A new standard for Scope 3 emissions transparency

Contents

Foreword

For over two centuries and into modern times, human ingenuity and the ongoing industrial revolution have led to great advancements, although with significant negative impact on our world's climate. Greenhouse gas emissions due to our industrious achievements have contributed to an increase in the earth's temperature, such that an additional increase of 1.5 degrees Celsius could result in catastrophic outcomes.

Responding to this rapidly unfolding crisis, governments and industries are being called to action. If public and private sectors can critically examine the underlying causes of climate change, intervene, and innovate, we will be able to help significantly reduce emissions and waste across industrial supply chains. In addition, the ability to scale circular economy models can lead to sustainable growth; growth that is decoupled from our dependency on natural resources.

Microsoft has made a commitment to become carbon negative by 2030, and to remove the impact of all our historical emissions by 2050.[1] Because of this commitment, we are compelled to focus on Scope 3 emissions, representing one of the largest contributors to greenhouse gas emissions, and attributed in great measure to processes within our supply chains.

In this regard, Microsoft cloud services and infrastructure represent an area of significant importance, as cloud services continue to scale globally. Accurate and transparent accounting and actionable reporting of Scope 3 cloud emissions can be daunting, requiring insights across diverse suppliers, partners, services, and infrastructure, often representing varying degrees of maturity and adaptability. Such methodologies must assume an integrated lifecycle view of supply chains, across the key areas of planning, design, sourcing, procurement, manufacture, distribution, usage, and circular approaches to maximizing the useful life of all infrastructure and materials, to encourage a shift towards sustainable closed loop models.

Building upon and extending the work reported in a 2018 paper from Microsoft, "The Carbon Benefits of Cloud Computing," this whitepaper offers insights into the Microsoft approach to methodologies for the calculation of Scope 3 cloud emissions. Based on these methodologies, with data derived across our cloud supply chain, and with a view to offering our customers transparent insights into the emissions impact of their Azure service usage, we present the inclusion of Scope 3 emissions within the Microsoft Sustainability Calculator. This calculator enables users to consistently and transparently view actionable cloud emissions data across relevant impact points in the value chain, across all scopes of emission.

As sustainability insights become more embedded within value chains, integrated decision-making will enable significant positive environmental impacts to help stabilize the earth's climate and restore its natural balance. Microsoft is committed to making and empowering continual progress, on this journey with our customers, partners, and communities.

Anand Narasimhan
General Manager of Cloud Supply Chain Sustainability Organization in Azure

[1] Brad Smith, "Microsoft will be carbon negative by 2030," Official Microsoft Blog, 16 January 2020, https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/

Executive summary

Greenhouse gas (GHG) emissions that occur upstream and downstream of an organization's core operations can be extensive, and for many sectors, make up the largest sources of emissions across the value chain.[2] Due to this significance, these indirect emissions are becoming more widely understood, and are a primary focus of sustainability and climate stewardship initiatives.

Microsoft is on a journey to cut its own emissions by more than half by 2030, including our direct emissions and those of our entire supply and value chain.[3] To achieve this goal, we are developing tools and processes to track our progress and guide our decision-making. We are also developing tools to empower our customers to do the same. Through the Microsoft Sustainability Calculator, we invite our customers to join us on this journey.

As depicted in Figure 1, the value chain encompasses Microsoft Azure cloud computing service and includes upstream carbon emissions from suppliers and logistics providers to manufacture and deliver component and hardware for use in our datacenters. Our own core operational datacenter carbon emissions are also emitted during the hardware use phase. After their useful life, downstream carbon emissions are emitted by Microsoft electronic waste recyclers and IT asset disposition circularity partners.

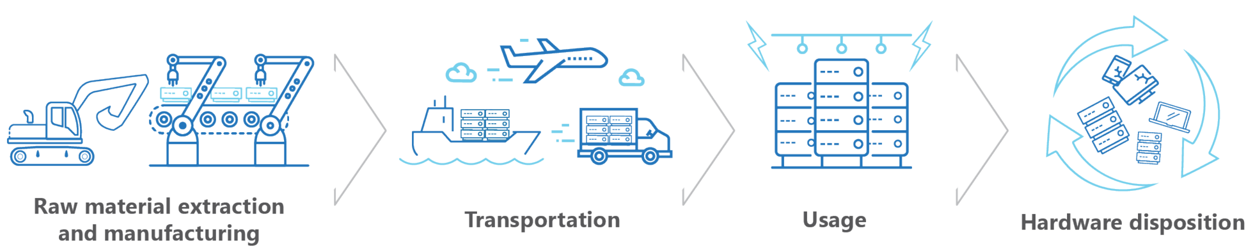

Figure 1: Microsoft Azure cloud computing value chain

Microsoft developed a new methodology to improve its estimation of its own value chain emissions and allocate those emissions effectively to customers. The process, outlined in Figure 2, (1) models component-level GHG emissions, (2) aggregates those emissions to the datacenter and region levels, and (3) allocates them to customers based on their Azure usage by month and

[2] Nicole Labutong, "How can companies address their scope 3 greenhouse gas emissions?," CDP, 13 July 2018, https://www.cdp.net/en/articles/companies/how-can-companies-address-their-scope-3-greenhouse-gas-emissions
[3] Brad Smith, "Microsoft will be carbon negative by 2030," Official Microsoft Blog, 16 January 2020, https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/

region. This methodology enables Microsoft to provide customers with their Azure-based emissions totals based on their specific hardware profiles, datacenters, and reporting month.

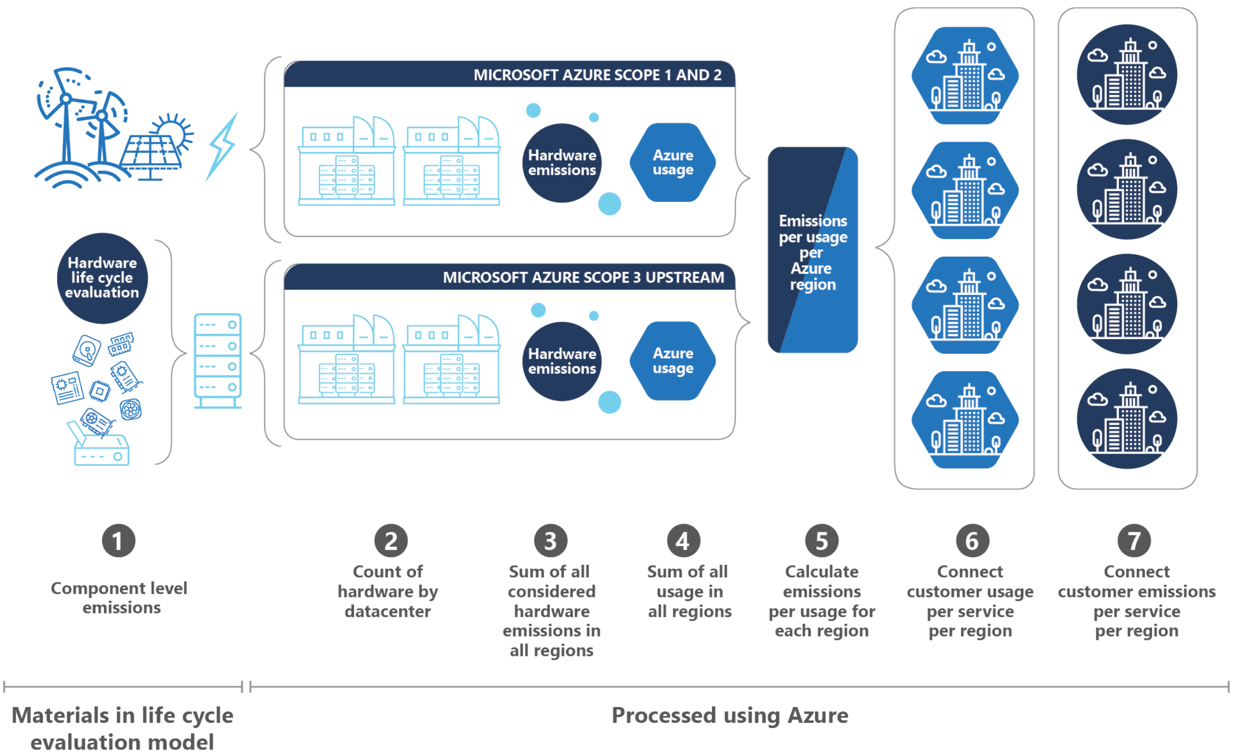

Figure 2: Microsoft Azure customer emissions allocation methodology

The Microsoft Sustainability Calculator is an innovative web-based user interface that allows our cloud customers to access the Microsoft emissions associated with their Azure cloud usage. The dashboard allows segmenting customer Scope 3 emissions data by Azure service type, region, and timeframe and provides information on public reporting. The Microsoft Sustainability Calculator allows Microsoft cloud customers to track their carbon emissions, carbon intensity scores, projected end-of-year emissions, and estimated emissions savings compared to certain model on-premises solutions.[4]

[4] "The carbon benefits of cloud computing," Microsoft, 2020, https://download.microsoft.com/download/7/3/9/739BC4AD-A855-436E-961D-9C95EB51DAF9/Microsoft_Cloud_Carbon_Study_2018.pdf

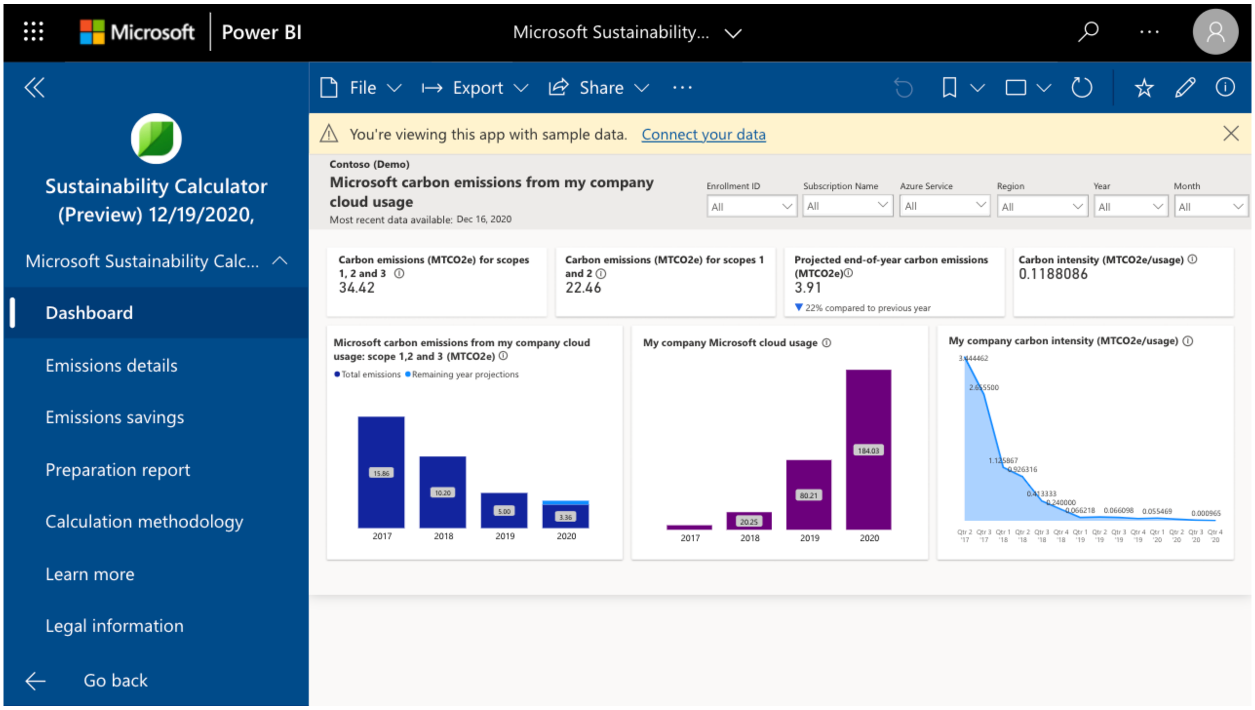

Figure 3: Microsoft Sustainability Calculator dashboard

The virtuous cycle of accurate, transparent scope tracking and reporting holds great potential for positive change. Realizing that change depends on proactive, collaborative efforts by companies with a will to lead. This paper is one step along a positive path, which we hope will spur further, greater steps by our customers and partners.

Introduction

Background, context, and introduction to cloud computing

Exponential growth in cloud computing is revolutionizing technology to such a degree that this era may be regarded as the Fourth Industrial Revolution (4IR). As described by the World Economic Forum, 4IR will feature major technological advances in artificial intelligence, robotics, genomics, materials sciences, 3D printing, and more. Businesses, governments, and civic institutions will collect, store, and analyze data at an unprecedented scale, speed, and depth. Cloud computing (large-scale, shared IT infrastructure available over the internet) is the engine that enables these technology advancements, which in turn drive cloud uptake as businesses strive to reduce total cost of ownership, realize greater business agility, deliver economies of scale, and offer ubiquitous data and application access.

This paper builds on the Microsoft report, "The carbon benefits of cloud computing," and its 2010 report, "Cloud Computing and Sustainability: The Environmental Benefits of Moving to the Cloud." This whitepaper presents a Scope 3 methodology to allow customers to transparently estimate their procured Microsoft cloud-based datacenter emissions within their value chains. In the 2018 report, Microsoft detailed a methodology to quantify and compare the energy and carbon footprint impacts of its cloud services IT applications with on-premises solutions. Among other key findings, that paper found that although total energy for cloud computing is expected to increase, cloud computing is significantly more energy- and carbon-efficient than traditional on-premises datacenter solutions. Microsoft is continuing to take aggressive steps toward reducing energy usage and has maintained 100 percent renewable electricity (achieved partially through power purchase agreements and renewable energy certificates) to power its datacenters. Microsoft is now looking beyond its own direct operational footprint to identify additional reduction opportunities across our value chain. For this updated study, Microsoft engaged WSP USA, a global consultancy with expertise in environmental sustainability, to validate the modeling of customer allocation of the upstream production and downstream hardware disposition emissions of the Azure cloud infrastructure.

Though the world's reliance on cloud computing is accelerating, the efficiencies gained by shifting from traditional on-premises datacenters to cloud operations is expected to keep the associated energy requirements essentially flat. By most estimates, in 2019, global datacenters consumed 200 terawatt-hours (TWh) of electricity each year, roughly 0.8 percent of the total electricity consumed globally. In North America alone, datacenters consume about 79 billion kilowatt-hours (kWh) of electricity each year—roughly 1.5 percent of the total electricity consumed in North America. Due to ongoing datacenter efficiency improvements, this number is expected to remain about the same through 2022 (while at the same time, global internet traffic and datacenter workload will dramatically increase) for the industry, as noted in Figure 1 below. This number would be higher if not for the material and emissions efficiencies that many commercial cloud datacenters can offer over on-premises solutions. The ongoing exponential growth of datacenters makes realizing those efficiencies even more critical.

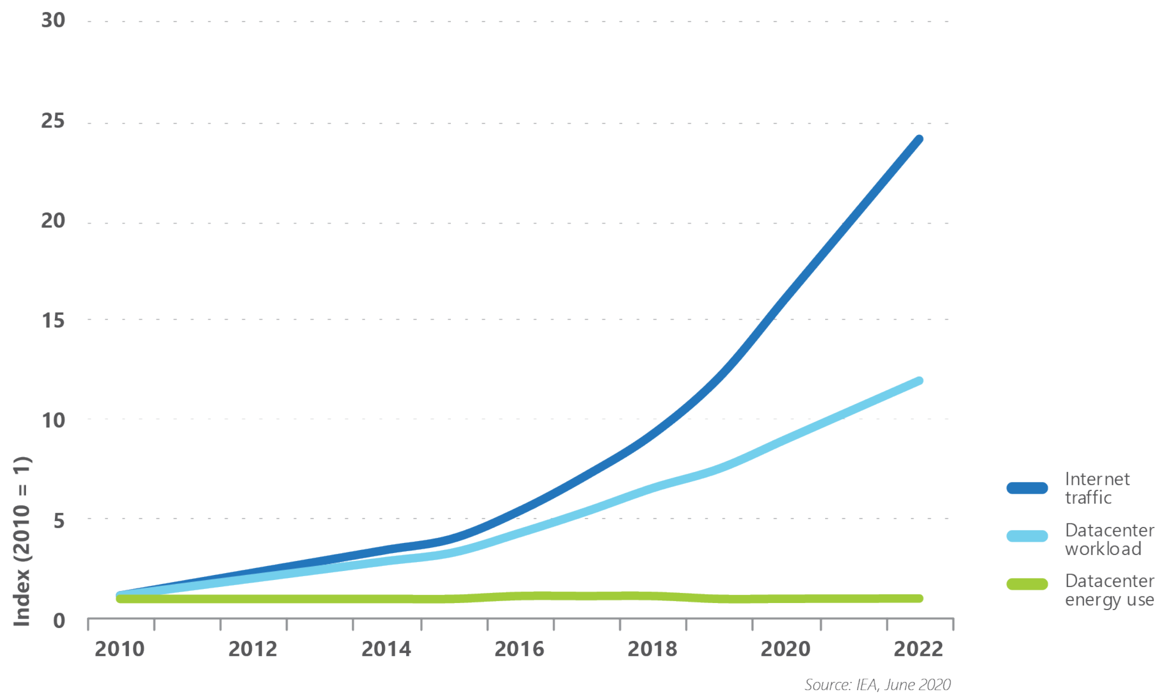

Figure 4: Global trends in internet traffic, datacenter workloads, and datacenter energy use, 2010-2022

Increasing demand for computing services is inevitable, and significant cloud growth will likely continue for the foreseeable future. This situation provides a unique opportunity to make significant contributions to energy efficiency, and Microsoft has recently announced a company-wide commitment to become carbon negative by 2030[5]—inclusive of its direct emissions and entire value chain. Microsoft has committed to removing by 2050 all the carbon the company has emitted (either directly or by electrical consumption) since it was founded in 1975.[6] Many Microsoft customers are making similar commitments, and Microsoft is committed to helping and empowering their journeys.

[5] Brad Smith, "Microsoft will be carbon negative by 2030," Official Microsoft Blog, 16 January 2020, https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/
[6] Brad Smith, "Microsoft will be carbon negative by 2030," Official Microsoft Blog, 16 January 2020, https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/

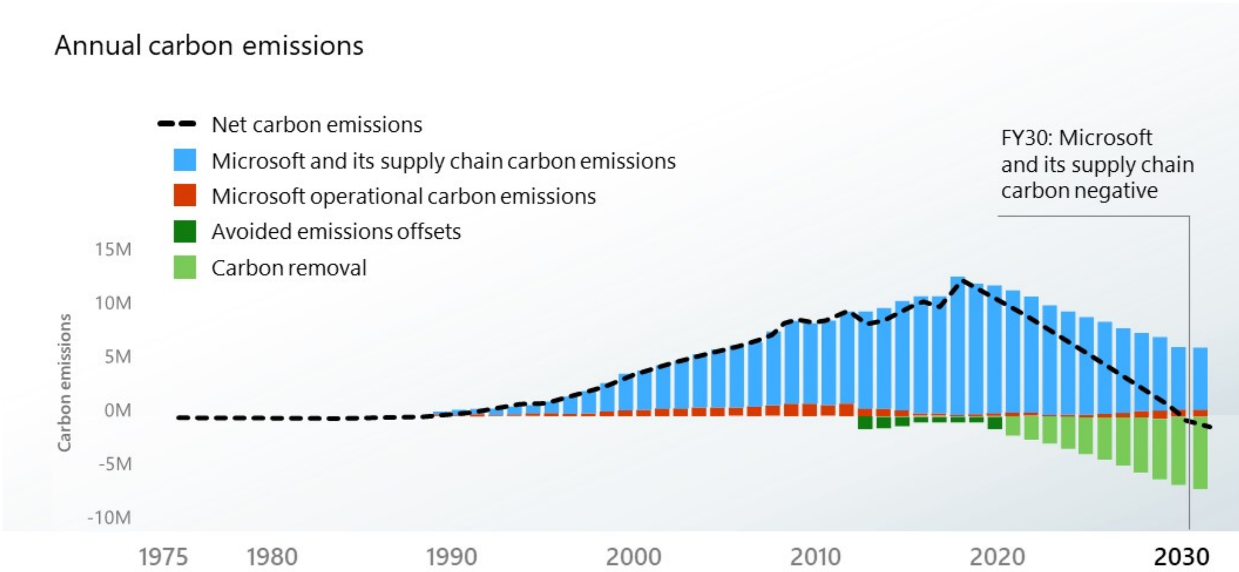

Figure 5: The Microsoft pathway to carbon negative by 2030

There has been a growing focus on value chain emissions due to evolving climate science and the recent formation of influential industry coalitions that promote and support organizational target setting. The Science Based Targets Initiative (SBTi) is a collaboration between the Carbon Disclosure Project (CDP), the United Nations Global Compact (UNGC), World Resources Institute (WRI), the World Wide Fund for Nature (WWF), and others. SBTi defines and promotes best practices and calls on companies to set targets aligned with science to limit global warming to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit warming to 1.5 degrees Celsius. SBTi criteria require carbon accounting across a company's value chain. Microsoft has established a SBTi target and is aiming to help empower cloud service customers to establish aggressive goals to reduce their carbon footprints.

For Microsoft (and many of its cloud customers), supply chain carbon emissions are much larger than those from direct operations and more difficult to quantify.[7] This represents a significant and largely unaddressed area of emissions, although a company's lack of direct control over its value chain activities can make collecting transparent and accurate supplier data difficult.

The private sector has enormous potential to drive environmental action. However, with supply chain emissions 5.5 times greater than operational emissions on average,[8] companies that are able should leverage their purchasing power and collaborate with their supply chains to create meaningful impacts. However, a critical component of this collaboration is that to calculate accurate data to provide *to* their supply chains, companies must first receive accurate data *from*

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[7] Nicole Labutong, "How can companies address their scope 3 greenhouse gas emissions?," CDP, 13 July 2018, https://www.cdp.net/en/articles/companies/how-can-companies-address-their-scope-3-greenhouse-gas-emissions

[8] "Global Supply Chain Report 2019," CDP, accessed 17 March 2021, https://www.cdp.net/en/research/global-reports/global-supply-chain-report-2019

their supply chains. Thus, supplier engagement and access to accurate, transparent, and practical data are necessary but sometimes challenging; without actionable data, organizations often have limited options for the data management and performance tracking needed to drive reductions.

Nevertheless, every company that is serious about reducing their emissions must include supply chain emissions in their efforts. When one company calculates its supply chain emissions, it can initiate a positive feedback cycle: To accurately quantify its supply chain emissions, a company must collect information from its suppliers. Its suppliers must then calculate their product-specific operational emissions (which may also encourage them to calculate their supply chain emissions). As reducing value chain emissions becomes the focus, the aim is that market forces will reward those who are most successful in doing so. As this process unfolds, carbon emissions accounting will become more standardized, and companies will have more information to help make better, longer-term decisions. This is a virtuous cycle that helps improve business, the earth's balance, and people's lives.

The current need for action, combined with the rapidly growing interest in value chain carbon impacts, offers large companies like Microsoft opportunities to establish supplier synergies and empower customers. As noted in Microsoft President Brad Smith's blog post,[9] the Microsoft Scope 3 reduction commitment will enable our customers to better understand the carbon impacts of their business with us, discover the potential benefits of fully migrating to Azure, and more completely and accurately report their IT service carbon footprints for the often hard-to-track Scope 3 emissions.

[9] Brad Smith, "Microsoft will be carbon negative by 2030," Official Microsoft Blog, 16 January 2020, https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/

Background

Scope 3 emissions as the next frontier in greenhouse gas management

The purpose of this paper is to share the steps Microsoft is taking to measure the carbon impacts of cloud computing infrastructure across its value chain to promote reductions and empower cloud customers to take similar action. Microsoft is making the results of this methodology available for Azure customers through the Microsoft Sustainability Calculator which is outlined later in this paper. These value chain emissions include carbon from both our upstream suppliers and logistics providers and downstream from electronic waste recyclers and IT asset disposition circularity partners. It is important to note the distinction between upstream and downstream, and one aim of this paper is to build and expand on previous efforts to improve energy and carbon efficiency from the direct operation of our Azure cloud datacenters.

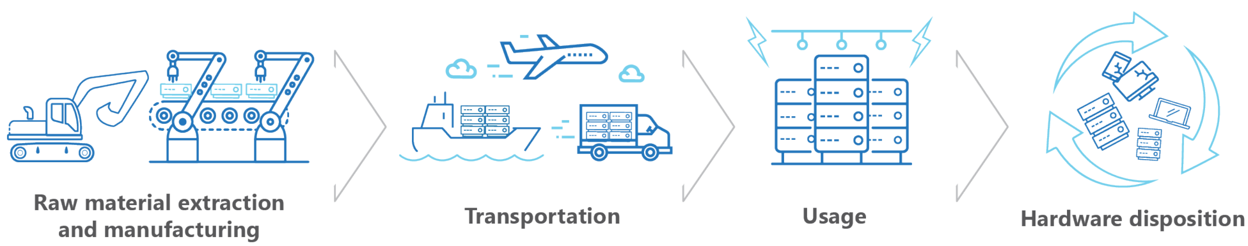


Figure 6: Product life cycle steps that result in Scope 3 emissions

It can be helpful to discuss emissions in "carbon math" accounting terms—the basic mathematical concepts that are important for understanding how carbon emissions relate to an organization's own footprint and those of its suppliers, customers, and peers. The Greenhouse Gas (GHG) Protocol[10] defines carbon accounting best practices and provides standards, guidance, tools, and training for businesses and governments to measure and manage carbon emissions. Per GHG Protocol (GHGP) guidance, carbon emissions are generally classified into three categories, known as scopes:

- **Scope 1:** emissions that directly result from business activities, such as stationary combustion of fuels for backup power generation in cloud datacenters.

[10] "Greenhouse Gas Protocol Corporate Accounting and Reporting Standard," Greenhouse Gas Protocol, accessed 17 March 2021, https://ghgprotocol.org/corporate-standard

- **Scope 2:** emissions that indirectly result from producing energy, such as exhausted from an electric power plant (Microsoft has committed to procuring 100 percent renewable electricity across our global operations, including datacenters).
- **Scope 3:** emissions that indirectly result from all other business activities, such as those associated with the upstream raw materials extraction, manufacturing, and delivery of cloud-based IT asset infrastructure (such as servers) from suppliers to be used in our cloud datacenters. This also includes emissions that occur from our circularity partners during the recycling process and disposal for IT hardware reuse.

The following illustration shows the relationship between the scopes within the value chain:

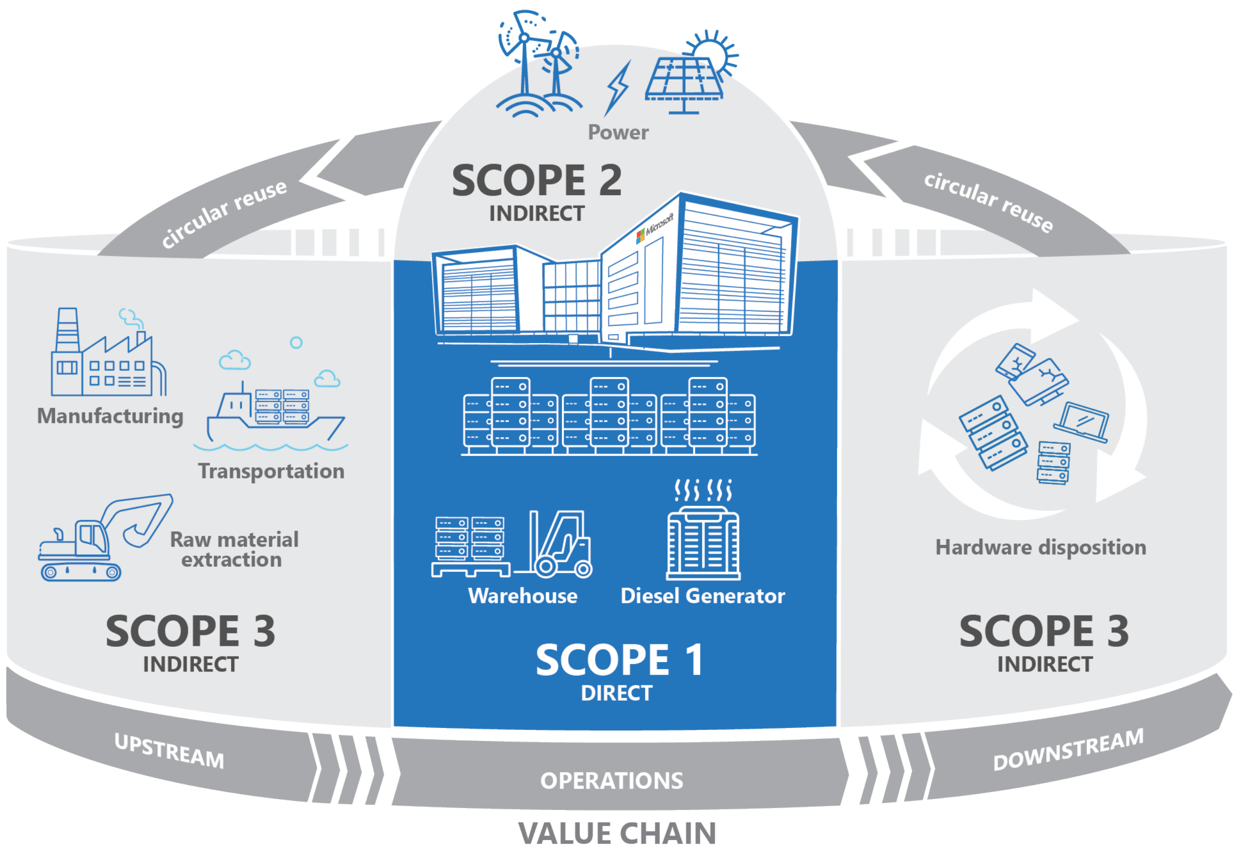


Figure 7: Examples of Scope 1, 2, and 3 carbon emission types in Microsoft cloud value chain

For many organizations (apart from certain direct-emission heavy sectors such as manufacturing and energy), their Scope 3 emissions are much larger than their Scope 1 and 2 emissions. This is because many companies purchase goods and services, such as datacenter hardware equipment, manufacturing, and disposition services, from suppliers instead of engaging their own in-house operations (which would create more Scope 1 and 2 emissions). For example, while a company may not be directly involved in raw material extraction or manufacturing, it may be indirectly responsible for the resulting GHG emissions because their products or services result from those emissions. Scope 3 emissions occur both up and downstream in value chains and result from component and hardware production processes, cloud service datacenter operation, hardware disposition management, and more. Therefore Scope 3 emissions can be so extensive—most value chains account for about 40 percent of global GHG emissions.[11] In 2020, Microsoft expects to emit roughly 16 million metric tons of carbon. Of this total, about 100,000 will be Scope 1 emissions, and about 4 million metric tons will be Scope 2 location-based emissions.[12] The remaining 12 million metric tons will be Scope 3 emissions.

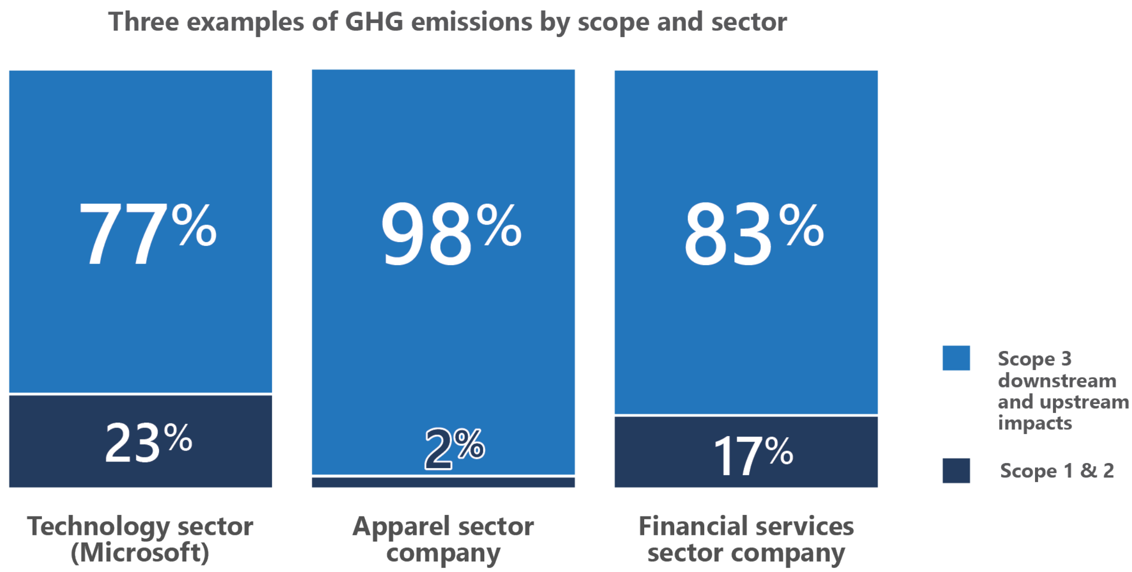


Figure 8: Three examples of GHG emissions by scope and category

A critical aspect to understanding emissions accounting is that the same emissions that are Scope 1 or 2 for one organization can be Scope 3 for another. For example, Microsoft Azure cloud services (as outlined in this paper) result in Scope 1, 2, and 3 emissions for Microsoft, but the allocated share of these emissions all count as Scope 3 emissions for Microsoft cloud customers who purchase those services. The matrix below illustrates these relationships.

[11] Nicole Labutong, "How can companies address their scope 3 greenhouse gas emissions?," CDP, 13 July 2018, https://www.cdp.net/en/articles/companies/how-can-companies-address-their-scope-3-greenhouse-gas-emissions
[12] Brad Smith, "Microsoft will be carbon negative by 2030," Official Microsoft Blog, 16 January 2020, https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/

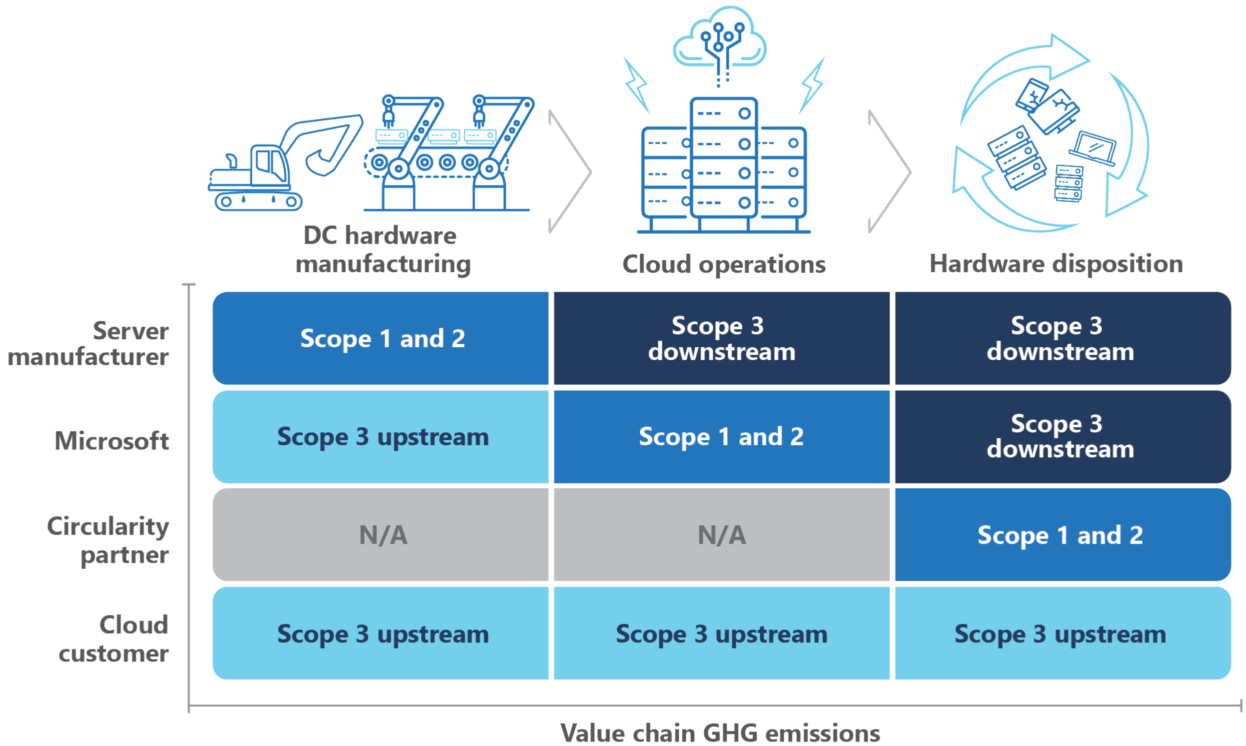


Figure 9: Carbon accounting scopes by stakeholder (Microsoft, partners, customers, etc.)

The GHG Protocol offers an example of counting the emissions of electricity generation used for an electrical appliance: the electricity generator's Scope 1 emissions are the appliance users' Scope 2 emissions, which are the appliance manufacturer and appliance retailers' Scope 3 emissions.[13] As such, each participant in this emissions microcosm has an opportunity to reduce their emissions share: (1) the electricity generator can use lower-carbon sources for generation, (2) the appliance manufacturer can increase their product's efficiency, (3) the appliance retailer can feature energy-efficient appliances in their store, and (4) the appliance user can use their appliance more efficiently. When each participant takes their effort seriously, the result of this multi-focused approach is an overall emissions reduction in this one microcosm that can combine with others to create powerful, global change.

This inter-relation between carbon scopes, suppliers, and customers puts Microsoft in a unique position and provides opportunities to unlock efficiencies with our cloud infrastructure suppliers and circularity providers, empower our cloud customers, and bridge the gaps between each.

[13] "Corporate Value Chain (Scope 3) Standard," Greenhouse Gas Protocol, accessed 17 March 2021, https://ghgprotocol.org/standards/scope-3-standard

Empowering cloud customers

The Scope 3 value chain methodology outlined in this paper will enable Microsoft cloud customers to better understand their cloud workloads' carbon impacts, discover the benefits of fully migrating to Azure, and allow more complete and accurate reporting of carbon footprints for Scope 3 emissions. Efforts like these are of growing importance due to the significant number of Microsoft cloud customers that include Scope 3 emissions in their science-based targets and require easy access to actionable data. The urgency of recent climate-science data has made addressing Scope 3 emissions a high priority for many companies that are serious about reducing their climate impacts.

More and more companies are voluntarily acting to reduce carbon across their entire value chain and setting targets to align with limiting global carbon to a 1.5 degree Celsius future. As described above, the Science Based Targets initiative (SBTi) helps promote the transition to a low-carbon economy. Currently, over 1000 companies are setting science-based emissions targets based on SBTi criteria, which (among other things) states that if Scope 3 emissions account for more than 40 percent of a company's overall emissions, that company must establish a target to negate that impact. The preferred target order is (1) absolute targets aligned with approved SBTi methods, and (2) intensity targets aligned with approved SBTi methods or supplier engagement. Companies may set one or more of these types of targets to cover at least two-thirds of their Scope 3 emissions.

While managing Scope 1 and 2 emissions can be challenging, doing so for Scope 3 emissions is much more so because they are more difficult to account for and control. Many Microsoft customers find measuring and managing Scope 3 emissions difficult due to the challenges of collecting transparent and accurate data across their many different suppliers, providers, and customers, and the complexities of current methodologies for obtaining value chain data.

Research approach

Methodology introduction

Microsoft has developed a new methodology (described below), which is third-party verified methodology for quantifying the aggregated life cycle carbon impacts of individual IT asset components across its cloud value chain and allocating them to cloud customers' specific usage per Azure service. The verified approach has advantages over other approaches, such as those that use common industry-average, supplier-specific, financial-based modeling; advanced industry-average service; and supplier-specific service intensity. Microsoft methodology will help advance industry best practices for more accurate estimation of accounting for Scope 3 emissions—as it is cloud-specific materials-based (as opposed to financial-based) and scalable across multiple services. The methodology is unique because it allows Microsoft to calculate its total cloud-specific emissions down to specific IT assets while still providing customers with emissions totals at the service level specific to their use. This provides more actionable Scope 3 data and more ways to reduce emissions over time.

Conventional financial modeling fails to account for procurement changes unless there is a direct spending change—in fact, under the financial model, spending more to achieve reductions can increase a company's apparent emissions. Focusing on materials helps solve these problems by providing more options and levers for achieving emissions reductions. For example, by requiring more carbon-efficient materials in products ordered from suppliers, organizations can more effectively measure, manage, and reduce their Scope 3 footprints. Results like these have informed Microsoft Scope 3 methodology.

The chart below compares the benefits of using the Microsoft Sustainability Calculator with the two most widely used current methods: the financial model and product or service-level life cycle evaluation. The Microsoft Sustainability Calculator solves scalability and geographic specificity challenges and performs in near real time. The current iteration of the calculator is a strong starting point that will further evolve to include the latest life cycle evaluation methods.

Scope 3 customer empowerment

Benefits	Financial model	Product or service-level life cycle evaluation	Microsoft sustainability calculator
Simplicity	○	○	○
Industry-specific	○	○	○
Microsoft cloud-specific	—	○	○
Accurate and actionable data	—	○	○
Scalability across infrastructure	—	—	○
Geography-specific	—	—	○
Near real-time performance tracking	—	—	○
Consistent methodology across time and products	○	—	○

The benefits in this figure were measured using specific scenarios for the Microsoft Sustainability Calculator. Results may vary depending on the design or configuration of these methods.

Figure 10: Scope 3 customer empowerment

Life cycle phases

To properly evaluate the life cycle impact of Microsoft Azure datacenters, it is important to understand their value chain locations and specific boundary constraints for the life cycle stages that are evaluated in this approach. Because Microsoft operates Azure datacenters using various types and quantities of IT hardware equipment (such as servers and racks), Microsoft must evaluate upstream supply chain hardware impacts prior to their use in Microsoft business operations. Because they are the first upstream point that this methodology captures, raw materials (such as plastics and metals) must first be extracted or reclaimed from old parts to manufacture new IT components such as disk drives and computer chips. After the materials extraction and manufacturing phase, the IT components are assembled into various IT hardware components (such as servers). After assembly, the finished products must be transported via multiple transportation modes (such as road, ocean, and air) for delivery to a Microsoft Azure datacenter dock. Once unpacked, the equipment is used in Microsoft Azure datacenter operations over their useful lifetime and then replaced by newer, potentially more energy-efficient equipment. Finally, during the downstream value chain hardware disposition phase, the equipment is recycled and reclaimed for reuse or re-assembly into newer parts, and the cycle begins again. When necessary, certain items may be securely disposed of. As outlined below, the full value chain contributes to this cycle's energy use and greenhouse gas outputs.

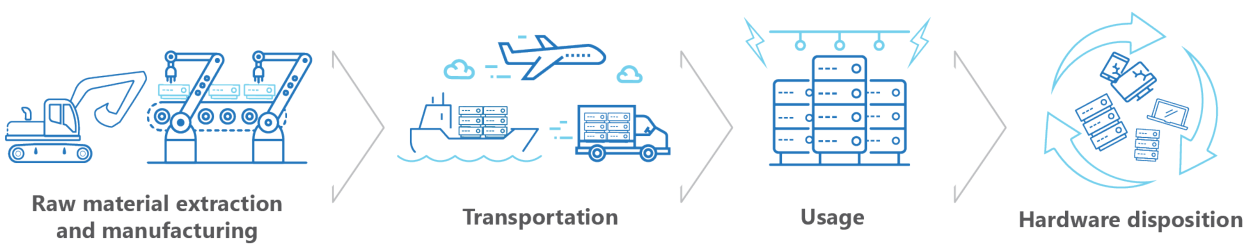


Figure 11: Value chain contributions to energy use and GHG outputs

The energy consumption and emissions for the life cycle phases described above include:

- **Raw material extraction and manufacturing**: using raw materials and assembling servers, networking equipment, and hard drives.
- **Transportation**: transporting IT equipment from the manufacturer to Microsoft datacenters. This will be included in future calculations, but at time of this paper's publication, transportation in supply chain information is limited.
- **Usage**: using electricity to run the servers, networking equipment, hard drives, and datacenter infrastructure (such as lighting, cooling, and power conditioning). Where relevant, usage also includes energy from internet data flows.
- **Hardware disposition**: recycling and reclaimed for reuse based on conservative assumptions about recycling rates.

Microsoft will refresh this model over time primarily through additional lifecycle assessments and evaluations from manufacturing of hardware components and continual improvement of transportation models.

Methodology process overview

Microsoft now quantifies carbon emissions in its cloud service based on aggregated IT hardware emissions and allocates them equitably to customers based on their actual usage. Microsoft customer-specific data outputs from this methodology will be available to all Microsoft cloud customers via a web tool called the Microsoft Sustainability Calculator, where they can be tracked, managed, and exported to help advance a variety of powerful carbon reduction efforts.

The flow chart below depicts the seven-step process included in the Microsoft Scope 3 methodology. These two methodologies further consolidate the seven steps:

- **Methodology for Microsoft Scope 3 emissions**: quantifying Microsoft Scope 3 cloud emissions at the individual component and IT hardware level
- **Methodology for Azure customer allocation**: connecting emissions to organizationally allocated cloud customer emissions based on service-level usage

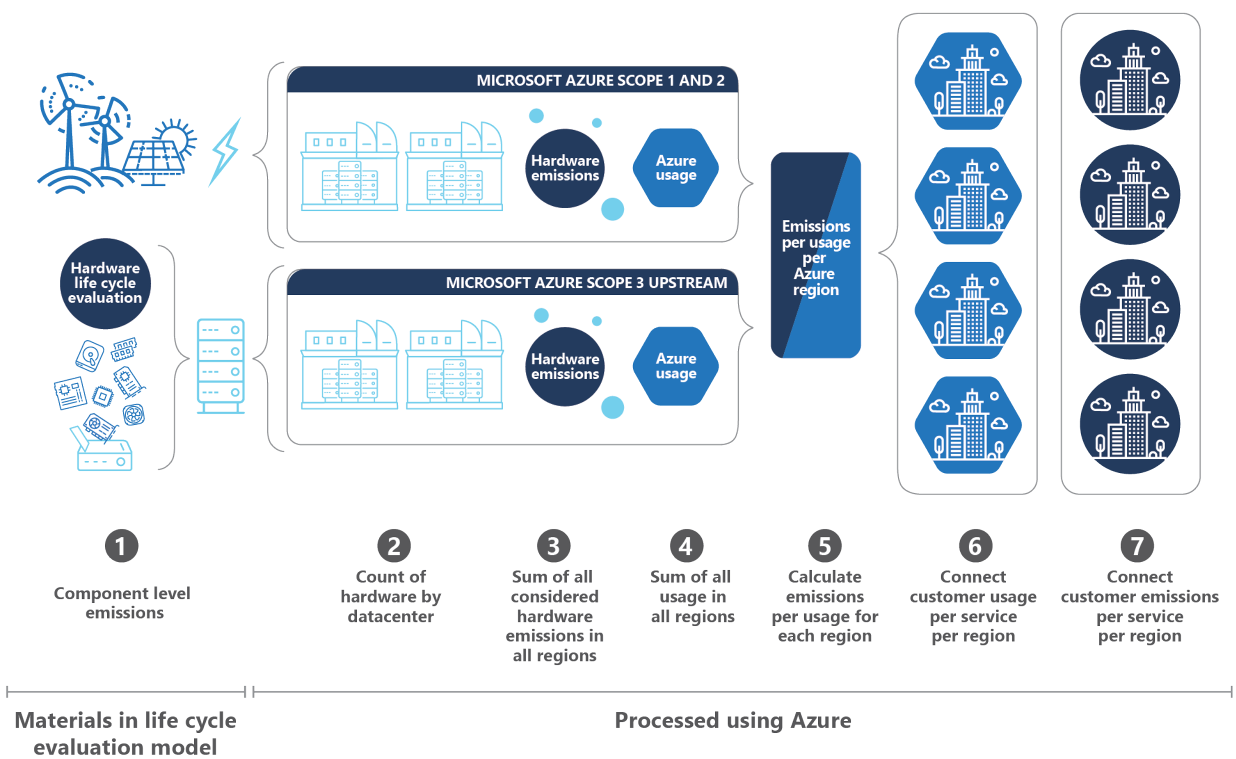


Figure 12: Scope 3 emissions allocation methodology

Methodology for Microsoft Scope 3 emissions

Step 1: Calculate cradle-to-gate and hardware disposition emissions for components and hardware

IT hardware equipment such as servers and network devices are comprised of thousands of individual components—common components include:

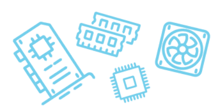
Number	Component Type	Description	
1	Rack	Rugged metallic construction that houses all IT equipment	
2	Disk drive	Component that stores data	
3	Server blades	Component that integrates many other components to perform computation	
4	FPGA	Field programmable gate array is a server component	
5	Power supply units	Component that provides stable power to servers	
6	Other	All components that do not fit into the categories listed above	

Figure 13: Common components in infrastructure

Microsoft previously developed and had verified an internal methodology, *Material Circularity and Life Cycle Carbon Emission Calculator v7.3*, to calculate component-level life cycle GHG emissions impacts of IT components such as those shown above. Using emission factor outputs for components from this methodology, we can calculate GHG emissions by aggregating component-level emissions contained within assembled IT hardware parts. Based on the hardware characteristics in our portfolio, we then combine these component-level emissions values to determine hardware-level emissions.

To quantify emissions, the process applies independently verified cradle-to-gate and hardware component-level life cycle evaluation emission factors to specific Azure hardware components that comprise common hardware types. Upstream cradle-to-gate emissions captured in these emissions factors include life cycle stages for component-level manufacturing, warehousing, and transportation to the Microsoft datacenter dock. Downstream hardware disposition emissions factors used for this analysis include hardware disposition, treatment, and disposal-transport factors for each hardware component.

Step 2: Calculate datacenter emissions for a given month

To calculate total Scope 3 hardware emissions for a given datacenter, Microsoft aggregates the hardware-level life cycle emissions from Step 1 above with hardware procurement databases for datacenter hardware. The approach uses material compositions to quantify individual component emissions across Microsoft Azure datacenters and calculates GHG emissions from materials used in a piece of IT equipment over an assumed lifetime of six years—if the equipment's actual life extends beyond that, its Scope 3 emissions for the extended time will be zero. If its actual life is shorter, the emissions will continue to be counted for the six-year estimate to ensure comprehensive accounting. This assumption is based on the average lifespan of cloud infrastructure materials within Microsoft datacenters.

After calculating all component and hardware-level emissions relevant to a given datacenter, Microsoft can determine the total emissions for a specific datacenter over a given time period using emissions aggregation.

Step 3: Calculate Azure datacenter region emissions

Because Microsoft operates its datacenters with an Azure regional model, this methodology aggregates emissions from individual datacenters using datacenter regional mapping.

Methodology for Azure customer allocation

Microsoft allocates IT hardware-based Azure cloud service emissions to individual cloud-based customers based on their Azure service usage. As outlined in the four steps below, Microsoft has developed a bottom-up approach for quantifying datacenter-specific emissions based on specific hardware types and then allocating the aggregate emissions to the individual customer level. This allocation approach and implementation through the Microsoft Sustainability Calculator were independently verified to ensure consistency with the GHG Protocol.

Step 4: Calculate total customer usage of Azure cloud services

To allocate Microsoft Scope 3 hardware emissions to Azure customers, Microsoft defines usage as the normalized cost metric associated with an IaaS, PaaS, or SaaS service. The process uses metric units because it is a usage measurement applied to all customers and is normalized to exclude discounts and other variables—the process attributes the total usage to Microsoft customers over specific time periods. Note that total Azure customer usage includes both direct customer use and a proportionate amount of overhead server capacity dedicated for delivering Microsoft Azure cloud services.

Step 5: Calculate Azure region-specific emission factors

Through a combination of total Azure datacenter region emissions in proportion to total Azure customer usage, we identify an Azure-specific emissions intensity factor for each Azure metric. Specifically, we divide the total Azure region emissions by total customer usage within that region. The result is a Microsoft region-specific emission factor per unit of customer usage for any given time period.

Step 6: Calculate total customer-specific emissions

This step quantifies customer-specific emissions for Azure services and regions based on customer-specific normalized cost metrics for usage related to Microsoft supplier-specific intensity factors. To quantify customer-specific emissions, we multiply a customer's individual and measured Azure usage by the Azure region-specific emissions factors in Step 5.

Step 7: Combine data and summarize

In this step, Microsoft Azure cloud customers can use the Microsoft Sustainability Calculator outlined below to create different aggregated views of emissions relevant to specific Azure services, regions, datacenters, and time boundaries.

The Scope 3 GHG emissions quantification and customer allocation methodology described above offers Microsoft and its cloud service customers an opportunity to consistently and transparently track their cloud computing global impact further along their value chains. It also offers opportunities to identify strategies to manage and reduce Scope 3 GHG emissions over time, which will benefit and empower Microsoft, its customers, and their entire value chains.

Application

Providing climate action insights to our customers

Microsoft Sustainability Calculator

The [Microsoft Sustainability Calculator]() is an innovative web-based user interface that allows Microsoft and its cloud customers to consistently and transparently track and manage their Azure service usage across all impact points in their value chains. Because suppliers, customers, investors, and regulators increasingly demand accurate Scope 3 emissions data for decision-making, a transparent, consistent, and easily accessible estimate is critical for public and external reporting. The calculator will also be useful for Microsoft customers that need actionable Scope 3 emissions data to support performance tracking for organizational targets and commitments. Because the application reflects our own supply chain and Scope 1, 2, and 3 emissions, customers can gain a more comprehensive view of their Azure-related Scope 3 emissions. This offers opportunities for both Microsoft and our cloud customers to collaborate and help unlock mutually beneficial synergies.

Some information relates to pre-released product which may be substantially modified before it's commercially released. Microsoft makes no warranties, express or implied, with respect to the information provided here.

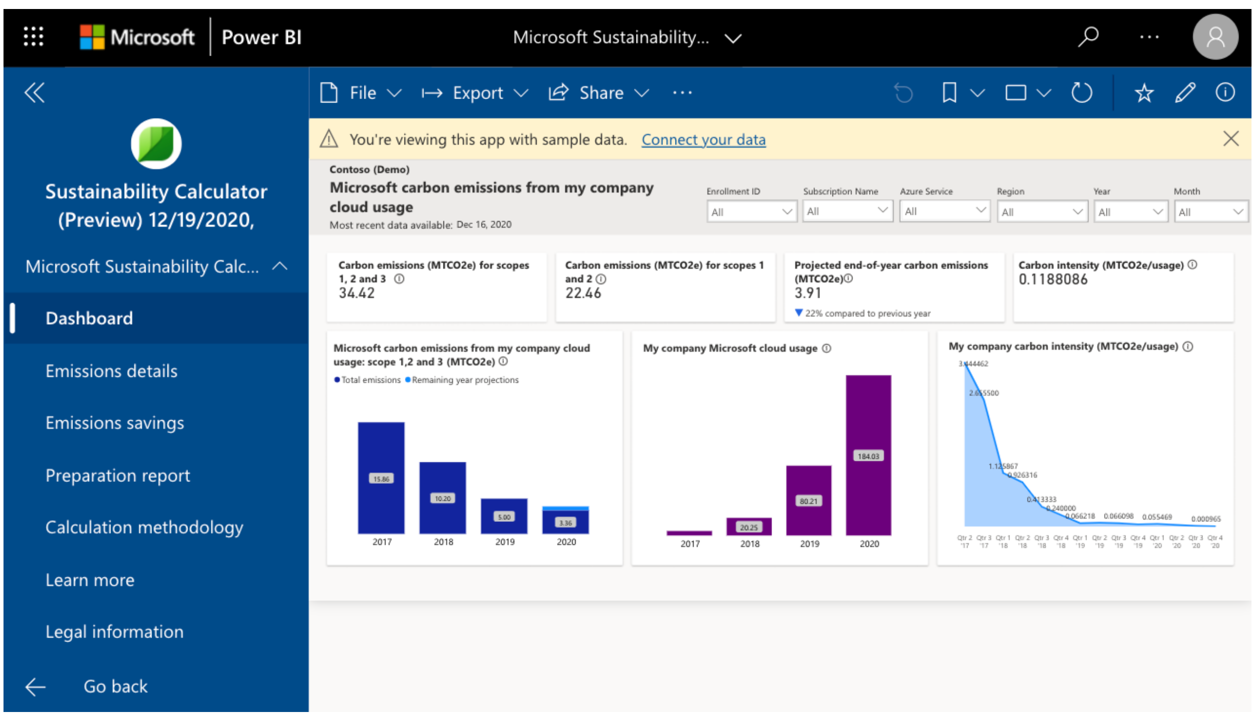


Figure 14: Microsoft Sustainability Calculator dashboard

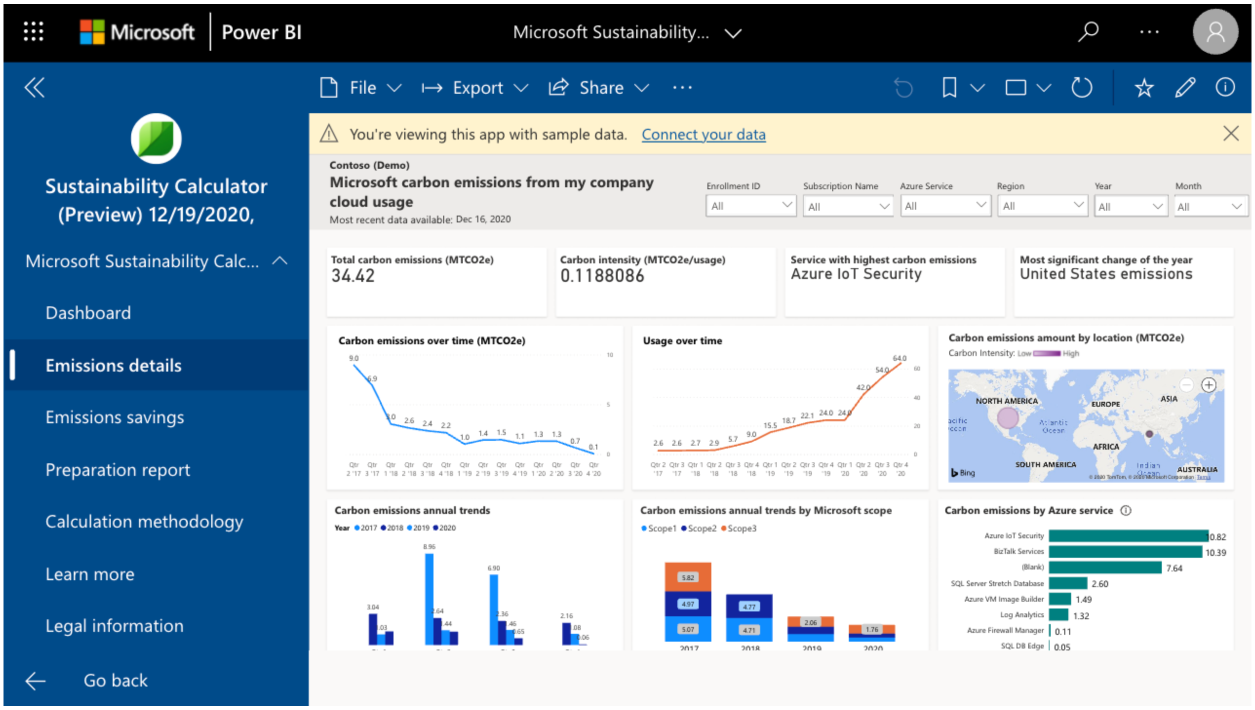


Figure 15: Microsoft Sustainability Calculator emissions details

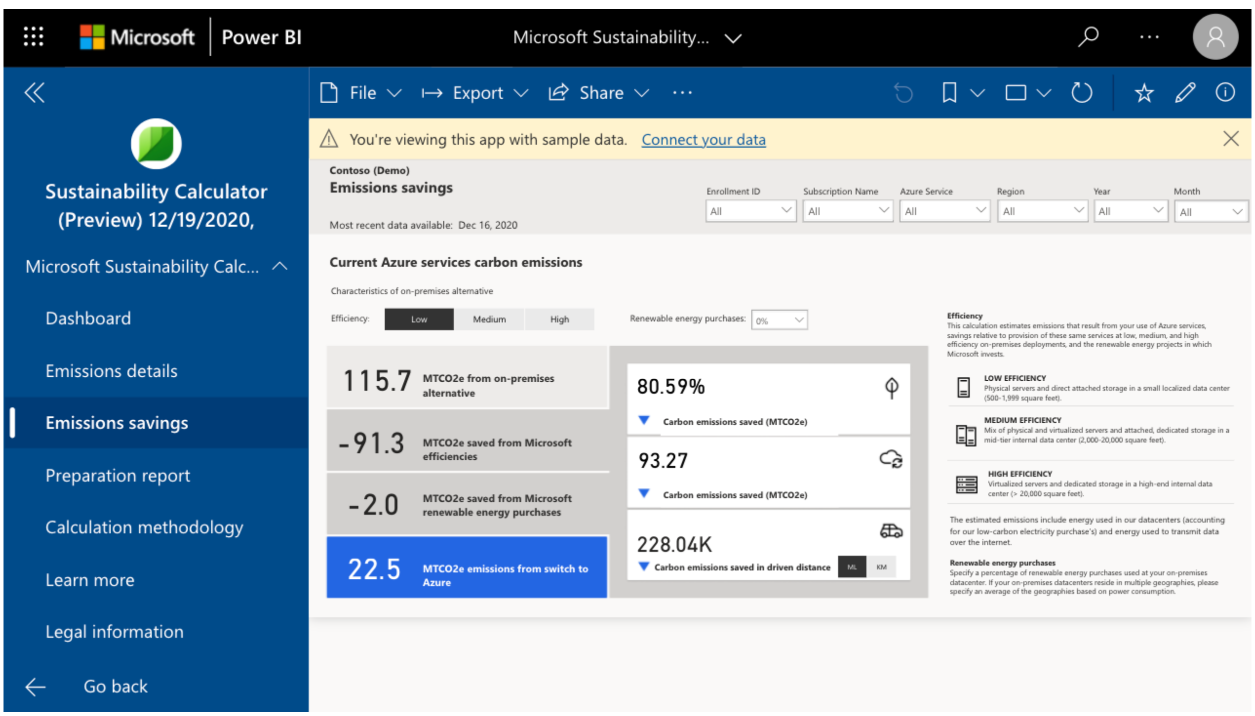


Figure 16: Microsoft Sustainability Calculator emissions savings

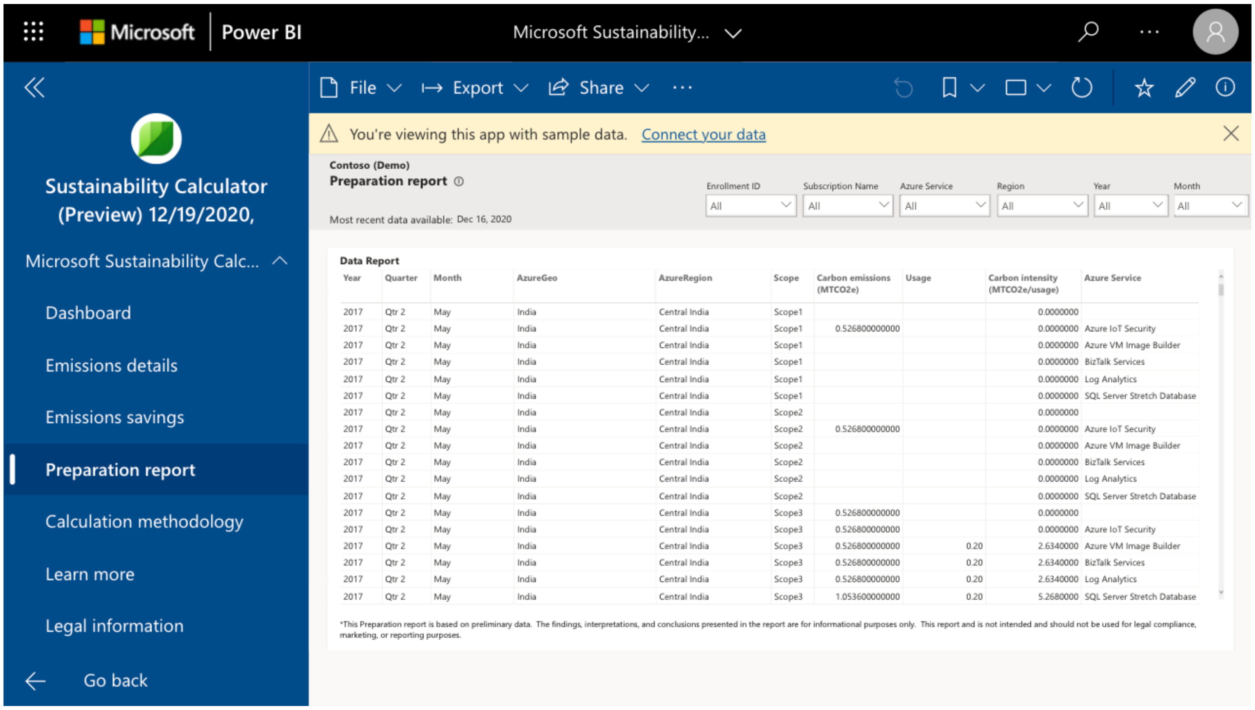


Figure 17: Microsoft Sustainability Calculator preparation report

As the screenshots above show, the Microsoft Sustainability Calculator dashboard displays Azure customer Scope 3 cloud emissions data as charts, absolute values, intensity values, percentages, and geographical location. The dashboard offers the ability to segment customer Scope 3 emissions data by Azure service type, region, and timeframe and offers information on public reporting and Microsoft global renewable energy project initiatives. Future updates will allow segmentation to the instance level, which can unlock further insights for customers.

The Microsoft Sustainability Calculator allows for a broader, more inclusive spectrum of data points that enable a more accurate assessment of the energy and carbon implications of common services used today.

By using the Microsoft Sustainability Calculator, Microsoft cloud customers can track their carbon emissions, carbon intensity scores, projected end-of-year emissions, and emissions savings over on-premises solutions.

Case study: Bühler

This case study was developed prior to the November 2020 public preview of the Microsoft Sustainability Calculator. For more recent case studies, please visit Microsoft.com/sustainability.

The Bühler Group is a leading developer of grains and food solutions, consumer foods, and advanced materials that contribute to the production of energy-efficient vehicles and buildings. Every day, around two billion people enjoy food produced on Bühler equipment, and one billion people travel in vehicles that include parts made with Bühler machinery.

Bühler has ambitious targets to become carbon neutral by 2030 and drive change across its customers' entire value chains—only a cross value chain approach will generate global scale impact. Scope 1 and 2 emissions are easier to track because the activities that produce them are internal. Scope 3 emissions are more challenging because supplier data is required. Bühler is extremely grateful to their supply base for providing the required data, but compiling that data can be a time-consuming and error-prone manual process. Using the Microsoft Sustainability Calculator makes it possible to capture the right data in the right format at the right time and visualize that data in an intuitive format that facilitates actionable conclusions that drive real change.

Bühler and Microsoft have ongoing collaborations in several areas and share a vision for optimizing the sustainability of their respective business operations. When Microsoft began early development of the calculator, Bühler was a natural partner for live testing.

Bühler extensively used all features and processes of the Microsoft Sustainability Calculator to determine the Scope 3 emissions associated with Microsoft. Bühler users describe the calculator as easy to use, with an intuitive dashboard that allows the quick generation of credible and useful data—including where their carbon footprint was highest. They found the inputs and processes that generate the results to be easy to understand and transparent. Bühler Sustainability Specialist Katharina Hilker says, "Having good quality data versus relying on rough estimation in Scope 3 was very helpful to our reporting process." The Microsoft Sustainability Calculator will become even more important to Bühler as they further incorporate Scope 3 data into decision-making.

Microsoft and Bühler are continuing their calculator collaboration. With Bühler's valuable input, Microsoft will continue to advance the Microsoft Sustainability Calculator to make it more powerful and useful in helping all companies achieve their sustainability goals.

Bühler's Digital Officer, Stuart Bashford, says, "If all big companies in the world worked like this, we'd actually have a chance to make a difference."

Appendices

Key terms and definitions

Amortization: a process by which a product's total emissions are accounted for over the course of its lifetime as opposed to at the specific time of emission. Amortization simplifies the emissions accounting process and more accurately reflects a product's emissions impact.

Cradle-to-gate: the period of a product's life from resource extraction (cradle) to the factory gate (i.e., before it is transported to the consumer).[14]

Cradle-to-grave: the period of a product's life from resource extraction (cradle) to its disposition (after which it is recycled or disposed of).

GHG Protocol: an organization that establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains, and mitigation actions.

Hardware disposition: recycling and reclaimed for reuse.

Life cycle evaluation: a methodology for determining the environmental impacts of a commercial product, process, or service throughout its life. Life cycle evaluations span from raw material extraction and processing to final disposal and cessation of activity. The span is often referred to as cradle-to-grave.

Material circularity: the degree to which the materials used in a product can be reused, repaired, refurbished, or recycled. Complete circularity means that whatever waste a product or process produces will become inputs for another product or process.

Scope 1 emissions: direct emissions that your activities create.

Scope 2 emissions: indirect emissions that result from the production of the electricity or heat you use.

Scope 3 emissions: indirect emissions from all other activities in which you are engaged. For a business, these Scope 3 emissions can be extensive and must be accounted for across its supply chain, materials in its buildings, employee business travel, and the life cycle of its products

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[14] "Product Life Cycle Accounting and Reporting Standard," Greenhouse Gas Protocol, September 2011, https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf

(including the electricity customers consume when using the products). A company's Scope 3 emissions are often far larger than its Scope 1 and 2 emissions combined.

Supply chain: the full sequence of individuals or companies involved in the creation and sale of a product or service.

Usage: using electricity to run servers, networking equipment, hard drives, and datacenter infrastructure (such as lighting, cooling, and power conditioning). Where relevant, usage also includes energy from internet data flows.

Value chain: the full sequence of individuals or companies involved in adding value to a product or service.

Common materials included in IT equipment

These IT components are comprised of thousands of materials, in varying quantities—emissions calculation focuses on the 22 most common. These materials typically make up 90-95 percent of the IT equipment composition:

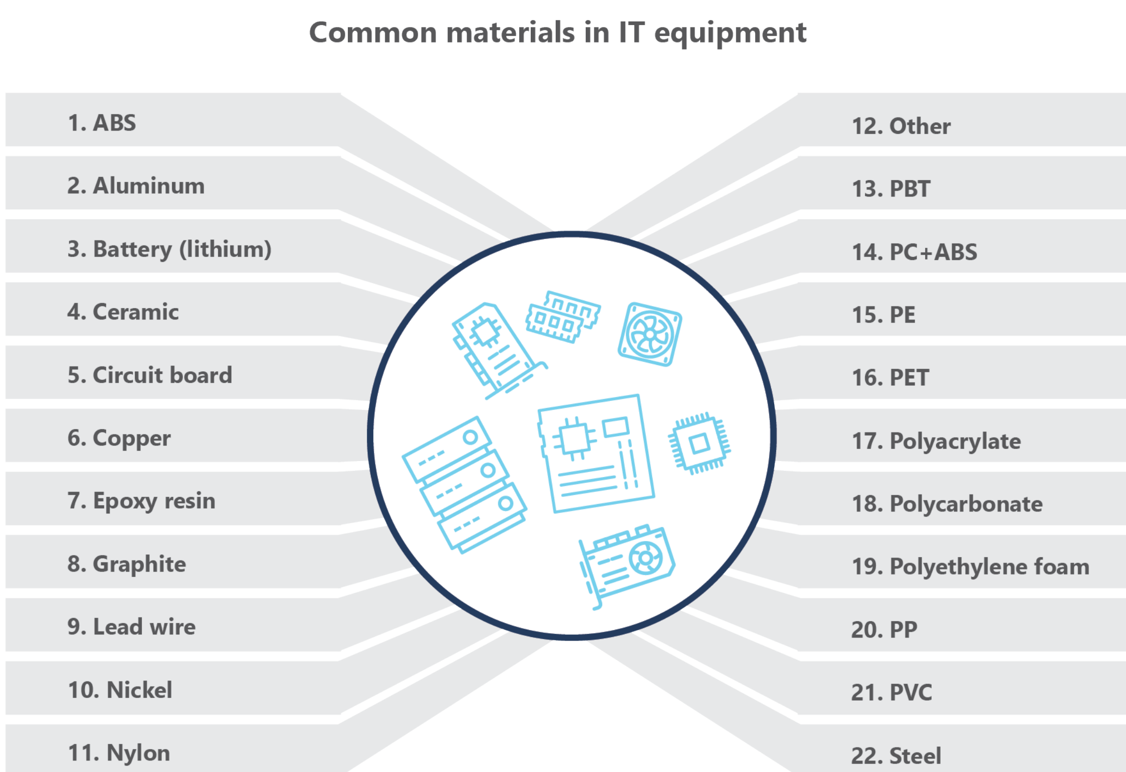

Figure 18: Common materials in IT equipment