Background Report

Development of GS-60 Standard for Trash Bags and Can Liners

November 30, 2022

About Green Seal
Green Seal® is a global nonprofit organization that pioneered the ecolabeling movement with a mission to transform the economy for a healthier, greener world. For 30 years, Green Seal's rigorous standards for health, sustainability and product performance have driven permanent shifts in the marketplace, empowering better purchasing decisions and rewarding industry innovators. With thousands of certified products, services and spaces from the world's leading companies, the Green Seal certification mark is a universal symbol that a product or service meets the highest benchmark of health and environmental leadership.

Our Mission.
To transform the economy for a healthier, greener world.

Our Vision.
A healthy society in balance with nature.

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Introduction

This background report summarizes research and technical justifications for Green Seal's proposed Standard for Trash Bags and Can Liners (GS-60).

In 2021, Green Seal studied the product category of trash bags and can liners and identified opportunities to support the acceleration of this industry toward greener product design. Through our standard development process, we define and recognize leadership in the market and then certify products so that purchasers can find what they need and know that the product will work as expected while also reducing health and environmental impacts. Green Seal's full standard development process is described in Appendix 1.

Reducing the Impacts of an Everyday Purchase
Trash bags and can liners are a daily need for our homes, offices, schools, and other indoor spaces. No alternatives currently perform as well as plastic liners for strength, odor control, and sanitation. Unfortunately, single-use plastic liners have large environmental impacts: they require high amounts of energy to produce, create greenhouse gas emissions, and contribute to the problem of plastic waste pollution. However, these products can be made with less virgin plastic without sacrificing performance – either by incorporating high levels of recycled content, or by producing a thinner liner during manufacturing. This creates an opportunity for people to purchase products that use a greener product design and have reduced environmental impacts. Green Seal's Standard for Trash Bags and Can Liners aims to recognize industry leaders that are developing safe and effective products that also greatly reduce their greenhouse gas emissions and plastic waste, and enable purchasers to easily identify these products for domestic, institutional, and commercial use.

Overview of Proposed Standard

Green Seal is proposing to develop a standard that provides verification for the following:

- The product works well: the bag is puncture and tear resistant, as appropriate for its stated use.
- The product has reduced environmental impacts, including a lower carbon footprint, and decreased plastic waste
- The product is free of hazardous chemicals.
- The product packaging has reduced environmental impacts

Intended Outcomes

Green Seal has the following intended outcomes for the development of the GS-60 Standard for Trash Bags and Can Liners:

Outcome 1. Reward and highlight industry leaders on today's market. Green Seal issues a feasible, market-relevant leadership standard that is a valuable tool for manufacturers.

Outcome 2. Provide valuable service to green purchasers and consumers. Purchasers specify GS-60 certified products in their specifications and green purchasing guidelines.

Outcome 3. Incentivize supply chain improvements and manufacturing innovations. To achieve certification, manufacturers invest in their supply chains to produce trash bags and can liners with high recycled content, or they invest in their manufacturing processes to create thinner liners that use less virgin plastic.

Document Guide

Part I provides a brief overview of plastic film trash bags and can liners, including a discussion of the products' life cycle and functional attributes, common ingredients and known hazards, and industry standard quality assurance practices.

Part II summarizes the justifications and intentions for Green Seal's proposed criteria for trash bags and can liners, organized by the products' main life cycle impacts.

Instructions for Submitting Public Comments

As of the publication date of this report, Green Seal has opened a public comment period for the development of criteria for trash bags and can liners. To submit comments on this background report or the proposed criteria, visit Green Seal's website.

PART I. PRODUCT AND MARKET RESEARCH SUMMARY

Below is Green Seal's market and technical research on the product category of trash bags and can liners. The information presented below supports the proposed criteria in Part II.

Product Category Overview

Product Category Terms

Generally, trash bags are for domestic and commercial purposes, whereas can liners are used in industrial, institutional, and medical applications. The product category also includes wastepaper basket liners (with capacity of 4, 7, 8, or 10 gallons), can liners (generic term, often 13 gallons), kitchen garbage bags (13 or 20 gallons), bags for outdoor and yard waste (39 gallons), contractor bags (42 gallons), and drum liners (55 gallons). Bags and liners are most often white, black, gray, clear, or red. For the purposes of the rest of this report, the terms *trash bags and can liners* will refer to all of these product sizes and uses.

Plastic Films

Plastic films are thin, flexible plastics used to make bags and wraps, including grocery bags, trash bags, dry-cleaning bags, and plastic wraps. Plastic films are typically made from any of three types of plastic: high-density polyethylene, low-density polyethylene, and linear low-density polyethylene. Plastic films can also be a blend of more than one plastic type. These different plastic materials—referred to as plastic resins—are defined by the raw materials, or polymers, used to make them. When plastic films are recycled, their constituent polymers remain intact. Thus, in general, recycled plastic films can be made only into new plastic film products of the same resin type. The full life cycle and manufacturing process of plastic films are detailed below.

A Brief History

Before the invention of plastic trash bags, many people threw garbage directly into the can or used paper bags or liners. Papers bags and liners could fail if waste was wet and did little to contain odors. In the 1950s, Canadian inventor Harry Wasylyk developed the first plastic trash bags. The bags were first used by Winnipeg General Hospital in Manitoba. In the 1960s, Union Carbide Company purchased the trash bag idea and began producing the first residential trash bags under the brand name Glad.[1] Trash bags are now essential products used in homes, offices, schools, hospitals, and other indoor spaces where waste is generated. In fact, American households alone use more than a billion trash bags each year.[2]

Current Product Market

To understand the scope of products on the market, Green Seal performed an analysis of 148 products from 56 manufacturers. The current environmentally friendly trash bags and can liners market is heavily influenced on the industrial and institutional (I&I) side by state and federal purchasing requirements that require some amount of post-consumer recycled (PCR) content. For example, since the 1990s, California has required 10 percent PCR content for all plastic bags of 0.7 mil or greater thickness, and the Environmental Protection Agency's Comprehensive Procurement Guidelines require 10 percent PCR content in bags of all sizes. The current product market consists of bags that are advertised to contain a range of recycled content between 0 percent and 97 percent. Additionally, there are products on the market that claim environmental preferability by source-reduction — i.e. using less virgin material up front by creating thinner liners through technology investments, or by using mineral additives that further decrease virgin plastic used in the final product. On the household side, conventional products with any level of PCR content are uncommon, and products that claim to be environmentally preferable averaged

[1] There's Nothing Trashy about the History of Trash Bags. https://www.aaapolymer.com/history-of-trash-bags/

[2] U.S. population: How many indoor garbage bags have you used in the last 30 days? https://www.statista.com/statistics/275927/us-households-quantity-of-indoor-garbage-bags-used-within-30-days/

25 percent PCR content. For both household and I&I uses, products' functional claims, such as a product's ability to stretch without tearing and resist being punctured by waste items, were also identified as important.

Plastic Pollution Problem

Trash bags, inherently a single-use plastic product, are part of a larger problem of plastic pollution. In 2018, Americans generated nearly 9 billion pounds of waste plastic films, bags, and wraps.[3] That same year, California alone reported 2.6 billion pounds of plastic films in its state waste stream, indicating the national figure may be even higher.[4] Demand for plastic films is expected to continue to increase. Globally, the plastic film market was valued at $183.46 billion in 2020 and is projected to increase to $220.25 billion by 2026.[5]

In the broader view, plastic waste in general is a significant challenge because so little of the plastic produced is recycled. For example, in 2018, the U.S. Environmental Protection Agency reported that 35.7 million tons of plastics were generated in the United States,[3] of which only 8.7 percent was recycled; the rest was either incinerated or landfilled (Table 2). Plastic production continues to increase with investments in the production of virgin plastic materials: "since 2010, companies have invested more than $200 billion in 333 plastic and other chemical products in the U.S., including expansions of existing facilities, new plants, and associated infrastructure such as pipelines."[6] This increase comes at a time when just over half of U.S. residents have access to curbside recycling at all—highlighting the lack of infrastructure to facilitate effective recycling strategies to reduce plastic pollution at the residential level.[7] At the national level, unrecycled plastic waste in the U.S. has increased, with fewer exports to other countries after the passage of the National Sword Policy by China in 2018. In fact, U.S. exports of plastic waste decreased by more than 60 percent between 2010 and 2018.[8]

Plastics that are not recycled nearly always end up in our waterways: more than 79 percent of plastic products eventually reach the ocean,[9] adding 14 million tons of plastic waste every year to marine environments.[10] The health and environmental impacts of plastic production are documented in more detail in the Life Cycle Impacts section.

Table 1. Plastics in Municipal Waste, by Weight, 1960–2015 (in thousands of U.S. tons)

Management Pathway	1960	1970	1980	1990	2000	2005	2010	2014	2015
Generation	390	2,900	6,830	17,130	25,550	29,380	31,400	33,390	34,500
Recycled	—	—	20	370	1,780	1,780	2,500	3,190	3,140
Composted	—	—	—	—	—	—	—	—	—

[3] Advancing Sustainable Materials Management: 2018 Tables and Figures. https://www.epa.gov/sites/default/files/2020-11/documents/2018_tables_and_figures_fnl_508.pdf#page=14
[4] 2018 Facility-Based Characterization of Solid Waste in California. https://www2.calrecycle.ca.gov/Publications/Download/1458
[5] Plastic Film Market – Growth, Trends, COVID-19 Impact, and Forecasts (2022-2027). https://www.mordorintelligence.com/industry-reports/plastic-film-market
[6] The Plastics Pipeline: A Surge of New Production Is on the Way. https://e360.yale.edu/features/the-plastics-pipeline-a-surge-of-new-production-is-on-the-way
[7] Sustainable Packaging Coalition 2020-2021 Centralized Study on Availability of Recycling. https://sustainablepackaging.org/wp-content/uploads/2022/03/UPDATED-2020-21-Centralized-Study-on-Availability-of-Recycling-SPC-3-2022.pdf
[8] The Impact of China's Environmental and Trade Policies on U.S. Plastic and Paper Waste Exports. https://agecon.unl.edu/impact-china%E2%80%99s-environmental-and-trade-policies-us-plastic-and-paper-waste-exports
[9] The environmental impacts of plastics and micro-plastics use, waste and pollution: EU and national measures. https://www.europarl.europa.eu/RegData/etudes/STUD/2020/658279/IPOL_STU(2020)658279_EN.pdf
[10] International Union for Conservation of Nature Issues Brief: Marine Plastic Pollution. https://www.iucn.org/sites/default/files/2022-04/marine_plastic_pollution_issues_brief_nov21.pdf

Combustion with energy recovery	—	—	140	2,980	4,120	4,330	4,530	5,010	5,350
Landfilled	390	2,900	6,670	13,780	19,950	23,270	24,370	25,190	26,010

Modified from American Chemistry Council and the National Association for PET Resources.

Product Life Cycle Overview

Green Seal's aim is to determine the most significant life-cycle impacts across the supply chain and identify products' leadership attributes that are verifiable via document disclosure, traceability reviews, and manufacturing plant on-site reviews. To identify the leadership attributes of a product category, Green Seal conducts a content review of company websites, industry association reports, and peer-reviewed journal articles. The summaries below describe the life cycle of trash bags and can liners with and without incorporating recycled content. These summaries provide part of the landscape analysis that Green Seal developed as a foundation for standard criteria development.

Trash bags and can liners are plastic films made from polyethylene resins of three densities: low-density polyethylene (LDPE), high-density polyethylene (HDPE), and linear low-density polyethylene (LLDPE).[11] These three materials have very similar life cycles and supply chains but differ in how their polymers are interlinked. The life-cycle stages of polyethylene films are as follows:[12,13]

- Raw Material Extraction and Processing Stages
    - Extraction of natural gas or crude oil (naphtha)
    - Refinement: raw material is processed into ethane
    - Thermal cracking: ethane to ethylene monomers
    - Polymerization: ethylene monomers produce polyethylene resin pellets
- Manufacturing Stage
    - Polyethylene resin pellets are made into trash bags and can liners
        - Melting
        - Mixing in additives
        - Blown extrusion process
    - Packaging Production
        - Typically, paperboard made from virgin and / or recycled paper fibers
    - Distribution
        - Product is shipped to distributors and retailers
- Use Stage
- Disposal and End-of-Life Stage
    - Landfill
    - Incineration
    - Recycling

The health and environmental consequences associated with each life-cycle stage are outlined in the next section.

[11] 2018 National Post-Consumer Plastic Bag & Film Recycling Report. https://www.plasticsmarkets.org/jsfcontent/FilmReport18_jsf_1.pdf
[12] Life Cycle Assessment of Reusable and Single-use Plastic Bags in California. https://plasticsparadox.com/wp-content/uploads/2021/01/Life-Cycle-Assessment-of-Reusable-and-Single-use-Plastic-Bags-in-California.pdf
[13] Life Cycle Analysis of Plastic Packaging. https://iopscience.iop.org/article/10.1088/1755-1315/616/1/012036/pdf

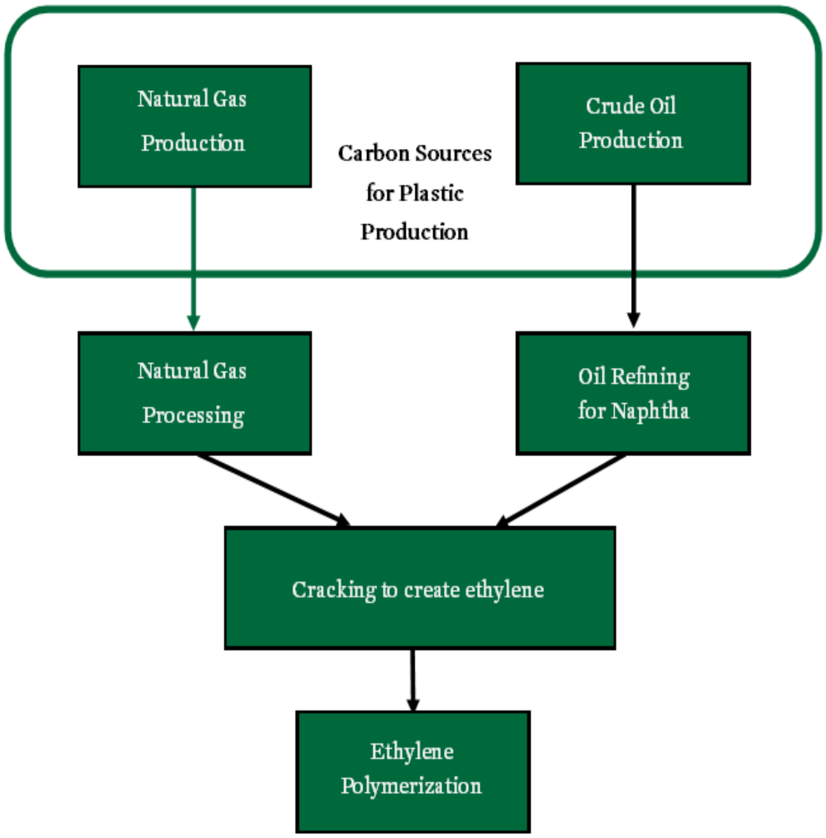

Figure 1. Raw material extraction and processing phases of virgin plastic resin production for polyethylene films. Modified from Al-Ma'adeed et al. 2011.

Plastics Recycling Process. Trash bags and can liners made from post-industrial and post-consumer recycled resins[14] have additional life cycle steps in the manufacturing stage: recovery and processing of plastic products.[15]

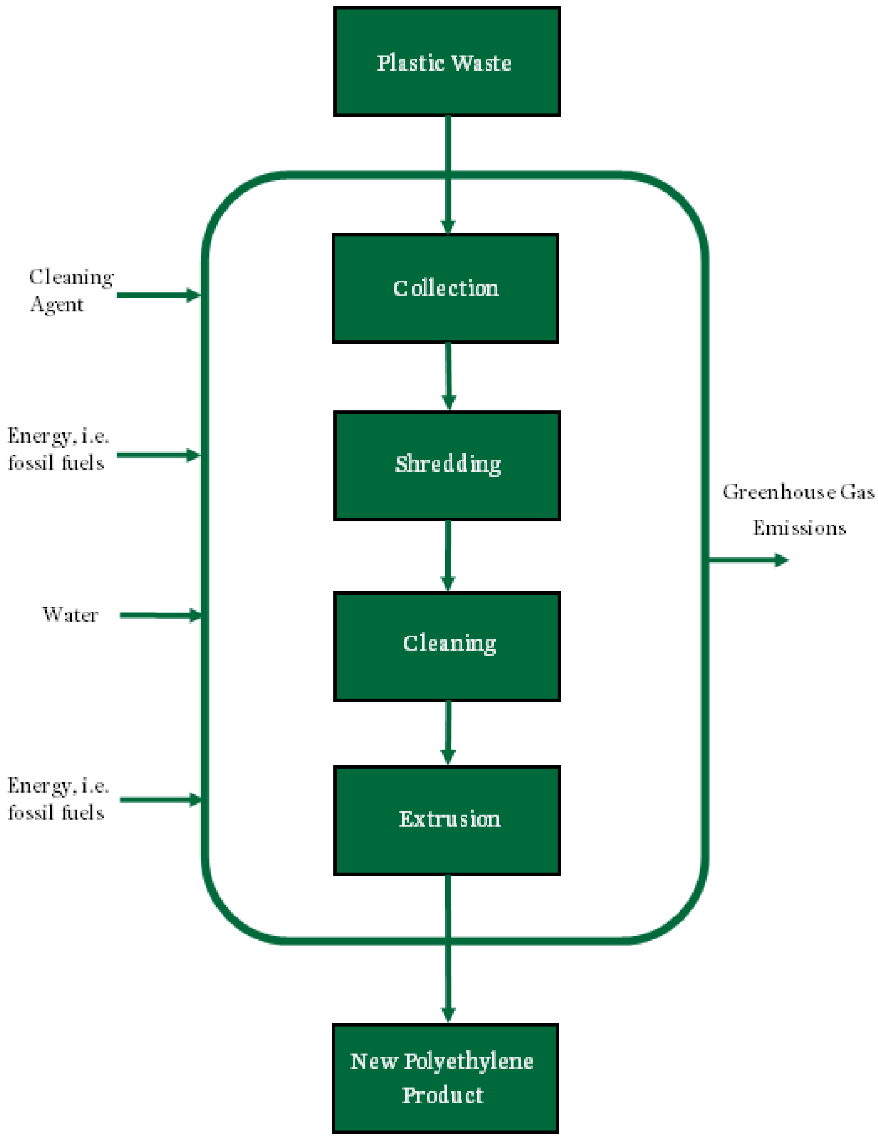

Figure 2. Production phase for recycled polyethylene products. Modified from Al-Ma'adeed et al. 2011.

[14] **Note Regarding the Proposed GS-60 Standard for Trash Bags and Can Liners:** Green Seal's proposed criteria defines post-consumer recycled resins by ISO 14021: "material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain." Additionally, Green Seal's impact analysis for the proposed standard does not distinguish between open loop and closed loop recycling.
[15] Life Cycle Impacts for Post-Consumer Recycled Resins: PET, HDPE, and PP. https://plasticsrecycling.org/images/library/2018-APR-LCI-report.pdf

Recycled resins can be recovered from either post-industrial or post-consumer sources. Plastics recovery and recycling most often occurs via an "open loop" system. In an open loop system, the primary recycled sources of plastics are recovered from municipal collection bins, retail front-of-house collection bins, retail back-of-house collection bins, and distribution centers.

- Manufacturing Stage
  - Recycled materials are recovered
- Transportation
  - Recycled materials are transported to manufacturing facility
- Sorting and Separation
- Reclamation
  - Recycled material is converted to plastic resin pellets

Life Cycle Impacts

When developing a product category standard, Green Seal reviews the product's life-cycle stages to determine the most significant impacts and today's best practices in life-cycle impact reduction.

Our summaries of the life cycle stages of plastic films use the framework of the ISO 14040 Standard: raw material acquisition, manufacturing, distribution and transportation, use, disposal, and end of life. The life cycle summaries are for plastic films made solely from virgin resins and, for simplicity, plastic film products made solely from recycled resins. In today's North American market, trash bags and can liners generally contain 0 percent to 50 percent recycled resins, with the remainder of the product produced from virgin resins, colorants, and some mineral additives.[16]

The impacts of plastic production are wide ranging and include large effects on energy use and emissions, documented harms to human health, and consequences for waterways and marine life. For example, millions of tons of plastic waste pollute our waterways and have harmful effects on wildlife.[17,10] Perhaps most notably, however, with its energy- and resource-intensive manufacturing process, plastic contributes to the release of greenhouse gas emissions and use of fossil fuels from the extraction, refining, manufacturing, transport, and waste management of plastic materials.[18] As a result, plastics play a role in climate change as products that are made from and release carbon.

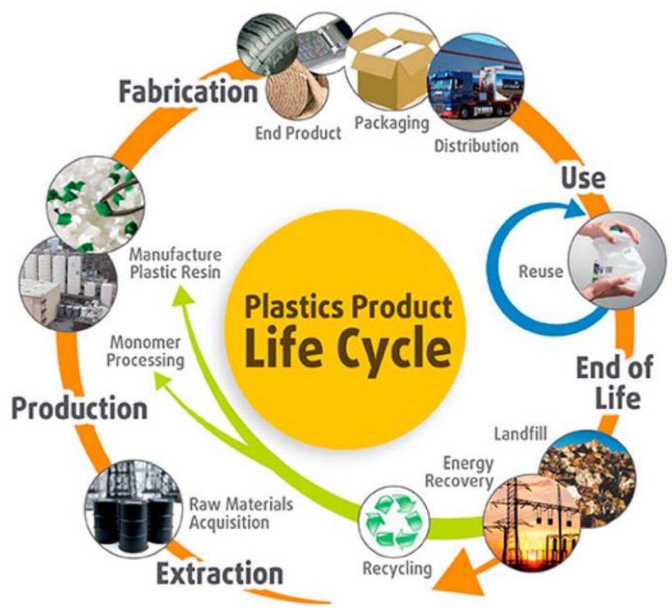

Figure 3. General plastic product life cycle. Source: Devasahayam et al. 2019

Virgin Plastic Production

The production of virgin plastic materials has high environmental impacts, mainly due to large amounts of raw material and energy inputs and associated

[16] Plastic Waste Management: A Review of Existing Life Cycle Assessment Studies. https://doi.org/10.3390/su13105340
[17] EPA Learn About Aquatic Trash. https://www.epa.gov/trash-free-waters/learn-about-aquatic-trash
[18] Plastic & Climate: The Hidden Costs of a Plastic Planet. https://www.ciel.org/wp-content/uploads/2019/05/Plastic-and-Climate-FINAL-2019.pdf

greenhouse gas emissions. Production of plastic for polyethylene films begins, as it does for other plastic products, with extracting crude oil or natural gas from wells, transporting that material, refining it into usable components in a process called cracking, and then creating plastic pellets through polymerization.[18] The major health and environmental impacts of each stage in this process are summarized in Table 2.

Table 2. Main health and environmental impacts from life cycle of polyethylene films

Life Cycle Stage	Emissions	Energy Use	Water Usage, Quality	Chemical Exposure	Waste
Raw material extraction and processing	x	x			
Manufacturing	x	x	x	x	
Transportation	x	x			
Use					x
Disposal, end of life	x	x	x		x

Raw Material Extraction and Processing Stages

Extraction and Refinement. Polyethylene films are made from fossil fuel raw materials—either crude oil or natural gas. Extracting and transporting these materials have several adverse environmental impacts including "GHG emissions, acidification, and eco-toxicity (air and water)."[19] Drilling for crude oil can also harm marine ecosystems or require land clearing of trees and other vegetation. Hydraulic fracking to produce natural gas requires large amounts of water, which generates a large amount of wastewater that can contain contaminants and be difficult to dispose of safely.[20] After extraction, crude oil and natural gas must be refined into usable components—naphtha and ethane, respectively. Crude oil is "heated in a furnace, which is then sent to the distillation unit, where heavy crude oil separates into lighter components"; one of those components is naphtha.[21] Natural gas is transported to a processing facility, where "different pressures and temperatures are applied to draw off each of the gases separately" to isolate ethane.[22] Yearly, an estimated 40 million metric tonnes of greenhouse gas emissions are generated from the process of refining raw materials for plastic production.[18]

Cracking. Additional refining of naphtha and ethane is necessary so that these materials can be used to produce polyethylene films. In cracking, high heat is used to break down the naphtha or ethane into smaller molecules, called ethylene, which is ultimately used to create plastic. Natural gas or other energy sources are burned to achieve the high temperatures needed—sometimes as high as 1,100°C.[18] This process produces high amounts of greenhouse gas emissions: "for ethylene production, fuel burning at the power plant to produce energy is by far the dominant source (78–93 percent depending on the fuel source) of adverse environmental impacts."[19] In 2015 alone, cracking to produce ethylene created 184.3 million to 213 million metric tonnes of greenhouse gas emissions—the equivalent of emissions from 45 million passenger vehicles driven for one year. The production capacity to process raw material inputs into ethylene is projected to grow 33 percent to 36 percent by 2025, and thus impacts from this process are expected to increase in the next several years.[18]

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[19] Environmental impacts of ethylene production from diverse feedstocks and energy sources. https://doi.org/10.1007/s13203-013-0029-7
[20] U.S. Energy Information Administration: Oil and petroleum products explained. https://www.eia.gov/energyexplained/oil-and-petroleum-products/oil-and-the-environment.php#
[21] British Plastics Federation: How is Plastic Made? A Simple Step-By-Step Explanation. https://www.bpf.co.uk/plastipedia/how-is-plastic-made.aspx
[22] Penn State Extension: How Plastic is made from Natural Gas. https://extension.psu.edu/how-plastic-is-made-from-natural-gas

Polymerization. The last step in the processing of raw materials for plastic films is polymerization: the primary ingredient of ethylene is bonded to other ethylene molecules to make a chain, which creates a plastic polymer.[23] This final step is also energy intensive,[24] requiring "temperatures between 260 and 300°C."[18] Any heat source that involves burning fossil fuels contributes to greenhouse gas emissions. Additives can also be introduced at this step to give polymers certain attributes like strength, flexibility, or resistance to solvents.[22] The polymers may then be shredded and delivered as pellets or flakes to the manufacturer to use to create a specific product.

Manufacturing Stage

Production. Manufacturers use plastic polymers in the form of pellets or flakes to create polyethylene films. The pellets are melted, blended, shaped, and solidified, often with additives to achieve desired product performance and qualities. Extrusion is used to push melted polymers through an opening that shapes them continuously into a film: "The continuous process enables the production of a consistent high-quality product to extremely accurate gauge."[25] The main impacts of this stage include the greenhouse gas emissions associated with burning energy to heat the polymers and shape them into the desired product. Extracting and manufacturing resources for plastic production can also produce chemicals harmful to human health, particularly for industry workers and neighboring communities. These chemicals have been associated with negative health outcomes that affect development, reproduction, the nervous system, and many other conditions.[26] Harmful exposure for industry workers is of particular concern when new films are manufactured with recycled content: at the high temperatures needed to mold the plastic, "toxic metals, volatile organic compounds (VOCs), phthalates, polycyclic aromatic hydrocarbons," and several other harmful substances can be released.[27]

Packaging. Product packaging for polyethylene films may be plastic or fiber-based material. Plastic packaging has similar life cycle impacts as those for polyethylene films. If it is fiber-based, the main life cycle impacts of the packaging are greenhouse gas emissions and water quality effects from manufacturing practices used during production and end-of-life disposal. For example, for fiber-based packaging made from virgin wood fiber, greenhouse gases are emitted during timber harvesting, pulp processing, and disposal. Paper products discarded in landfills can release methane—a potent greenhouse gas.[28] Additionally, the bleaching of some product packaging can release persistent organic pollutants, including dioxins, furans, and the carcinogen chloroform, into the air and water. These pollutants are toxic to humans and aquatic life.

Distribution Stage

Transportation. The distribution of polyethylene film products involves moving finished goods to retailers and commercial and institutional settings. The main impact of this phase is the greenhouse gas emissions associated with burning fuel; the amount of greenhouse gas emissions generated from this transport depends on the distance traveled, the amount of product shipped, and the frequency of trips over a given time period. One estimate indicates that overall transportation associated with plastic production accounts for 1.7 percent of the total impacts of the process.[13]

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[23] Making Plastics: From Monomer to Polymer. https://www.aiche.org/resources/publications/cep/2015/september/making-plastics-monomer-polymer#
[24] Energy demand and efficiency measures in polymer processing: comparison between temperate and Mediterranean operating plants. https://doi.org/10.1007/s40095-015-0200
[25] British Plastics Federation: Film Extrusion. https://www.bpf.co.uk/plastipedia/processes/film-extrusion.aspx
[26] Plastic and Human Health: A Lifecycle Approach to Plastic Pollution. https://www.ciel.org/project-update/plastic-and-human-health-a-lifecycle-approach-to-plastic-pollution/
[27] An overview of chemical additives present in plastics: Migration, release, fate and environmental impact during their use, disposal and recycling. https://doi.org/10.1016/j.jhazmat.2017.10.014
[28] Third National Climate Assessment. https://nca2014.globalchange.gov/report/sectors/forests

Use Stage

Quality of Product and Functional Performance. The largest impact of the use stage of polyethylene films is related to performance: products should work as intended, without ripping, tearing, or leaking, so that they are not discarded prematurely. The durability of polyethylene films depends on the use of the product: can liners meant for use in household kitchens require less resin strength than those used in institutional cafeterias. The proposed product functional requirements proposed in GS-60 are explained below.

Ingredient Composition. Of plastic resin types, polyethylene has a less hazardous ingredient profile than polyvinyl chloride and polypropylene. Polyethylene films are not known to be made with hazardous chemicals or additives that would result in dermal exposure to the user during the use stage. The proposed hazard prohibitions are explained below.

Disposal and End-of-Life Stages

Plastics, including polyethylene films, are generally disposed of in one of three ways: landfilling, incineration, or recycling. For the purposes of this section, Green Seal will detail the impacts from mechanical recycling only.

FIGURE 13

Climate Impacts of Plastic Packaging Waste Disposal Options (kg CO_2e/metric ton)

Activities/Processes	Recycling	Landfill	Incineration
Collection/Self-Haul	45	35	35
Material Handling	650	25	38
Virgin Material Offset	-2,090		
Biodegradation		0	
Incineration			2,894
With Energy Recovery			
Natural Gas Offsets			-2,040
Renewable Energy Offsets			-30
Total	**-1,395**	**60**	**898**

Note: This analysis assumes that all incineration is conducted with energy recovery, as exact data on the ratio of incineration without energy recovery is currently not available. While incineration without energy recovery does exist, it results in 2,894 kg CO_2e of greenhouse gases per Mt of plastic burned, which is the same as open burning. US EIA, International Energy Outlook, 2017 (data for 2015) estimates that renewable energy accounted for 17 percent of worldwide electricity generation in 2015.

Source: Sound Resource Management Group, Inc provided this analysis based on the sources available at *https://www.no-burn.org/plastic-climate-appendix*.

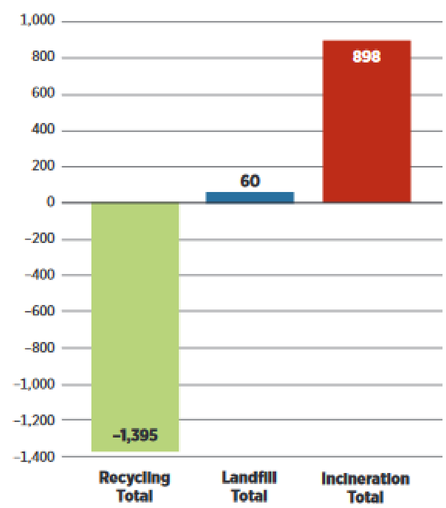

Figure 4. Greenhouse gas emissions estimates from landfilling, recycling, and incinerating plastic waste.[18]

Landfilling. In the U.S., more than 75 percent of plastic waste is sent to landfills.[29] Of the three disposal options, landfilling emits the least amount of greenhouse gases as its own process (Figure 3). In fact, the "emissions related to landfilling plastic packaging result primarily from the fossil fuel use associated with the sorting and handling of the wastes prior to landfilling and the transportation of the waste from the collection point to the landfill."[18] However, landfills can pose other problems, such as health risks from toxic substances leaching into soil and waterways, and "cannot be viewed as a long-term solution for plastic waste management."[18]

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[29] U.S. Government Accountability Office: Can Chemical Recycling Reduce Plastic Pollution? https://www.gao.gov/blog/can-chemical-recycling-reduce-plastic-pollution

Incineration. Plastic waste can be incinerated (burned) to generate energy for use in other processes. However, incinerating plastic waste itself causes greenhouse gas emissions through the energy needed to heat the plastic. This method of disposal is seen as more energy and emissions intensive than recycling or landfilling: "emissions of greenhouse gases alone are estimated at approximately 900 kg CO_2 equivalent per metric ton of plastic waste incinerated, roughly 15 times the volume of emissions when this waste is landfilled."[9] In 2015, emissions from incinerating plastic were estimated at 5.9 million metric tonnes of carbon dioxide equivalent.[30] Burning mixed plastic waste can also release harmful chemicals, including nitrous oxides, volatile organic compounds, carbon monoxide, and polychlorinated biphenyls. These chemicals have been shown to damage human health.[9]

Recycling. Although recycling plastic resins requires some inputs of energy and water, this is the most environmentally friendly option for disposal because the recycled plastic displaces new plastic and thus avoids the harms associated with processing virgin raw material.[31] Recycling plastic resins involves collecting and sorting post-consumer plastic, then processing the recovered material at a reclaimer to clean and make it ready for the plastic manufacturer. Each step has associated greenhouse gas emissions from energy and transportation inputs. Water consumption is also a concern when post-consumer plastic are converted into "clean recycled resin ready for use to manufacture a plastic product."[15] Plastic trash bags and can liners themselves are inherently not recyclable due to their nature of holding waste materials, but they can contain recycled plastic resins.

End of Life. Because plastics do not biodegrade quickly in the environment, polyethylene films can have end-of-life impacts after disposal. Landfilled plastic can escape collection pathways or be directly added to the environment via littering. The products can ultimately enter waterways: it is estimated that 79 percent of plastic products reach the ocean,[9] and more than 14 million tons of plastic are added to the ocean each year.[10] In addition to harming wildlife,[17,10] plastics in oceans contribute to climate change, through their own decomposition and by interfering with natural marine processes. For example, "sea surface plastic degradation alone has been estimated to release 76 metric tonnes of methane annually worldwide," and microplastic pollution may interfere with marine organisms' ability to help the ocean act as a carbon sink that stores carbon dioxide from the atmosphere.[32]

Opportunities for Impact Reduction

Of the impacts described above, Green Seal has identified three main impact reduction opportunities for standard development:

- reducing greenhouse gas emissions and plastic waste associated with the product and in product packaging;
- ensuring products' functional performance; and
- confirming the absence of hazardous chemicals that harm human health.

The proposed criteria that align with those impact reduction opportunities are in Part II.

Reducing Emissions and Waste by Using Less Virgin Plastic

How Recycling Reduces Emissions

[30] Plastic & Climate: The Hidden Costs of a Plastic Planet. https://www.ciel.org/project-update/plastic-climate-the-hidden-costs-of-a-plastic-planet/
[31] Life cycle assessment of end-of-life treatments for plastic film waste. https://doi.org/10.1016/j.jclepro.2018.07.278
[32] Microplastics and climate change: our ocean needs bold decisions. https://seas-at-risk.org/general-news/microplastics-and-climate-change-our-ocean-needs-bold-decisions/

With plastic production expected to increase globally, it is important to understand how mitigation strategies, such as reducing virgin content, will affect greenhouse gas emissions.[18] Recycling of plastics has clear, quantified environmental benefits. Studies show that incorporating recycled content into plastic products results in net reductions of greenhouse gas emissions by eliminating emissions associated with the manufacturing of virgin material. For example, using 100 percent recycled materials compared with 100 percent virgin materials reduces roughly 70 percent of the greenhouse gas emissions per kilogram of plastic resin produced.[15]

The effect of plastic production can be measured by total carbon dioxide emissions or by a carbon emissions factor expressed as carbon dioxide equivalent (CO_2e). Carbon emissions factors—a way to measure greenhouse gas emissions from a specific activity—vary based on location, life cycle phase, waste disposal method (recycling, incineration, landfill), and type of material. For example, production in the U.S. is mainly based on natural gas for feedstock, whereas production in Europe is oil based. A difference in extraction methods results in different assessments of the greenhouse gas emissions for an activity, and thus different carbon emissions factors. As a result, greenhouse gas emissions from average plastic production, not including material use and disposal, of all types in the United Kingdom is 3.12 MT CO_2e/tonne,[33] versus a global estimate of the cradle-to-grave impacts of all types of plastic production of 5.1 MT CO_2/tonne.[34]

Although assessments of carbon emissions can vary, Green Seal's research shows that using recycled content can result in lower greenhouse gas emissions than using virgin material. The savings come from (1) eliminating greenhouse gas emissions from extracting and manufacturing the raw material, and (2) not incinerating plastic waste, which can release stored carbon all at once to the atmosphere. Global estimates of all plastic production indicate a more than 72 percent reduction in CO_2 produced when new products are made with 100 percent recycled content from mechanical recycling, compared with 100 percent virgin material.[34] For high-density polyethylene, some estimates show that using just 30 percent recycled content achieves a more than 10 percent reduction in greenhouse gas emissions in the manufacturing phase alone.[35] Studies that look specifically at trash bags and can liners note that incorporating 30 percent PCR content reuses an estimated 1.8 billion pounds of plastic film—saving about 810,000 metric tonnes of carbon dioxide emissions, equivalent to taking 173,000 cars off the road for one year.[36]

Challenges with Recovering Plastic Films to Be Used in Trash Bags

More than a billion trash bags are estimated to be used each year by American households.[2] Although recycling these products would reduce greenhouse gas emissions, cut plastic waste, and save energy, collecting them faces several challenges. Trash bags are destined for landfills; they have not historically been intended to be recycled, and they are typically not collected in curbside programs because they can damage recycling equipment. Instead, plastic films are usually collected by businesses in the back-of-house (e.g., pallet wraps and product overwraps) or by retailers that provide front-of-house recycling bins (store drop-off programs).

Additionally, the size and color of materials can affect whether they are recycled at facilities. For example, small plastic items—less than two by two inches—are not recycled because they "get caught or fall between the belts and gears of machinery at the Materials Recovery Facility. They end up being treated as trash."[37] Plastic films are also typically not sorted by color during the recycling process; the

[33] Government conversion factors for company reporting of greenhouse gas emissions. https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
[34] Material Economics. The Circular Economy a Powerful Force for Climate Mitigation. https://materialeconomics.com/publications/the-circular-economy-a-powerful-force-for-climate-mitigation-1
[35] How2Recycle Recycled Content Calculator. https://fr.how2recycle.info/calculator
[36] Data Sort: Impacts of boosting PCR in trash bags. https://resource-recycling.com/plastics/2018/05/22/data-sort-impacts-of-boosting-pcr-in-trash-bags/
[37] Plastics: What's recyclable, what becomes trash — and why. https://apps.npr.org/plastics-recycling/

resulting recycled material is a blend of whatever colors were present in the collected material.[38] For food wraps, product overwraps, and case wraps, blended colors are less desirable than clear plastic films. Trash bags, on the other hand, can be made in a broader color range and could therefore incorporate higher levels of recycled plastic films. However, the color of films still plays a role: black plastic films are typically not recycled "because the infrared technology used by recycling facilities to sort plastics cannot 'see' the color black. As a result of this failure, most black plastic items end up in our landfills, incinerators, oceans and rivers after just a single use."[39]

Plastic films collected from the residential sector through store drop-off programs are a relatively small source compared with the plastic films collected through commercial back-of-house recycling. According to the American Chemistry Council, the total amount collected in 2018 was 1 billion pounds, with only 18.7 percent (187 million pounds) coming from the residential sector.[11] Barriers to collecting more residential plastic film include removal of drop-off bins from some stores during the COVID-19 pandemic, plastic shopping bag bans and restrictions on local collection in several states, and low participation rates.

The quality and consistency of collected material affect potential end market applications for the recovered plastic films. Commercial back-of-house films are significantly cleaner and more consistent in quality than bags from store drop-off bins, which tend to be more varied in color, quality, and type, and have higher levels of contamination. Inconsistency of recovered plastic films can create processing challenges, with each load needing to be examined and tested to evaluate its quality.

Recognizing Virgin Plastic Efficiency

Because of the challenges noted above in generating high-quality PCR content for use in trash bags, the average amount of PCR content in most bags remains low: currently, of the 6 billion pounds of trash bags manufactured yearly in the U.S., "most contain only a small amounts of post-consumer resins."[40] Additionally, the results of Green Seal's market analysis show that while incorporating recycled resins in plastic bags does have documented benefits, the PCR content alone is an unreliable indicator of environmental preferability. This is because bags featuring PCR content may still incorporate the same amount of virgin plastic as PCR-free bags in the same size and use category ─ making the presence of PCR content on its own an unreliable indicator of products that reduce virgin plastic use.

To address the challenges in obtaining high-quality PCR resins, some manufacturers have invested in other strategies for reducing virgin material in trash bags. For example, investments in the technology used during product manufacturing can produce a liner that is thinner, and thus uses less virgin plastic to create up front. In an emissions reduction calculator, thin liners produced fewer greenhouse gas emissions than thicker liners, even in some cases where thicker liners incorporated PCR content. Mineral additives can also reduce the amount of virgin material in a bag and provide additional strength and protection from market volatility. Manufactures can also recoup the materials used in their own industrial process to increase the amount of recycled content in a liner.

Addressing the barriers in the section above will require investments in supply chains to create a supply of high-quality PCR content, but because other viable strategies exist for manufacturers to also reduce their use of virgin plastic, Green Seal has come up with a new concept – plastic efficiency – for recognizing bags that reduce the highest amount of virgin plastic possible while still performing as intended.

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[38] The Association of Plastic Recyclers: PE Film. https://plasticsrecycling.org/pe-film-design-guidance
[39] Why Black Plastic Is Bad News. https://www.beyondplastics.org/fact-sheets/black-plastic
[40] Great Consumer Products Made from Post-Consumer Plastic – Trash Bags – Part 2 of 4. https://blog.erema.com/post-consumer-plastic-trash-bags

Market Data Collection. To create the concept of plastic efficiency, Green Seal's market analysis covered 148 products from 56 companies. Both conventional and green products were included in the data collection. A product was determined to be "green" if it claimed to reduce virgin plastic use through recycled content, mineral additives, or by having a thinner liner than competitors. Since health care bags are currently not scoped into the proposed standard, they were not included in the market data collection.

Efforts were made to collect data from a variety of manufacturers, and to diversify the manufacturers selected in each size category of trash bag or can liner. As a result, each size category includes a minimum of 20 products from several manufacturers and is not dominated by any company. The following size categories were used:

- 10 gallons
- 11 – 19 gallons
- 20 – 30 gallons
- 31 – 39 gallons
- 40 – 49 gallons
- 50 gallons and above

Determining Virgin Plastic Use for Plastic Efficiency. To create our method of recognizing leadership as bags that are the most plastic efficient, Green Seal used the following methodology:

- The weight of plastic for each bag was determined by multiplying the bag width, length, and gauge in this formula: ((width x length x gauge)/15/1000)) = weight of liner
- The weight of the liner was then multiplied by the percentage of non-virgin plastic material in the liner. Any advertised mineral additives and post-industrial recycled content were considered as non-virgin plastic material.
- The amount of non-virgin plastic material was subtracted by the total liner weight to get the weight of virgin plastic in a liner.

Example:
For a bag that is 28 inches by 45 inches at a gauge of 0.8 mil with 30 percent recycled content:

((28 x 45 x 0.8)/15/1000) = 0.067 lbs

0.067 lbs x 30% = 0.020 lbs

0.067 lbs – 0.020 lbs = 0.047 lbs of virgin plastic

The result of this analysis influenced the criteria in Part II of the document in which Green Seal sets requirements for both the minimum amount of post-consumer recycled content required and the maximum amount of virgin material allowed in a liner.

Commitments to Incorporating Post-Consumer Recycled Content

Several organizations support the strategy of using PCR content to reduce the impacts of plastic production and use. Many groups and some consumer brands (e.g., Walmart and Keurig Dr. Pepper)[41,42] have made public commitments to incorporating PCR content in plastic packaging, including plastic films. Below is a summary of the commitments made by industry associations, states' current purchasing

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[41] Waste: Circular Economy. https://corporate.walmart.com/esgreport/esg-issues/waste-circular-economy
[42] Keurig Dr. Pepper Corporate Responsibility: Our Goals. https://www.keurigdrpepper.com/content/keurig-brand-sites/kdp/en/our-company/goals.html

requirements for plastic films, and other sustainability programs' approach to PCR requirements in their standards. These commitments highlight the demand for high-quality PCR content as more groups advocate for and require its use in products and product packaging.

Recycle More Bags

Recycle More Bags is a call to action spearheaded by plastic producers, trash bag manufacturers, and other organizations in the recycling industry. The group of signatories is calling on "government legislation and procurement policies to require 20 percent post-consumer recycled (PCR) content in garbage bags and plastic carryout bags by 2025."[43]

U.S. Plastics Pact

The U.S. Plastics Pact, founded by The Recycling Partnership (see below) and the World Wildlife Foundation, is a commitment by brands, retailers, government agencies, and nongovernmental organizations to achieve targets for increasing circularity of plastics. The goal of the pact is to unify "diverse public-private stakeholders across the plastics value chain to rethink the way we design, use, and reuse plastics, to create a path toward a circular economy for plastic in the United States." Although the pact does not recommend a specific commitment to PCR content, it has set goals to incorporate overall more recycled content in plastic packaging. For example, by 2025, the average amount of recycled content or bio-based content in plastic packaging should be 30 percent.[44]

The Recycling Partnership

The Recycling Partnership is a nonprofit organization funded by private corporations to create change in recycling practices across the supply chain. In 2019, it released *Bridge to Circularity*, which details actions needed to increase the amount of recovered waste in the U.S. and decrease the need for virgin materials. Although the report does not specify an amount of PCR content to be incorporated in plastics or plastic films, it advocates for monetary investments in residential recycling to help capture the 340 million pounds of available post-consumer plastic. This investment will help manufacturers set and meet goals for incorporating PCR content into their products.[45]

Association of Plastic Recyclers Demand Champions

The Association of Plastic Recyclers (APR) is a trade association that represents the plastic recycling industry. One of its programs—the APR Recycling Demand Champions—rewards businesses, universities, and other organizations that commit to increasing their use of PCR content. Purchasers can commit to purchase products with PCR content, and manufacturers can purchase PCR material and use it in their products. Both avenues drive market demand for PCR content.[46]

Table 3. Programs' minimum PCR content requirements for trash bags and can liners

Organization	Products < 0.7 mil	Products ≥ 0.7 mil
EPA Comprehensive Procurement Guidelines[47]	10%	10%

[43] Keeping Plastics in the Circular Economy Recommendation for Recycled Content Minimum for Plastic Bags. https://d12v9rtnomnebu.cloudfront.net/diveimages/Call_to_Action_PCR_Film_01-05-19.pdf
[44] U.S. Plastics Pact Launches to Ignite Change Toward Circular Economy for Plastic. https://usplasticspact.org/launch-august2020/
[45] FAQs: The Bridge to Circularity. https://recyclingpartnership.org/bridge-to-circularity-faq/
[46] APR Recycling Demand Champions. https://plasticsrecycling.org/images/Programs/Recycling_Demand_Champions/APR_Demand_Champion_Flyer.pdf
[47] EPA Comprehensive Procurement Guidelines for Non-Paper Office Products. https://www.epa.gov/smm/comprehensive-procurement-guidelines-non-paper-office-products#06

New Jersey State Requirements[48]	None Required	Products > 0.7 mil but less than 0.8 mil: 5% by January 2024 10% by January 2027 Products > 0.8 mil but less than 1.00 mil 10% by January 2024 20% by January 2027 Products ≥ 1.00 mil 20% by January 2024 40% by January 2027
California State Requirements[49]	None Required	10%
Washington State Requirements[50]	None Required	10% by January 2023 15% by January 2025 20% by January 2027
New York Purchasing Specifications[51]	10% (Exemption for bags smaller than 13 gallons)	10% (Exemption for bags smaller than 13 gallons)
LEED Ed. 4.1[52]	None Required	10%

Ensuring Quality: PCR Content Certification for Plastic Resins

When plastic film products are evaluated, the PCR content must be validated as PCR content through a chain of custody and traceability review. Green Seal will require that the PCR resins purchased and used in a certified product are certified as PCR.

A chain of custody tracks the path of raw materials through each stage of processing and manufacturing. It includes each entity that takes legal and/or physical possession of the material or product. A chain of custody system may track the origin of raw materials, production practices, and raw material composition. The primary objective is to provide transparency and assurance that materials in the final product meet minimum requirements for sustainability standards—that is, that the product claims are credible.

Chain of custody evaluations are being applied to supply chains for forest products, textiles, and plastics. For example, the Forest Stewardship Council (FSC) Chain of Custody certification follows the path of wood products from forests through the supply chain so that customers can trust that FSC-certified products are coming from responsibly managed sources.[53]

Three chain of custody models can be used to track the flow of materials through the supply chain: identity preservation, segregation, and mass balance. Under an identity preservation model, certified

[48] §§1-23 C.13:1E-99.135 to 13:1E-99.157. https://pub.njleg.state.nj.us/Bills/2020/AL21/391_.PDF
[49] Recycled-Content Trash Bag Program. https://www.calrecycle.ca.gov/buyrecycled/trashbags
[50] Department of Ecology State of Washington: Recycled content minimums. https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Waste-reduction-programs/Plastics/2021-plastic-pollution-laws/Recycled-content-minimums.
[51] GreenNY Specification: Trash Bags. https://ogs.ny.gov/greenny/trash-bags
[52] LEED O+M: Existing Buildings v4.1 Green Cleaning Indoor Environmental Quality. https://www.usgbc.org/credits/existing-buildings-interiors-existing-buildings/v41/eq130?return=/credits/Existing%20Buildings/v4.1
[53] Forest Stewardship Council: Chain-Of-Custody Certification. https://us.fsc.org/en-us/certification/chain-of-custody-certification

materials (here, recycled content) are not mixed with any material from other sources, whether certified or uncertified (virgin resins). The segregation model allows mixing of certified materials from different sources if the certified materials are kept separate from uncertified materials throughout the manufacturing process. Mass balance accounting allows certified and uncertified materials to be mixed if the quantities are documented and appropriately balanced among final products.

Green Seal views chain of custody for PCR content as necessary to provide third-party assurance that product claims are valid. As prices rise for PCR materials and more regulations require minimum amounts of PCR content, verification of the sourcing of plastic materials becomes increasingly important. Programs that provide verified chain-of-custody review for plastic PCR resins are described in Appendix 4. Green Seal will require that the PCR resins used in a product have received verification from one of these programs as being PCR.

Protecting Human Health: Ingredient Hazard Review

Polyethylene

Several plastic polymers, such as polystyrene and polyvinyl chloride, present concerns for human health. For example, exposure to the phthalates in polyvinyl chloride products can affect immune responses and "possibly contribute to the development of asthma in adults,"[54] and the production of polyvinyl chloride utilizes high amounts of chlorine, which can produce dioxins – a highly persistent compound that is associated with causing "cancer, reproductive and developmental problems, damage to the immune system," and impacts on hormones.[55] However, polyethylene polymer is widely considered safe for human health.

Polyethylene is used to create plastic bottles, films, bags, containers, "flexible food packaging, shrink-wrap, stretch film and overwrap films … children's toys, and molded caps and closures." Humans are therefore exposed to polyethylene through many consumer products, with the main pathways of exposure being dermal and ingestion. Occupational workers who make plastic may also be exposed to polyethylene through inhalation when fumes are released during the manufacturing process.[56]

Toxicity studies for polyethylene find it generally safe and effective for its intended use. For example, a review of toxicity studies done in animals concluded that the "available data support the conclusion that Polyethylene is safe for use in cosmetic formulations in the practices of use and concentrations described."[57] Polyethylene is also not listed as hazardous on authoritative lists for carcinogens, mutagens, reproductive toxins, skin corrosion, asthmagens, and several other endpoints of concern.[58] The main component of polyethylene—ethylene—is considered 99.9 percent pure in the United States,[57] and ethylene itself is not a chemical of high concern for human health or the environment.[59] In fact, unlike other plastic types, polyethylene polymers are not known to contain any chemicals of high concern.[59] As a result, Green Seal will review products, including additives, against our foundational criteria for hazardous chemicals to provide assurance that hazardous chemicals are not intentionally introduced during product manufacturing. The chemical hazard review of the proposed prohibited ingredients is in Part II.

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[54] The Role of Exposure to Phthalates from Polyvinyl Chloride Products in the Development of Asthma and Allergies: A Systematic Review and Meta-analysis. https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.10846
[55] EPA Learn about Dioxin. https://www.epa.gov/dioxin/learn-about-dioxin
[56] NOVA Chemicals Product Risk Profile: SCLAIR® Polyethylene – Not Coloured (All Grades). https://www.novachem.com/wp-content/uploads/SCLAIRNotColoured_RP_AMER_EN.pdf
[57] Final Report on the Safety Assessment of Polyethylene1. https://doi.org/10.1080%2F10915810601163962
[58] Internal review of Green Seal's authoritative list database.
[59] Plastics Scorecard: Evaluating the Chemical Footprint of Plastics. https://www.bizngo.org/images/ee_images/uploads/plastics/plastics_scorecard_2015_2_25e.pdf

Confirming Products' Functional Performance

Ensuring products' functional performance is critical for reducing waste—if a trash bag does not work as intended, it is more likely to be discarded—and for dispelling perceptions that green products do not work as well as conventional ones. To test the efficacy of their products, manufacturers typically use standardized testing methods. According to Green Seal's market review and direct discussions with product manufacturers, two tests are commonly used for efficacy testing of trash bags and can liners: dart impact tests (ASTM 1709-16ae1) and tear resistance tests (ASTM D1922-15R20). Additionally, product manufacturers typically perform testing to demonstrate wet load[60] and dry load[61] capacity. Generally, these tests are internally developed by the manufacturer; there is no standardized test method for wet and dry maximum loads.

Tests for puncture and tear resistance are described in Appendix 2.

[60] Measurement of how much wet weight a can liner or trash bag will hold.
[61] Measurement of how much dry weight a can liner or trash bag will hold.

PART II. SUMMARY OF PROPOSED CRITERIA

Guidance for Reviewing the Proposed Criteria
Below are the proposed criteria for the GS-60 Standard for Trash Bags and Can Liners, organized by the relevant life cycle phase. Criteria that are relevant across multiple phases are not repeated. For the full standard document, visit Green Seal's website.

Boxed Text
The proposed criteria that a product must comply with to receive certification are presented in boxed text.

Italicized Text
In the boxed text, italics identify words or phrases that are defined in "Annex A - Definitions" of Green Seal standards. The definitions themselves are normative—that is, they convey substantive information that is critical to the interpretation, implementation, and intent of the criteria. For the full list of defined terms in the standard, visit Green Seal's website.

Life Cycle Phase: Manufacturing

Requirements for Post-Consumer Recycled Content

Trash bags and can liners that use virgin plastic content create numerous environmental concerns, in particular high greenhouse gas emissions and contributions to plastic pollution. Green Seal proposes to require minimum levels of post-consumer recycled (PCR) content to align with state and federal requirements, as well as encourage manufacturers to divert plastic waste from the environment and reduce greenhouse gas emissions associated with extracting and refining virgin materials. In line with several state and other sustainability programs, an exemption is proposed for liners thinner than 0.7 mil (17.8 microns).

Post-Consumer Material. Products shall contain a minimum amount of 10% *post-consumer material*.

Exemption: Products below 0.7 mil (17.8 microns) in thickness are exempt from containing *post-consumer material.*

PCR Content Certification and Mass Balance Accounting

Increasingly, regulatory bodies are requiring PCR content in plastic products, including trash bags and can liners. The price of PCR materials has also increased in recent years, incentivizing negative actors to claim PCR content when the materials are not PCR. As a result, assurance bodies need to provide verification of PCR content claims. One way to confirm PCR content is through a chain of custody and traceability review that PCR content, is in fact PCR content, and a mass balance accounting to show the minimum PCR content claimed in a product is validated.

Green Seal is proposing to require products applying for certification to document they purchase PCR resins from a supplier who has undergone a third-party review of their PCR content. Green Seal will accept chain of custody reviews from organizations endorsed by the Association of Plastic Recyclers (APR) as having a rigorous validation process through its APR PCR

Certification Program.[62] Green Seal will then perform a mass balance accounting of the PCR content to ensure the levels of purchased resin meet the output claims in the product.

Post-Consumer Material Certification. The manufacturer shall provide sufficient documentation that the *post-consumer material* in the product is certified as such by an organization endorsed by Association of Plastic Recyclers PCR Certification Program.

Post-Consumer Material Calculations. The manufacturer shall demonstrate it purchases and uses sufficient supplies of *post-consumer material* to produce the amount of product reported. The percentage of *post-consumer material* shall be calculated using the following equation:

% of *post-consumer material* = Mass of *post-consumer material* / Mass of finished product

This calculation shall be based on a mass balance analysis over a period of time not to exceed the previous twelve months.

Requirements for Virgin Plastic Use Reduction

As noted above, the use of virgin plastic in trash bags and can liners has a significant impact on the environment. Green Seal is proposing to require products demonstrate their "plastic efficiency" by meeting feasible yet leadership maximum allowances on virgin plastic use in the product, in addition to meeting minimum requirements for PCR content. The levels of allowable virgin plastic will depend on the gallon capacity of the liner.

Product Size	Maximum Weight of Virgin Plastic in Liner (lbs)
10 gallons	0.011
11 – 19 gallons	0.015
20 – 30 gallons	0.036
31 – 39 gallons	0.041
40 – 49 gallons	0.046
≥ 50 gallons	0.070

Energy Use Reporting

The manufacturing phase of plastic contributes to greenhouse gas emissions as fossil fuels are burned to create energy for heating polymers and shape them into products. Green Seal is proposing to collect energy use information from manufacturing facilities to understand (1) the amounts of energy used in product manufacturing, and (2) opportunities for future requirements for energy use reductions or use of energy from sustainable sources.

Energy Use Reporting. For each facility that manufactures the product, manufacturers shall disclose the annual energy intensity in BTUs /year/ton of product produced.

[62] APR PCR Certification. https://plasticsrecycling.org/apr-pcr-certification

Life Cycle Phase: Product Use

Products' Functional Performance: Puncture and Tear Resistance

Products that do not perform as intended end up as waste. Green Seal proposes to require product testing to verify claims on labels or in marketing materials, and to confirm that green products perform as well as conventional ones. The main relevant product tests are for puncture resistance and tear resistance. Through piloting of the proposed standard, Green Seal will collect more information on potentially relevant benchmarks in the proposed test methods.

Product Performance. The product shall demonstrate that it performs effectively as marketed for its intended use, as measured by the following standard test methods.

Puncture Resistance. The product shall demonstrate that it performs as well as or better than a nationally recognized or market-leading product in its *product class* when tested according to ASTM D1709.

Tear Resistance. The product shall demonstrate that it performs as well as or better than a nationally recognized or market-leading product in its *product class* when tested according to ASTM D1922.

Alternative Performance Requirements. Alternatively, the product shall demonstrate that it performs as well as or better than a nationally recognized or market-leading product in its *product class* for the key parameters required for it to fulfill its intended functions, as defined above. Comparison testing shall use an objective, scientifically validated method conducted under controlled and reproducible laboratory conditions. Test methodology and results shall be documented in sufficient detail.

Prohibited Components

In Green Seal standards, "Prohibition" applies as follows: components classified as prohibited cannot exist in Green Seal–certified trash bags and can liners if intentionally added, or at or above 100 ppm if present as a contaminant.

Green Seal proposes to prohibit chemicals that are found on certain authoritative lists which designate them as hazardous and/or toxic.

In addition to chemicals found on such designated lists, Green Seal also proposes to prohibit additional chemicals, listed below, which have not yet been classified as hazardous but for which there is strong evidence that supports the view that they are likely hazardous. Green Seal takes the precautionary approach, defined in our Standards Development Manual:

> The precautionary principle is summarized as follows: "When there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation" (Principle 15 of the Rio Declaration, 1992). In determining criteria, Green Seal is guided by the precautionary principle.[63]

[63] Green Seal Standards Manual. https://greenseal.org/wp-content/uploads/Green-Seal-Standards-Development-Manual.pdf

Carcinogens. The use of ingredients and intentional additives that are likely, potential, possible, probable, reasonably anticipated, or known human carcinogens will be prohibited. Green Seal references carcinogen lists, giving priority to international and national lists, including the International Agency for Research on Cancer (IARC), National Toxicology Program (NTP), U.S. Environmental Protection Agency (EPA), and U.S. Occupational Safety and Health Administration (OSHA).

Mutagens. Mutagens are proposed as prohibited and defined according to the Globally Harmonized System criteria for germ cell mutagenicity. These include any substance that meets the criteria for Hazard Category 1 (H340), chemicals known to induce heritable mutations or to be regarded as if they induce heritable mutations in the germ cells of humans. Category 1 criteria are consistent with the European Union classification and labeling criteria for Category 1 and 2 mutagenic substances.[64]

Reproductive Toxins. Chemicals known to cause reproductive toxicity are proposed to be prohibited and include both male and female reproductive toxins and developmental toxins. California Prop 65 is the most readily available and accepted source for these compounds and shall be cited for this list.[65]

Toxic Release Inventory Persistent, Bioaccumulative, and Toxic (TRI BPT). Trash bags and can liners most often end up in landfills and can leach harmful chemicals into soil and water sources. Substances that are classified as persistent, bioaccumulative, and toxic in the U.S. EPA Toxic Release Inventory[66] shall be prohibited.

Phthalates. Phthalates have been associated with endocrine disruption and are used as solvents in fragrance ingredients. Alternative solvents for fragrances are widely available. Examples of phthalates include Bis (2-ethylhexyl) phthalate DEHP (CAS 117-81-7); Dibutyl phthalate DBP (84-74-2); Benzyl butyl phthalate BBP (85-68-7); and Diisobutyl phthalate DIBP (84-69-5).

Heavy metals. Lead, hexavalent chromium, and selenium are prohibited because of their neurotoxicity.

Per- and Polyfluorinated Substances (PFAS). PFAS are a unique group of human-made chemicals whose strong carbon-fluorine bonds confer the ability to repel water and grease in food packaging, paints and coatings, firefighting foam, cookware, textiles, and several other product categories. Their unique chemical structure also makes them very resistant to breaking down in the environment. As a result, PFAS have been found around the world in the environment, wildlife, and human bodies and have been associated with health and environmental harms.[67] As part of Green Seal's work to address PFAS as a group of hazardous chemicals across Green Seal product categories,[68] PFAS will be prohibited in trash bags and can liners.

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[64] I. Langezaal, The Classification and Labelling of Carcinogenic, Mutagenic, Reprotoxic, and Sensitising Substances (Ispra, October 2002).
[65] California Office of Environmental Health Hazard Assessment: The Proposition 65 List. http://oehha.ca.gov/prop65/prop65_list/files/P65single061110.pdf
[66] EPA Tri-Listed Chemicals: https://www.epa.gov/toxics-release-inventory-tri-program/tri-listed-chemicals
[67] Green Seal Proposal for New Chemical Class Prohibition: Per- and Polyfluoroalkyl Substances (PFAS) Prohibited in Cleaning and Personal Care Products. https://greenseal.org/wp-content/uploads/PFAS_Revision_Proposal_December-2021.pdf
[68] Prohibiting PFAS Chemicals. https://greenseal.org/prohibiting-polyfluorinated-chemicals-call-for-comment/

Bisphenol A, Bisphenol S, Bisphenol F. Bisphenol A (BPA) is an endocrine disruptor that may cause fertility damage, eye damage, skin sensitization, and respiratory irritation.[69] BPA is ubiquitous in the environment and has been detected in human blood, urine, breast milk, and other fluids and tissues.[70,71,72] Concerns about widespread exposure to BPA and toxic effects on fertility and fetal development have prompted bans on their use in baby products in several countries.[73] In addition, European Union REACH regulation restricts the use of BPA in thermal papers.[74]

Bisphenol S (BPS) and bisphenol F (BPF) are structurally similar to BPA, making them common substitutes in BPA-free products.[75,76] Many studies have documented that BPS and BPF exposure may have associated health risks comparable to those for BPA. For example, exposure to BPS and BPF has been associated with reproductive impacts, including toxic effects to human placental cells[77] and antiandrogenic effects.[78] BPF has been observed to penetrate skin at a high rate and induce skin sensitization.[79] In laboratory animals, both chemicals have induced effects similar to BPA during early development, including "cardiac edema, spinal malformation, craniofacial deformities,"[80] and immunotoxicity during embryonic and larval development.[81] Additionally, BPF has been shown to induce significant neurotoxicity effects in zebrafish embryos.[82] As a result of these impacts, and Green Seal's adherence to the precautionary principle, BPA, BPS, and BPF will be prohibited in products.

Ozone-Depleting Compounds. Some consumer products release compounds that contribute to breaking down ozone—a layer of atmospheric gas that protects Earth from ultraviolet radiation. When the ozone layer breaks down, the increased ultraviolet radiation causes health conditions, such as skin cancer and impaired immune systems, as well as damage to crops and marine food chains.[83] Ozone-depleting compounds listed by U.S. EPA as Class I and Class II Ozone Depleting Substances[84] will be prohibited.

[69] European Chemicals Agency Substance Infocard: 4,4'-isopropylidenediphenol. https://echa.europa.eu/substance-information/-/substanceinfo/100.001.133
[70] Exposure to bisphenol A, bisphenol F, and bisphenol S in U.S. adults and children: The National Health and Nutrition Examination Survey 2013-2014. https://pubs.acs.org/doi/10.1021/acsomega.8b00824
[71] Bisphenol A concentrations in maternal breast milk and infant urine. https://doi.org/10.1007/s00420-012-0834-9
[72] Urinary, circulating, and tissue biomonitoring studies indicate widespread exposure to bisphenol A. https://doi.org/10.1289/ehp.0901716
[73] BPA and its analogs increase oxidative stress levels in in vitro cultured granulosa cells by altering anti-oxidant enzymes expression. https://doi.org/10.1016/j.mce.2022.111574
[74] European Chemicals Agency: Substances restricted under REACH. https://echa.europa.eu/substances-restricted-under-reach/-/dislist/details/0b0236e18155ec2b
[75] Bisphenol analogues other than BPA: Environmental occurrence, human exposure, and toxicity – A Review. https://pubs.acs.org/doi/10.1021/acs.est.5b05387
[76] Concern about the Safety of Bisphenol A Substitutes. https://doi.org/10.4093/dmj.2019.0027
[77] Bisphenol A, bisphenol F, and bisphenol S: the bad and the ugly. Where is the good? https://doi.org/10.3390/life11040314
[78] A new chapter in the bisphenol A story: bisphenol S and bisphenol F are not safe alternatives to this compound. https://doi.org/10.1016/j.fertnstert.2014.11.005
[79] Toxicological profile of bisphenol F via comprehensive and extensive toxicity evaluations following dermal exposure. https://doi.org/10.1080/15287394.2021.1997843
[80] Acute toxicity, teratogenic, and estrogenic effects of bisphenol A and its alternative replacements bisphenol S, bisphenol F, and bisphenol AF in zebrafish embryo-larvae. https://pubs.acs.org/doi/pdf/10.1021/acs.est.7b03283
[81] Immunotoxicity of bisphenol S and F are similar to that of bisphenol A during zebrafish early development. https://doi.org/10.1016/j.chemosphere.2017.11.125
[82] Bisphenol F-Induced neurotoxicity toward zebrafish embryos. https://pubs.acs.org/doi/10.1021/acs.est.9b04097
[83] EPA Ozone: good up high, bad nearby. https://www.epa.gov/sites/default/files/documents/gooduphigh.pdf
[84] EPA Ozone-Depleting Substances. https://www.epa.gov/ozone-layer-protection/ozone-depleting-substances

Fragrances. Fragrances are often added to consumer products to provide a pleasing scent or mask odors. However, added fragrances have been associated with health harms[85] and are considered a source of indoor air pollution.[86] Fragrances added to trash bags will be prohibited.

Chlorinated compounds. Chlorinated compounds in plastic most often refer to the use of polyvinyl chloride (PVC) or additives to soften polyvinyl chloride. Chlorinated compounds used in this context can have a variety of human health and environmental impacts. Additionally, the "use of PVC is problematic and that there are significant health issues at all stages in the lifecycle."[87] Because of these impacts and the documented alternatives to the use of PVC, chlorinated compounds will be prohibited.

Biocides and antimicrobial agents. Added to consumer products, antimicrobial agents and compounds meant for killing bacteria and other organisms can ultimately enter the environment through landfills, and subsequent leachate that gets into soil and waterways. Once in the environment, these compounds can persist and harm wildlife. Biocides and antimicrobial agents have not been identified as functional ingredients for trash bags and can liners. Biocides and antimicrobial agents will be prohibited.

Prohibited Components. The product shall not contain any of the following *components*; an exception shall be made for products that would not contain these *components* but for the addition of *post-consumer material*.

- *Carcinogens, mutagens,* and *reproductive toxins*
- Toxic Release Inventory Persistent, Bioaccumulative, and Toxic (TRI PBT) Chemicals
- Phthalates
- The heavy metals lead, cadmium, mercury, hexavalent chromium, or selenium; either in the elemental form or compounds
- *Per- and Polyfluorinated Alkyl Substances (PFAS)*
- Bisphenol A, Bisphenol S, Bisphenol F
- *Ozone-depleting compounds*
- *Fragrances*
- Chlorinated compounds
- Biocides and antimicrobial agents

Life Cycle Phase: Disposal and End of Life

Packaging Requirements

Trash bags and can liners are typically packaged in cardboard or paperboard boxes. To minimize the contribution of packaging to the product's life cycle impacts, Green Seal proposes to require that packaging either have a significant amount of post-consumer recycled content, be source-

[85] Health and societal effects from exposure to fragranced consumer products. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5122698/
[86] The fragranced products phenomenon: air quality and health, science and policy. https://link.springer.com/article/10.1007/s11869-020-00928-1
[87] Microplastics negatively affect soil fauna but stimulate microbial activity: insights from a field-based microplastic addition experiment. https://royalsocietypublishing.org/doi/10.1098/rspb.2020.1268

reduced, have an effective take-back program or be recyclable. The requirements are intended to reduce the use of virgin material, water and energy consumption, and greenhouse gas emissions. The criteria align with existing requirements for packaging set forth in Green Seal's other product standards as well as other 3rd party standards used for verifying environmentally preferable packaging (e.g., ECOLOGO Standard UL 126 and GECA SPSv2.01-2020).

Primary and Secondary Packaging. *Primary* and *secondary packaging* shall meet the following requirements, based on the packaging material type:

- Packaging made from paper, paperboard, cardboard, or other nonplastic material shall be *recyclable* and contain at least 50% *post-consumer material*, or demonstrate that efforts were made to use the maximum available *post-consumer material.*
- Packaging made from plastic shall be *recyclable*, be *source-reduced*, contain at least 25% *post-consumer material*, or be a *refillable package* with an *effective take-back program*.

Additionally, Green Seal is proposing to require that product packaging be free of certain hazardous ingredients. The criteria align with existing requirements for packaging set forth in Green Seal's other product standards, as well as other 3rd party standards used for verifying environmentally preferable packaging (e.g., ECOLOGO UL 126), and several state packaging laws (e.g., California, Washington, and New Hampshire).

Colorants. *Primary* and *secondary packaging* may be printed using *colorants*, provided that these *colorants* contain a sum concentration of less than 100 ppm by weight of lead, mercury, cadmium, and hexavalent chromium.

Heavy Metal Restrictions. The heavy metals lead, mercury, cadmium, and hexavalent chromium shall not be *intentionally introduced* in *primary* and *secondary packaging*. Further, the sum of the concentration levels of these metals shall not exceed 100 ppm by weight (0.01%); an exception is allowed for packaging that would not exceed this maximum level but for the addition of *post-consumer material*.

Other Restrictions. Phthalates, bisphenol A, and chlorinated packaging material are prohibited from being *intentionally introduced* to plastic *primary* or *secondary packaging*; an exception is allowed for packaging that would not have added phthalates, bisphenol A, or chlorinated packaging material but for the addition of *post-consumer material*.

PFAS in Packaging. Certain PFAS are approved by the U.S. Food and Drug Administration for use in paperboard for food packaging products to provide grease and water resistance.[88] However, Green Seal has found no evidence that PFAS are used as additives to treat fiber-based packaging for trash bags and can liners. It is our understanding that PFAS additives are not necessary in the packaging of trash bags and can liners because the packaging is not exposed to grease or water during shipping or use. Additionally, to our knowledge, no other regulatory bodies are requiring verification of PFAS-free fiber-based packaging for nonfood service uses.

[88] U.S. Food & Drug Administration: Per- and Polyfluoroalkyl Substances (PFAS). https://www.fda.gov/food/chemical-contaminants-food/and-polyfluoroalkyl-substances-pfas

Because PFAS are so prevalent in the environment, it is possible that fiber or plastic packaging that incorporates recycled content may unintentionally contain PFAS from contaminated recycled feedstock. Verifying the quality of recycled content is challenging. In fact, other standards that verify recycled content restrict only the addition of new fluorinated substances during manufacturing and additives in the finished product, as opposed to verifying the quality of the recycled material (GECA RPv1.0ii-2015). The presence of PFAS in packaging is also not a direct exposure pathway of concern; PFAS are not expected to be absorbed dermally during the handling and use of packaging.

As a result, Green Seal will not require verification of PFAS-free packaging for trash bags and can liners. Green Seal will continue to monitor the evolving issue of PFAS use and impacts and may revisit this criterion as more information becomes available.

Product Labeling Requirements

Appropriate recycling of product packaging will increase the amount of available recycled content and prevent contamination of recycled feedstocks. To encourage consumers to make good recycling decisions, Green Seal proposes to require plastic packaging to be marked with the correct Resin Identification Code for its type of plastic resin.

Resin Identification Code. If plastic, the packaging shall be marked with the appropriate Resin Identification Code.

Appendix 1. Green Seal's Standard Development Process

Green Seal's standard development process uses an open, transparent, and systematic approach to developing health and environmental criteria for product categories. Aligned with best practices for standard development, including ISO 14024 and ISEAL's Standards Code, and drawing from life-cycle methodology, including ISO 14040 and U.S. Environmental Protection Agency (EPA) Life Cycle Assessment: Principles and Practices, Green Seal's standard development process is as follows:

Identify impact reduction opportunities.
Green Seal first confirms that a product type or category (here, trash bags and can liners) is widely available in the North American market and that variations in its raw materials, formulas, production, packaging, use, and disposal may allow for a distinction between conventional and sustainable products.

Conduct a product life-cycle review.
Green Seal conducts life-cycle mapping and a life-cycle phase impact review. Green Seal identifies the regulatory or market framework that shapes the product life cycle, including regulations and legislation; environmental, health, and consumer advocacy priorities; and health and environmental claims made by product manufacturers.

Engage expert stakeholders.
Green Seal engages stakeholders, including producers, users, and public interest groups. Green Seal conducts informational interviews to gather data, record perspectives, uncover issues that are not studied or publicized, and consider technical and market guidance.

Implement market surveys and ingredient screenings.
Green Seal gathers information on product efficacy testing, active ingredients, raw materials, additives, contaminants, and packaging. During this phase, Green Seal highlights opportunities to design a healthier product and opportunities to phase out health and environmental hazards from the supply chain. Green Seal screens ingredients against the 12 foundational criteria (e.g., prohibitions on carcinogens, mutagens, and reproductive toxins) that make up Green Seal's framework for assessing products.

Design measurable, meaningful requirements for impact reduction.
Green Seal identifies the top five to 15 most critical, feasible, and measurable opportunities for reducing the health and environmental impacts across the product's life cycle. This may include limits on water and energy use in the manufacturing phase, the prohibition of hazardous ingredients with "non-regrettable" substitutes, and requirements for a specified percentage of recovered materials in place of virgin materials.

Collect and publish public comment and public response.
Green Seal publishes proposed criteria and encourages stakeholders to submit comments, suggest clarifications, and provide substantive criticism. Green Seal publishes all formally submitted comments, plus responses to each substantive issue identified by commenters.

Issue final criteria or standard and initiate product certifications.
After resolving or addressing all substantive issues, Green Seal issues the final criteria or the final standard, at which point products are eligible to achieve the Green Seal certification.

Appendix 2. Overview of Polyethylene Density Types

High-density polyethylene (HDPE), low-density polyethylene (LDPE), and linear low-density polyethylene (LLDPE) share many characteristics, but the polymer chains of LDPE and LLDPE are branched whereas HDPE has polymers arranged in a more crystalline structure. Because of this difference in polymer structure, HDPE films are more rigid and stronger than LDPE and LLDPE films.

Plastic Resins
In 1988, the Society of Plastics Industry (SPI)[89] created the Resin Identification Code (RIC) to ensure consistency in plastic manufacturing and recycling. This system distinguishes seven categories of plastics, defined by their polymers.[90] The RIC system is now administered by ASTM International, which provides standards for identifying and labeling plastics in ASTM D7611/D7611M-21.[91]

PE
Polyethylene (PE) is a resin used to make plastic products ranging from food wraps and grocery bags to detergent bottles and milk jugs. The several versions of PE include high-density polyethylene, low-density polyethylene, and linear low-density polyethylene.

HDPE
High-density polyethylene can be used to make rigid plastics (e.g., milk jugs and detergent bottles) or plastic films (e.g., trash bags, can liners, and food packaging). Films made from HDPE can be very thin (typically 0.0005 to 0.3 inch thick) and are available in translucent or opaque colors. Properties of HDPE include moisture and chemical resistance, strength, light weight, affordability, and durability. HDPE is classified as RIC #2.

LDPE
Low-density polyethylene is commonly used to make plastic bags (e.g., grocery bags and trash bags) and plastic wraps. It can also be used to make squeezable bottles, lids, toys, and housewares. LDPE film is very flexible and has good optical clarity, chemical resistance, and moisture resistance. LDPE is classified under RIC #4.

LLDPE
Linear low-density polyethylene is most commonly used in film applications, including food and nonfood packaging and shrink or stretch film. Generally, LLDPE has similar properties as LDPE, but its production is less energy intensive.[92] LLDPE is classified under RIC #4.

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[89] Now known as the Plastics Industry Association.
[90] Understanding Plastic Recycling Codes: Your Guide to the RIC. https://sustainablebrands.com/read/corporate-member-update/understanding-plastic-recycling-codes-your-guide-to-the-ric
[91] Standard Practice for Coding Plastic Manufactured Articles for Resin Identification. https://www.astm.org/d7611_d7611m-21.html
[92] Major polyethylene compounds. https://www.britannica.com/science/polyethylene#ref283108

Appendix 3. Common Standardized Test Methods for Plastic Films

Dart Drop Test ASTM 1709 (puncture resistance)
The Dart Drop Test (also referred to as Falling Dart Impact Test or Free-Falling Dart Method) is commonly used by manufacturers to assess the durability and strength of plastic films. The test standards were developed by ASTM International "in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee."[93] The latest edition of the test, ASTM D1709-16ae1, was released in May 2017. ASTM D1709-16ae1 is technically equivalent to ISO 776501:1988 with a few variations in test specifications.[94] Labs offering this test include Intertek, Labthink, and DDL Inc.

ASTM D1709-16ae1 is actually two test methods, the choice of which depends on the required impact resistance of the plastic film. Test Method A uses a dart with a 38 mm (1.5 inches) diameter dropped from 0.66 m (26 inches). This method is applicable for films that are expected to be punctured by masses of less than 50 g to about 6 kg. Test Method B uses a dart with a 51 mm (2 inches) diameter dropped from 1.5 m (60 inches) and is applicable to films that would require a mass of 0.3 kg to about 6 kg to fail.

In both methods, samples are tested using the standard technique or an alternative. The standard approach uses a staircase method to determine the point at which 50 percent of test samples fail:[95] if a test specimen passes, the drop weight is increased by one unit, and if the specimen fails, the drop weight is decreased by one unit. The alternative technique groups samples and uses one dart weight per group. The weight from group to group varies in uniform increments. These two techniques yield similar results.

Elmendorf Tear ASTM D1922 (tear resistance)
The Elmendorf Tear test measures how well a plastic film resists tearing. These resistance measurements provide insights into the durability of the product. The test standards were developed by ASTM International and are equivalent to ISO 6383-2. The latest edition of the test, ASTM D1922-15R20, was released in April 2020. Labs offering this test include Applied Technical Services, Labthink, and Intertek.

The test protocol offers two options for test samples. The preferred test sample is a constant radius testing length. According to Intertek, "this sample provides a constant radius from the start of the tear strength measurement—useful for materials where the tear may not propagate directly up the sample as intended."[96]

The other common test sample is a rectangular type. It uses an Elmendorf-type tearing tester to determine the average force that will spread tearing through a plastic film after a tear has been started. Typically, 10 samples are tested. A sample is clamped in place and the tester uses a knife to create a slit in the sample. A pendulum is then released to spread the slit to the edge of the test sample. The tester calculates the average tearing force by measuring the energy lost by the pendulum as the sample tears. Results are recorded in grams-force.

[93] Standard Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method https://www.astm.org/d1709-16ae01.html
[94] ASTM D1709-16ae01 has a larger tolerance on the drop height in Test Method B, smaller tolerances on the dart diameters for Test Methods A and B, and the requirement for a vented dart well in 5.1.1. Also, the ISO method does not allow the alternative testing technique described in Section 11 of ASTM D1709-16ae01.
[95] Referred to as the Impact Failure Weight
[96] Elmendorf Tear ASTM D1922. https://www.intertek.com/polymers/testlopedia/elmendorf-tear-astm-d1922/

Appendix 4. Chain of Custody Programs, Post-Consumer Resin Traceability

Several organizations offer chain of custody reviews for recycled content. At the time of publication, the organizations below are endorsed by the Association of Plastic Recyclers PCR Certification Program.[97] Summaries are for informational purposes only; consult each organization to see the full standard text.

UL Standard 2809
UL 2809, Environmental Claim Validation Procedure (ECVP) for Recycled Content includes chain-of-custody methods to that ensure recycled content claims are credible.[98] The procedures outlined in this standard include segregated supply chain management of materials, chain of custody between sites, and mass balance accounting. Manufacturers seeking certification under UL 2809 are required to submit documentation, undergo a facility on-site audit, and participate in an annual review.

For PCR content that is segregated from other sources in the supply chain, traceability and recordkeeping begin at the sorting and separation center. At each stage in the supply chain, documentation must be recorded to ensure segregation of materials is maintained.

If materials are transferred between sites, UL 2809 requires batch identification and records of the transfer of the batches to be documented by each facility. For each receiving site in the chain of custody, the following information must be recorded: supplier name, date shipment was received, quantity of material received, and unique identifier of the shipment for the inventory tracking system. For each sending site in the chain of custody, the following information must be recorded: customer name, date shipment was shipped, quantity of material shipped, and unique identifier of the shipment for the inventory tracking system.

The UL standard includes provisions for mixing of materials using an allocation system (mass balance or credit accounting). The allocation system must have a clearly defined system boundary (i.e., where materials flow in and out of the system), which may be a single facility, site, or group of facilities. On entering the system, the PCR materials are converted to credits. Credits are valid for one year. When materials leave the system as a final product, the credits are converted to a mass of allocated recycled content. Inputs to the system are tracked, including date materials were received, record of shipping, source of materials, shipment composition, material mass, conversion factors used to create credits for the shipment, and number of credits created. When credits are withdrawn (i.e., the system uses them to create products), the following information is recorded: date the credit was used, identity of the material carrying the recycled content, conversion factors used to convert credits to recycled mass units, shipment material mass, percentage allocated recycled content in the product, and shipping records.

SCS Standard
The Recycled Claim Standard (RCS), developed by SCS Global Services, is another standard to track recycled content through the supply chain.[99] The standard requires manufacturers to implement traceability practices to track the flow of all input materials for products certified under the standard. Manufacturers must develop and document procedures for segregating and identifying recycled content in the production phase. Diagrams or descriptions are used to show how a chain of custody is maintained throughout the manufacturing process to track the flow of all input materials, internal material flows, and material outputs. The SCS standard uses mass balance accounting to ensure that the recycled content used

[97] APR PCR Certification Program Frequently Asked Questions. https://plasticsrecycling.org/images/PCR_Certification/APR_PCR_Certification_FAQs.pdf
[98] Verifying recycled plastics using Recycled Content Validation. https://ul-performance-matters.com/verifying-recycled-plastics-using-recycled-content-validation-ul.html
[99] SCSglobal Services Recycled Claim Standard. https://www.scsglobalservices.com/services/recycled-claim-standard

in production is appropriately allocated to final products. Annual audits of manufacturers' facilities are performed to ensure continued conformance with the SCS standard.

Other Groups

Green Circle and AM Testing & Services also offer chain of custody validation for PCR resins. Green Seal considers these programs credible for chain of custody verification because they have been endorsed by the Association of Plastic Recyclers PCR Certification Program.