Promoting Green Low-Carbon Hyperscale Data Centers and Digital Application Services

Background

With the rapid expansion of the global digital economy, the demand for Hyperscale Data Center has exhibited an explosive growth trend. According to a McKinsey research report, global demand for Hyperscale Data Center capacity is projected to nearly triple by 2030, indicating that future requirements for data computation and storage will be immense. In particular, both AI and non-AI workloads will serve as key drivers for the growth in global Hyperscale Data Center capacity demand, with AI workloads estimated to account for approximately 70% of the total demand, highlighting the core role of AI technology in the future digital economy.

As global demand for computing power rises, the electricity demand for Hyperscale Data Centers has reached 100 MW or more. According to data from the Ministry of Economic Affairs, the average annual growth rate of electricity demand in Taiwan from 2024 to 2028 will be approximately 2.5%, with the electricity demand for AI technology projected to increase from 240 MW in 2023 to 2.24 GW by 2028—an eightfold growth. In addition to driving up the overall scale of electricity consumption, the synchronized nature of AI workloads causes power demand to fluctuate rapidly within short timeframes and elevates peak loads, intensifying the pressure on grid capacity and system dispatch. Furthermore, while the construction cycle for AI Hyperscale Data Centers is relatively short, large-scale power generation facilities, transmission and distribution projects, and related environmental impact assessments and administrative procedures often require longer lead times. Coupled with the highly concentrated nature of Hyperscale Data Center power demand, these facilities are easily limited by regional transmission and distribution capacity and existing grid congestion, increasing the difficulty of delivering large volumes of electricity. Therefore, constructing a comprehensive green digital service ecosystem and promoting low-carbon operational models have become critical challenges for maintaining national digital competitiveness.

Global Outlook and Domestic Progress

1. Global Outlook

Digital transformation must be coupled with the deployment of emerging Green Computing technologies, complemented by appropriate policy frameworks and governance, to fully realize their potential for environmental, social, and economic sustainability. To enhance data center energy efficiency and provide end-users with more energy-efficient infrastructure options, Singapore has released the "Green Data Centre Roadmap," "Green Mark for Data Centres 2024," and "Sustainable Software Development Guidelines," striving to guide data centers toward sustainable development while supporting the continuous growth of the digital economy. OCP (Open Compute Project) is a global open computing collaborative community and a critical platform for innovation efficiency and sustainable industrial collaboration for global data centers and AI infrastructure. It is dedicated to the joint development of more efficient, cost-effective, and sustainable IT infrastructure, assisting the industry in transitioning from traditional proprietary solutions to open architectures and accelerating innovation diffusion and market adoption.

To address the challenges of high power density and synchronized fluctuating loads associated with AI operations, major international players such as NVIDIA have announced that they will introduce High-Voltage Direct Current (HVDC) distribution architectures for Hyperscale Data Centers in 2027. This is in response to the increased power scales driven by the rapid growth of computing power. They aim to promote the standardization of voltage levels and interface specifications through industrial collaboration, co-develop key equipment such as Solid-State Transformers (SST) with strategic partners, and gradually establish verification mechanisms and operational safety requirements for DC-native equipment to form a scaled international supply chain, safety standards, and operation and maintenance systems.

2. Domestic Progress

Regarding spatial layout, domestic and international cases also show that the site selection for Hyperscale Data Centers has gradually shifted from merely pursuing land and network conditions to integrated planning with power supply capacity. Taipower has recently proposed the "Power Couple" concept, which emphasizes guiding high-power-demand industries such as AI to regions with a diverse power mix—including renewable energy, energy storage, and gas-fired units. By matching supply and demand, this approach reduces transmission losses, enhances power supply efficiency, and avoids congestion in the existing grid. Meanwhile, Inzai City in Japan, in addition to its stable geological conditions, low disaster risk, and transportation location, has also pre-prepared power infrastructure such as ultra-high-voltage cables and substations to gradually establish the conditions for data center cluster development.

Taiwan possesses industrial foundations in HVDC/SST equipment supply chains, semiconductor chips, high-efficiency computing modules and equipment, power infrastructure, and green energy and energy storage. It is well-positioned to bridge into next-generation green, low-carbon Hyperscale Data Center power architectures and related testing and verification development. Taiwan's Hyperscale Data Center industry also has a complete layout ranging from HPC chips, communications, and thermal management to power, servers, system integration, and cloud service ecosystems. In response to the global net-zero transition trend, the Ministry of Digital Affairs released the "Green Software Reference handbook (Draft) " and the concept of a "Voluntary Green Software Label " in 2025 to help strengthen green software development and sustainable management capabilities, capturing opportunities for international cooperation and market expansion.

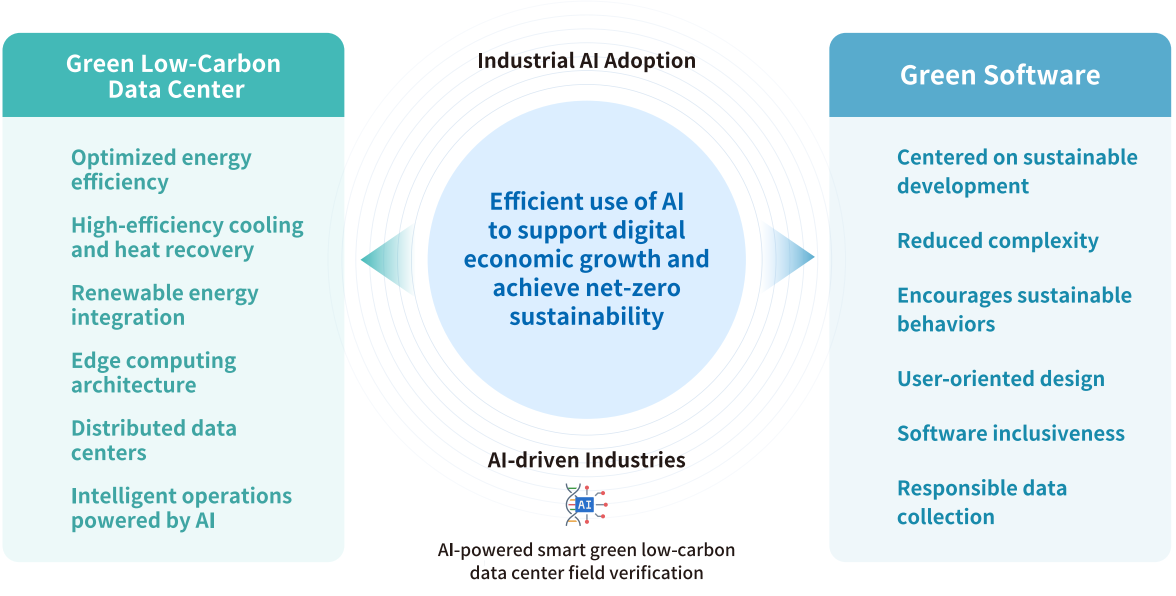

Figure 1 Vision for Green Low-Carbon Hyperscale Data Centers and Digital Application Services Development Strategy

Source: Taiwan Science and Technology Office for Net-zero Emission(T-STONE)(2025)

Strategic Planning Frameworks

Strategy 1: Accelerate Adoption of Emerging Technologies

This strategy adopts a dual-track approach of "hardware layout" and "software layout," covering multiple technical fields such as renewable energy integration, energy storage systems, advanced cooling systems, hardware energy efficiency optimization, virtualization and integration, energy management systems, modular and containerized Hyperscale Data Centers, AI and machine learning applications, and carbon reduction strategies, in order to comprehensively enhance Hyperscale Data Center energy efficiency, reduce carbon emissions, and strengthen operational resilience.

Strategy 2: Promoting the practical verification of green low-carbon data centers and HVDC 800V standard testing

This strategy focuses on international development trends and key technical requirements for HVDC Hyperscale Data Center power supply architectures, establishing a domestic standard testing and verification system and capacity. It promotes the establishment of complete mechanisms for product testing, system verification, and field demonstration, while leveraging our nation's industrial advantages to encourage domestic manufacturers to invest in key equipment development. Furthermore, through international supply chain collaboration, the strategy seeks to participate in the development of international standards and verification specifications, driving investment and upgrading across the domestic information and power industry chains.

Strategy 3: Develop Metrics and Certification Systems

International practices currently involve the widespread use of the Power Usage Effectiveness (PUE) metric to measure energy-saving performance, while also establishing diverse energy efficiency indicators and management mechanisms. It is recommended that Taiwan, based on international practices and in response to its unique industrial structure and environmental conditions, propose a framework centered on establishing diverse energy efficiency indicators and minimum requirements categorized by power consumption scale. This would provide a more precise and comprehensive assessment mechanism, systematically guiding operators to strengthen their energy management capabilities through the phased advancement of standards.

This strategy draws on Singapore's Green Mark for Data Centers (GMDC) certification system to establish a Green Label for Data Centers (GLDC Taiwan) mechanism. Its purpose is to utilize specific indicator assessments and institutional designs to enable Hyperscale Data Center operators to enhance their service image and competitiveness through green certification, while progressing toward higher energy efficiency and sustainable operation goals.

Strategy 4: Enable Sustainable Digital Services

Software plays a core role in the modern digital economy, and its energy consumption and carbon emissions are receiving increasing attention. Establishing a voluntary green software labeling mechanism, through the construction of a Software Carbon Efficiency Rating (SCER) system and software carbon emission calculation standards and evaluation criteria, encourages software developers and users to proactively choose environmentally friendly and efficient software products.

To encourage users to proactively choose environment-friendly digital services and applications, establishing a Green Digital Service Certificate (GDSC) system is a key strategy. This system tracks and verifies the carbon footprint and environmental impact of digital services through an Impact Framework mechanism and issues Green Digital Service Certificates. Through these certificates, enterprises and consumers can clearly understand the environmental impact of using digital services and make more eco-friendly choices.

Strategy 5: Developing AI Low-Carbon Hyperscale Data Center Net-Zero Campus

AI Low-Carbon Hyperscale Data Centers are characterized by high power density, concentrated power usage, significant load fluctuations, and short construction periods. They have stringent requirements for stable low-carbon power, transmission and distribution capacity, communication connectivity, and cooling conditions. Therefore, it is advisable to adopt a specialized zone approach to integrate land, power, communication, and administrative coordination resources.

This strategy will identify suitable locations that possess surplus power supply, expandable substation and transmission capacity, and proximity to backbone fiber-optic communication nodes, while also featuring low disaster risks and favorable development conditions. Priority will be given to the preparation of power grids, substations, common utility ducts, and necessary public facilities. This will be combined with planning for renewable energy, energy storage, backup power sources, and free cooling, to form specialized zones suitable for accommodating high-density computing loads.

Additionally, a site selection guidance and supporting coordination mechanism will be established to encourage operators with high power demand to prioritize locating in areas with better power conditions. This will reduce regional grid pressure, shorten construction timelines, enhance the efficiency of matching power supply and demand, and drive the coordinated development of Hyperscale Data Centers and energy infrastructure.

Potential Benefits

By deploying emerging technologies for green and low-carbon Hyperscale Data Centers and combining our nation's industrial advantages in semiconductor chips, high-performance computing (HPC), Hyperscale Data Centers, power, green energy, and energy storage, a comprehensive and competitive green computing industry chain will be formed. Through the introduction of advanced green and low-carbon Hyperscale Data Center technologies, field verification, and the establishment of relevant metrics, system performance and energy-saving effectiveness can be verified. It is expected that by 2035, these efforts will assist in developing a domestic green and low-carbon Hyperscale Data Center and digital application service industry ecosystem, improving Hyperscale Data Center energy efficiency by more than 10% and achieving energy-saving benefits of over 20 billion kWh.

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Taiwan Science and Technology Office for Net-zero Emission (T-STONE)
Email: T-STONE@niar.org.tw