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Thought Leadership Series

THE PROMISE OF THE CIRCULAR ECONOMY

Transforming the electronics value chain from linear to circular.

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Most companies that operate within the electronics sectors—OEMs, contract manufacturers, distributors, and suppliers—have some form of corporate social responsibility (CSR) program in place. These programs are often based on a commitment to the triple bottom line that includes financial performance, environmental stewardship and social citizenship.

While robust CRS programs reflect changing societal values, they can create tension when they run counter to core business objectives of maximizing revenue and profitability. There are unavoidable costs that electronics companies incur to comply with environmental regulations such as REACH, RoHS, and WEEE, and to ensure they don't use conflict minerals. And they incur additional costs through voluntary CSR initiatives that go beyond regulatory compliance, but which may not contribute to the top or bottom line.

This creates a dilemma for even the best-intentioned companies as there are very real environmental and business consequences of not pursuing robust environmental and socially responsible practices.

Consider the problem of electronic waste. The volume of global e-waste has been rising steadily in recent years, and is expected to reach an estimated 50 million tons this year up from 41 million tons earlier in the decade, according to the United Nations. This increase is caused in large part by the rapid pace of product replacement—shorter product lifecycles for smart phones, laptops, printers, TVs, and other consumer electronics—the lack of products designed for repairability and recycling, and the lack of comprehensive, cost-effective recycling options for consumers and businesses.

Illegal shipments of e-waste from the U.S. reportedly contribute to the mountains of unregulated e-waste sites around the world, in China and Hong Kong, Kenya, Mexico, Pakistan, Taiwan, and elsewhere. The presence of lead, mercury, and other neurotoxins in the water and air at these sites is at dangerously high levels, threatening the health of local communities.

E-waste also contributes to the flourishing trade in counterfeit electronic components. In 2011, the U.S. Senate Armed Services Committee released a report that identified counterfeit electronic parts to be a national security risk for military and government electronics systems, tying the problem to parts collected from e-waste sites in China and shipped back to the U.S.

From linear to circular

Clearly, managing e-waste is not a business imperative, even though the social and environmental costs are high. For e-waste recycling and other voluntary CSR initiatives to become core business objectives requires they deliver business value either by reducing cost or generating new revenue streams, or preferably both.

This is a fundamental challenge for today's linear business model, which consists of four steps: resource extraction, manufacturing, consumption and disposal. There is no process baked into the linear model for reuse and recycling of disposed products and materials because waste is excluded from the value chain.

Attitudes, however, are starting to change. Indeed, there's a growing consensus among business leaders and government officials around the world that the linear model is unsustainable. Research conducted by Accenture, for example, suggests that over the next two decades population growth, resource supply disruptions, rising and volatile material prices, and the scarcity of natural resources will result in trillion-dollar losses for companies and countries whose growth is tied to the use of scarce natural resources.

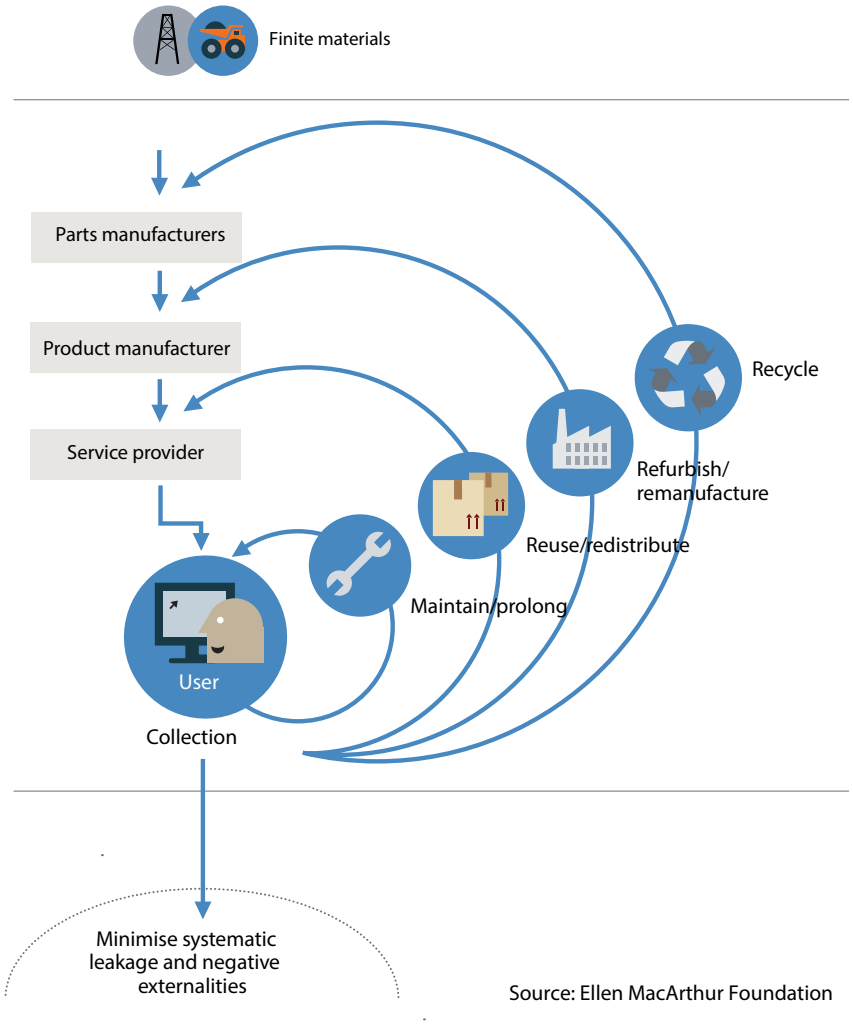
One approach that is gaining attention is to transition from the linear model to a closed-loop model that relies on waste as the primary input for new product creation. Dubbed the circular economy, this model aims to reduce resource extraction and maximize the reuse and recycling of materials that are fed back into the production process. As the circular-economy model gains momentum, the demand for recycled resources will increase, and so will prices, which will help reverse those trillion-dollar losses and, according to Accenture, creates trillion-dollar opportunities.

The full-blown circular model includes closed-loop systems for both energy and material inputs. The former emphasizes the use of renewables such as solar, wind and biofuels. The latter emphasizes the reuse of materials in the physical production cycle. The figure on this page captures the production side of the closed-loop system, highlighting the different forms that material reuse can take.

At its core, the circular model is restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all times throughout their lifecycles, according to the Ellen MacArthur Foundation (EAF), a pioneering non-profit organization dedicated to accelerating the transition to a circular economy. Members of the Foundation from the technology sector include Apple, Cisco, Dell, Google, HPE, IBM, Philips, and Schneider Electric. *(Continued on page 5)*

The circular-economy business model

The emphasis is on eliminating disposal and focusing on transforming waste into reusable inputs in a closed-loop production system. The model aligns with the emergence of the sharing economy, the shift toward digital product-as-a-service models, and demands new thinking for product design, collaboration, and procurement.



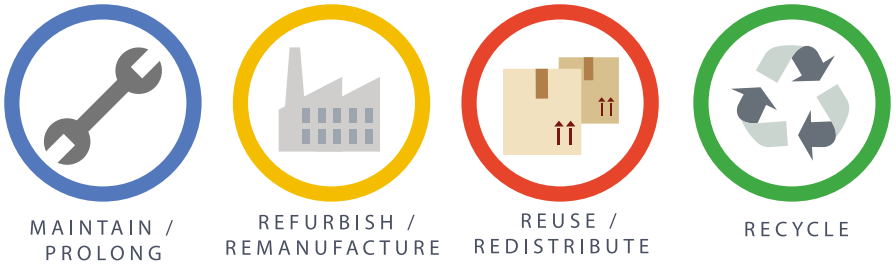
Source: Ellen MacArthur Foundation

Case Study: Google's circular data centers

A member of the Ellen MacArthur Foundation, Google is applying circular-economy principles to the lifecycle management of the servers it uses in its own data centers.[1] The company manages the manufacturing and assembly operations of its custom-built servers and purchases the components from suppliers, including CPUs, motherboards, flash devices, hard disk drives, and memory modules.

The four circular-economy initiatives detailed below and described in the Google case study have contributed to Google avoiding spending hundreds of millions of dollars on new servers, according to the company.

1. **Maintain/Prolong.** Google has a proactive maintenance program for extending the life expectancy of the components in its servers. As servers fail and need repair, the company replaces defective parts with refurbished parts from its in-house inventory. Hard drives and disks and memory modules are the most commonly repaired components, according to the company. Failed parts are replaced with either new or refurbished parts.
   In 2015, 75% of components used in Google's spare parts program were from refurbished inventory.



Source: Google

2. **Refurbish/Remanufacture.** When servers from Google data centers are decommissioned, they are sent back to the central hub, where they are dismantled and de-kitted into their usable components. They are inspected and stored, ready to be reused as refurbished inventory. Refurbished parts are used to build remanufactured servers and are then deployed back into data centers. Once components are in inventory, Google makes no distinction between refurbished and new inventory. They are considered equivalent. In 2015, 19% of servers Google deployed were remanufactured machines.

3. **Reuse/Redistribute.** Google redistributes excess component inventory as determined by its internal quarterly Excess and Obsolescence process, which analyzes the lifecycle stage of components and their total cost of ownership relative to new hardware. The components are either put back in inventory, sold or recycled. After removing proprietary Google technology from the components, the components marked for resale are sold on the secondary market. Most of the components resold are either memory modules, hard drives or OEM networking equipment. In 2015, Google resold nearly 2 million units on the secondary market for reuse by other organizations.

4. **Recycle.** Google maximizes the recycling of all data center material, including the electronic equipment. Hard drives and storage tapes that cannot be resold are crushed and shredded. These crushed materials along with plastics and metals from other electronic waste are then combined and sent to a recycling partner for secure processing and recycling into reusable materials. ■

[1]Shobhit Rana and Kate Brandt, *"Circular economy at work in Google data centers," September 2016.*

The trillion-dollar business value of the circular model that Accenture, EAF, and others have identified is derived from a set of practices:

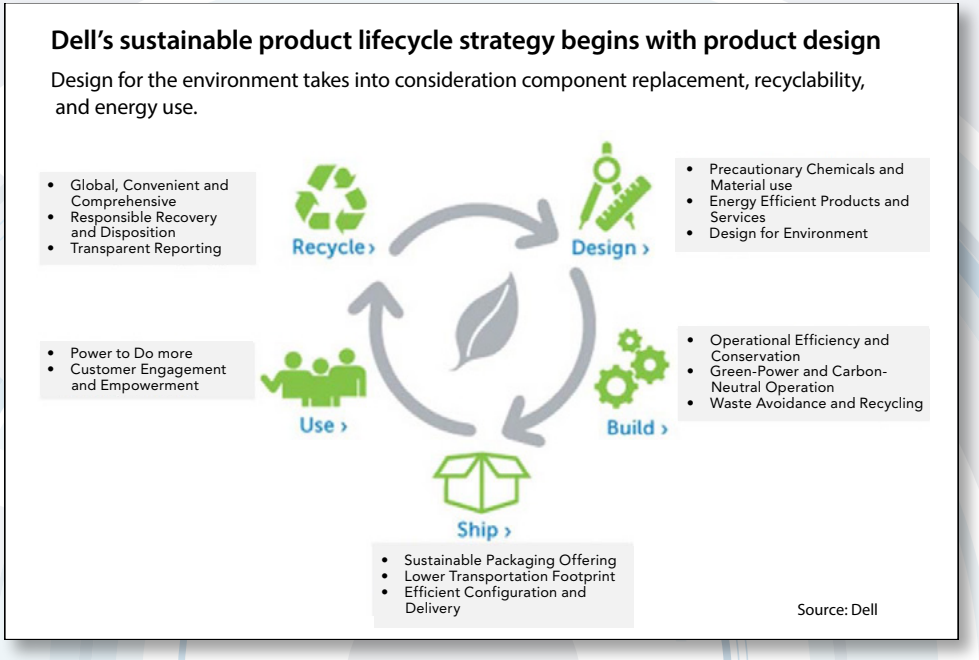
1. **Prioritize resource reuse**, including both materials (plastics and metals) and energy (solar, wind, and biochemical).
2. **Aim for zero waste** in the production process, which can be achieved by shifting from disposal to recycling and increasing resource efficiency of both materials and energy.
3. **Adopt a use-based product model** to replace the purchase-based model, where products and assets are shared and traded to maximize their productivity.
4. **Change design criteria** to extend the product lifecycle by designing for durability, repair, refurbishing and recycling.
5. **Optimize systems** by leveraging artificial intelligence, big data, cloud, Internet of Things, remote sensing, 3D printing, and other technologies to boost performance, make processes and products more efficient, and remove waste and inefficiencies from supply chains, logistics, and distribution operations.
6. **Create closed loops** for components such as CPUs, memory, and hard drives, and materials such as plastics so they can be reused over and over through many product cycles.
7. **Design and build virtual and digital products** instead of stand-alone physical products. Digital products deliver a service—product-as-a-service, infrastructure-as-a-service, platform-as-a-service, and so on—and can be upgraded and enhanced through software downloads, reducing material use and waste.

There are examples of circular best practices across the electronics sector in all seven of these circular-economy areas. Resource reuse is perhaps the most common one that electronics companies have been focusing on. For example, instead of sending e-waste to a toxic dump in Hong Kong, the waste is processed to reclaim gold, copper, aluminum, and plastics which are sold on commodity markets and/or processed for reuse in new components and finished goods. The U.S. Environmental Protection Agency estimates that there is between 40 and 800 times more gold, and 30 to 40 times more copper in a metric ton of circuit boards than in a metric ton of ore.

Industry standouts such as Apple and Dell have been exploiting this opportunity for a number of years. In 2015, Apple reported it recovered over 61 million pounds of reusable metals and plastics, including over 2,200 pounds of gold. The company takes back used computers, phones, and tablets regardless of the manufacturer as part of its commitment to reduce e-waste and reuse metals in new devices. Apple's long-term goal is to create a closed-loop supply chain "that uses only renewable resources or recycled materials," according to Apple's latest environmental report.

Similarly, Dell refurbishes and resells some of the products it collects from organizations such as Goodwill, and recycles materials from those that cannot be refurbished. The company recovers materials from used technology products in 78 countries, including plastic that is reuses and other materials that it reclaims and sells on commodity markets.

Dell ships the recycled plastic to its manufacturing partners in China where it is shredded, melted and blended, then molded into new plastic parts. The company uses closed-loop plastics in the manufacture of more than 90 different products. The process Dell developed became the model for UL's environmental closed-loop standard, according to the company. Last year, Dell reported it used over 5.5 million pounds of closed-loop plastics.



The future is circular

What Apple, Dell, and other industry innovators are doing is just the beginning. Rethinking product design to align with circular-economy principles, for example, is one area that can be transformative. Business leaders must be mindful that this is a very different approach from product design in the linear model, where product managers and engineers are largely responsible for the process. The circular product design transformation is a multi-year process.

Of course, changing the design process is complex, and requires input and collaboration from a variety of players, both inside and outside the company: procurement, marketing and sales, as well as raw material and component suppliers, distributors, retailers, recyclers, customers, government agencies, industry associations, energy providers, and others across the expanded value chain.

Input from all these contributors is valuable for informing and developing strategies for improving product functionality, lifecycle management, re-usability, recyclability, packaging, and a host of other product and process characteristics.

Here again, Dell is a pioneer in designing products for the circular economy. This includes design for reuse, where Dell product designers work closely with asset recovery partners and recyclers. These relationships have led to design upgrades such as single-door service access on laptop components that facilitates easier servicing and recycling of components. (See figure.)

The results are reflected in the ratings of Dell's products by independent organizations. For example, this year, iFixit gave Dell's Latitude E5270 a score of 10 out of 10 for repairability.

But while laudable, the efforts of individual companies are not sufficient to transform industrywide business models or eliminate the global scourge of e-waste. Pre-competitive initiatives sponsored by industry organizations are important for driving meaningful industrywide change.

One such circular-economy example is the work being done by the International Electronics Manufacturing Initiative (iNEMI), a research consortium, that is exploring reuse and value recovery of hard disk drives (HDDs). Hard drives are ubiquitous but reclamation and reuse is low. Yet, the demand for low-cost refurbished drives is increasing due in large part to the growth in cloud infrastructure. (See the Google case study on page 4.)

The iNEMI working group—which includes Celestica, Purdue University, the U.S. Department of Energy Critical Materials Institute, and Seagate —is examining the causes of low reclamation and specific actions that can be adopted to improve value recovery. Challenges include the common practice of physically destroying drives for security reasons, and design and cost constraints that prevent the dismantling of HDDs to access reusable components.

While the group's ultimate objective is to design HDDs for plug-and-play re-use, the next-best interim outcome is to optimize the HDD component for reuse, according to Mark Schaffer, an iNEMI consultant and project manager. If successful, the HDD project could pave the way for future projects that may focus on memory, CPUs, solid-state drives, and even cell phones.

In addition to value recovery projects, there's great promise that emerging technologies, such as artificial intelligence and the Internet of Things can be harnessed to accelerate the advance of circular-economy innovation. The data produced by networks of IoT devices across the supply chain and in factories around the world may soon be able to provide analytics on the source of a finished product, calculate the energy used to produce it, predict when it will need servicing, and calculate its reclamation value. Products will be able to advertise their availability to potential users in sharing networks.
And one day, with any luck, the concept of waste will become a relic of a bygone era.

Action items

1. **Learn.** Familiarize yourself with circular-economy concepts, principles, trends, and best practices. There are a number of sources for case studies and cutting-edge thinking, including Accenture, Ellen MacArthur Foundation, and McKinsey & Co. Conferences, too, are valuable opportunities to learn and make connections.

2. **Experiment.** Identify circular-economy project opportunities within your company that focus on modest, practical steps that deliver business value by lowering costs and/or generating revenue.

3. **Engage.** Closed-loop circular processes are about fundamental organizational and operational change, which requires broad participation from across the organization, supply chain, customer base, and beyond. Engage with supply-chain partners, participate in industry groups, and collaborate with customers on circular-economy projects.

4. **Technology.** Digital technologies are enablers of circular-economy success. Exploiting IoT, cloud, AI, and other emerging technologies brings greater visibility to factory utilization, supply chain efficiencies, waste and energy use and creates a competitive advantage.

5. **Leadership.** As with any major cultural change, transitioning to a circular-economy business model will fail without senior management leadership.

By Bruce Rayner, Contributing Editor

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