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Assessing the State of Food Grade Recycled Resin in Canada & the United States

Environment and Climate Change Canada
Environnement et Changement climatique Canada

STINA™

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Executive Summary

Background

The Government of Canada is working towards a vision of zero plastic waste, where all plastics are kept in the economy and out of landfills and the environment and has committed to working with industry to reach at least 50 percent recycled content in plastic products, where applicable, by 2030. The aim is to increase the amount of plastic waste re-circulated in the economy and to consequently reduce the amount being landfilled or littered.

In support of these goals, Environment and Climate Change Canada (ECCC) commissioned Stina Inc to synthesize available information with industry interviews to better understand the barriers and solutions for increasing recycled resin in food packaging. The focus was on mechanical recycling processing and production of food grade PCR, and Stina staff interviewed companies known to produce or consume large quantities of food grade post-consumer resin (PCR) in North America.

In Canada, all packaging materials used in the sale of foods are subject to the provisions of Division 23 of the *Food and Drug Regulations* (Regulations). The United States Food and Drug Administration has similar regulations found in the *Code of Federal Regulations*. This report delves into the practical challenges that brand companies and their value chain face on increasing the circularity of plastics specific to food grade packaging.

ECCC provided the following objectives for the report:

1. Characterize and quantify, where possible, supplies of food grade recycled resins produced in Canada and the United States, including trends in production.
2. Identify barriers and solutions for increasing recycled resin in food packaging applications over the next five to ten years.

The report focuses on polyethylene terephthalate (PET), high-density polyethylene (HDPE), and polypropylene (PP) as these are the main resins currently used in both new, virgin food packaging as well as processed into recycled PCR for use in food grade packages. It highlights both general information about food grade PCR and information specific to each of the three resins, related to:

- **Generation and Potential Sources for Food Grade PCR** – what are the potential sources of PET, HDPE, and PP food grade recycled plastics?
- **Collection and Processing Capacity for PCR** – how is the feedstock collected and what reclamation opportunities exist to process recycled plastics into food grade PCR?
- **Use of Food Grade PCR** – how are converters and brands incorporating recycled plastics into their food grade packaging and products?

Details about the "Probability for Circularity," or what is needed to achieve more collection, recycling and use of PET, HDPE and PP in food grade applications are also provided in the report for each of the three resins. Recycling is only one element of a circular economy but unlocking the challenges for use of post-consumer resin in food contact applications is essential for the full transition to circularity from the predominant linear system

The report distills the responses from interviews and principally seeks to convey the opinions and technical understanding of the interviewees, which represent companies across the plastic recycling value chain. To protect the confidential nature of the interviews, there is no direct attribution to any specific interviewee or company.

Findings

In Canada and the United States, the vast majority of plastic products and packaging produced each year and placed on the market is not suitable for processing into food grade PCR.[1] Out of all the plastic produced, packaging is the primary focus area for sources of suitable plastic for use in PCR for food contact applications. Within the packaging portion, the focus is on rigid plastics (predominantly PET and Natural HDPE bottles). More exhaustive research is needed to document an accurate total of suitable plastic for use in the production of food grade PCR.

> **The lack of supply of suitable feedstock to process into food grade PCR** was noted as the biggest challenge across the list of interviewees.

Interviews and research indicate three main reasons that a specific package or product may not be recycled or processed into food grade post-consumer resin:

1. The package or product was initially produced using non-food grade resin (virgin or PCR);
2. Converters add non-food safe additives during product or packaging production; or
3. Packaged products leach non-food safe contaminants into the package.

The Bureau of Chemical Safety (BCS) within Health Canada's Food Directorate conducts evaluations of the chemical safety of food packaging products, on a case-by case basis, taking into consideration the merit of each individual application.

1 In addition to insight through conducting the Annual Plastic Recycling Study, tracking the state of play for plastic recycling for more than 15 years, review of waste composition studies and information from resin producers, estimates are based on Stina Inc's institutional knowledge of production, consumption, and recovery of major categories.

Barriers and Solutions

BARRIER: LIMITED SOURCE OF FOOD GRADE SUITABLE PLASTIC—Flat or declining recycling rates for the three main plastic categories used in food grade packaging means that there is very little source material available to be recycled back into food grade recycled resin. In the case of natural HDPE bottles, fewer products that are suitable for food grade PCR are being generated for market.

The list of potential contaminants (e.g., chemicals) in the marketplace either contained in packaged products or in the packaging itself, poses risks to recyclers, converters, and CPGs. Reclaimers and converters are currently hamstrung by lack of suitable supply because most of the material collected for recycling today is not of suitable quality to be processed into food grade PCR.

SOLUTIONS:

- Greater transparency in the chemical composition of products to ensure suitability of products for recycling in food-grade PCR;
- Decreased use of non-food safe resin and additives in non-food applications to expand the potential portion of total plastic suitable for food-grade applications;
- Greater design for recycling (e.g., avoid multi-material packaging formats) to improve quality of collected material. See Association of Plastic Recyclers Design® Guide
- More incentives for consumers and businesses to recycle more plastic, growth in collection, and more and improved infrastructure to sort and segregate specific streams of plastic to capture more plastics suitable for food grade processing.

BARRIER: LACK OF RECYCLED CONTENT VERIFICATION REQUIREMENTS (Legislated or Industry-driven) LIMIT BENEFITS TO COMPANIES—Today there are products on the market that claim use of PCR but actually contain post-industrial resin or off specification virgin resin. Recognized and accepted standards to verify recycled content allow those companies using PCR to realize their competitive advantage and/or gain recognition for using post-consumer feedstocks that reduces waste and conserves resources by recirculating consumed items.

SOLUTION: Requiring recycled content verification (e.g., standards and labeling) reduces false claims and drives greater market efficiency. There are emerging schemes and technologies in the labeling and tracking spaces.

BARRIER: LACK OF ECONOMIC DRIVERS—The environmental benefits of using PCR are currently overshadowed by the economic drivers of a linear economy including low-cost disposal, low-cost virgin resin prices, and little market accountability for producing a product that is not recyclable. It is often cheaper to dispose rather than to recycle plastic waste or use virgin plastic instead of PCR.

SOLUTION: Various economic incentives could be used that value products and packages with lower overall environmental impacts, including rewarding companies committed to using PCR in their food packaging. Decoupling the price of recycled resins from virgin via recycled content requirements or advanced disposal fees would help level the playing field between virgin resin and PCR.

Significant system changes and innovations are needed to disrupt the linear model and redirect recyclable materials back into the economy. Many interviewees noted that companies struggle with where to place the most weight for environmental benefit when designing new packages or products. For example, use of recycled content can at times conflict with recyclability. Understanding how food safety guidelines and needs align with life cycle impacts, use of recycled content and recyclability is where public and private collaboration may be most needed. Increased feedback between the interconnected players in the value chain is critical for circularity. Extended Producer Responsibility programs that have variable fees based on the environmental attributes of a product (i.e., eco-modulation fees) is one means of facilitating feedback between producers with recyclers and encouraging continuous improvement.

Glossary

Circularity/Circular Economy: (From the [Ellen MacArthur Foundation]) System in which economic activity builds and rebuilds overall system health. Based on three key principles: Design out waste and pollution; keep products and materials in use; and regenerate natural systems. Recycling is one component to achieve circularity but reducing and reuse are other key elements.

Consumer Abuse: When consumers use containers for unintended uses that can lead to contamination during recycling, i.e., using a milk jug to store used motor oil. The motor oil can be absorbed into the container and render is non-food safe.

Consumer Packaged Goods Company (CPG): A company that sells packaged goods to consumers and businesses. In many cases, also a brand company.

Converter: Company that takes plastic feedstock like flake or pellets and makes a finished product. This finished product could be pre-form bottles or a roll of packages that a CPG then fills, or it could be something like irrigation tubing or composite lumber.

Food Grade: Food safe; any product suitable for contact with foods or beverages.

Intrinsic Viscosity (IV): A polymer attribute related to its molar mass, which provides an indication of the polymer's characteristics, including melting point and tensile strength.

PCR: Post-Consumer Resin. Recycled plastics collected from consumer/residential and business/commercial sources that have met their intended use. PCR does not include post-industrial scrap.

Plasticizer: Chemical substance added to a polymer to improve its plasticity and reduce brittleness.

Post-commercial: Plastics that met their intended use that are collected from commercial or business sources. Includes items like crates, buckets, and clear commercial film that may become PCR.

Post-industrial: Plastic scrap generated during the manufacturing process that does not leave the manufacturing facility as a finished item (includes trimmings or off spec products) that may become post-industrial resin (not PCR).

Reclaimer/Recycler: Company that buys sorted, collected plastics, often in bale form, and clean and process it into a feedstock to be used by a converter. The terms are used interchangeably within this report.

rPET, rPE, rHDPE rPP: Recycled PET, PE, HDPE, or PP. May be from any source. *For this report, all recycled plastics refer to post-consumer and not post-industrial materials, unless otherwise noted.*

Solid Stating: A step in PET processing that increases the chain length of the polymer, used to increase the mechanical properties of the plastic.

Sorbed/Sorption: The act of taking in and holding something. In this report, chemicals are sorbed into a plastic through absorption.

Tackifiers: Chemicals used to add tack or stickiness to items like stretch film.

Introduction

The Government of Canada is working towards a vision of zero plastic waste, where all plastics are kept in the economy and out of landfills and the environment and has committed to working with industry to reach at least 50 percent recycled content in plastic products, where applicable, by 2030. The aim is to increase the amount of plastic waste re-circulated in the economy and to consequently reduce the amount being landfilled or littered.

This report provides information pertaining to recycled content, specific to food grade applications, and will address key information gaps related to the supply of food grade recycled resin in Canada and the United States. For the purpose of this report, any of the challenges for producing or using "food grade plastics" would likely apply to other applications for which the type of plastic used is governed by specific regulations related to food or product safety. This includes, but is not limited to, medical/pharmaceutical items and many personal care products with active ingredients, which also have regulations that govern the packaging used.

Report Objectives

1. Characterize and quantify, where possible, supplies of food grade recycled resins produced in Canada and the United States, including trends in production.
2. Identify barriers and solutions for increasing recycled resin in food packaging applications over the next five to ten years.

Note: This report is qualitative and not a state of science report. Its scope is limited to information gleaned from interviews of key industry stakeholders, existing reports, and internal market knowledge of the authors.

Background

Plastics are collected for recycling from numerous sources in several ways. Households and businesses generate waste plastic packaging and products that are suitable for recycling. Both sources meet the definition of post-consumer, with the materials generated meeting their intended use before collection. Recyclable materials can be collected via curbside or drop-off collection from individuals or businesses as well as from large generators consolidating their own scrap materials for market. Most of the commercial material generated by large businesses and manufacturers is segregated by resin at the source. Conversely, much of the curbside or drop-off material in Canada and the U.S. is from single- or dual-stream systems, wherein multiple plastic resins and other materials, like paper or metal, are collected together and then sorted at a material recovery facility (MRF). The convenience of mixed collection of materials increases consumer participation, but also increases overall contamination of the various materials collected. This makes the material more challenging for a recycler to process, but especially for any plastic recycler that is trying to make a recycled plastic for food-contact applications.

Recycling is only one element of a circular economy, but unlocking the challenges for use of postconsumer resin (PCR) in food-contact applications is critical to the full transition to circularity.

In Canada and the United States, the vast majority of plastic products and packaging produced each year and placed on the market is not suitable for processing into food grade PCR.[2] Out of all the plastic produced, packaging is the primary focus area for sources of suitable plastic for use in PCR for food contact applications. Within the packaging portion, the focus is on rigid plastics (predominantly PET and Natural HDPE bottles). More exhaustive research is needed to document an accurate total of suitable plastic for use in the production of food grade PCR.

With recycling rates flat or declining for most plastic categories, the momentum for a linear economy is strong with market forces driving the use of virgin plastic over PCR and the disposal of scrap plastic over its recovery for recycling. The status quo of collection, sortation and processing is currently insufficient to meet most public and private recycling goals for recycled content in packaging and particularly food-contact packaging. Additionally, the cost to process plastics to meet food grade requirements is often higher than virgin plastic, making it costly for some brands to incorporate significant amounts of PCR in any packaging. For example, segregated collection of post-consumer plastics, such as deposit return systems, improve the overall quality of that specific stream of material, making it easier and less costly to process to higher quality PCR. Additional significant system changes and innovations are needed to disrupt the linear model and redirect recyclable materials back into the economy.

The use of recycled plastics in food-contact containers is governed by Health Canada and the United States Food and Drug Administration (FDA). A Letter of No Objection (LONO or LNO) can be issued to a petitioner for a specified food packaging end use and is only an opinion on the acceptability of a material. (See section *on Testing and Qualification of Food Grade PCR* (p. 23) for further details). Most PET processing in North America relies on the LONO for the processing equipment, while for PE and PP, the LONO is more commonly given to an individual company for its specific process. Most LONOs provide conditions for the type of food and the process for which the container or package made with PCR can be used, such as: "articles for contact with aqueous, acidic, low alcoholic (8 percent or less), and dry foods at room temperature (120°F) or below"; or "articles for contact with all types of food under Condition of Use A (High temperature heat-sterilized (e.g., over 212 °F))."[3] Reclaimers and converters noted that having a Letter of No Objection does not necessarily mean the company is actually processing food grade PCR.

In support of feedstock sourcing for food applications, Health Canada identifies source control measures[4] which may include but are not limited to:

- documenting and maintaining records of all sources of recycled materials, from related batch numbers through to production lots of finished products;
- limiting the source of collection to food-contact plastics. For example, only polystyrene cups, plates, cutlery from school cafeterias;

2. In addition to insight through conducting the Annual Plastic Recycling Study, tracking the state of play for plastic recycling for more than 15 years, review of waste composition studies and information from resin producers, estimates are based on Stina Inc's institutional knowledge of production, consumption, and recovery of major categories.
3. https://www.fda.gov/food/packaging-food-contact-substances-fcs/food-types-conditions-use-food-contact-substances
4. https://www.canada.ca/en/health-canada/services/food-nutrition/legislation-guidelines/guidance-documents/guidelines-determining-acceptability-use-recycled-plastics-food-packaging-applications-1996.html

- promoting the use of collection sites for plastics containers designated with the label 'for food-contact use only';
- sorting procedures to limit the plastic resin type;
- implementing visual inspection systems and other devices to detect and reject containers that may contain potential hazardous or toxic substances.

There is a need to balance best practices with the practicality of having consumers (individuals or businesses) sort several different types of similar plastics into distinct streams. Consumer behavior and motivation is an important part of any recycling system, but there must also be connection between the source of new products and packaging and the design of the recovery system.

Methodology

Environment and Climate Change Canada (ECCC) commissioned Stina Inc (Stina) to synthesize insights into the barriers and solutions for increasing recycled resin in food packaging. The Stina Project Team leveraged its extensive network of industry contacts to interview companies — at the various stages of material use — to document key challenges the companies face when using postconsumer resin (PCR) in food grade applications.

Interview selection focused on companies known to produce or consume large quantities of food grade post-consumer resin (PCR) in North America. The scope focused on post-consumer (including post-commercial) resin. Stina applied internal company knowledge and evaluated data and information readily available from ECCC, select studies, and market reports relevant to food grade recycled resin. Stina's internal knowledge of post-consumer plastic collected for recycling stems partly from conducting the Annual Plastic Recycling Study (Study) for the past ten years for the United States and Canada for bottles, film, and non-bottle rigid plastics. This knowledge shaped the selection of interviewees and the development of interview questions.

Research References

- Health Canada Guidelines for Determining the Acceptability and Use of Recycled Plastics in Food Packaging Applications
- US FDA's Guidance for Industry: Use of Recycled Plastics in Food Packaging: Chemistry Considerations (2006)
- 2019 NAPCOR PET Recycling Report (available for purchase)
- Stina Inc 2018 Post-Consumer Plastics Recycling in Canada
- Stina Inc 2019 U.S. Post-Consumer Plastic Recycling Data Report
- ECCC/LURA Recycled Plastics Technical Workshop: What We Heard, 2020
- IBWA/RRS Analysis of Food Grade Recycled PET (rPET) and Recycled HDPE (rHDPE) in the United States, 2020
- ECCC/Deloitte Economic Study of the Canadian Plastic Industry, Markets and Waste (Summary Report), 2019
- Center for Management Technology Webinar: North America Food Contact Recycled Plastic, 2021
- Stewardship Ontario The_New_Blue_Economy_Model.pptx
- Foodservice Packaging Institute Blue Mountain Plastics Case Study, 2016
- National Zero Waste Council Less Food Loss and Waste, Less Packaging Waste, 2020

Data Gaps & Assumptions

This research required interview questions that involve proprietary and confidential information. Like the survey for the Annual Plastic Recycling Study (Study), Stina must maintain confidentiality regarding specific company processing details and capacity. Interviewees shared information in confidence with the understanding that their information would be shared in aggregate form only to protect proprietary and confidential information, and that they would have an opportunity to review the findings prior to the report's publication. Quantitative findings are based on estimates developed through interviews, literature review and previous marketplace knowledge. The findings are not comprehensive of all reclaimers producing PCR. This study provides primarily qualitative information.

For more than ten years, Stina has collected quantitative data that provides foundational working knowledge on the state of film, bottles, and non-bottle rigid plastic recycling for the United States and Canada. Historically, this annual Study has not specifically reported on food grade specific processing capabilities; however, such questions could be included in future surveys. Although 2019 U.S. Post-Consumer Plastic Recycling Data Report is limited to the United States due to funding limitations, Stina applied working knowledge of material flow and processing capabilities to provide qualitative insight for this report.

Interviews did touch on post-industrial plastic but given the focus by most companies on sourcing post-consumer plastic for food grade applications, less focus was placed on post-industrial plastics. Priority was placed on gathering insight on polyethylene terephthalate (PET) and polyolefin resins (polyethylene, PE and polypropylene, PP), given the few market players for other resins such as polystyrene (PS). Resins with smaller market share are inherently more challenging to collect and process because recyclers require a critical mass of material to warrant collection and processing.

Interview Process

Stina conducted sixteen interviews covering key perspectives around the value chain, putting priority on companies with direct experience in the use or production of food grade PCR. These companies serve both Canada and the United States. The interview process included the following steps:

- Developing interview questions that were specific to the interviewee and his or her organization's role in the value chain, as well as questions common to all interviewees, such as those regarding barriers to PCR use and recommendations for increased use of food grade PCR;
- Scheduling and conducting interviews (two Stina staff participated in each interview for comprehensive questioning and documentation);
- Synthesizing interview responses with other available information and affirming relevant findings with interviewees in follow-up correspondence; and
- Vetting high-level assessments and draft report with select interviewees with distinct technical and institutional knowledge of plastic recycling.

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Profile of Interview Group

Stina staff prioritized outreach to senior leadership and subject matter experts. Our goal was to connect with market share leaders and innovators to gather insight on trends and barriers for increased use food grade PCR (predominantly PET and Polyolefins). The sixteen interviews were with:

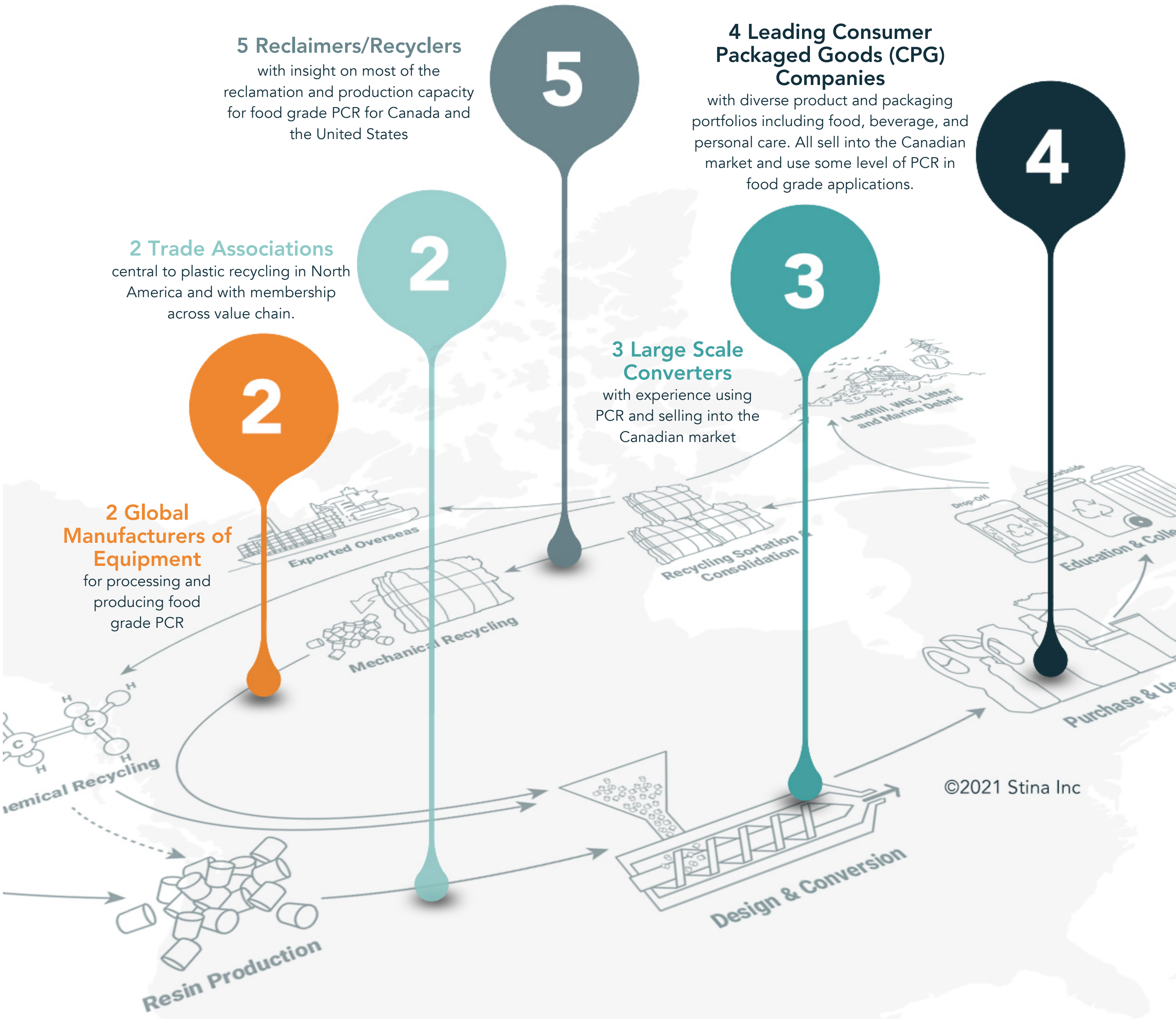
5 Reclaimers/Recyclers
with insight on most of the reclamation and production capacity for food grade PCR for Canada and the United States

4 Leading Consumer Packaged Goods (CPG) Companies
with diverse product and packaging portfolios including food, beverage, and personal care. All sell into the Canadian market and use some level of PCR in food grade applications.

2 Trade Associations
central to plastic recycling in North America and with membership across value chain.

3 Large Scale Converters
with experience using PCR and selling into the Canadian market

2 Global Manufacturers of Equipment
for processing and producing food grade PCR



Gathering Insight on PCR Usage Around the Value Chain

Sample Interview Questions

For Reclaimers/Recyclers:

1. What is your current capacity for producing food grade and non-food grade recycled resin?
    a. What is the feedstock for each food grade resin you produce?
2. What is the greatest challenge for achieving food grade with mechanical recycling, and what are the solutions?
3. Tell us about your letters of non-objection.
    a. How much of a barrier is the administrative process to get a LONO?
4. What limits your capacity for producing more food grade recycled resin?
5. Did you create your own process or purchase equipment that has its own LONO or combination of both?

For Product Manufacturers Using Food Grade PCR

1. What kinds of products do you manufacture using food grade recycled resin?
    a. What's the biggest barrier to using PCR in your food grade applications?
    b. What percentage of PCR are you able to use in your various food grade applications?
    c. Do you use food grade PCR in non-food grade applications?
2. Why do you use PCR in food grade applications?
3. What chemicals or compounds concern you when considering use of food grade PCR?
4. In your view, what actions are most needed to enable manufacturers to increase the amount of recycled content used in plastic food packaging and who should take these actions?

For Equipment Suppliers

1. Given the breadth of packaging formats and their components (inks, colorants, additives, etc.), what is the most challenging to detect? and to remove? in creating food grade?
2. Is the LONO application a barrier to bringing equipment to market for food grade processing?

For All Interviewees

Which barrier is the most significant? (Options provided to interviewees)

1. Lack of design for recycling – the supply of PCR that's most able to displace virgin is declining (fewer food grade natural HDPE bottles produced) while the supply of packaging with the greatest barrier to becoming food grade PCR is growing (film)
2. Potential for chemical or heavy metal migration in food-contact applications containing PCR
3. Lack of standards for verifying PCR
4. Environmental benefits of using PCR are overshadowed by economic drivers for a linear economy: low-cost disposal and low-cost virgin resin
5. Other?

Interview Findings

State of Play for Food Grade PCR

Generation: Potential Sources for Food Grade PCR

Key Questions: *How much of the plastic produced and placed on the market is not food safe? And how much plastic is used in applications that renders it not food safe due to the plastic absorbing contaminants from products or consumer misuse/abuse?*

Canada and the United States are separate sovereign nations with different trade considerations, regulations, and market differences; however, the movement of plastic – both virgin and recycled – across borders is significant. With this in mind, many of the details herein rely heavily on United States (U.S.) recycling data because the U.S. generates the majority share of the feedstock of PET (polyethylene terephthalate), HDPE (high-density polyethylene), and PP (polypropylene) bottles and containers used to make both food grade and non-food grade post-consumer resin (PCR) in North America.

Understanding that the underlying goal of packaging is to protect a product in transit between production and consumption is critical – the technical functionality of any package is tantamount to reducing product loss. Interviewees noted that there are technical and practical challenges to 1) making all packaging recyclable and 2) using PCR in packaging. The degree of challenge varies by resin and packaging format. For example, flexible packaging is generally even more challenging than rigid plastic packaging formats, both in achieving recyclability and use of PCR; however, flexible packaging may have other benefits in overall lifecycle impact. One converter noted that, "recycling drivers in flexibles are lagging compared to rigids." Rigid plastic packages have also had more focus regarding design for recycling and collection.

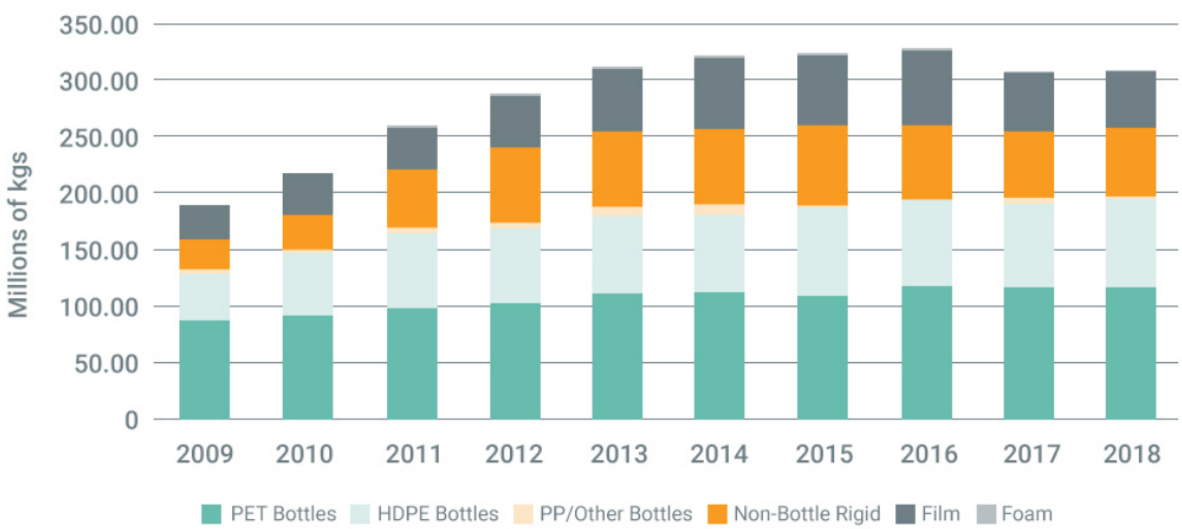
Reclaimers estimated that the bulk of natural HDPE (nHDPE) bottles are produced for food grade applications, especially compared to colored HDPE bottles, but more information is needed on production and end uses. The exact breakout of nHDPE and polypropylene bottles that are used in food grade applications is not well documented. Similarly, according to industry experts, most PET bottles are used for food and beverages, with some smaller percentage used for household and personal care products.

The Canadian Beverage Association indicates that over 70 percent of PET beverage bottles in Canada are recovered through beverage container recycling programs[5]. Even with this particular success, both Canada and the U.S. face low average national recycling rates for plastic bottles, including PET, and other plastics. In addition to low recycling rates, generation of some of the containers most sought after

5. https://www.canadianbeverage.ca/news-media/blog-posts/beverage-bottle-recovery/

as post-consumer feedstock for food grade HDPE PCR—natural HDPE bottles—has been gradually declining. U.S. resin sales for nHDPE bottles in 2018 totaled 680 million kilograms and only 196 million kilograms of nHDPE bottles were recovered for recycling. Resin sales decreased in 2019 to 677 million kilograms and nHDPE recovered for recycling fell to 184 million kilograms. PET bottle generation has grown, but recovery of bottles for recycling has not kept pace. In 2019, the amount, by weight, of PET bottles recovered for recycling in the United States fell[6]. In 2018, the latest year of the Canadian plastic recycling report,[7] Canada recovered 116.1 million kilograms of PET bottles and 31.4 million kilograms of nHDPE for recycling.[8] The following chart (Figure 1) shows that Canadian PET and HDPE bottle recycling grew steadily starting in 2009 but leveled off in 2016.

Figure 1. Canadian Post-Consumer Plastic Recycled[2]



While some "non-bottle rigid" plastic, such as clamshells and dairy tubs, may be suitable for food grade PCR, sorting the numerous, mixed sources of these containers, including mixed resin bales, and then processing segregated streams is usually cost prohibitive under current market conditions. Another packaging format that is difficult to recover for recycling and utilize back into food grade PCR is film or flexible packaging. Use of this format is on the rise as more companies seek to reduce the weight of their packages and their plastic consumption. Additionally, legislation that collects fees based on the weight of packaging introduced into the market will likely encourage more use of film and flexibles.

Most of the film collected for recycling is low- or linear low-density polyethylene (LD or LLDPE). There are FDA LNOs that would allow for the production of food grade LDPE PCR, but no interviewees were aware of any food grade PCR originating from film currently being produced in Canada or the United

6. 2019 U.S. Post-Consumer Plastic Recycling Data Report
7. The 2019 Annual Survey was limited to U.S. sourced plastic recovered for recycling and does not include details about plastics sourced in Canada due resource limitations.
8. 2018 Post-Consumer Plastics Recycling in Canada

States. Sourcing only film that is used for food grade applications is logistically difficult because collectors (normally retail take-back programs) and recyclers require the critical mass gained by combining multiple types of polyethylene film for efficient recycled material collection, transport, and processing. This creates streams that include both HDPE and LDPE post-consumer film packaging and bags for food and non-food items, as well as LDPE or LLDPE commercial stretch and pallet wraps. This mixed stream is likely why no food grade PCR originating from film is currently produced in Canada or the United States.

Key Question: *What is most needed to recycle more plastics—better package or product design at entry into the marketplace or more infrastructure to collect, sort and process what is generated?*

Recycling more plastics as part of a shift to a circular system will require a systems approach: from the initial design and production/formation of the package to the design of the collection and sorting pathways, through recycled feedstock production, and finally PCR use and consistent markets for this material. This highly integrated, complex, and dynamic plastic recycling system made it critical to interview a wide swath of the value chain.

A converter reiterated that, "design for recycling is critical because the way a package starts its life impacts what it could be used for next." One consumer packaged goods company commented that design guidance such as that provided by the Association of Plastics Recyclers[9] should be used more to encourage bottle and related component designs that don't adversely impact the recycling stream in terms of quality and yield. For example, consider clear bottles with either removable or small labels. Other interviewees acknowledged that more deposit systems in the U.S. and Canada would improve the recycling rate for bottles significantly and provide more readily recyclable high-quality material for reclaimers that could be suitable for both food-contact and other applications that require high quality PCR. Lastly, it must be noted that most interviewees acknowledged that a funding mechanism will be needed to supply the capital needed to improve infrastructure, with options including extended producer responsibility schemes or other financial incentives for recyclers.

Processing Capacity for PCR

Key Question: *Should more emphasis be placed on the need to manage source of material (segregated supply) or rely on the process to mitigate potential contaminants (design of packaging)?*

One of the key goals of this research and report is understanding trends in production of recycled content plastic suitable for food grade end uses. All recyclers interviewed said that their capacity to process more food grade PCR is limited by available supply. Many noted they would expand their capacity to meet additional demand for food grade PCR if there were more guaranteed suppliers of recycled material from the right sources. They reiterated that source matters – one must have a known source of reliable feedstock to be confident you are producing a recycled plastic that is indeed safe for

9. https://plasticsrecycling.org/overview

food contact. Knowing what a bottle contained or what it may be exposed to along its journey of use, collection, sorting, and storage is important and must be factored into the recycling process. And plastic resin absorption propensity varies, with polyolefins typically being more absorbent than PET.

Some potential contaminants to recyclers are intentionally a part of the package and include additives, barriers (e.g., to extend shelf life), and inks from the packaging itself, as we well as chemicals contained in some non-food packaging. For example, bottle colorants may not be food safe, including some that use heavy metals to produce saturated colors. This is one part of why colored HDPE containers currently have no accepted pathways to food grade PCR. The diverse line of products packaged in colored HDPE containers is also a factor. Conversely, putting more non-food products in natural HDPE bottles could be problematic for mechanical recyclers as it could increase the number of non-food bottles in the natural HDPE stream. This would make it more difficult to process this broader mix of containers back to food safe PCR unless the products that pose a health risk are clearly labeled and handled separately from the recycling stream intended for the production of PCR for potential use in food-contact applications. As the source of potential recyclables is growing more complex, and thus more challenging, the recycling processes to produce food grade PCR must be robust, maintain the environmental benefits of recycling, and still be cost-effective in removing contaminants. Recyclers are the engines of a circular economy and need greater support by way of supply of material that is readily recyclable.

For traditional mechanical reclaimers there are three key components of processing used to remove contaminants: heat, vacuum, and time. Heat is used to remelt plastics and higher melt temperatures can volatize more chemicals out of the plastic. Heat is more challenging to use with polyolefins because of their lower melting points. Vacuums are used to pull the volatiles out of the processing equipment. Vacuums can also be used to mold plastics in certain processes. Reclaimers noted that a robust and vented vacuum step to remove volatile contaminants is also critical in polyolefin processing. Lastly, the time of heating or vacuum use can improve the efficiency of either process to remove contaminants. Regardless of resin or specific processing steps, reclaimers have significant protocols for continuous monitoring during the production of food grade resin, including lot testing and sampling of material throughout the shift day.

Understanding the chemical nature of contaminants is key to developing the proper combination of heat, time, and vacuum to their removal. While some contaminants are volatile and can be removed with heat, time, and vacuum, others (e.g., polyvinyl chloride labels) require specialized sorting equipment. Volatile chemicals typically come from the products contained within packages, such as acetone, which can be absorbed into the plastic. With higher melting points for PET, volatiles may be more easily removed, but there are upper processing heat limits for polyolefins since the plastic itself cannot withstand high temperatures, as mentioned above. Not all of these contaminants exist in all streams, but they are of notable concern within the entire plastic recycling industry.

Approximately 2.6 billion kilograms of all post-consumer plastics[10] were recovered for recycling in 2018 (the last data available for both U.S. and Canada sourced plastic).[11] Based on interviews and industry information there is an estimated 660 million kilograms of capacity to produce PET food grade PCR in the U.S. and Canada. This represents 60 percent of the total PET processing capacity reported in 2019. The remaining 40 percent of capacity is used to process PET that is not used for food grade end uses, including non-food packaging and materials like polyester or carpet.

The capacity to process food grade nHDPE recycled resin is less than 20 percent of the 2019 total reported HDPE bottle processing capacity of approximately 590 million kilograms. Capacity numbers for PP cannot be shared to protect the confidentiality of the small number of polypropylene recyclers. Data from the 2018 Post-Consumer Plastic Recycling in Canada report indicates that Canada processed several million kilograms more than it collected, for both PET and HDPE, reflecting greater processing capacity than collection that year.

To combat the supply issue, interviewees noted the need for much greater collection of food grade material and acknowledged that container deposit programs support this goal. Interviewees also noted the growth of vertical integration – resin producers and converters are buying reclamation capacity and brands and reclaimers are buying converting equipment to make their own packaging such as bottle pre-forms. This integration gives companies more control over feedstocks and the PCR levels best suited to their products and goals.

Equipment manufacturers stated that, "We're already using the best technology for mechanical recycling processes. The jury is still out for enhanced (or chemical) recycling. This is where the potential is, especially for olefins." Chemical recycling can be energy intensive, and one equipment manufacturer noted that getting back to a usable PCR pellet via chemical recycling processes still requires some investment in equipment and capacity to sort, clean and/or pelletize the feedstocks through mechanical processes. And, it is predicted, that at least initially, chemical processing will be even more expensive than traditional mechanical processing of plastics.

In conclusion, the steps required for food grade PCR make its processing more costly than that of non-food grade PCR. Coupled with supply/demand dynamics related to limited supplies of suitable PCR, the cost for food grade PCR is often higher than virgin plastic, making it costly for some brands to incorporate significant amounts of PCR in packaging. The whole system benefits when there is greater focus on quality from package design through to collection and processing.

10. For the purposes of this report, we are using the U.S. EPA definition of post-consumer since much of the plastics collected for recycling in North America are sourced from the United States. "Post-consumer material" is defined as a material or a finished product that has served its intended use that is then diverted or recovered before it is disposed as solid waste. It is the material consumers and businesses collect for recycling; it does not include manufacturers' scrap, which is commonly reused in the original manufacturing process.
11. 2019 U.S Post-Consumer Plastics Recycling Data Report

Use of Food Grade PCR

One reclaimer stated that they were not sending much PCR to Canada for use in food grade applications, but instead for automotive applications and personal care bottle converters that want "good quality" resin. Further, demand pressure from EU and Mexico for PCR is driving the price up and taking raw material (in bale form) volume away from some North American reclaimers. The general picture of end uses of PCR indicates that much of the post-consumer plastic collected for recycling that is suitable for reprocessing into food grade PCR—primarily natural HDPE and PET bottles—is going into non-food contact applications such as fiber, personal care product containers, and durable applications such automotive parts or landscaping and culvert pipe.

Buy Recycled Products Directory

Products by Resin - listed in the Directory

PET	51%
PP	17%
EPS/XXPS	8%
HDPE	7%
Unidentified	5%
PS	3%
LLDPE	3%
PE	2%
HIPS	1%
LDPE	<1%
Other	<1%
Olefiin	<1%

- Stina vets and posts products made using post-consumer plastics to aid businesses and consumers in their search for recycled content goods and packaging.
- More than half of the products listed are made with PET, and most of these PET products are clothing and other non-packaging products.
- The Directory is voluntary so is not a precise representation of the market but rather an indication of types of products on the market that contain PCR.

The good news is that for the interviewed converters and CPG companies, using more PCR in food grade applications is a goal. And some Canadian companies are indeed already using PCR in various food grade products. Ice River Springs' Sustainable Solutions water bottles made in Ontario, Canada are a notable success story, using 100 percent post-consumer PET. Other North American converters have created processes to use PCR in things like cereal bag liners, although the source of this PCR comes from bottles rather than film. These cereal bags are not currently recycled in a stream that can be processed back to food grade PCR.

There are challenges to using more PCR in food packaging, with supply of resin suitable for food-contact a principal barrier to increased usage. The IBWA/RRS "Analysis of Food Grade Recycled PET (rPET) and Recycled HDPE (rHDPE) in the United States" report noted that for the US, a 30 percent PET recycling rate supports nine percent PCR usage rate in beverage bottles. Further, RRS calculated that for the US to meet 25 percent PCR use in beverage bottles (without significant growth in other applications), the U.S. PET recycling rate would have to be 52 percent— more than 60 percent greater than the current recycling rate.[12] Similar trends and numbers would be true for growth in PCR use for Canadian companies.

Key Question: *What is the most cost-effective way to bring transparency to products and packages that may contain contaminants that are not food safe to reduce the risk to recyclers, converters, and CPGs working to increase recycled content in food-contact applications?*

Other challenges related to the desire to mitigate liability were also noted in interviews. Across the range of interviewees, a central theme emerged that all parts of the food-contact value chain are risk averse. Several interviewees noted strict internal barriers to using more food grade material in packages. They noted that upstream regulation is critical. It is difficult to manage so many potential chemical risks because there is less direction in North America about what [chemicals] can be used in packaging and products from the start. Concerns about use of PCR in food-contact applications are concentrated on contaminants that can be "sorbed" into plastic containers from products or secondary uses (like using a milk jug to hold used motor oil), which then can leach into new products packaged in the PCR containers.

Because polyolefins are more prone to absorbing additives and volatiles from products, or consumer secondary use, into the thickness of the plastic, the migration of these from the bottle or package back into food or beverage products is a particular concern with these resins. Consumer packaged goods company (CPG) interviewees noted that these concerns are not limited to just food product packaging but include concerns about many personal care product packages as well. The use of PCR is application dependent at the brand level and some products aren't likely to ever use mechanically recycled material because of concerns or uncertainties about perceived safety of the recycled plastic. Additionally, CPGs worry about deviation from the standard look, taste and/or smell of their food or beverage products and

12. IBWA/RRS Analysis of Food Grade Recycled PET (rPET) and Recycled HDPE (rHDPE) in the United States, 2020

packages. Thus, odors and appearance of packaging matter when using PCR. Further, concerns about the efficacy of the packaging to protect products, errant inclusion of non-food safe materials, or general failure of processing to remove every possible contaminant creates a scenario in which the current use of PCR in packaging is the exception rather than the norm and is concentrated in the PET bottle-to-bottle / bottle-to-sheet space.

Rigorous standards and verification of both PCR use claims and of post-consumer recycled plastics placed on the market for use could relieve some of the concerns within industry about the source and processing efficacy of the PCR available for use for food grade applications. Unenforced requirements on PCR usage and false claims have led to market inefficiencies according to one veteran recycler during the interview process.

Beyond the cost of processing and using food grade PCR, there are also technical and functional needs to consider for the package. As one CPG noted, the actual use and amount of PCR plastic is often determined by the product—a dry good has different packaging needs and chemical migration may be limited compared to a liquid, especially something like an acidic carbonated soft drink. Production needs, like hot fill processes, or shelf-life needs also impact container type and PCR use.

The disconnect between what is entering the consumer market and what is likely to be recovered to meet recycled content requirements is very large. As noted earlier, the potential source of food-contact safe plastic is very limited and, in some cases, declining. Currently, there are limited financial drivers or feedback between producers and recyclers in the marketplace to drive production of products that can be viably reprocessed into high quality PCR. However, the formation of organizations like the Canada and U.S. Plastics Pacts will help improve dialogue across the value chain to find solutions. Additionally, mechanisms such as "eco-modulation" within container deposit systems and extended producer responsibility programs (EPR), like in California and France, respectively, use fees and economic forces to drive packaging design and selection toward more readily recyclable packaging design, recycled content use, and/or lower life cycle impact depending on the modulations.

Several of the CPG interviewees said that it would be helpful to have more specific guidance on how to design a food grade container that would be suitable for collection and recycling into usable food grade PCR. Health Canada also provides guidance[13] on ways to limit or even eliminate the migration of chemical contaminants into foods from recycled plastic packaging by:

- Restricting use of recycled plastic packaging to contain certain food types (such as dry foods, foods with natural protective shells, raw fruits, and vegetables);
- Limiting the conditions of use for recycled plastic packaging materials (such as use at room temperature or below);

13. https://www.canada.ca/en/health-canada/services/food-nutrition/legislation-guidelines/guidance-documents/guidelines-determining-acceptability-use-recycled-plastics-food-packaging-applications-1996.html

- Restricting use to food packaging applications where there is no or unlikely possibility of migration of potential contaminants to foods (e.g., the wrappings of cartons of beverages which are contained in boxes, use in egg cartons, etc.).

As noted previously, the use of PCR currently comes at a cost premium, and the use of food grade resins further expands the delta between low-cost virgin and recycled resins.

Testing and Qualification of Food Grade PCR

In Canada, all packaging materials used in the sale of foods are subject to the provisions of Division 23 of the *Food and Drug Regulations* (Regulations). The U.S. FDA has similar regulations found in the *Code of Federal Regulations*, but this report will focus on details specifics to the Canadian Regulations. Unlike impermeable glass or metal containers, plastic packaging carries the risk that chemical contaminants from packaged products or consumer abuse or misuse may be absorbed by the plastic and remain in recycled materials. The underlying concern that contaminants may leach into a food product from a recycled plastic is a principal concern in the use of PCR plastics in food packaging. The Regulations do not prohibit the use of PCR in food-contact packaging, but Section B23.001 prohibits the sale of foods in packaging materials that may impart harmful substances to their contents.

Packages can be voluntarily evaluated on the chemical safety of recycled content packaging. The Bureau of Chemical Safety (BCS) within Health Canada's Food Directorate conducts evaluations of the chemical safety of food packaging products, upon request, based on information submitted by petitioners. These safety assessments are conducted on a case-by-case basis taking into consideration the merit of each individual application. If the BCS considers a product to be acceptable for its proposed use, a Letter of No Objection (LONO) is issued to the petitioner for the specified food packaging end use. This letter is only an opinion from Health Canada on the acceptability of a material and does not relieve the food seller of its responsibility under Section B.23.001 of the *Food and Drug Regulations* and other regulations that are relevant to its use.[14]

While a LONO is not required to make or sell PCR, most reclaimers and converters find that it is an important document to have to show that your PCR meets Health Canada and/or FDA requirements for food-contact packaging. Brand companies often require LONO to purchase PCR and other companies making non-food contact products prefer the higher quality PCR material for their manufacturing processes.

Health Canada and the FDA have similar protocols and pathways for testing and receiving a Letter of No Objection. A separate application is required for each, but most interviewees noted that if you can meet FDA guidelines then you can meet Canadian guidelines and vice versa. Thus, for the purposes of this report, having a process in place to meet the criteria of one assumes the ability to meet the criteria of the other agency. Some interviewees were concerned that there may be some divergence in the future

14. Information herein from Health Canada is a synopsis of more detailed information provided by the agency. Full details are available on the website.

now that plastic manufactured items have been listed on Schedule 1 (List of Toxic Substances) of the *Canadian Environmental Protection Act, 1999* (CEPA). However, Environment and Climate Change Canada and Health Canada confirmed that the listing of plastic manufactured items on Schedule 1 of CEPA was an administrative step made on the basis of ecological harm, rather than harm to human health. Health Canada has further confirmed that the CEPA listing will not impact its regulations or requirements for food-contact packaging.

To obtain a LONO it is expected that the inbound feedstock source contains a predictably high percentage of a specific resin type with small percentages of known contaminants. Suppliers of recycling equipment for processing food grade PCR often outline the specifications required for inbound or source material required to establish the limitations of the process to handle contaminants. LONO applications are written around a specific inbound feedstock. Currently, PET inputs are well known and well documented, but the same is not true for most PP or PE feedstocks due to resin use in a more diverse product portfolio including food and non-food applications.

Obtaining a LONO requires significant resources from an administrative and testing perspective according to the reclaimers interviewed. However, a LONO offers significant financial benefit to reclaimers in the market thus the resources required to obtain a LONO are generally worth the effort. Interviewees noted that most companies hire a third-party company to work through the LONO process on their behalf. This third-party submits the samples and guarantees that the materials and data presented are accurate, including any challenge testing results.

Health Canada provides the following details on testing to replicate the potential consumer abuses on a specific set of containers:

> *In cases where plastic food containers may have been used by consumers for secondary purposes (such as storing motor oil, pesticides, etc.), a protocol which demonstrates the efficacy of a clean-up process can be established by exposing plastic packaging (either in container form or as flaked or pelletized resin) to selected surrogate contaminants. The choice of model contaminants should be made up of a concoction of compounds which reflect the anticipated commercial contaminants available to consumers (automotive fuels and oils, solvents, pesticides, toxic organic salts involving heavy metals, antifreeze, household cleaners, etc.). The material is then subjected to the recycling process. Subsequent analysis of the resulting material for the levels of the residual contaminants would demonstrate the efficacy of the recycling process.*

Similar steps may be taken with chemical recycling processes wherein contaminants are “spiked,” and the efficacy of the chemical process is tested to see how these contaminants are removed. The chemical processing of plastic feedstock, including depolymerization, is expected to remove things such as additives and pigments bound in the polymer matrix.

To develop criteria in deciding what levels of contaminants in the recycled materials would be acceptable and not compromise the health of consumers, the Health Products and Food Branch takes the position that a probable daily intake (PDI) of 25 ng/kg b.w. (body weight) or less of a contaminant in food arising from recycled food-contact articles will generally be of negligible risk to consumers. This dietary exposure can, in most cases, be estimated based on the residual level of the contaminant in the finished article and taking into consideration such factors as the density and thickness of the article, the ratio of food to contact surface, the consumption factor, the recycled resin content of the article and if appropriate, market penetration, or prevalence of the product in the marketplace. In these calculations, complete (i.e.,100 percent) migration of the contaminant from the food-contact material to the food is assumed. Some interviewees noted that there are too many potential risks from potential contaminants in general and that by limiting unnecessary use of such contaminants or better managing known health risks we could greatly increase the supply of recyclable plastics.

Health Canada acknowledges that using PCR plastic in food-contact packaging may necessitate the use of the recycled content in a non-contact layer, "Recycled plastics separated by an *effective barrier* [emphasis added] made of an acceptable virgin plastic or other appropriate material such as aluminum would present no concern with respect to migration of potential contaminants into food." But these barriers bring their own challenges in circularity. For example, adding an aluminum barrier to a thin film plastic package to protect the product from chemical migration would currently render that new package unrecyclable, raising questions about the net environmental benefit of using PCR with a metal barrier compared to other fully recyclable, but heavier alternatives. Some interviewees discussed whether the use of a thin plastic laminate layer would be an effective barrier against contaminant migration. There are many variables to consider such as the type of material, its thickness, the condition of use, the impact on the recyclability of the package.

Interviewees from all segments of the value chain discussed the importance of knowing your source material and having proper testing protocols in place to verify that processing pathways are removing contaminants. And while Health Canada and FDA regulations may focus on contaminants arising from products and consumer use of containers, many recyclers, converters, and brands test for other "marker" chemicals that may also impact flavor or odor of packaged foods. These include limonene, a flavor and fragrance additive which also serves as an oil dissolver in cleaning agents; and acetaldehyde, which is naturally occurring in things like coffee and ripe fruits, but may be produced by the UV degradation of PET. For these two chemicals, brand concerns center more on flavor or odor impacts and less on toxicity. Limonene can be absorbed by olefins from the packaged products and serves as one of the surrogates for non-saturated hydrocarbons. It will prevail in mechanically recycled PE and has to be pulled off with a vacuum so being able to process the plastic to remove limonene is critical to showing process efficacy and protecting the viability of the PCR for use in new packaging.

Findings by Resin

Based on interviews and review of the reports noted as reference, the following section provides an overview of findings by resin type. This report focuses solely on PET, PE, and PP plastics due to the more developed nature of their recycling systems and the opportunity to produce food grade PCR.

Polyethylene Terephthalate (PET): Rigid

Source – Available to Recyclers

The primary source of food grade recycled PET postconsumer resin (PCR or rPET) are beverage and food bottles and jars. This includes a wide variety of food and beverage items including water, juice, sports drinks, teas, carbonated drinks, condiments, nut butters, dressings, pasta sauces and ice cream. Most bottles and jars are clear, but some are tinted translucent green, light blue or brown. A small number of PET food and beverage containers are opaque colored PET. There is also a segment of PET packaging for non-food items, including kitchen, laundry, and bathroom products.

There is significant room for improvement as far as design for recycling within the PET packaging space to cut down on yield loss and improve the supply of food grade PCR. For example, even PET bottles collected through container deposit programs have yield losses[15] as high as 30 percent due to caps, labels, incompatible bottles, and errant loss of good bottles that are sorted out with the "bad" bottles. Curbside recycling programs have even higher yield losses.

Full-wrap or shrink labels and PETG are problematic for recyclers. One trade association noted that there still exists, on the market, PET water bottles with PVC labels, which are known to be extremely detrimental to recyclers. With the exception of light blue and green PET bottles, markets for color PET are very limited, particularly for opaque color and white PET bottles. Titanium dioxide is one concern in the PET bottle stream as many bottles that could be recycled are rejected because of their coloration. Dark colored and black containers may not be sorted at all at MRFs because the pigments block near infrared (NIR) sortation used to separate different resins. Design for recycling considerations are essential for capturing and recycling as much PET as possible.

Collection

Provinces and states with container deposit programs can capture specific streams of PET beverage bottles through a separate system to create bales of high-quality food grade source material, typically free of non-food and non-PET containers. Curbside collected PET is more likely to include both food and non-food containers, as well as opaque PET containers and missorted non-PET plastics.

15. Yield loss is a measure of how much of the total weight or volume of a baled material is not usable for processing to recycled resin.

The National Association of PET Container Resources (NAPCOR) estimates the 2019 regional recycling rate (US, Canada, and Mexico) for PET bottles to be 35 percent.[16] In 2019, PET bottles had the largest drop in kilograms recovered out of all the major plastic categories recovered for recycling[17]. Given disruptions from the pandemic in 2020, it is likely this trend will continue, further exacerbating the supply shortfalls for recycled content goals.

Processing

The PET recycling industry is the most mature plastic recycling segment with years of experience in producing food grade rPET. The higher rate of rPET used in food grade applications compared to other resin is directly tied to the properties of PET. As a resin, it does not absorb volatiles like olefins – these contaminants usually only infiltrate at the surface level. The recycling process also provides opportunities to remove more contaminants. PET has a melting point (230-260° C) which is significantly higher than the melting point of polyolefins. Plastic that can be processed at higher temperatures provides the opportunity for de-volatizing contaminants; desiccant and extrusion steps provide other opportunities for removal of volatiles. Additionally, as a condensation polymer, the PET recycling process also provides opportunities to restore physical properties, improving the quality of the rPET pellets produced to meet specific grades and uses. For example, to produce new PET bottles, the rPET must have an intrinsic viscosity (IV) of at least 0.8 dL/g. During the PET recycling process of "solid stating" the IV can be raised to a level compatible for bottles. PET thermoforms, typically have a lower IV than bottles, but are suitable food grade rPET feedstock because of the solid stating process. However, increasing the IV is another cost for reclaimers that already run operations with tight margins.

Probability for Circularity: PET

There are no easy solutions for achieving circularity for food grade PET. Historical demand for rPET came predominantly from the fiber market (e.g., clothing and carpet), displacing virgin resin, according to a PET industry veteran. Fiber has been the dominant North American end use for recycled PET bottles with bottles (for both food/beverage and non-food/beverage), sheet (used to make thermoforms) and film, strapping and other end markets making up the remainder of the end uses for rPET.[18] In regions with recycled content requirements for packaging, the end market segmentation varies with more rPET going back into new packaging.

Over time, technology was developed to process PET back to food grade quality and now there are competing demand pulls for a limited supply of rPET, with bottle end market share increasing year over year. At present collection levels, all interviewees in the PET space agreed that growth in food grade applications containing rPET will be hindered by a lack of supply.

Package appearance and functionality is important to brands. Similar to concerns about gels, specks or "fish eyes" in films, carbonated beverage bottles need high quality, thicker bottles to protect the taste

16. https://napcor.com/news/4970-2/
17. 2019 U.S. Post-Consumer Plastics Recycling Data Report
17. 2019 U.S. Post-Consumer Plastics Recycling Data Report

and carbonation levels of the product. PCR rPET used for these bottles must produce a bottle that is essentially virgin quality. This may slow the conversion of brands with a large portfolio of carbonated beverages. Further, yellowing of PET plastics can be the result of multiple heat cycles in the recycling process and APR notes this yellowing is exacerbated by barrier layers, like nylon,[19] and oxygen scavengers that protect bottled contents. This discoloration can be mitigated by processing adjustments, but also by the addition of pale blue resin or small amounts of virgin resin pellet, but this can increase costs. Designing bottles to reduce barrier impacts may be critical to the long-term achievement of recycled content goals. For example, one CPG noted that green or brown PET bottles won't show yellowing because of the tint of the bottle so beverages that require nylon barriers may be better suited in green or brown bottles. This would serve to provide an obvious way to segregate them from the clear stream, but other impacts to common end uses (e.g., green bottles recycled into strapping), would need to be more fully explored).

While some brands like Ice River Springs are using 100 percent PCR PET in their bottles, the average PCR content in total beverage bottles is quite low; a PET expert estimated that beverage bottles currently contain an average of about 9 percent rPET. Some CPGs are only focused on specific sizes or individual brand portfolios to incorporate more PCR use in their portfolios. Many interviewees said it is difficult to meet content goals, especially when it is not required legislatively. Legislation like CA AB793, which requires PCR use in PET CRV (Container Redemption Value) deposit bottles, will drive even small producers to use PCR in bottles in a phased timeline, 25 percent by 2025 and 50 percent by 2030[20]. One interviewee noted that brands with big California market shares may shift an entire production line to include the required percent of PCR to avoid manufacturing solely for the California market. Conversely, a small manufacturer may shift away from the California market due to the complexities of niche runs for a relatively small market share.

As more policy and legislation and brand commitments come into play to drive the use of PCR in PET bottles, there will be more pull on the supply leading up to 2030. In an already tight supply market, rPET prices will likely rise. Investments are urgently needed in collection and then processing infrastructure to increase supply of bottles to be reclaimed and converted to PCR. Conversely, other packaging or fiber manufacturing may struggle to find sufficient supply of baled bottles to meet needs.

In addition to more potential for producing food grade rPET from traditional mechanical recycling processes, there exists the potential for virgin-equivalent PCR both from the PET virgin resin producers that are developing capacity to chemically recycle post-consumer PET and startup companies deploying microwave technology. These developments also require more collection of PET with limited contamination.

Beyond beverage containers, a significant portion of food packaging market share is thermoformed packages, including berry clamshells, deli containers, and cups and other foodservice ware. Thermoform

19. https://plasticsrecycling.org/pet-guidance-table
20. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB793

PET recycling is happening in select markets. In general, all PET clamshells are aggregated and baled regardless of original use, meaning not all recycled thermoformed PET packages are food packages. However, because inputs are known and the process is designed to remove any predicted contaminants, this material can and is processed back to food grade rPET to be used in new PET food grade packages.

Thermoform recycling is still emerging in most of North America – many PET thermoform packages are lost to disposal instead of being used to produce new thermoformed PET packaging. One interviewee noted that PET thermoforms are typically more brittle, and processing generates more fines (very small pieces of plastic that are hard to capture). In addition, look-alike packaging, like clamshell containers made from PP, PS and PLA (polylactic acid), is plentiful and are problematic for PET reclaimers. Thermoform designs often include hard to recycle components like moisture pads and strong label adhesives that further degrade feedstock quality. All of these factors contribute to yield loss for recyclers. One trade association noted that the demand pull for brand commitments may be sufficient in the coming years to drive further segregated collection of PET thermoforms because bottlers and packaging converters will need this feedstock to meet growing demand.

Polyolefins (PE and PP)

As noted earlier, polyolefins are more likely to absorb chemicals from packaged product. Both polyethylene (PE) and polypropylene (PP) have significantly lower melting points than PET meaning lower temperature, but a more aggressive wash process with high vacuum to de-volatize the resin is needed/used during the recycling process to remove contaminants. Scent reduction is also critical because both odors caused both by contents and added fragrances in nHDPE typically need to be removed to use the rPE for new containers. One industry report noted that residual odor/ taste may be an issue as polyolefin recycled content increases beyond 25 percent.[21]

Many of the interviewees are using little or no food-contact rPE or rPP because of concerns about chemical or odor migration into food products. Also, because one can't solid state[22] polyolefins to improve their mechanical properties, there is limited ability to get PCR back into specific packages and containers that have specific technical or functional needs, like those used in hot filled processes.

As noted, unlike many of the companies making food grade PET PCR, which use the LONO for the equipment, LONOs for HDPE and PP processing are specific to the processor or converter. A major olefin reclaimer noted that they needed a process that was of sufficient scale to create a PCR resin that meets the needs of the market, so they created their own process. Additionally, being able to handle the streams generated by curbside collected nHDPE and PP means that the process has to be sufficiently robust to handle the inconsistencies in the container mix and other variables within nHDPE and PP bales.

21. IBWA/RRS Food grade bottle report
22. A step in PET processing that increases the chain length of the polymer, used to increase the mechanical properties of the plastic. Not applicable to polyolefin processing.

Additional challenges exist for PE film recycling, including the use of additives like calcium carbonate, tackifiers, barrier layers, and heavy inks and printing on overwraps.

Polyethylene (PE): Rigid

Source – Available to Recyclers

The available supply of plastic to make food grade recycled high-density polyethylene (rHDPE) is currently limited to only nHDPE bottles; there are no current LONOs/LNOs for colored HDPE bottles and containers like those used for personal care products and laundry detergents. The lack of food grade processing for colored HDPE bottles and containers is related to both the package itself (e.g., use of non-food safe colorants) and the wide range of products contained therein, many of which are not food safe either.

Most nHDPE bales include high percentages of milk, water, and juice bottles as a source feedstock for food grade processing, but a small percentage (estimated by one interviewee as 2-5 percent of the natural HDPE stream) contain non-food or beverage products, including acetone and nail polish remover. The use of nHDPE resin in food and beverage bottles and containers sold into the North American marketplace has been declining for a few main reasons: less dairy milk from cows being sold into market with the rise of milk-alternative beverages; a shift to dairy milk packaged in cartons and even white tinted milk jugs; and in the case of Canada, many regions buy and sell milk packaged in LDPE plastic bags/pouches.

Collection

Even with the high value of nHDPE as a recycled feedstock, dairy jugs and bottles are often excluded from bottle deposit schemes in North America, so the incentive for consumers to return and recycle these containers is lacking. Alberta, Northwest Territories, and Saskatchewan do include dairy jugs in their deposit schemes, but the small populations of these provinces only provide a small uptick in the amount of nHDPE collected for recycling. British Columbia will include dairy containers in their deposit system in February 2022.

Production

Simply put, there is not nearly enough nHDPE collected to meet the demand pull for natural HDPE PCR. One reclaimer noted they are actively importing bales from suppliers in Europe and other places to boost production.

For the companies that can make new packages with rHDPE, well-defined operating procedures are critical. With well-defined operating procedures, it is possible to run food grade and non-food grade PCR at the same facilities; understanding needs for line clearance procedure—all material removed, lines cleaned, etc.—allows a converter to switch between the two. This allows companies to take advantage of a diversified product portfolio, allowing them to be more resilient in the face of normal market ups and downs. For example, a film packaging converter may use non-food PCR in packages for lawn and garden or construction product packages. However, several CPG noted, it is generally easier to keep food grade and non-food grade package or product production separated.

Polyethylene (PE): Film

Unlike bottles, of which only a few use LDPE as the predominant resin, film packaging uses both HDPE and LDPE/LLDPE (low- or linear low-density polyethylene) resins in significant amounts. Currently, little or no PE film packaging is processed back into flexible food packaging. As noted previously, there are FDA LNOs for LDPE PCR, but no interviewees were aware of any food grade PCR originating from film being produced in Canada or the United States. Thus, packages made with LDPE or LLDPE have no current supplies for PCR resin for food grade applications. A few HDPE film food packages are using PCR, some at levels greater than 50 percent PCR, but the PCR is typically only used in middle layers to protect the technical needs of higher performance "skin" layers needed to seal a package. Food grade film packages made with PCR HDPE use resin derived from the nHDPE rigid stream, which is already severely source limited.

Polyethylene film is currently the only film or flexible packaging that is collected at scale in North America, and the majority of the film collected for recycling is LDPE or LLDPE. The path to getting a Letter of No Objection depends on understanding the source material and potential contaminants, and it is currently very difficult for film processors to build an application and mechanical recycling process to handle:

- Combination of resins (high- and low-density polyethylene, as well as other non-PE resins);
- Combination of food and non-food grade packages;
- Heavily printed overwraps, many with non-food grade inks; and
- Commercial films that may contain tackifiers or may have been fumigated in storage.

The specific challenge for PE film is that most consumer bags and overwraps, whether for food or non-food applications, are collected together in the same bins and then are often consolidated with commercial films and polybags. This is important in order to collect sufficient quantities to bale, transport and then process. Most consumer film and bags packages also look and feel very similar, making it nearly impossible to create a sorting pathway for consumers to segregate food-contact from non-food contact film packages in a consistent way. It is likely that any LONO testing, and processing would have to assume a broad range of packaging, with mix of high- and low- density polyethylene films and various inks, additives (like tackifiers in stretch wraps) and barriers present in the stream in order to create food safe PCR from recycled PE film. This would likely be costly and require robust process testing.

Additionally, the actual production of a recyclable mono-material polyethylene film package is challenging for converters due to its thinness and heat profile (i.e., the film may warp or melt while being sealed). Thus, using PCR in film is especially challenging because the thin material leaves little room for imperfections. Chemical migration and flavor concerns also exist with film packages. There is a balance between designing a recyclable package and a highly efficient, lightweight package, which may need effective barrier layers to protect the food products, rendering this package non-recyclable. Reclaimers and converters also noted that using PCR can make PE films darker in appearance, but the coloration doesn't typically impact function as long as work is done to minimize quality imperfections like gels, specks, and "fisheyes," which can impact the package's ability to protect products. As one film converter noted, "Customers want [PCR in film] and it's doable. There has been some movement away from need for pristine looking films."

Another converter noted that starting with PCR for non-food packages is a great first step for film because, "there are so many opportunities to offset the usage of virgin," noting, that it is important to figure out how to incorporate high levels of PCR into non-food film packages and retail bags first before having the same targets for food packages.

Probability for Circularity: PE (Rigid and Film)

Nearly all the PE PCR used for food-contact packaging relies on the LONO/LNO from the reclaimer making the PCR or converter making the packages and not the equipment manufacturer. Converters using the PCR to make food-contact packages or products or brands using the packages typically requests chain of custody details from suppliers to document ability to meet Health Canada and FDA requirements.

Because nHDPE is an untinted resin it can be used in many applications. Much of the current demand for PE PCR is used by non-food end uses like pipe and, in California, non-food containers in compliance with the Rigid Plastic Packaging Container law.[23] Both of these uses create significant demand for nHDPE PCR, which has kept the prices of this resin well above rPET and virgin HDPE prices for years. This price premium and challenges associated with resin processing back to food grade means that little rHDPE is being used in food and beverage containers and packaging currently. The existing examples of products containing food grade rHDPE include films like cereal box liners and candy wrappers and yogurt drink and supplement powder containers. Many interviewees did note that they are not using food grade PCR in their HDPE direct food-contact packaging at commercial scale, but are using it in secondary packaging, including retail bags and outer packaging for food items, which have less stringent LONO conditions.

Polypropylene (PP): Rigid

Source – Available to Recyclers

The current source of post-consumer polypropylene (PP) for food grade PCR is tubs, lids, containers, often used to package dairy products like yogurt and cottage cheese, and bottles. Converters noted that PP typically has less issue with "consumer abuse" than other packages like milk jugs or bottles because

23. https://www.calrecycle.ca.gov/plastics/rppc

things like yogurt containers are less likely to be used by consumers for non-intended uses, such as to hold chemicals, and then be recycled.

Conversely, polypropylene (PP) containers typically are heavily printed and have more additives like plasticizers to improve the overall qualities of the bottle or container. PP does melt and dry at slightly higher temperatures than PE, and these higher temps do help with some volatile and semi-volatile removal, but additives like plasticizers don't devolatilize at the melt temperatures. Additionally, while not typical of tubs, PP bottles may be multilayer with some sort of barrier that increases the rPP processing burden. Thus, most of the total PP reclamation capacity is for non-food grade PCR; with much of the PP PCR going into packaging for non-food items like personal care products.

Collection

One particular challenge for PP is current MRF sortation practices. The material is either sorted into a single stream of combined food-contact and non-food containers, or into "mixed plastic" streams wherein containers of many types of resins are combined into a baled commodity. This exacerbates the chain of custody challenge of understanding where containers destined for food grade processing have been and what contaminant exposures they may receive in sorting and transit. An equipment manufacturer noted, "The challenges [with processing PP] are getting it back in sufficient supply and having to do a lot of processing to get [contaminants] out with the varied set of packaging found in the bales."

Understanding and managing sources of bales destined for both food grade and non-food grade processing is critical as most post-consumer PP bales are sourced from similar facilities that may have different methods for collecting PP and have little understanding for the need to protect food grade containers from cross-contamination, nor the volumes or technology available to make this separation practical at this time.

Production

PP PCR production technologies and capacity are still emerging, especially for food grade recycled polypropylene (rPP). Today there are only a handful of PP recyclers in North America, and there is more demand for even non-food grade PP PCR than the capacity to produce. Many reclaimers can process both food grade and non-food grade bales on different lines within a single facility to diversify what pellets they can produce. Interviewed reclaimers noted that installing new processing lines won't create more supply of finished PCR until more inbound tubs and containers are available for recycling – this includes both more PP collection by material recovery facilities and more sortation to create segregated PP bales by those facilities that may already collect PP. One CPG noted, "there is lot of conjecture right now that we can get enough material to meet the demand for PP PCR use."

Ideally packages with recycled content would be able to move through the recycling system again, but there are concerns about PCR use impacting finished color of packages—darker colors are often harder for near-infrared technologies to sort properly. There is a fine balance between PCR use and being able to capture and recycle a specific container again.

Probability for Circularity: PP

Currently, all PP sells for the same price, but it's unknown if the demand pull for food grade PCR will support a price premium in the future. Because of the aforementioned processing factors, some interviewees weren't sure that high levels (like 50 percent) of PP PCR is doable with mechanical recycling processes. Thus, advances in chemical processes are likely needed to be able to incorporate high percentage of PCR PP in any packaging. For example, chemical recycling can remove things like plasticizers, copolymers, and non-food product contaminants, The scaling up of chemical processing of PP is expected to happen by 2025 and will likely be needed to meet the needs for food grade PCR. But this supply of food grade PP may come at significant cost to end users. As with the other resins, increased collection of high-quality material is needed to meeting growing capacity and demand for rPP, regardless of recycling process.

Discussion: Barriers & Solutions

All of the sixteen interviewees, representing companies throughout the plastic recycling value chain and doing business in Canada and the U.S. conveyed a need for systemic change in both Canada and the U.S. for more plastic to be re-circulated in the economy. Given the ratio of generation and reclamation capacity in the U.S. compared to Canada, the state of play of plastic production and recovery in the U.S. greatly impacts the barriers and solutions for Canada reaching specific goals for plastic management. The two countries are highly integrated regarding purchase, use, and recovery of plastic products.

The lack of supply of suitable feedstock to process into food grade PCR was noted as the biggest challenge across the list of interviewees.

As part of the interview process, Stina asked all interviewees what they see as the biggest barrier(s) to using more PCR in food grade applications. All interviewees expressed concern about the lack of supply of suitable sources of feedstock with some focusing upstream on generating better supply through design for recycling and phasing out unnecessary contaminants and others focusing on collecting more of what is currently produced.

Barriers

All the barriers brought forward by interviewees fell within the following three major areas:

- **LIMITED SOURCE OF FOOD GRADE SUITABLE PLASTIC:**
    - Sources of PCR that are most able to displace virgin are declining because A) not enough recyclables are being collected to create the supply of PCR and B) fewer products and packages that are suitable for food grade PCR (e.g., natural HDPE bottles) are being produced for market. At the same time, the supply of film packaging with the greatest barriers to becoming food grade PCR is growing, often displacing rigid packaging that is more readily recyclable but has a heavier lifecycle impact.
    - The high number of potential contaminants (e.g., chemicals) in the marketplace either contained in plastic packaging or in the packaged product, pose risks to recyclers, converters, and CPGs. Instead of taking on liability for creating or sourcing contaminant-free recycled plastic, using of virgin plastic is often more attractive.
- **LACK OF RECYCLED CONTENT VERIFICATION REQUIREMENTS (Legislated or Industry-driven):**
    - Today there are products on the market that claim use of PCR but actually contain post-industrial resin or off specification virgin resin. Recognized and accepted standards to verify recycled content allow those companies using PCR to realize their competitive advantage and/or gain recognition for using post-consumer feedstocks that reduces waste and conserves resources by recirculating consumed items.
    - Greater transparency of environmental claims reduces false claims and drives greater market efficiency.
- **LACK OF ECONOMIC DRIVERS:**
    - All of these barriers are interconnected but beyond the production and verification standards, there are other economic drivers impacting use of PCR. Environmental benefits of using PCR are overshadowed by the economic drivers of a linear economy including low-cost disposal, low-cost virgin resin prices, and little accountability for producing a product that is problematic for recyclers or making a false claim about recycled content or recyclability. Policies in Canada and the U.S. do not yet valorize products with the lowest environmental impact. It is often cheaper to dispose than to recycle or use virgin instead of PCR. Known toxins such as polyfluoroalkyl substances (PFAS) are commonplace and used in food grade applications as well as cosmetics but are unwelcome to those trying to purify recycled plastic for potential use in food grade applications.

System Changes Needed

A circular system is more complex than a linear "take, make, waste" system because circularity requires feedback between the interconnected players in the value chain. Reclaimers are impacted by what CPGs put in the marketplace, and CPGs are dependent on reclaimers to process their products and packages back into high quality feedstock so that converters can produce new packages that CPGs use for their products. Currently there is more plastic waste produced that poses contamination risks than readily recyclable products suitable for food grade applications.[24] This is a foundational barrier to circularity, or for plastics to be re-circulated in the economy.

Disincentives for Waste/Incentives for Recovery

Interviewees emphasized different barriers for use of PCR in food grade applications relative to their organization's position in the value chain, but everyone spoke of the need to overcome economic barriers to incorporating significant levels of food grade PCR in packaging. There is a need to decouple the price of recycled resins from that of virgin resins. One converter noted that they have had many conversations with brands about use of PCR in packages, but the buyers often balk at the price differential and are unable to commit to significant purchases. If they are already price-sensitive for non-food applications, use of food grade PCR is even more cost prohibitive since it costs more to process plastic to food grade quality. Mandates for the use of minimum content in plastic products, like those in place in California and proposed elsewhere, can achieve this decoupling by requiring that certain manufacturers use post-consumer resin in specific containers and packages regardless of the cost of virgin. One interviewee noted, "policy that levels the playing field defrays the cost of the [processing] technology." Such policies for non-food packages also consume the supply of food grade PCR as most companies prefer near virgin quality resin for consistency and lack of potential residual odor. However, without more focus on better collection, the limited supply may drive up prices if market demand continues to grow.

Lastly, as noted previously, interviewees acknowledged that container deposit programs can support the goal of collecting more beverage bottles by providing clear incentives for consumers to recycle food safe packages that are then suitable to make food grade PCR.

Increase PCR Usage in Non-food Grade Applications

Many interviewees were cautious about mandating high levels of PCR for a wide range of food grade packages and emphasized the opportunity to increase recycled content in non-food grade applications. But some interviewees noted that without setting high targets there could be a failure to stimulate transformative change and push innovation and design needed to achieve circularity and the reduction of waste. One interviewee stated food safety is not counter to legislation [that requires PCR]. But another cautioned that forcing an unrealistic target can create uncertainty in the market and without significant funding for enforcement, compliance is not guaranteed and must be enforced. Interviewees with experience meeting compliance standards indicated that unenforced government mandates can result in companies finding loopholes more attractive than compliance because compliance often comes with increased cost.

24. In addition to insight through conducting the Annual Plastic Recycling Study, tracking the state of play for plastic recycling for more than 15 years, review of waste composition studies and information from resin producers, estimates are based on Stina Inc's institutional knowledge of production, consumption, and recovery of major categories.

Converters and CPGs explained that the food product typically dictates the package needed and, in many ways, how that package is designed. For example, it would be counter to the larger sustainability needs of reducing food waste to have a package that was unable to meet shelf life needs because of a shift to higher PCR content. One solution put forth by interviewees is a focus on incorporating more PCR in secondary food packaging first allows the ability to work toward innovations that could lead to more PCR use in primary contact packages. Another point to note from interviews was that it would be better to require smaller percentages of PCR in more product categories with expected increases over time rather than require a high percentage in applications that might push the design limits.

It was also noted by interviewees that some packages may simply be overengineered. Trash bags are an example of a product that could contain more PCR. Trash bags are destined for the landfill, but conversations with large producers of trash bags indicate most bags on the market contain little or no PCR. The reason often provided is that ultrathin, strong bags with a drawstring are difficult to make using PCR. There are companies producing trash bags with more than 70 percent PCR, but they are the exception and not the rule. Increasing the use of PCR in something as common as trash bags, even at low percentages, could have significant impacts on offsetting the use of virgin plastics.

Key Question: *There are always tradeoffs in moving toward circularity so when innovators are designing for circularity what is most important: recycled content, design for recyclability, lowest overall environmental impact, etc.?*

Clarity on Design Goals

In addition to feedback between producers and reclaimers, the transition to circularity requires resolutions between often conflicting objectives of design and innovation. For example, CPG innovations for the lightest package to reduce carbon footprint often leads to challenges for reclaimers—thinner packages like light-weighted bottles and films can create challenges in collection, sorting, and reclamation. Also, many companies have sustainability goals that include achieving recyclability or compostability by 2025 or 2030. These goals may overshadow the drive to use more PCR in the short-term.

Without clear direction on the most desirable attributes in packaging there is a barrier to the innovation needed to achieve circularity according to all those interviewed. Consumers have little insight regarding the environmental impact of products and their packaging. There is little cache currently for recycled content; mainstream consumers are not generally willing to pay more for products with recycled content according to interviewees from major CPGs. With more transparency about environmental impacts there may be a shift from the current focus on package appearances. If the product is safe for consumers, the market may become more tolerant of imperfect appearances such as gels and different package colors. There may even be appreciation for indicators of recycled content, like gray bags or color variations, as noted by several interviewees in the converter space. Currently imperfections suggest risk of product failure or contamination.

All but one interviewee expressed that a practical approach to reducing plastic waste is to push higher percentages of recycled content in non-food grade applications because there are fewer barriers to using PCR, but such an approach should be part of a transition plan and not the end game. Putting PCR in non-food grade applications still leaves the question of what will happen to those products that are not readily recyclable but contain PCR (e.g., clothing or construction materials)? Also, with plastic recycling there is a point at which the plastic is too degraded or contaminated for further viable use. Several interviewees discussed the need for policy that creates better on ramps for circularity and off ramps for the legacy chemicals. Sometimes to compensate for riskier material in applications, converters may use more plastic as a barrier and that does not actually contribute environmental benefit because now a heavier package is in use.

Interviewees noted the need for more transparency to drive a more efficient marketplace, but it is important to note that with more transparency comes further aversion to risk in assuming liability for removing known toxins (e.g., PFAS). A recent study shows that more than half of cosmetic products sold in Canada and the U.S. have high levels of "forever chemicals," or fluorine-based toxins. Several companies that also do business in the European market noted the degree of risk with toxins is less in Europe because there are fewer toxins in the marketplace due to significant regulatory enforcement.

Regulatory compliance requires that standards and verification be clearly defined. Much has yet to be defined regarding verification of post-consumer recycled content (i.e., what role will mass balance account play). There is a need for innovation in traceability and reporting. Such innovation requires significant investment. Several interviewees noted the potential within emerging technologies for sorting plastics and digital watermarking of packaging that will allow improved recovery of feedstocks that meet the specifications and requirements of downstream processors. Infrastructure investments will also be needed to incorporate such technology. Development of secondary sorting facilities would enable the aggregate of lower-volume materials to achieve the critical mass necessary for sorting by material type and provide a pathway for adding more materials to municipal collection programs. Increased supply of sorted plastics will also require increases to traditional mechanical recycling capacity as all noted they would expand operations if there was more supply.

Key Question: *Which entities should provide the guiding principle for the most sustainable design for circularity?*

The Association of Plastic Recyclers provides the APR Design® Guide with recyclability guidance. The Canadian and U.S. Plastic Pacts are defining a list of plastic packaging that is to be designated as problematic or unnecessary. Many of the interviewees are engaged in the Pacts and noted that there are packages that by design are challenging, as well as non-food safe additives, and the actual products contained in the packaging that pose significant barriers to reclamation of post-consumer plastic to food grade PCR. Clear feedback with financial drivers for CPGs to design for recycling are not yet common. Provinces and states with fees on packages that adjust based on their environmental impact or impact on the recycling system are limited. With greater accountability and transparency in the marketplace as far as the relative cost of a product that enters the market and contributes to the barriers in circularity or contributes valuable feedstock, there will be greater incentive to design for circularity.

Key Questions: *Is it possible to reduce the use of unnecessary toxic materials in the marketplace and increase the potential source of safe feedstock for food grade PCR? Who is responsible for handling legacy products that carry known toxins?*

Requiring high levels of PCR in food grade applications is essentially calling into question how to avoid toxins in our packaging and products. While more difficult to use PCR in food-contact applications, one interviewee noted that if it is required then industry will have to work out the challenges and will drive more meaningful change towards circularity. This also raises the question of what role chemical recycling will play in the transition to circularity. Even the interviewees within the mechanical recycling space acknowledged the need for chemical recycling to deal with the contamination challenges to safely get more plastic back into the marketplace. Given the amount of potentially problematic feedstock on the market for reclaimers to reprocess into food grade PCR, there is a need to A) increase the supply of food safe products entering the market and B) determine how to deal with what is in the marketplace that poses a risk. With the potential for digital watermarking, there becomes the possibility of recyclers sorting out what is not food safe and the implementation of variable fees to producers based on the cost their product carries in the recycling marketplace. After a product can no longer contribute value to the recycling stream some noted they should be used for fuel or be chemically recycled.

All parts of the system, from Health Canada down to recyclers, are risk averse with regards to food-contact applications and this does limit the amount of post-consumer plastics that is reprocessed into food grade PCR. Unfortunately, the interview process also shed light on the fact that post-industrial scrap does not necessarily provide a safe stream of feedstock for PCR. For example, the reason the scrap failed to enter the market could relate to a mishap in formulation that might carry its own risk for food grade use.

Key Question: *What role will chemical recycling play in the production of food grade PCR?*

Conversion technology allows a portion of the waste stream to be purged into other products of value (e.g., methanol) or energy but it also comes with its own environmental and environmental justice considerations given the locations of facilities and the communities impacted by the petrochemical industry. Some chemical recycling pathways, such as pyrolysis of polyolefins to produce naphtha, require downstream processing at large refineries or petrochemical facilities where the PCR content would be a "drop in a bucket" relative to the scale of production. Mass balance accounting, with adequate standards and verification, allows for the production of virgin-equivalent resin with meaningful PCR content by assigning the molecules from post-consumer sources, which are indistinguishable from virgin feedstock sources to a specific, smaller lot of material.

One interviewee stated, "Infrastructure to produce raw materials will be around for decades and chemical recycling may be ripe to integrate directly into virgin resin. Chemical recycling technology distills out and purifies in a way that mechanical recycling can't. But chemical recycling will work best as a compliment and not a competition to an optimized mechanical recycling infrastructure."

Conclusion

While there are pathways to make gains in the supply and use of PCR in food-contact applications, much more effort and investment, from across the value chain, will be required to support the Government of Canada's target of 50 percent PCR content by 2030. Given that reclaimers stated they would expand capacity if there was more supply of recyclables, the focus should be on supporting production of products that are suitable for food contact and getting that material collected.

While there is growth in PET bottle production, a good source for food contact PCR, generation of natural HDPE bottles is declining. However, use of PE film and flexibles, currently a challenging application in terms of collection, recyclability, and to produce suitable food grade PCR, is increasing. But, thin plastic film can reduce greenhouse emissions through reduction of food waste through extended shelf life in a highly globalized food network.

There is a need for a holistic, systems-based approach to more recovery and reduction of environmental impact from plastics. Throughout the process, care must also be taken not to achieve the target and the associated environmental benefits at the expense of other unintended consequences that may come at a greater environmental cost.

Interviewees conveyed increased focus within their companies on working toward improved environmental performance. Use of PCR within food safety guidelines is a critical step in the journey toward circularity and improved environmental performance of packages and products.

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