Intelligent Telecom Energy Storage White Paper

Introduction

With the large-scale deployment of 5G networks and Data Centers (DCs), the number of 5G sites increases exponentially, and the power consumption of devices at network sites and in equipment rooms increases significantly, causing a sharp rise in network-wide power consumption. Sites, equipment rooms, and DCs now have higher requirements for energy storage density, energy efficiency, and intelligence. Traditional lead-acid batteries, featuring low energy density, large size, heavy weight, short cycle life, low charging and discharging efficiency, and extensive management and O&M, can no longer satisfy the network development requirements. Therefore, they are gradually replaced by lithium batteries with higher performance. Lithium energy storage has become a trend in the telecommunications industry. The rapid development of 5G and electric vehicles accelerates this process.

Most of the current lithium batteries, however, are composed of a simple Battery Management System (BMS) and battery cells. They provide simple functions and exert high expansion costs, and therefore are used in limited scenarios. Drawing on an insight into future network evolution, and leveraging battery technology, network communications, power electronics, intelligent measurement and control, thermal design, AI, big data, and cloud management, ZTE has innovatively proposed a "new dual-network architecture and new L1-L5 evolution hierarchy" and is promoting the rollout of smart lithium batteries, thereby meeting new service requirements of 5G networks and driving energy structure transformation. By proposing the new hierarchy of five levels, ZTE hope to drive the evolution of energy storage towards intelligence in the telecommunications industry.

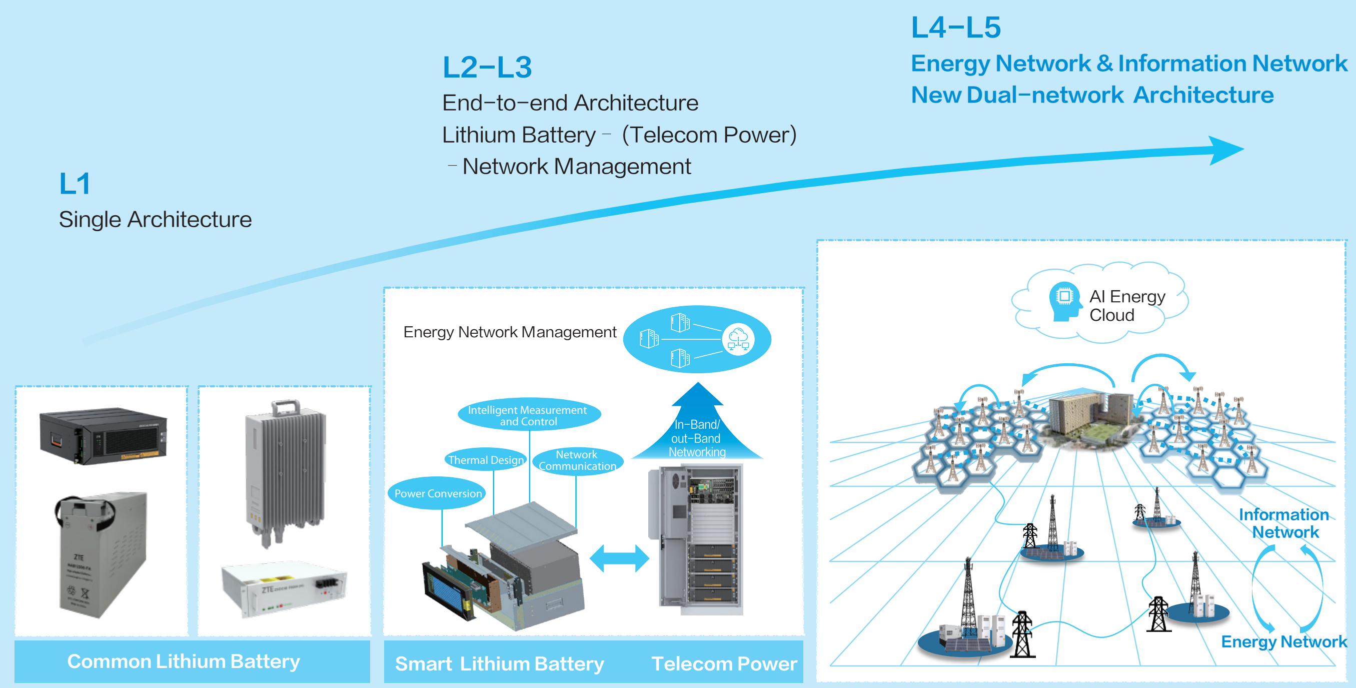


Figure 1: Evolution of Telecom Energy Storage Architecture

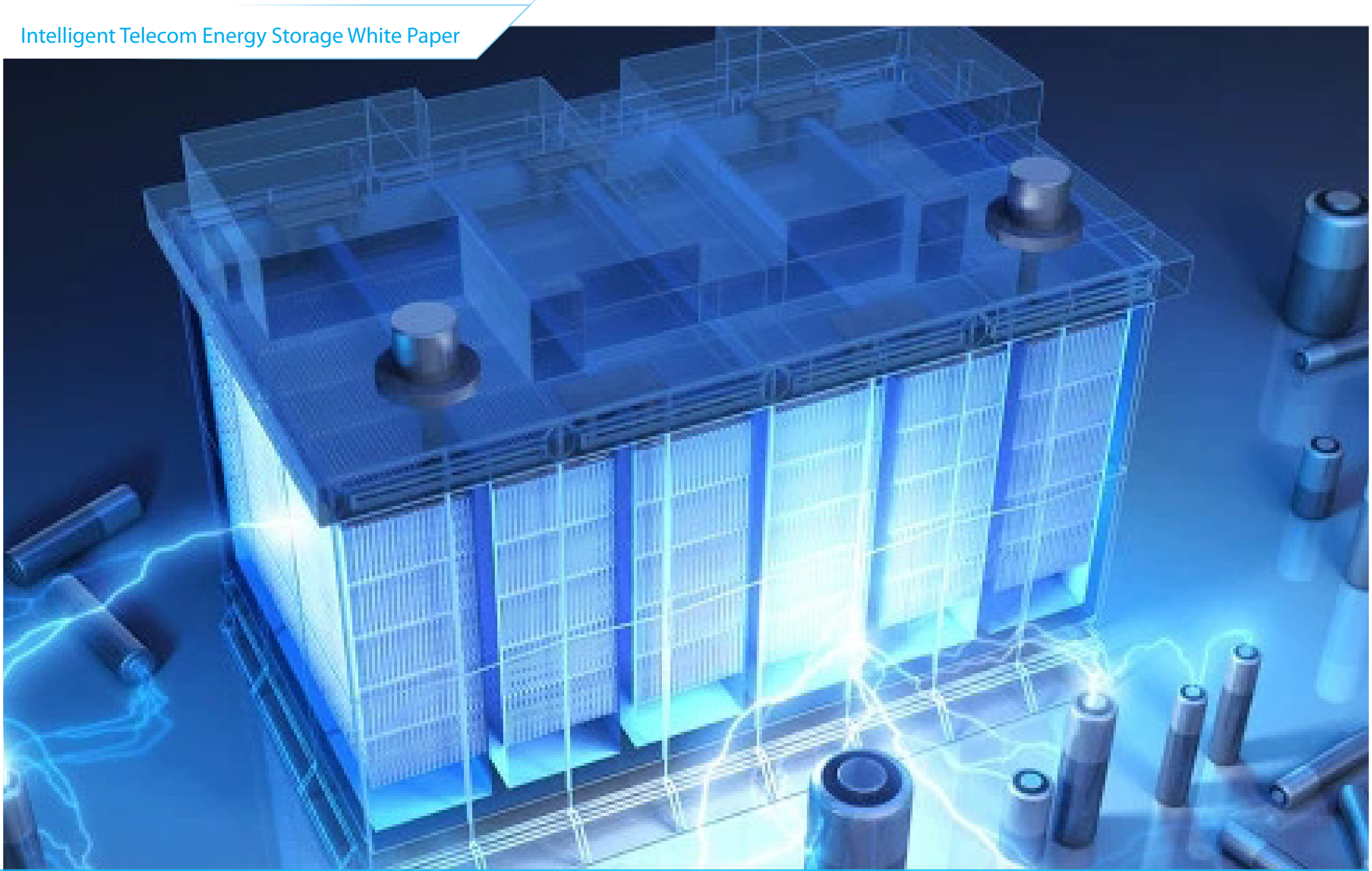
New Telecom Energy Storage Architecture

Telecom energy storage is evolving from the previous "single architecture" to the current mainstream "end-to-end architecture", and ultimately to the "new dual-network architecture"(see figure 1).

Single-architecture, the lithium battery system, as an isolated execution component, mainly provides the power backup function. In this case, the cycling performance is not fully utilized, undermining the asset value. Due to extensive power backup management, the power backup is either redundant or insufficient at different sites, leading to asset waste. The operational status of the lithium battery system cannot be visualized or identified, resulting in passive responses in O&M.

End-to-end architecture, a site energy storage information network is established in "lithium battery-power supply/gateway-EMS" mode to remotely monitor the status of lithium devices, set parameters, and detect faults. The enhanced local BMS and interoperability with the Energy Management System (EMS) have taken the intelligence of lithium batteries to a higher level. Although the end-to-end architecture facilitates the intelligent evolution of lithium batteries, it needs to be further upgraded because it falls short of outer site coordination and scheduling of network-wide energy storage, and cannot satisfy the application of such technologies as big data and AI assistance.

New dual-network architecture, features an energy network and an information network with full-scenario connectivity of the public power grid, as well as the power generation, power consumption, and energy storage devices at network sites, enabling the interconnection between network-wide energy storage information and energy resources. Based on the integration of these two networks, an energy cloud is established to manage energy streams through information streams. The new architecture is the cornerstone of transformation from passive energy storage to active energy storage and active security, maximizing full-lifecycle value of energy storage. It ultimately achieves bidirectional flow of information streams and energy streams in network-wide energy storage, paving the way for the future comprehensive application of site energy storage, new energy applications, and zero-carbon network evolution.



New Definition of Hierarchy of Intelligent Energy Storage Intelligence

Based on the three architectures, ZTE have innovatively defined five levels to achieve expected intelligent telecom energy storage, namely, L1 (Passive Execution), L2 (Assisted Self-intelligence), L3 (Conditional Self-intelligence), L4 (High Self-intelligence), and L5 (Interconnection)(see figure 2).

L1 Passive Execution	L2 Assisted Self-intelligence	L3 Conditional Self-intelligence	L4 High Self-intelligence	L5 Interconnection
Replacement of lead-acid batteries	Basic control & Management	Multiple technologies Integration	New dual-network Architecture	Energy internet technology and new energy
• Power backup • Wthout or with Simple BMS • Dumb devices	• Basic BMS • Networking by Telecom Power • EMS • End-to-end Architecture	• Stronger performance • More application scenarios • More secure and reliable functions • End-to-end Architecture without Telecom Power	• Dual-network Integration and Cloud-network synergy • Active learning and Active energy storage • Active security and intelligent cloud maintenance • Capacity management and asset optimization	• Complete interconnection • Bidirectional interflow • Maximum energy sharing • Most efficient energy use • Cleanest energy supply • More Potential

Figure 2 New Definition of Hierarchy of Intelligent Telecom Energy Storage

L1 (Passive Execution) corresponds to the single architecture. At this level, common lithium batteries, acting as a passive execution component to replace lead-acid batteries, offer higher performance but similar functions. The lithium batteries are still dumb devices with limited application scenarios.

L2 (Assisted Self-intelligence) and L3 (Conditional Self-intelligence) correspond to the end-to-end architecture. L2 provides preliminary management that makes lithium batteries intelligent. At L2, lithium batteries are capable of independent execution, partial perception, and partial analysis. With a basic BMS, lithium batteries are connected through the power supply system to the EMS that provides basic functions like voltage/current balance, real-time parameter check, and over-current/over-voltage protection.

Compared with L2, L3 is much more intelligent. With the introduction of power conversion and partial decision-making and enhancement of the perception capability, L3 is capable of independent execution and perception and partial decision-making. It offers more powerful functions:

Stronger performance, such as higher energy density, super multi-group cascading, and equalized control with higher precision.

More application scenarios, such as intelligent hybrid use, intelligent parallel operation, intelligent peak-load shifting, intelligent peak-load shaving, and intelligent boosting.

More secure and reliable functions, such as SOC/SOH, remote alarm, intelligent theft prevention, and preventive O&M.

ZTE offers sophisticated L3 products and solutions with innovative functions that cater for all the 5G network scenarios and make the power system of 5G networks more intelligent, maximizing the efficiency of network power supply and O&M and reducing the Total Cost of Ownership (TCO).

L4(High Self-intelligence) makes a big leap in the intelligence level of telecom energy storage. L4 is integrated with new technologies such as AI, big data, and IoT, and is upgraded from the end-to-end architecture to the new dual-network architecture. L4 uses an intelligent management mode with three layers, namely, cloud, EMS, and device(see figure 3):

Intelligent sensing and control on the device side, including the

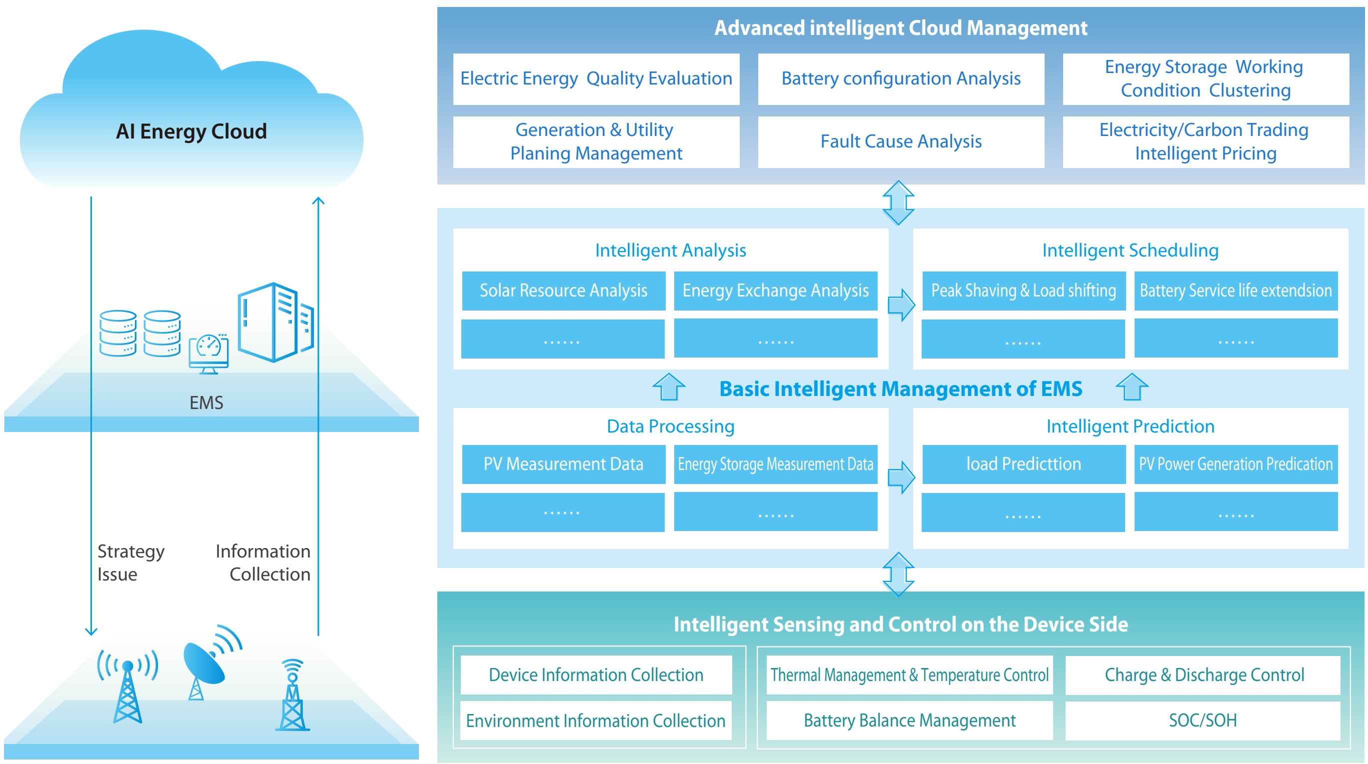


Figure 3 Intelligent management mode with three layers

functional modules such as collection of device and environment information, thermal management, temperature control, charging and discharging control on the device side.

Basic intelligent management of the EMS, including the functional modules on the EMS side such as data processing, intelligent prediction, intelligent analysis, and intelligent scheduling. Each module consists of multiple sub-functional units, and the functions are expanded and improved through the upgrading of sub-units.

Advanced intelligent cloud management, integrates AI algorithms to complete higher-level management analysis and decision making, such as price gaming and capacity planning, and provides policy guidance and distribution for lower-level management to achieve cloud-based management of network-wide energy storage.

This intelligent management mode can be deployed in a stepwise manner with the improvement of the management level. L4 represents a shift from partial decision-making to independent decision-making. With less human intervention, L4 enables more secure operation, more efficient O&M, wider application, and greater economic benefits. At present, ZTE is focusing on L4, of which the specific functions and advantages are reflected in four aspects:

Dual-network integration and cloud-network synergy, The information network and the energy network are integrated, and the energy cloud performs comprehensive and streamline management to the energy flow through the information flow. The cloud network is linked together to implement intra-station and out-station coordination and scheduling. Combined with the intelligent management of the cloud, EMS and device, the self-hybrid use, self-peak-load shifting, self-peak-load shifting and self-boosting applications are achieved.

Active learning and active energy storage, based on historical data, active learning (power grid, load, irradiation and carbon trading information) and dynamic data analysis (environment data, power grid quality and load fluctuation) are used to implement active energy storage with multiple energy resources(solar energy , diesel generator, power grid),such as the optimal charging and discharging strategy of energy storage , real-time AI scheduling for energy storage and supply, and priority to green energy. The energy storage can be changed from static to dynamic, and from island management to parallel network management, therefore maximize the energy storage value of the whole network.

Active security and intelligent cloud maintenance, based on historical work data , status monitoring on lithium battery and AI learning, the more accurate SOX algorithm is used to actively optimize the charging and discharging strategy , and extend the lifecycle of lithium batteries; detects, analyzes, diagnoses, and repairs faults based on different self-intelligence operating levels,

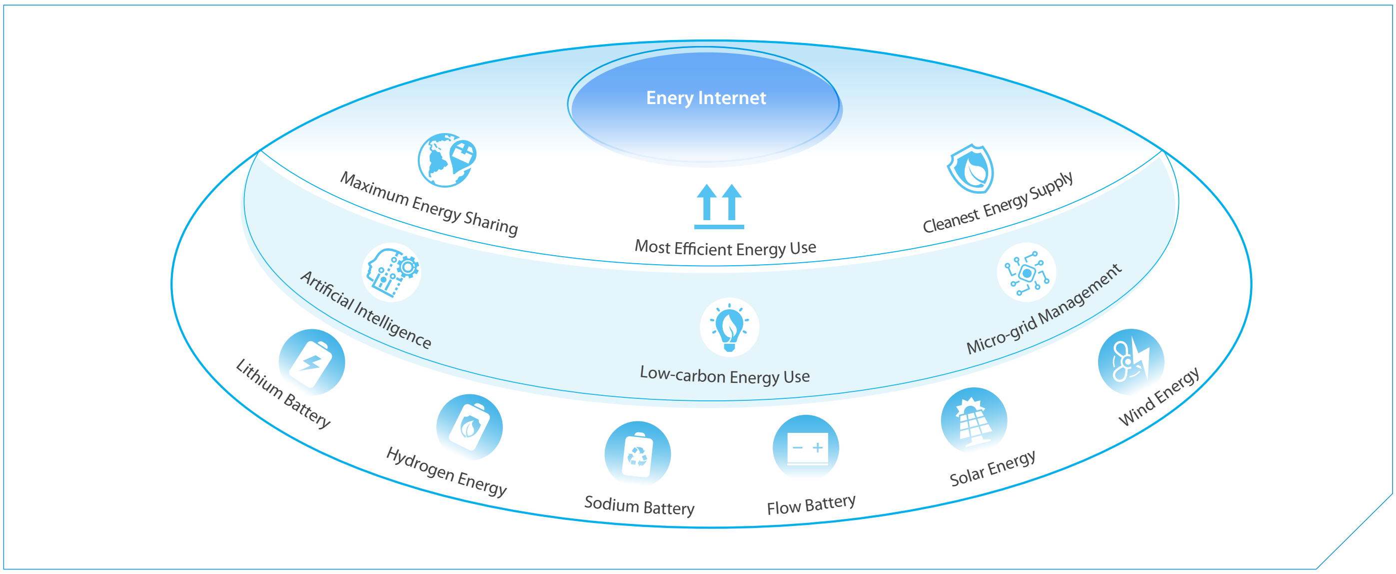


Figure 4 Overview of L5 Interconnection

and cooperates with the predictive control algorithm to ensure the full lifecycle security of lithium batteries; Through cloud-network synergy, the remote cloud management for all scenarios is realized, to reduce manual site visits, and progress from easy O&M to intelligent cloud O&M and O&M free.

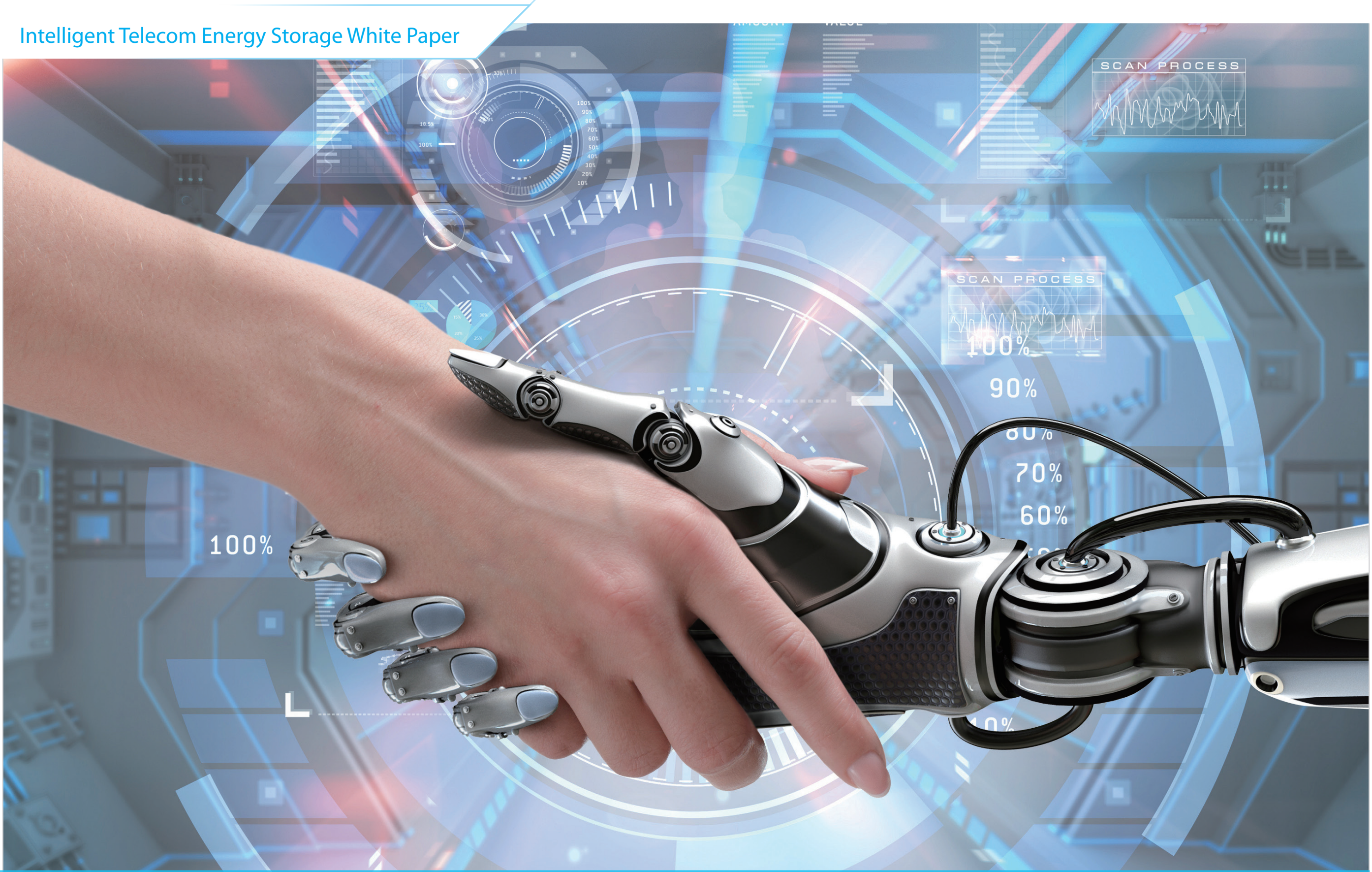
Capacity management and asset optimization, by comparing with energy storage running status and the resource allocation among the sites through AI and big data analysis, implement fine AI configuration and capacity planning for all the sites in the whole network. In this way, the existing network energy storage resources can be reused to the maximum extent, the assets can be optimized, the cost can be reduced and the efficiency can be improved, bringing additional economic benefits.

L5(Interconnection) is the ultimate phase of intelligent evolution of energy storage in the dual-network architecture, achieving full independence in execution, perception, analysis, decision-making, and intent. With the revolution of energy Internet technologies and new energy uses, energy storage will give full play to its potential (see figure 4).

Multi-energy application and low carbon energy use, it will support the integration and co-working of multiple energy storage methods(lithium battery, sodium battery, flow battery, fuel cell etc.), and comprehensive energy supply optimization(solar energy, wind energy, hydrogen energy, biological material energy etc).

Intelligent learning and algorithm upgrading, network-wide AI learning, extracting the optimal scheduling method that meets the energy architecture network, achieving self-optimization; it can evaluate carbon indicators, and develop the optimal carbon emission strategy and the optimal carbon emission result through continuously improved algorithms.

Complete interconnection between energy and information networks, and bidirectional flow in each network, connected to the regional energy Internet through micro-grid system, to completely exchange information on different energy storage types and energy types, and implement bidirectional scheduling based on the security algorithm, allowing customers to accomplish their best outcomes.



Prospect

With the development of global action aiming to reach peak carbon dioxide (CO2) emissions and achieve the goal of carbon neutrality, the energy structure has been undergoing accelerated transformation towards the direction of "low carbon, electrical energy, and digitalization". As an important part of the energy system, revolutionary changes are taking place in the functions and uses of energy storage. ZTE proposes the "Intelligent Telecom Energy Storage" White Paper, aiming to drive continuous development and progress of the telecommunications industry through technological accumulation and practice. In this way, ZTE can create greater value for customers, and achieve maximum energy sharing, most efficient energy use, and cleanest energy supply, thus embracing a sustainable energy future. ZTE remains committed to shouldering more responsibilities despite the challenges ahead to achieve intelligent evolution of renewable energy.