CISCO'S CIRCULAR ECONOMY JOURNEY AND EMBEDDING CIRCULARITY INTO PRODUCT DESIGN

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Abstract

Cisco is the worldwide leader in technology that powers the internet. They have committed to an ambitious corporate environmental sustainability strategy titled "The Plan for Possible," aiming to help build a regenerative future through clean energy, circular economy, and resilient ecosystems. The paper outlines Cisco's journey from a linear consumption model towards a circular one, which is integral to reaching their goal of net-zero greenhouse gas emissions across their value chain by 2040. Central to the circular economy strategy is embedding circularity into product design. At Cisco, this starts with 25 Circular Design Principles categorized into 5 focus areas: Material Use; Standardization and Modularization; Packaging and Accessories; Smart Energy Consumption; and Disassembly, Repair, and Reuse. Since its fiscal year (FY) 2019, Cisco has been integrating these principles into its products, with the goal of incorporating them into 100% of new products and packaging by fiscal year 2025. To meet this goal, Cisco has developed and scaled an operating system to develop processes and tools, align business strategies, and empower their people. This resulted in a large-scale transformation to how Cisco approaches product development, including the establishment of a circular design governance model, cross-functional engagement structures, and a web-based evaluation tool to assess compliance. As of fiscal year 2023, 27% of Cisco's new products and packaging align with the Circular Design Principles. With robust governance and tracking systems in place, Cisco is making progress toward its circular design objectives and has set up a circularity infrastructure that can continue to adapt to future product and packaging design needs.

Introduction and Motivation

Cisco's Approach to a Circular Economy

Cisco is the worldwide leader in technology that powers the Internet. Our products and services include networking, collaboration solutions, security solutions, wireless and mobility, data center, Internet of Things (IoT), video, analytics, and software solutions. We believe that running a great business shouldn't be at odds with caring for and contributing to the communities where a company operates. That is why in 2023, Cisco unveiled our next-generational environmental sustainability strategy, The Plan for Possible (Cisco, 2023)[1]. This plan seeks to help connect a regenerative future by transitioning to clean energy, transforming to a circular model, and fostering resilient ecosystems. Circular Transformation is one of the key priorities in our plan, which focuses on how we can evolve to a circular and regenerative economy. We are doing this by taking a holistic approach to how we design, build, deliver, and take back and reuse products to minimize waste streams, optimize material use, and extend the useful life of our hardware products.

The Opportunity Ahead

Moving from a linear consumption model, where products are manufactured, used, and discarded, to a circular model, is a major paradigm shift. It challenges long-held beliefs about the true value of natural resources and the lasting legacy of waste streams. It accounts for the environment as a stakeholder, a notion largely omitted from the current economic model. We have a goal to reach net zero greenhouse gas emissions across our value chain by 2040, so evolving to a circular business model has been and remains a key piece in the larger puzzle to reach this goal. Getting circularity right presents tremendous opportunity, while failing to make the transition only delays inevitable commercial and environmental challenges, as 45% of emissions are directly linked to the production of goods and the management of land (Ellen MacArthur Foundation, 2019)[2].

For Cisco, this shift means leading an industry largely reliant on virgin and non-renewable materials and water to a less extractive and more resilient future. For our supply chain, it means rethinking our approach to the design process,

product lifecycle management, sourcing, and logistics, while extending our responsibility to reclaim, repair, disassemble, and extend the useful life of hardware.

As a Fortune 500 company with a wide product portfolio, we need a systemic solution to embed circularity across our complex supply chain in a way that creates long-lasting impact. Our Circular Economy approach extends from how we design, make, and deliver our products to promoting use and reuse in environmentally sustainable ways (Cisco, n.d.)[3]. We also apply Cisco technology to support our customers in their own circular transformations.

Current State of the Technology Industry Uses

Although more companies are developing their own sustainability strategies to reduce waste and pollution, the Information and Communications Technology (ICT) industry still generally operates in a linear consumption model, relying on new production of equipment to meet demand. Thus, we still see a significant impact to natural resources and sustained levels of greenhouse gas emissions. Additionally, electronic waste (e-waste) is one of the fastest-growing waste streams in the world, where less than 20% of e-waste is collected and recycled, leading to health, pollution, and material impacts such as the loss of rare earth elements (UN Environment Programme, 2019)[4].

Transforming into a circular model requires enterprise-wide changes to how a company thinks about its product design, supply chain, infrastructure, and go to market models. Barriers include macro-level challenges such as financial, technological, regulatory, and value chain limitations. Organization-specific challenges include cultural, organizational, expertise, and marketing concerns (Oghazi and Mostaghel, 2018)[5]. Mindset and culture change of both internal stakeholders and customers is a key challenge that organizations face, as an organization may be accustomed to linear design approaches, and many customers are accustomed to using products without much thought given to end of life value. Another challenge is the need to foster innovation and collaboration with suppliers, customers, policymakers, and others to design circular products and systems, which is needed for radical rethinking of existing materials, components, and processes (LinkedIn, 2023)[6]. There are existing tools and methods to support design decisions, such as the Material Circularity Indicator, developed by The Ellen MacArthur Foundation and Granta Design. This tool helps companies identify additional circular value from their products and materials and analyze risk (Ellen MacArthur Foundation, n.d.)[7]. However, although designing for material efficiency has become embedded in business practices for many companies, historically, designing for the larger circularity model, such as for product life extension and recycling, have not been considered in design tools and practices (Bakker et al., 2014)[8]. A study by Bocken et al. (2016)[9] suggest that holistic product design strategies are ones that focus on slowing resource loops by extending product longevity, closing the loop by recycling materials, and narrowing resource flows by reducing resource use associated with the product and production process.

Approach & Discussion

At Scale: Circular Design

Over the past 4 years, we have been embedding, accelerating, and scaling our circular design program, which focuses on how we can design our products and systems to enable reuse, minimize environmental impact and resource use, drive innovation, and realize value for our stakeholders.

Cisco's circular design program began in fiscal year 2019 with multiple product teardowns. Product teardowns allowed the team to understand opportunities available in product designs that will make Cisco products more circular. Learning from these teardowns led to the creation of Cisco's Circular Design Principles and focus areas (Fig. 1), which provides guidance on how to integrate sustainability across the product lifecycle. The 25 Circular Design Principles are organized across 5 design-related focus areas and guide design decisions: 1) Material Use, 2) Standardization and Modularization, 3) Packaging and Accessories, 4) Smart Energy Consumption, and 5) Disassembly, Repair and Reuse (Cisco, 2023)[10].

Focus area	Principle
Material use	• Use recycled instead of virgin materials • Use lightweighting techniques to minimize material use • Remove cosmetic features that do not serve an engineering purpose
Standardize and modularize	• Design modular subassemblies to enhance repairability and upgradability • Use standard modules (main subassemblies) across products • Use standard components across products • Use standard materials, finishes, and processes
Packaging and accessories	• Remove accessory items that are not required for a standard configuration • Reduce virgin packaging materials used • Design products for efficient packaging and transportation • Eliminate foam packaging • Optimize packaging efficiency with bulk/multipack packaging
Smart energy consumption	• Increase energy efficiency and reduce the energy consumption of products • Reduce product energy use related to temperature control systems • Develop scalable energy usage and low-power modes • Optimize the energy efficiency and energy consumption of the front-end power supply
Disassembly, reuse, and repair	• Optimize the design of components for repair, reuse, and replacement • Ensure product structure allows for identification and accessibility of valuable components • Use homogeneous materials that are compatible for recycling • Design batteries to be easily removable, or eliminate batteries altogether • Design products to be disassembled using common tools • Simplify fastening and joining methods • Apply design practices and joining methods that optimize the recovery of plastics at end of life • Design metal parts with disassembly in mind • Design products to allow for self-service data wiping

Figure 1. Cisco's 25 Circular Design Principles, categorized into the 5 focus areas.

Cisco set a goal to incorporate Circular Design Principles into 100% of all new products and packaging by fiscal year 2025 (Cisco, 2023)[10]. Aligning to implement the Circular Design Principles and to measure our progress was a massive, cross-functional effort that required an integrated strategy. Over the past 4 years, we have developed and scaled an operating system to develop processes and tools, align business strategies, and empower our people to make progress toward our fiscal year 2025 goal (Fig. 2). Cisco's supply chain and engineering teams are now aligned on our near- and long-term sustainability goals, and the circular design program is operating with key guardrails firmly in place:

- Circular design governance model is operational and comprised of 1) Steering Committee to inform on strategy; 2) Oversight Committee to govern the principles and scoring rubric; and 3) Audit Committee to validate outcomes. All three committees are represented by leaders and Subject Matter Experts from both engineering and supply chain.
- Broad engagement structure is in place that allows for top-down and bottom-up feedback, tool/methodology improvements, and critical dialogue to take place in collaborative settings.
- Web-based Circular Design Evaluation Tool was developed for teams to evaluate the product and packaging designs against the Circular Design Principles.
- Circular design requirements are documented in the new product development process and associated project management tools. All new product and packaging designs are required to be scored in the evaluation tool prior to its release to production, and scores greater than 75% count towards the public goal.
- Real-time dashboard tracks compliance, scores, and progress towards goals, and is available to all users and part of monthly director/manager review processes.
- Interim goals and deliverables are in place for senior and executive leadership to advance circular design objectives as part of their core work and responsibilities.
- Progress our circular design goal, along with our other public goals, is reported annually in Cisco's environmental, social, and governance (ESG) Reporting Hub.
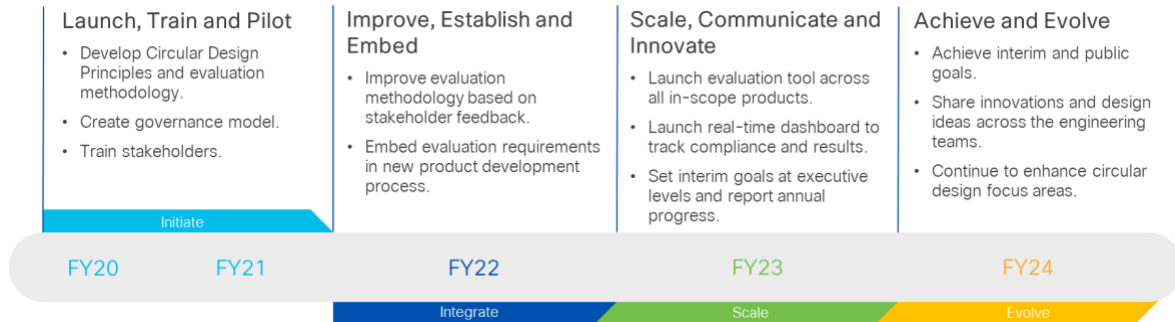
Figure 2. Timeline describing the establishment of the circular design program and operating system.

As a result, more than a quarter (27%) of Cisco products and packaging released in fiscal year 2023 incorporated the Circular Design Principles. With cross-functional commitment and a solid operating system in place, we believe we have built the foundation to make progress toward our 100% circular design goal by the end of fiscal year 2025.

Developing Processes and Tools

In fiscal year 2021, we developed a methodology and subsequent web-based tool that enables Cisco to track progress against our Circular Design Principles goal and empowers our engineers to evaluate their design decisions for circularity. The Circular Design Evaluation Tool is based on a series of questions related to each design principle and tabulates a score based on the extent to which the principles are applied to each design. Packaging scores are calculated based on principles associated with the Packaging and Accessories focus area. Product scores are calculated by combining scores from the four remaining focus areas (Material Use, Standardization and Modularization, Smart Energy Consumption, Disassembly, Reuse and Repair). Using the tool, the engineering teams can connect the Circular Design Principles to their design decisions and identify where the principles are already incorporated in the design and where the gaps are. After piloting the tool with many engineering teams, in fiscal year 2022, we integrated the Circular Design Evaluation Tool into a pre-existing central platform for hardware and software development at Cisco. This integration was key in achieving high rates of adoption for Circular Design Principles. The tool was also built to be easily updated to incorporate future requirements into the Circular Design Principles and evaluation methodology.

Circular Design Principles need to be considered at the beginning of the new product development process to ensure that product and packaging designs are designed with circularity in mind. To facilitate this, we have embedded requirements for circular design across the new product development process and associated project management tools. This includes a requirement to capture circularity requirements in the initial product requirement document and the recommendation to evaluate the product and packaging design as they are iterated upon throughout the development process. All new product and packaging designs must be scored in the evaluation tool before its release to production. Designs scoring 75% or higher are considered to have substantially incorporated the Circular Design Principles and count toward our public goal. We recognize that despite our best efforts, certain product and packaging designs may not reach the 75% score. In these cases, we will work to address any challenges that prevent us from reaching the scoring threshold. To support the mandatory scoring requirement, a real-time dashboard was developed to track compliance, scores per design, and the overall progress towards goals. It is available to the teams involved in the new product development and has been embedded into monthly review processes between vice presidents, directors, and managers.

Aligning Business Strategies

As Cisco started the journey to build out the circular design program, it was critical that it could not be done in isolation –we needed engagement and support across the value chain. We worked both internally with all teams involved in new product development and externally with suppliers on circularity. To ensure input was gathered from diverse stakeholders, a governance model was created to inform the circular design strategy, provide review for the evaluation methodology, and to validate the outcomes of the evaluations. As a result, we established a governance model which comprised of:

1) **Steering Committee** to inform on strategy.
2) **Oversight Committee** to govern the principles and evaluation methodology.
3) **Audit Committee** to validate circular design evaluation outcomes.

All 3 committees are still operational today and are represented by leaders and subject matter experts from engineering and supply chain teams.

Having a cross-functional governance model and getting executive buy-in across the value chain was key to scaling the circular design efforts across Cisco's businesses, as this gave permission to teams to allocate resources and time to investigate more sustainable solutions for product and packaging designs. In turn, this has empowered our engineers to think outside of the traditional framework and take ownership for designing our products for circularity.

Along the way, we ensured we were bringing together the varying priorities and interests of their stakeholders. These conversations surfaced that trade-offs sometimes needed to be made, such as:

- **Foam vs carbon emissions**: Foam is a very light, effective, and affordable material for protecting a product during transport. When replacing it with recyclable materials such as thermoform plastic or fiber-based solutions, the total weight of the packaging may increase, thereby leading to an increase in carbon emissions during transportation. The recyclable alternatives are often more expensive than foam too. Ultimately, in this scenario, Cisco decided to prioritize circularity benefits over the potential increase in carbon emissions and cost, as eliminating foam will reduce the amount of landfill waste the packaging creates.
- **Standardization vs technology advancements:** Standardized designs enable removable, replaceable, and interchangeable components that can be used in multiple assemblies within a product and across product lines. This can improve maintenance service, enabling circular processes for component return, repair, recovery, and reuse while optimizing waste management processes and procedures. However, component standardization may result in decreased flexibility for design changes, as required component modification may or may not be applicable to all assemblies. We recognize that this is an ongoing challenge and consider trade-offs on a case-by-case basis.
- **Industrial design vs circularity**: Cisco's products are designed to have a certain look and feel that describes Cisco's brand of quality and innovation. However, the current industrial design guidelines do not always align with the Circular Design Principles. We recently completed a project with Cisco's industrial design agency partner to update the guidelines so engineering teams can design products that meet both industrial design and circular design standards. We began by identifying the discrepancies between these standards and conducting interviews with stakeholders to determine opportunities for alignment. Then, we summarized the changes into an updated industrial design playbook where circular design is now a design pillar and included guidelines such as avoiding the usage of fully cosmetic and non-functional plastic parts and optimizing the product form for packaging.

To further align the circular design strategy across the businesses, interim goals and deliverables were set in place for executives to advance circular design objectives as part of their core work and responsibilities. These quarterly and yearly goals ensure that there are resources allocated to meet the deliverables and provide governance for the interim goals. At the end of each fiscal year, Cisco reports on the progress that was made towards the 100% Circular Design Principles goal in our ESG Reporting Hub (Cisco, 2023)[11].

Empowering People

To accelerate progress towards achieving our fiscal year 2025 goal, we developed a comprehensive, gamified, online training program (Fig. 3) in fiscal year 2021 to educate and align employees on what designing for circularity means, the evaluation methodology, the scoring process, and the targeted design outcomes. It was rolled out across the company and was a required training for certain engineering and supply chain teams. By the end of fiscal year 2023, more than 6900 employees completed the circular design training.

Figure 3. Screenshot from the training program, where the user goes through an exercise to understand the implications of different design decisions.

In addition, there were executive communications to change hearts and minds about *why* the principles were being adopted, as well as external engagement with suppliers and manufacturing partners, as the changes would invariably impact their business via material usage, assembly processes, packaging, and other design elements. A broad engagement structure was also put in place that allows for top-down and bottom-up feedback, tool/methodology improvements, and critical dialogue to take place in collaborative settings. The program team regularly presents in various forums to share progress updates and solicit feedback on the evaluation methodology and tool from the engineering and supply chain teams. Employees who are interested in learning more about circular design can also attend company-wide monthly forums to hear from internal and external speakers.

Engineering teams are also encouraged to think innovatively on how to design the products to enable reuse and minimize environmental impacts. These innovations include novel materials, components, or process changes that can reduce the environmental impact of a product or packaging. Teams can submit their innovation in the evaluation tool, and these submissions are reviewed by a Circular Design Innovation Committee twice a quarter and assigned points based on how it reduces the environmental impact of the product or packaging. These points are added to the product or packaging's overall circular design score. High-scoring product and packaging designs and innovation submissions receive recognition from their executive leadership. This catalyzes the sharing of new ideas and increases collaboration across product and packaging teams on how to design for circularity. These high-scoring designs and innovations are also incorporated into internal and external case studies to further highlight circular designs and share ideas across the business. An example of an innovation that was submitted this past fiscal year was focused on modularity. In a select model of the Cisco Network Convergence System 2000 Series (NCS2K), the chassis has been designed with modular housing that can host two different types of power supply units (PSUs). This enables the power supply unit to be replaced on site instead of needing to bring the entire product back to Cisco. It also provides customer flexibility to choose the type of power supply unit used without needing a new housing. When environmental trade-offs are taken into consideration, the modular design can decrease the raw materials and emissions needed to manufacture new components and can enable a circular closed loop process for module return, repair, recovery, and reuse (Cisco, 2023)[10].

Product Success Stories

As a result of the successful implementation of the circular design operating system, we are seeing real changes in the way our products are being designed to enable reuse and minimize environmental impact. Here are a few examples:
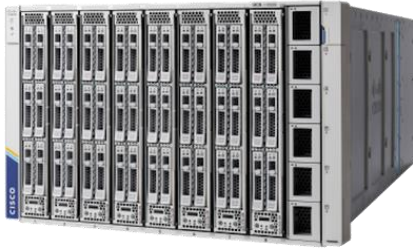
UCS-X Servers

Figure 4. Photo of a UCS-X fully configured product

For more than a decade, Unified Computing System (UCS) servers have been engineered to be sustainable by design and energy-efficient, which has led to the product (Fig. 4) being awarded the 2023 SEAL Sustainable Product Award (Seal Awards, 2023)[12]. Built with modular, easily removable components, its upgradeable designs help to extend the use of the chassis, power supply, cooling, and other major components, and it is optimized for repair, reuse, and eventual recycling. This architecture allows the X-Series to consume roughly 50% less raw material over three generations than traditional rack servers. The team has also eliminated wet paint, reduced powder coating by 62% compared to the prior generation and implemented post-consumer recycled resin in 77% of plastic parts. Cisco offers multipack shipping for smaller units and high-volume orders to reduce packaging, and customers can opt out of product accessories they don't need, such as power cords. Customers receive the product in packaging made of recycled materials, and they can use QR codes to access documentation digitally, eliminating the use of paper.

Data centers can consume as much as 50 times the energy of typical commercial office buildings (Department of Energy, n.d.)[13]. The latest X-Series architecture also features technology innovations such as efficient 54V power distribution, intelligent fan controls, zone-based cooling, and 80 PLUS Titanium-rated power supplies. It is cloud managed by Cisco Intersight, enabling constant monitoring and policy-based controls to dynamically adjust power usage for optimal efficiency. In a scenario where the X-Series is used to replace 64 previous-generation servers, customers can use 3.3X less hardware and reduce almost 100,000 kWh of energy and almost 40 tCO2e of emissions per year. As a large enterprise typically can have thousands of servers deployed in their data centers globally, deploying the X-Series can help them reduce energy consumption, carbon emissions, and raw material usage.

Webex Room Bar

Figure 5. Photo of the front of the Webex Room Bar

Released in fiscal 2022, the Webex Room Bar (Fig. 5) is a video collaboration bar for huddle spaces and small meeting rooms. It was redesigned with a simplified architecture to reduce the number of internal components compared to its predecessor, resulting in more than 32,000 pounds of material savings per year. It uses at least 55% post-consumer recycled plastic resin. We have also eliminated the use of foam in the regular box-in the-box packaging for the Room Bar by using a fiber-based double-tray design. When connected to certain displays, the Room Bar can automatically configure the brightness and latency of the display for natural video conferencing upon installation and turn the display on and off automatically, thereby saving energy.

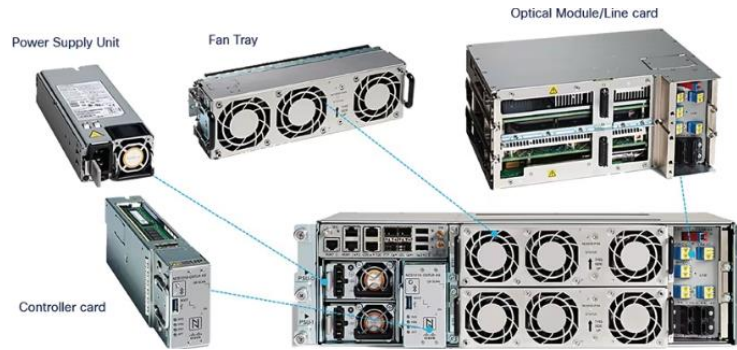Cisco Network Convergence System 1000 Series (NCS1K) product family

Figure 6. Photo of the NCS 1010 shelf components

Cisco's NCS1K product family is a complex system made up of controller cards, optical interfaces, fan trays and power suppliers. Given this complexity, thoughtful design for circularity is even more important. We developed the NCS 1010 (Fig. 6) for multiple, extended lifecycles with redundant fans (one can be repaired while the other runs), easily replaceable modules, and a working hours counter that provides refurbishers with runtime data. To enhance the product's energy efficiency, the product uses intelligent cooling, selective power shut down, and an 80 PLUS Platinum-rate power supply. We collaborated with suppliers to reduce plastic and waste in packaging, such as shipping mounting brackets in fiber-based envelopes instead of plastic bags.

Tracking Progress via Goals

Circular Transformation is a key pillar in Cisco's strategy to connect a regenerative future and circular design helps to enable it. Circular Design Principles also play a key role with helping us achieve our goal (Fig. 7) of reaching net zero across our scope 1, 2, and 3 greenhouse gas emissions. Along with the goal of incorporating Circular Design Principles into 100% of all new products and packaging designs by fiscal year 2025, additional public goals around reducing material use were also set. Taking our learnings from the circular design program, we are replicating elements of its operating system for these goals to set milestones along the way to show progress and build momentum. Here is our progress:

Figure 7. Cisco's public sustainability goals, organized by their goal year.

- **50% Post-Consumer Recycled (PCR) Plastic:** Our goal is that half of the plastic used in our products (by weight) will be made of recycled content by end of fiscal year 2025. The scope of this goal excludes plastics

contained in commodity components (e.g., plastic screws, fans, and cables) and in products designed and manufactured by our Original Design Manufacturers. PCR plastic is reclaimed through recycling and reprocessing into pellets for reuse. Plastic in Cisco products is primarily concentrated in a few categories: IP phones, collaboration devices, access points and Meraki products. Material changes to a few high-volume products had huge impacts but reaching the 50% goal requires greater precision. The team scaled a "Champions" approach, with representation from key stakeholders across commodity management, component engineering, product operation and engineering. They've documented all existing and planned plastic parts – type of plastic, place in lifecycle, volume, commonality across platforms, etc. – and segmented the parts by feasibility for replacement with recycled plastic, accounting for factors like durability, application requirement, color matching, cosmetics, etc. With centralized funding to overcome obstacles, like qualifying alternate materials, testing, performance validation, and securing samples, the team is scaling their operation. 24% of plastics used in our products (by weight) is from recycled content in fiscal year 2023 (Cisco, 2023)[11].

- **75% Reduction in Foam Use:** At Cisco, we are working to reduce our total foam packaging use by 75% at the end of fiscal year 2025 against baseline fiscal year 2019. In fiscal year 2024, we launched a tiger team effort to target top opportunities and design foam out of our packaging portfolio. Our teams are experimenting with alternate materials that are renewable and recyclable, while still cushioning and protecting Cisco products on their long journeys from manufacturing to final customer. Success with fiber-flute, molded pulp and thermoformed protective cushions have established a solid foundation of foam-free alternatives and a proactive approach to the impending global regulations around packaging waste. Fiscal year 2023 closed with a 22% reduction in packaging foam use by weight (Cisco, 2023)[11].

- **No Paper Project:** This internal circular initiative focused on reducing the many sheets of paper in the form of licenses, manuals and compliance documentation that were routinely shipped with Cisco's hardware and software solutions. By moving to electronic delivery, Cisco reduced its material use, waste, cost, and bottlenecks in manufacturing, while enhancing the customer experience. While there are business critical and legal reasons that require some paper shipments, as of fiscal year 2023, we have removed 67% of paper (by weight) from our products compared to our baseline in fiscal year 2020. Now, around 1000 product offerings have implemented pointer card and QR codes for customer digital access to product documentation. Our focus for fiscal 2024 is to create a solution for customers to access their software license information digitally and to launch this new capability for products with software licensing (Cisco, 2023)[10].

Conclusion

Cisco's circular design program has transformed the way its products and packaging are designed by embedding Circular Design Principles into how we design and build our products. This effort involves changing mindsets and implementing process controls across the product journey, where the incorporation of Circular Design Principles acts as the final approval point for any new product and packaging design release. Cisco makes sure product sustainability, specifically circular design, is a core consideration in its design process. Not everyone takes this approach. Often companies incorporate one element of circularity, such as reuse, but ignore the other elements such as material selection or component standardization. Cisco's holistic approach to sustainability and Circular Economy is an important part of what sets us apart.

Looking ahead, we will leverage the Circular Design Evaluation Tool and operating system to incorporate future requirements related to product and packaging design requirements as we explore how Cisco can continue to design our products and packaging to support our evolution to a regenerative, circular model. For example, if energy efficiency standards increase, or there is a mandate to use bio-based plastics in Cisco products, Cisco will be able to efficiently incorporate such design mandates into the overall design process. In other words, the processes and tools we have put in place today, along with the governance model created to align business strategy, and the engagement model we have to empower our people, have created systemic change across Cisco that can scale to meet evolving requirements. We have created a circularity infrastructure that is already delivering results and will continue to adapt to future product and packaging design needs.

References

[1] Cisco, The Plan for Possible: Connecting a regenerative future, https://blogs.cisco.com/csr/the-plan-for-possible-connecting-a-regenerative-future, 2023.

[2] Ellen MacArthur Foundation, Completing the picture: How the circular economy tackles climate change, https://www.ellenmacarthurfoundation.org/completing-the-picture, 2019.

[3] Cisco, What Goes Around Comes Around, https://www.cisco.com/c/en/us/about/circular-economy/product-lifecycle.html, 2023.

[4] UN Environment Programme, UN report: Time to seize opportunity, tackle challenge of e-waste, https://www.unep.org/news-and-stories/press-release/un-report-time-seize-opportunity-tackle-challenge-e-waste, 2019.

[5] Oghazi, P., Mostaghel, R., Circular Business Model Challenges and Lessons Learned—An Industrial Perspective. Sustainability, 10, 739, 2018.

[6] LinkedIn, What are the common challenges of implementing circular design principles, https://www.linkedin.com/advice/1/what-common-challenges-implementing-circular-smdqe#:~:text=These%20factors%20can%20create%20barriers,low%20demand%20for%20circular%20products, 2023.

[7] Ellen MacArthur Foundation, Material Circularity Indicator, https://www.ellenmacarthurfoundation.org/material-circularity-indicator, n.d.

[8] Bakker, C., Wang, F., Huisman, J., den Hollander, M., Products that go round: exploring product life extension through design. Journal of Cleaner Production, 69, 10, 2014.

[9] Bocken, N., de Pauw, I., Bakker C., van der Grinten, B., Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33, 308, 2016.

[10] Cisco, Product sustainability, https://www.cisco.com/c/m/en_us/about/csr/esg-hub/environment/product-sustainability.html#circular-design, 2023.

[11] Cisco, Strategy, goals, and emissions data, https://www.cisco.com/c/m/en_us/about/csr/esg-hub/environment/goals.html#active, 2023.

[12] Seal Awards, ESG leaders recognized at 2023 Seal Business Sustainability Awards, https://sealawards.com/sustainability-award-2023/, 2023.

[13] US Department of Energy, Data Centers and Servers, https://www.energy.gov/eere/buildings/data-centers-and-servers, n.d.

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