Interplay Between Data Centers and Electricity Markets

2.1 Introduction: Power Markets and Data Centers

IIJ's core business is in the telecommunications market, a market that has transformed considerably since telecommunications were liberalized in Japan in 1985, unleashing the principles of competition. The services themselves have also developed in many ways, with the shift from telephones to the Internet, and from fixed lines to mobiles, and market size has roughly tripled, going from 5 trillion yen in 1985 to 15 trillion yen in 2020. Over that time, liberalization has brought various benefits to users, such as cheaper service fees and the availability of a whole range of services on the Internet.

In its electricity markets, meanwhile, Japan embarked on the full liberalization of retail electricity in 2016 as part of electricity system reforms, but in comparison with the telecommunications market, it is taking longer for sufficient user benefits to appear. Japan's telecommunications market was able to follow the US model as a forerunner, and the evolution of technology has had a direct impact on communications costs (optical fiber has led to explosive growth in the amount of data that can be transported) and service content (with chip transistor density doubling every 18 months, CPU processing power has also increased explosively). Yet there was no successful national-scale model to follow for the electricity market, and from the outside looking in, it would seem that liberalization is still a trial-and-error affair here. Power generation costs depend on fossil fuel prices and investments in renewable energy power plants, and changing the market structure through technology takes time, which may be the reason why the progress of liberalization in the electricity market has been slower than in the communications market. Global events have also had a major impact, including a sharp run-up in the cost of fossil fuel needed for generating power triggered by the Ukraine crisis, and this has made it even more difficult to tell what lies ahead for the electricity market.

IIJ uses electricity to provide services, and in data centers in particular, our customers use electric power as part of colocation services. So as a substantial power consumer, we have been working with stakeholders including electric utilities and equipment vendors to ensure we can receive a stable supply of electricity, reduce costs, and move toward carbon neutrality by reducing power consumption and making use of renewable energy. No industry can sustain commercial activity without electricity, and data centers consume a lot of power, so we believe we need to look beyond our position as a single power consumer and tackle the various issues around electric power head on. Here, we discuss challenges in the electricity market from a power consumer's perspective and explain how we plan to address them.

2.2 Electricity Market Challenge 1: Electricity Costs

Of the three electricity market sectors—power generation, transmission and distribution, and retail—the 1995 revision of the Electricity Business Act, in principle, liberalized entry into the power generation sector. The liberalization of the retail sector, meanwhile, proceeded in stages, with the extra-high-voltage category being liberalized first, followed by the high-voltage category, which serves small and medium-sized factories, and then the low-voltage category, which serves residential needs, thus completing the full liberalization process. Many retail electric power companies took this opportunity to enter the market, and just as electricity prices were lowered and the effects of liberalization began to appear, the rise in electricity procurement costs driven by the recent surge in fuel prices led to the collapse of small-scale retailers, resulting in increases in electricity prices.

Electricity costs are generally said to account for 30–40% of data center operating costs (Figure 1). Comparing March 2021 and January 2023, the fuel cost-adjusted price increased by 15.82 yen/kWh (TEPCO extra-high voltage), which has meant 40–50% increase in data center costs overall. We will continue to do what we can on our end, including energy saving initiatives, but the situation is such that we cannot avoid passing some of the increases through to customers.

2.3 Electricity Market Challenge 2: Carbon Neutrality(Energy Savings and Renewable Energy)

A goal of the Paris Agreement, an international treaty on climate change, is to achieve carbon neutrality by 2050 by reducing greenhouse gas (CO2, methane, N2O, CFCs) emissions. Over 120 countries/territories have ratified the agreement, and the Japanese government also made its own "carbon neutral by 2050" declaration in October 2020. In December 2022, the government

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finalized its Basic Policy for the Realization of GX (Green Transformation), which clarifies its approach to and the process for, among other matters, promoting rigorous energy-saving initiatives, making renewable energy the main power source, using nuclear power, encouraging the use of hydrogen and ammonia by industry, the development of the electricity and gas markets, resource diplomacy, and the storage battery industry. Japan's Sixth Strategic Energy Plan, released in October 2021, also sets numerical targets for the 2030 energy mix, as shown in Figure 2, calling for energy savings equivalent to around 9% of the mix and a renewable energy ratio of 36–38% to total, up from 22–24% previously. As a substantial power consumer, IIJ also believes that it needs to take the initiative on energy savings and the use of renewable energy in an effort to achieve carbon neutrality.

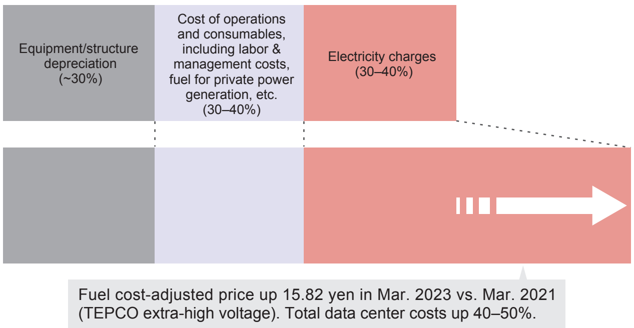

Figure 1: Typical Data Center Cost Structure[*1]

Carbon Neutral Data Center Model

To achieve carbon neutrality, we need to create a new model that organically links the generation equipment that supplies the power and the data centers that consume that power. IIJ has formulated a carbon-neutral data center reference model (Figure 3) that combines multiple power plant complexes, power storage equipment, supply and

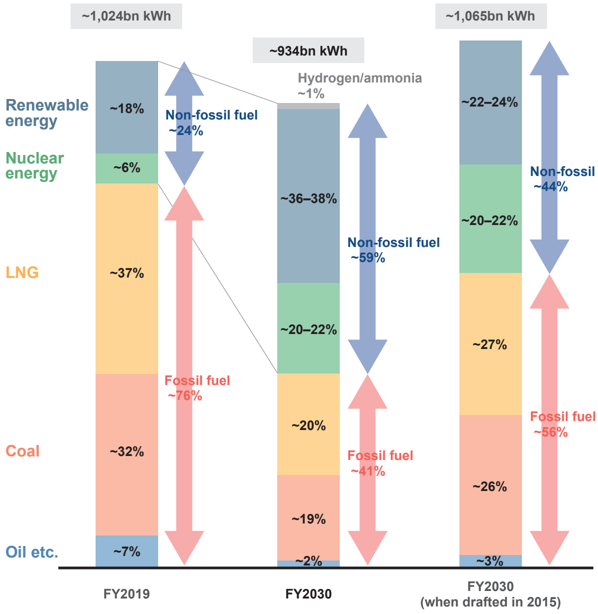

Figure 2: Energy Mix in the Sixth Strategic Energy Plan[*2]

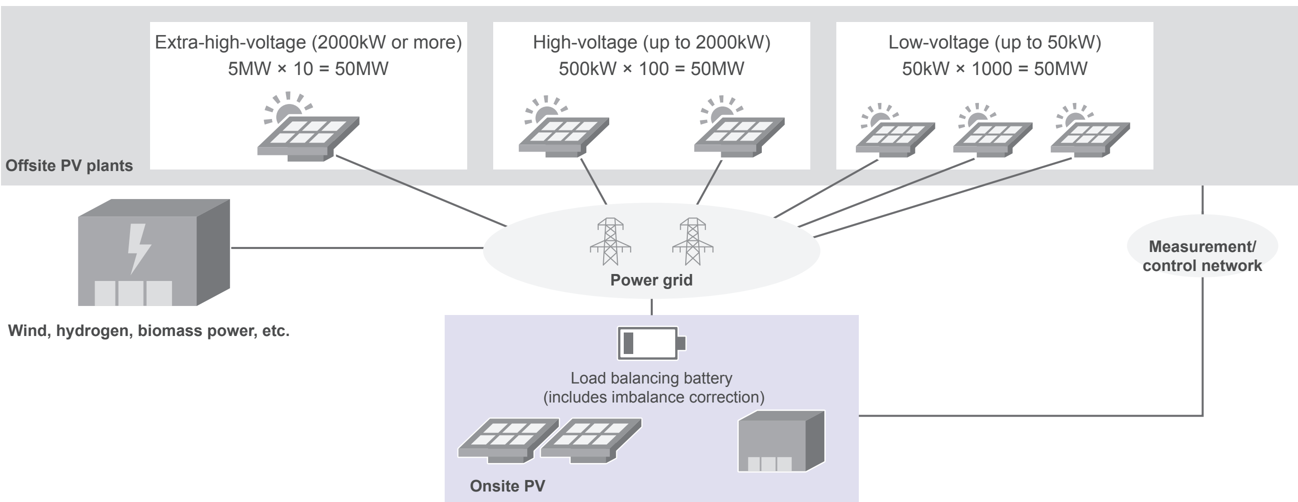

Figure 3: Carbon Neutral Data Center Reference Model

*1 Source: Adapted by IIJ from the website of Nikkei Xtech (https://xtech.nikkei.com/atcl/nxt/column/18/02096/063000007/).

*2 Source: Adapted by IIJ from the website of the Agency for Natural Resources and Energy (https://www.enecho.meti.go.jp/about/special/johoteikyo/energykihonkeikaku_2022.html.html).

demand control, and the like, and going forward we will be conducting technical tests and working with external partners on both the business and technological fronts, and applying this model when modifying our own data centers or building new ones.

■ Energy Saving Trends and IIJ's Track Record

Japan's Energy Saving Act was revised in 2022 to add data centers to the list of industries subject to its benchmark system. PUE (power usage effectiveness) was adopted as the benchmark indicator, with a target of 1.4 or lower being set. Data center operators are due to report for the first time in July 2023, with the law now calling on these companies to pursue further energy savings and use electricity efficiently.

PUE is found by dividing total data center facility energy consumption by IT equipment energy consumption, with a PUE closer to 1.0 indicating better efficiency. The average in Japan is said to be around 1.7. An Uptime Institute survey of data centers worldwide showed the 2022 average to be 1.55, a substantial improvement from 2.5 in 2007.

The increasing use of power by data centers has been perceived as a problem with serious implications for the environment, with people saying that data centers globally will consume 51% of the world's power by 2030. A survey jointly conducted by the Lawrence Berkeley National Laboratory in the US and others in 2020, however, showed that while data center compute capacity increased sixfold from 2010 to 2018, data center power consumption only rose 6%, from around 194TWh in 2010, or around 1% of the world's energy consumption, to 205TWh in 2018.

Figure 4 plots changes in power consumption for three types of data centers: traditional (traditional colocation), cloud

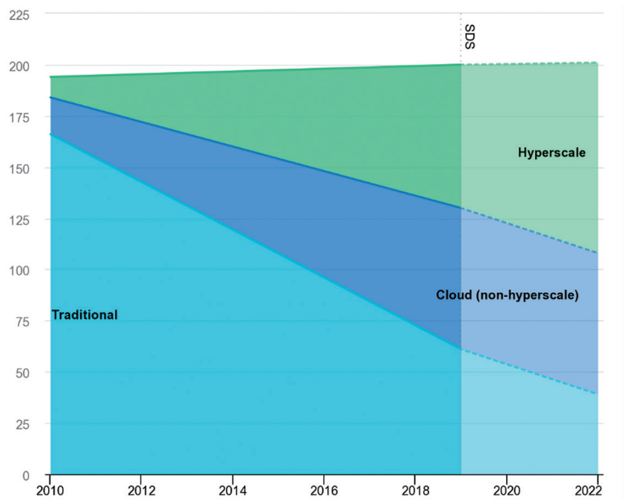

Figure 4: Global Data Center Energy Demand[*3]

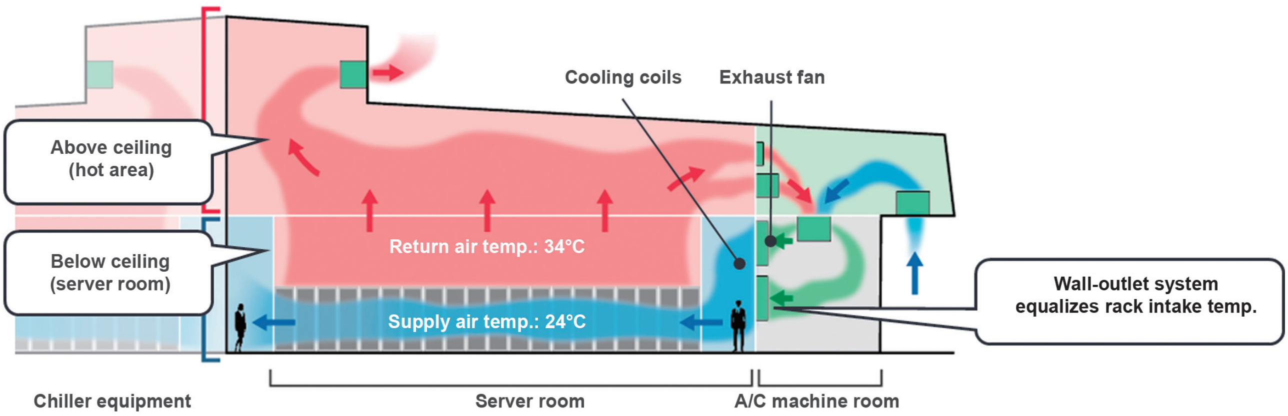

Figure 5: Outside-air Cooling Method at Shiroi Data Center Campus

*3 Source: IEA (https://www.iea.org/data-and-statistics/charts/global-data-centre-energy-demand-by-data-centre-type-2010-2022).

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(non-hyperscale), and hyperscale (large-scale data centers for cloud providers). The share of power consumed by hyperscale data centers increased by nearly 30% from 2010 to 2018, and this spread of hyperscale data centers capable of processing lots of data without using much power has likely been a factor in limiting the growth in overall data center power consumption, leading to better PUE readings.

■ IIJ's Initiatives

IIJ operates its own data centers in Matsue-shi, Shimane prefecture, and Shiroi-shi, Chiba prefecture, where it has introduced energy-saving technologies to make the facilities run efficiently. Air-conditioning systems are the next biggest consumer of power in the data center behind IT equipment, and IIJ uses outside-air cooling systems (Figure 5). Standardizing on 230V power input for the IT equipment made it possible to adopt a three-phase four-wire power distribution system that can supply the 400V output of the UPS (uninterruptible power supply) to the servers without having to step it down and incur transformer losses (FIgure 6). These efforts have resulted in a PUE of 1.2.

Figures 7 and 8 show actual PUE readings. Matsue Data Center Park (Matsue DCP) opened in 2011 and has consistently achieved a PUE in the 1.2–1.3 range since 2017. Shiroi Data Center Campus (Shiroi DCC) went live in 2019, and its PUE has improved as its utilization rate has increased, and we expect it to move into the 1.3–1.4 range in FY2022.

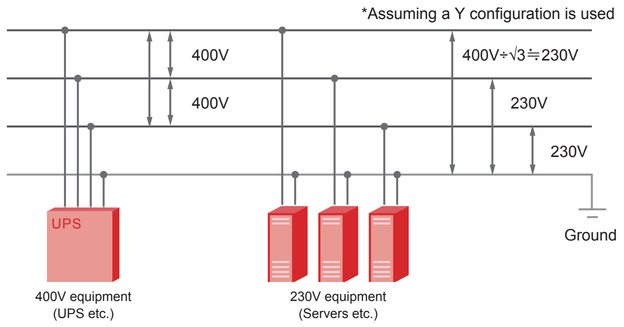

Figure 6: Three-phase Four-wire System

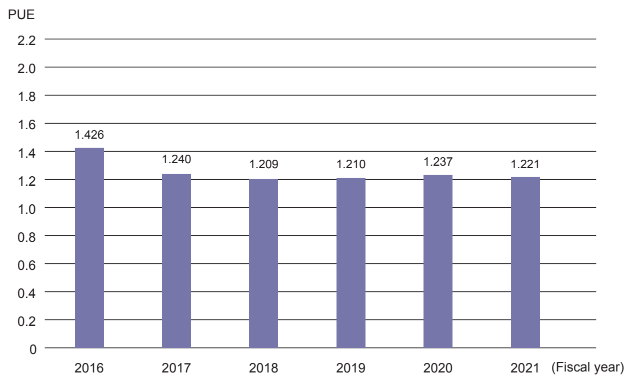

Figure 7: Matsue Data Center Park PUE (annual averages)

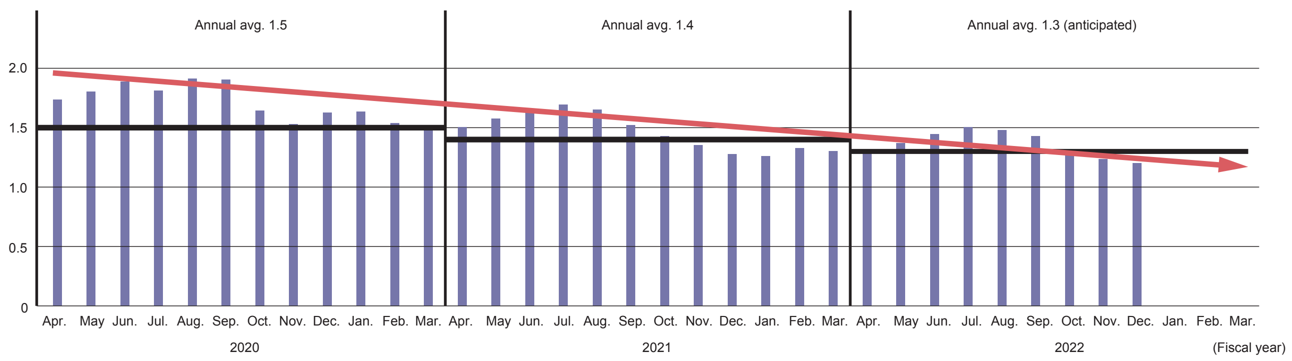

Figure 8: Shiroi Data Center Campus PUE (monthly averages)

Renewable Energy Trends and IIJ's Initiatives

In the sci-fi novel Project Hail Mary, currently being adapted into a Hollywood film, a quarter of the Sahara is covered with panels to collect huge amounts of solar energy, which, as a knock-on effect, induces natural disasters, such as frequent tornadoes in Spain, causing great harm to humanity. While this is fiction, the installation of solar panels can have adverse effects in real life too, including environmental destruction leading to landslides and the problem of how to dispose of panels after removal, so there are many issues to overcome if their use is to expand in Japan.

Renewable energy generation capacity is set to accelerate globally, however. As illustrated in Figure 9, the EIA reported in December 2022 that over the next five years through 2027, global renewable energy capacity is set to increase by 2,400GW (2.4TW), which is equivalent to the entire installed power capacity of China today.

Of all the world's industries, the IT industry has made the most progress adopting renewable energy. Figure 10 shows the top 10 procurers of renewables through PPAs (power purchase agreements), under which companies purchase renewable energy directly from power producers. Five of the 10 are data center operators (Google, Facebook, Amazon, Microsoft, QTS). The use of renewable energy can of course help with investor relations, but globally, the cost of generating renewable energy from wind and solar is coming down more than the cost of generating power conventionally using fossil fuels, so for data center operators that constantly consume large amounts of power, the shift toward renewables also reflects economic rationality.

IIJ is also pursuing renewable energy initiatives. In February 2022, we began using electricity derived from deemed renewable energy sources, which add energy attribute certificates to electricity from power utilities, at Matsue DCP. RE100 is an international initiative under which companies aim to procure 100% of the energy they consume in their business activities from renewables. In October 2022, the technical criteria for RE100 members were revised such that with respect to power purchased from retailers and energy attribute certificates, only power procured from generation facilities within 15 years of the facility being commissioned or expanded/upgraded is recognized as renewable energy for RE100 purposes, and so looking ahead, companies are likely to increasingly install new onsite generation facilities to meet their own power needs and introduce offsite corporate PPAs. Moreover, Japan's Energy Saving Act is slated for a revision in April 2023, adding new measures on transitioning to non-fossil fuel energy and requiring

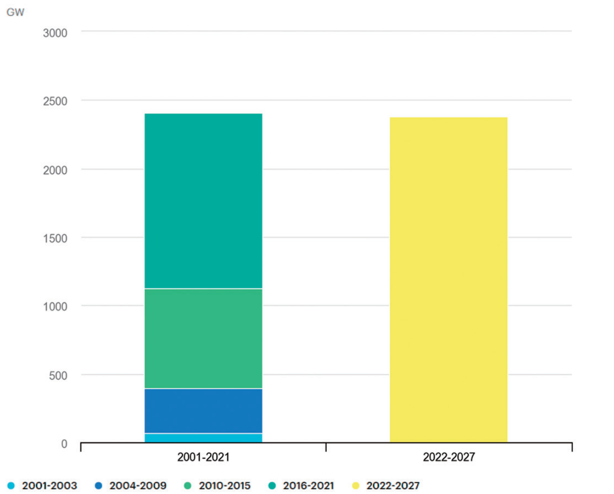

Figure 9: Use of Renewable Energy to Accelerate over 2021–2027[*4]

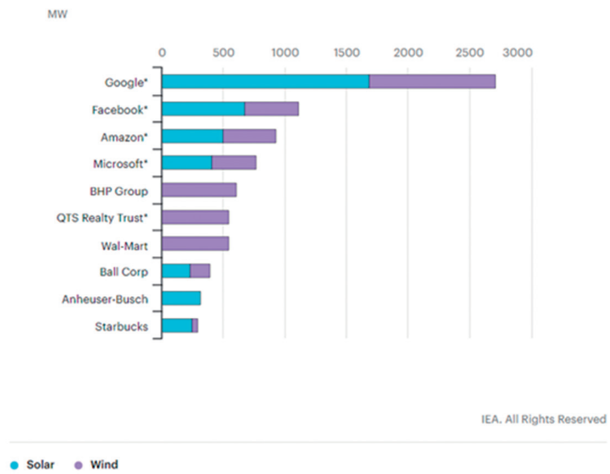

Figure 10: Top 10 PPA Procurers (2019)[*5]

*4 Source: IEA Renewables 2022 (https://www.iea.org/reports/renewables-2022/executive-summary).

*5 Source: IEA (https://www.iea.org/commentaries/data-centres-and-energy-from-global-headlines-to-local-headaches).

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companies to report on their usage of non-fossil fuel energy, so an increasing number of companies can be expected to put effort into adopting renewables.

Onsite solar power generation systems, depicted in Figure 11, are scheduled to go into operation at both Matsue DCP and Shiroi DCC during fiscal 2022, but one issue is that only a small amount of power (a few percent) relative to total data center usage can be generated from onsite systems. With the cost of generating renewable energy dropping every year, our next step will be to look at engaging in offsite corporate PPAs and ownership of power generation plants that deliver power through the grid.

2.4 Electricity Market Challenge 3: Creating New Markets for the Stable Supply of Electricity

■ Entry into New Markets, the Capacity Market

The Great East Japan Earthquake of 2011 marked a turning point, prompting reforms to the electric power system that have been underway in stages since 2015 with the objectives of ensuring a stable supply of electricity, curbing electricity charges, and expanding options for power consumers and business opportunities for operators. New markets have been created as shown in Figure 12.

The capacity market is one of those new markets. Electricity market liberalization and the decline in non-renewable power

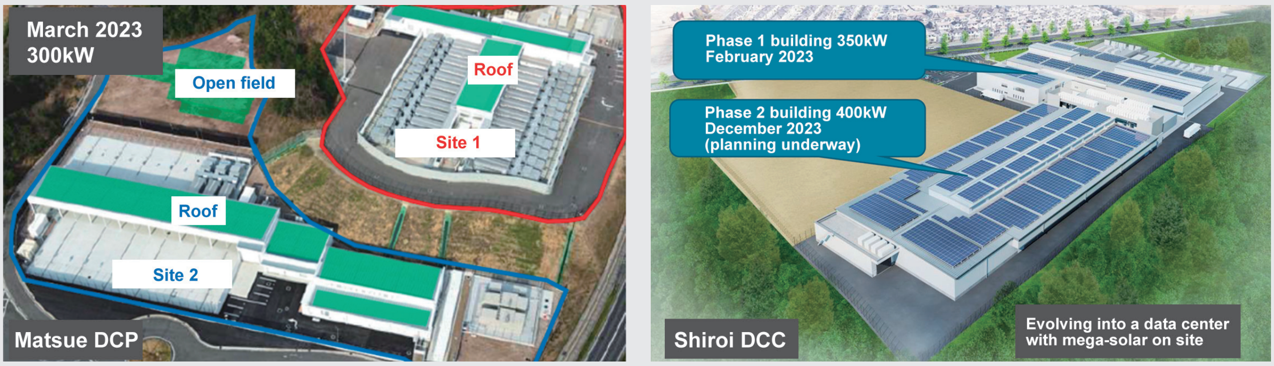

Figure 11: Installing Onsite Solar Power Facilities

Value (power source etc.)	Value (product) traded		Market
Electric energy (kWh value)	Actual electricity generated	→	Wholesale electricity market (spot, baseload market, etc.)
Supply capacity (kW value)	Generation capacity	→	Capacity market
Balancing capacity (△kW value)	Ability to balance supply/ demand in short term	→	Call for balancing capacity → Balancing market
Other (Environmental value)	Environmental value attached to electricity generated from non-fossil fuel power sources	→	Non-fossil fuel value market

Figure 12: New Trading Markets[*6]

*6 Source: Adapted by IIJ from the website of the Organization for Cross-regional Coordination of Transmission Operators, Japan (https://www.occto.or.jp/capacity-market/shikumi/capacity-market).

plant utilization and market prices owing to the growing use of renewable electricity bring about the risk of investments in new generation capacity not moving forward because the prospects of recouping those investments is less predictable. To reduce this risk and ensure electricity supply capacity is available into the future, the capacity market allows participants to trade in supply capacity (kW) instead of amount generated (kWh).

Participants in the capacity market trade in stable power supplies, variable power supplies, and demand-driven power supplies. Within the demand-driven category, from fiscal 2024 IIJ will be supplying electricity as part of a virtual power plant (VPP)[*7] aggregated by Kansai Electric Power Co. At Shiroi DCC, we will use the lithium-ion storage batteries, installed to smooth out summertime air-conditioner power consumption, to facilitate our demand response (DR)[*8], one means of controlling the electricity demand/supply balance for a VPP. We will use the batteries' surplus capacity as well as onsite solar power generation to respond to requests to reduce grid power consumption, thus receiving payments from the aggregator and reducing our data center operating costs (Figure 13).

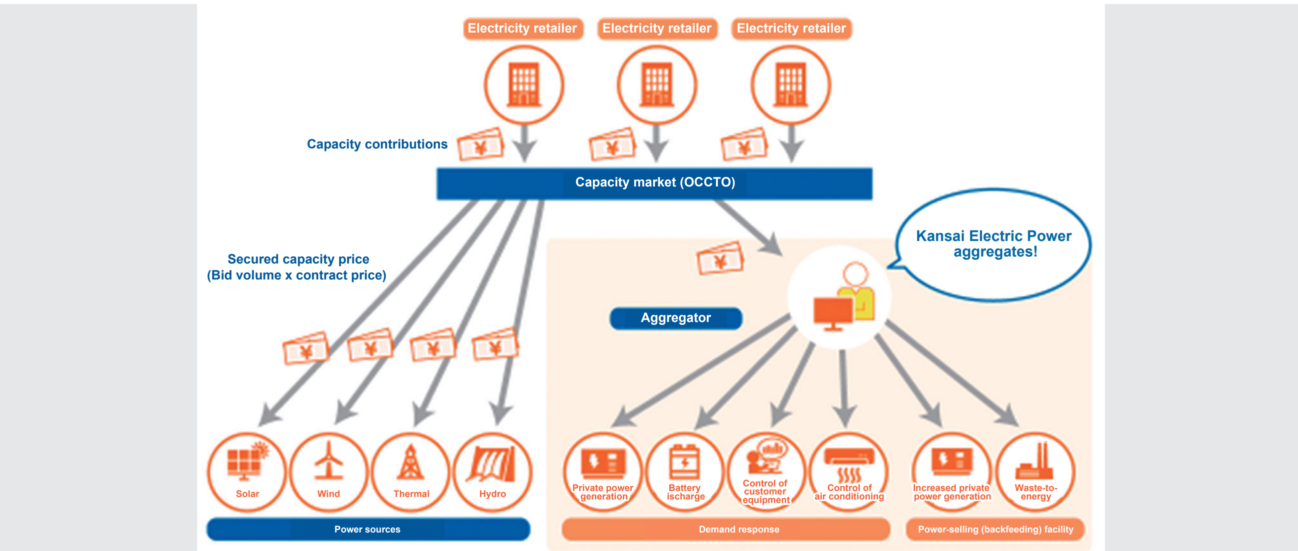

Figure 13: Participating in the Capacity Market[*9]

*7 VPP (virtual power plant): A collection of regionally dispersed power generation facilities—storage batteries owned by companies and local governments, small power generation facilities, and the like—controlled by an aggregator in an integrated manner so as to function like a single integrated power plant.

*8 DR (demand response): DR refers to controlling the electricity supply/demand balance by controlling the electricity usage of consumers through methods such as setting different electricity rates for different times of the day and paying consumers who refrain from using electricity during peak hours.

*9 Adapted by IIJ from the website of Kansai Electric Power (https://www.kepco.co.jp/energy_supply/energy/vpp/market.html).

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2.5 Conclusion

This article has discussed how we are addressing issues in the electricity market as a consumer of power in our data centers. In closing, I would like to explain what IIJ hopes to provide to data center users on the power supply front.

First is the ability to visualize power consumption. Going forward, data center users will likely be called on to save more energy than ever before. So users also need to know how much electricity they are using. We plan to move forward quickly with the development of a system that will provide detailed data on each customer's current power usage.

Secondly, we hope to provide renewable energy value. Efforts to achieve carbon neutrality will continue to advance, and in that context, we are looking at the prospect of building a platform that will enable us to provide the environmental value of renewables to our customers based on the ability to visualize data center users' renewable energy breakdown by type and as a percentage of total energy consumed.

As an operator of data centers that use large amounts of electricity, we will continue striving toward carbon neutrality as part of our social responsibility, and we hope to be able to continue reporting on the positive results of our efforts.

Isao Kubo
General Manager, Infrastructure Services Department, Infrastructure Engineering Division, IIJ.
Mr. Kubo joined IIJ in 2008. He oversees the data center business and the construction of Matsue DCP and Shiroi DCC. His aim is to achieve carbon neutrality as soon as possible.

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