# THE IMPACT OF ENERGY EFFICIENCY AND DECARBONIZATION IN DATA CENTERS — POTENTIAL FOR NEW BUSINESS OPPORTUNITIES —

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## SUMMARY

- Electricity consumption in data centers (DCs) is increasing rapidly. In conventional DCs, each rack typically requires 2-4 kVA, but DCs designed for generative AI are now at 20 kVA or more, with racks forecast to exceed 200 kVA in the future.
- In response to rising electricity consumption, DCs are moving forward with energy efficiency and decarbonization. Notable methods include liquid cooling systems and the use of renewable energy.
- The impact of DC energy efficiency and decarbonization on business is significant. As the power supply and demand balance worsens, renewable energy source development will likely become integrated into DC operations.


## 1. BUSINESS ENVIRONMENT SURROUNDING DATA CENTERS

A data center (DC) is a facility responsible for processing data, providing network connections, and managing IT equipment such as servers and communication devices. Valued at USD 329.3 billion in 2023, the global DC services market is projected to grow at an annual rate of 5.9% to USD 438.7 billion by 2028.[1] As such, DCs are positioned as crucial infrastructure in the evolving digital society. However, the expansion of the DC market poses challenges, notably its substantial electricity consumption, which is driving significant changes in the business landscape. Focusing on these changes, this report outlines the current challenges and discusses new business opportunities.

### 1-1. INCREASE IN ELECTRICITY CONSUMPTION

One characteristic of DCs is their significant electricity consumption. According to a report by the International Energy Agency (IEA), global DC electricity consumption was estimated to be 460 TWh in 2022 and is expected to more than double to 1,000 TWh by 2026.[2] This is a level comparable to the annual electricity consumption of Japan. In terms of the share of global electricity consumption, DCs accounted for 1.8% in 2022, with an increase to about 3% anticipated by 2026. The electricity consumption of DCs continues to rise as the market expands, prompting countries to adopt a cautious stance toward this trend (Figure 1). Even Ireland, which has been a leader in attracting DCs, has shifted to a policy of regulating the construction of new DCs, and a stricter business environment for new DC development is gradually emerging.

1 Estimated by the research firm Statista. The DC services market encompasses services related to servers, storage, and network equipment.
https://www.statista.com/study/35990/data-centers-statista-dossier/
2 https://iea.blob.core.windows.net/assets/6b2fd954-2017-408e-bf08-952fdd62118a/Electricity2024-Analysisandforecastto2026.pdf

**Figure 1: Regulatory trends in new DC construction by country/region**

| Country/Region | Regulatory trends in new DC construction |
|---|---|
| Ireland (Dublin) | • EirGrid has imposed a moratorium on accepting no new transmission network connections for DCs until 2028 |
| Netherlands (Amsterdam) | • Introduced energy efficiency standards and renewable energy usage requirements for new DCs<br>• In 2022, the Senate passed a motion to request the government to halt the construction of a new DC by Meta |
| Germany | • Passed an energy efficiency bill that includes DC regulations. Mandated that DCs at 200 kW or more must reuse 20% of their waste heat by 2028 |
| Singapore | • The government banned new constructions in 2019. Approved the establishment of some environmentally-friendly DCs in May 2024 |
| China (Beijing) | • Prohibited the construction and expansion of DCs in central urban areas of Beijing<br>• Mandated the inclusion of renewable energy sources in the power supply since 2021 |

Source: Compiled by MGSSI based on various report reports

## 1-2. FACTORS INCREASING ELECTRICITY CONSUMPTION AND ASSOCIATED ENVIRONMENTAL IMPACT

The electricity consumption of DCs has increased with the spread of cloud services, but recently, the adoption of generative AI has led to a rapid increase in electricity consumption. Looking at electricity consumption per rack[3] by DC application, enterprise DCs[4] typically require 2–4 kVA, whereas hyperscale DCs[5] need 6–8 kVA. For generative AI-focused DCs, demand escalates to 20 kVA or more. In this way, the electricity demand of DCs is escalating rapidly (Figure 2). Future consumption is predicted to reach 60–100 kVA per rack, and even exceed 200 kVA in 2025. In terms of individual DCs, a large 50 MW DC consumes as much electricity as 15,000 households, and a 100 MW DC consumes that of 30,000 households, making the consumption of a single facility comparable to that of a small town.

The increase in DC electricity consumption can also be analyzed from the perspective of changes in server heat output. During the cloud boom, the enhanced performance of CPU servers increased their heat output from approximately 150 W to 300 W and from there to around 500 W. However, the use of GPU servers has advanced with the acceleration in AI development, leading to heat outputs exceeding 10,000 W. Thus, with improvements in CPU performance and the adoption of GPU servers, the electricity consumption of IT equipment in DCs has increased.

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3 A rack is a specialized housing designed to efficiently store and manage IT equipment such as servers and storage and network devices. Typically, a rack measures about 200 cm in height, 50 cm in width, and 100 cm in depth.

4 Enterprise DCs are for general IT systems, which primarily cater to the development, operation, and maintenance of IT services.

5 Hyperscalers are companies that possess server resources on the scale of one million units or more. Examples include AWS, Microsoft, Google, IBM, Netflix, Alibaba, Baidu, and Tencent. DCs targeting such companies are characterized by their expansive space and high scalability.

**Figure 2: Power consumption per rack and the progression of the DC business**

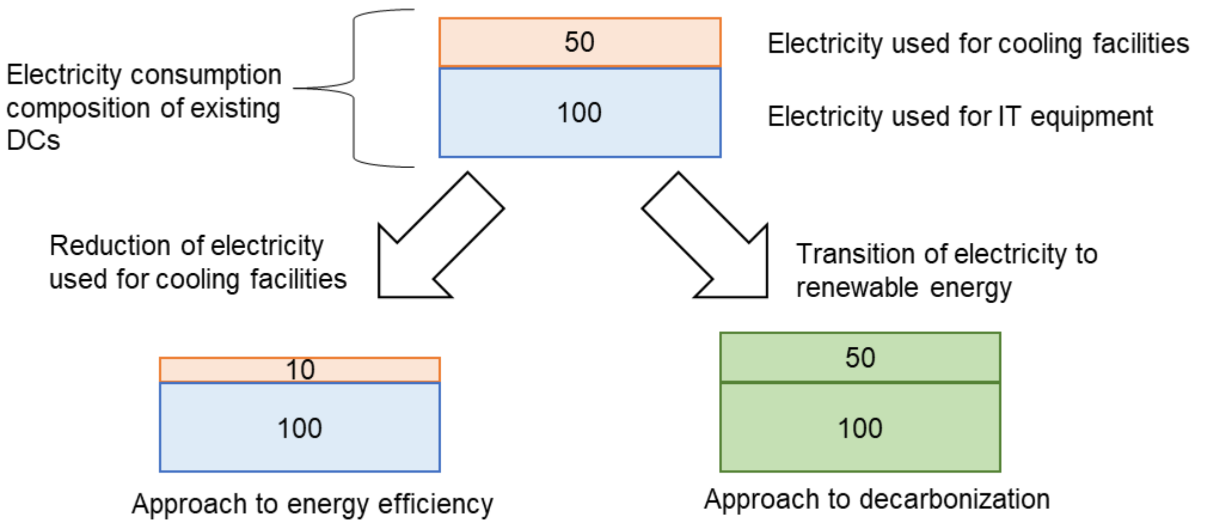
| DC target | | Enterprises | Hyperscalers | Generative AI developers |
|---|---|---|---|---|
| DC applications | | General IT systems | Cloud, web services | Generative AI |
| Power per rack | | 2–4 kVA | 6–8 kVA | 20kVA or more |
| Receiving capacity of DC facility | | 2–5 MW | 20–50 MW | Up to 1 GW |
| Heat generated by one server | | 150W | 250–500 W | 10,000W or more |
| DC business strengths | IT systems | ○ | — | ○ |
| | IT equipment | ○ | — | ○ |
| | Networks | — | ○ | ○ |
| | Cooling facilities | — | ○ | ○ |
| | Electrical facilities | — | ○ | ○ |
| | Buildings | — | ○ | — |
| | Property | — | ○ | — |
| DC service sales point | | • IT system development<br>• Operation & maintenance | • Large space<br>• Expandability | • Computational resources & cooling capacity<br>• Low-cost power |
| Main businesses | | • IBM, NEC, Fujitsu and other IT service providers | • Telecommunications carriers, DC specialists, REITs, etc. | • Big tech, generative AI startups, etc. |

Source: Compiled by MGSSI based on various media reports

## 2. STRATEGIES FOR ENERGY EFFICIENCY AND DECARBONIZATION IN DATA CENTERS

Electricity usage in DCs is divided into two types: electricity for cooling systems and electricity for IT equipment (Figure 3). The latter is essential for maintaining performance and stable operation, making it difficult to reduce. Therefore, approaches to address the increase in electricity consumption include consumption reductions through advances in cooling facilities, and efforts in decarbonization through energy transitions.

**Figure 3: Conceptual diagram of DC power consumption composition and reduction approaches**

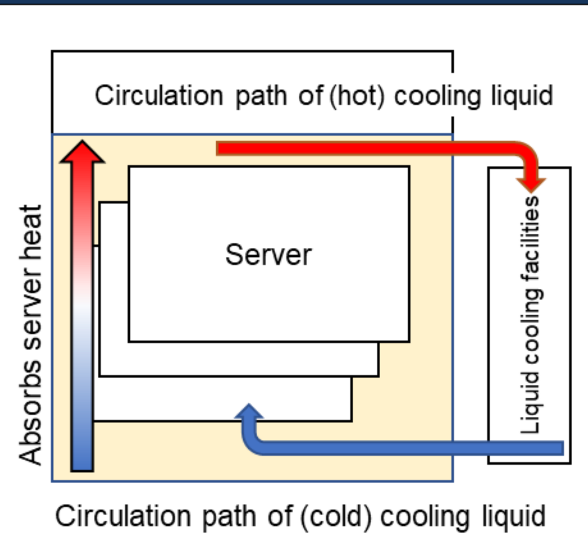
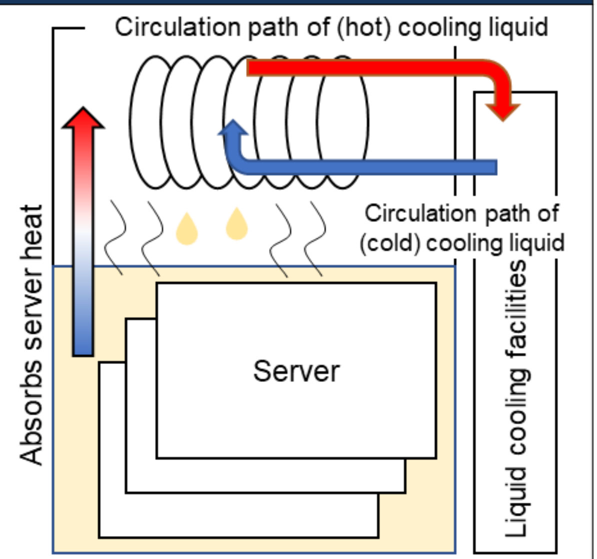



Source: Compiled by MGSSI based on various sources (figures for illustrative purposes only)

## 2-1. ADVANCEMENTS IN COOLING SYSTEMS FOR ENERGY EFFICIENCY

Conventionally, air conditioning is the common method for cooling. However, due to recent increases in heat output per rack, air conditioning is no longer sufficient to adequately cool servers. Accordingly, liquid cooling technologies are now gaining attention. While the limit of cooling by air-conditioning is 30 kVA per rack, liquid cooling can handle greater heat outputs and is extremely energy efficient. Liquid cooling includes direct-to-chip cooling and immersion cooling, the latter of which involves immersing IT equipment in liquid. Immersion cooling is further divided into single-phase and two-phase systems (Figure 4). Direct-to-chip cooling is expected to be used in existing DCs, and its standardization is progressing. However, there are many challenges to implementing immersion cooling. The first challenge is the environmental impact of the coolant used. Existing coolants have a high global warming potential, which hampers decarbonization efforts.[6] The second is server maintenance. Since IT equipment is immersed in liquid, maintenance entails removing the liquid and other tasks that differ from traditional maintenance methods, potentially increasing operational costs. The third is the adaptation of IT equipment to immersion. Equipment must be compatible with the cooling method, and the risk of failures due to the liquid interfering with the equipment makes the dual use of liquid and air cooling difficult.

**Figure 4: Characteristics and mechanisms of immersion cooling systems**

| Item | Single-phase | Two-phase system |
|---|---|---|
| Schematic |  |  |
| Overview | • Liquid circulates inside the housing to cool the server<br>• The liquid flows from the bottom to the top of the housing<br>• The liquid absorbs heat and is cooled by cooling facilities<br>• Liquids used are lubricants, etc. | • Cooling by evaporation of liquid<br>• Coil at the top of the housing cools the vaporized gas and turns it into a liquid<br>• The coil is cooled by refrigerant<br>• The liquid used is a fluorinated material |

Source: Compiled by MGSSI based on various data

## 2-2. ENERGY TRANSITION FOR DECARBONIZATION

Efforts to reduce the environmental impact of electricity used in DCs have advanced through the use of renewable energy. There are increasing efforts to use renewable energy sources such as solar and wind power in DCs to reduce $CO_2$ emissions with the aim of decarbonization. In June 2024, Google contracted with NV

[6] Global warming potential (GWP) is a measure of the global warming impact when greenhouse gases are emitted into the atmosphere. GWP measures the warming effect a specific gas has on the Earth's climate over a defined period, usually 100 years, relative to carbon dioxide ($CO_2$). The GWP of $CO_2$ is defined as 1, and such effect of a specific gas is expressed as a numerical value in comparison to other greenhouse gases.

Energy, a utility company in Nevada of the US, to purchase 115 MW of geothermal energy for their DCs. As such, procuring renewable energy has become crucial for DCs, and operators urgently need to establish supply chains for renewable energy procurement.

## 3. BUSINESS CHALLENGES ARISING FROM ENERGY EFFICIENCY AND DECARBONIZATION EFFORTS

Multiple business impacts are anticipated as DC operators make progress toward energy efficiency and decarbonization (Figure 5). These changes are necessary for business continuity. This section outlines the business rationale for energy efficiency and decarbonization.

**Figure 5: Impact of energy efficiency and decarbonization on DC business**

| Business Layer | Scope of Impact | Description of Impact |
|---|---|---|
| IT systems | Impact of the cloud services market | — |
| IT equipment | Impact associated with energy efficiency (Support for liquid cooling) | • Support for liquid cooling of physical IT equipment, cables, etc.<br>• Collaboration in operation & maintenance of IT equipment and demonstration of compatible refrigerants, etc. |
| Networks | | |
| Cooling & electrical facilities | Impact of energy efficiency (Introduction of liquid cooling) | • Establishment of equipment and operational structure for server maintenance |
| Buildings | | • Handling of liquids, building management in compliance with fire codes and other legal requirements |
| Property | Impact of decarbonization (Procurement of renewable energy) | • Securing a location with a good supply of electricity, not just low cost |
| Power | | • New layer of DC business also covering power supply development |

Source: Compiled by MGSSI based on various media reports

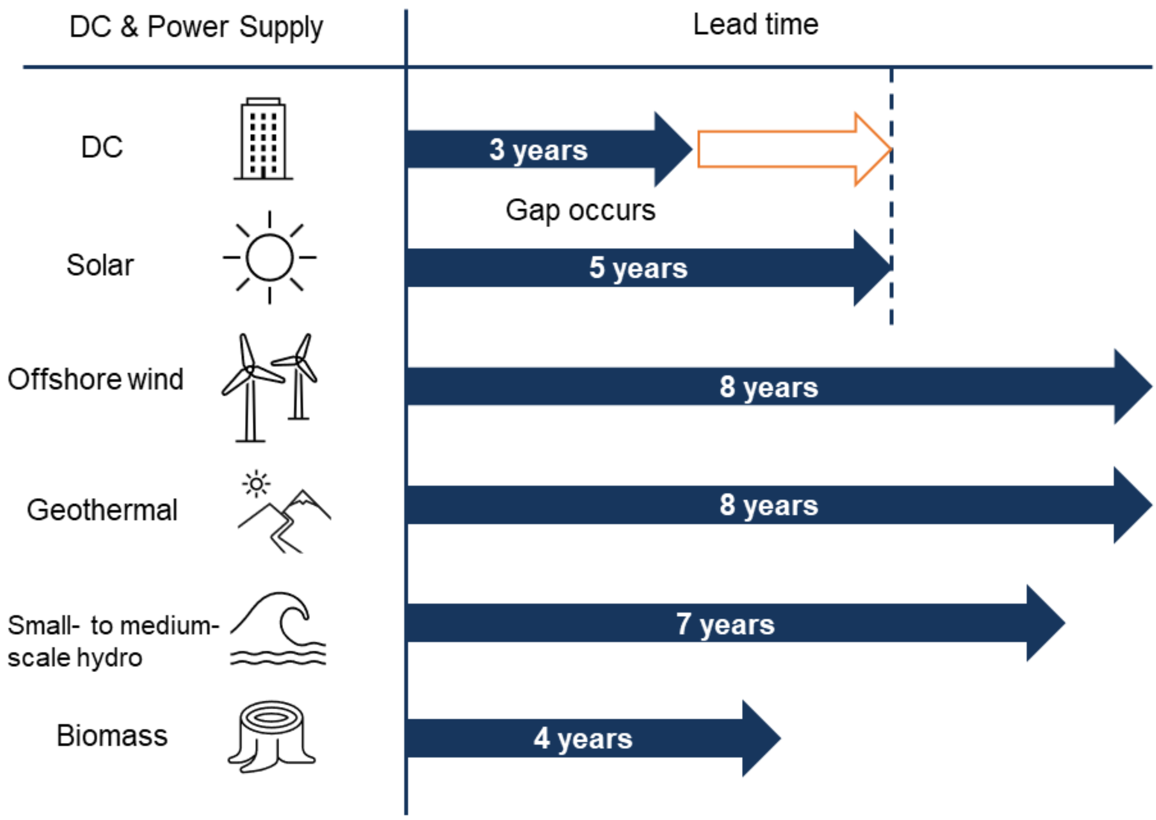
### 3-1. IMPACT OF ENERGY EFFICIENCY

The introduction of liquid cooling accordingly requires changes to server maintenance methods and other operational practices to accommodate liquid cooling. In the case of immersion cooling, these necessary adjustments extend to building management, including fire code compliance, and to IT equipment and cabling. Although standardization of immersion cooling is progressing, its implementation is limited to collaborations between some IT and equipment manufacturers. As a result, there is a growing need for DC operators to drive demonstrations and other collaborative efforts to standardize the industry as a whole.

### 3-2. IMPACT OF DECARBONIZATION

As the DC market expands, the increased power consumption will necessitate increased power supply capacity. However, the balance of power supply and demand is expected to worsen. The typical lead time for opening a conventional DC, which includes power contracts, land acquisition, and construction, is estimated at 2-3 years, whereas starting operations for renewable energy sources may require 5-8 years (Figure 6). Therefore, rather than procuring power while constructing DCs, it is necessary to consider a process where power sources are secured or developed before the construction of a DC begins.

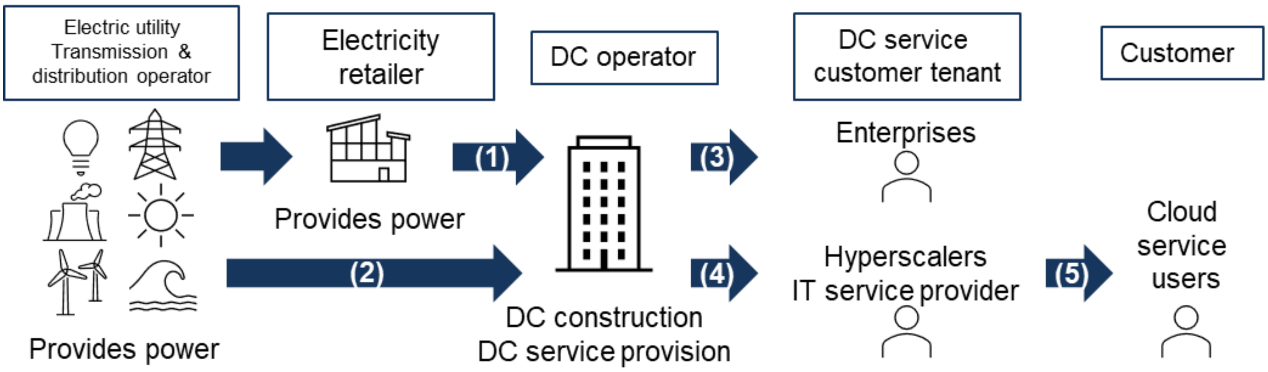
**Figure 6: Lead time for DCs and renewable energy sources**




Source: Compiled by MGSSI based on various data

For example, with solar power, there can be a gap of about two years in lead time between the opening of a DC and the availability of power. Closing this gap will be a major challenge for the future, given the growing demand for DCs. In the DC business value chain so far, DC operators have contracted with power utilities to supply electricity to their tenants (Figure 7). As the supply-demand balance is expected to deteriorate, competition for power procurement by DC operators will likely intensify. Therefore, the development of renewable energy sources is likely to be included in DC projects to improve the power procurement environment.

**Figure 7: Power procurement and DC services value chain**




| Sales Channel | Provider | Recipient | Value Chain Characteristics |
|---|---|---|---|
| (1) | Electricity retailer | DC operator | • Conventional value chain model of electricity sales<br>• Off-site PPA* applicable for renewable energy |
| (2) | Electric utility Transmission & distribution operator | DC operator | • Direct transactions with electric utilities and transmission & distribution operators<br>• On-site PPA applicable for renewable energy |
| (3) | DC operator | Enterprises | • DC services provided using IT system development, operation and maintenance as the sales point |
| (4) | DC operator | Hyperscalers IT service provider | • Hyperscalers, especially cloud providers, also function as users of DC services |
| (5) | Hyperscalers IT service provider | Cloud service users | • Tenants provide cloud services to users<br>• Users access via network |

Source: Compiled by MGSSI based on various data
*Power Purchase Agreement. A long-term contract between an electric utility (seller) and an electricity consumer (buyer). Cases of DC operators entering into PPAs to provide renewable energy will increase.

## 4. CONCLUSION AND OUTLOOK

This section reexamines the direction of business opportunities in the context of making DCs energy-efficient and decarbonization. Changes in cooling facilities resulting from energy-saving measures indicate potential business opportunities in locations previously unsuitable for DCs. While DCs have conventionally been established in colder regions to minimize cooling power needs, enhanced cooling capabilities and energy efficiency now make it feasible to consider warmer regions or livelihood zones with constrained power supplies for the location of new DCs. The advancement of renewable energy procurement driven by decarbonization indicates the potential for simultaneous development of renewable energy sources together with DC construction due to the increasing need for additional power supplies. DC operators were previously just power consumers, but they can differentiate themselves by establishing their own power supply systems in the future.