
Prepared for the National Retail Federation (NRF)
Consumer shopping behaviors and preferences have been changing. For example, shopping has been shifting to more online ordering, such as the surge in ecommerce during the COVID-19 pandemic. There is also growing consumer awareness that shopping decisions have an impact on greenhouse gas (GHG) emissions and climate change. Many consumers are looking for more sustainable solutions (i.e., to lower GHG emissions), but it can be difficult to understand how shopping behaviors can contribute to lower impacts. At the same time, reports are raising alarms on the climate crisis and nature loss, and it is important to understand and address impacts across the retail value chain.

The aim of this report is to outline the major GHG emissions hotspots associated with retail products and identify key levers for emissions reductions, including actions consumers can take. To do this, Pure Strategies reviewed life cycle assessment (LCA) studies on a range of retail products including food and beverage, apparel, household and personal goods, and consumer electronics products. The hotspots were areas where there were major contributions to a product’s total GHG emissions.

The analysis of the literature highlights several key findings across the product value chain:

1. **Raw material production and extraction** is a leading source of GHG emissions especially for products that use agricultural-based materials, fossil fuel-based materials or mined materials.

2. **Product manufacturing** is a hotspot for some electronics, household goods and apparel, but in many cases is not the biggest GHG emissions contributor.

3. **Retail operations** GHG emissions are typically smaller than other value chain phases such as raw material production and product use. They are also impacted by variables that the consumer influences (e.g., products selected, total miles needed for those products and use/waste considerations).

4. **“Last mile” transportation (from retailer to home)** can be highly variable depending on consumer choices, but typically is not the leading source of GHG emissions.

5. **Product use and disposal phase** is another leading source of GHG emissions especially for electronics, household appliances and items that need or use hot water (e.g., shower products, cooking foods or washing clothes). Consumer waste also drives GHG emissions, depending on the quantity and the method used to dispose of products when they are no longer needed (e.g., donating, reselling, recycling, composting or landfilling).
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<td>• Minimize the total miles needed to get all the purchased items from the retailer to home (e.g., fewer total trips for the products purchased)</td>
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<td>• Choose formats with less packaging material per unit of product</td>
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<td>• Choose more energy- and water-efficient products (e.g., appliances)</td>
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There may be different actions consumers can take depending on the shopping method used:

- **Actions in black apply regardless of where you shop**
- **Actions in gold apply when shopping at a bricks-and-mortar store**
- **Actions in blue apply when shopping online via ecommerce**
INTRODUCTION

The retail industry is both impacted by and contributing to climate change. Retailers face increasing supply chain disruptions and risks associated with a changing climate, and many are taking action to curb emissions from their operations and supply chains (National Retail Federation, 2021).

Further, consumers are more aware that shopping decisions have an impact on greenhouse gas (GHG) emissions and are increasingly willing to take personal action to combat sustainability challenges (Bailey, 2022; Priceless Planet Coalition, 2021). Despite this growing consumer awareness, it can be challenging for a shopper to understand the key drivers of emissions, and which specific purchasing decisions or behaviors have lower impacts.

At the same time, consumers are shifting where they purchase items, using a combination of retail models (Boudreau, 2021; Gee et al., 2020). In-store shopping continues to be the primary means for product purchases, and the number of physical stores is increasing (National Retail Federation, n.d.). However, online ordering, home delivery services and curbside pickups are increasingly common, especially due to the COVID-19 pandemic (Boudreau, 2021; Fernandez, 2021; Gee et al., 2020). Online shopping rates in particular have increased over the last decade; ecommerce peaked in 2020 and although levels have since dropped, ecommerce is still expected to continue to grow (Boudreau, 2021; Gee et al., 2020; NRF, n.d.; U.S. Census Bureau, 2022).

Consumers are hearing conflicting information around whether ecommerce or bricks-and-mortar shopping at stores is better for the environment (Boudreau, 2021; Rai, 2021). This can lead to inconsistent assumptions or confusion about how best to incorporate sustainability considerations in purchasing decisions.

The aim of this report is to review literature and studies on the life cycles of a broad range of retail products and summarize the major GHG emissions hotspots. A hotspot is an area with a major contribution to a product’s GHG emissions and as a result typically is an important opportunity to reduce GHG emissions.

Though this report highlights levers that consumers can influence, it is clear that businesses, governments and non-governmental organizations have critical roles to play to mitigate and reverse global climate change. This report does not set out to outline all possible ways to reduce all GHG emissions sources for retail products, but instead focuses on the main hotspots and the consumer connection to these and how they can contribute to GHG emission reduction through their behaviors and decisions.
Pure Strategies reviewed life cycle assessment (LCA) peer-reviewed studies and public reports focused on retail products to help identify general GHG emissions hotspots and reduction opportunities.

This review focuses on GHG emissions because it is a major impact of interest for retailers and consumers, and it was a consistent topic of study in the available literature. This review included LCA studies on retail food and beverage, apparel, footwear, household and personal goods, and consumer electronics products; it did not include automobiles, fuel retail or other specialties. Retail company sustainability reports were also reviewed when they included results from LCAs’ or GHGs’ inventories of the companies’ value chains.

GHG emissions are not the only sustainability impact associated with a product’s life cycle that consumers should be mindful of when selecting and using retail products. Impacts on water, air, land use, waste, worker health and rights, livelihoods and others are also important factors to consider, but comparative literature on these impacts is more limited so insights were not included in this analysis.

An LCA is “a tool to assess the potential environmental impacts and resources used throughout a product’s life cycle, that is, from raw material acquisition, via production and usage phases to waste management” (Subramanian and Yung, 2016). Figure 1 provides a simplified outline of the major phases of a retail product’s life cycle.

LCAs can assess GHG emissions, waste, land use, impacts to water and other environmental impacts.
This section summarizes the major hotspots that are applicable generally to many types of retail products. It is important to note that any specific product may be subject to variation, but broadly, these hotspots emerged among the many types of products assessed.

Phases of the Life Cycle and Typical Drivers of Impacts

- **Raw Materials Production and Extraction**: Agriculture, fossil fuels and mining
- **Product Manufacturing**: Energy and fuel use
- **Retail Operations**: Energy, fuel use and refrigeration
- **“Last Mile” Transportation (from retailer to customer)**: Energy and fuel use from total distance traveled (miles per trip, total trips) and type of transport
- **Product Use and Disposal**: Energy and water use in preparation and use; product and packaging waste

*Figure 2. Summary of GHG hotspots in retail products and key drivers of emissions (this is used to generalize typical impacts and does not represent all products or any one specific product). Typical Scale of Emissions Impact: High = Red, Medium = Orange, Low = Yellow*
Raw Material Production and Extraction

For many retail products, raw material production is a major emissions hotspot. Activities in this phase occur before a product is manufactured and include agriculture and mining or extraction of non-agricultural resources (e.g., fossil fuels). This phase also includes processing those resources into ingredients, packaging, fibers or other materials used in the manufacturing stage.

For foods and beverages, agriculture is often the main hotspot across the life cycle (Gee et al., 2020; Sala and Castellani, 2019; Weber and Matthews, 2008). Some LCAs show that agricultural production can be responsible for anywhere from 50% to 90% of GHG emissions for a range of food types (Gee et al., 2020). There is variation, though. A study on organic pasta found that primary production of wheat accounts for 17% of the global warming potential of the life cycle of the product, whereas the use phase (44%) and “last mile” transportation (20%) were the two bigger drivers of emissions (Gnielka and Menzel, 2021). This demonstrates that the scale of agriculture as a hotspot varies by product but is typically a key driver of emissions for many foods.

For many non-food items, the raw material production and extraction phase is still a GHG emissions hotspot but represents a smaller percentage of overall emissions than it typically does for foods and beverages. For example, Sala and Castellani looked at a range of household goods including detergents, hygiene products, soaps and shampoos, furniture, mattresses, footwear, textiles and paper-based products (2019). They found the biggest emissions hotspot was activities occurring before items are produced (i.e., the upstream phase), but when compared with food items, this upstream phase contributed a smaller proportion of overall emissions (Figure 3) (Sala and Castellani, 2019).
Consumers have influence even at this early phase. The key levers include selecting products with lower-impact materials and with fewer total materials and fewer new products/materials. For example, a study on plastic toothbrushes found the raw materials phase to have the greatest environmental impact but switching to a bamboo handle resulted in such a notable reduction in emissions that the raw materials phase was no longer the biggest hotspot (Lyne et al., 2020).

Seeking out reused products or those that have recycled content in packaging can have lower emissions compared with new items with virgin material (Benavides et al., 2018). Additionally, selecting more concentrated product formats with more compact packaging can also help shoppers minimize the impacts associated with raw material production. For example, consider buying a more concentrated laundry detergent (Kim and Park, 2020), or selecting bar body soap instead of liquid body soap (Koehler and Wildbolz, 2009).
The product manufacturing phase includes emissions associated with processing or converting raw materials and packaging into finished products. The Figure 3 summary from Sala and Castellani’s review of a range of household goods shows that the manufacturing (i.e., production) phase had a similar level of impact as the use phase, but both were lower than the raw materials phase (2019). Other apparel-specific studies have similar findings that clothing production is a major hotspot (Sohn et al., 2021) but in many cases is not as impactful as raw material production (Munasinghe et al., 2021).

For food, that same study found manufacturing to be the second biggest contributor to GHG emissions, but still a significantly smaller impact than raw material production (Sala and Castellani, 2019). Other food product LCAs have also found the manufacturing phase to have significantly smaller impacts than the raw material phase (Gnielka and Menzel, 2021).

When it comes to electronics, however, manufacturing and production can be one of the bigger drivers of emissions. A meta-analysis of LCAs on electronics found the manufacturing phase of the life cycle to be the next biggest contributor behind the product use and disposal phase (Subramanian and Yung, 2016). An LCA of an HP computer workstation also found manufacturing to be the second biggest contributor to GHG emissions, behind the product use phase (Sphera, n.d.).
The retail phase includes operations and processes associated with the sale of the finished product to a consumer, and can occur through multiple channels (e.g., bricks-and-mortar stores, ecommerce or omnichannel). It includes transportation between retail facilities (e.g., warehouses, distribution centers and stores), but it does not include the final leg of transport from the retail facility to the consumer’s home, which is considered the “last mile” in this report. Gee et al. provides a helpful visual example of various grocery retail models and their associated supply chains (Figure 4) (2020).

Generally, retail operations are not a major hotspot, with GHG emissions typically smaller in this phase compared with other phases such as raw material production and product use (Lyne et al., 2020; Pattara, 2012; Sala and Castellani, 2019; Sphera, n.d.; Weber and Matthews, 2008). The NRF “Retailers Reaching for Net-Zero” guidance reported that up to 98% of a retailer’s GHG emissions occur outside its operations (i.e., its scope 3 emissions that are upstream and downstream). However, retailers are working on efficiencies and GHG emissions reduction efforts in their operations, as highlighted in the Net-Zero report.

Retail operations are not typically leading sources of emissions.
While the overall impact from retail operations is relatively less than other value chain aspects, there is a notable amount of variability in emissions from energy used for warehouses, distribution centers and stores, packaging used and transportation impacts (Boudreau, 2021; van Loon et al., 2015). In some cases, bricks-and-mortar retail stores’ lighting, heating, cooling and refrigeration needs for display cases can contribute more emissions when compared with ecommerce fulfillment centers that do not need a consumer interface (Gee et al., 2020; Preston et al., 2021). However, most studies acknowledge there are many variables and tradeoffs to consider that impact the overall emissions from retail, including some downstream aspects, namely the “last mile” of transportation (Gee et al., 2020; Preston et al., 2021).
The last mile of transportation, from the retailer to the customer’s home, is one area that is subject to a wide range of variation depending on consumer choices, including the retail model used, the number of items purchased and the method of transportation.

For traditional bricks-and-mortar shopping, the last mile carbon footprint is critically impacted by the method and distance of travel and grouping purchase instances into as few trips as possible (and including other tasks into the shopping trip, i.e. trip chaining) (Hischier, 2018; van Loon et al., 2015). Generally, use of shared transportation, public transportation, biking or walking over motorized, private transportation can help reduce emissions (Fernandez, 2021; Gnielka and Menzel, 2021; Rai, 2021). If motorized transportation is used, electric is typically better than gas (Fernandez, 2021; Rai, 2021). Reducing the distance traveled to stores can also help (Gnielka and Menzel, 2021).

For online ordering, “rush shipment” for rapid last mile delivery has a larger impact because it increases the likelihood of air transport or deliveries on trucks that are partially empty, contributing to overall inefficiencies (Preston et al., 2020). Shipping options that are more efficient include no-rush shipments, consolidating items into one box or choosing to ship an online order from a local store’s inventory (Cheris et al., 2017; Fernandez et al., 2021). Additionally, minimizing returns of items ordered online is best; increasing the number of items you return subsequently increases the emissions impact of items the consumers keep (Hischier, 2018; Preston et al., 2020).

Regardless of whether consumers shop online or in stores, there are multiple ways to minimize emissions from the last mile. The total amount of miles, as well as form of transportation used, are the key factors to optimize at this stage in the value chain.
The product use phase is another major GHG emissions hotspot and is typically the main contributor for most electronics, household appliances and some food items (Gnielka and Menzel, 2021; Sala and Castellani, 2019; Sphera, n.d.; Subramanian and Yung, 2016). Electronics and appliances require power for operation and use (e.g., heating up water, electricity for charging).

Consumers can influence emissions associated with product use by selecting more energy efficient models, choosing lower impact energy sources to power products, and using electronics or appliances in a way to maximize the product’s life span (Subramanian and Yung, 2016). For example, consumers could consider purchasing a dishwasher with an Energy Star® Label that exceeds U.S. federal minimum standards for efficiency and only run the appliance when it is fully loaded (DOE, n.d.).

If food and beverage items require energy for preparation, the use phase is typically a significant hotspot. For example, studies have found that preparation of pasta, which requires energy to boil water, can contribute significantly to the overall GHG emissions of the product (Gnielka and Menzel, 2021). In the case of pasta, this use phase typically has a greater environmental impact than the production of raw materials and usually is more impactful than the last mile and product disposal (Gnielka and Menzel, 2021). In addition to using efficient appliances and renewable energy, consumers can reduce product use emissions from pasta by minimizing the amount of water boiled, using a lid on the pot and reducing heat after the water starts boiling (Gnielka and Menzel, 2021).

The use phase is also a hotspot for many household goods (e.g., detergents, soaps and shampoos, furniture, mattresses and textiles), though often it is slightly less impactful than the raw materials phase (Sala and Castellani, 2019). For apparel specifically, many studies find the use phase to be a major hotspot, but that impact can be highly variable depending on consumer use and behavior (Munasinghe et al., 2021; Sohn et al., 2021). Key factors that impact emissions include frequency of washing and drying, ironing, drycleaning and energy efficiency of appliances used (Munasinghe et al., 2021; Sohn et al., 2021).

Consumers have opportunities to use household products and apparel in a more sustainable way and select products designed for durability. For example, Levi Strauss & Co. launched a consumer campaign providing sustainable denim care instructions to encourage washing less frequently, using cold water, line drying and donating clothing when no longer needed (Levi Strauss & Co., 2020).

Waste, especially food waste, and how it is handled is also a contributor to GHG emissions. The method used to dispose of products, such as landfills, incinerating or recycling, impacts total GHG emissions at the end of a product’s life (Buzby, 2022). Some methods have lower emissions, such as donating, reselling and recycling, compared with disposing (e.g., landfills) (Sala and Castellani, 2019, Subramanian and Yung, 2016).
CONSUMER LEVERS TO REDUCE GHG EMISSIONS

Consumers have more influence on GHG impacts than many may realize. As the discussion above points out, that is because many GHG emissions hotspots are connected to consumer choices and behaviors. Below are actions shoppers can take to reduce GHG emissions in three key areas, from which products they buy to how they are transported home, used and disposed of.

Product Selection
When selecting which products to purchase in-store or online, consider:

- Seeking out reused and recycled products, or packaging with recycled material
- Selecting products in more concentrated or compact formats
- Choosing formats with less packaging material per unit of product
- For food and beverages, selecting more plant-based options
- Choosing more energy and water efficient products (e.g., appliances)

Last Mile Transportation
When deciding how to transport the product home, i.e., “the last mile,” consider:

- If shopping in-store...
  - Walk, bike or use public transportation
  - When using a personal motorized vehicle, electric is better
  - Combine shopping occasions with other stops and away from home trips (i.e., trip chaining)

- If shopping online ...
  - Avoid rush delivery
  - Consolidate shipments

Regardless of where you shop...

- Minimize the total miles needed to get all the purchased items from the retailer to home (e.g., fewer total trips for the products purchased)

Use and Disposal
When preparing, using and disposing of products, consider:

- Minimizing the number of products returned
- Minimizing product waste (e.g., food waste)
- Conserving energy and water when using products
- Reusing and recycling product packaging
- Donating, reselling or recycling products that are no longer needed
GHG emissions from retail products arise from each phase of the life cycle. The hotspots are typically found at the raw materials production and extraction phase and the product use and disposal phase. The impacts associated with manufacturing are significant for electronics as well as for many household goods and apparel. While retail operations using ecommerce, bricks-and-mortar or omnichannel models are not typically a significant driver of emissions, there are opportunities across all these fulfillment methods to reduce emissions. Further, the last mile transportation phase can be a source of notable emissions depending on delivery and transportation methods chosen by retailers and consumers.

Though there are opportunities to reduce impacts throughout the life cycle of retail products, the existing research points to hotspots that consumers can influence with their purchase decisions and behaviors to lower overall emissions. The key levers are product selection, how the product is transported “the last mile” and the way the consumer uses the products.

An additional insight from the research reviewed for this report was that one should not oversimplify these levers. For example, assuming that one type of retail model will always be better than another overlooks other important considerations. Rather, the key to reducing emissions is optimizing the multiple factors the consumer controls while also improving the rest of the life cycle, which includes retailers and manufacturers also achieving GHG reductions.
ABOUT PURE STRATEGIES
Pure Strategies has been transforming business through sustainability performance since 1998. Our team helps companies initiate and enhance existing sustainability programs by assessing environmental and social impacts, establishing meaningful sustainability goals and strategies, and making changes to products and supply chains that deliver value to the business and society. Pure Strategies is proud to be a certified B Corp. Please visit our website for more information about our services and clients: purestrategies.com

ABOUT THIS REPORT
Pure Strategies has supported NRF’s sustainability program since 2021. This included creating an industry guide, Retailers Reaching for Net-Zero: a guide for taking science-based action to reduce greenhouse gas emissions. NRF funded the research and development of this report.

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