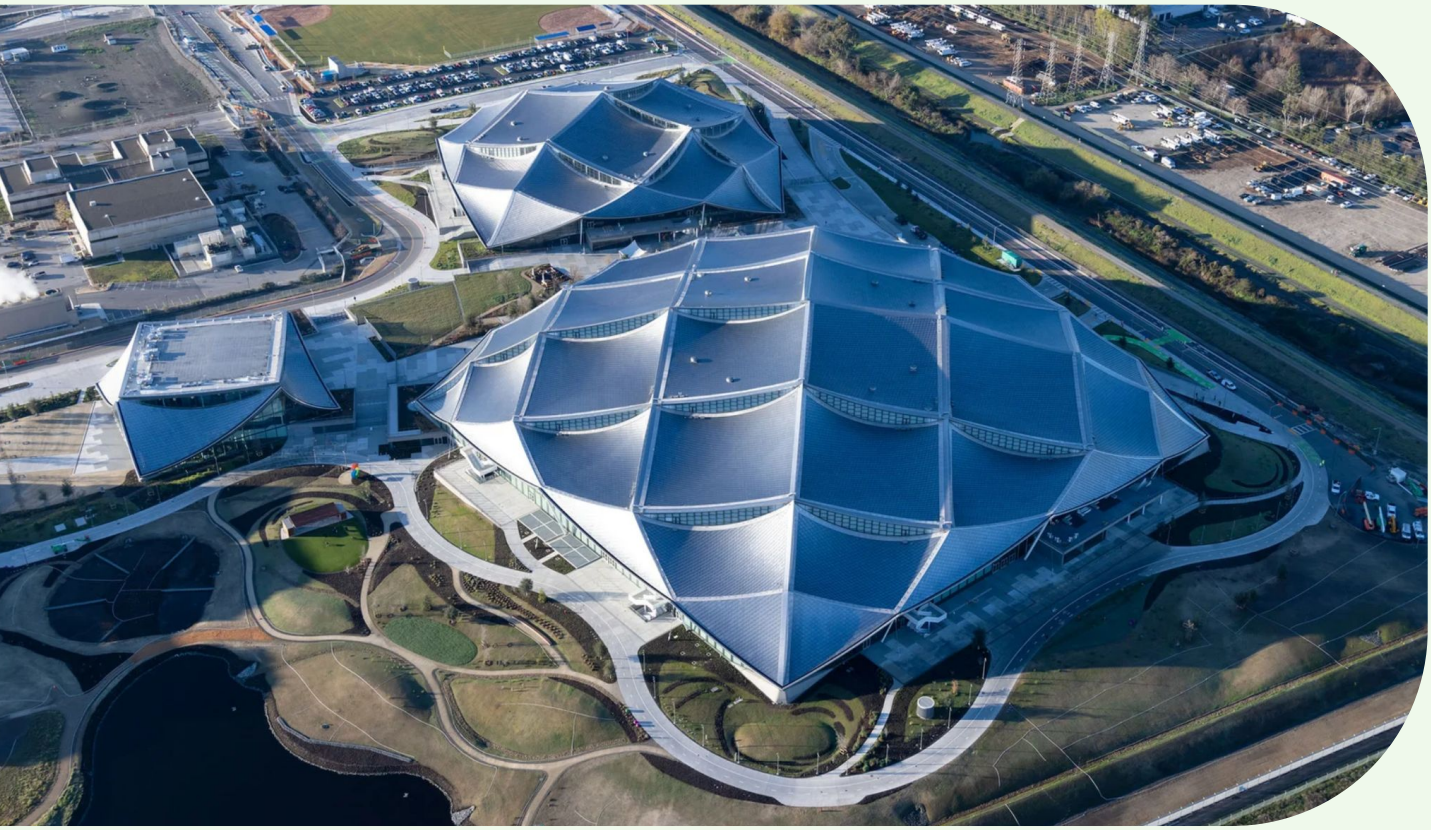
Edition 1.0
September 2024

g.co/hardware/DeviceCarbonReduction

Consumer Hardware Carbon Reduction Guide

Google



Our goal

At Google, we have an ambitious goal to reach net-zero emissions across all of our operations and value chain by 2030.

In addition to our own operations, this also covers our consumer hardware products, including the entire supply chain, transportation, use of our devices, and impact at the end of our devices' lives.

Introduction

Our consumer hardware group has been working to reduce the carbon footprint of our devices for several years and, in keeping with the company's aim to build a more sustainable future beyond Google, we want to share our approach more broadly.

We hope this guide will be helpful to corporations looking to augment their existing carbon accounting efforts with carbon-aware design and operations, ultimately resulting in actionable carbon reduction opportunities and meaningful carbon reductions.

We recognize that corporations are at different stages of their carbon journey. Some are focused on emissions reporting and initial quantification. Others have extended their work to add a focus on carbon reductions. Still others have already begun to reduce their carbon footprint by actively pursuing lower carbon options through operational, design, and procurement decisions. While this guide focuses on consumer electronics at Google, we believe this approach could be applied outside of the consumer electronics space with appropriate modifications.

At the simplest level, we are focused on finding the hotspots—in this case, the parts of our consumer hardware products that contribute the most to their overall carbon footprint—and then trying to reduce them. This is an iterative process. We identify hotspots; get more accurate data on those hotspots; assess the carbon footprint again to see if new hotspots have been identified or old ones are less 'hot' than originally thought; and then iterate. Then, we try to find the right people to help reduce those hotspots.

In theory, that's really it. In practice, it's a bit more challenging. We outline this in more detail throughout this guide, which we hope will provide some insight or guidance for those working to reduce the carbon footprint of their own products.

Focus on the big stuff and only get detailed on what matters

Step 1

Perform a light-touch screening analysis to get a general sense of likely hotspots

First, we need a high-level carbon emissions assessment to get a general sense of where to focus. Overall company hotspots are often concentrated in the products with the highest manufacturing or sales volume and it's likely we'll want to get much more detailed on these.

For example, at Google, we spend a lot of time understanding what goes into making our Pixel phones and how our smart home devices are used, and less time focusing on the carbon footprint of some of the accessories. In addition, products that are particularly expensive to make might also be carbon-intensive.

Often, but not always, the more expensive components are more complex to make and this frequently drives up carbon footprint. Financial data (or "spend data") related to how much is spent on materials and components is a reasonable screening mechanism for carbon footprint. Spend data can tell us where to look initially and where to gather primary data for deeper analysis. (More on data types below.)

> "We all work in a resource-constrained world. So we really want to focus our limited resources on the places where we can have the biggest impact. Basically, it's a don't-sweat-the-small-stuff outlook."
>
> – Julie
>
> Head of Net Zero Strategy and Environmental Footprinting, Consumer Hardware

Step 2

Perform more in-depth analyses on the high-impact products

Now that we have a sense of which products are likely the company-level carbon hotspots, we want to find the product-level hotspots.

There are a number of different approaches to carbon footprinting. For a physical product, a life cycle assessment (LCA), governed by ISO standards 14040 and 14044,[1] is one of the most powerful tools for understanding the carbon footprint and identifying levers to reduce it.[2] Life cycle assessments determine the environmental impact of the product under consideration throughout its entire product life (see Figure 1). They include the impact of [1] extracting raw materials and refining them into the materials that are ultimately used; [2] manufacturing each component and assembling all the components into the final device; [3] transporting the device to the customer; [4] the impact of using the device (in the case of consumer hardware, this is the impact of the electricity consumed throughout the device's lifetime); and then [5] the impact of disposing of that device at the end of its use (e.g., recycling or landfilling). Life cycle assessments can look at many different environmental impact categories (such as primary energy demand, water usage, and more). In this guide, we focus only on carbon footprint.

For consumer hardware, the carbon hotspots are likely going to be either making the product (usually the case for mobile devices) or using the product (usually the case for products that are plugged in most or all of the time).

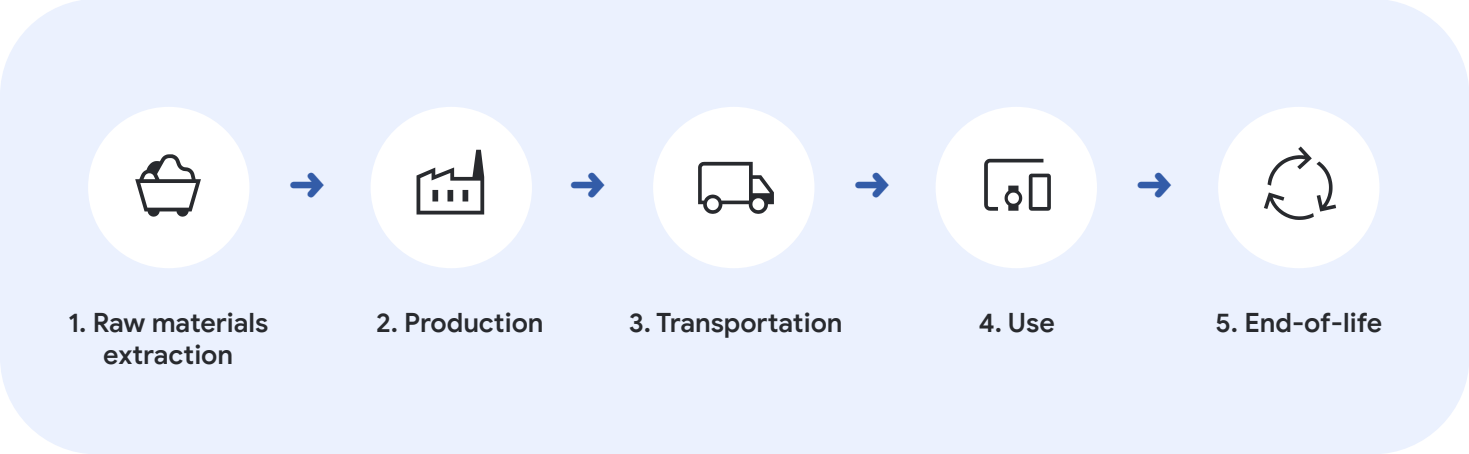


Fig. 1. The life cycle phases in a product life cycle assessment

[1] International Organization for Standardization. (2006). ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework
International Organization for Standardization. (2006). ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines
[2] This guide focuses on companies that make physical things. If you sell services, that's a different conversation.

A quick note on data types

Carbon footprinting often relies on a mix of primary and non-primary data, where primary data is gathered and used for high-impact components or life cycle phases, and non-primary data is sufficient for components or life cycle phase with smaller impacts.

For example, at Google, we have detailed primary information on the processes and materials that go into making the aluminum in the enclosures for our phones. (Enclosures were one of the highest contributors to our phone carbon footprint until we switched to recycled aluminum.)

Conversely, we use proxy data sets from our LCA software databases to model small electronic components, such as capacitors and resistors, because the carbon footprint of these components is much less significant relative to other components. Even if we expended more resources to gather primary data on these components, the results would not change the carbon footprint of the devices appreciably, nor our priorities for carbon reduction.

Primary data

Primary data is supplier data that directly reflects inputs that go into a component or life cycle phase, such as material types and masses, energy inputs (e.g., watt-hours of electricity consumed during a manufacturing process, or watts of power used over the cycle time of a process), and more. Internal experts, such as design and manufacturing engineers, can often help provide primary data about key manufacturing components and information about electricity consumption while using devices.

Non-primary data

Non-primary data is proxy data. It could be representative of industry averages, but is not specific to exact components and processes. External references such as LCA databases (some are free, some require a fee to use), industry associations, and academic papers often have information on the carbon footprint of materials and some common manufacturing or industrial processes.

Step 3

Iterate, this time with (more) primary data

Once we have a sense of the highest impact categories—including which products and life cycle phases of each product type contribute the most to the overall carbon footprint—we gather as much primary data as possible for these areas. This then helps us identify more specific hotspots, and possibly identify pathways for hotspot reduction.

For premium mobile consumer hardware devices, carbon hotspots (high-impact components and life cycle phases) are likely to include enclosure components and the semiconductors used to run the devices. In general, large pieces of metal should be considered closely, as should highly polished glass components and advanced semiconductors. For products that are always plugged in and consuming electricity (e.g., smart TVs or smart speakers), the emissions impact of using the product is also often a hotspot. There are other hotspots, too. These are just ones we should definitely consider.

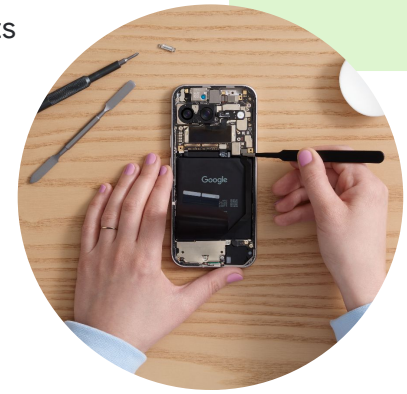
We perform LCAs using as much primary data as we can on the best-selling products by volume and the products that likely have the highest carbon footprints. We devote fewer resources to the life cycle phases and components that have low carbon impacts. There are multiple LCA tools available (usually at a cost). Experts in specific fields can generally point to the tools that are most appropriate for different product types. For example, at Google, we use an LCA software tool with a database known for its depth in electronics. There are other software tools that specialize in the impact of other product types, such as textiles.

A quick example at the product level

As a screening step, we looked at our sales and manufacturing records, and identified that our home streaming devices have been extremely popular over the years.

We determined we should do a more detailed analysis on these products. We performed detailed LCAs, conforming to the ISO standards we mentioned above. In the process, we realized that because these devices are always plugged in, we should carefully consider the carbon emissions associated with the electricity used by the devices. So we made sure to get excellent primary data on device use.

We contacted various internal teams to understand the different operating modes of the devices (actively playing back video, screensaver, sleep) and how much time devices typically spend in each mode. In our lab, we then tested the power draw of the devices in each of these modes. (The information on mode type, time spent in each mode, and power draw in each mode is primary data.) We had the results verified by an independent expert consultant. As an extra step, we published a Product Environmental Report, where anyone can look at a summary of the results.



Step 4

Look at the entire portfolio

Once we have a good sense of the carbon hotspots for each of our major products, we aggregate the information to find the hotspots across the full portfolio, not just at the product level, to enable us to identify our biggest carbon reduction opportunities.

The first step is aggregating by life cycle phase. We can take the carbon footprint of each product, multiply it by a demand or production metric (for consumer hardware, we multiply the carbon footprint of each product by the sales or manufacturing volume of each product for a certain time period), and then we can develop a carbon heat map for the entire system. This visual tool clearly identifies where to focus next.

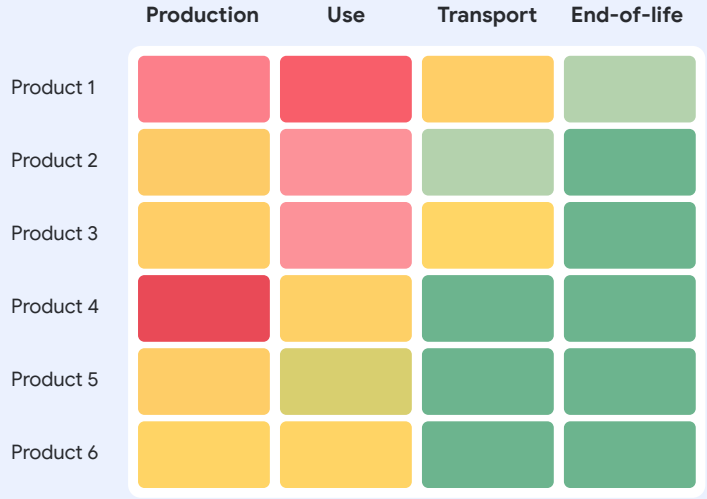


Fig. 2. Carbon footprint heatmap—the boxes with the warmest colors indicate the highest contributors to overall carbon footprint

Advocate for carbon-aware decisions where there is direct control

Now we can look at system-level hotspots to identify who has control over the hotspots and engage with those people.

For consumer hardware, our hottest hotspots are often in the manufacturing and use life cycle phases. Once the hotspots are determined, it's time to look for ways to reduce those hotspots. Carbon footprint reduction options will differ based on hotspot sources. To reduce the impact of *using* products, the focus is generally on reducing the electricity consumption of the products, as the carbon footprint of the electricity used through the product lifetime is responsible for the carbon impact in this life cycle phase. At Google, we have engaged with our software and electrical engineers to drive down power draw for devices that are always plugged in (e.g., our home streaming and smart speaker devices). We have also engaged with our product managers and UX teams to ensure user experience is as intended and that power draw reduction is a goal in the project.

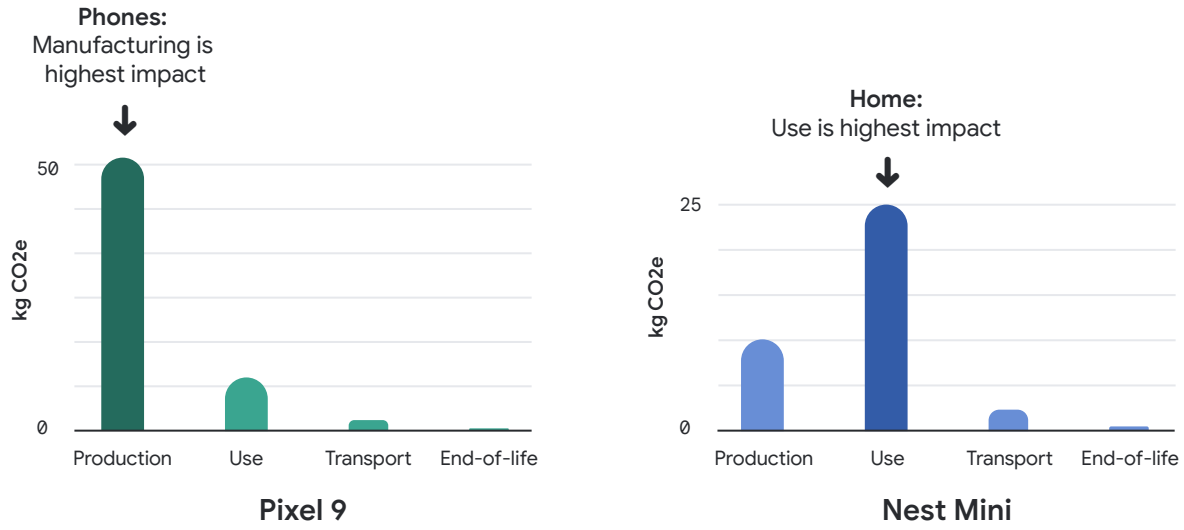


Fig. 3. Life cycle hotspots can differ based on device type

To reduce the impact of *manufacturing* products, we need primary data on material types and input masses, manufacturing process types, and process yields. This enables us to determine specific hotspots within the overall manufacturing hotspot and, crucially, to identify options to reduce the carbon footprint, which is the ultimate goal of this work.

For large metal parts, often switching from primary to recycled metal will reduce the carbon footprint of that component. For components with complex manufacturing processes, using clean electricity to make the component can reduce its carbon footprint dramatically. In cases where components are machined for long periods of time, we frequently ask if there is an opportunity to reduce machining time. We also highlight the importance of yields to various design and operations teams. The carbon footprint takes into account all the components that need to be made to get a single good component. For example, if yields are 50%, then the carbon footprint of that component is twice as high as it would be if yields were 100%.

Once we have reduced the impact of the hottest hotspot, we move to the next hottest hotspot.

In our consumer hardware group at Google, we engage with nearly all the design and operations functions within our teams, including our partners in industrial, product, electrical, and hardware design, along with software and manufacturing engineering, product management, procurement, and finance. While the technical analyses identify where the carbon reduction opportunities are, these cross-functional partnerships are critical to realizing the carbon reduction opportunities.

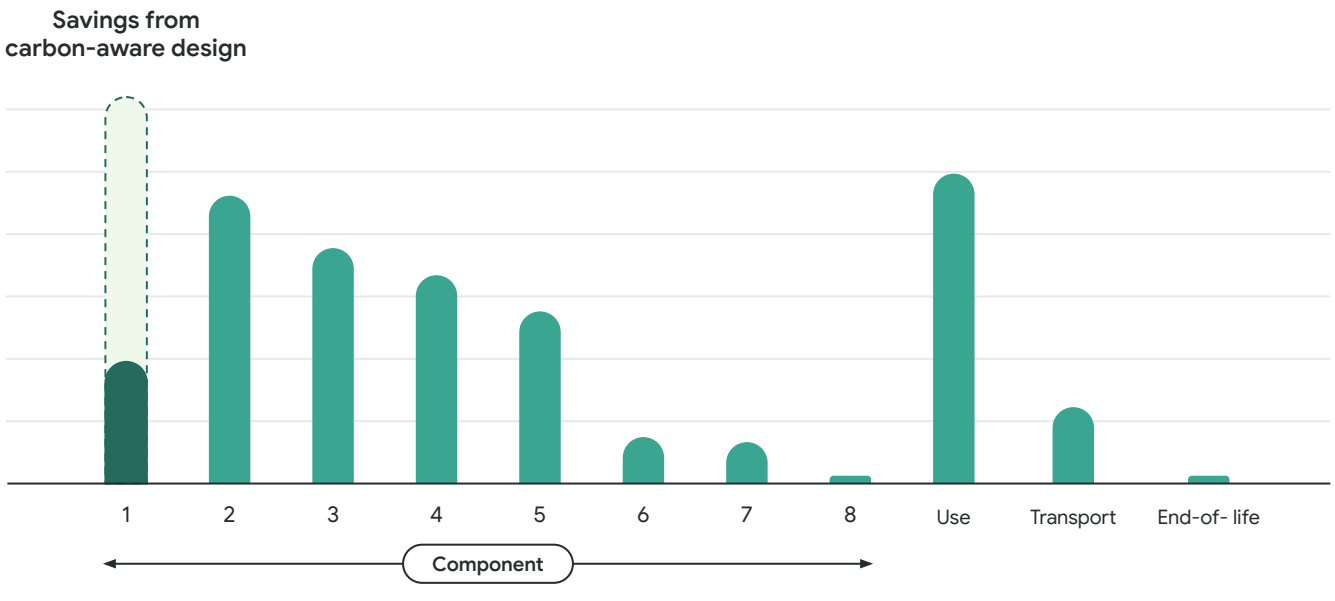


Fig. 4. Carbon hotspot ranking by component and life cycle for a sample device

Engage and partner with the supply chain

After influencing most of what we can in the design and operations spaces (what we directly control), we have found that most of the remaining manufacturing-associated carbon footprint is within the supply chain.

Let's now apply our hotspot approach to the supply chain and segment suppliers by carbon impact. We take the LCA work we already did and aggregate it at the organizational or company level. Instead of mapping by life cycle phase, this time, we map by commodity and find the hotspot commodities.

Now we need to determine who supplies each commodity. We engage our procurement teams to find out who the suppliers are for the hotspot commodities. We want to minimize our *future* carbon emissions, so we ask our procurement teams to assess who the current and *future* suppliers are for the hotspot commodities.

We engage with the highest impact suppliers for the highest impact commodities. We found we need to deeply engage with perhaps less than 10% of our total Tier 1 supplier base.[3] With hundreds or thousands of suppliers, it might not be scalable to engage deeply with all suppliers. Following the hotspot approach enables manufacturers to engage with a much smaller number of suppliers, while retaining significant coverage of their carbon footprint. Often, these suppliers are commonly used within an industry, and thus there might be broader-scale opportunities to collaborate with these suppliers and other customers on collective efforts to reduce overall industry emissions—something we are starting to do.

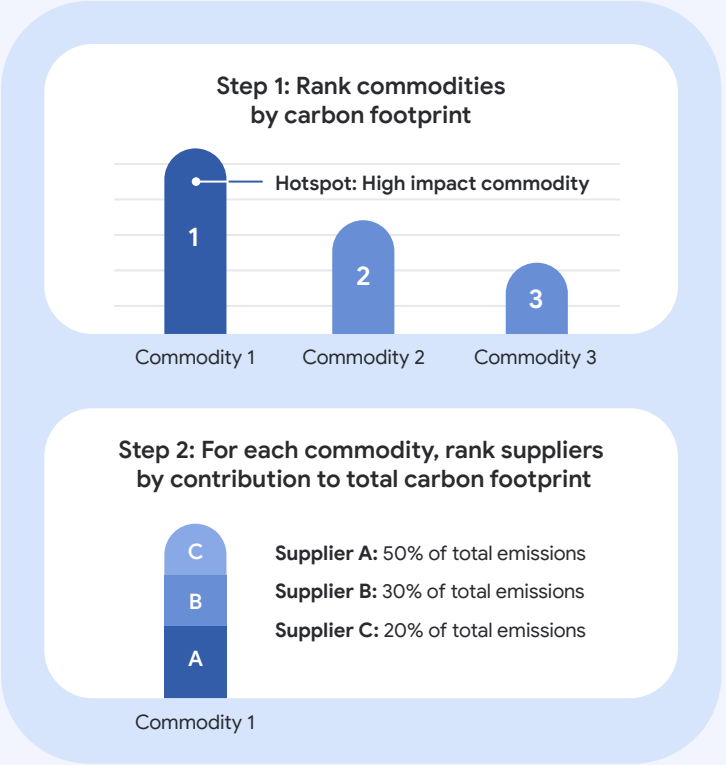


Fig. 5. Organizational carbon hotspot ranking by commodity

"We've found that many suppliers have different approaches to carbon reduction and we're working with them to understand their needs and challenges so we can develop mechanisms to support them and others."

– Aditi

Sustainability Lead,
Consumer Hardware
Supplier Engagement Programs

[3] Tier 1 typically designates the suppliers with whom a company has direct financial relationships, and thus the greatest degree of influence. Tier 2 designates the suppliers of the Tier 1 suppliers. Tier 3 designates the suppliers of the Tier 2 suppliers, and so on.

Supply chain clean electricity

Generally speaking, the majority of supply chain emissions stem from electricity consumption.

To reduce these emissions, we need to help the high-impact suppliers use less electricity in general and shift to clean electricity. We ask our high-impact suppliers if they have ideas on how to improve energy and process efficiency. These might include replacing older, traditional interior lighting with LEDs or replacing an older process cooling water system with a high-efficiency chiller. Small efficiency gains can result in some of the most cost-effective carbon reductions.

Moving suppliers to clean electricity might require providing education (several groups, including CEBA's Clean Energy Procurement Academy and Schneider Electric's Catalyze programs specialize in this) or helping provide access.

The supply chain transition to clean electricity is unlikely to happen entirely on its own in a short timeframe. Even without monetary resources to direct, asking component suppliers if they can provide clean electricity sends a signal that customers are interested. Sufficient interest might lead to more supplier effort to use clean electricity.

Finally, we need to ensure that suppliers' emissions and reductions are well-documented; appropriately allocated to us and other customers; and traceable. This will be important for measurement and accounting, so that any carbon reduction achievements we report can be properly supported with evidence.

Partner with industry groups to scale impact

Many industry groups are now specifically devoting consideration to sustainability generally and GHG emissions reduction work specifically.

There might be opportunities to increase industry alignment on the importance of carbon reduction and encourage partners to collaborate on industry-wide challenges. The particulars of each opportunity and focus area are specific to each industry. Google is leading work with a number of relevant industry consortia.

For example, we are working with SEMI's Semiconductor Climate Consortium (SCC)—a global semiconductor consortium with representatives from all parts of the semiconductor value chain—to streamline carbon accounting to reduce duplicative data requests for the supply chain and increase data quality for all members. Data quality improvements will directly lead to better hotspot identification, which will then ideally lead to industry-wide carbon reduction opportunities.

Conclusion

Our approach to reducing the carbon footprint of our consumer hardware is entirely about focusing on the big stuff and making changes that matter: find carbon hotspots at the product and company level; get the most actionable data; and work with all internal and external partners to reduce those hotspots.

We hope that sharing our approach to carbon footprinting, carbon reduction, and supply chain engagement prioritization will be helpful in your journey. Although the focus of this guide is on reducing the carbon impact of our consumer hardware devices, we think the overall structure of the approach could be applicable and scalable to other industries, as well.

We recognize our process isn't perfect and it evolves through time. We'd love to hear what you're doing, as well as suggestions for improvement, technical questions, or ways you've found this helpful.

Please reach out to let us know:

consumer_hardware_net_zero@google.com ➜

Authors and contributors

Julie Rapoport

Head of Net Zero Strategy and Environmental Footprinting, Consumer Hardware

Aditi Kale

Sustainability Lead, Consumer Hardware Supplier Engagement Programs

Mike Labanowski

Net Zero and Environmental Footprinting Lead, Consumer Hardware

Joe Palazzo

Net Zero and Environmental Footprinting Lead, Consumer Hardware

Alexis Baillie

Net Zero and Environmental Footprinting Lead, Consumer Hardware

Katie Morgenroth

Head of Sustainable Design and Creative Processes, Consumer Hardware

Google

Consumer Hardware Carbon Reduction Guide

We'd love to hear about ways you've found this guide helpful, technical questions you have or suggestions to improve it.
Let us know at:

consumer_hardware_net_zero@google.com →

Google is driving sustainability innovation in many different areas across our products and operations.
Check out the latest news and progress at:

sustainability.google →