Microsoft

Four pillars of a successful circular datacenter hardware program

Introduction

With millions of servers in hundreds of Microsoft datacenters around the world, reducing electronic waste, or e-waste, is a critical focus. In 2020, as part of our goal to become zero waste by 2030, we set a target of reusing or recycling 90% of our decommissioned cloud hardware by 2025.

We met that goal a year early in 2024, and Microsoft Circular Centers were a key part of that success. These centers are dedicated areas within Microsoft datacenter campuses where decommissioned servers and cloud hardware are routed and processed for reuse or recycling. Starting in 2020 with a single facility, the program has expanded to include Circular Centers in North America, Europe, and Asia. This expansion is part of building a well-structured circular supply chain that has enabled our success in using resources efficiently, saving costs, helping ensure security of our cloud, and advancing progress toward our sustainability goals. For example, we have successfully reused over 3.2 million components through internal and external channels in FY24, recognizing a 30% increase or more in value recovery through our Circular Center program.

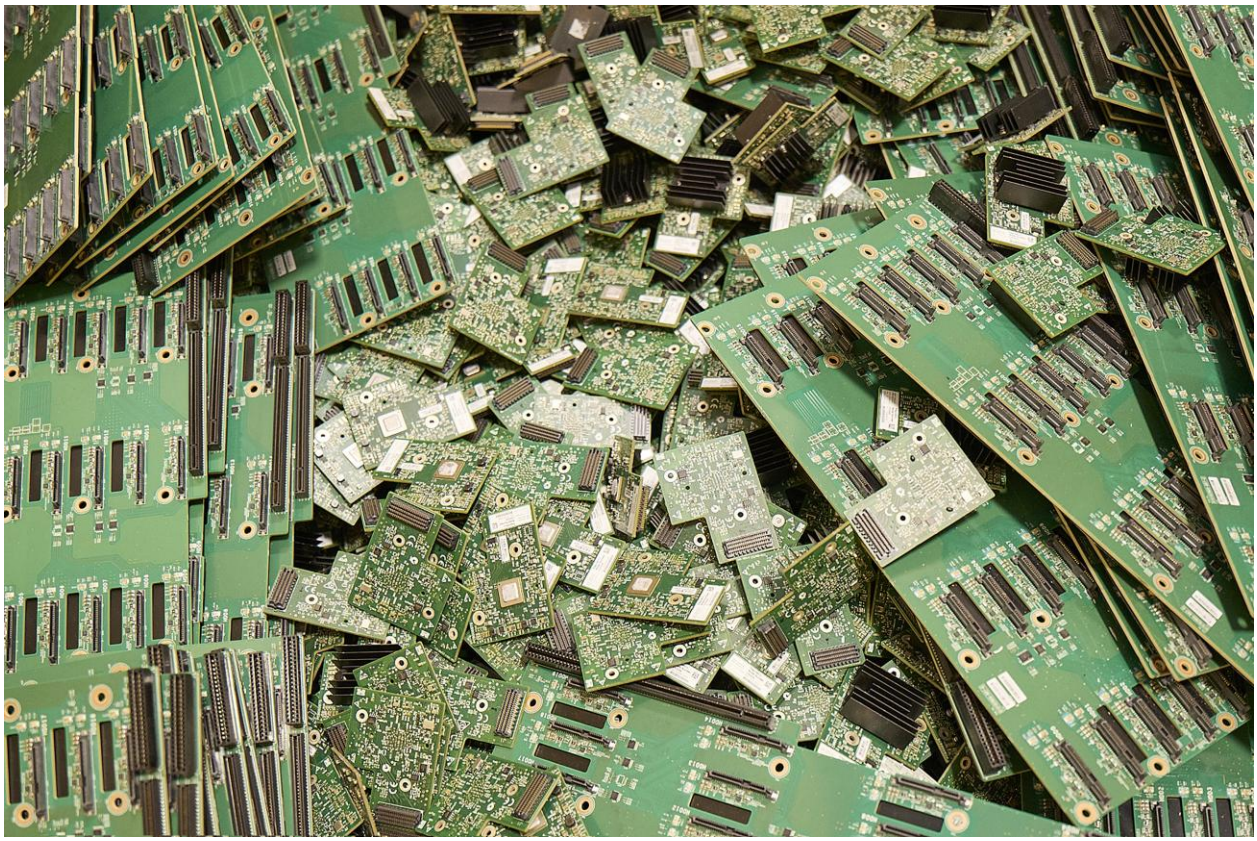
Drawing on the learnings and best practices of Microsoft Circular Centers, this white paper provides actionable insights and practical guidance for organizations looking to establish or enhance their own circularity programs.

We outline four key pillars of an effective circularity program:

- **Engage the ecosystem.** Collaborate with suppliers and third parties to develop channels and processes for material and component reuse, as well as maximizing recycling efficiency.
- **Automate operations.** Establish efficient reverse logistics processes based on your program objectives, and implement agile, scalable systems that automate operations.
- **Prioritize internal reuse.** Identify components that can be reused within the organization to help reduce external procurement costs, the Scope 3 emissions attached, and lead times.
- **Measure and report.** Prioritize accurate tracking and transparent reporting of reuse and recycle metrics to gain insight into specific opportunities for improvement and to achieve compliance.

By focusing on these aspects from the earliest planning stages of a circular program, these pillars can help lay the groundwork for a successful and scalable approach.

Engage the ecosystem



Microsoft Circular Centers work with both original equipment manufacturers (OEMs) of our hardware as well as information technology asset disposition (ITAD) companies that recycle e-waste. In addition to harvesting parts for our own internal reuse, some components are sold to these third-party entities to be reused, refurbished, or recycled.

Building a successful circularity program requires collaboration with suppliers and third-party service providers for material recovery, component reuse, and recycling efficiency. To build this ecosystem, we focus on the following:

1. **Identifying the right collaborators.** It's important to work with companies whose business strategy and capabilities align with the goals and objectives of your circularity program. For example, one key consideration for Microsoft Circular Centers is working with OEMs and ITADS that operate globally, at high volumes, and have expertise and experience with reuse and recycling.

   Another critical factor is working with companies that have existing closed-loop systems or take-back programs that comply with local, national, and

international regulations. And finally, the companies should be able to provide detailed tracking of materials, performance data, and impact – and integrate with your existing enterprise resource planning (ERP), supply chain, and sustainability dashboards.

2. **Choosing components for harvesting.** Focus on harvesting components that are available at high volume, and work with the ecosystem to determine which have high demand and a strong monetary value. This ensures that the effort to harvest these components is justified by their financial return.

   Logistically, the component should be easy to locate and easy to remove by technicians. Each additional step required for removal can affect whether the resale value outweighs the time spent on harvesting. If certain components are valuable but difficult to remove, it may be more practical to sell the entire asset instead.

3. **Selling components for reuse.** Some contracts with OEMs stipulate that certain components cannot be resold. For example, there are specific parts Microsoft cannot sell until their warranty support expires. In this case, the material can be held for resale later or be recycled instead of sold for reuse.

   To facilitate resale, Microsoft created the Circularity Hub, a platform designed to streamline the resale of harvested components with ITADs. The Circularity Hub allows ITAD customers to browse and bid on available inventory. Qualified customers are onboarded to the platform and once components are harvested, they are listed on the Circularity Hub and customers are notified. Customers can upload their bids, and the highest bidder is awarded the supply. The platform and process help us create better matches between components and buyers.

Strategically aligning with third-party collaborators helps maximize reuse potential and ensure that valuable components are effectively repurposed.

Automate operations

A critical factor in establishing a successful circularity program is prioritizing the scalability of underlying processes and systems.

With millions of servers in more than 300 Microsoft datacenters around the world, Microsoft needs a streamlined and scalable way to process, sort, and route decommissioned servers, including tracking components, shipping, receiving, testing, packing, and storage. When we first piloted our Circular Center in Amsterdam in 2020, our vision included building a global circularity network. To achieve that vision, we needed an agile and flexible supply chain management application and an automated, scalable system for routing components.

We chose Microsoft Dynamics 365 Supply Chain Management and Microsoft Power Platform to facilitate the process of reuse and recycling and give us visibility into the data necessary to manage the process. We also developed an end-to-end planning system, the Intelligent Disposition and Routing System (IDARS). IDARS creates and executes an optimal plan for hardware components, helping us to define sustainable paths for components as they progress through their lifecycle across the supply

chain, from upstream suppliers to downstream options for circularity. IDARS also aligns disposal with security and privacy requirements to provide Circular Center operators precise instructions on how to dispose of the asset and keep the Microsoft Cloud and customer data protected.

Sustainability is an important consideration from the earliest stages of the Azure hardware design process — including energy efficiency, repairability, upgradability, durability, and an optimized disposition plan for components.

For companies designing a circular hardware program, a central factor is creating processes and choosing systems that can scale to meet long-term goals. Critical considerations include:

- **End-to-end product and material traceability** Implement technologies that identify and monitor products and components throughout their lifecycle, ensuring data is shared effectively with ecosystem partners.
- **Efficient collection, sorting, and reverse logistics.** Develop strategies for the physical collection, transportation, and management of products and components to optimize efficiency.
- **Design for resource optimization.** Focus on product designs that facilitate easy disassembly and repairability, while prioritizing the use of recyclable or reusable materials in product development.
- **Ecosystem partnerships.** Ensure processes and systems are automated and scalable to ensure long-term viability with suppliers, customers, and partners.

Prioritize internal reuse

One of the potential benefits of a circularity program is that it can provide its own organization with a steady source of spare components and parts. Growing reuse internally can increase resilience by lowering dependence on external suppliers, decreasing costs, and reducing the Scope 3 emissions inherent in manufacturing new components.

At Microsoft, many of the servers sent to our Circular Centers are harvested for parts, some of which are recertified and used to repair servers currently active in the datacenters.

In addition to extending the life span of each component, this process also reduces the need to purchase new parts – which in turn results in shorter lead times, cost savings, and carbon reductions. It provides a reliable supply of critical components, which is particularly important for those parts not readily available in the market.

A successful internal reuse program includes three key facets:

1. **Identifying candidates for reuse.** A good component candidate must be easily swapped in or out for repairs. This involves looking at how the part is

installed, including both the mechanism and any bonding agents used to secure it. For example, a good candidate for reuse can be replaced by hand or with commonly available tools, without destroying any surrounding enclosures in the server. Non-ideal candidates for reuse would include parts welded or glued into place, as removal could inflict damage to the surrounding hardware and the component itself.

A circularity strategy begins in the design phase. In 2022, Microsoft created Ecodesign requirements to enable greater reuse potential, ensuring hardware is designed to be repaired, harvested for parts, and recycled efficiently when decommissioned. Microsoft's Ecodesign requirements provide guidance on designing products for repairability, reuse, and recycling. Key components such as data storage devices, memory, processors, and motherboards must be easily disassembled for repair or reuse using common tools. Additionally, plastic parts over 25 grams must be clearly marked with material type and be separable by hand or with commonly available tools to facilitate recycling. The product must also be designed to achieve a minimum recyclability rate of 70% by weight.

2. **Understanding the lifecycle of the hardware.** Aligning the availability of parts harvested to the demand for those parts in current products is critical. At Microsoft, our hardware design engineers work to maximize technological advancement while still looking for opportunities to increase future reuse throughout the server fleet. We also target components with high demand and limited supply alternatives, beginning with parts no longer available in the market.

   Once a reliable internal reuse supply chain is established, the scope of components harvested can continue to expand and adapt based on a company's needs.

3. **Measuring program outcomes.** The availability of metrics to measure the success of an internal reuse program can promote adoption of internal reuse. By monitoring and reporting data on critical measures such as component quality and program efficacy, a circularity program can show the value and usability of reused components with key stakeholders, dispelling the misconception these components are lower quality than brand-new parts.

   At Microsoft, harvested components undergo tests that hold them to the same quality and functional standards as a new part. Quality, trust, and transparency can be fostered further by showcasing component quality profiles in an internal company catalogue or portal. Once a component is recertified and reinstalled, the efficacy and impact should be tracked, such as what the spare parts helped to create, refurbish, or repair. For example, one metric that Microsoft measures is servers that were repaired using harvested parts.

Reporting and measuring

Monitoring the progress of a circularity program requires a structured, data-driven approach that aligns metrics with their objectives and timeline. Accurate tracking and transparent reporting provide insight that can be used to make tangible changes to processes, explore alternative approaches, and help achieve compliance.

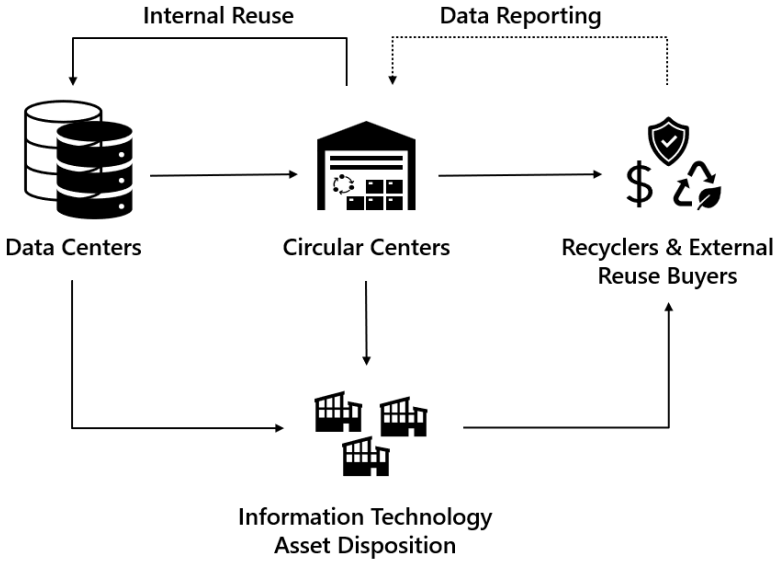
This section focuses on the calculation for reuse and recycle, which can feed into other sustainability key performance indicators such as program cost savings and carbon reduction. Microsoft Circular Centers use a methodology based on the weight of material disposed. This calculation uses kilograms of material reused and material recycled as well as a factor of recycling efficiency that accounts for material recovery after losses in the recycling process (see Figure 1).

Figure 1: Calculation for Reuse and Recycle percentage based on material weight.

$$Reuse\ and\ Recycle = \frac{Reuse\ (kg) + (Recycle\ (kg) \times Recycling\ Efficiency\ \%)}{Total\ Material\ Disposed\ (kg)}$$

The data used for this metric is reported by our downstream vendors (see Figure 2). OEMs and ITADs are required to document how our material is disposed in every batch of material sold from the datacenter or Circular Center. If reused, 100% of the material's weight is counted towards reuse. If recycled, it is multiplied by its respective recycling efficiency factor.

Figure 2: Asset disposition flow chart with data reporting from ITADs.



This data collection system integrates anomaly detection. It flags any outliers for review by the operational team, which also collaborates with downstream reporting vendors to reconcile supplier data and ensure accurate records of material handling, data consistency, and compliance.

Conclusion

Establishing a circular datacenter hardware program provides a practical approach to help meet compliance and security needs, increase cost savings, and reduce environmental impact.

At Microsoft, we believe in setting ambitious goals, using robust metrics, and collaborating with our ecosystem to drive significant advancements. In this paper, we explored the best practices leveraged by Microsoft Circular Centers to enable reaching the goal of a 90% reuse and recycle rate for decommissioned cloud hardware a year early.

This paper shares the learnings and best practices from Microsoft Circular Centers. We continue to invest in expanding our circularity efforts and pilot new innovations that help us optimize reuse and recycling. Read our innovating for zero waste blog for more details.

See more of our Microsoft datacenter sustainability initiatives here.