DATA CENTERS & THE ENVIRONMENT

2019 REPORT ON THE STATE OF THE GREEN DATA CENTER

REPORT FINDS TYPICAL ENTERPRISE DATA CENTERS IN THE SURVEY CAN SAVE UP TO $38 MILLION AND OVER 350 TONS OF E-WASTE ANNUALLY

SUPERMICRO

DATA CENTERS & THE ENVIRONMENT REPORT

The data center industry has made significant gains in recent years in terms of performance, scale and value. These gains come with costs and environmental impacts. Supermicro's second annual report on the state of green data centers builds on the work from last year by identifying industry trends on the status and best practices for green data centers. The report researches the level of progress data center leaders are making toward green initiatives. According to the survey data, data center operators are making incremental improvements toward greener initiatives. However, there are still many missed opportunities around data center efficiencies. Respondents noted they are repurposing existing equipment as well as utilizing long refresh cycles. Unfortunately, older equipment is less efficient due to the inherent design technology of newer equipment. As a result, businesses adopting new technologies will be more competitive and potentially greener.

Green Data Centers: Reducing Costs While Helping the Environment

GREEN DATA CENTERS CAN REDUCE ENVIRONMENTAL IMPACT BY OVER 80% AND SAVE ENOUGH ENERGY TO KEEP THE LIGHTS ON IN LAS VEGAS FOR 37 YEARS, BUT ONLY 12% OF TODAY'S DATA CENTERS ARE GREEN

Green data centers are designed to minimize both energy use and environmental impact. They are architected to use less electric power, providing significant cost-savings (both CAPEX and OPEX) than data centers having standard or legacy designs. Green data centers also create less e-waste, contributing to a cleaner environment (Figure 1). Green data centers help businesses reduce costs while also doing good for society.

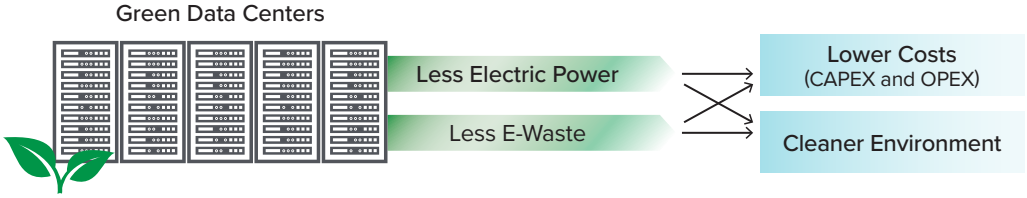


Figure 1: Advantages of Green Data Centers over Legacy Data Centers

This report details the status of green practices for data centers, involving improvements to efficiency and the reduction of e-waste, based on the responses of data center leaders to the second annual Supermicro Data Centers & the Environment survey. We encourage you to use the information in this report to guide you in creating a greener data center.

Green Data Centers—Average Responses and Impacts

The data center features have been averaged from the survey. These averaged features are:

- Power density per rack is 15 kW
- Server inlet temperature is 23.5°C (74.3°F)
- Server refresh cycle is 4.1 years

Features of an ideal green data center based on respondents with highly optimized designs. These data centers comprise 12% of the respondents, and are considered green data centers:[1]

- Power density per rack above 25 kW
- Server inlet temperature above 26.5°C (79.7°F)
- Server refresh cycle of 2–3 years

Savings of Ideal vs. Average Data Centers

Savings per year for green vs. average data centers, per respondent with an average of 68 data center racks worldwide:

- Power Effectiveness savings: $470K
- Refresh cycle savings: $900K and 12 tons of e-waste
- Total Cost to the Environment (TCE) savings: $1.4M and 12 tons of e-waste (Figure 2).

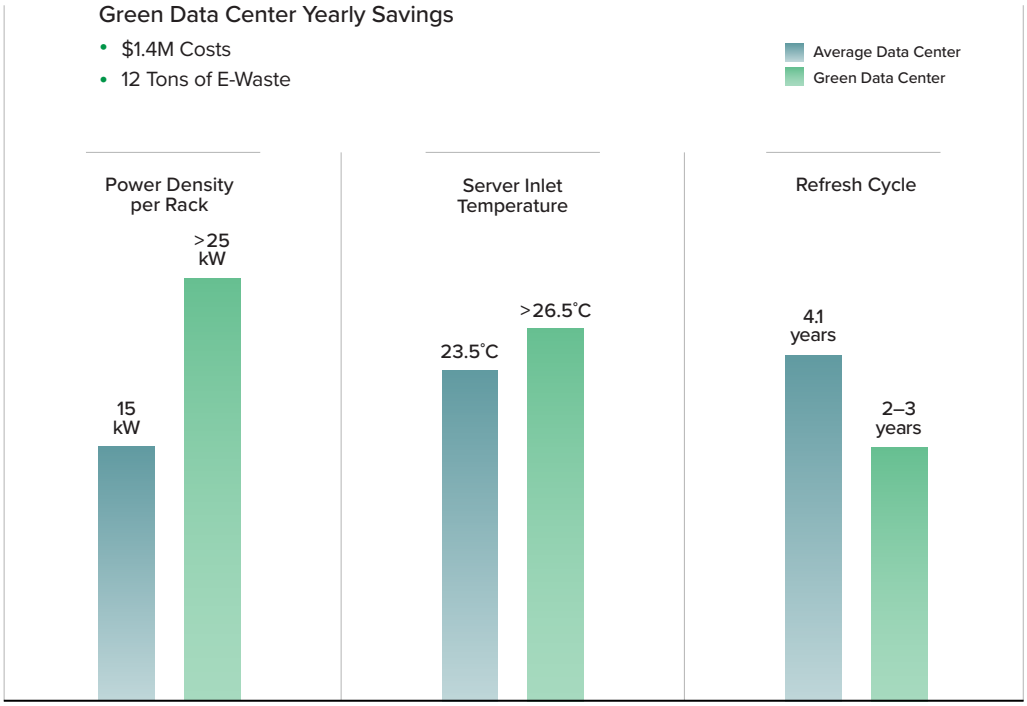


Figure 2: Savings of Green Vs. Average Data Centers

Respondent Demographics

The second annual Supermicro Data Centers & the Environment survey provides an overview of the major trends shaping IT infrastructure delivery and strategy. The survey was conducted via email in October 2019. It includes responses from 1,362 data center operators and IT practitioners globally across enterprises, service providers, and SMBs and represents a comprehensive cross section of key demographics including job function, data center geography, industry vertical and size.

The survey consists of 16 questions. 377 qualified respondants report both (1) internal data centers, and (2) direct involvement in data center selection and management at their organizations (Figure 3). The survey results are based on the responses of these 377 data center executives, IT managers, and technical facilities experts.

The respondents to the survey represent a comprehensive cross section of key demographics:

- About one-fifth of the participants represent enterprises (firms with over 1,000 employees), about one-fifth medium-sized businesses, with three-fifths of the respondents from small businesses that comprise the majority of the sample.
- A wide variety of verticals are represented in the survey, including 21% service providers (telecom, cloud, and colocation services), 22% manufacturing, and 15% education.
- Participant data centers representing a global sample are predominantly located in the Americas (79%), with significant data center presence in Europe/Africa (32%), and Asia (22%).
- 70% of respondents comprise C-level executives (27%) and engineers (43%) with the remaining 30% engaged in critical IT and facilities management functions.

Note: respondents were not required to answer all questions, and as a result the number of respondents for individual questions varies. Some questions allow for multiple answers and totals may not add to 100%. All data visuals are sourced from survey responses.

Job Function

Engineering	43%
C-Level	27%
Critical Facilities Management	13%
IT Management	11%
Other	6%

Business Size

Small Office	39%
Small Business	22%
Medium Business	13%
Large Business	5%
Very Large Business	21%

Verticals

Manufacturing	22%
Education	15%
Telecommunications	12%
Transportation/ Utilities/Energy	8%
Software or Cloud Services	7%
Retail/Wholesale/ Distribution	6%
Government	5%
Consulting/Professional Services	3%
Colocation or Multi-Tenant Data Centers	2%
Healthcare	2%
Financial	2%
Others	16%

Data Center Location

North America	71%
Europe	27%
Asia/Pacific	16%
South America	8%
Oceania	6%
Africa	5%

Figure 3: Respondent Demographics

Green Data Center Awareness

ONLY 50% OF DATA CENTERS CONSIDER ANY GREEN DATA CENTER METRICS AS KEY SUCCESS FACTORS FOR THEIR DATA CENTER

The Supermicro Data Centers & the Environment report identifies some of the key learnings and green practices that will help keep data center operators and IT experts in the forefront of this highly competitive and important industry. In the survey, data center leaders are asked a strategy question on how they measure the success of their data centers. A large percentage of the respondents report

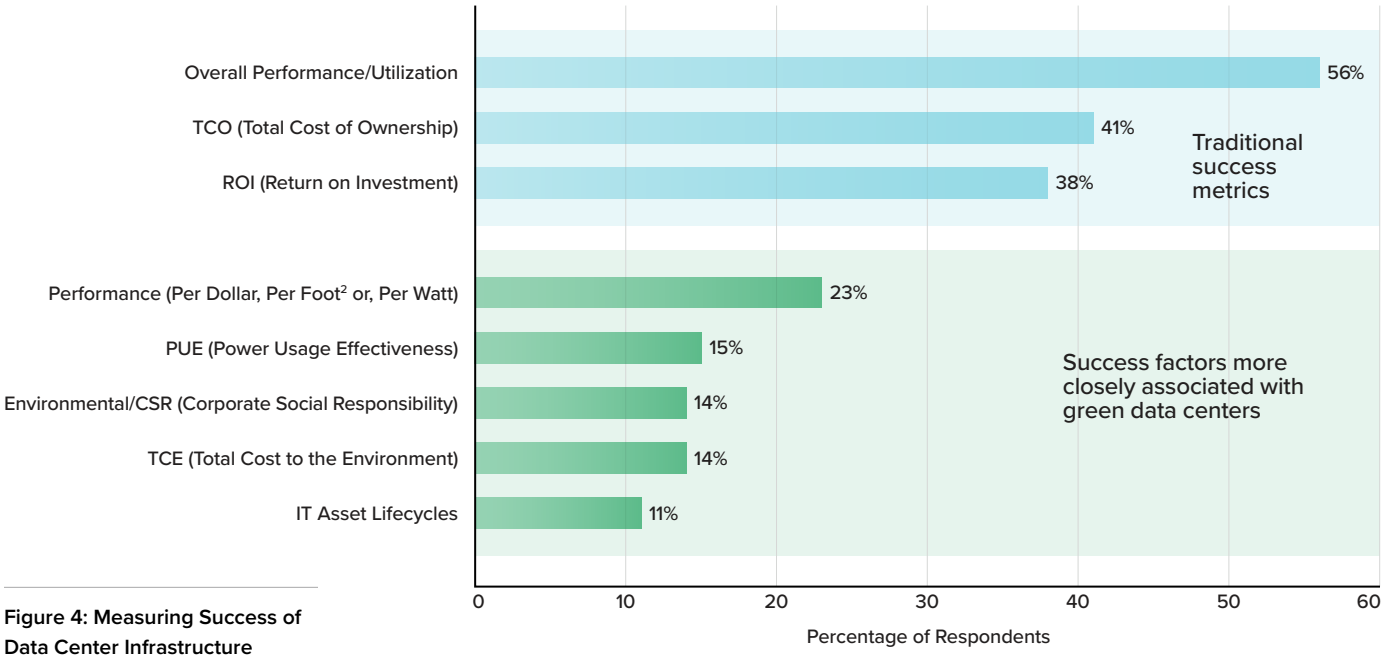


Figure 4: Measuring Success of Data Center Infrastructure

that overall data center performance, Total Cost of Ownership (TCO) and Return on Investment (ROI) are their primary measures of success (Figure 4).

Notably, these areas do not focus on reducing energy use and lowering environmental impact. The success factors more closely associated with green data centers such as Efficiency, Power Usage Efficiency (PUE), Information Technology (IT) Asset Lifecycles, and Corporate Social Responsibility (CSR) / Total Cost to the Environment (TCE) are mentioned as strategic success factors much less often.

> "San Jose-based Supermicro's global survey on green data centers reveals that most companies don't thoroughly consider power consumption and minimizing e-waste when choosing data center equipment. As a leading Silicon Valley company in innovation and sustainability, Supermicro has long championed green computing, and I invite the industry to learn more about its impacts and opportunities."
>
> *— Sam Liccardo, Mayor of the City of San José, Silicon Valley*

It is important to note that numerous companies and industry organizations are devoted to improving the state of the art of data center design and power utilization effectiveness. ASHRAE, IEEE, Energy Star, The Green Grid and Emerge Alliance are among those organizations continuously seeking to champion new ideas and new technologies leading to more energy efficient data centers. Data center industry leaders are encouraged to seek out these sources, as well as IT equipment and server system manufacturers, to learn the best green technologies and practices that can be achieved with ever-tightening budgets.

Green Data Center Awareness Best Practice: TCO and TCE

Total Cost of Ownership (TCO) is a well-known measure that assesses capital expenses as well as operational expenses (CAPEX plus OPEX). Data centers leaders often use this to gauge the success and effectiveness of their facility design.

However, TCO misses an important and impactful benefit that green data centers provide. The component missing from the TCO equation is the additional impact to the environment. The TCE, or Total Cost to the Environment includes many factors, such as power consumption and e-waste. Data center leaders should add TCE to their strategy as they measure data center success.

Green Data Center Power Effectiveness

ONLY 12% OF DATA CENTERS ARE DESIGNED FOR OPTIMAL POWER EFFECTIVENESS COSTING THE AVERAGE DATA CENTER APPROXIMATELY $500K PER YEAR

Green data centers are designed for power effectiveness to reduce operating costs. In addition to dollar savings, improved data center power effectiveness also contributes to reduced environmental impact and reduces TCE. The study looked at two ways to improve power effectiveness: increased rack power density and free-air cooling.

Data center power density delivers green power effectiveness by reducing the data center space required, which reduces costs, but importantly fits more servers into a smaller space. This requires the use of multinode and blade systems. These systems use shared power and cooling infrastructure (power supplies and fans) versus a single rackmount server with individual power supplies and fans. From recent studies[3,8,12] multinode systems are about 10% more efficient and blade systems in the range of 10–20% more efficient than rackmounts and deliver higher densities. Thus, increased rack power density leads to improved power efficiency and effectiveness.

A second green power effectiveness opportunity is free-air cooling. Data centers designed to run at higher temperatures can be cooled with outside air, and thus need less computer room air conditioner (CRAC) equipment for cooling. Currently, most data centers actively cool the hot air generated by servers due to legacy concerns about system reliability. Data center operators can reduce power usage by using outside air, or free-air cooling, and selecting modern systems that support higher thermals without impacting reliability or performance.

MULTINODE SERVERS

Supermicro BigTwin™ (2U 4 node server)

High-density multinode servers deliver massive computing power in minimal space to handle workloads like High Performance Computing (HPC), Artificial Intelligence (AI), cloud, grid, and analytics, while reducing costs, energy, and space requirements.

Multinode servers provide significant power and space savings compared to standard industry rackmount servers. They integrate two or more server nodes into a single equivalent 1U form factor, thus saving rack space.

Their main advantage for green data centers: saving power due to shared components including power supplies, fans, enclosures, and cabling.

- **Blade Servers:** optimized to use less space and energy, minimizing power consumption
- **Multinode Servers:** designed with two or more independent server nodes in a single enclosure; ideal for enclosures with limited space.
- **Hyperconverged Infrastructure (HCI) Servers:** combined storage, compute, and networking into a single system that decreases data center complexity and increases stability.

Multinode Servers with Shared Power and Cooling Improve Green Data Center Power Efficiency

Data center rack power density (Figure 5) is studied in this survey as a measure of green data center server consolidation and energy efficiency, with higher rack densities representing higher levels of server consolidation. Today, the average power consumption for a data center rack is approximately 7kW.[2] A majority of survey respondents (57%) report a data center power density of <10kW per rack (Figure 5). Separately, 17% of respondents report power densities >30kW per rack, a value few data centers considered until recently.

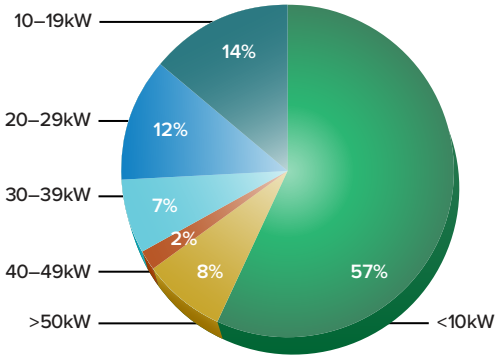


Figure 5: Data Center Power Capacity per Rack

To demonstrate the importance of green data center power efficiency improvement, the average power efficiency savings achieved by upgrading from 1U rackmount servers to 2U/4-Node multinode servers was determined for rack power density levels from Figure 5. The multinode servers were assumed to deliver 10% power savings.[3] The average yearly operating expense (OPEX) savings per rack ranged from $1,520 for the lower power density racks (< 10 kW) and up to $6,780 for the higher power density racks (40–49 kW). Over an average server refresh cycle of 2–3 years this accumulates to significant savings (Figure 6).

Power Capacity per Rack	OPEX Savings per Rack per Year with Multinode Servers
Less than 10kW	$1,520
10–19kW	$2,210
20–29kW	$3,370
30–39kW	$5,250
40–49kW	$6,780

Figure 6: Cost Savings with Multinode Servers

The trend with data center power density is clear—it is growing and will only get higher as more demand materializes.[2,4,5] Supermicro believes the trend toward higher green data center rack densities is likely to continue.

Server Free-Air Cooling Enhances Green Data Center Power Efficiency

An effective way to increase data center temperatures is to utilize servers that support free-air cooling. The Supermicro survey results indicate that many data centers are employing this design technique.

Data center server inlet temperatures are studied in this survey as a measure of green data center free-air cooling (Figure 7) as a means of reducing PUE and increasing green power efficiency. Today, the average data center temperature is between 23°C–24°C depending on the facility.[6] Consistent with this finding, more than half of survey respondents (51%) report data center temperatures between 21°C–24°C (Figure 7).

"Although our data center industry is focused on efficiency and sustainability, we must and can do more. It is the only way forward. Every step counts, including economizing power consumption, minimizing e-waste and reducing environmental impact in order to support a fully green and efficient data center industry. This report is an informative advancement in this direction."

— Stijn Grove, Managing Direct, Dutch Datacenter Association

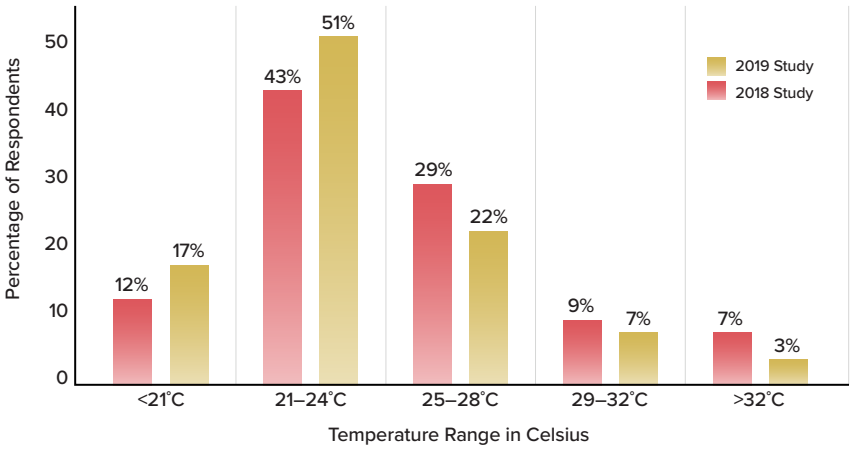


Figure 7: Data Center Ambient Inlet Temperatures

Ambient Inlet Temperature	OPEX Savings per Rack per Year with Temperature-Optimized Servers
21C–24C	–
25C–28C	$6,314
29C–32C	$12,628
>32C	$14,996

Figure 8: Cost Savings with Temperature-Optimized Servers

However, nearly one-third of survey respondents (32%) report data center inlet temperatures above 25°C, with some (10%) ranging over 29°C. The trend with data center temperature is clear—it is increasing and will only get higher. Supermicro believes the trend toward higher green data center temperatures is likely to continue.

Green data center energy savings from free-air cooling can be significant, from 4% to 5% for every 1°F (0.56°C) increase in server inlet temperatures.[6] The average energy savings achieved by upgrading to servers optimized for free-air cooling was calculated for the data center ambient inlet temperatures from Figure 7. The servers were assumed to deliver 4% power savings per 1°F increase for 15 kW racks (the average power density from the survey). Savings were calculated from the inlet temperature range of 21°C–24°C. The average yearly OPEX savings per rack ranged from $6,314 for a relatively small data center inlet temperature increase up to $14,996 for the largest inlet temperature increase (Figure 8).

Green Data Center Optimized System Refresh Cycles

ONLY 37% OF DATA CENTERS HAVE OPTIMIZED REFRESH CYCLES TO TAKE ADVANTAGE OF THE LATEST TECHNOLOGIES; AND TO REDUCE COSTS AND E-WASTE

From the survey, today the average server refresh cycle stands at 4.1 years, with fully 63% of survey respondents mentioning that they refresh their hardware every four years or longer (Figure 9). This refresh cycle is getting longer, not shorter. However, server technologies update at much faster rates—for example, x86 processors update on a two to two-and-a-half year cadence.[7] Keeping servers longer appears to reduce acquisition costs and e-waste, but new servers are more efficient and provide more compute cores and better performance. So acquisition cost savings are quickly consumed by higher operating costs which include the power and cooling, higher software licensing costs of less efficient and lower performance servers. Data centers need the latest technologies to be efficient, and for their companies to be competitive, yet most are skipping the features and benefits of one or two server generations. For companies in competitive industries this problem must appear impossible to solve and simply intolerable.

Disaggregated Servers

One solution is disaggregated servers. By utilizing the disaggregated server architecture, data centers can refresh faster, improve performance, lower energy use, and also reduce capital and e-waste. Disaggregated servers give data centers the ability to spend less time and money on refreshing servers so that they can afford to refresh faster, and thus take advantage of the latest technologies. 63% of survey respondents mentioned that they refresh their hardware every four years or longer (Figure 9). By using disaggregated servers, data centers can refresh faster, improve performance, lower energy use, and also reduce CAPEX and e-waste.

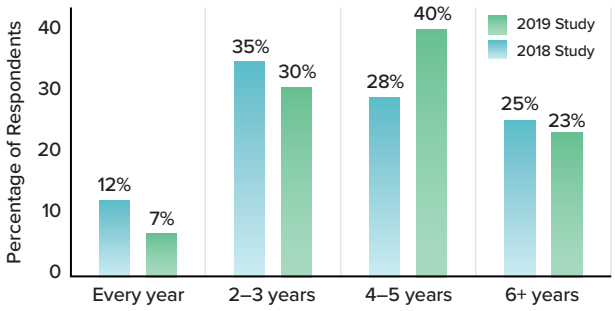


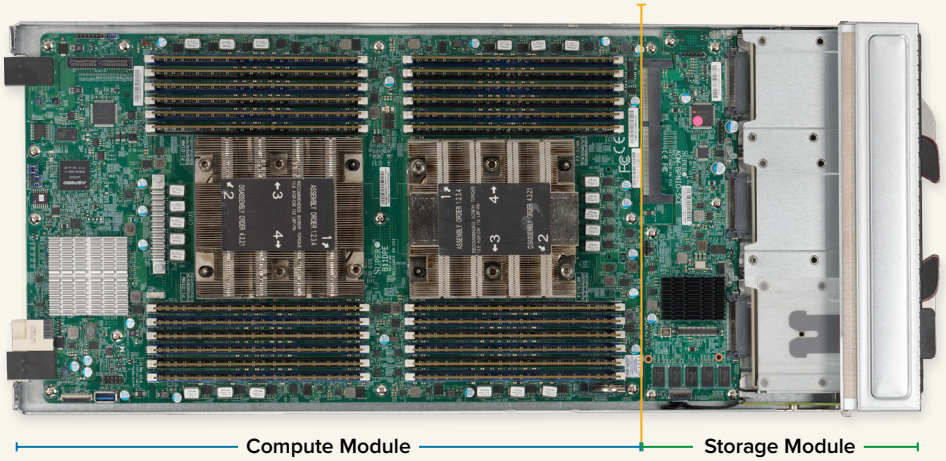
Figure 9: Frequency of Data Center System Refresh/ Replacement

In the past, in order to take optimal advantage of server technology improvements, data centers had to replace the entire server—even though many of the components (chassis, cables, power supplies, network switches, fans, management and I/O) still had many years of useful life remaining. This server design approach results in a significant waste. This basic data center design limitation inspired the innovative functionality of the disaggregated server.

DISAGGREGATED SERVERS

The 6U SuperBlade utilizes a disaggregated architecture that enables the independent upgrades of system components. Each blade is composed of a storage module and a separable compute module with CPU and memory that can be refreshed at faster rates than the rest of the system.

Supermicro 6U Disaggregated SuperBlade®



The disaggregated design is simple: separate the CPU/DRAM module and the NIC/Drives module on the motherboard. Redesigning the server to be modular enables data centers to upgrade the CPU/DRAM module while retaining the other components that are not ready for end-of-life. Replacing the CPU/DRAM modules can cut refresh capital costs by at least 44%.[8] Less spending on refresh means that data centers can refresh more often, not less. And having the latest generation processors and memory, with yearly performance and efficiency improvements of at least 15%, means data centers can keep pace with corporate compute demands and meet other company goals. For an average data center, CAPEX savings could equal $900K per year.

"The 2019 survey findings establish again that consideration of the environmental impact for data center equipment selection continues to be an IT industry challenge. We are continuing our focus on Resource-Saving Architecture to help end-customers save both energy and hardware acquisition costs while reducing the environmental impact."

—Charles Liang, President and CEO of Supermicro

In addition to the TCO benefits of 44% lower refresh cost over a full acquisition (rip-and-replace) refresh, reduced provision time of 77%, and reduced shipping costs, disaggregated servers have total cost to the environment (TCE) benefits of 82% reduction in material shipping weight and significantly reduced e-waste.

Optimal Refresh Cycle

The optimal data center refresh rate (Figure 10) depends on the trade-off between reducing CAPEX and e-waste through long refresh cycles to keep purchased equipment longer, balanced with reducing OPEX by refreshing equipment more rapidly to obtain the latest high-efficiency technologies. The effect of disaggregated servers on this trade-off is to reduce CAPEX and thus accelerate the optimum refresh rate, i.e., to refresh more quickly. This optimizes OPEX and e-waste as well.

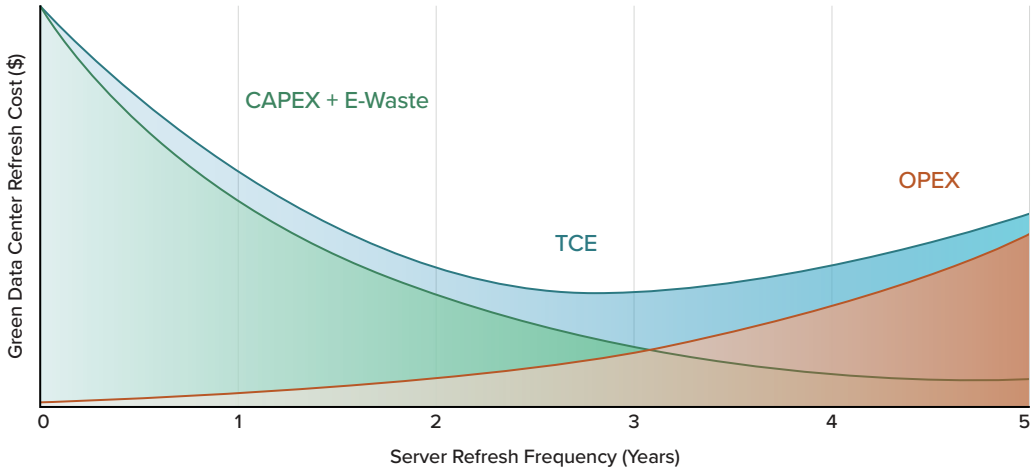


Figure 10: Green Data Center TCE

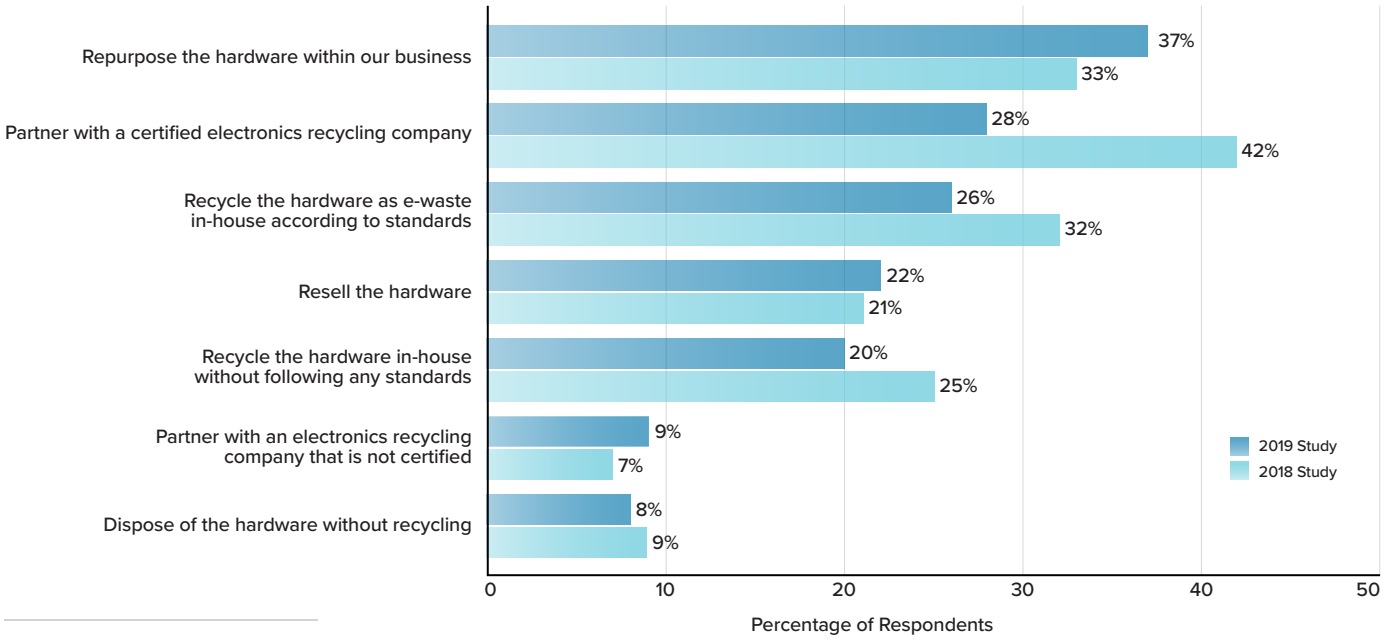


Figure 11: Decommissioning Outdated Server Hardware

E-Waste

Whatever systems and practices green data centers choose to improve efficiency and capital expenses, they must still contend with the problem of e-waste electronic products nearing or at the end of their useful lives.

Survey respondents were asked how their companies handle outdated data center server hardware when it is decommissioned. More than one-third (37%) reported repurposing their hardware to other tasks (Figure 11), indicating a trend toward product life cycle extension, but the number of less-demanding tasks available for repurposed hardware is limited and the lifetimes of repurposed equipment in those less-demanding tasks is still short.

THE E-WASTE PROBLEM

E-waste is a significant global problem. Latest estimates show that the world now discards approximately 50 million tons of e-waste per year, greater in weight than all of the commercial airliners ever made or enough Eiffel Towers to fill Manhattan.[9] *The Wall Street Journal* reports that data centers may account for 2 million tons of this e-waste each year.[10]

The EPA reported that although e-waste represents only a small 2% of U.S. solid waste, it accounts for a very high percentage (70%) of hazardous waste.[11] Yet only 20% is formally recycled. This makes it all the more important for data centers to adopt formal decommissioning and recycling programs to minimize the impact of e-waste to the environment.

Important Finding: Change in Data Center Delivery Model

The large, privately-owned enterprise data center facility remains the foundation of corporate IT, with half of respondents (50%) reporting that they operate their own data centers (Figure 12). Some firms have gone in the opposite direction and have either replaced most of their computing infrastructure with public cloud, managed services, or colocation models (24%). Still others are taking a middle route, increasingly opting for a mix of infrastructure types: running some services in the cloud, some in colocation and managed services facilities, and keeping some on-premises (26%).

Compared to the 2018 survey, this year's survey indicates that many companies are, perhaps counter-intuitively, moving to the first, in-source model (owner owned and operated) at the expense of outsourced and hybrid solutions. This trend bears examination in future surveys.

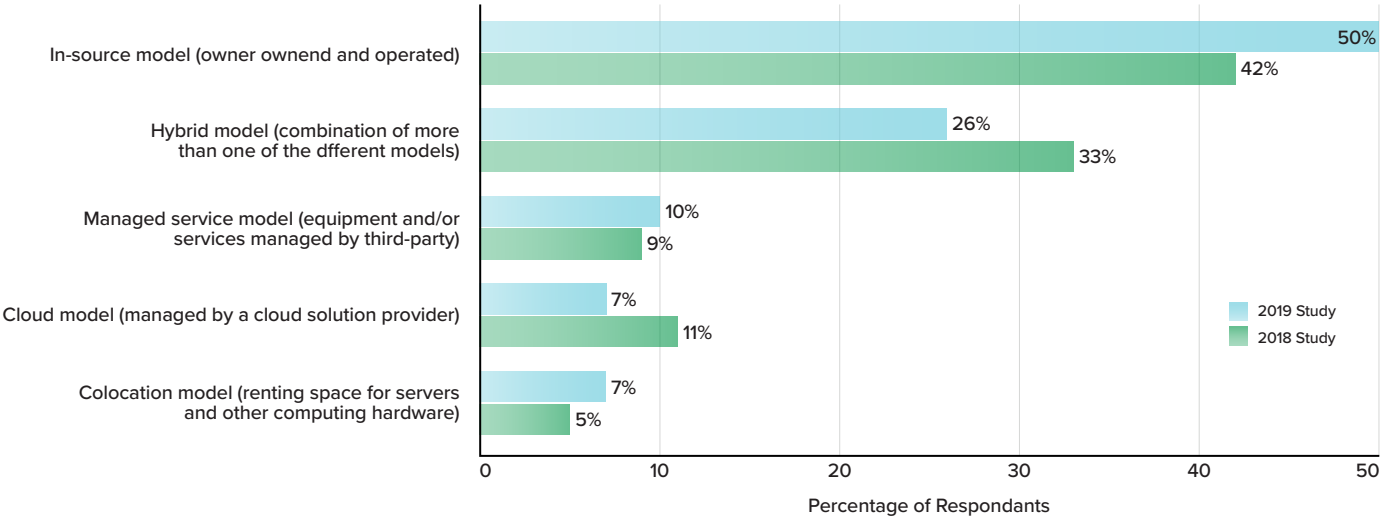


Figure 12: Data Center Delivery Model

Conclusion

With a focus on innovative technology advancements for green data centers and Total Cost to the Environment (TCE) as a metric, Supermicro has prepared this Data Centers & the Environment 2019 report that presents the status of data centers worldwide today. It is clear from the responses outlined in this report, that there are opportunities for the industry to significantly reduce environmental impact of data centers while also achieving compelling cost savings.

ENDNOTES

(1) Michael Galarnyk, "Explaining the 68-95-99.7 rule for a Normal Distribution," *Towardsdatascirence.com,* June 3, 2018, https://towardsdatascience.com/understanding-the-68-95-99-7-rule-for-a-normal-distribution-b7b7cbf760c2

(2) Bob West, "Understanding the Interplay Between Data Center Power Consumption/Data Center Energy Consumption and Power Density," Datacenters.com, August 29, 2018, *https://www.datacenters.com/news/understanding-the-interplay-between-data-center-power-consumption-data-center-en#targetText=Today%2C%20the%20average%20power%20consumption,or%20more%20kW%20per%20rack*

(3) Patrick Kennedy, "Supermicro BigTwin NVMe Review: The 2U 4-node NVMe chassis you have been waiting for," Servethehome.com, February 13, 2017, *https://www.servethehome.com/supermicro-bigtwin-nvme-2u-4-node-nvme-chassis/*

(4) Yevgeniy Sverdlik, "Data Center Power and Cooling Trends to Watch in 2019," Datacenterknowledge.com, January 9, 2019, *https://www.datacenterknowledge.com/power-and-cooling/data-center-power-and-cooling-trends-watch-2019*

(5) Jim Witham, "Top 2019 Trends Impacting the World's Escalating Demand for Data and Power", Datacenterfrontier.com, February 14, 2019, *https://datacenterfrontier.com/top-2019-data-and-power-trends/*

(6) "Server Inlet Temperature and Humidity Adjustments," Energystar.gov, n.d., *https://www.energystar.gov/products/low_carbon_it_campaign/12_ways_save_energy_data_center/server_inlet_temperature_humidity_adjustments#targetText=Data%20centers%20can%20save%204,increase%20in%20server%20inlet%20temperature.&targetText=A%20CIO%20magazine%20article%20claims,in%20an%20ultrasonic%20humidification%20unit.*

(7) Arne Verheyde, "Intel Vies to 'Recapture Process Leadership' as it Returns to Two-Year Cadence," Tomshardware.com, October 26, 2019, *https://www.tomshardware.com/news/intel-10nm-7nm-process-leadership-xe-graphics-gpu-dg1*

(8) "Data Center Strategy Leading Intel's Business Transformation," Intel.com, August 2019, *https://www.intel.com/content/dam/www/public/us/en/documents/white-papers/data-center-strategy-paper.pdf*

(9) "Global E-waste Statistics Partnership Launches Web Portal to Help Address Global E-waste Challenge," Unu.edu, June 4, 2019, https://unu.edu/media-relations/releases/global-ewaste-statistics-partnership-launches-web-portal.html

(10) Rhiannon Hoyle, "Cloud Computing Is Here. Cloud Recycling Is Next," Wsj.com, July 29, 2019, *https://www.wsj.com/articles/scrap-metal-market-targets-the-cloud-as-its-next-recycling-project-11564401605*

(11) Rick Leblanc, "E-Waste Recycling Facts and Figures," Thebalancesmb.com, October 15, 2019, *https://www.thebalancesmb.com/e-waste-recycling-facts-and-figures-2878189*

(12) "Achieving Exceptional TCO Savings with 8U SuperBlade," Supermicro.com, June 2018, *https://www.supermicro.com/white_paper/white_paper_SuperBlade.pdf*

About Super Micro Computer, Inc.

Supermicro (SMCI), the leading innovator in high-performance, high-efficiency server technology is a premier provider of advanced server Building Block Solutions® for Data Center, Cloud Computing, Enterprise IT, Hadoop/Big Data, HPC and Embedded Systems worldwide. Supermicro is committed to protecting the environment through its "We Keep IT Green®" initiative and provides customers with the most energy-efficient, environmentally-friendly solutions available on the market.

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