PLASTIC INGENUITY

Thermoform Circularity Report

2023

REPORT CONTENTS

Letter from Dan Kuehn — President / CEO

Welcome to Plastic Ingenuity's second-annual Thermoform Circularity Report.

Three months before Covid school closures began, I was invited to present to my daughter's second grade class about what I do for a living at a plastic manufacturing company. I opened the discussion by asking the students to raise their hands if they thought "plastic was bad." Sadly - but unsurprisingly - all but one student raised their hands. Sadly – but surprisingly – the one student who did not raise their hand was NOT my daughter; my daughter raised her hand with the rest of the young plastic skeptics. (The one enlightened hand belonged to the son of an engineer at a bioplastic / biofuels development firm.)

I was confronted with the reality that I, like the plastic industry in general, had done a very poor job explaining the benefits of plastic and the indispensable role it plays in the modern economy. Most people don't consider how the convenience, safety, and affordability of the products they use daily are made possible by plastic, nor do they consider the environmental benefits plastic provides in terms of reduced greenhouse gas (GHG) emissions. This circularity report seeks to help restore a balance to the narrative about plastic in the niche corner of plastic thermoforming.

As you will see in the report, we have continued to build on the success of our prior sustainability activities with a focus on the topics most important to our customers. Furthermore, we continue to add resources to our organization to drive PI's technological understanding and know-how to help further the sustainability goals of our customers and our customers' customers.

We have many things to celebrate in 2022, such as the addition of Omid Nabinejad, a Ph.D. in polymer science, to the PI team. Over the past 12 months, Omid has brought his scientific expertise and R&D acumen to bear on material-related customer projects and PI-led material development.
2022 was also the first full year of operation for our Tooele, UT manufacturing facility, which extrudes and thermoforms PET exclusively, with an emphasis on running parts with high concentrations of post-consumer recycled PET.

From a customer perspective, we were honored in 2022 to receive the Innovation Supplier of the Year award from Sargento for our work in obtaining Critical Guidance recognition through APR and other recycling collaborations with this important customer. We were also a finalist in the SPC Responsible Sourcing Awards for a laminated PCR tray and, separately, PI circularity services won gold in the Sustainable Medicines Packaging Awards.

In 2023, we will continue our engagement through customer collaborations and with industry organizations. We are proud members of The Recycling Partnership (TRP) and are funding partners of two TRP subgroups: the Polypropylene Recycling Coalition and the newly established PET Recycling Coalition. We are particularly excited to see the progress the PET Recycling Coalition will make for PET thermoform recycling, which is poised to greatly expand over the coming years. We remain active and hold leadership roles in organizations such as National Association for PET Container Resources (NAPCOR), Association of Plastics Recyclers (APR), Foodservice Packaging Institute (FPI), Plastics, and the Healthcare Plastics Recycling Council (HPRC).

We will continue to develop the necessary tools to help our customers make the right decisions to meet their sustainability-related goals. Over the course of the next year, we will begin cataloging and measuring the carbon emissions of our business, with the eventual goal of reducing our emissions per unit of product produced. We will also work towards achieving International Sustainability & Carbon Certification (ISCC+) certification in preparation for deploying a mass-balance approach when using post-consumer materials derived from enhanced recycled technologies such as depolymerization. The investments and advancements being made in enhanced recycling are emerging as the new frontier of plastic technology. We are watching these developments closely and engaging where we can add value for our customers.

Overall, the investments of time, money, and resources we are making – along with similar investments made by others in the industry – leaves me exceedingly optimistic that we will get past the obstacles to establishing a truly circular plastic economy and will continue to reduce GHG emissions. Despite the prevailing anti-plastic narrative, I believe the consistent presentation and explanation of the science and realities describing the benefits of plastic will ultimately convince a skeptical public of the virtues of using plastic in many, if not most, applications.

At the very least, I expect better results when canvassing my daughter's fifth grade class later this year. Thanks in part to recent dinner conversations, I'm confident at least two hands will stay down when I ask the same question I posed almost three years ago. A turning tide needs to start somewhere.

Sincerely,

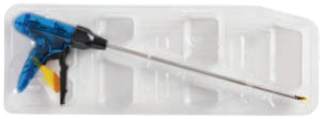
Dan Kuehn

About Plastic Ingenuity.

With seven strategic locations, Plastic Ingenuity is one of the largest custom thermoformers in North America. Our experience, reach, and genuine dedication to our customers allows us to bring your packaging vision to life, scale your product, and create a partnership that lasts beyond your product's lifecycle.

CROSS-INDUSTRY EXPERIENCE, INDIVIDUALIZED EXPERTISE

Food



Healthcare

Consumer Goods

7
LOCATIONS

850+
EMPLOYEES

13.4%
5Y CORPORATE CAGR

7 STRATEGIC LOCATIONS

- HQ: Cross Plains, Wisconsin
- Mazomanie, Wisconsin
- Tooele, Utah
- Maumelle, Arkansas
- Oxford, North Carolina
- Monterrey, Mexico
- Guadalupe, Mexico

It starts with our team.

It all starts with our people. At Plastic Ingenuity, our success is defined by those that have created a labor of love. What is important to our team, becomes the core focus of our company. Through a sense of ownership impacted by profit-sharing, to an employee tenure that has delivered a lifetime of experience to our customers, to the impact our team has had on our communities, Plastic Ingenuity remains great, because our team is great.

28 YEARS average tenure of PI design engineers

50 YEARS of service to our customers since our inception in 1972

42% of profits bonused back to employees

"I feel the pride in the parts I make each day. I give my all, because I know that my success will be directly rewarded."

We are all in this together and actually mean it. That's why for the last 50 years, Plastic Ingenuity has given back a 42% discretionary profit-sharing bonus twice a year to the entire team. From interns, to cleaning crew, to production, to accounting – if you're on the PI team, you're sharing in the success of the company. Aligning compensation with both individual and company performance has created a mutual sense of ownership as we deliver our very best to our customers.

2022 award-winning innovations and circularity services.

At Plastic Ingenuity, creating award-winning innovations and services for our customers is ingrained in our DNA. And throughout the years, it has paid off. Take a look at the awards and accolades PI has earned specific to our sustainability efforts.

SARGENTO

INNOVATION

PARTNER OF THE YEAR

CRITICAL GUIDANCE

RECOGNITION

X2 INNOVATIONS

Received Critical Guidance Recognition from APR for two PP structures with oxygen barrier properties.

FINALISTS

Finalist 2022 — Sustainable Medicines Packaging AWARDS

DESIGN AWARD

INNOVATOR — AWARDS

RESPONSIBLE SOURCING

CASE STUDY

Incorporating 80% PCR into Legacy Food Tray

THE RESULTS

7%
reduction in material usage

30
cars removed from the road

6319
trees planted

THE CHALLENGE

Creminelli Fine Meats, a crafter of ready-to-eat charcuterie, turned to Plastic Ingenuity for a sustainability assessment of their packaging. Creminelli strives for a packaging that reflects the values of their organization. Enhancing the sustainability of the thermoformed tray was seen as an opportunity for improvement, and a potential differentiator for consumers.

THE PROCESS

PI conducted a sustainability assessment. The process started with a thorough review to discover optimization opportunities. Design attributes were compared to the APR design guide to determine the impact on recyclability. A determination of recycling was made and options for improving the design for recovery were proposed. A sustainability improvement road map was created. Trials and testing were conducted to ensure performance.

THE SOLUTION

PI engineering determined the trays could be down-gauged to reduce material usage without compromising performance. Tray footprints were maintained to minimize disruptions to the packaging processes.

Comparing the tray structure to the APR design guide revealed the structure contains a barrier film that renders the package non-recyclable. The barrier film is an integral component to provide food preservation properties. Reducing shelf-life by eliminating barrier properties is not an acceptable trade-off. Preserving the food was top priority.

PI proposed the use of post-consumer recycled content in the tray to improve the circularity of the package and reduce inherent greenhouse gas emissions. 80% PCR was selected for implementation.

THE IMPACT

1.23 recycled water bottles per unit

11,284,180

recycled water bottles used annually

Community Impact

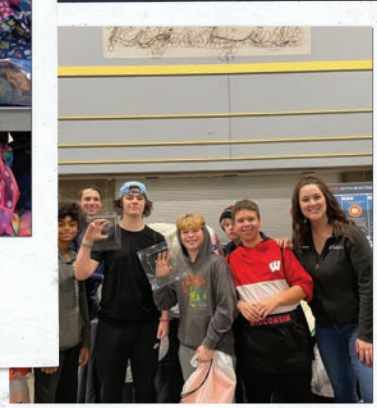
Loop the L
Clean th

WI Latino Chamber of Commerce Sponsorship

The Student Packaging Association of University of Wisconsin-Stout sponsorship

The Student Packaging Association of University of WI-Stout collaboration

Back Pack Buddies Program



Future Quest for MMSD

The PI team wears pink for breast cancer awareness month

Summertime means intern time! We love teaching and learning with our interns

The annual PI whiffle ball tournament

Celebrating employee anniversaries from 15 to 35 years of service

Safety first! The PI Team sharpens their fire extinguisher skills

The annual PI picnic is a favorite memory for most

The products we deliver and the experience we have gained is equally important as giving back to the community in which we serve. Through community events, mentorship opportunities, and peer-driven moments, we believe what's important to our team and those in our area, is important to us.

A look at the last 50 years of Plastic Ingenuity history.

From our start in 1972 with just 5 employees, Plastic Ingenuity has grown into one of the largest thermoformers in the nation. In 2022, we celebrated our 50-year anniversary achieved through the resiliency, innovation and team expertise only earned by a lifetime of practice. In staying true to our mission statement, conservation has been a part of that since day one. It wasn't always easy, but it was always better... together.

1972

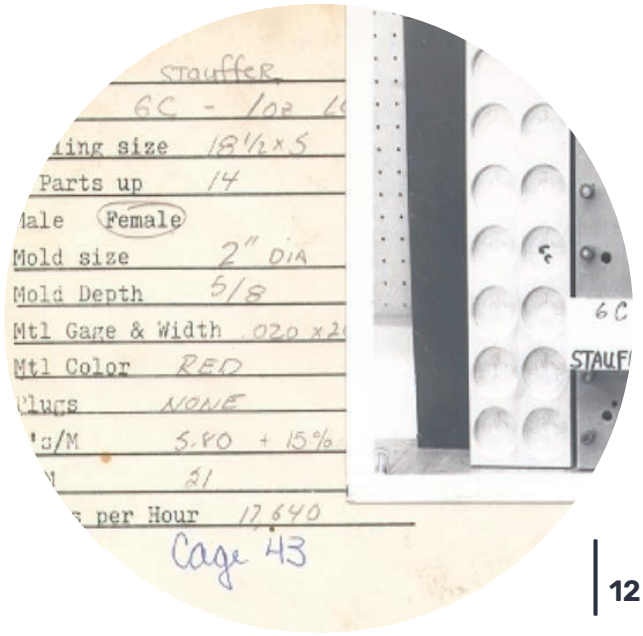
WHERE IT ALL BEGAN

Joe Kuehn borrows $50K to start Plastic Ingenuity in a 1,300 sq. ft. Madison, Wisconsin garage.

1973

FINALLY, A BREAK

While facing a grim outlook, Plastic Ingenuity landed a big break. PI was challenged to deliver parts to Stauffer Cheese under a tight deadline. Well, needless to say - PI delivered.



1975

HEADQUARTERS

With some family and community help, PI expanded into Cross Plains, Wisconsin, which to this day, remains the current corporate headquarters.

1976

ALL UNDER ONE ROOF

Now up to 50 employees, in-house extrusion begins.

1987

LET'S PLAY PICTIONARY

Pictionary is HUGE. And when you make the parts that keep all the components in place, it becomes a very busy time.

1990

WE'RE EXPANDING

PI purchased a 50,000 sq. ft. facility in Oxford, North Carolina.

1992

EXPANDING AGAIN

PI built a 50,000 sq. ft. facility in Maumelle, Arkansas featuring inline thermoforming technology.

1992

REDUCING WATER CONSUMPTION

Plastic Ingenuity installed a closed loop cooling system for our thermoforming machines to reduce water consumption by over 250,000 gallons per month.

1993

PAVING THE WAY

The PI Electrical Engineers develop proprietary, first-of-its-kind, source code to enable real-time control of our thermoforming machines

1996

ALL FROM SCRATCH

When we say custom, we mean it. In 1996, Plastic Ingenuity built their first, entirely from scratch thermoformer.

2006

HEAT RECOVERY

We installed a system that recovers wasted heat from our operations. This heat is then pumped into the warehouse to help heat during the winter months. This avoids sending over 81 metric tons of Greenhouse Gas (GHG) into the atmosphere per year.

2007

RAIN GARDENS

PI's HQ in Cross Plains, WI borders the Black Earth creek, a world class trout stream. To protect this ecosystem, we developed 5 rain gardens that reduce storm water run-off.

2007

A SOLAR FUTURE

PI installed solar panels that generate over 13,000 kWh of energy per year, removing nearly 19,000 lbs. of GHG per year.

2018

THE GREAT FLOOD

Through PI resiliency, the team powered through the great Cross Plains flood as 15 1/3" of rain poured down within 24 hours. Even with the flood, all orders remained on time.

2019

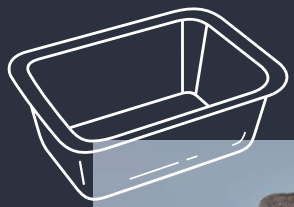
SAVING ENERGY

We installed energy-efficient lights and occupancy sensors throughout our facilities. This reduced our energy consumption in lighting by 66%.

"This effort is only the beginning."

PLASTIC INGENUITY INITIATIVES

Sustainability Initiatives at PI



The thermoformed products we create at Plastic Ingenuity touch millions of lives daily, from playing an essential role in preserving the food we serve our families to protecting the medical devices and medicines trusted to save lives. Given their lightweight nature and relatively low energy use to produce and transport, plastic packaging has lower greenhouse gas emissions per package than alternatives. When you factor in preservation attributes, such as extending the useful life of perishable foods, thermoformed packaging offers significant benefits to society.

Circular and sustainable thermoforming is our mission. We must improve end-of-life outcomes for thermoforms. We need solutions that keep thermoforms out of landfills and our environment so we can continue to reap their benefits. In the spirit of this mission, we further developed our circularity and sustainability capabilities in 2022. The following section highlights key progress made in these areas.

Circular and sustainable thermoforming is our mission. We must improve end-of-life outcomes for thermoforms.

Sustainable Packaging Stakeholder Study

In 2021, PI set forth to better understand the needs and driving forces of key stakeholders leading the march towards circularity. We conducted live listening sessions with sustainability and packaging experts from CPGs, retailers, and healthcare organizations. Participating stakeholders included packaging engineers, sourcing and procurement professionals, operations managers, marketing experts, and sustainability leaders. The results of this study were insightful and formed the foundation of our circularity strategy.

We renewed this effort in 2022 to track stakeholder progress and further explore areas in need of more study. This included a focus on the sustainability priorities of healthcare companies, such as medical device manufacturers, pharmaceutical companies, and life sciences. The results and discussion of this study can be found on pages 21-37. We plan to continue these discussions in 2023 and beyond.

Sustainability Initiatives at PI

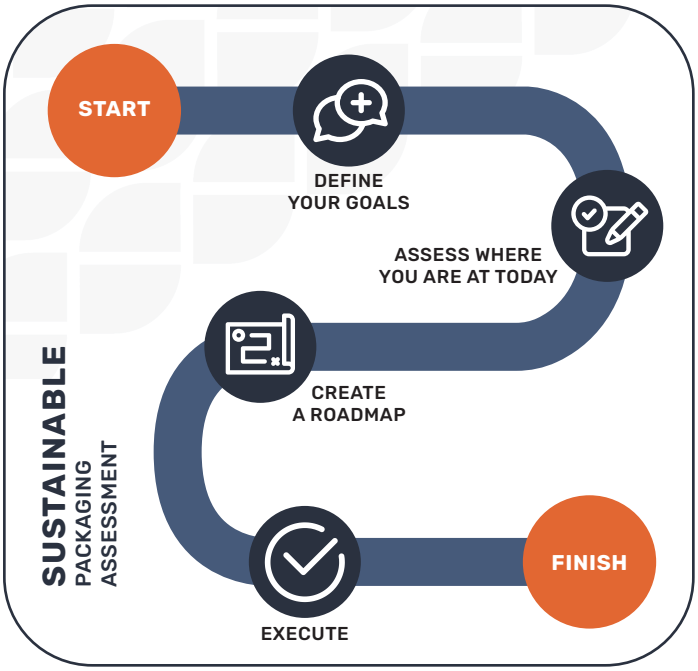
Circularity Services

Developing and refining PI's circularity services was an area of emphasis in 2022. The impact of these services can be seen within various sections of this report, including Case Studies, Customer Stories and Awards & Recognition.

A Sustainable Packaging Assessment is the main service we provide to enhance the circularity of any packaging. This collaborative process is initiated with a cross-functional discussion between PI and the customer to capture key sustainability and circularity objectives of the organization and identify a specific opportunity for further exploration. We then create a Sustainable Packaging Assessment including design and material choices, analyzing the impact different options have on the environment. Next, we create a roadmap of the packaging's current state, its desired state, and all the steps in between. This plan creates a clear path with specific actions to result in a more sustainable package. We control the entire process from design to delivery, allowing us to achieve shared goals.

Additional services PI offers customers include recyclability assessments, take-back programs, and life cycle assessments. Through innovation, education, and influence, we work with our customers to reach their internal circularity goals, offering a range of tailored services.

This will enable us to offer materials derived from advanced recycling techniques to our customers. We expect to be certified by the end of the first quarter in 2023.



Post-Consumer Recycled Materials

The demand for the use of post-consumer recycled material in packaging is accelerating, fueled by brand circularity commitments and legislative mandates. The benefits of PCR are numerous and enormous. Introducing PCR into packaging keeps valuable material out of our landfills so it can recirculate in our economy.

PI launched a strategic initiative in 2022 to strengthen our ability to meet accelerating PCR demand. We meticulously vetted PCR PET reclaimers, both from a technical and business operations perspective. Select reclaimers were chosen for qualification trials on our extrusion and thermoforming equipment. Thorough quality testing was completed to ensure performance and cosmetic requirements could be met before adding these new sources to our PCR portfolio. In tandem with these trials, significant investments were made in PI's processing equipment to enable the efficient extrusion of these PCR materials at the purity levels necessary for food-grade packaging.

This effort is only the beginning. We will continue to expand our portfolio of PCR to meet the progressive circularity needs of our customers. This will include further development of PCR from recycled thermoforms, known as Thermoform Clean Wash Flake.

Sustainability Initiatives at PI

Advanced Recycled Materials – ISCC PLUS Certification

Recycled materials from advanced recycling techniques are expected to grow significantly in scale in the coming years. Advanced recycling is a suite of novel recycling techniques intended to complement mechanical recycling by focusing on hard to recycle materials. These techniques break the polymer down to a precursor and/or purify out impurities like colorants and additives.

Many of these advanced recycling techniques involve mixing the recycled inputs with traditional inputs derived from fossil fuels. It becomes nearly impossible to trace the exact recycled molecules to the end products. However, a chain of custody mass-balance system can track the recycled inputs and outputs used to create a product.

ISCC PLUS is a third-party certification standard for mass balance systems. PI initiated the ISCC PLUS certification process in the fourth quarter of 2022 for our Mazomanie, WI and Cross Plains, WI facilities. This will enable us to offer materials derived from advanced recycling techniques to our customers. We expect to be certified by the end of the first quarter in 2023.

Sustainable Design Integration

Designing truly recyclable packaging is difficult and we must not forget that the primary job of a package is to preserve and protect its contents. The Association of Plastics Recyclers (APR) design guide can help simplify the process for packaging creators. The design guide identifies features deemed preferable or detrimental to recycling through the collective knowledge of their recycler membership base and years of testing new innovations.

We sought to ingrain these principles into our design and development process at PI. Recycling experts from APR visited PI's Cross Plains headquarters in March of 2022 to provide hands-on design guide training for our design engineers, tool designers, commercial, marketing, and client support teams. The learnings were then institutionalized by incorporating them into our design procedures.

Carbon Accounting

We believe climate change is the largest threat facing the planet. We also believe a thriving future for humanity is possible if we all do our part and commit to immediate action. Plastics will play a vital role in these efforts given their well-established carbon footprint benefits compared to alternatives. As a responsible plastic packaging provider, we are committed to minimizing the carbon footprint of our operations and products. We are proactively launching a strategic initiative to quantify our Scope 1, 2, and 3 emissions.

> **"Designing truly recyclable packaging is difficult."**

Packaging Sustainability Stakeholder Study

> **"Sustainability is ensuring our resources are sustained for current and future generations."**

Transitioning to a more circular packaging economy will require intense collaboration at all levels of the value chain. Upstream packaging innovation and downstream system interventions are critical to unlocking circular outcomes for plastic packaging. Though daunting, progress is achievable if stakeholders approach this challenge with a common understanding and an aligned objective.

In 2021, PI set forth a mission to better understand the needs and driving forces of key stakeholders leading the way to packaging circularity. Insights from these sessions informed our strategic efforts for 2022, as we aligned our sustainability services and capabilities with the identified needs of these stakeholders. The launch of our Sustainable Packaging Assessment Process, detailed on page 19 of this report, is an example of how these learnings were integrated into our business.

The packaging sustainability stakeholder study continued in full force during 2022. We conducted live listening sessions with sustainability and packaging experts from consumer packaged goods (CPGs), retailers, and healthcare organizations. Participating stakeholders included packaging engineers, sourcing and procurement professionals, operations managers, marketing experts, and sustainability leaders.

We asked stakeholders to define their goals, describe the drivers of those goals, and provide specifics on packaging tactics to achieve those goals. The insights gleaned from these discussions will continue to reinforce the foundation on which we are building our sustainability organization.

Packaging Sustainability Stakeholder Study

2021 Recap: Key Findings

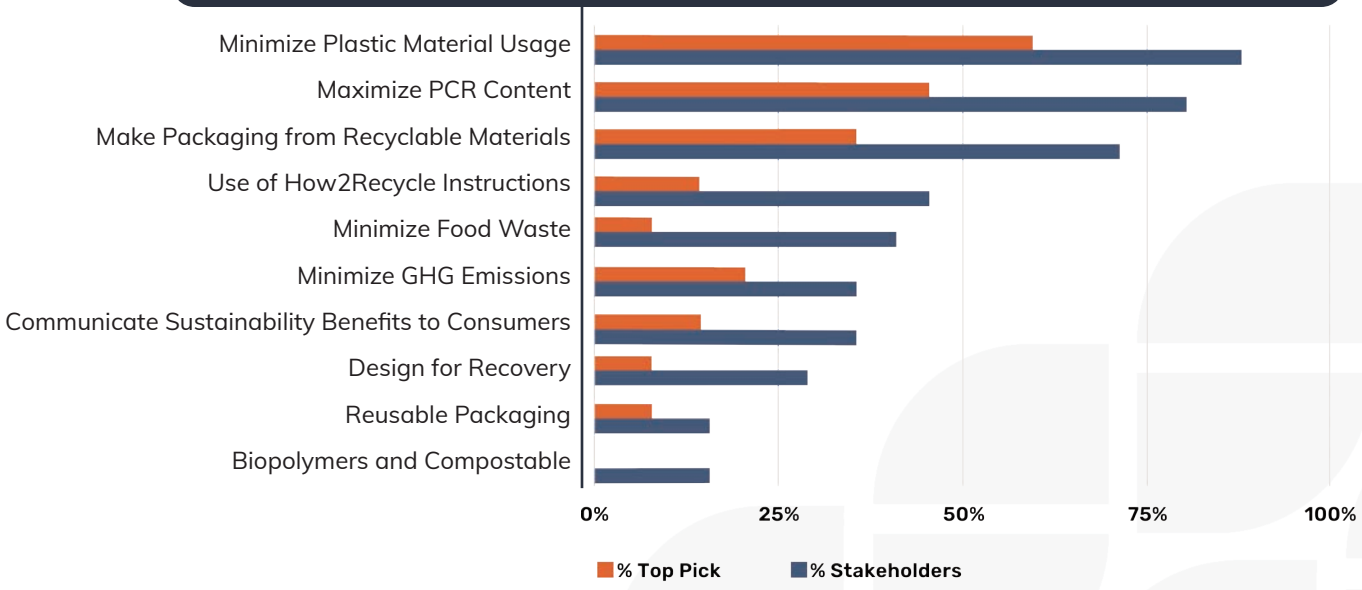
The following section provides a brief recap of key findings from the 2021 study before we dive into the 2022 study results. An emphasis on circularity emerged as a pattern across many stakeholders when asked to define sustainability. Corporate responsibility and accountability were a common refrain. Several stakeholders emphasized the role of recycling in sustainability but were careful to acknowledge there is much more to sustainability than recycling.

Retailer directives, Non-Governmental Organization (NGO) leadership, legislative policy, and consumer influence were commonly cited as key drivers of sustainability actions. CPG stakeholders overwhelmingly cited large retailers as the main influencers of their sustainability strategy. Healthcare packaging stakeholders cited bulk buying agencies as major influencers. The Ellen MacArthur Foundation and The New Plastics Economy were specifically identified by most stakeholders as NGOs having significant influence on sustainability strategy. Legislative policy was also a key driver cited by most stakeholders. Several organizations classified policy as an enabler to help achieve their goals. Stakeholders are aware of shifting consumer expectations, especially in younger demographics, as companies are expected to be more sustainable.

The discussions revealed a broad spectrum of sustainability goals across organizations. The graph below summarizes these goal statements and corresponding "Top Picks" denoting high priority.

Minimizing plastic material usage was the top goal statement identified. This can entail eliminating packaging material altogether or shifting to plastic alternatives. Maximizing post-consumer recycled (PCR) content registered a close second. Stakeholders are focused on adding PCR to their packaging to enhance circularity, but limitations include supply constraints and price pressures. Food producers are mindful of the harmful climate change contributions of food waste and will not make any change that potentially increases food waste.

2021 STUDY RESULTS



Packaging Sustainability Stakeholder Study

2022 Study Results

What is Sustainability?

Each interview was initiated by asking the stakeholder to define sustainability. Sustainability is an ambiguous term, with meanings varying from individual to individual. Our definition of sustainability often reflects our individual values and experiences. When discussing sustainability with internal or external stakeholders, it's important to make sure definitions are aligned. Gaining a common understanding is a critical footing for effective collaboration.

The United Nations (UN) definition of sustainability was cited in interviews as a useful benchmark. The UN defines sustainability as, "Meeting the needs of the present without compromising the ability of future generations to meet their own needs[1]." The UN created the Sustainable Development Goals (SDGs) to provide a framework for organizations and governments to follow to ensure the development of new goods and services is sustainable. This is a holistic, people-centered approach with categories ranging from "no poverty" to "peace and justice" and everything in between[2].

Packaging provides society with many benefits. It plays a critical role in enabling progress towards many of the SDGs, from preserving the foods we eat to protecting the medical devices and medicines trusted to save lives. However, responsible consumption, SDG goal #12, is essential for packaging to be truly sustainable. Too much packaging of all formats and material types ends up in landfills, is incinerated, or worse yet, leaches into our environment every year.

Transitioning to a circular economy is viewed by organizations as a necessity to achieving responsible consumption. Many of the sustainability definitions shared during our interviews in 2022 were seen through the lens of circularity enabling responsible consumption. A sustainability expert in food packaging shared this holistic view, "Sustainability is ensuring our resources are sustained for current and future generations. How are our resources going to be sustained 50 to 100 years from now? From water to habitable land and so on, blanketed across the globe."

Packaging Sustainability Stakeholder Study

What's Driving Sustainability?

A confluence of forces is increasing the priority of sustainability within organizations and driving progress. Many of the forces identified in the 2021 study continue to be relevant. The proportion of sustainable-minded consumers is growing, especially among younger cohorts. This is driving brands to reevaluate the sustainability of the goods and services they market. NGOs are helping to catalyze change through voluntary corporate commitments to sustainability frameworks. None is more influential than The Ellen MacArthur Foundation. The scale and buying power of large retailers and group purchasing organizations is another key driver. Organizations using tactics such as Environmentally Preferred Purchasing procedures tend to place higher value on sustainable items.

One factor newly identified in the 2022 study is investor influence. Capital investors are placing a higher weight on corporate responsibility when evaluating potential investments to ensure those companies will thrive in the long-term as the ecosystem grows more sustainable. BlackRock CEO, Larry Fink, was specifically cited as an influential leader driving the emphasis on sustainability at the C-Suite level of organizations. A stakeholder shared, "Sustainability goals are now factored into executive compensation. This provides accountability and influences action from the top down."

Legislation and regulation were commonly cited as influencers of change. This is especially true for organizations operating at the global level. Extended Producer Responsibility (EPR) legislation accelerated in 2022, with California and Colorado signing EPR into law[3]. Maine and Oregon enacted such policies in 2021. Although the laws will not take effect for several years, organizations are taking note of potential impacts and planning accordingly. Taxes levied on single-use plastics are impacting stakeholders operating on the global stage. "The taxes are starting to add up," stated a MedTech packaging expert.

ELLEN MACARTHUR FOUNDATION

> **"Sustainability goals are now factored into executive compensation."**

Packaging Sustainability Stakeholder Study

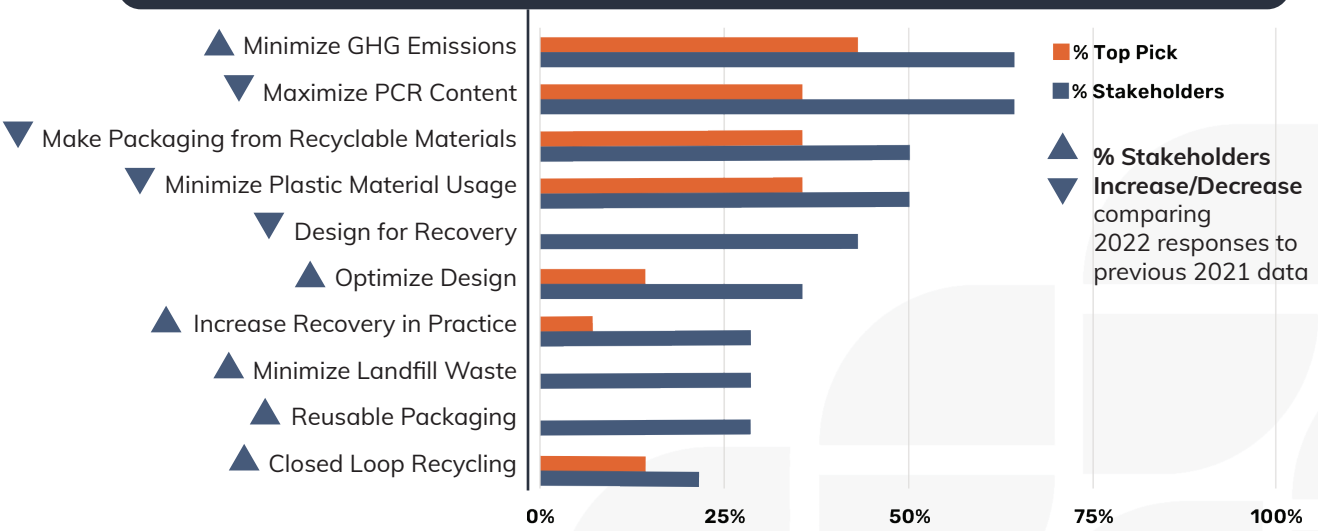
Sustainability Goal Analysis

Nearly all (92%) of the organizations we interviewed in 2022 had well defined sustainability goals at the time of the discussion. This number was 67% in our 2021 study. The proliferation of sustainability goals underscores the growing priority sustainability has gained in organizational strategy.

Stakeholders were asked to describe their organization's packaging sustainability goals. The answers were dissected into individual goal statements and high priority goals were identified as "Top Picks." The following table and graph summarize the findings:

GOAL	% Stakeholders	% Top Pick
Minimize GHG Emissions	64	43
Maximize PCR Content	64	36
Make Packaging from Recyclable Materials	50	36
Minimize Plastic Material Usage	50	36
Design for Recovery	43	0
Optimize Design	36	14
Increase Recovery in Practice	29	7
Minimize Landfill Waste	29	0
Reusable Packaging	29	0
Closed Loop Recycling	21	14

2022 STUDY RESULTS



Packaging Sustainability Stakeholder Study

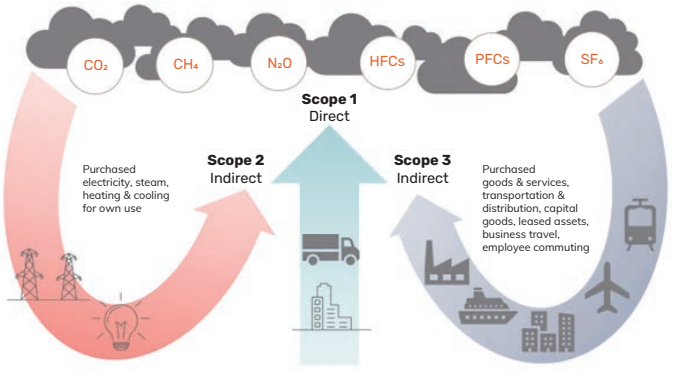
Minimize Greenhouse Gas (GHG) Emissions

The top sustainability goal identified by stakeholders in 2022 is to "Minimize GHG Emissions," as 64% of organizations interviewed have a goal to reduce their greenhouse gas emissions, including 43% that denote it as a top pick. This compares to 33% and 20%, respectively, from the 2021 study.
"It's important for us to partner with companies that are focused on improving their emissions from cradle to the grave," shared a food packaging expert.

The Science Based Target initiative (SBTi) was commonly cited as an influential NGO helping to drive climate action. SBTi helps organizations in the private sector set science-based emission reduction targets[4]. The science-based targets are intended to align with the goals of the Paris Agreement to limit global warming to well-below 2 degrees Celsius above pre-industrial levels. SBTi provides organizations with the framework needed to assess Scope 1, 2, and 3 emissions and guidance to set ambitious reduction targets. Organizations are held accountable for progress.

In 2022, 62% of the organizations interviewed have made SBTi commitments[5]. Additional stakeholders stated their companies plan on participating soon. SBTi's 2021 progress report outlined the exponential growth of pledges, reflecting the commitment of the private sector to take climate action. SBTi commitments were made by 2,253 companies by the end of 2021. These companies collectively represent $38 trillion in market capitalization, or roughly 35% of the global market cap.As of November 2022, the number of companies making commitments stood at over 4,000.

Methods to achieve GHG reductions vary amongst stakeholders. Organizations are implementing renewable energy generation, such as wind turbines, near production facilities. Some organizations are investing in renewable energy through Virtual Power Agreements. Fleet electrification is becoming common as organizations seek to decrease their transportation footprint. "We are aiming for net zero at our facilities by 2030. We added wind turbines this year to cover our power needs," shared a food packaging stakeholder.



GHG Scope 1, 2, & 3 Emissions

Source: Edison Energy

Maximize Post-Consumer Recycled (PCR) Content

A reported 64% of stakeholders listed "Maximize PCR Content" as a packaging goal their organization is working toward, and 36% listed this as a top pick, tied for the second highest of any other initiative captured. Introducing PCR into packaging keeps valuable material out of our landfills so it can recirculate in our economy. The demand for PCR fuels the economic incentives our recycling industry needs to operate. Outside of the economic benefits, using PCR significantly lowers the carbon footprint of a package and reduces the use of virgin materials. Brands are discovering that using PCR can enhance brand equity with sustainability minded consumers.
"We want to add PCR to our packaging whenever possible," shared a CPG expert.

A detailed analysis of PP and PET recycling can be found on pages 44-47 and 50-55 of this report, respectively. Recycled materials for packaging applications are in high demand due to brand owner commitments and legislated mandates. However, the supply of recycled materials is insufficient. In addition to packaging, a significant amount of recycled material is consumed in the fiber and durable goods industries. These industries are also under significant pressure to increase the amount of PCR in their products. Collection and recovery need to increase to meet this accelerating demand.

Packaging Sustainability Stakeholder Study

Maximize Package Recovery

Increasing the recovery of all packaging types is necessary to unlock true circularity in packaging. The 2022 study identified four goal types related to improving recovery rates. These goals could have been grouped together under an "Increase Recovery" category. These are intentionally kept as separate goals in this analysis because exploring the nuanced differences between the individual actions leads to more impactful insights. Had these four goals been grouped together, it would have been the most-cited (92%) and highest top pick (67%) of any category.

I. MAKE PACKAGING FROM RECYCLABLE MATERIALS

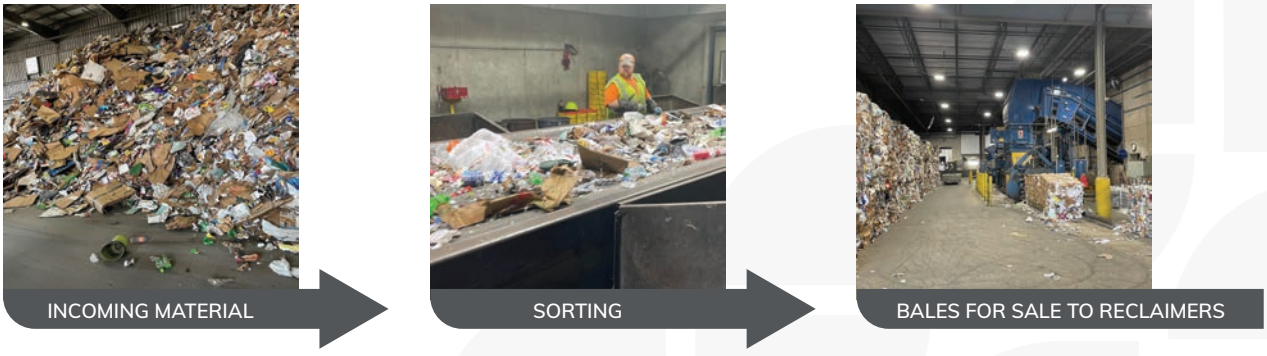
50% of stakeholders listed "Make Packaging from Recyclable Materials" as a goal their company is working toward, and 36% listed this as a top pick. Material selection is a critical aspect of creating a package that is truly recyclable. PET, HDPE, and PP are the most recycled polymers in the U.S. Organizations select these material types whenever possible to tap into existing recycling infrastructure and end markets. Stakeholders are also aware of the impact of colorants and additives, which can impact sortation and end market value. Monolayer structures are preferential to multilayer structures, given potential recycling complications.

When evaluating material changes for recyclability, stakeholders are cognizant of approaching these changes deliberately to not create unintended harmful effects. "Packaging has a job to do and that is protect the product. If it doesn't do that, it is not sustainable," shared one stakeholder about designing sustainable packaging.

II. DESIGN FOR RECOVERY

43% of stakeholders listed "Design for Recovery" as a goal their company is working toward. None listed this as a top pick. Choosing a highly recycled polymer, like PET, is not enough to ensure a package design is optimized for recovery. Stakeholders recognize the importance of following design for recycling guidelines, such as the Association of Plastic Recyclers Design Guides[6]. Stakeholders operating globally also identified RecyClass[7] and CEFLEX[8] as additional guides their designers use when creating new packaging.

APR's Design Guide informs packaging designs by itemizing guidance at the design attribute level. Each key attribute is classified as Preferred, Detrimental to Recycling, Renders Package Non-Recyclable, or Requires Testing based on the impact on recycling. Designers should use preferred features and avoid features that render a package non-recyclable whenever possible. An example of guidance is shown below.



Packaging Sustainability Stakeholder Study

The RecyClass tool operates by asking the packaging designer to answer a series of questions regarding the design.
The questions pertain to the key design attributes that influence a package application's compatibility with recycling.
Designers have visibility to the impact of their answers on the interim result as they progress through the survey. The tool calculates a final assessment at the conclusion of the survey, with grades ranging from A – F. Specific European country results are provided for the item based on the current state of recycling infrastructure and markets in the region.

The Circular Economy for Flexible Packaging (CEFLEX) initiative is a collaboration representing the packaging value chain.
The mission of CEFLEX is to make all flexible packaging in Europe circular by 2025.
CEFLEX provides design guidance to advance their mission.

III. INCREASE RECOVERY IN PRACTICE

29% of stakeholders listed "Increase Recovery in Practice" as a goal their company is working toward, and 7% listed this as a top pick. There is recognition amongst stakeholders that following design for recycling guidance is just part of the package recovery process. For a package to be truly deemed recyclable, according to the Federal Trade Commission's Green Guides[9], it must satisfy four criteria. The following section details these criteria and known challenges associated with each.

Collection:

60% of consumers have access to a collection system that accepts the item.

Not enough people have access to recycling programs that accept all types of packaging formats. Bottles are commonly accepted in most programs, but trays and tubs are not always, even if they are the same material as the bottle. The Recycling Partnership estimates that only 60% of American households have recycling collection services that are equitable to their trash collection services[10]. Simply put, not enough people have access to robust curbside recycling programs.

Sortation:

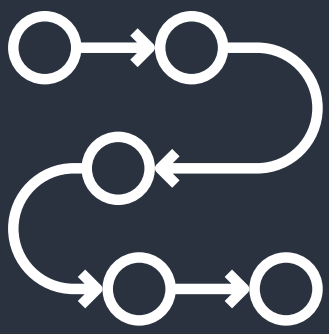
The item is most likely sorted correctly into a market-ready bale of a particular plastic.

It is no surprise that America's recycling infrastructure needs modernization. This is not a criticism of Material Recovery Facilities (MRFs) – recycling is hard. The fact is the rapid evolution of packaging formats has placed significant burdens on our MRFs and recyclers. Packaging shape, labels, adhesive, and ink choices can impact the ability to sort and reprocess. This underscores the importance of following design for recycling guidance.

Reprocessing:

The item can be further processed through a typical process cost effectively.

It is very common for beverage containers, like water bottles, to be reprocessed into recycled content for use in food contact applications, like bottles or thermoforms. It is also common for packaging items to be recycled into durable goods. As an example, Polyethylene bags can be converted into polymer-based lumber and durable furniture. These materials need to be processed efficiently to capture market demand.



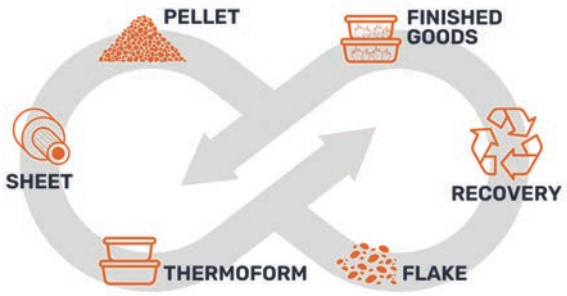
End Markets:

The item must have market value or be supported by a legislatively mandated program.

A strong end market for PCR material can create the necessary incentives for MRFs to operate. It is difficult to justify the equipment investments needed to capture and process a packaging format without a stable, mature market. In addition to upstream recycling innovation, such as the utilization of recyclable materials and designing for recovery, stakeholders are focused on downstream interventions to make recovery of their packaging in practice a reality. Often, these downstream challenges are too large for one company to solve alone. Collaborations like The Recycling Partnership's Material Coalitions enable change at the community level by pulling together private sector expertise and resources.

IV. CLOSED LOOP RECYCLING

21% of stakeholders listed "Closed Loop Recycling" as a goal their company is working toward, and 14% listed this as a top pick. These stakeholders are exploring recycling scenarios that enable a truly circular pathway by reusing material recovered from their packaging. This is of most interest in applications that currently do not have a pathway in residential recycling. The logistics of these programs tend to be complex, and stakeholders are mindful of potential GHG emissions associated with excess transportation. Life Cycle Assessment tools are commonly leveraged to help stakeholders determine if closed loop recycling programs have truly lower environmental impacts than alternative end-of-life outcomes.



Packaging Sustainability Stakeholder Study

Minimize Plastic Material Usage

Half (50%) of stakeholders listed "Minimize Plastic Material Usage" as a goal their company is working toward, and 36% listed this as a top pick. Stakeholders are under pressure from NGOs and consumers to reduce the amount of plastic used in their packaging. Stakeholders are accomplishing this by optimizing designs to make sure the minimum amount of plastic is used (detailed in next section) or by substituting plastic for another substrate.

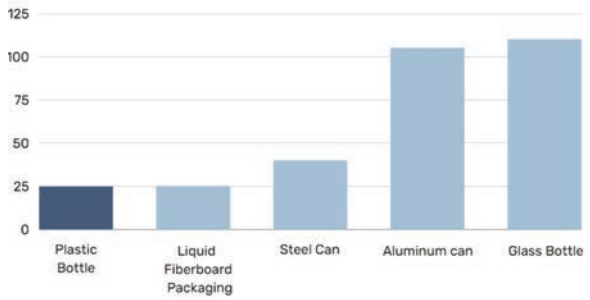
Stakeholders recognize substituting plastics for other substrates cannot be accomplished without compromise. "It is very difficult to offer the same protection and customer experience as plastics," shared a packaging expert. Plastic has certain functions that are very challenging, if not impossible, to replicate with alternative materials. Plastic is very lightweight, durable, has excellent preservation attributes, and can be molded into an endless array of shapes and sizes. Most importantly, plastic tends to have a lower carbon footprint than alternatives. A McKinsey report in 2022 found that plastic has a lower carbon footprint in 13 of 14 applications studied with LCAs[11]. A 2020 study by The Imperial College of London reached similar conclusions[12].

Plastics have a lower greenhouse gas impact in 13 of the 14 nonplastic alternative applications analyzed, including both direct and indirect value-chain emissions.

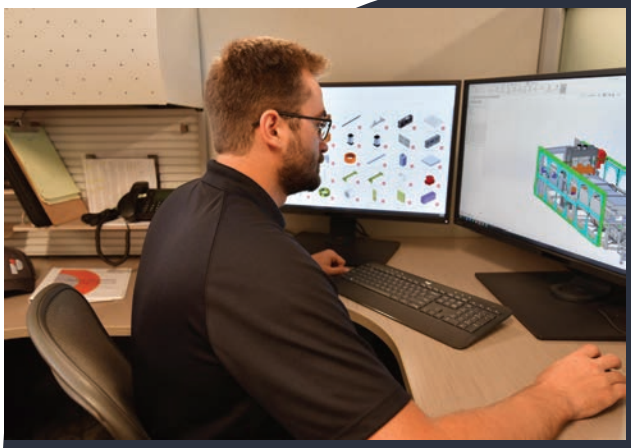
% difference in total greenhouse gas contribution in United States, 2020

Comparison	Sector	Application	*Plastic vs*	Next-best alternative	
Plastics vs alternative materials	Packaging	Grocery bag	HDPE	Paper	80
		Wet pet food packaging	PET/PP	Aluminum or steel	70
		Soft drink container	PET	Aluminum	50
		Fresh-meat packaging	EPS/PVC	Paper	35
		Industrial drum	HDPE	Steel	-30
		Soap container	HDPE	Glass	15
	Building and construction	Municipal sewer pipe	PVC	Concrete or ductile iron	35-45
		Residential water pipe	PEX	Copper	25
		Insulation	PU	Fiberglass	80
	Consumer goods	Furniture	PP	Wood	50
	Automotive	Hybrid fuel tank	HDPE	Steel	90
		BEV² battery top enclosure	PP/glass fiber	Steel	10
	Textiles	Carpet	PET/nylon	Wool	80
		T-shirt	PET	Cotton	15

Source: McKinsey – Climate Impact of Plastics



Source: Imperial College of London: Examining Material Evidence, The Carbon Footprint, 2020



Optimize Designs

About one-third (36%) of stakeholders listed "Optimize Designs" as a goal their company is working toward, and 14% listed this as a top pick. Optimizing the sustainability of packaging designs is a broad ambition. Desired outcomes are dependent on how organizations define sustainability and focused areas of improvement. Stakeholders are deploying a variety of strategies to accomplish this ambition, depending on their desired outcomes. As an example, organizations seeking to minimize their material usage are exploring ways to right-size packaging footprints and decrease structure thickness. "Reducing waste is a key tenet of a circular economy. We are asking ourselves, what can we do to improve our packaging," shared a sustainability expert.

Some organizations have a holistic perspective on the role of packaging design in the sustainability of their product offerings. These stakeholders stated their organizations take into consideration all stages of their distribution channels when optimizing their packaging design. This may mean decreasing trim sizes to maximize shipping efficiencies. Optimizing design is an emerging imperative for healthcare companies, as we will detail in the healthcare stakeholder summary to follow.

Packaging Sustainability Stakeholder Study

Minimize Waste to Landfill

Nearly 1 in 3 (29%) stakeholders listed “Minimize Waste to Landfill” as a goal their organization is working toward. No one listed this goal as a top pick. The stakeholders clarified that this goal is related to waste generated in their operations. Operational sustainability, including zero waste initiatives, are becoming core components of organizations sustainability approach. Pharmaceutical companies interviewed were most in tune with operational sustainability metrics. Take-back programs were identified as initiatives of interest to reduce operational waste from manufacturing processes. These are detailed in the healthcare stakeholder study to follow.

Reusable Packaging

Another 29% of stakeholders listed “Reusable Packaging” as a goal their company is working toward to reduce waste. No one listed this goal as a top pick. There are some key considerations stakeholders consider when evaluating reusable models. This includes the infrastructure needed to collect the item from users, sanitize it, and return it for further use. Another factor is the expected number of return cycles before the package is lost from the system. This has some important ramifications on material selection and design integrity. For example, if an 80% return rate is expected, that sounds high; however, it means there will be only five uses out of a package before it is lost as waste. Stakeholders need to look at reusable system designs holistically to make sure systems are created that result in improved environmental outcomes compared to conventional single-use models.

Reusable models are common today in manufacturing settings. Reusable systems are prevalent for work-in-process (WIP) trays used in automated assembly processes. The trays are used in assembly processes that support healthcare, automotive, and consumer goods.

> **“We want to completely eliminate unnecessary waste.”**

Packaging Sustainability Stakeholder Study

HEALTHCARE
Sustainability Goal Analysis

Half of the stakeholders interviewed in 2022 represent the healthcare industry. Organizations interviewed include manufacturers of medical devices, pharmaceutical products, and life science applications. The healthcare industry is under significant pressure to increase the sustainability of their offerings.

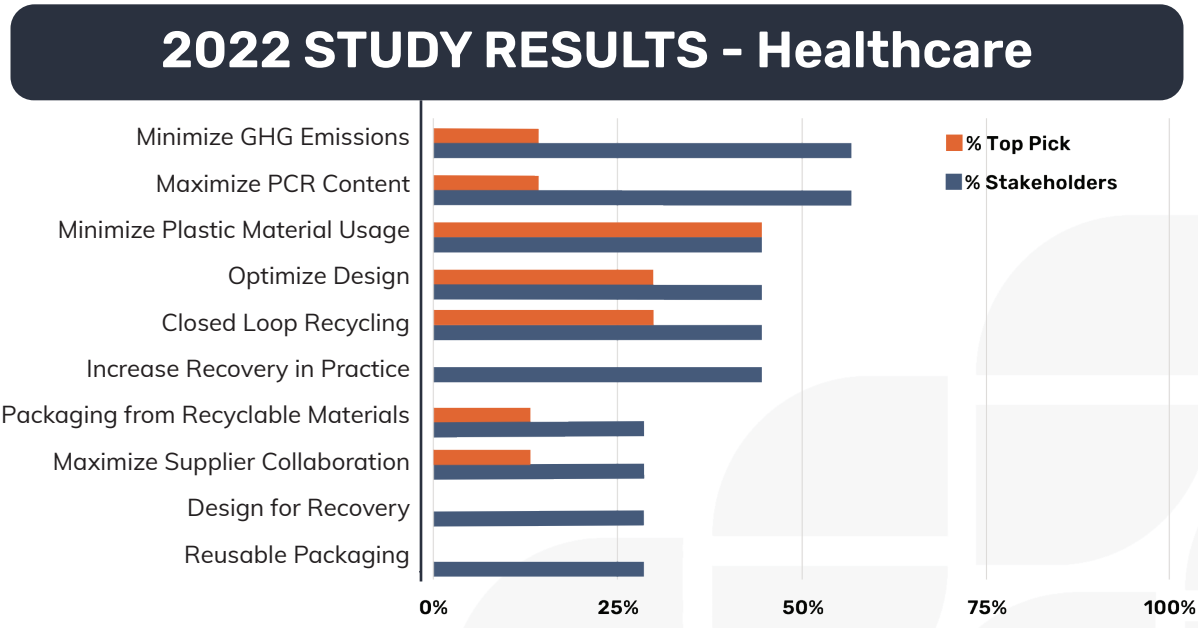
Drivers are comparable to other industries but there are influences unique to the healthcare industry. Healthcare packaging stakeholders cited Group Purchasing Organizations (GPOs) and their Environmentally Preferred Procurement (EPP) policies as major influencers. EPPs are being integrated into contract tenders, providing motivation for MedTech organizations to increase focus on the sustainability of their products and packaging.

NGOs, such as Practice Greenhealth[13], are providing a framework and resources for the healthcare sector to leverage for sustainability initiatives. Global legislation was commonly identified as a major influencer for those organizations operating globally. “Government regulates where industry fails to act. That's exactly what's happening,” stated a stakeholder.

Healthcare Service Providers (HSPs) are committing to zero or reduced waste goals, causing renewed focus on end-of-life outcomes for medical device packaging. End user feedback, such as from nurses, is influencing packaging design. “Our packaging is in the realm of over-packaging. Nurses are noticing the over-packaging of our products,” shared a packaging expert.

Isolating the sustainability goals detailed by healthcare organizations provides some interesting insights to analyze.

GOAL	% Stakeholders	% Top Pick
Minimize GHG Emissions	57	14
Maximize PCR Content	57	14
Minimize Plastic Material Usage	43	43
Optimize Design	43	29
Closed Loop Recycling	43	29
Increase Recovery in Practice	43	0
Make Packaging from Recycled Materials	29	14
Maximize Supplier Collaboration	29	14
Design for Recovery	29	0
Reusable Packaging	29	0



Packaging Sustainability Stakeholder Study

Minimize GHG Emissions

In a tie with "Maximizing PCR Content," "Minimizing GHG Emissions" was most cited by healthcare organizations as a goal they are working toward (57%). However, only 14% listed this as a top pick. Healthcare organizations, especially pharmaceuticals companies, are cognizant of the impact their products and processes have on our ecological systems. "We are committed to no adverse impact of our pharmaceuticals on the environment, including climate, water quality, and waste," stated a stakeholder. Emission reduction commitments, like the Science Based Target initiative, are ways healthcare organizations are setting targets and holding themselves accountable. The CDP is another organization cited as enabling the transparent disclosure of environmental impacts.

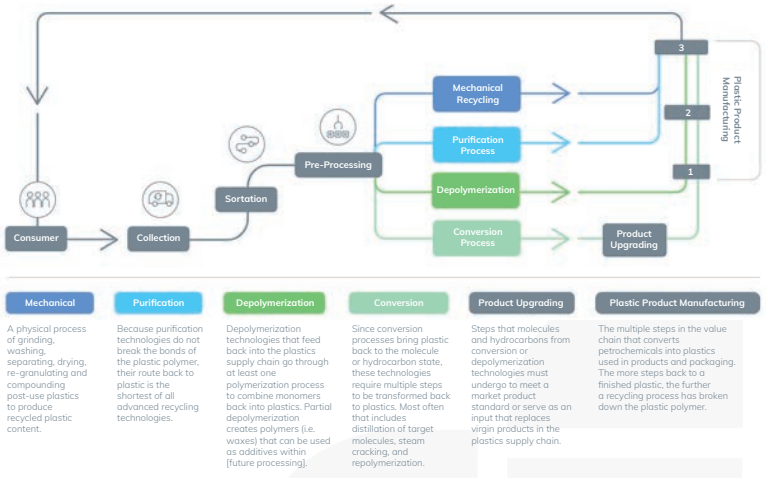
Maximize PCR Content

Both "Maximizing PCR Content" and "Minimizing GHG Emissions" were cited by 57% of healthcare organizations as a goal they are working toward, though only 14% listed this as a top pick. It is surprising to see PCR content as a healthcare packaging goal given the regulatory requirements constraining the use of PCR in Sterile Barrier System (SBS) packaging. "One of the things that drives me out of my mind are the rules that don't allow recycled content in our packaging," lamented a packaging development leader. Healthcare stakeholders expressed interest in PCR for secondary and tertiary packaging since those applications are less constrained.

Regarding SBS packaging, medical device manufacturers are optimistic about the potential of advanced recycling techniques and mass balance systems to help them unlock opportunities to support the use of PCR materials. "It has potential if manufacturers come on board, regulators are okay with it, and it is economically feasible," shared a stakeholder.

Advanced recycling is a suite of novel recycling techniques intended to complement mechanical recycling by focusing on hard-to-recycle materials. Advanced recycling may also be known as chemical recycling or molecular recycling. There are many different types of advanced recycling methods, but they are typically characterized into three types: Purification, Depolymerization, and Conversion. Each type breaks the polymer down to a precursor and/or removes impurities like colorants and additives[14].

MedTech companies can leverage a mass balance approach to support PCR markets without compromising performance or compliance. Mass balance is a chain-of-custody protocol that tracks recycled content through manufacturing processes. These protocols are needed when inputs from recycled plastics are mixed with fossil fuel-based inputs. It is not possible to trace the exact recycled molecules to the end products. However, recycled plastic used in manufacturing is recorded and balanced with the certified recycled content in end products. ISCC PLUS is a standard used to certify a manufacturer's mass balance accuracy through third party audits. All members of the value chain must follow the standard to ensure chain-of-custody is intact.



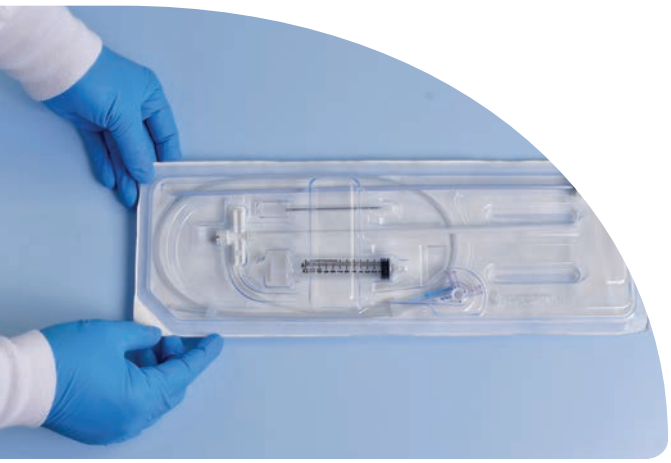
Source: Closed Loop Partners – Evaluating the role of Molecular Recycling Technologies

Packaging Sustainability Stakeholder Study

Minimize Plastic Material Usage

"Minimize Plastic Material Usage" was cited by 43% of healthcare organizations as a goal they are working toward. It was the highest listed top pick of any goal captured (43%). A common struggle for packaging engineers is balancing the desire to minimize materials with the need to ensure the packaging system is robust enough to withstand the rigors of distribution. Product scrap due to defects caused by insufficient packaging systems is not acceptable but the practice of "over-engineering" to eradicate risk is no longer accepted. "A lot of packages are overengineered or just use too much material. A little bit of packaging reduction goes a long way," shared a stakeholder. Package engineers must leverage design expertise and material innovation to solve this dilemma.

> **"We are looking for ideation and innovation partners where we both roll up our sleeves."**



Optimize Designs

"Optimize Designs" was cited by 43% of healthcare organizations as a sustainability goal they are working toward. It was tied for the second highest listed top pick of any goal captured (29%). Given the challenges associated with incorporating PCR materials, many organizations are focusing on optimizing designs to advance packaging circularity. "A good waste reduction strategy starts with design," stated a packaging expert. Balancing performance requirements with the need to minimize materials and waste can be a challenge. Stakeholders recognize a need to optimize the efficiency of packaging designs from the beginning by starting with the end in mind. "We need to leverage the collective design expertise of our value chains to solve problems," shared a stakeholder.

Various tactics to optimize the design of healthcare packaging were discussed among stakeholders. Organizations are looking at adding structural features to packaging sidewalls so part weight can be reduced. Trim footprints are examined given the potential to reduce material usage and increase downstream efficiencies, like shipping pack-out. Minimizing packaging headspace is a tactic used to decrease material usage and increase shipping efficiencies. Packaging systems are reviewed holistically to determine if unnecessary components can be eliminated. Container nest heights are analyzed to determine if reductions can be made to increase shipping efficiency.

This minimalist approach can be a departure for some MedTech companies accustomed to sticking with "tried-and-true" packaging systems to eliminate risk. Stakeholders are determining new development procedures to enable the optimization of designs, without adding risks. This includes developing multiple solutions in a "parallel path" to determine true failure points and build in minimum factors of safety. Deviating to this new approach requires sufficient resource allocation, budget, and leadership alignment. "We are looking for ideation and innovation partners where we both roll up our sleeves," stated a stakeholder.

Packaging Sustainability Stakeholder Study

Increase Package Recovery

Like the overall study findings, the healthcare respondents identified four goals associated with increasing the recovery of packaging. These four goals are discussed below. Increase Package Recovery would have been the top-cited goal had these four goals been grouped together, with 71% of organizations citing one or more of these goals as a key to their sustainability strategies.

I. CLOSED LOOP RECYCLING

43% of stakeholders listed "Closed Loop Recycling" as a goal their company is working toward, and 29% listed this as a top pick. Recycling collection systems for healthcare packaging are lacking, especially in clinical settings. This is causing organizations to turn to closed loop recycling methods to recover their packaging items for reuse into new packaging.

Take-back programs are a form of closed loop recycling. The interest in these types of programs is growing in importance, as evidence by the results of this study. Take-back programs can be a creative option to recycle an item when traditional recycling collection systems are not available. "We have a take-back program for packaging. Customers will ship back easily recyclable items like PET bottles and cardboard," shared a life science packaging expert.

An example of closed loop recycling is shown in the schematic below. The trays are collected after use. They are shipped to a local recycler to sort out any contaminates and then grind into flake. The flake is then shipped back to the tray manufacturer for reuse into production of new trays.

II. INCREASE RECOVERY IN PRACTICE

43% of stakeholders listed "Increase Recovery in Practice" as a goal their company is working toward. No one listed this as a top pick. "Our customers are demanding recycling systems for our products," shared a life science packaging stakeholder. According to the Healthcare Plastics Recycling Council (HPRC), 2,000 to 3,000 tons of non-hazardous medical waste is generated daily[15]. Capturing these high-quality materials for future use is paramount as new avenues of supply are needed to meet the increasing demand for PCR materials.

Healthcare packaging faces some unique challenges on the pathway to increasing recovery rates. Healthcare Service Providers (HSPs) lack the infrastructure and systems necessary to efficiently collect, aggregate, and transport their waste to reclaimers. Although most of the plastic waste generated is non-hazardous, many MRFs view healthcare waste as undesirable due to the perception of contamination. Additionally, the amount of waste generated at an individual provider is not significant enough to incentivize a MRF to collect the waste directly from the provider, thus highlighting the need for aggregation. This topic is discussed in greater detail in the "SPOTLIGHT: Healthcare Plastics Recycling Council (HPRC)" article of this report.

III. MAKE PACKAGING FROM RECYCLABLE MATERIALS

29% of stakeholders listed "Make Packaging from Recyclable Materials" as a goal their company is working toward, and 14% listed this as a top pick. Healthcare packaging is made in a variety of formats and materials. Common materials used for rigid healthcare packaging include PETG, HIPS, PET, PP, HDPE, and PVC. Many of these widely used materials, such as PETG, do not have existing robust recycling markets. However, their function, especially in sterilization processes, is nearly impossible to duplicate with other materials. Stakeholders are transitioning to materials with more robust recycling markets, when possible, but the ability to do so is limited by performance requirements, qualification hurdles, and existing recycling markets. "There are a lot of mixed multilayer materials in healthcare packaging, whereas our recycling infrastructure is designed for rigid monolayers," a packaging expert shared.

> **"There are a lot of mixed multilayer materials in healthcare..."**

IV. DESIGN FOR RECOVERY

29% of stakeholders listed "Design for Recovery" as a goal their company is working toward. None listed this as a top pick. Stakeholders recognize that packaging design plays a key role in the eventual likelihood of recovery for recycling. However, given the lack of recycling infrastructure currently for healthcare packaging, higher priority is placed in other areas. This may change as infrastructure develops for healthcare packaging in clinical settings. The HPRC "Design Guidance for Healthcare Plastics Recycling" document was listed as a resource used by organizations for this goal[16].

HPRC HEALTHCARE PLASTICS RECYCLING COUNCIL

Packaging Sustainability Stakeholder Study

Maximize Supplier Collaboration

"Maximize Supplier Collaboration" was cited by 29% of healthcare organizations as a goal they are working toward, and 14% listed this as their top pick. The emerging focus on sustainability is new to several of the organizations we interviewed. Stakeholders stated a clear need to collaborate with value chain partners to help them identify opportunities to improve the sustainability of their packaging. "We are taking sustainability very seriously, but we are just getting started. We need some ideas," a packaging expert candidly shared. Tethering goals to the objectives of immediate customers, like the GPOs, was suggested as one effective tactic to establish direction.

Conclusion

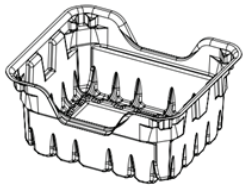
Shifting to a more sustainable future for packaging is a monumental undertaking. Stakeholders across industries are activated to tackle this challenge head on and lead the way to circularity. An unprecedented level of collaboration and synchronicity is required to realize these commitments. The challenges we face as a packaging industry are too steep to face alone. We must work together to make the progress that is rightfully expected of us.

"The goal is to reduce material in both weight and footprint. Beyond that, to move to a material that's more sustainable with regard to either having more recycled content or a more recyclable material."

Reusable Packaging

"Reusable Packaging" was cited by 29% of healthcare organizations as a goal they are working toward. No one listed this as their top pick. This goal was most identified for trays used in automated processes. Shifting to a multi-use model for these types of applications requires significant consideration and investment. The payback, both in terms of capital and carbon, often depends on the efficiency of the system and design.

Capital equipment needs to be tailored to the geometry and structure of a reusable tray. This transition can create complications when attempting to retrofit existing equipment. Reusable trays need more structure to withstand the rigors of multiple cycles. This is typically accomplished by adding more material to the tray. It is important to have a realistic idea of the number of cycles to design the trays accordingly. Reverse logistics that minimize transportation need to be determined.



[1]United Nations Sustainability
[2]United Nations Sustainable Development Goals
[3]Sustainable Packaging Coalition - EPR Guide
[4]Science Based Targets
[5]SBTiProgressReport2021.pdf (sciencebasedtargets.org)
[6]The Association of Plastics Recyclers | APR Design® Guide (plasticsrecycling.org)
[7]RecyClass
[8]CEFLEX | A circular economy for flexible packaging
[9]Federal Trade Commission - Green Guides
[10]The Recycling Partnership: By the Numbers
[11]McKinsey - Climate impact of plastics
[12]Imperial College of London - Examining Material Evidence: The Carbon Fingerprint
[13]Practice Greenhealth
[14]Closed Loop Partners Evaluating the Role of Molecular Recycling Technologies
[15]Healthcare Plastics Recycling Council (HPRC)
[16]Design Guidance | HPRC

CASE STUDY

Creating a Starbucks Cold Drink Strawless Lid

THE RESULTS

20
designs in 4 days

5
sets of samples in 5 days

1B
Starbucks straws eliminated every year

THE CHALLENGE

Starbucks, the largest coffee chain in the world, has a robust three-decade history as a leader in eco-conscious initiatives. In 2018, they tackled their largest sustainability project to date, by pledging to eliminate plastic straws from all their stores by 2020. Incorporating circular design principles to reduce or eliminate unnecessary packaging components was the primary goal.

Starbucks enlisted Plastic Ingenuity to assist with this opportunity. In 2016, Plastic Ingenuity worked with Starbucks to help design the Nitro Cold Brew lid. This innovation effectively targeted a niche segment of consumers who preferred cold brew without ice. The design offered an inspiring model for a strawless solution but required modifications to accommodate a wide variety of cold drinks.

THE PROCESS

The first round of brainstorming included four Plastic Ingenuity Design Engineers and 11 design options to effectively address all the specifications. After these initial iterations, it was decided the next phase of designs would focus on a hybrid solution featuring aspects of the current hot coffee lid, but with the Nitro Cold Brew lid profile.

PI's engineering team leveraged this information to inspire a second round of examples. PI submitted 20 additional designs in four days, which ultimately led to the final design. Once the design was identified and approved, five sets of samples were handcrafted by our Prototype Technicians and sent to Starbucks to test form, fit, and function.

Additionally, PI's quality control team implemented an extensive testing process including a custom assessment called the "tilt test". This ensured all requirements were met and the highest quality product was supplied. This collaborative, efficient, and economic process resulted in an effective and sustainable design.

THE SOLUTION

Plastic Ingenuity developed a thermoformed polypropylene lid to eliminate the need for plastic straws. The rapid turnaround facilitated Starbucks' ability to successfully transition to strawless by its 2020 goal. The lid was successfully designed to reduce spilling, splashing, and ice migration through the drink opening with the same effectiveness as a straw. A win-win for Starbucks and the pursuit of a circular economy.

THE IMPACT

20

created 20 designs in 4 days with 5 sets of samples in 5 days

1 Billion

Starbucks straws eliminated per year

> System-wide challenges cannot be overcome by one company acting alone.

INDUSTRY COLLABORATION

Industry Collaboration

Industry Collaboration

Shifting to a circular economy for packaging requires an immense amount of collaboration. System-wide challenges cannot be overcome by one company acting independently. Therefore, we are active contributors and seek leadership opportunities in every association we support. Our collaborative mindset derives unique value for our customers and associates.

2022 highlights include:

- Became a new funding member of the recently established PET Recycling Coalition
- Celebrated upgrade of PP to “widely recycled” status thanks to the efforts of the PP Recycling Coalition
- Joined Healthcare Plastics Recycling Council’s steering committee and co-led Advanced Recycling project team
- Participated as a Member Champion of Plastics Industry Association’s New End Market Opportunity (NEMO) team focused on developing end market opportunities for food grade recycled PP
- Presented or participated in panel discussions at Smither’s Sustainability in Packaging U.S., the[PACK]out, Medical Design & Manufacturing (MDM) West, and Connect in Pharma

“We want to partner with companies that care about the future of the planet.”

Industry Collaboration

PI is proud to contribute to the following organizations in the pursuit of circularity for plastic packaging:

- Associated Recyclers of Wisconsin (AROW)
  AROW brings together a dynamic cross section of industry professionals from both private and public sectors, all dedicated to waste reduction, recycling, and product stewardship.

- Association of Plastics Recyclers (APR)
  APR promotes development of the plastics recycling industry by providing leadership for long-term industry growth and vitality.

- Foodservice Packaging Institute (FPI)
  FPI brings together the entire foodservice packaging value chain from raw material and machinery suppliers to packaging converters to foodservice distributors and foodservice operators/retailers.

- Healthcare Plastics Recycling Council (HPRC)
  HPRC is an industry consortium comprised of MDMs, material manufacturers, converters, waste collectors, recyclers, and hospitals. HPRC focuses on identifying barriers to plastics recycling and developing solutions along the entire value chain.

  Steering Committee and Co-Lead of Advanced Recycling Project Team

- National Association for PET Container Resources (NAPCOR)
  NAPCOR provides a forum for its members to collaborate with peers on key projects and address significant issues affecting PET packaging throughout its life cycle.

  Board Member and Chair of Thermoforming Committee

- Plastics Industry Association (PLASTICS)
  PLASTICS brings equipment makers, brand owners, processors, and material suppliers together to align their efforts to put recycling at the forefront of their businesses.

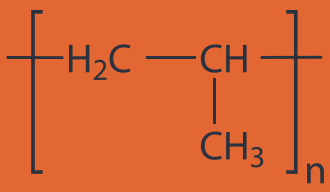
  Recycling Committee and Member Champion of food grade recycled PP NEMO project

- Sustainable Packaging Coalition (SPC)
  SPC brings packaging sustainability stakeholders together to catalyze actionable improvements to packaging systems and lend an authoritative voice on issues related to packaging sustainability.

- The Recycling Partnership
  The Recycling Partnership is a nonprofit organization that leverages corporate partner funding to transform recycling for good in states, cities, and communities nationwide.

  Funding members of the PP Recycling Coalition, which is focused on increasing access for people to recycle polypropylene through curbside recycling programs, ensuring more recycling processing facilities can sort the material successfully, and stimulating a robust end-market of high-quality recycled polypropylene for reuse in packaging, and the PET Recycling Coalition, a robust group of stakeholders driving improvements that transform the PET plastic recycling landscape.

SPOTLIGHT: PP RECYCLING COALITION



POLYPROPYLENE RECYCLING COALITION
AN INITIATIVE OF THE RECYCLING PARTNERSHIP

The Recycling Partnership launched the Polypropylene Recycling Coalition in 2020 to increase access for people to recycle polypropylene (PP) through curbside recycling programs, ensure more recycling processing facilities can sort the material successfully, and stimulate a robust end-market of high-quality recycled polypropylene for reuse in packaging.

The coalition model combines grants, community level education, and big data analysis to accelerate progress. The coalition provides grants to recycling facilities for capital equipment to improve the capture of PP packaging items.

Rapid progress has been made since the coalition was formed. This progress resulted in the achievement of a major milestone in 2022 when most rigid PP containers were upgraded to "Widely Recycled" by the How2Recycle program.

Noteworthy impacts include:

30 **$7M**

30 grants totaling over $7 million

10% **27M**

Improving curbside access to PP affecting approximately 10% of households, 27 million people

36M

Increasing PP recovery by an estimated 36 million pounds annually

Plastic Ingenuity joined the Polypropylene Recycling Coalition in August 2021. We are energized by the progress the coalition has made in two years. We will continue to focus the resources needed to grow the recycling ecosystem for this very important packaging polymer.

Please visit Polypropylene Recycling Coalition - The Recycling Partnership for more information.

SPOTLIGHT

PP Recycling Landscape

Understanding the challenges of recycling PP in comparison to its polyethylene terephthalate (PET) and high-density polyethylene (HDPE) counterparts is paramount to identifying potential solutions to address these challenges. According to research by Resource Recycling Systems (RRS), approximately 3.5 billion pounds of rigid PP packaging is sold every year, with the majority comprising thermoform applications, as depicted in the graphs on this page.

The significant use of PP is testament to its superior utility as a packaging polymer. Benefits of PP for packaging applications include:

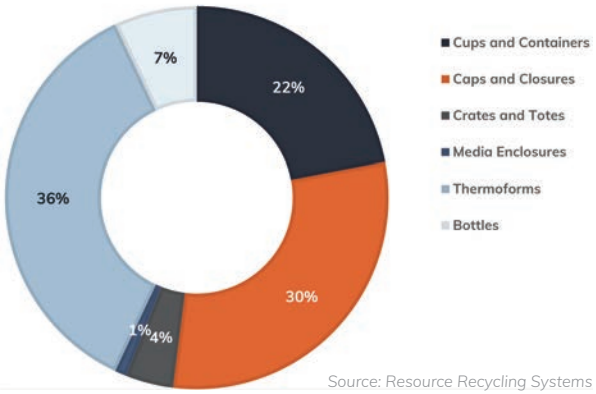
- Lowest density of any solid polymer commonly used for packaging
- Ideal blend of physical properties, like rigidity and impact strength
- Can be clarified for use in applications that need a clear substrate
- Microwavable without losing its integrity
- Dishwasher safe in most formats
- Commonly used for chilled application and can be enhanced for use in frozen conditions
- Suitable for high temperature filling and processing conditions making it ideal for hot-fill pasteurization and retort cooking packaging processes
- Excellent moisture vapor transmission properties for preserving products sensitive to vapor transmission

PP packaging applications are diverse in format, shape, and size. Applications for PP in packaging are nearly endless: PP can be thermoformed into a cup or tray, blow molded into a bottle, injection molded into a container or five-gallon pail. This diversity makes PP items more complicated to sort and process than other resins with more homogeneous formats, like PET beverage containers or HDPE milk jugs. This challenge is particularly impactful for sortation processes dependent on manual sortation methods, rather than near infrared (NIR) or optical automation.

Additionally, past reliance on export markets for recovered plastic waste often resulted in PP being included in mixed plastic bales rather than sortation into PP bales. This export factor hindered the development of a robust market for PP reclamation.

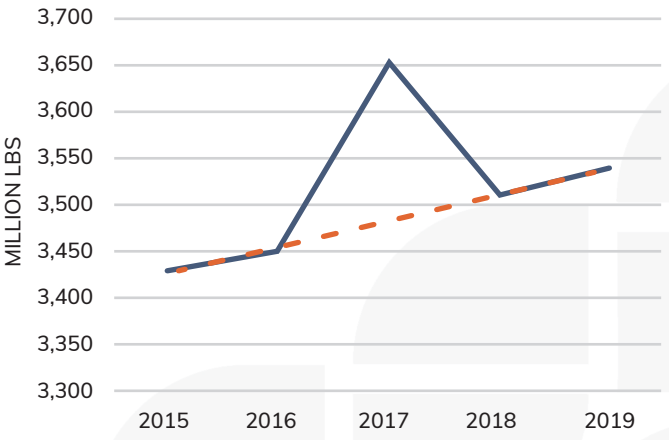
PP has been commonly recycled for less than a decade. Reclamation is still maturing as compared to the more established infrastructure associated with PET and HDPE. A silver lining for the future of PP includes increased investments and the growth of end markets, which leads to promising reclamation opportunities.

PP CONTAINERS AND PACKAGING APPLICATIONS (U.S. 2018)



Source: Resource Recycling Systems

5-YR TREND IN PP PACKAGING SALES (U.S.)



~3.5 billion lbs generated in the U.S. (2018)
3.2% growth from 2015-2019

Source: Resource Recycling Systems

SPOTLIGHT

The demand for recycled polypropylene (rPP) is growing in high value packaging markets, such as food grade rPP. Currently, there is very little food grade rPP produced, but the demand exists, and PP reclaimers are responding by investing in capabilities and filing for FDA Letters of Non-Objection.

Consumer brands with recycled content commitments use food grade rPP for personal care and nutraceutical applications (vitamins, supplements, etc.). Major retailers, dairy brands, and quick service restaurants (QSR) are shifting from polystyrene to PP, particularly in food and food service applications, to capture the benefits of preferred material health characteristics, improved recyclability, and potential for increased recycled content opportunities. The rPP food contact (foodservice and food packaging) markets will eventually benefit once more food grade rPP becomes available.

PP Recycling Outlook

Substantial investments are being made to grow PP recovery, ultimately improving the quantity and quality of recovered PP. Demand is driving higher value markets and recycled content. This is due to myriad of advancements, including education opportunities, continued innovation, and strategic investments, including:

Investment:
The Recycling Partnership - PP Coalition

Sortation:
Technologies like artificial intelligence (AI) & robots addressing PP sortation challenges; materials recovery facilities (MRFs) transitioning from mixed plastic to PP sorting

Reclamation:
PP reclamation capacity growing

Quality:
Growth in FDA No Objection Letters to produce food grade rPP

End Markets:
Brands are demanding recycled content and requiring progress reporting to meet US Plastic Pact and other commitments

New Markets:
Virgin PP producers are investing in recycling and recycled content

Advanced Recycling:
New reclamation technologies like PureCycle open the door to reclaiming hard-to-recycle forms, producing food grade rPP with virgin-like properties

Innovation:
Digital watermarks and fluorescent markers on packaging are unlocking the potential of near infrared (NIR) detection and sortation

SPOTLIGHT

Additionally, Braskem, a large supplier of polyolefins, is planning to expand post-consumer resin production as part of the company's new sustainability commitments. Braskem announced a goal to sell 300,000 tons of recycled content products by 2025, increasing that to 1 million tons by 2030[1].

In September 2020, PureCycle Technologies began raising a $250 million bond used to complete the company's first commercial plant in Ironton, OH, which is expected to produce more than 100 million pounds of ultra-pure recycled polypropylene annually[2].

The Recycling Partnership's PP Coalition is focused on increasing collection and sortation, providing grants available to MRFs to improve PP sorting (specifically the recovery of PP #5) and to communities for outreach and education. The need to improve MRF economics by improving bale quality is driving technology improvement through additional optical sorting, AI and robotics. The capability of Advanced Recycling Technologies to accept mixed polymers and hard to recycle forms is creating additional demand for the collection and sorting of plastics (e.g., Recent $100M investment in PRF by IRG).

Conclusion

Polypropylene is a widely used polymer for a diverse array of packaging applications. PP recycling is less mature and has unique challenges compared to other polymers, like PET and HDPE. Advancements in technology and investments in recovery at all levels of the recycling value chain are enabling PP circularity. Plastic Ingenuity will continue to support these circular advancements so we can continue to reap the many benefits this polymer provides.

> **"The goal is to reduce material in both weight and footprint. Beyond that, to move to a material that's more sustainable with regard to either having more recycled content or a more recyclable material."**

[1]Plastics Recycling Update – November 18, 2020
[2]Plastics Today – Oct 15, 2020

CASE STUDY

Tyson Foods Ensures Recyclability through APR Critical Guidance Program

THE RESULTS

7
different designs in tray family

0
compromise to performance

100%
capture rate in the lab simulation

THE CHALLENGE

Tyson Foods, the fastest growing portfolio of protein-centric brands, desired a recycling assessment on their Hillshire Snacking tray family. As Tyson expands its brand, feeding more and more people, they value finding a sustainable way to do it.
The goal of this initiative was to ensure package compatibility with curbside mechanical recycling by leveraging APR's (Association of Plastic Recyclers)' Critical Guidance Recognition Program.

THE PROCESS

Plastic Ingenuity conducted a sustainable packaging assessment of the Hillshire Snacking tray family. This assessment included a recyclability evaluation using APR PP Critical Guidance protocol as a guide. As part of the upfront assessment, Plastic Ingenuity recognized the paper component in the attached label was not compatible with recycling systems.

Plastic Ingenuity facilitated conversation to source a polypropylene label instead of paper. The most difficult and aggressive design was chosen for the Critical Guidance testing. Logic being that if he most aggressive design passes, the others will pass as well. A variety of tests were conducted to simulate the recycling process: sortation, processing, and physical property tests. In addition, the new PP pressure-sensitive label was tested to guarantee there was no impact on recyclability.

THE SOLUTION

Test results showed all required APR protocols were successfully met for the tray and new label.
The results were reviewed with APR, and Critical Guidance Recognition was issued. Overall, Tyson's tray family met and exceeded the strictest APR PP Critical Guidance protocols.

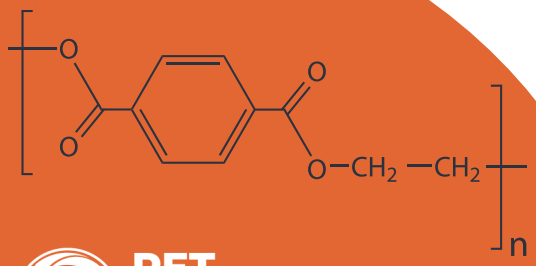
THE IMPACT

APR Tyson Foods Ensures Recyclability through APR Critical Guidance Program

100%

Capture Rate in NIR Sorting Test

SPOTLIGHT: PET RECYCLING COALITION



PET Recycling Coalition
THE RECYCLING PARTNERSHIP

> "How do we get [the consumer] more involved in the circular economy?"

The Recycling Partnership launched the PET Recycling Coalition in 2022 to further bolster the recycling of PET packaging.

The coalition will focus on the following opportunities:

Increasing the capture of PET bottles

Broadening the acceptance of PET trays, cups, and clamshells in community recycling collection programs

Unlocking new supplies of recycled PET for packaging manufacturers

Strengthening recycling systems for pigmented and opaque PET

The coalition provides grants to recycling facilities for capital equipment to improve the capture of PET items, like bottles and thermoforms. This will ultimately lead to increased consumer access to PET recycling systems and additional volume of PCR PET for use in the market. The coalition model combines grants, community level education, and big data analysis to accelerate progress. The effectiveness of this model is evidenced by the rapid progress made in PP recycling enabled by the PP Recycling Coalition in its first two years.

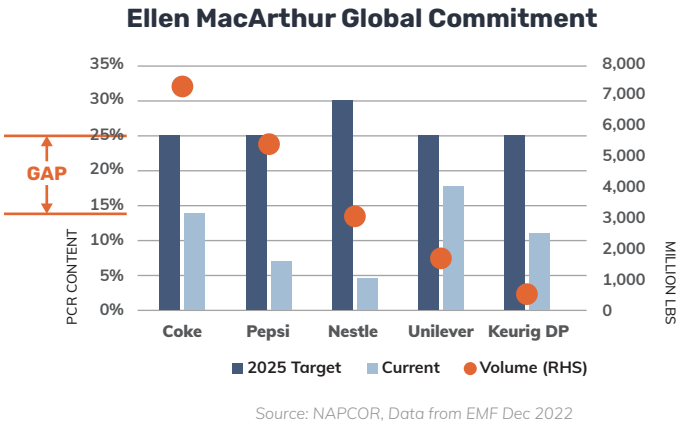
Plastic Ingenuity became the first thermoformer to fund the PET Recycling Coalition in October 2022. Our unique perspective and experience in thermoform circularity will aid the coalition's efforts and derive value for PI and our customers. Key milestones are well within reach, including returning PET thermoforms to "widely recycled" status in the How2Recycle platform.

Please visit PET Recycling Coalition - The Recycling Partnership for more information.

SPOTLIGHT

PET Recycling Landscape

The demand for the use of post-consumer recycled (PCR) PET material in packaging is accelerating, fueled by brand commitments and legislative mandates. The leading global beverage brands have made significant commitments to add PCR PET material to their bottles. These PCR commitments are shown in the chart below, courtesy of NAPCOR[1]. PCR targets are shown in the dark blue bars of the chart, with current level in light blue. Overall volume is shown in orange with the scale on the right-hand side.

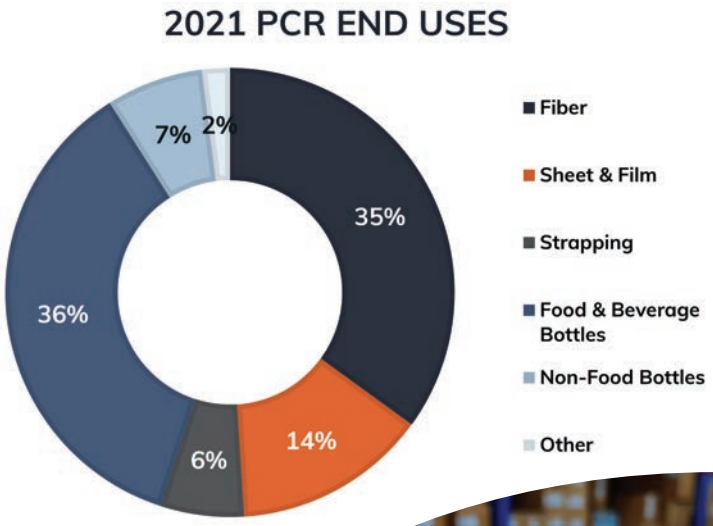


Source: NAPCOR, Data from EMF Dec 2022

The demand for PCR fuels the economic incentives our recycling industry needs to operate.

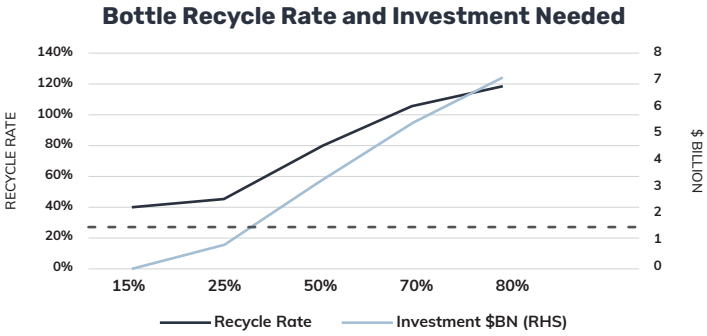
Introducing PCR into packaging keeps valuable material out of our landfills so it can recirculate in our economy. The demand for PCR fuels the economic incentives our recycling industry needs to operate. Outside of the economic benefits, using PCR significantly lowers the carbon footprint of a package and reduces the use of virgin materials. Brands are also discovering that using PCR can enhance brand equity with sustainability minded consumers.

PCR PET is in high demand and packaging applications are competing with other industries over the limited supply. Recycled PET material is used in a variety of end markets. In addition to packaging, a significant amount of recycled PET is consumed in the fiber and strapping industries. These applications can use lower grade PCR PET since they tend to be more forgiving than packaging, and there is significant pressure to increase the amount of PCR in fiber and strapping products. In positive news for packaging end markets, packaging surpassed fibers as the largest consumer of PCR PET in 2020 for the first time ever[1]. Also, it's estimated that thermoforms are the largest consumer of recycled PET material recovered from California's container redemption system.



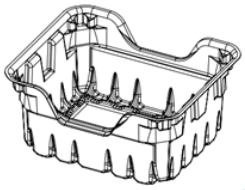
SPOTLIGHT

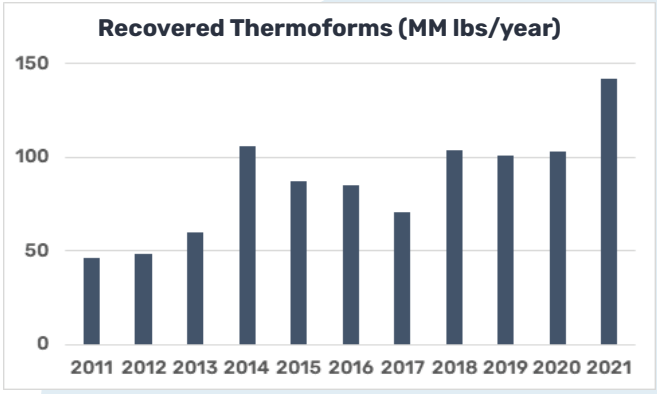
The existing supply of PCR PET is insufficient. In 2021, recycling rates for PET beverage containers were around 28.6%[1]. That can be seen in the dashed line of the chart below[1]. Target PCR content amounts are shown on the x-axis. This model estimates that a recycling rate of 45% would be needed to achieve 25% PCR in all beverage containers, shown in the dark blue line. This would require an investment of nearly $1 billion in reclamation capacity, shown in the light blue line. That does not include investments needed for increased collection and sorting.



Source: NAPCOR

Thermoformed packaging made from PET is recyclable when design for recycling guidelines are applied. However, thermoform recovery rates significantly lag behind beverage containers. A total of 142 million pounds of PET thermoforms were collected in U.S. and Canada in 2021[1]. This equates to a recovery rate of 7.6%, assuming total generation of 1,871 MM lbs. This is much lower than the 28.6% recovery rate for beverage containers. The PET thermoform recovery rate is a conservative estimate, given difficulties quantifying the inputs to the rate calculation. The following chart shows the steadily increasing recovery of PET thermoforms[1]:





Source: NAPCOR

Although 142 million pounds sounds like a lot of material (and it is!), capturing unrecovered thermoforms has the power to transform the PCR market. On a positive note, domestic reclamation of PET thermoforms has increased by 60% since 2017[1]. This is evidence of a rapidly emerging market for recovered thermoforms.

SPOTLIGHT

PET Reclaimer Survey

Plastic Ingenuity surveyed nine of the leading PET reclaimers in North America to get a better understanding of the PCR PET market dynamics. PCR demand in thermoforms is expected to increase significantly over the coming years for the reasons highlighted above. The reclaimers surveyed account for nearly 950,000 U.S. tons of rPET capacity. The reclaimers were asked a series of questions regarding their perspective on the market and current bottlenecks they face. The following sections highlight key learnings discovered during the conversations.

Capacity and Utilization

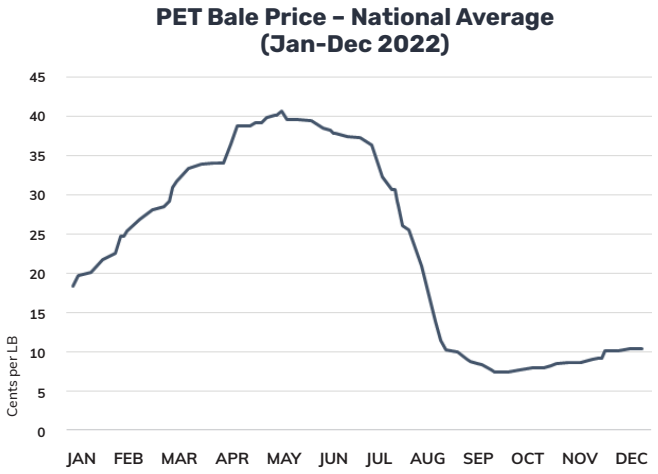
Reclaimers are operating well below their installed capacity. The utilization is calculated to be 67% by dividing the amount of bottles collected (1,928 MM lbs.) by the estimated industry capacity (2,890 MM lbs.) in 2021[1]. Several reclaimers are expanding capacity aggressively despite the bottleneck in bottle supply, while others are taking a "wait and see" approach to expansion. They expressed willingness to invest in new capacity if recovered bottle supplies increase.

Feedstock Sourcing

Most of the reclaimers source post-consumer PET bottle bales from localities near their production facilities. The bottle bales collected from curbside sources do have some percentage of thermoforms. The reclaimers did not list an allowable percentage, but research indicates thermoforms comprise on average 8.1% of a PET curbside bale1. Some reclaimers stated they prefer zero thermoforms in their bales since they primarily sell to bottlers who do not allow them. The reclaimers purchase flake on the open market to supplement their operations when bottle bales are limited.

Feedstock Market

PET bale prices had a volatile year in 2022, as evidenced in the chart below, courtesy of RecyclingMarkets.net[2]. Bale prices spiked to near-record levels in the beginning half of the year with a peak national average around $0.40 per pound. Pricing fell significantly at the end of summer with national average pricing dipping below $0.10 per pound. Consensus opinion is the decline was due to a combination of factors. Supply of recovered beverage containers is highest in the summer months as consumption increases. At the same time, recessionary fears softened demand for PCR in fiber and construction markets. The combination of excess supply and tapering demand shifted the market into a correction. This is worth monitoring since bale pricing has significant implications on the recovery of PET items and PCR adoption in the market.



Source: recyclingmarkets.net

SPOTLIGHT

End Markets

As discussed above, end markets for PCR PET include packaging, such as bottles and sheet for thermoforms, fibers, and strapping. Bottles are viewed as the highest value end market due to the high purity level and physical properties required for bottle-to-bottle recycling. Strapping and fibers are commonly viewed as the lowest value markets.

Equipment Considerations

All reclaimers surveyed deploy solid state polycondensation (SSP) units to increase the Intrinsic Viscosity (IV) of their outputs. It is the IV that determines the physical properties of the PET, with a higher IV being preferred for more demanding applications. The position of the SSP unit in the process does vary from reclaimer to reclaimer. Some are using it after the wash/rinse/dry process while others are using it after pelletizing. The later it is used in the process, the higher the IV that can be achieved with the pellet.

The wash/rinse lines also appear to be areas where reclaimers attempt to differentiate themselves. The effectiveness of the washing process correlates to the level of purity that can be achieved in the final product. Several reclaimers stated they build their own wash lines.

Quality & Certifications

All reclaimers surveyed provide PCR PET with a letter of no objection (LNO) from the FDA for use in food containers. Only one reclaimer surveyed offers certified PCR. This PCR is certified by a third party to be from post-consumer sources. The other reclaimers are self-certifying and audited by their customers for compliance.

Recycled Thermoforms

PET thermoforms are recycled in practice by inclusion in low percentages with PET bottles collected curbside. Material Recovery Facilities (MRFs) typically cap the level of thermoforms included in bottle bales at 10-20% depending on agreements they have in place with their customers, the PET reclaimers. Unfortunately, many of these agreements do not allow thermoforms at any level[1].

MRFs are starting to sort and market thermoform-only bales on the West Coast. This signals that a market is emerging for PCR material from recovered thermoforms, known as thermoform clean wash flake (TCWF). Although the market is just starting to emerge, this demonstrates recovered thermoforms have value.

None of the reclaimers surveyed are marketing TCWF. However, most reclaimers accept thermoforms in their bottle bales.

> **"We need to design for recovery to increase the likelihood of plastic being recycled."**

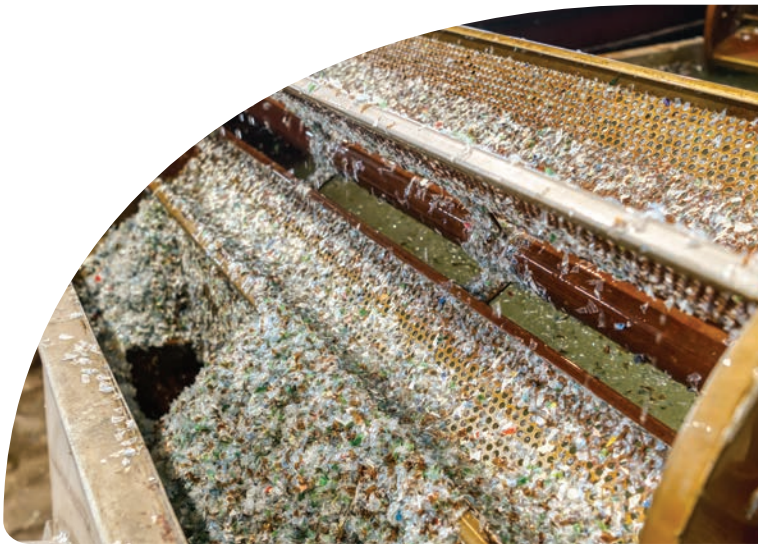
A market is emerging for PCR material from recovered thermoforms, known as thermoform clean wash flake.

SPOTLIGHT

The reclaimers listed a variety of issues with thermoforms in their process:

- Their equipment was not designed to denest or separate thermoforms.
- Residue from labels and food causes issues.
- The shape of the flake (flat, instead of curly) presents conveying challenges.
- Thermoform cracking in hot wash process causes fines that result in yield loss.
- Barrier layers impact efficiency and produce fines.
- Variation in intrinsic viscosity causes issues with the final product.
- Lack of availability of thermoform-only bales hinders ability to experiment.

Several reclaimers expressed a desire to do more work with TCWF as the market develops. Reclaimers expressed equipment can be optimized to process a higher level of thermoforms in bales.



Conclusion

Escalating demand for PCR PET in packaging markets is expected to incentivize efforts to recover additional PET items, like thermoforms, for recycling. These efforts will be catalyzed by initiatives such as the PET Recycling Coalition. PI will continue to support these initiatives, striving to unlock a more circular future for thermoformed packaging.

[1]NAPCOR 2021 PET Recycling Report
[2]recyclingmarkets.net

CASE STUDY

Wahl Transforms Their Packaging from PVC to PET

THE RESULTS

102K
pounds transformed from PVC to PET annually

25
parts/SKUs transitioned to PET

5K
samples produced

THE CHALLENGE

Wahl, a producer of professional and home grooming products, was seeking alternatives to PVC (polyvinyl chloride). The goal for Wahl was to move their packaging material from PVC, a problematic plastic, to PET plastic (polyethylene terephthalate). PVC is a challenging material because it acts as a contaminate in the PET recycling system. The elimination of PVC is a common goal of influential retailers and Non-Governmental Organizations (NGOs).

THE PROCESS

Plastic Ingenuity, a long-term valued partner of Wahl Clipper Corporation, worked with Wahl's packaging engineers to identify potential PVC alternatives. PI engineers evaluated the performance requirements of each tray and suitability for material replacement. PI searched through a portfolio of materials and suggested feasible options for each Wahl application. PET was chosen as the primary replacement option for Wahl given its acceptance in the recycling system and compatible physical properties. In order to qualify the PET structures, PI ran samples of each tray and sent them to Wahl for testing.

THE SOLUTION

It was determined that the packages could be switched from PVC to PET, therefore improving sustainability and circularity. Comparing the legacy product to the new PET version, the PET products are now more recyclable, as durable, and meet NGO and key retailer goals.

THE IMPACT

102K pounds transformed from PVC to PET annually

25 parts transitioned to PET

SPOTLIGHT: HEALTHCARE PLASTICS RECYCLING COUNCIL

HPRC
HEALTHCARE PLASTICS RECYCLING COUNCIL

Applying Technical Knowledge and Experience to Sustainability in Healthcare

The Healthcare Plastics Recycling Council (HPRC) is a technical consortium with members from healthcare, recycling, and waste management industries. The common goal uniting these stakeholders is to improve the recyclability of plastic products and packaging used in healthcare settings. The council's efforts are project-based collaboratives designed to increase plastic recycling efforts in clinical settings. HPRC is active in the United States and Europe.

The council's flagship accomplishments include the Hospicycle toolkit for hospitals seeking to integrate recycling practices into their operations. Their Design Guidance for Healthcare Plastics Recycling is a guide designers can use to optimize their packaging for recycling. HPRC's efforts in the field of advanced recycling research is helping stakeholders understand the potential of the technology to enable a more circular future for healthcare plastics.

Plastic Ingenuity joined HPRC in October 2021 as a regional value chain member. Throughout the course of 2022, PI members were active contributors to HPRC projects aimed at furthering advanced recycling research and updating design for recycling guidance. PI joined the steering committee of HPRC in October 2022 to accelerate progress toward a circular future for healthcare thermoformed packaging and products.

> **"Sustainability will be the future—not just for our company but for the medical industry in general."**

SPOTLIGHT

Healthcare Plastics

Healthcare packaging provides immense benefits to society. Packaging is integral to protecting the devices and products trusted to ensure good health. Plastic packaging has many functional benefits that are difficult to replace without severe compromise, including sterility, durability, and efficacy. These benefits have a direct impact on patient care. Thermoforms are widely used in healthcare settings, from medical device protection to pharmaceutical product preservation.

According to HPRC, over 32 billion pounds of healthcare plastics were produced globally in 2020. This number is expected to grow to 48 billion pounds by 2025. This growth is a testament to the immense utility plastic packaging provides for the healthcare industry. Unfortunately, most of these plastics are disposed of in landfills or by incineration. The need to improve end-of-life outcomes and circularity for healthcare plastics has never been more urgent.

A confluence of forces is inspiring sustainability action in healthcare organizations. Organizations are adapting to the demands of a growing proportion of environmentally conscious end users. Influential NGOs, such as Practice Greenhealth, are accelerating change by providing frameworks and resources for organizations to leverage their sustainability efforts. The buying power of Group Purchasing Organizations (GPOs) and proliferation of Environmental Preferable Purchasing (EPP) initiatives are emphasizing the importance of sustainability factors in purchasing decisions. Sustainable practices and zero waste commitments are emerging at the healthcare facility level. This has ramifications on packaging design and end-of-life considerations. Legislative policy, regulation, and investment community focus on ESG are influencing strategies at the highest levels of healthcare organizations.

Present Day Landscape

The use of plastic packaging in healthcare facilities is abundant. Examples of commonly used plastic packaging include sterilization wrap, irrigation bottles, basins, pitchers, trays, flexible sterile barrier pouches, and rigid sterile barrier thermoformed trays[1]. Nearly all healthcare plastic packaging is incinerated or disposed of in a landfill despite the fact most of these polymers are technically feasible to recycle. For example, irrigation bottles are commonly made of clear high-density polyethylene. Rigid trays are commonly made of clear PET. Mature recycling markets exist for these materials.

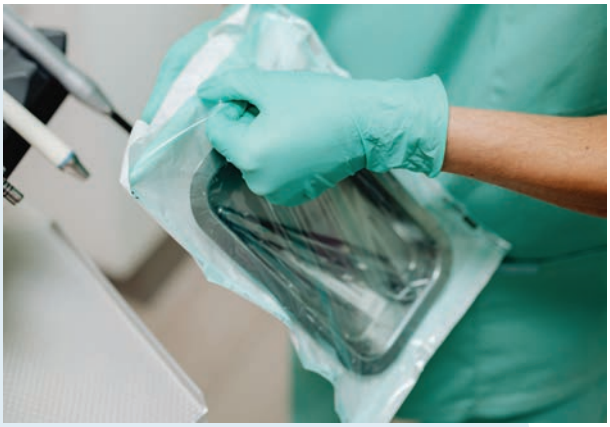
Healthcare packaging faces some unique challenges on the pathway toward circularity. Flexible packaging is used extensively in healthcare settings. HPRC estimates that 60% of plastic waste generated by healthcare facilities is flexible material. These films are often comprised of multiple materials and laminates. Flexibles offer many environmental benefits due to their lightweight nature and subsequent greenhouse gas savings through production and distribution. However, film formats are challenging to recycle and have not been traditionally desired by recyclers as a feedstock.

Healthcare Service Providers (HSPs) lack the infrastructure and systems necessary to efficiently collect, aggregate, and transport their waste to plastic reclaimers for recycling. Although most of the plastic waste generated is non-hazardous, many Material Recovery Facilities (MRFs) view healthcare waste as undesirable due to the perception of contamination. Additionally, the amount of waste generated at an individual provider is not significant enough to incentivize a MRF to collect the waste directly from the provider, thus highlighting the need for volume aggregation.

Nearly all healthcare plastic packaging is incinerated or disposed of in a landfill despite the fact most of these polymers are technically feasible to recycle.

SPOTLIGHT

At the packaging design level, FDA regulatory requirements constrain the use of post-consumer recycled materials in sterile barrier packaging. Advanced recycling is a potential solution for circularity since recycled polymers can be broken down to the molecular level and rebuilt into virgin quality material before entering a new product. Medical device manufacturers are working to determine how to take advantage of the potential of the various advanced recycling technologies. Closed-loop recycling, known as "Take Back" schemes, can provide a circular option for specific applications, but these are challenging to scale and do not make sense for every application.



Opportunities

Stakeholders from all segments of the healthcare value chain are collaborating to identify solutions to overcome the barriers noted above. Solutions to healthcare infrastructure challenges are coming into focus. These include convenient collection stations, on-site storage, and linkage to waste aggregators and recyclers. At the same time, recycling technology is advancing at a rapid pace. This will unlock efficiency gains necessary for the economical recycling of many healthcare packaging formats. Advanced recycling offers potential solutions for hard-to-recycle materials, like flexibles and PETG rigid trays.

The escalating demand for PCR materials in other industries, such as beverage containers and food packaging, and limited supply of traditional feedstocks, are motivating recyclers to explore new feedstock sources. Healthcare plastics are potentially attractive feedstocks for recycling since they are comprised of a high amount of virgin polymers. Source collection, volume aggregation, sortation logistics, and contamination risk management will be key to unlocking this potential.

Packaging designers seeking to increase the circularity of their products can reference the HPRC Design Guidance for Healthcare Plastics Recycling. The guidance pulls in expertise from the global recycling community, including the Association of Plastic Recyclers (APR), RecyClass, and a Circular Economy for Flexible Packaging (CEFLEX). Stakeholders interested in collaboration opportunities to break down barriers to plastics recycling in healthcare can contact HPRC for more information.

Plastic Ingenuity will continue to devote the resources necessary to unlock a more circular future for healthcare thermoforms.

[1]HPRC Advanced Recycling White Paper Phase 1

> One thing that is changing in our environment is that we are trying to use more sustainable materials.

CASE STUDY

Healthcare Packaging Material Innovation

THE RESULTS

133%
increase in devices per pallet

57%
reduction in transatlantic freight costs

52%
reduction in packaging material costs

THE CHALLENGE

Merit Medical Systems, Inc., a manufacturer of single-use medical devices for interventional and diagnostic procedures, turned to Plastic Ingenuity to design a solution to eliminate shipping damage, decrease material waste, and reduce packaging costs.

Merit's inflation devices for angioplasty procedures consist of multiple configurations, including a range of sizes, lengths of tubing, and various gauges. Unfortunately, the delicate gauge often incurred damage during global distribution from vibration, shock, and environmental stresses. Due to the challenges Merit faced passing validation, the product line launched using single-device, single-use packaging consisting of a PETG tray and insert, Tyvek lid, carton, and heavy duty corrugate. As the product line expanded, this stop-gap solution led to increasing material waste, labor, warehousing, and distribution.

THE PROCESS

Material selection is critical for shipping trays. Commonly used materials like HIPS are rigid and unforgiving. To develop a solution capable of delivering the protection required, we leveraged Eastalite™ copolyester, a novel foamed PETG material. As the first commercial Eastalite™ application on the market, this material provides a lower density than traditional rigid materials, greater abrasion resistance, and improved shock absorption and impact strength.

After selecting the material, we designed a bulk universal tray capable of accommodating all devices, sizes, and configurations with one tray. The universal cavity design prevents device vibration and movement, improving product protection with zero rejects in the bulk pack solution.

THE SOLUTION

Our universal transport tray design innovation created a single packaging component that works with multiple devices within the same product line. The design not only accommodates all devices, sizes, and configurations in one tray, but it also offers improved product protection, minimum bending to the flexible tubing, no tray-to-product contact, and reusability. This first-to-market Eastalite™ application provides cushioning to prevent damage to the delicate device while being robust enough for reuse ≥ 4x.

The solution exceeded all functional, economic, and environmental goals. With increased efficiencies, the packaging labor burden was reduced 57% and cube utilization was optimized 133% to accommodate 1,400 devices/pallet vs 600 devices/pallet.

THE IMPACT

57% reduction in transatlantic freight weight costs

20K LBS.

yearly packaging material waste reduction

"What will resonate with consumers, and effectively motivate behavior change?"

GOOD INFORMATION

A GUIDE TO

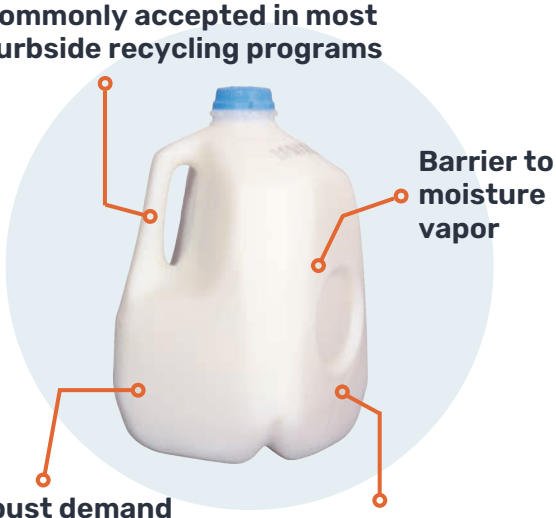
Essential Polymers

1 PET Polyethylene terephthalate

Water bottles ▫ Produce containers ▫ Soda bottles

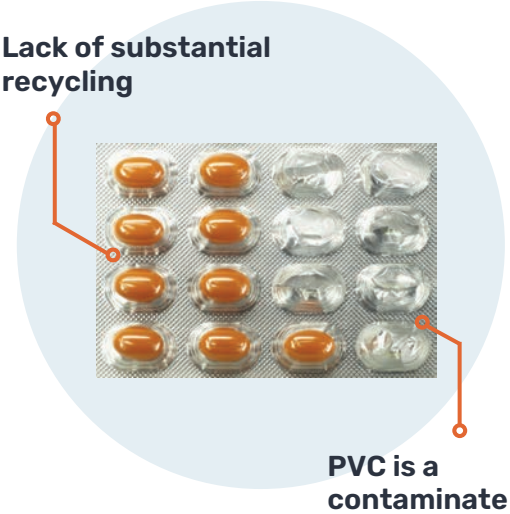
2 HDPE High-density polyethylene

Milk jugs ▫ Shampoo bottles ▫ Detergents



3 PVC Polyvinyl chloride

Siding ▫ Pipes ▫ Blister Packs



4 LDPE Low-density polyethylene

Grocery bag ▫ Six-pack rings ▫ Tubing

Not typically accepted in most curbside recycling programs

LDPE films jam material sortation equipment

Best way to recycle is dropping off at a local store collection bin

5 PP Polypropylene

Drink cups ▫ Yogurt cups ▫ Rigid trays

Increasingly accepted in most curbside recycling programs

PP is often sent to the low value mixed bales

Sortation optimized with automation technology

6 PS Polystyrene

Meat trays ▫ Drink cups ▫ Plastic utensils

Foamed PS provides very low GHG emission benefits during transportation

Not recycled at a high rate as sortation facilities struggle with low bulk density

7 OTHER All Others

POLYETHYLENE TEREPHTHALATE GLYCOL (PETG) IS THE MOST COMMON

Clamshells ▫ Jars ▫ Medical device packaging

PET and PETG look similar and can cause issues when mixed with PET bales

Much of PETG is used at hospitals which do not have the infrastructure to efficiently recycle PETG

Sustainable Packaging in the Eyes of the Consumer

The evolution of packaging is a reminder of how innovation and education impact consumer behaviors. There is a rich history in the United States of leveraging messages to drive new behaviors around consumption and waste. In the 1940s the message was “Use it up and wear it out” for the war effort. In the 1950s-1960s the narrative changed to “Buy what you want and throw it away.” The 1970’s decade witnessed a shift to the simple “Don’t litter” campaign. Next came the “Reduce, reuse, and recycle” messaging in the 1980s-1990s. Currently, the simple mantra of “Recycle” has grabbed the reigns, with the other Rs quietly stepping aside[1].

Changing and convincing consumers’ behaviors to focus primarily on recycling has been an effective endeavor in the court of public opinion since the early 2000s. According to the Shelton Group, 95% of Americans think recycling helps the environment, while 75% say it’s the best way to help our planet[1]. Additionally, 76% of American consumers say recycling makes them feel better about purchasing goods and services[1].

Across all end-use segments, 60-70% of consumers would pay more for sustainable packaging.

However, despite the overwhelming support for recycling, 49% of Americans believe the recycling system is flawed and not effective[1]. Even more telling, 30% are not confident their recyclables are being recycled, a drastic increase from 2019 where only 14% of consumers lacked confidence in the recycling world[1].

A reported 42% of Americans want to be viewed as responsible consumers doing their utmost to buy products and packaging that is sustainable[1]. If the consumers believe their recyclables are being landfilled, despite their efforts, the prospect of recycling begins to lose its trust and momentum.

It is critical for brand owners to address these concerns and provide new solutions and messaging to adjust and validate behaviors once again. Further erosion of the consumer’s trust is not a path to sustainability.

> **“We try to have zero impact on the environment.”**

Consumer Insights

What is the message, then? What will resonate with consumers, and effectively motivate behavior change? Let's go back full circle to the 1940s when the messaging was "Use it up and wear it out," a reference to utilizing materials until the efficacy has been exhausted, prolonging usefulness and extending viability. That is the core message behind today's push to increase circularity.

To understand the current state of consumer thinking, and the potential to evolve to a circular economy, McKinsey launched a survey in 10 countries around the world to evaluate consumers' attitudes toward packaging. Responses from the US uncovered five key findings surrounding the packaging landscape[2].

Overall, consumers rank sustainability relatively moderate as a buying consideration. Consumers in the survey prioritized price, quality, brand, and convenience as more important than sustainability. This trend was evident in the packaging realm as well. The benefits of hygiene, shelf life, and convenience ranked higher than environmental impact. This shift can partially be attributed to the impact of COVID-19, and the renewed concern for health and safety.

Second, despite the moderate ranking for sustainability preferences, 55% of survey respondents remain concerned about the environmental impact of packaging[2]. They worry about a wide range of issues, not one single factor, such as ocean debris. It's more than that.

Third, consumers are willing to pay more for sustainable solutions, and would consider purchasing additional sustainably packaged products if more were available, and clearly labeled as sustainable or recyclable.

Fourth, if you ask consumers what they want to see going forward, they are almost equally interested in recyclable and recycled plastic packaging, and in fiber-based substitutes, with 53-57% of consumers viewing plastics as extremely or very sustainable[2].

The Future of Packaging According to Consumers

Many industry participants are asking themselves whether consumers will pay for sustainable solutions. These are some of the responses and statistics gleaned from the survey[2]:

Incremental improvements using existing substrates could probably be introduced fairly rapidly across most end-use areas surveyed.

Fast-food packaging available today vs preferred in the future, % of respondents

Fiber-based | Multi-material/laminated | Plastics based | Glass or metal | No preference

	Available alternative packaging preferred now[1]	Preferred alternative packaging in the future[2]
Paper-based cartons	31	16
Flexible paper	31	14
Packaging combining plastic, paper, and aluminum foil	21	15
Plastic bottles and containers made out of recycled plastic materials	18	14
Aluminum foil wraps	16	11
Plastic bottles and containers that are fully recyclable	16	18
Plastic films that are fully recyclable	15	22
Plastic films made out of renewable raw materials that are compostable	14	21
Metal containers	10	7
Glass bottles and jars	8	12
None of these packaging types are available to me in this product category	7	20

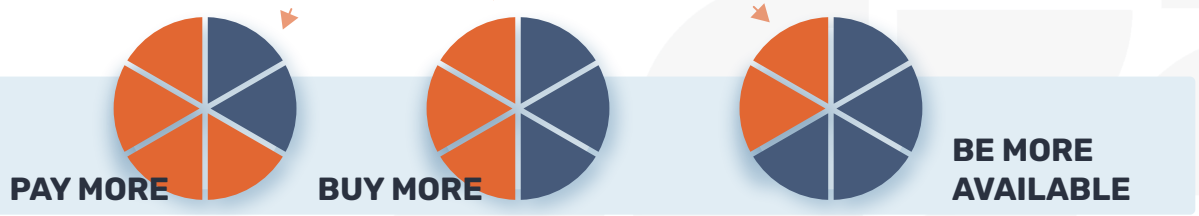
[1]Question: Which of the following package types have been available to you as alternatives when purchasing products in this category?
[2]Question: What types of sustainable packaging would you like to see made available to you in the following product category?

Source: McKinsey & Company Packaging Survey (Aug 2020)

Across all end-use segments, 60%-70% of consumers would pay more for sustainable packaging. A willingness to pay more was equally distributed across end-use segments.

Half (52%) of consumers said they would buy more products with sustainable packaging if those products didn't cost more than conventionally packaged ones.

Approximately 35%-36% of respondents would buy additional sustainably packaged products if they were more available in stores, available for more products, and better labeled to indicate sustainable packaging.



Consumer Insights

The last bullet is noteworthy because it highlights price isn't the only influence on purchasing behaviors. Ensuring consumers understand they are buying more sustainable packaging is a crucial factor to emphasize.

The survey also assessed what kind of sustainable packaging US consumers expect to see more often. Preferences vary across the different end-use areas surveyed. Although not all consumers have strong specific preferences, a few common themes can guide players in the packaging value chain as they get to grips with consumer priorities[2]:

Consumers are equally interested in recyclable and recycled plastic packaging and in fiber-based packaging. Their specific preferences depend on the end use.

Overall, consumers want plastic film and rigid packaging to be recyclable or to include higher levels of recycled content.

Consumers expect more compostable packaging to be introduced.

Within specific categories, consumers prefer:

Produce (fresh fruit, vegetables, fresh meat)
Consumers want more recyclable or compostable films and more paper- and board-based packaging.

Beverages
The most important request is for plastic bottles that are more recyclable or entirely made from recycled content. In this segment, consumers also ask for more metal and glass packaging.

Packaged dry food
This segment similarly has a prominent level of interest in recyclable and recycled plastic packaging and fiber-based packaging.

Dairy products
We found strong demand for plastic packaging (both flexible and rigid) that is either fully recyclable or compostable or includes recycled content.

Frozen food
US consumers want plastics with more recycled content.

Pet food
US consumers want plastics with more recycled content.

Household products
As with beverages, US consumers ask for plastic packaging with more recycled content and high recyclability.

If we've learned anything over the past 80 years, we realized that consumer behaviors will change based on education and industry innovations.
The messages will continue to evolve, and the most successful brands will adapt to these trends and behaviors to help achieve our goals to become a self-sustaining, circular economy.

[1]Shelton Grp
[2]McKinsey Report

MYTH-BUSTING FACTS

MYTH: Consumers just need to recycle more!

FACT: Yes, consumer behavior is very important, but only 52% of American households have access to curbside recycling programs. We need to expand equitable access to recycling for all Americans and build trust in the system.

Source: The Recycling Partnership, Paying It Forward

MYTH: Plastics are a major contributor to climate change.

FACT: Plastics typically have a lower carbon footprint than alternatives. A 2022 report from McKinsey found that plastics offer greenhouse gas (GHG) savings in 13 of 14 packaging applications studied compared to alternative materials. The GHG savings ranged from 10-90%.

Source: McKinsey, Climate impact of plastics

MYTH: Plastic recycling is broken.

FACT: According to the EPA, nearly 6.2 billion pounds of plastic were recycled in 2018. This figure provides evidence of a functional recycling ecosystem for plastics. We need to expand recycling access, fix system-wide challenges, support emerging end markets, and design packaging to be recycled in practice for our recycling system to truly thrive.

Source: EPA Plastics: Material-Specific Data

MYTH: Plastics in healthcare settings are not recyclable.

FACT: 90% of healthcare plastics can be recycled using mechanical or advanced recycling processes. A vast majority of these plastics are free from bio-hazard contamination.

Source: HPRC Advanced Recycling Research

MYTH: There will be more plastic than fish in the sea by 2050.

FACT: We need to address plastic debris in our waters, but this claim is unsubstantiated as an article from BBC illustrates.

Source: BBC, Will there be more fish or plastic in the sea in 2050?

MYTH: Thermoforms are not recycled.

FACT: According to NAPCOR, 142 million pounds of PET Thermoforms were recovered in 2021. That sounds like a lot of material (and it is!) but we need to do better (and we will!).

Source: NAPCOR 2021 PET Recycling Report ($)

Letter from Sakif Ferdous — Chief Revenue Officer

When I had the opportunity to join Plastic Ingenuity in 2020, I had to take a moment and evaluate whether joining a plastics company aligned with my core values as a person. As someone who grew up in Bangladesh, I was all too familiar with the issue of plastic waste. Bangladesh was the first country in the world to ban plastic shopping bags – more than 20 years ago – but to questionable effect. Plastic bags still littered our streets, clogged our rivers, and hung off our telephone wires. This reality made me think: Why – despite an outright ban, frequent crackdowns by the government, and high visibility of the problem – were plastic bags still a litter issue? Perhaps it is because the issue of plastic waste is a complex problem that defies a simple solution.

Solving such a complex problem requires a data-driven approach, collaboration among stakeholders, and a resistance to knee-jerk reactions. Most importantly, it requires time and intellectual honesty. Regardless of where we stand in the plastic waste debate, we must ask ourselves a few important questions to forge the best path forward:

1. What benefits do plastics provide in the context we are evaluating?
2. What is the true cost of plastic – economical, environmental, and social, within this context? How does it measure up against the benefits?
3. What are some viable, scalable alternatives? What are their true costs?
4. Which path – elimination, alternative materials, reduction, reuse, recycling, or something else – provides the highest benefit for the lowest true cost in this context?

These questions are not easy to answer. There are a lot of "it depends" responses, since so much of the ideal solution does indeed depend on the individual use case, disposal scenario, and access to recycling infrastructure. One must also factor in legislation and market trends to ensure that we aren't just solving for current conditions, but also looking ahead to the future.

These questions are complicated enough that we launched an entire suite of circularity services in 2022 – including Sustainable Packaging Assessments, Recyclability Consulting, and Life Cycle Analysis – to help our customers make informed decisions specific to their package. Some outcomes – like material reduction and incorporation of PCR content into existing designs – were relatively straightforward. Others – like obtaining Association of Plastic Recyclers (APR)'s Critical Guidance Recognition or developing novel, sustainable materials – were far more complex. Regardless of the effort required, the PI team excelled in finding the best solution to each customer's unique sustainability objectives.

When I joined PI over two years ago, I was neither an expert in plastics nor in sustainability – just someone who recognized a complex problem and wanted to be part of the solution. Since then, I have had the opportunity to dive deep and learn from some of the best minds in the industry. The reality is that the performance and benefits provided by plastics are impossible to match with other materials today, at least without significant tradeoffs in GHG emissions. Unfortunately, plastics – like many other packaging materials – also contribute to the accumulation of waste. Both these statements are true, and it would be dishonest to pretend otherwise. At PI, we believe we can solve the waste issue by creating a truly circular economy, and this report highlights the many ways we are doing our part and some of the results we are already seeing. This is only the beginning.

Best Regards,

Sakif Ferdous

Sakif Ferdous

GLOSSARY OF TERMS

Association of Plastics Recyclers (APR) = International trade association representing the plastics recycling industry.

Advanced Recycling = A suite of novel recycling techniques that turns plastic polymers back into their original molecules so they can be used again in new products. These processes make it possible to recycle formats that are difficult to recycle mechanically.

Carbon Footprint = Total amount of greenhouse gases (including carbon dioxide and methane) that are generated by a product, process, or service. These greenhouse gases are the main contributors to climate change.

Circular Economy = A model of production and consumption that reuses, refurbishes, and recycles existing materials and products as long as possible.

Circular Economy for Flexible (CEFLEX) Packaging Initiative = Collaboration of over 180 European companies, associations, and organizations representing the value chain of flexible packaging, working to make all flexible packaging in Europe circular by 2025.

Circularity = Measure of a product or service's alignment with the objectives of a circular economy.

Environmental Social Governance (ESG) = Stakeholder-centric approach for doing business in an ethical manner, focused on the impact of a company in the areas of Environmental, Social, and Governance.

Environmentally Preferred Purchasing (EPP) = Practice of purchasing products or services that have a less negative effect on human health and the environment.

Group Purchasing Organization (GPO) = Leverages the collective buying power of its members to secure discounted prices from suppliers and retailers.

Healthcare Plastics Recycling Council (HPRC) = Consortium of industry peers across the manufacturing, healthcare, and recycling industries seeking to improve the recyclability of plastic products and packaging within healthcare.

Life Cycle Assessment (LCA) = Methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service.

GLOSSARY OF TERMS

Material Recovery Facility (MRF) = Receives single stream post-consumer waste for communities, typically made of paper, glass, plastic, aluminum, and steel. Sorts those articles into bales for sale to material reclaimers for processing into usable material.

Mechanical Recycling = Process to recover plastics waste via mechanical actions involving grinding, washing, separating, drying, re-granulating, and compounding. The polymers stay intact.

Non-Governmental Organization (NGO) = Nonprofit organization that operates independently of any government, whose purpose is to address a social or political issue.

Post-Consumer Recycled (PCR) Content = Materials made from items that have served their intended purpose in the market.

Post-Industrial Recycled (PIR) Content = material waste generated during mass production that is later used to manufacture new products.

Reclaimer = A company that purchases sorted and baled post-consumer articles from MRFs and processes back into usable material for sale into recycled material end markets.

Recyclable = Per Federal Trade Commission Green Guides, the following criteria must be met to claim a product is recyclable:

Collection = 60% of Americans must have access to collection systems for the item.

Sorting = It must be able to be sorted with like items and materials.

Reprocessing = It can be turned into a reusable material in an economical manner.

End Markets = Robust end markets for the recycled material must be available.

RecyClass = Cross-industry initiative that advances plastic packaging recyclability while promoting the traceability of plastic waste and recycled plastic content in Europe.

Recycled Content = Material derived from recycling a product.

Recycling = The process of converting waste into usable material.

GLOSSARY OF TERMS

Resin ID Code (RIC) = Numbering system managed by American Society for Testing and Materials, known as ASTM International (ASTM), for the identification of plastics for sortation purposes. The RIC is not intended for consumer instruction on the ability to recycle a product.

Sustainable Packaging Coalition (SPC) = Member-based organization whose mission is to bring sustainable packaging stakeholders together to catalyze actionable improvements to packaging systems and lend an authoritative voice on issues related to packaging sustainability

Sustainability = Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

PLASTIC INGENUITY

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Thermoform Circularity Report 2023

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