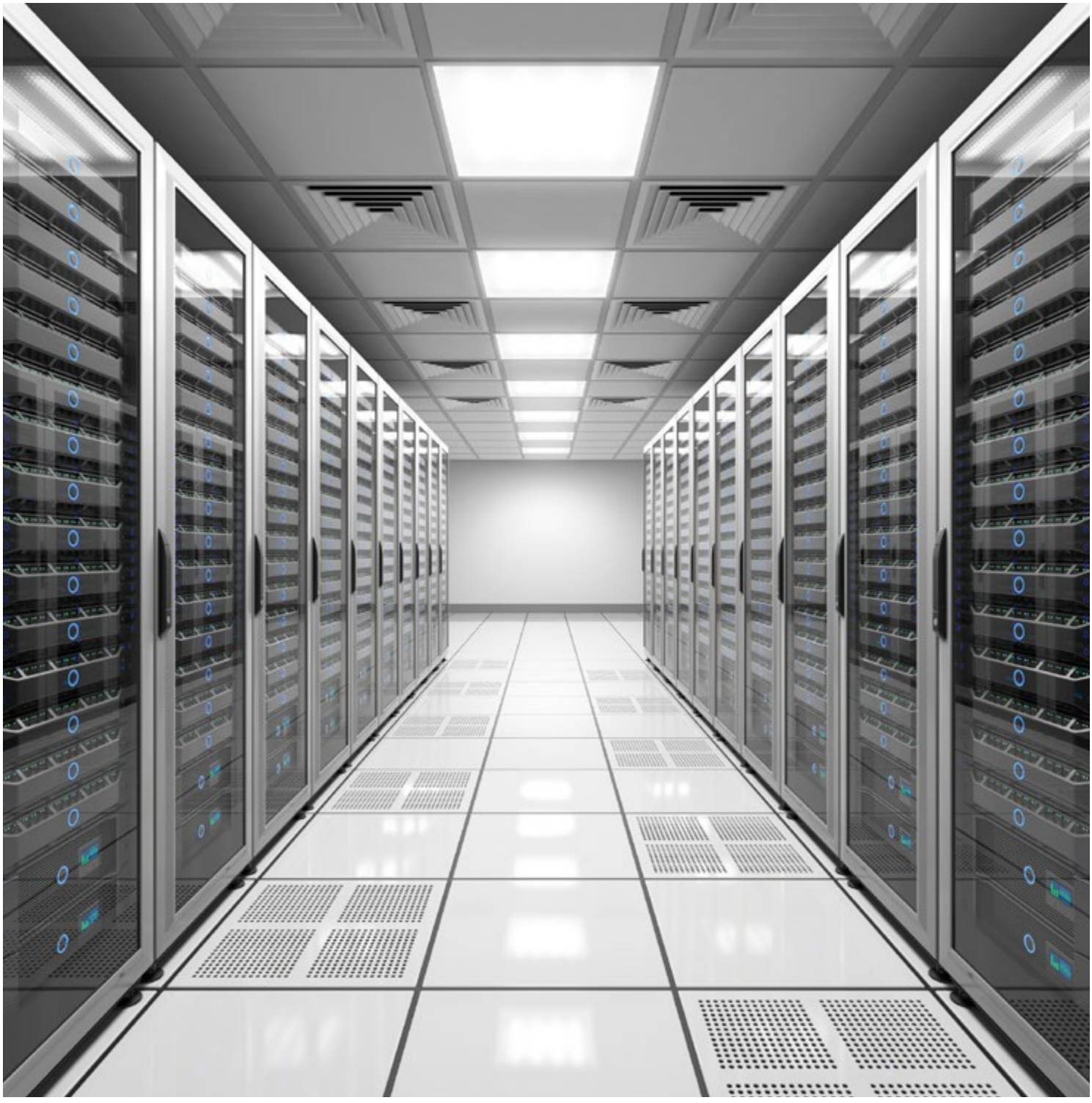
A paradigm shift in total cost of ownership

From procurement to product innovation:

How companies are hardwiring sustainability across the value chain to future-proof their business



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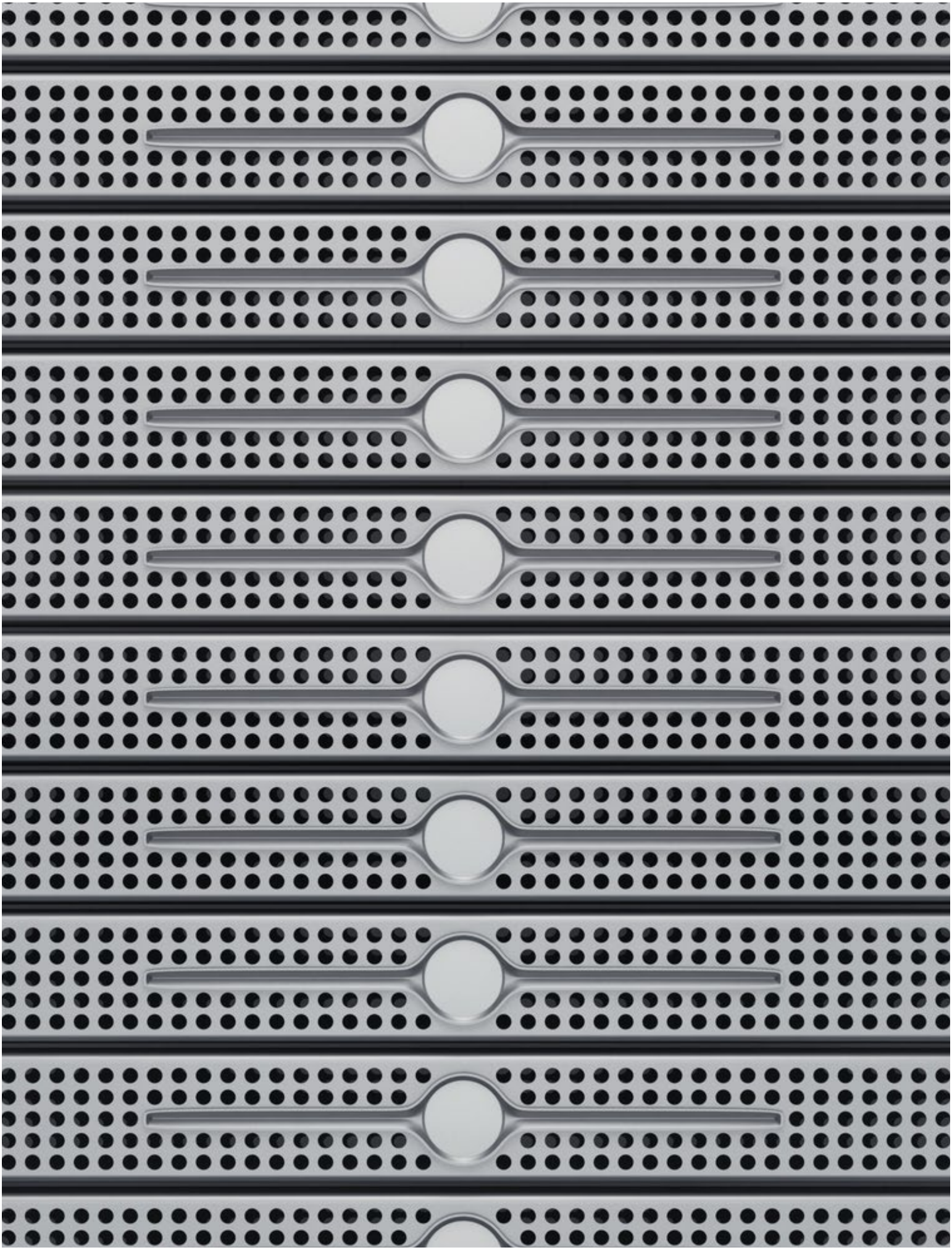


CONTENTS

Executive summary

Sustainability is driving innovation: from Silicon Valley companies to Washington, D.C., procurement agencies to suppliers in Shenzhen. It has become a business necessity because it saves money, smooths operations, diminishes risk in supply chains and opens new business opportunities.

Major purchasers no longer base their choice of goods and services on sticker price alone. The way in which total cost of ownership (TCO) is evaluated has reached a tipping point, leading major purchasers, including the U.S. military—the world's largest user of fossil fuels—to reduce the hidden environmental costs in the manufacture, operations, support and disposal of their acquisitions. Sustainability has been incorporated into traditional procurement practices because it lowers costs to end-users and to the environment. This paradigm shift is directing billions of dollars toward the low-carbon economy, creating new markets and driving suppliers to innovate in order to meet these demands, and to ensure a growing share of profits in the future.

Embedding sustainability in procurement is crucial, because manufacturing and consumer use can account for 95 percent[1] of the impact of products, dwarfing that of a company's own operations. New acquisition guidance from the Department of Defense reflects this TCO approach, by asking suppliers to hardwire new, innovative designs into their products and services that limit environmental impact.

Hewlett Packard Enterprise (HPE), a defense supplier and a major purchaser in its own right, engineered a line of energy optimized servers based on the latest low-energy, high-performance processor technology, called Moonshot, to meet the computing demands of its customers with breakthrough energy efficiency. The case study included in this report shows how HPE's Moonshot servers compare to traditional servers, in light of the Department of Defense's acquisition guidance. The study finds that replacing traditional servers with extreme low-energy (ELE) servers like Moonshot would have the potential to cut annual greenhouse gas emissions by up to 100 million tons—the equivalent of taking up to 20 million cars off the road for a year, approximately five times the direct emissions (Scope 1 and Scope 2) that HPE emits in a year. In this scenario, customers would save up to $12 billion in internal energy costs, and total environmental impact could be reduced by up to $20 billion.

1 Airport Cooperative Research Program (ACRP) Report 56

Such innovation is crucial to cutting the energy used by cloud computing. In terms of global energy consumption, the "cloud" ranks sixth overall—behind the United States, China, Russia, India, and Japan, but well ahead of Germany, Canada, Brazil, and France.[2] Suppliers are developing low-carbon technologies to meet the demands of the new purchasing signals of their customers—and creating ever more business opportunities.

Some of the world's largest purchasers, including Walmart, Unilever, General Motors, the Department of the Navy, and the U.S. General Services Administration (the main procurement arm of the U.S. government) are incorporating sustainability into their value chain evaluations and procurement decisions. They are wielding their purchasing power to reduce the resources required to make and use their products and are asking suppliers to calculate and disclose their environmental impacts. Such disclosure helps organizations to identify and assess environmental risk and opportunity and to track year-on-year performance improvements. For defense contractor Lockheed Martin, this means using in-space servicing to extend the life of satellites, so they can be replaced less frequently. General Motors is among the automakers turning to electric vehicles, to be sold to consumers and federal agencies alike.

69%
of Global 500 companies reported increased demand for lower-carbon products and services in 2016

Such change is happening throughout the value chain, according to the global nonprofit CDP, which receives climate disclosures from thousands of suppliers in China and around the world. Through CDP's supply chain program, 89 purchasing organizations with $2.7 trillion in collective annual spend use CDP's globally recognized environmental reporting platform to engage with their key suppliers on greenhouse gas management. CDP's vast data, collected from companies that represent 55 percent of the stock traded in the world, illustrates that what is measured can be managed:

- Of Global 500 companies, 55% found business opportunities resulting from modified consumer behavior due to climate change; 69% reported increased demand for lower-carbon products and services in 2016.[3]
- 77% of Global 500 companies said they engaged with their suppliers on climate change strategies in 2016, up from 67% three years earlier.
- 58% of these companies engaged with their customers on climate change, more than three times the number just three years earlier.

2 "Clicking Clean: A Guide to Building the Green Internet", May 2015

3 Statistics based on responding Global 500 companies

For companies across the globe, sustainability is an issue of dollars and cents, of cutting costs while boosting sales and customer loyalty. Environment-related initiatives are being integrated into traditional procurement practices, as sustainability managers prove their relevance to a company's core business.

The following examples, taken from company disclosures to CDP in 2015, show how sustainability has become a necessity for businesses to satisfy increasing customer interest:

General Motors has invested $7.4B to research and develop future generations of electrified vehicles, *"to develop and bring to market affordable products that incorporate technologies to displace petroleum with biofuels and electricity, improve fuel efficiency, reduce emissions, improve vehicle safety, and provide additional value and benefits to our customers."*

Praxair, the industrial gas maker, has invested heavily to meet customer demand for products with a lower carbon footprint. In 2015, its new eco portfolio—applications that offer customers environmental benefit—accounted for 32 percent of sales, or more than $3 billion in revenue. *"This focus on environmental innovation is yielding positive market results,"* the company said in its disclosures to CDP.

Alcoa discusses how *"our customers are increasingly asking for innovations and products to enhance their energy efficiency and reduce the CO_2 emissions associated with the usage of their products.... As a result of increased customer demand for energy efficiency, our Engineered Products & Solutions business group signed a number of valuable contracts throughout 2014, including a $1.1 billion 10-year supply agreement with Pratt & Whitney for enhanced, energy-efficient jet engine components."*

Everyone benefits from innovation based on sustainability: Companies increase the competitiveness of their product portfolio, their customers save money on energy, effective suppliers gain a willing buyer for their energy-saving technology, and environmental impacts are reduced throughout the value chain. This is business-driven sustainability—internal operations evolving to spur product and supply chain innovation.

Introduction

Forward-looking companies are experiencing one of the largest paradigm shifts in the history of business—one in which leading organizations are hardwiring sustainability into design, production, sourcing and end use in order to ensure the lowest cost to themselves, their customers and the planet. Purchasers are driving innovation and producing dramatic savings by demanding sustainability throughout the life cycle of their acquisitions. Acquisition decisions need to be made in consideration of the following questions:

- How do environmental factors affect not only environmental but also financial and social costs?
- How can embedding sustainability into a "total cost of ownership" (TCO) approach to purchasing drive innovation in product development?
- How can we incorporate environmental benefits and cost savings into our products?

Understanding how sustainability shapes business goals has led to design and sourcing innovations at organizations as diverse as the **U.S. Department of Defense, General Motors, Hewlett Packard Enterprise, Unilever** and **Walmart**. Addressing costs throughout the value chain and product life cycle leads to more collaboration among partners, vendors and buyers, greater financial savings, and innovative product design. It also advances understanding of how sustainability initiatives affect business goals.

The major sellers and buyers mentioned above have emerged as leaders by creating a new framework for business in which sustainability is built into the core practices of product development, sales and procurement. By taking a TCO approach and assessing environmental factors throughout the life cycle of products and services, they are able to transform societal and environmental challenges into business opportunities.

What is TCO?

Total cost of ownership (TCO) refers to the total cost of owning a product or service. For both sellers and buyers, it provides a basis for understanding the direct and indirect costs of owning a product. Today, the concept of TCO has evolved beyond just manufacturing time and the costs of parts to include a myriad of factors including operations, research, training, risk and opportunity. With expanded environmental regulations and the volatile prices of natural resources, TCO is increasingly factoring sustainability into the cost of a product or service.

This shift in awareness of cradle-to-grave impact and risk helps sellers to innovate. At the same time, buyers are able to align their criteria for purchasing materials and products with their commitment to environmental issues, while reducing costs.

Most organizations have yet to tap this potential, which starts with measuring the emissions of their supply chains and those of consumers using their products. According to recent data from the not-for-profit CDP, which works with companies and investors to reduce their environmental impact, fewer than 20 percent of Global 500 companies even measure these emissions, known as Scope 3, and under 15 percent actually attempt to manage them.[4]

This presents an enormous business opportunity. By properly assessing the cradle-to-grave environmental impact of their products and services, organizations can uncover significant cost savings and push innovation in business.

4 CDP Global Dataset, 2016.

A new perspective: looking beyond the four walls

A new perspective: looking beyond the four walls

Companies need to consider the environmental impact of their supply chains and their customers. Many companies find that their own operations account for a small fraction of the cradle-to-grave environmental impact of their goods and services, according to academic studies[5] and CDP.

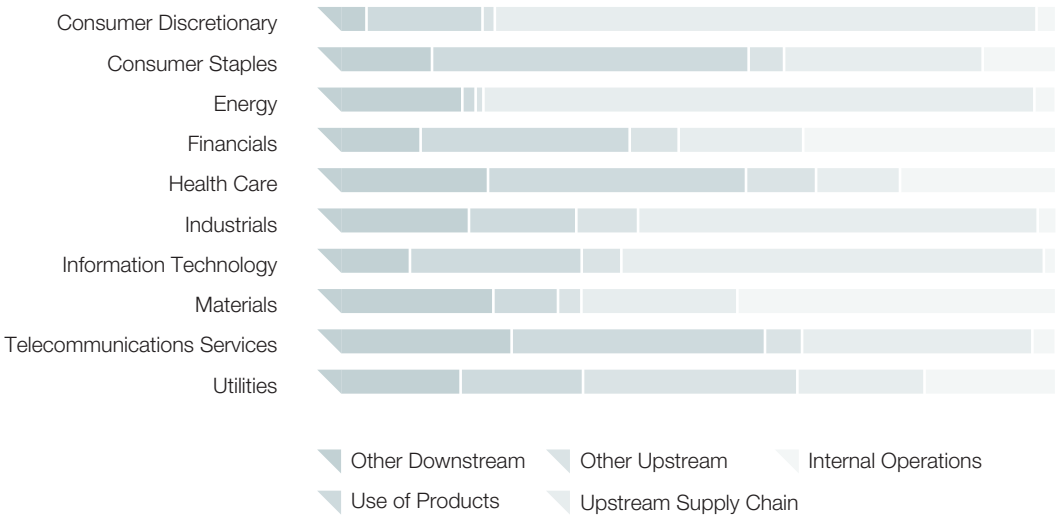
For instance, Figure 1 (following) shows CDP data for 290 companies reporting the greenhouse gas (GHG) emissions of their value chain, grouped by sector.[6] In most sectors, internal operations account for less than 20 percent of total GHG emissions. Most emissions come from the supply chain and/or from the use of their products and services.

5 See, for instance, Huang, Y.A., Weber, C.L., and Matthews, H.S., "Characterization of Scope 3 Greenhouse Gas Emissions for Streamlined Corporate Carbon Footprinting," *Environmental Science & Technology*, 43 (22), 8509–8515, 2009, and Huang, Y.A., Lenzen, M., Weber, C.L., Murray, J., and Matthews, H.S., "The role of input-output analysis for the screening of sectoral and corporate carbon footprints," *Economic Systems Research* (special issue on input-output analysis for carbon footprinting), Vol. 21, no. 3, 217–242, 2010.

6 These 290 companies reported on 13 or more Scope 3 categories in 2013, with at least six categories having estimates.

FIGURE 1

Average share of GHG impacts from value chain segments for ~290 companies comprehensively reporting Scope 3 emissions to CDP



Companies are increasingly working with their entire value chains to lessen environmental impacts across the product life cycle. According to recent CDP data, 77 percent of Global 500 companies responding to CDP said they engaged with their suppliers on climate change strategies in 2016, up from 67 percent in 2013. Their responses also indicated that 58 percent of the Global 500 engage with consumers on climate change topics, as their consumers are demanding environmentally sustainable products and services.[7]

As more businesses choose to look at their value chains to better assess environmental risks and costs, we are witnessing the emergence of a smarter approach to business—one in which companies have a clearer understanding of how environmental factors translate into financial returns.

7 Responses from CDP's climate change questionnaire collected in 2016.

CDP's supply chain program

CDP's supply chain program enables organizations to collaborate with key suppliers to manage climate and water risks and seize opportunities to succeed in a changing climate.

Global purchasing organizations experience significant exposure to environmental risks from the emissions and water management practices of companies in their supply chains. By embedding sustainability criteria into purchasing practices and collaborating with strategic suppliers, members of CDP's supply chain program are leveraging the power of disclosure to enable suppliers to take actions that reduce cost and build resilience. In 2016, 89 of the world's leading companies, with more than $2.7 trillion in collective annual spending, requested business-critical climate change and water information from more than 8,200 suppliers through CDP. In 2015, more than 4,000 suppliers from 82 countries made disclosures to customers through the CDP supply chain platform, contributing to the largest database of corporate environmental data in the world. This collaborative effort captures necessary data from suppliers while eliminating duplication, and provides a standardized platform for comparison and deeper analysis.[8]

8 CDP supply chain program.

BIG STRIDES FOR BIG BUSINESS

Walmart's suppliers report savings of $199 million through emissions reduction projects

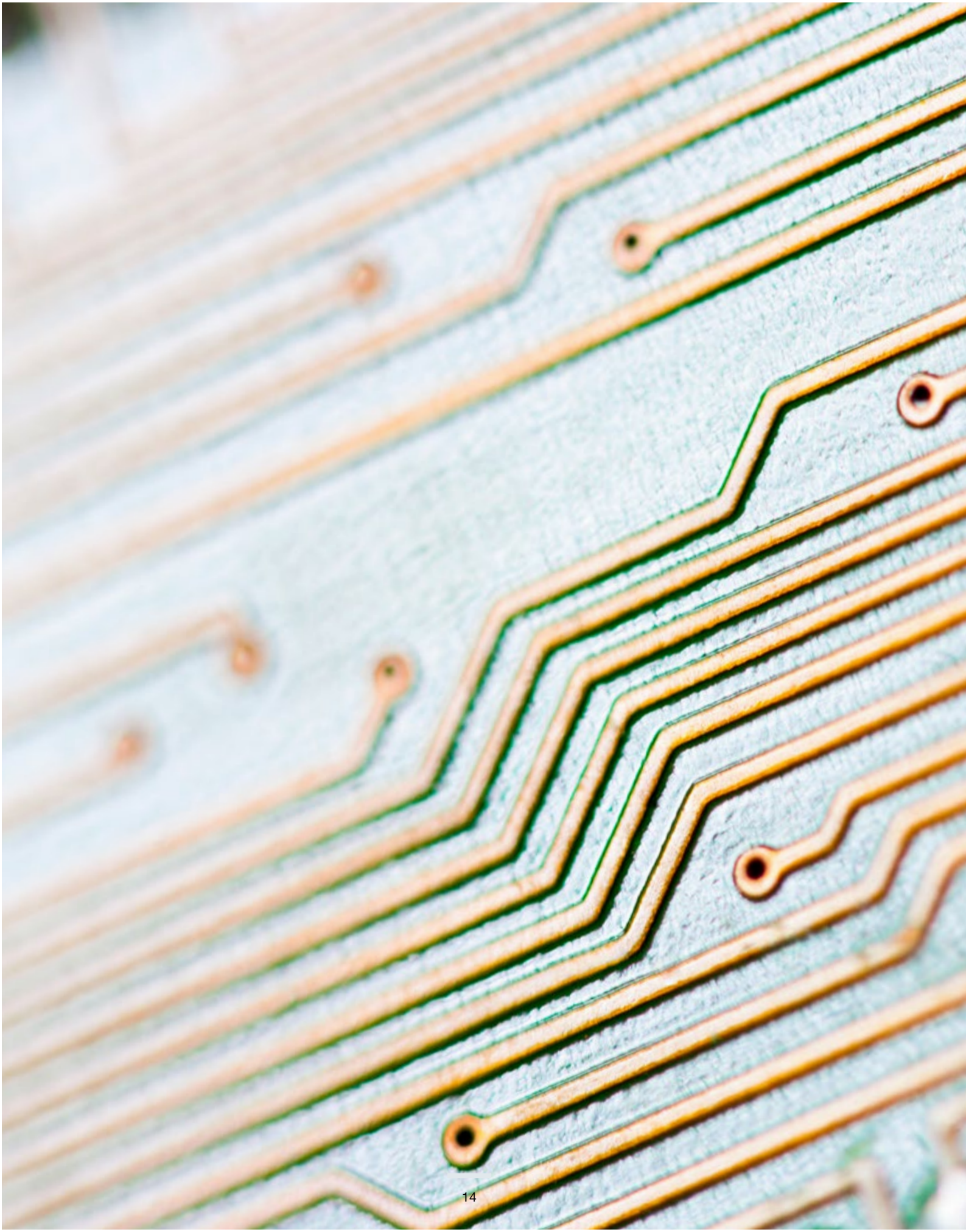
Walmart asked almost 1,200 of its largest suppliers to report their emissions performance in 2014 through CDP's Supply Chain questionnaire. Approximately 720 Walmart suppliers made disclosures, of which 550 (76%) reported GHG emissions and 365 (51%) reported an emissions reduction target. The emissions reduction projects reported by these suppliers realized US$199 million in savings and reduced the suppliers' emissions by over 108 million metric tons (MMT) of CO_2e. In 2015, Walmart achieved its goal of eliminating 20 MMT of GHC emissions from its global supply chain ahead of schedule, and has eliminated 28.2 MMT to date.

Walmart explains the rationale for engaging key suppliers in its own 2015 disclosure to CDP as follows: "We recognize that many of our suppliers are feeling pressure to integrate sustainable practices into their business or to make their products in ways that have less impact on the environment; however, we don't see this as a negative request of our suppliers. We see this as a motivating factor to help drive waste out of their businesses and their supply chains and save money in the long run. We believe that as our suppliers begin to make sustainable changes to their businesses, and while it may take an initial investment, it can provide a strong payback and significant savings thereafter."[19]

Unilever makes gains with sustainable living plan

One of the greatest benefits Unilever has seen from embedding environmental sustainability into its value chain is achieved through its Sustainable Living Plan. According to Pier Luigi Sigismondi, Chief Supply Chain Officer: "Unilever has made cumulative cost avoidance and savings of over €400m through eco-efficiency measures in our factories since 2008. All of our brands are now produced in factories that send zero waste to landfill across our global network of 240 factories in 67 countries. Our waste program since 2008 has avoided costs of more than €200m and created over 1,000 jobs."

19 Walmart's 2015 CDP Climate Change response



Technology industry drives innovation through early adoption

Technology industry drives innovation through early adoption

The explosion of data underlies a major shift in how the technology industry does business—and tracks costs. "Green IT" continues to be a hot topic of debate as governments, large businesses, and customers demand IT equipment that can process proliferating data with less energy. Such concerns have increased recently as new trends in IT—cloud computing, the rise of wireless and mobile devices, social media, the Internet of things, and big data—have collectively changed the technology landscape and the way data is created and consumed.

Approximately 10 percent of electricity globally goes toward powering the entire IT ecosystem—including data centers and communications networks, as well as the manufacture and use of computers and other connected devices—according to recent estimates that place electricity usage between 1,100 and 1,800 terrawatt-hours (TWh).[9] Data centers themselves currently account for 2 to 3 percent of global electricity demand, and the IT sector is among the fastest-growing users of energy.[10] Were it a country, the IT sector would be the 12th-largest national consumer of electricity.[11] In addition to the societal impacts, the electricity used by data centers costs managers up to $25 billion globally.[12]

A number of important trends are shaping the IT sector, especially the markets for server and data centers. For instance, driving the major build-out of the largest, or "hyperscale," data centers is the

9 Mills, M.P. (2013), "The Cloud Begins with Coal: Big Data, Big Networks, Big Infrastructure, and Big Power; An Overview of the Electricity Used by the Global Digital Ecosystem," available here.

10 "America's Data Centers Are Wasting Huge Amounts of Energy".

11 NRDC.

12 IDC, as cited by Mills, suggests this number was around $30 billion in 2012.

demand from third-party cloud services and the growing need to organize and analyze large data sets.[13] Even within traditional server workloads, like that of corporate IT, trends such as increasing workforce mobility and remote work require more intensive use of servers, as do the broader range of devices and growing multimedia content. Collectively, these trends are fueling exponential demand for computing and graphics, while taxing traditional servers' ability to provide these services efficiently.

The combination of these trends—an increasing market, changing demands, significant operating costs and a large-scale sustainability issue—makes today's server market ripe for large-scale innovation. Technology companies are researching and developing products that have lower use costs and environmental impact. A good example of this shift is Hewlett Packard Enterprise's (HPE's) development of a line of extremely low-energy servers that are optimized for operations such as big data analytics, HPC, virtual desktops, and media-processing usage, and that require dramatically less electricity to operate in a data center.[14]

~10% of electricity globally

goes toward powering the entire IT ecosystem—including data centers and communications networks

As part of this development process, HPE assessed the carbon impact of its entire value chain, a first for the IT sector.[15] In 2016, HPE received 40 requests from its corporate and government customers to share data through CDP's supply chain program, reflecting an increasing demand for such information on the part of those customers. Recognizing the need to engage its own key suppliers to ensure that they were collaborators in innovation, HPE joined CDP's supply chain program to disseminate its data to suppliers representing 95 percent of its production spend. With its newly acquired knowledge in hand, HPE saw that 94 percent of the GHG emissions associated with its products came from a combination of the use phase (53 percent) and its supply chain (41 percent).[16] For its server line, HPE discovered that GHG emissions in the use phase accounted for between 70 and 90 percent of total emissions

13 IDC (2014) Worldwide Hyperscale Server 2014–2018 Forecast: Strong Hyperscale Buildout Continues and IDC (2014) Worldwide Modular Server 2014–2018 Forecast and 2013 Vendor Shares

14 HPE Moonshot System http://www8.HPE.com/us/en/products/servers/moonshot/index.html.

15 HPE reported its full Scope 3 inventory (all 15 categories recognized by the GHG Protocol Scope 3 Standard) in May 2013.

16 Data taken from Hewlett-Packard Company's 2016 CDP response. Internal operations defined as Scope 1, Scope 2, business travel, and employee commuting; products as Use of Sold Products, and Supply Chain as all other emissions.

HP 2015 GLOBAL CARBON FOOTPRINT

over the product's life.[17] Significant efficiency gains in the use phase of servers can therefore have profound consequences for both HPE's footprint and that of its customers.

"Moonshot addresses the insatiable need for customers to add more digital services and manage server operating costs, as these costs have grown and become a significant part of their bottom line. This product helps to address the desire for reductions in cost, energy, space, and environmental impacts."

–Antonio Neri, EVP and GM, Enterprise Group, Hewlett Packard Enterprise

HPE seized on the market demand for servers that have higher utilization rates and significantly lower energy consumption while handling customer workloads more efficiently. The resulting Moonshot line of servers is part of a growing class of servers called Extreme Low Energy (ELE) servers or micro-servers. These servers have chassis that incorporate high-performance, energy-optimized server modules in different combinations to meet varying demands.

HPE achieved this optimization by asking suppliers to optimize server-grade processor, memory, networking and storage technology to reduce energy use yet maintain high performance. These server modules can support new Web-scale workloads, but use much less electricity and take up less space. Together, these innovations lower TCO by 15 to 75 percent.[18]

With innovative products like Moonshot, HPE customers save money on energy and space, suppliers find a willing buyer for energy-saving technology, and HPE develops a competitive product portfolio that cuts the environmental impact of its entire value chain.

17 See, for instance, Weber, C.L., "Uncertainty and Variability in Product Carbon Footprinting: Case Study of a Server," *Journal of Industrial Ecology*, 16(2), 203, and work by Apple, HPE, and Fujitsu.

18 Values taken from HPE's Moonshot ROI Business Calculator, developed using energy testing and modeling from HPE's Power Advisor. Range shows minimum and maximum range for different workloads. Workloads considered in this work are dynamic web (in both a virtualized and non-virtualized environment), application delivery, and video transcoding. More details available in Technical Appendix.

The Federal Government brings new shift to scale

In addition to multinationals, the U.S. government is integrating sustainability considerations into its value chain.

One such example is the world's largest supply chain: the **U.S. Department of Defense** (DoD), with a budget of $496 billion in FY2015.[20] The DoD has piloted an innovative guidance for assessing the hidden cost of environmental factors in the manufacture, operations, support, and disposal of its acquisitions. This acquisition guidance—the "Streamlined Life Cycle Assessment Process for Evaluating Sustainability in DoD Acquisitions"—will perform such assessments with efficiency and in the financial terms understood by acquisition officers and program managers. The guidance is being refined in collaboration with major suppliers such as **General Electric**, **3M**, and **Lockheed Martin**.

The DoD approach brings sustainability analysis to the fore, clarifying the total environmental and health impacts of the production and use of the goods and services it buys. With this shift from a traditional cost-benefit analysis to total life-cycle costs, both upstream and downstream, the guidance forces suppliers to monetize impacts and communicate them to senior leadership. With this information and buy-in, they can make better design and investment choices up front.

20 "DoD Releases Fiscal Year 2016 Budget Proposal"

DoD guidance five-step process

1 Define the Scope of Analysis

2 Develop a Life-Cycle Inventory (LCI)

3 Estimate Life-Cycle Impacts

4 Estimate Sustainability-Related Life-Cycle Costs

5 Synthesize Results and Iterate

Since the guidance was drafted, the DoD has completed five pilot programs with suppliers. Reactions to the programs have been extremely positive, and the DoD is currently updating its guidance based on the programs' findings. If officially adopted, the DoD's acquisition guidance could be of tremendous benefit, as it would encourage suppliers and partners along its substantial supply chain to ascertain that their offerings were in line with the DoD's new goals. This guidance could also serve as a model for other organizations to analyze the total costs of their value chain. (Please see the Case Study for a sample analysis of HPE's Project Moonshot Using DoD Guidance analysis and projection).

Similarly, other federal agencies are following suit and testing their own programs. In April 2016, the U.S. Department of the Navy joined CDP's supply chain program to ask its top 100 suppliers—including HPE and Lockheed Martin—to disclose their climate impacts, signaling that carbon efficiency will be a factor in awarding future contracts.

The U.S. General Services Administration (GSA) has been asking its largest vendors and contractors since 2015 to publicly disclose their GHG emissions and set targets for reducing them via CDP's supply chain program. The GSA says this initiative helps the agency to "operate more sustainably, while giving participating suppliers an opportunity to plan more comprehensively to cut costs and carbon in preparation for increasing carbon disclosure expectations in specific contracts in the future."[21]

These federal efforts at sustainability are being felt throughout the corporate sector, making clear that business can no longer meet the "bare minimum" in sustainability. And those who do not look at their entire value chain and product life cycle will miss out on future business opportunities from buyers choosing partners leading in sustainability.

21 U.S. General Services Administration: "GSA Launches New Supply Chain GHG Emissions Reporting Pilot."

Lockheed Martin

As a major military contractor, Lockheed Martin knows that 80 percent of defense program costs result from the use of products purchased. Consequently, Lockheed Martin has focused on designing its products in such a way as to cut costs and environmental impacts throughout their life span, which can top 30 years. By looking at the entire value chain, Lockheed Martin has been able to assess how environmental issues affect its own bottom line and its clients' total cost of ownership.

With this outlook, Lockheed Martin is well-prepared for guidance drafted by the Department of Defense. It is collaborating with the DoD on pilot projects to apply the guidance to the production and use of satellites, micro-grid architecture and air defense system components.

Lockheed has said, "The Department of Defense has historically focused on conventional costs to evaluate acquisitions, but has overlooked other significant costs." For satellites, such costs normally include that of input procurement, launches, labor and fuel, but not the costs of current and future regulations or so-called externalities such as the pollution costs borne by society. "Assessing the true costs helps the DoD create more sustainable and resilient architectures, given budgetary constraints."

By applying this DoD draft guidance, Lockheed developed an in-orbit space servicing solution that extended the life of existing satellites by several years, saving $2.4 billion over 10 years. Over $2 billion are direct cost savings to the DoD, mainly the result of reexamining the materials used in satellites and rockets. By reducing the manufacture and the number of launches of satellites, a Lockheed Martin solution can greatly reduce the costs of operation and deployment as well as the societal/environmental impacts, while maintaining the resiliency of its constellation of satellites. On a per-satellite basis, the proposed space servicing solution has a return on investment of 274 percent.

The U.S. Federal Government leads by example

In March 2015, the White House issued Executive Order 13693 to cut the U.S. government's GHG emissions by 40 percent over the next decade from 2008 levels. This could save taxpayers up to $18 billion in energy costs as the government raises the share of electricity it consumes from renewable sources to 30 percent.[22] A significant step for sustainable business in itself, the executive order also shows how the U.S. government is managing this process and what this means for suppliers. The Council on Environmental Quality, an executive-branch division that coordinates federal environmental efforts, is tracking whether major federal suppliers disclose and set goals to cut GHG emissions.[23] Additionally, the seven top federal purchasing agencies are each asked to propose five new procurements each year that include "contract requirements for vendors or evaluation criteria that consider contractor emissions and greenhouse gas emissions management practices."[24]

By establishing such a rigorous program for reporting and implementation, the executive order sends the clear message that the bar is being raised for federal agencies and their suppliers to manage emissions, cut costs and increase accountability.

22 Office of the Press Secretary FACT SHEET: "Reducing Greenhouse Gas Emissions in the Federal Government and Across the Supply Chain."

23 Council on Environmental Quality,"Federal Supplier Greenhouse Gas Management Scorecard"

24 See further details in the "Implementing Instructions for Executive Order 13693 Planning for Federal Sustainability in the Next Decade" at whitehouse.gov.

The ripple effect

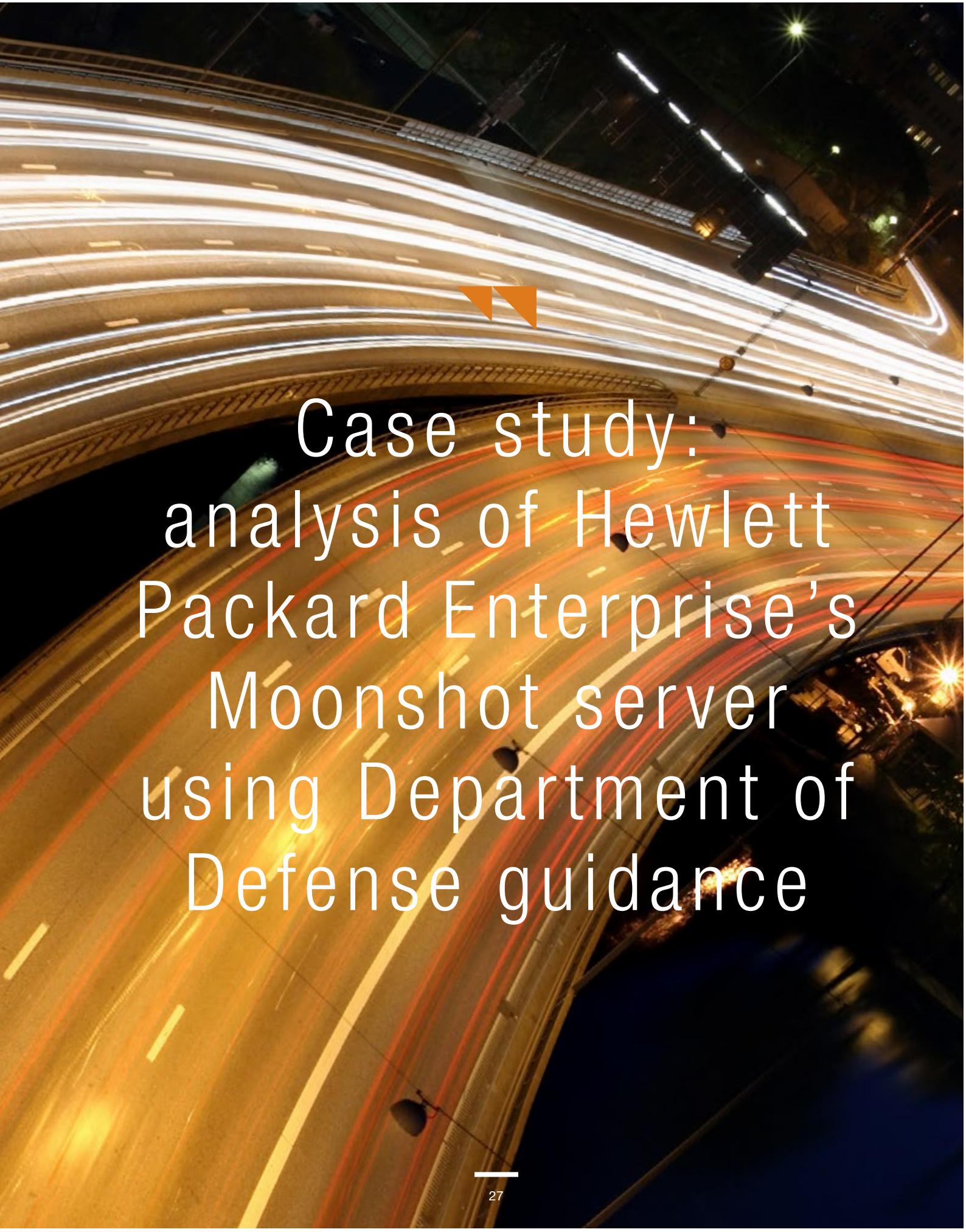
The ripple effect

We are in the midst of a major paradigm shift for business—one in which greater environmental accountability and better management of resources and costs drive businesses to look outside their own operations to hardwire sustainability into their value chains. As companies' own operations represent a small fraction of their cradle-to-grave environmental impacts and costs, companies are embedding sustainability in the core of product development, sales and procurement. Large environmental and financial savings accrue to companies that take a total-cost-of-ownership approach to sustainability. By looking at the total cost across their value chains, businesses and governments can begin to focus on engaging value-chain partners in creatively reducing financial and environmental costs.

By hardwiring environmental sustainability initiatives into TCO processes, organizations can follow in the footsteps of innovators like HPE and the Department of Defense to identify and account for hidden environmental costs throughout their value chain, while at the same time pushing new boundaries for innovation and sustainability. Collaboration among stakeholders is a key to effecting this transformation, enabling both buyers and sellers to create significant financial and environmental impact.

By reassessing costs and embedding sustainability in their procurement practices, purchasers are driving product innovation and a TCO approach throughout value chains. As sustainability becomes integrated into core business goals and practices, organizations are collaborating with upstream and downstream buyers to cut both emissions and costs. This creates a ripple effect, with suppliers and customers multiplying each other's environmental and economic impact.

The reward to business is tremendous, as shown in the above examples. From procurement to product sales, companies will reap the benefits in many forms across their entire value chain, including a more sustainable business, an innovative product line, greater customer loyalty, and the potential for major financial savings.



Case study: analysis of Hewlett Packard Enterprise's Moonshot server using Department of Defense guidance

CASE STUDY:

Analysis of Hewlett Packard Enterprise's Moonshot server using Department of Defense guidance

This case study analyzes the potential cost savings of Hewlett Packard Enterprise's (HPE's) Moonshot servers based on the U.S. Department of Defense's (DoD's) draft acquisition guidance, which assesses the life-cycle impacts and costs of purchased systems. This is meant as an illustrative calculation for buyers based on DoD's analysis method—not an official DoD calculation.

The following section estimates the energy, CO_2, and broader sustainability savings of upgrading from an average traditional server to a Moonshot energy-optimized system. It applies DoD's acquisition guidance as a method to show how a buyer would assess the total cost of ownership and external costs over a five-year period. Additional technical details associated with this analysis can be found in the "Technical Notes" section of this report.

Applying the method[25] to HPE's energy-optimized Moonshot servers reveals considerable savings in regard to both financial and environmental impact. HPE's internal testing and energy

25 The DoD's acquisition guidance method was altered slightly in the analysis performed here, mostly to account for the difference between public and private sector discount rates (a 7% internal discount rate is assumed in this analysis, whereas the acquisition guidance would call for a 0.4% discount rate based on the current yield of a 5-year U.S. Treasury Bond).

modeling shows that a Moonshot server reduces a customer's energy consumption by 20 to 90 percent, depending on the workload for which it is designed and operated. It occupies only 10 percent of the data center space of traditional servers of similar performance.

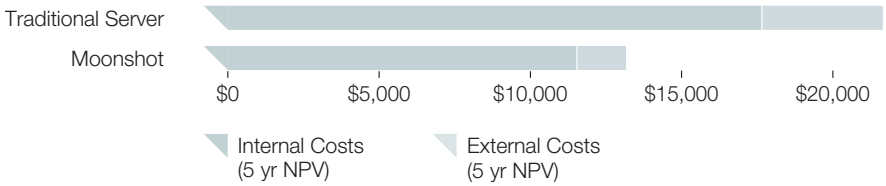
Following is an illustration of the average potential savings from three workloads where energy-optimized servers can effectively compete: dynamic web, application delivery, and video transcoding. Energy-optimized servers, such as Moonshot, lead to substantial savings in sustainability as measured by total external costs and financial performance (i.e., TCO). Figure 2 below shows average internal cost (i.e., TCO over 5 years with a 7 percent discount rate) and external cost (i.e., sustainability), in which energy-optimized servers like Moonshot show TCO is 35 percent lower and environmental impacts 45 percent lower.

For example, on a non-virtualized dynamic web workload, customers save 27 percent on total cost of ownership—15 percent lower up-front costs and 65 percent lower operating costs. On this workload, they can reduce their environmental impact by 60 percent, largely through using 65 percent less energy during the product's life cycle.

Other workloads can produce even larger energy savings.[26] Where environmental impact is concerned, most categories tracked by the DoD method are dominated by the use phase of the servers (for example, 90% of climate impact from traditional servers is related to product use). On the other hand, there is considerable environmental impact from producing the servers, such as human and ecosystem toxicity and metal

FIGURE 2

Streamlined sustainability assessment of 1 traditional server vs. the equivalent performance Moonshot solution, averaged across 3 typical workloads



26 For instance, comparing traditional servers to Moonshot devices for application delivery and video transcoding workloads produces energy savings of approximately 70% and 90%, respectively. Comparing Moonshot servers to traditional servers on a virtualized dynamic web workload reveals 20% energy savings. See "Technical Appendix" for further details.

depletion (the production phase represents about 60%, 50% and 90% of the total life-cycle impact in these categories, respectively).

On a societal scale, we have estimated the potential savings between 2015 and 2019, both in line with current estimates of sales of energy-optimized servers and assuming an optimistic scenario of energy-optimized servers replacing all traditional rack servers within that period. The potential savings in both scenarios are dramatic. Current estimates are that energy-optimized servers will grow considerably from 2 percent of the total server market in 2015 to 11 percent by 2019.[27] This would save nearly 40 TWh of electricity and more than 30 million tons of CO_2 emissions, the equivalent of taking 6 million cars off the road for a year. This is also the equivalent of taking 9 coal-fired power plants off the grid for one year.[28] In this scenario, customers would save up to $3.8 billion in energy costs and the total environmental impact could be reduced, in economic terms, by up to $6 billion.

These totals represent projections only of expected sales. If all organizations took a total-cost-of-ownership and life-cycle sustainability perspective, and all applicable traditional servers were replaced by energy-optimized devices over the next five years,[29] we estimate triple the savings: 120 TWh of electricity, $12 billion of internal energy savings, $20 billion of total environmental impact, and a reduction of 100 million tons of GHG emissions worldwide. This is the equivalent of taking more than 20 million cars off the road for one year, or removing 29 coal-fired power plants from the grid for one year.

The potential GHG emissions avoided through Moonshot products are one to five times the emissions from all of HPE's internal operations over this five-year period. In other words, the use of one new product line could save up to five times the amount of emissions that HPE incurs for all its operations.[30] By looking outside its company walls for sustainability advances, sales opportunities and new markets, HPE can multiply its emissions savings many times over while creating new sales opportunities in a growing market.

27 Based on extrapolation to 2019 of Gartner's 2014 forecast of the projected market penetration of extreme low-energy (ELE) servers. See Gartner (2014) Forecast: Extreme Low-Energy Servers and Processors, Worldwide, 2014. Values represent number of x86 servers replaced by ELE servers assuming an equivalence of 3–4 ELE processors to every one typical x86 processor replaced.

28 Estimate from US EPA.

29 Given the wide potential range of applications and the five-year period, it is difficult to estimate this potential. As described in the "Technical Appendix," this optimistic projection builds on projections of density-optimized server sales by IDC and several market forecasts for microserver sales, including Oppenheimer (2012, "Cloudy with a Chance of ARM"), and IDC (2014, "Worldwide and U.S. Server 2014–2018 Forecast Update: 2Q14") in addition to basic desk research and comparisons to publicly available estimates from RBC Capital Markets, Transparency Market Research, and Markets and Markets. In total, these sources suggest that the total applicable market (given a total market capture of all server workloads capable of using energy-optimized devices) is at least 18% of the total x86 market. It is assumed, based on HPE's internal guidance, that on average one traditional server will be displaced by one Moonshot cartridge.

30 Hewlett-Packard Company's internal emissions (Scope 1 and Scope 2) were reported as 1,432,100 metric tons CO_2e in 2015 according to CDP data. We compare this to the projected annually averaged savings associated with HPE's share of the energy-optimized market using the market total values derived above. HPE's market share was estimated internally using projected sales values.

Sustainability TCO and the potential of energy optimized servers

LOW END:

Expected sales of energy optimized servers through 2019

30M tons of CO_2 = **6M** cars off the road*

9 coal-fired power plants offline*

Customer energy savings: **$3.8B**

Environmental impact savings: **up to $6B**

*for one year

HIGH END: TRIPLE THE SAVINGS

Imagining a sustainability TCO approach (all applicable traditional servers replaced with energy optimized devices through 2019)

100M tons of CO_2 = **20M** cars off the road*

29 coal-fired power plants offline*

Customer energy savings: **$12B**

Environmental impact savings: **up to $20B**

*for one year

One HPE product, Moonshot, can avoid the equivalent of the emissions of HPE's internal operations by up to 5 times

Technical notes

Technical notes

Goal and scope

The goal and scope of this analysis was to compare the life cycle of a typical, traditional rack-mount server to an equivalent system of HPE Moonshot servers in a streamlined approach across several types of server workloads (dynamic web with and without virtualization, application delivery, and video transcoding).

Previous work

Life-cycle assessment (LCA) of electronics has been a growing field for several years, owing to the increasing awareness of the energy usage of data centers and the cloud, as well as to the energy and resource intensity of producing electronic components, semiconductors in particular.[31] Generally, this work has shown a somewhat important production phase and a relatively more important use phase, although these vary depending on the type of electronic device, assumed lifetime, and the type of environmental impact considered (it should be noted that some authors find a considerably more important production phase[32]). Previous work specific to servers has generally shown the use phase to represent 75 to 95 percent of the carbon footprint associated with the server's life cycle, depending on assumptions regarding the useful life, use profile, and electricity mix associated with the use phase. The relatively high importance of the use phase is due primarily to the relatively longer life of servers compared to that of other personal electronics (i.e., smart phones), as well as to a much higher proportion of active use due to relatively more continuous workloads. However, the production phase can become dominant even with the relatively long life and high usage, depending on the electricity mix associated with the use phase.[33]

Data and methods

In general, streamlined LCA approaches can make use of one of two types of methods: input-output–based methods or process LCA–based methods (or a hybrid thereof). The use of input-output and hybrid methods (as are used in the DoD acquisition guidance) is challenging in the case of relatively fast-changing technologies like electronics, for two reasons: first, because production methods change relatively quickly, and, second, because prices change quickly, so the proper inputs to the model are not always clear. While process LCA methods face the same challenges vis-à-vis quickly changing production methods, price uncertainty plays a particularly large role in the case of electronics, therefore a streamlined-process LCA approach was chosen. Three primary data sets were utilized: teardown

31 Estimate from US EPA.

32 See Williams, E. (2004) "Energy Intensity of Computer Manufacturing: Hybrid Assessment Combining Process and Economic Input-Output Methods." *Environ. Sci Tech.* 38 (22) 6166–6174.

33 See, for instance, Weber, C.L., "Uncertainty and Variability in Product Carbon Footprinting: Case Study of a Server" *Journal of Industrial Ecology* 16(2), 203, and work by Apple, HPE, and Fujitsu.

data for the typical rackmount server from Teehan (2013),[34] the Ecoinvent 3.1 database, and an internal return-on-investment (ROI) calculator built by HPE.[35]

Functional unit (HPE ROI calculator)

The functional unit selected was the life cycle of one traditional rack server and the equivalent number of Moonshot server cartridges assumed in the HPE ROI calculator for each workload.

Different server implementations perform with varying efficiently across different workloads, and so too does the specific traditional server and Moonshot cartridge performance vary across workloads. For targeted workloads, the indicated number of Moonshot servers provides equivalent or greater performance than one traditional server due to efficiency improvements inherent in the Moonshot design. The workloads considered in this analysis were chosen for a combination of their overall expected future importance and their applicability to energy optimization (dynamic web hosting—both virtualized and non-virtualized, application delivery, and video transcoding). Table 1 below shows key characteristics of both the traditional and Moonshot servers across the workloads.

TABLE 1

System parameters for assumed servers across chosen workloads

Workload	Traditional server model	Number and type of processors: traditional	Moonshot cartridge	Number and type of processors: moonshot	Moonshot cartridges per traditional server
Dynamic web	HPE DL320e Gen 8	1 Intel® Xeon® E3-1200v2	HPE Proliant m300	1 Intel® Atom™ C2750 Processor	1
Dynamic web virtualized	HPE DL380p Gen 8	2 Intel® Xeon® E5-2600 v2	HPE Proliant m300	1 Intel® Atom™ C2750 Processor	10
Application delivery	HPE DL380p Gen 8	2 Intel® Xeon® E5-2600 v2	HPE Proliant m710	1 Intel® E3-1284Lv3, 1.8GHz (3.2Ghz Turbo)	3.5
Video transcoding	HPE DL380p Gen 8	1 Intel® Xeon® E5-2600 v2	HPE Proliant m710	1 Intel® E3-1284Lv3, 1.8GHz (3.2Ghz Turbo)	0.5

34 Teehan, P., and Kandiklar, M. (2013), "Comparing Embodied Greenhouse Gas Emissions of Modern Computing and Electronics Products," *Environmental Science & Technology* 47, 3997–4003.

35 HPE Moonshot Business Value Calculator

The HPE ROI calculator was also used to determine functional equivalencies for the support system for the servers (racks and switches) as well as the total power usage associated with each system's use phase in each workload. Because of the modular design of the Moonshot system, less supporting equipment is needed (for example, in the dynamic web workload, the Moonshot system requires one server rack versus two for the equivalent traditional server solution, and two rack switches versus four). The Moonshot system also requires less network cable, but this was assumed to be immaterial to the system's life-cycle impacts.

Production phase (Teehan [2013] and Ecoinvent 3.1)

Teehan (2013) provides teardown information for the electronic server and rack switches, which forms the basis of the streamlined bill of materials for the production phase of the traditional rack servers and rack switches. Teardown information is often utilized for electronics LCAs because of the need for detailed measurements of the circuit board and integrated circuit within the modeled product. It is assumed that the server and rack switches from Teehan (2013) are similar enough to current-generation servers and switches (its total mass) to serve as a model for this streamlined study. Modeling of the server and switch followed the methods of Teehan (2013), with only slight alterations, to add a hard drive to the server and to adjust the number of processors in 2P servers (for web-virtualized and application delivery workloads). Following Teehan (2013), an alteration was made to the Ecoinvent 3.1's approach to integrated circuitry by adjusting the integrated circuit process to match the measured silicon dye content. Answers for carbon footprint were checked with Teehan's (and other previous) results and were found to be comparable, typically within 5 to 10 percent. All processes used in Teehan's study (which utilized Ecoinvent 2.1) were bridged to their equivalent Ecoinvent 3.1 process.

After deriving initial results for the traditional server, it was determined that, consistent with previous results, the production phase represented less than 15 percent of the total impact associated with the production and use phases across workloads (range from 3 to 11 percent) over an assumed 5-year lifetime. Because of the relatively minor importance, and because of the lack of data for newer-generation technology such as system-on-a-chip processors, it was conservatively assumed that the production phase of the considerably smaller Moonshot system was roughly equal to the production of the equivalent traditional system. This is likely to be a very conservative assumption, owing to the fact that across most workloads the fully equipped Moonshot system weighs over 80 percent less than the equivalent traditional system, and Teehan (2013) has shown that generally the impacts (at least the carbon footprint) of producing electronics scale close to linearly with mass. However, this was seen as an adequate assumption for the streamlined goal of this project.

Use phase (HPE ROI calculator)

The ROI calculator provides data on the annual power consumption for the equivalent systems across each workload. These data are taken from a combination of laboratory testing and simulation. For example, for the dynamic web workload in a non-virtualized environment, the ROI calculator estimates roughly 24,000 kWh/yr for the Moonshot system and 67,000 kWh/yr for the traditional system for 45 traditional servers and 45 m300 modules. The assumed PUE factor is 1.7 for all systems, and it is assumed that electricity costs $0.10 per kilowatt hour. All reported energy values take into account power consumption by the servers and rack switches as well as estimated cooling power based on a 1.7 PUE. The environmental impacts (emissions, water use, land use, etc.) associated with all power were modeled as a global average based on data from the International Energy Agency and Ecoinvent 3.1 (values thus represent life-cycle impacts including upstream production of fuels as well as T&D losses). An average value for typical energy savings per traditional server displaced was constructed based on a simple linear average of the workloads.

End of life

Based on input from HPE that the end of life of its traditional servers and that of its Moonshot servers were likely similar, and based on previous analyses finding that end of life represents a very small proportion of certain environmental stressors (e.g., carbon footprint), the phase was assumed to be equal between Moonshot and traditional solutions.

Impact assessment

All environmental impacts associated with production and use of the traditional server and Moonshot systems were valued using Enviance's patent-pending method for evaluating the environmental and financial materiality of environmental impacts.

Market size estimates

To explore the potential impact of energy-optimized servers such as HPE's Moonshot devices it was necessary to estimate the potential market size for such servers within the overall electronic server market. A variety of market research reports on the extreme low-energy (ELE), microserver, and overall server market were consulted.[36] Constructing such an estimate is somewhat challenging, since a variety of terminology is used to describe similar parts of the server market (ELE, microserver, energy-optimized server) and is not fully consistent, and market estimates are made using a variety of units including ELE/microserver units sold, traditional servers displaced by ELE/microservers, and total revenue. As discussed above, this study assumes a different number of Moonshot cartridges equivalent to one traditional server for each different workload and traditional

36 Given the wide potential range of applications and the 5-year period, it is difficult to estimate this potential easily. As described in the "Technical Appendix," this optimistic projection builds on projections of density-optimized server sales by IDC and several market forecasts for microserver sales, including Oppenheimer (2012, "Cloudy with a Chance of ARM") and IDC (2014, "Worldwide and U.S. Server 2014–2018 Forecast Update: 2Q14"), in addition to basic desk research and comparisons to publicly available estimates from RBC Capital Markets, Transparency Market Research, and Markets and Markets. In total, these sources suggest that the total applicable market (given a total market capture of all server workloads capable of using energy-optimized devices) is at least 18% of the total x86 market. It is assumed, based on HPE's internal guidance, that on average one traditional server will be displaced by one Moonshot cartridge.

server type where possible, consistent with HPE's internal ROI calculator. This compares to different assumptions across analysts' reports on the functional equivalence of ELE/microservers to traditional x86 servers; for instance, Gartner assumes an equivalence of three to four ELE processors for every traditional x86 server processor displaced.

Generally, market estimates for ELE servers only were taken as a lower boundary on market potential for two primary reasons. First, HPE's internal calculations show that the functionally equivalent number of energy-optimized servers to one traditional server varies but can be less than one for some workloads (see Table 1), and previous analysts assumed lower equivalent performance. Second, it is unclear whether previous analysts' definitions include all processors used by energy-optimized servers, including new-generation energy-optimized Intel Xeon processors (as used in two of the workloads considered here).

It was therefore assumed that if server procurers took a total-cost-of-ownership and sustainability perspective, the broader market potential could be considerably larger. To derive this broader market value, several market projections were consulted, including projections of microserver, density-optimized server, and ELE server sales. The final speculative value used here assumes that at least 18 percent of the total x86 market *could* be displaced by energy-optimized devices if all applicable server workloads that could use energy-optimized devices did so.[37]

About CDP

CDP, formerly Carbon Disclosure Project, is an international, not-for-profit organization providing the global system for companies, cities, states and regions to measure, disclose, manage and share vital information on their environmental performance. CDP, voted number one climate research provider by investors, works with 827 institutional investors with assets of US$100 trillion and 89 purchasing organizations with a combined annual spend of over US$2.7 trillion, to motivate companies to disclose their impacts on the environment and natural resources and take action to reduce them. More than 5,600 companies, representing close to 60% global market capitalization, disclosed environmental information through CDP in 2015. CDP now holds the most comprehensive collection globally of primary corporate environmental data and puts these insights at the heart of strategic business, investment and policy decisions. Please visit https://www.cdp.net/ or follow us @CDP to find out more.

About HPE

Hewlett Packard Enterprise (HPE) is an industry leading technology company that enables customers to go further, faster. With the industry's most comprehensive portfolio, spanning the cloud to the data center to workplace applications, our technology and services help customers around the world make IT more efficient, more productive and more secure. Please visit www.hpe.com to find out more.

37 See footnote 30.

CDP contacts

Paul Simpson
CEO

Lance Pierce
President, CDP North America

Betty Cremmins
Senior Manager, Supply Chain

Maxwell McKenna
Partnerships Manager

Media inquiries

Zoe Tcholak-Antitch
Communications, CDP North America
Zoe.antitch@cdp.net

Co-author of HPE Moonshot case study

Enviance
www.enviance.com

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Addison
Design by Addison www.addison.com

CDP North America Strategic Partner

Hewlett Packard Enterprise