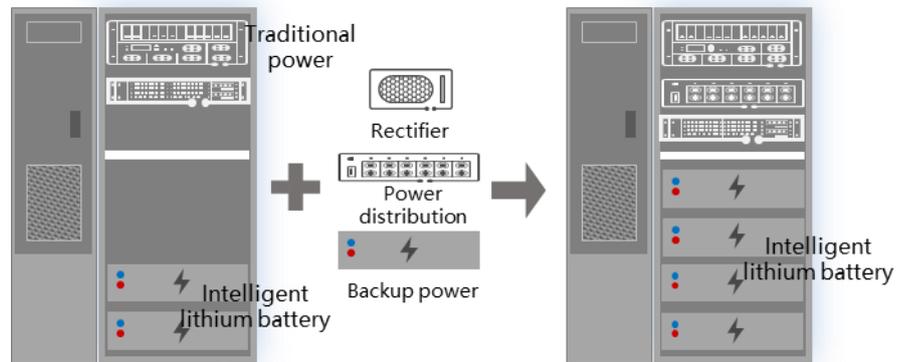
5G intelligent power of new outdoor sites supporting smooth evolution



- Indoor Scenarios

One Site One Cabinet is compatible with 2G/3G/4G and supports smooth evolution to 5G in terms of power, power distribution, and backup power.

5G intelligent power of new indoor sites supporting smooth evolution

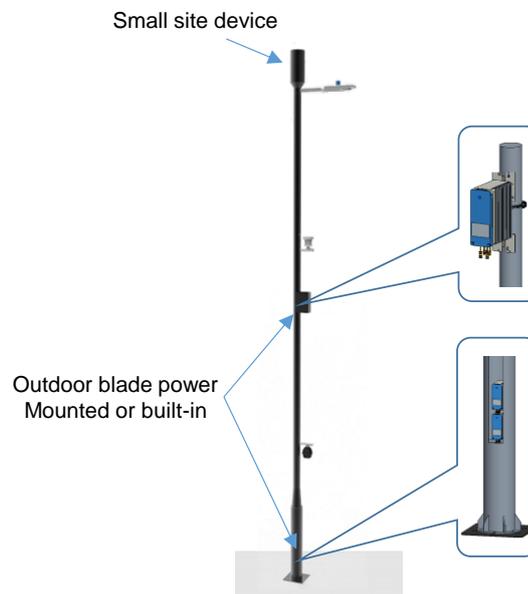


5G Power: one site one cabinet for 5G

4.3 Small Sites

Small sites are installed flexibly in various scenarios. Small sites adopt small and light blade power and support multiple installation modes including pole-mounted and wall-mounted installation. The devices are perfectly compatible with the environment. In the 5G era, the requirements for service continuity and reliability of the power supplies and backup power of small sites are increasing. Backup power ports are required to support on-demand power backup.

5G intelligent power of new small sites supporting smooth evolution



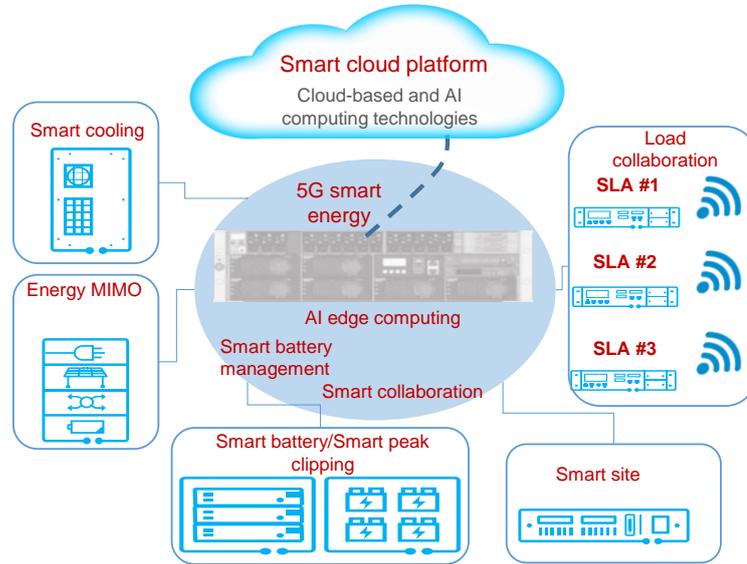
4.4 Intelligent Power

Traditional power supplies and backup power cannot meet the requirements of the 5G era. Site power needs to be centered on the power supply to implement collaboration between the power supply and site devices such as batteries, air conditioners, and mains, and linkage between the power supply and network loads. The 5G era witnesses the evolution from traditional power to intelligent power.

- Intelligent Architecture and Four-Layer Collaboration

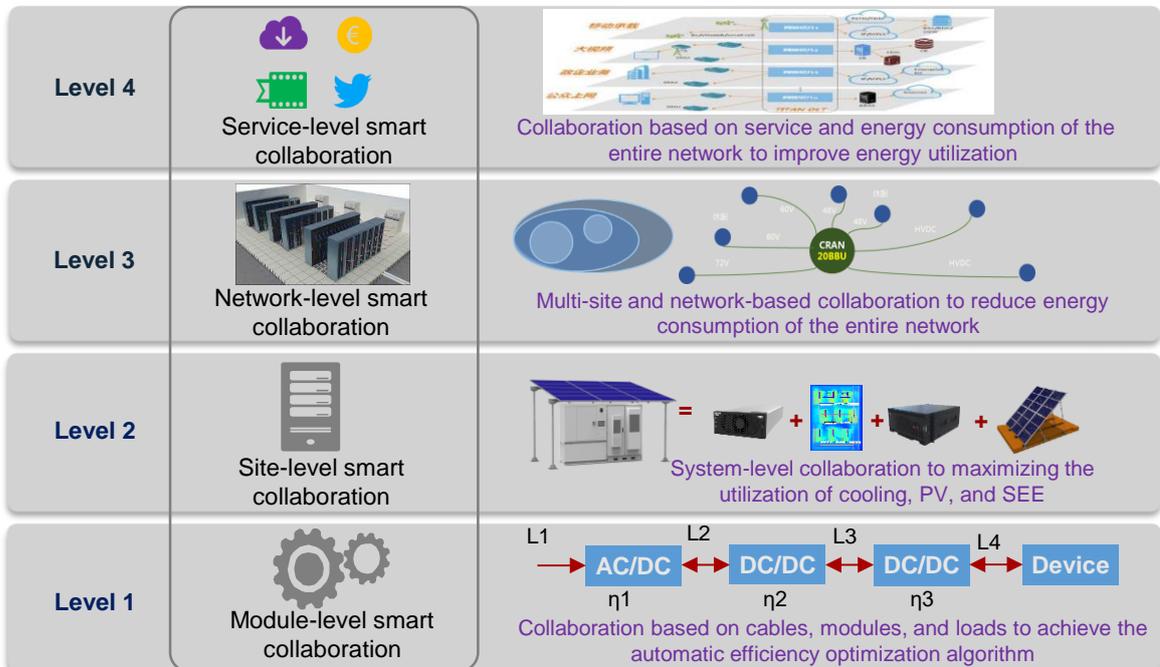
The 5G intelligent power network architecture consists of the smart O&M platform, 5G intelligent power, and intelligent components. Based on edge computing of Cloud + AI, it supports the optimal construction and management of 5G intelligent power.

Cloud + AI-based 5G intelligent architecture



Module-level, site-level, network-level, and service-level intelligent collaboration achieves efficient energy saving for the entire site and entire network.

Four-layer intelligent collaboration achieving efficient E2E energy saving



- Typical Features of 5G Intelligent Power
 - (1) Load Collaboration

The 5G intelligent power works with loads to dynamically adjust the output voltage of the power supply based on the intelligent algorithm, power of the load device, and power cable loss to achieve the optimal end-to-end power supply efficiency.

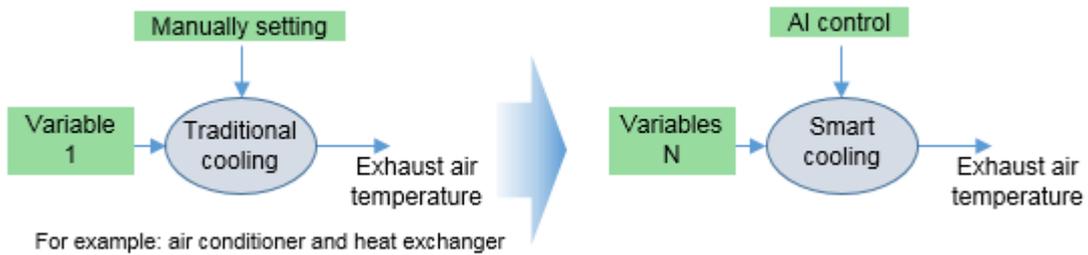
(2) Intelligent Energy Storage

Intelligent energy storage implements dynamic voltage boosting, accurate prediction of capacity, health status, and smooth capacity expansion by means of parallel connection of old and new batteries, batteries of different capacities, vendors, and types.

(3) Intelligent Cooling

Based on AI, the temperature control transfers from the traditional mode that includes only one variable (ambient temperature) to the mode that achieves the linkage between the temperature control and other factors such as the ambient temperature, device temperature, service status, and weather forecast. This feature enables efficient energy saving.

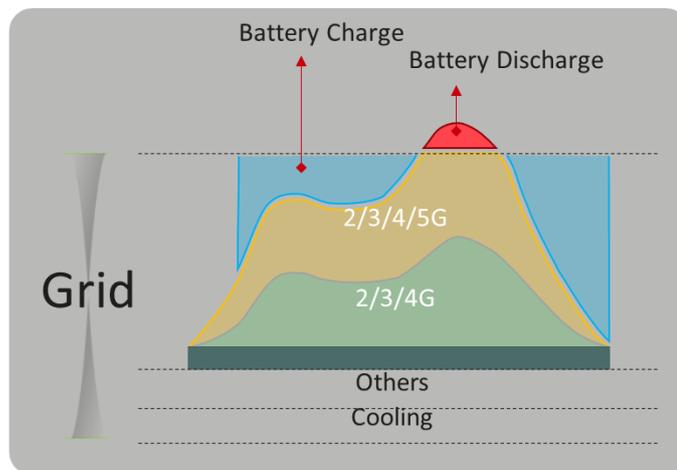
5G power achieving intelligent cooling



(4) Intelligent Peak Clipping

The intelligent energy scheduling algorithm is based on software-defined power and intelligent energy storage. Compared with traditional solutions, the 5G power configures the mains input based on the typical power instead of the peak power, which reduces the cost of mains modernization greatly.

5G power achieving peak clipping



4.5 Efficient Energy Saving

The 5G intelligent powering system features efficient energy saving. Different from the single-component high-efficient design in the 4G era, the 5G intelligent powering system is designed in an end-to-end manner from the aspects of power supply, conversion, backup power, cooling, power distribution, and load, pursuing the ultimate goal of 0 bits at 0 watts.

5G intelligent power achieving efficient energy saving of power supply-site-full link



- **Efficient Power Supply**

The 5G intelligent power uses the advanced power and electronics technologies to achieve the maximum efficiency of 98% power conversion and reduce power conversion loss.

- **Efficient Site**

The 5G intelligent power achieves efficient sites through joint measures such as efficient power supplies and efficient cooling.

- **All-Link Energy Saving**

The 5G intelligent power works with the main equipment to achieve efficient all-link energy saving through intelligent and dynamic voltage boosting and intelligent shutdown.

- **New Energy Achieving Green and Energy-Saving Sites**

Energy saving and emission reduction have become the basic social responsibility of enterprises. The cost of new energy such as PV is decreasing, and the cost effectiveness of new energy is increasing. The 5G intelligent power supports pure PV and PV + battery without diesel generators to save energy.

4.6 Intelligent Lithium Battery

- **Replacing Lead with Lithium Battery**

Lithium batteries have been developing for about two decades. With the rapid application of electric vehicles especially in recent years, the cost of lithium batteries drops swiftly. The capital expenditure (CAPEX) is expected to be the same as that of lead-acid batteries in 2021. Lithium batteries, featuring the long cycle, high rate, small size, and lightweight, becomes the best choice to replace lead-acid batteries in the telecom energy field.

- **Evolution from Traditional Lead-Acid Batteries to Intelligent Lithium Batteries**

The AI algorithm and advanced power and electronic conversion technology achieves Intelligent lithium batteries, featuring real-time monitoring of the state of charge (SOC) and state of health (SOH), current equalization in parallel connection, dynamic voltage boosting, application security in high/low temperature scenarios, and the intelligent anti-theft function. In consideration of the effective protection of battery assets, we need to have batteries flexibly expanded by connecting new and old batteries, and batteries of different manufacturers, capacities, and types in parallel.

- **Battery Application from Power Backup to Power Backup + Cycle**

In the 5G era, traditional lead-acid batteries are difficult to meet the requirements of mains modernization, short-term power backup, and high-density energy storage due to the short cycle and small capacity of electric discharge at a high discharge rate.

With its excellent cycle and rate performance, intelligent lithium batteries reduce mains modernization through intelligent peak clipping, reduce customer electricity fees through off-peak power consumption, and implement refined configuration to cope with short-term power backup at a high discharge rate.

4.7 Smart O&M

To meet the requirements of final service applications, the 5G network needs to achieve higher power availability (PAV), site energy efficiency (SEE), O&M efficiency, and site security.

- PAV

PAV is short for power availability. It represents the reliability of the DC power supply at the site. The definition is as follows:

$$PAV = \frac{\text{Design duration of the site} - \text{Site disconnection duration due to power supply failure}}{\text{Design duration of the site}}$$

Intelligent management of site availability achieves precise investment.

The 5G power is oriented towards deep intelligent evolution of PAV.

- The 5G power should be able to manage the site PAV.
- The 5G power should support PAV forward-looking O&M.

- SEE

SEE is short for site energy efficiency. It represents the end-to-end energy efficiency level of a site. The definition is as follows:

$$SEE = \frac{\text{Total energy consumption of main equipment}}{\text{Total energy input of the site}}$$

In the 5G era, network energy consumption is greatly increased. Effective management of site energy efficiency can greatly reduce network O&M costs.

- The 5G power should be able to manage the SEE.
- The SEE should be combined with traffic statistics.

- Simple O&M

ICT network O&M is developing towards an unmanned, automated, and remote trend, achieving simple and efficient O&M.

- Builds a comprehensive digital perception capability.
- Replaces manual O&M with automatic O&M.
- Accurate site visit reduces the cost of site visits.

- Smart Security

Implements production security and asset security for sites based on digital and Cloud & AI technologies.

- Smart security is based on comprehensive digitalization.
- New security technologies such as smart video, smart lock, and smart alarm
- Cloud & AI technologies