Amazon Sustainability

Carbon Methodology

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amazon

What's in Amazon's 2024 Carbon Footprint?

A carbon footprint measures the total greenhouse gas (GHG) emissions caused by the direct and indirect activities of a company.[1] These emissions are broken into three categories—Scope 1, 2, and 3 emissions. Scope 1 emissions come directly from a company's operations, such as the fuel used by Amazon's delivery fleet. Scope 2 emissions are indirect emissions resulting from the generation of purchased energy, like the electricity used to power Amazon facilities.[2,3] Scope 3 emissions include activities that take place beyond a company's operational boundary, for example, the production of Amazon devices such as the Kindle, or purchase of packaging materials used in our fulfillment operations.

To calculate Amazon's carbon footprint, we use the operational control approach to account for a diverse set of direct and indirect emissions that occur upstream of, within, and downstream of our operations. Our boundary includes the following emission sources:

- Amazon's last mile delivery fleet
- Amazon-operated freight, including trucks and airplanes
- Purchased delivery services (e.g., postal services) and other contracted freight
- nergy, and refrigerants for cooling used in our operations such as data centers, fulfillment facilities, retail stores, and corporate offices
- Amazon-provided packaging used in our fulfillment operations
- Amazon-branded product manufacturing, such as Echo devices, Kindle e-readers, Amazon Basics, Whole Foods Market brands, and other Amazon Private Brands products
- Goods and services that enable our operations such as business travel, office supplies, corporate events, outside consulting services, and other expenditures
- Capital goods, such as emissions from building construction, vehicles, and manufacturing of servers and equipment
- Employee commuting
- Customers' trips to Amazon's physical stores
- Our customers' use of Amazon devices
- Amazon devices end-of-life treatment

We evaluate the quantity of GHG emitted for each of these activities by taking the amount of the activity conducted (e.g., miles traveled, or gallons of fuel burned) multiplied by its emissions factor (e.g., grams carbon dioxide equivalent[4] (CO_2e) per kilowatt-hour (kWh) of electricity used), which provides a representative value for the CO_2e associated with that activity. Once the emissions for our activities are calculated, we sum them to produce the carbon footprint for Amazon's business, spanning our physical and online retail businesses, cloud computing, device manufacturing, and beyond.

Our approach to quantifying our carbon footprint reflects the complexity of our business by combining both operational and financial records from Amazon operations around the world. We first estimate our carbon emissions for all activities within our boundary using a spend-based environmental assessment model, then enhance the accuracy with process-based

1. Amazon calculates and reports their carbon footprint in accordance with "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)" including the "GHG Protocol Scope 2 Guidance (An amendment to the GHG Protocol Corporate Standard)" and "Technical Guidance for Calculating Scope 3 Emissions (Supplement to the Corporate Value Chain (Scope 3) Accounting and Reporting Standard)", published by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). We refer to this collectively, as the GHG Protocol (GHGp).
2. Amazon reports emissions according to GHGp's market-based method (MBM) in both Scope 2 and Scope 3 (as applicable) which accounts for renewable energy Amazon purchases to support its operations.
3. These indirect emissions come from electricity consumed by Amazon's global facilities under Amazon's operational control (e.g., owned, leased, and co-located Amazon Web Services (AWS) data center infrastructure, fulfillment center and delivery network buildings, on-site electric vehicle charging, corporate offices, customer service centers, physical stores, and financially-integrated subsidiaries (e.g., Whole Foods Market)).
4. GHG emissions are converted into the standard unit of CO_2e via Global Warming Potentials (GWPs). For example, one kilogram of methane has a GWP of 28, meaning that those methane emissions are equivalent to 28 kilograms of carbon dioxide (CO_2). This conversion reflects the fact that methane traps heat 28 times more effectively than CO_2 over a 100-year time horizon.

calculations or lifecycle assessment (LCA) models, when applicable. Each year, we work to continuously improve our estimates and assumptions used for emission calculations.

This carbon footprinting approach consists of these scientific measurements:

- **Financial:** We combine data on Amazon's spending with industry-average, spend-based emissions factors (e.g., a standard amount of CO_2e emissions associated with every dollar of spending on a particular activity). We use this model to reflect carbon emissions from activities, equipment used in our warehouses, and purchased goods and services such as office supplies and advertising services.

- **Transportation:** We track the emissions resulting from shipping products and equipment to Amazon warehouses and facilities, between warehouses, and outbound to our customers' homes, Amazon lockers, and other pickup points. This includes estimated emissions from customers' trips to physical stores.

- **Refrigerants**: We include the emissions that occur across our global operations from the cooling and refrigeration occurring within our facilities.

- **Energy:** We account for the impacts of the purchased electricity, back-up power generation, and heating used in our offices and facilities, as well as the carbon free electricity generated from our project commitments around the world.

- **Packaging:** We measure the materials and processes behind all the boxes, mailers, and other packing items Amazon uses in our fulfillment operations.

- **Amazon Devices:** We developed a specialized carbon footprint model to address the complexity of the manufacturing, use, and end-of-life of Amazon devices, including Echo devices, Kindle e-readers, Fire Tablet, Fire TV, Ring, and Blink. This starts at the component level—including where components are sourced and how they are manufactured into products—and extends to customers' use of the product and the eventual product end-of-life.

- **Amazon Products and Supplier Provider Emissions:** We utilize LCAs, and supplier provided data to calculate emissions across our supply chain. This approach is used for our sold products, and for materials and equipment used across our operations.

- **Amazon Buildings:** We use building design models to calculate the emissions associated with the construction of Amazon facilities. Source data comes from material, equipment, and procurement inventories; as well as internally and externally developed, and supplier-provided LCAs.

- **Business Travel:** We incorporate third party calculated emissions based on trip level information for air, rail and car business travel.

- **Employee Commuting:** We estimate emissions associated with our employees' transit between their homes and worksites using survey results on how our employees regularly come to work (car, bus, walking, biking, shuttle, etc.) and the distance they travel.

Our team uses these approaches to transform activity and spend data into emissions measurements for Amazon's specific business activities (e.g., shipping, packaging). We then compile the outputs of these calculations to assemble a company-wide carbon footprint.

Our carbon footprint meets the widely adopted international standard of the GHG Protocol (GHGp).[5] Scope 1 and Scope 2 were independently assured by Ernst & Young LLP, and Scope 3

5. WRI and WBCSD's GHGp delineates what actions fall within scope for international standards for corporate footprinting.

was independently verified by Apex Companies, LLC.

As measurement techniques evolve, we adapt the way we measure and report our footprint, including the recalculation of prior year(s) data to enable consistent comparison over time. This may occur, for example, when we refine a calculation methodology, add new activity data as it becomes available or when we improve the way we collect data from our existing sources. When the change is significant, we apply the current year's models, calculation methods, emission factors, and company structure to prior year(s) data to calculate the comparable total carbon emissions.

The following sections elaborate on the science and data behind each of the emissions models we've developed to measure Amazon's carbon footprint.

Financial Emissions Model

Using the Economic Input-Output Life Cycle Assessment (EIO LCA) method, our spend-based model combines expenditure data from Amazon's general ledger with industry-specific, spend-based[6] emissions factors published by the U.S. Environmental Protection Agency (EPA). EIO LCA emissions factors account for the "cradle-to-gate" emissions required to produce one dollar of goods or services from any industry, including emissions from the extraction of raw materials, energy use, supply-chain transportation, and manufacturing. This method leverages economic input-output data assembled by governments to track the "recipe" of inputs required to produce any good or service.[7] EIO LCA accounts for the carbon emissions from producing each of these intermediate inputs, and from the production of all inputs from further up the supply chain.

We apply EIO LCA by mapping our expenditures to one or more industry sectors and multiplying the appropriate emissions factors by the dollars spent. For example, spending on parcel delivery by third-party carriers is mapped to the couriers and messengers sector and shipping boxes are mapped to paperboard container. This method is the most efficient way to tie all corporate activity into an approximated carbon footprint. Outside of Amazon, this method is commonly used to estimate carbon footprints by a variety of organizations, from major corporations that disclose their carbon emissions, to government entities like the U.S. Department of Defense, and even individuals who wish to understand the environmental impact of their personal activities.[8]

Transportation Emissions Model

The transportation of products to customers is an integral part of Amazon's business. Trips differ by mode, purpose, productivity, timing, and other localized variables, resulting in a broad range of emissions associated with transportation activities. To account for this complexity, we use a robust modeling framework that estimates carbon emissions at the trip level and accommodates different levels of data availability. We give priority to fuel- and distance- based calculations, but if this information is not available, we rely on a spend-based approach to calculate emissions. The scope of our assessment includes transport activities managed by Amazon and our third-party transportation providers, as well as the emissions generated from customers' trips to Amazon retail and Whole Foods Market stores.

Emissions Sources for Transportation

Transportation activities generate carbon emissions through the combustion of fossil fuels, and from the supply chain activities related to vehicle fuels. The emissions model for transportation covers emissions associated these "well-to-wheels" impacts. This is both the emissions associated with the well-to-tank (e.g., extraction, refinement, and distribution of fuels) and tank-to-wheels emissions created from the use of transportation fuels.

6. When using the term "spend" in this document, we are referring to the United States Dollar (USD).
7. Li, M.; Ingwersen, W.W.; Young, B.; Vendries, J.; Birney, C. useeior: An Open-Source R Package for Building and Using US Environmentally-Extended Input–Output Models. Appl. Sci. 2022, 12, 4469. Retrieved online: https://doi.org/10.3390/app12094469.
8. Henderson, A., M. Bruckner, K. Scanlon, W. Ingwersen. The USEEIO framework to create IO models: application to the DoD and case demonstration. LCA XVIII, Fort Collins, CO, September 25-27, 2018. Retrieved online.

For well-to-tank impacts, the emissions model estimates the carbon-intensity of the "well" fuels (e.g., grams of CO_2e per megajoule) based on data and logic from Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model.[9] GREET is an LCA tool used to evaluate various transportation fuels like diesel, gasoline, hydrogen, natural gas, and biofuels. For tank-to-wheel, we use transportation fuel related emission factors from both GREET and the United Kingdom's Department of Environment, Food and Rural Affairs (DEFRA). Fuel consumption rates for vehicles are based on fleet averages from a variety of country and region-specific sources, including the U.S. EPA, U.S. Department of Energy, European Union, United Nations, and the International Council for Clean Transportation.

Supplier Provided Transportation of Products and Equipment

For some segments of Amazon's logistics network, we receive emissions directly from third-party transportation providers. These providers calculate emissions using Smart Freight Centre Accredited tools[10] that follow Global Logistic Emissions Council methodology, and we evaluate and include the supplier provided "well-to-wheel" emissions when available.

Customer Trips to Stores

Our model calculates the aggregate emissions from customer trips to Amazon's physical stores (i.e., Whole Foods Market, Amazon Fresh and Amazon Go) using publicly available travel behavior information from the Federal Highway Administration's National Household Travel Survey (NHTS). The model focuses on the following three variables that affect emissions for this category of activities:

Distance driven *– We use NHTS data to estimate the typical distance a customer drives for "goods purchasing" based on their setting (e.g., urban, suburban, or rural). We assume customers only travel to a single destination and that all trips are direct and round trip.*

Mode of transportation used *– NHTS data indicates how likely a customer is to use a certain mode of transportation among the following five categories: car, light-duty truck (e.g., truck, SUV, van), transit (e.g., bus, rail), non-motorized (e.g., walking, biking), and other.*

Total customer trips per year *– We estimate the number of customer trips to each physical store based on the store's setting (e.g., urban, suburban, or rural*).

After assembling the data and emissions factors for all vehicle and transportation modes, and estimated trips per store, we multiply the distance traveled by each mode by the appropriate emissions factor to each store. Finally, we multiply that product by the total number of customer transactions in the year.

Refrigerant Emissions Model

Emissions related to cooling and refrigeration are present across Amazon's global operations. These occur through normal business processes such as the cooling of our data centers,

corporate offices, and fulfillment facilities, and refrigeration for our Whole Foods Market stores and other grocery operations. We calculate the emissions associated with refrigerant materials across Amazon's facilities through a combination of data collection mechanisms. Where primary data is unavailable, we use estimation based on each facility's type and size, or intensity of electricity usage in the case of data centers. Amazon's refrigerant emissions are represented by total leakage of refrigerant material which occurs through normal operations multiplied by the global warming potential (GWP) of the specific material used.

9. Wang, M., Elgowainy, A., Lu, Z, Baek, K. H., Bafana, A., Benavides, P. T., Burnham, A., Cai, H., Cappello, V., Chen, P., Gan, Y., Gracida-Alvarez, U. R., Hawkins, T. R., Iyer, R. K., Kelly, J. C., Kim, T., Kumar, S., Kwon, H., Lee, K., Lee, U., Liu, X., Masum, F., Ng, C., Ou, L., Reddi, K., Siddique, N., Sun, P., Vyawahare, P., Xu, H., and Zaimes, G. Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model ® (2022 .Net). Computer Software. USDOE Office of Energy Efficiency and Renewable Energy (EERE). 10 Oct. 2022. Web. doi:10.11578/GREET-Net-2022/dc.20220908.2.
10. https://www.smartfreightcentre.org

Energy Emissions Model

We calculate the carbon footprint of energy used from purchased electricity, and fuel used for back-up power generation and heating across Amazon's facilities, including data centers, fulfillment network facilities, retail stores, and corporate offices. Electricity emissions factors account for direct power plant emissions, as well as upstream emissions, and transmission and distribution losses. Fuel emission factors account for combustion of fuels and upstream emissions associated with fuel production. The primary source of carbon emissions for our facilities is the electricity used to power our operations. We collect usage data from our facilities around the globe and process data from utility invoices to gain visibility into electricity and fuel usage. When usage data is unavailable, we estimate usage based on the usage from facilities with similar characteristics (size, type, location). In the case of data center back-up power generation, we use an estimate of fuel consumption based on the intensity of electricity use at the site. We then calculate carbon emissions by multiplying actual or estimated usage by the appropriate emission factor (e.g., regional electricity grid mix, CO_2e per kWh, or fuel combusted CO_2e per liter).

For electricity specifically, we use the GHGp's market-based method to demonstrate the impact of our renewable energy investments. For more information on our renewable energy measurements in support of our goal of matching 100% of the electricity consumed by our global operations with renewable energy, see our Renewable Energy Methodology.

Calculating the carbon emissions of energy relies on accurate emissions factors data from a variety of local, national, and regional sources. For example, electricity consumed by a site is multiplied by an emissions factor specific to its locality. Carbon from electricity generation varies widely by utility provider, state, country, and region due to the variety of technologies used for generation. Some countries rely heavily on coal, while other regions use significant amounts of low-carbon wind or hydropower. Our emissions model assigns the most precise emissions factors available for each facility based on its location. When supplier specific emission factors are not available, we assign state, province, sub-region or region level factors, and then national averages. In the U.S., the authoritative emissions factor sources come from the EPA's eGrid data (electricity emissions by U.S. grid sub-region), while the International Energy Agency provides average electricity emissions per kWh for almost every country in the world. For heating, we use fuel combustion emission factors from UK DEFRA in our energy model.

Packaging Emissions Model

Amazon uses a detailed emissions model to quantify the carbon footprint of each type of Amazon packaging (e.g., corrugate boxes or envelopes) from production to end-of-life. Carbon emissions are released during the raw material extraction, processing, manufacturing, and disposal of packaging. Our environmental packaging model quantifies the carbon footprint of every package from manufacture to end-of-life given key parameters like material type, mass, and dimension. In total, the emissions model produces life cycle carbon emissions factors for hundreds of packages based on Amazon's data on packaging materials, thickness, and recycling rates. We apply region-specific packaging emissions factors (where available) on a per-package basis to outbound shipments to calculate total emissions from packaging. The calculation covers emissions from raw materials and intermediate products, transportation overbox manufacturing, and end-of-life packaging (i.e., recycling or disposal). This service uses industry-standard LCA data from commercial LCA databases and supplier specific LCAs to model the impacts of raw materials and manufacturing processes.

Amazon Devices Emissions Model

We quantify the carbon footprint of Amazon devices sold during a given year using detailed data on the components of each device and the quantity sold each year. We produce detailed, parameterized models for our major device types, including Fire TV, Echo, Fire Tablets, Kindle, Ring, and Blink. We calculate the carbon footprint of each device type by inspecting the device's "Bill of Materials"—which details the mass and makeup of each component used in a device—and model life cycle emissions of each component using supplier specific inputs and a mix of commercially and publicly available LCA databases. After each stage of the life cycle is modeled, our research team creates emissions factors for each device by aggregating the carbon emissions from the manufacturing, transportation, and device end-of-life phases. We scale these emissions factors by the quantity sold to estimate the carbon footprint associated with manufacturing, transportation, and the end-of-life treatment of all Amazon devices sold in a given year. To calculate the emissions associated with the use of our devices, our methodology relies on telemetry data to determine the number of active devices in the field. We then multiply that by each device's average annual energy use. See our Devices Product Carbon Footprint Methodology for more information.

To match our customer's use of their devices with renewable energy sources, we calculate the emissions associated with the electricity grid that corresponds to the country in which the device is located. The electricity consumption is matched via renewable energy investments and is allocated in accordance with GHG Protocol market boundaries to offset average electricity grid emissions. Overall, annual emissions for devices are then determined by combining the annual emissions from all life cycle phases.[11]

Amazon Branded and Supplier-Provided Product Emissions

To calculate emissions associated with Amazon Private and Whole Foods Exclusive Brand products, we use LCA emission factors both by unit and weight sold from Amazon.com and Whole Food Markets. These LCAs are sourced from internal or external analysis, or supplier provided assessments based on the bill of materials and characteristic of the supply chain. Also covered by this approach, Amazon uses supplier provided LCAs to calculate the emissions from equipment used in Amazon's operations and supply chain such as warehouse carts and vehicles.

Amazon Building and Emissions Model

Amazon accounts for emissions for the use of our buildings within our other models but we incorporate the emissions associated with building lifecycle such as the materials and manufacturing, transportation of those components to the site, and construction in a separate building model.

Based on each building design, we built a model to calculate the emissions associated with the construction of Amazon facilities. These incorporate individual building plans, materials, internally and externally developed LCAs, and supplier provided data to estimate each building's emissions based on the actual building design or similar building designs based on similar characteristics (i.e., type, size and location).

Business Travel Emissions Model

For emissions from air and rail travel, mileage and car rentals, Amazon provides trip level details including travel origin, destination, mode of transport (such as aircraft type, class of service, aircraft seating, etc.), and associated costs to a third-party partner. Using a hierarchical approach based on specificity of data, a distance-based approach is prioritized to calculate each trip's emissions using the provided detail multiplied by supplier specific,

11. See our Device Renewable Energy Methodology for more information on Device's renewable energy matching calculation.

regional, UK DEFRA, and International Civil Aviation Organization (ICAO)+ derived emission factors. Amazon then combines these individual trip calculations to determine our total business travel emissions.

Employee Commute Emissions Model

We estimate the emissions associated with employees commuting to and from work at Amazon locations using a model that follows the GHGp recommended distance-based approach for employee commute estimation. We conduct a representative survey to understand how employees commute each day and what mode of transportation they use, such as walking, carpooling, biking, driving alone, or taking public transportation. Using the survey results, we generate estimated emission factors based on the distances employees reported traveling, the percentage of employees using each transportation mode, the associated mode's tailpipe emission factor based on available national, regional, and industry data sources. Finally, we multiplied the emission factors by the number of employees and the frequency of their commute to calculate the Amazon employee commute carbon emissions.