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CMI Recycling Committee
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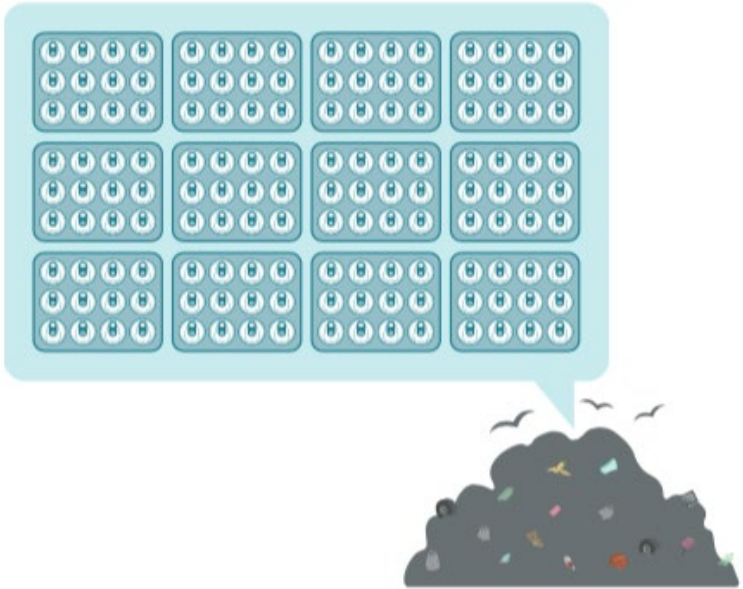
RECYCLING UNPACKED

The average U.S. citizen consumes 800 beverages packaged in disposable containers each year.

Despite current recycling efforts, the majority of these 200+ billion containers end up in the trash.

Around 45 billion aluminum cans end up in landfills each year in the United States alone. That's the equivalent of each U.S. citizen tossing nearly a dozen 12-packs of used aluminum cans in the trash every year.



This is a symptom of our linear model of consumption, where valuable materials are lost rather than being recovered for continued, high-value reuse.

What would be the impact savings over time if all these materials were collected and recovered instead?

This study explores the circular potential for each packaging type under current and future scenarios, considering how product design and recycling infrastructure influence the quality and quantity of material recovered over multiple recycling loops.

We find that aluminum cans have the highest **circular performance** and the highest **circular potential** of three beverage packaging materials evaluated in the United States.

According to our model, collecting and recycling 100 percent of aluminum cans compared to the 2020 baseline has the potential to save an additional **6 million metric tons of carbon dioxide equivalent (CO2e) each year** - the same as the annual CO2e emissions from electricity used in over 1 million U.S. homes.

Circular Economy: A Few Definitions

A circular economy is an alternative to the current linear model; it is waste-free by design, leverages renewable resources, and equitably generates economic, natural, and social capital safely within the planetary boundaries.

It acknowledges that we live on a planet with finite resources, and therefore aims to retain valuable and critical materials flowing in the economic system at their highest and best value.

Closed-Loop Recycling:

Refers to reintegrating recycled materials back into the same type of product without significant losses in material quality or functionality. In this paper, we use bottle-to-bottle and can-to-can recycling as a proxy for closed-loop recycling, to highlight the circular potential of recovering and reusing these materials at the same quality over multiple recycling loops.

Open-Loop Recycling:

Refers to using recycled materials in products that differ from the original product system, typically changing the material quality or function. If the material loses significant quality or value, this can also be referred to as downcycling.

See Metabolic's Seven Pillars of the Circular Economy framework for more information: https://www.metabolic.nl/news/the-seven-pillars-of-the-circular-economy

A successful recycling system should create a strong and reliable source of secondary materials that can compete with primary resource production.

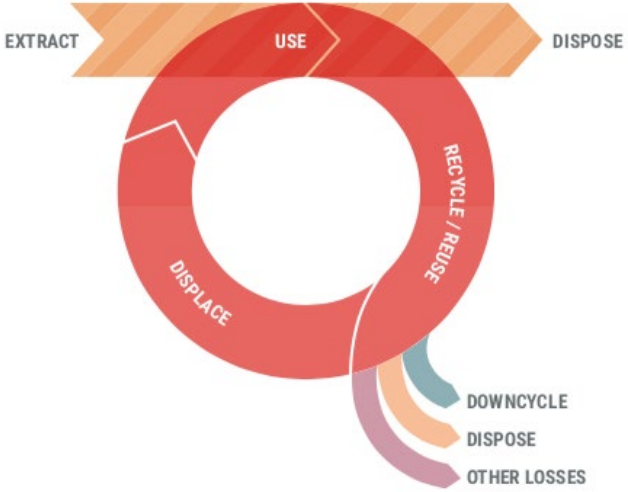
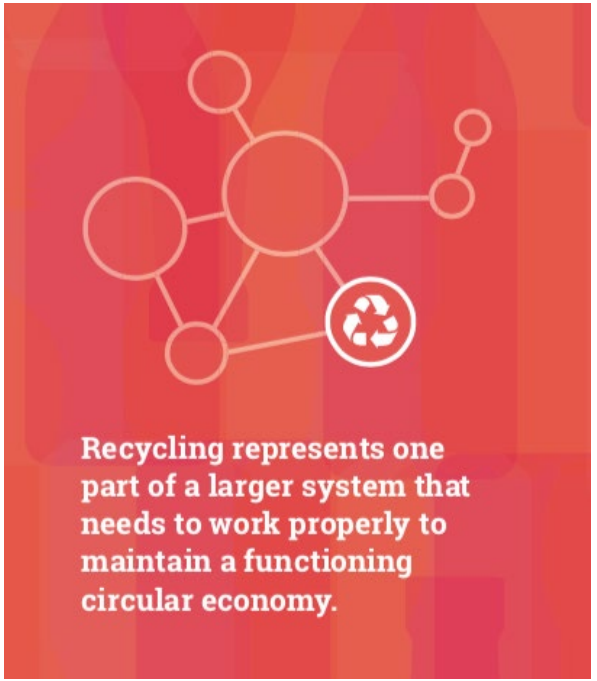


Fig. 1 Stages in a circular material recovery system.



Product design and material selection are key criteria for circular performance.

The way a product is designed, and the inherent properties of the materials it is made of, greatly influence whether the product is destined for continuous circulation or eventual disposal.

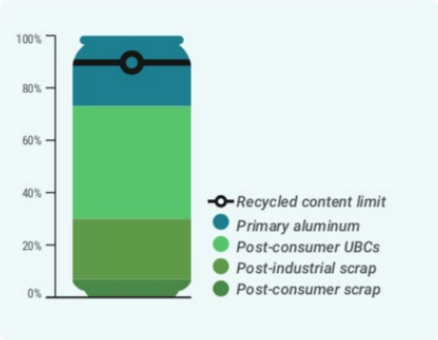


Fig. 2 Recycled content of an aluminum can[23,24]

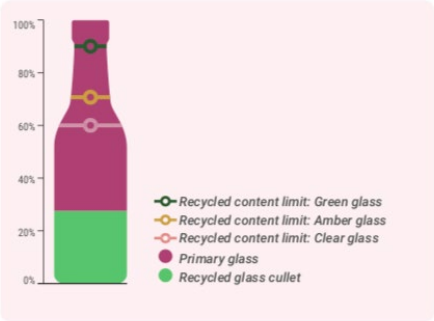


Fig. 3 Average recycled content and maximum recycled content for different colors of glass bottles

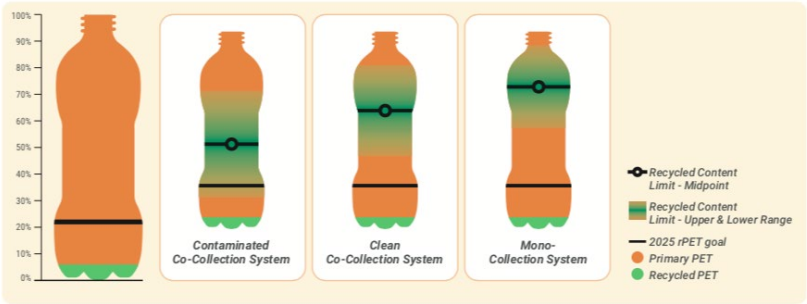


Fig. 4 Estimated recycled content amount, goals, and recycled content limit thresholds for PET bottles

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Our analysis combines three methods to assess the current circular performance and impact reduction potential under future improved collection scenarios for aluminum cans, glass bottles, and PET bottles.

Impact Assessment

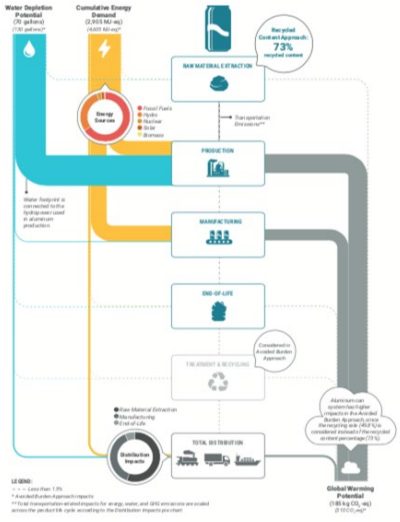
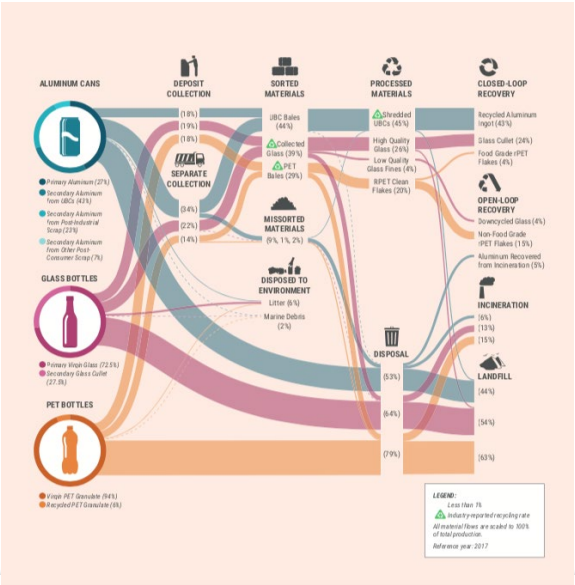


Fig. 8 **Aluminum Cans: Environmental Impacts per Life Cycle Stage**
Functional Unit: Provision of 1000 L of beverage in 12-oz cans, 0.0334 kg per can, 73% recycled content (recycled content approach), 49.8% recycling rate (avoided burden approach). Use phase excluded from scope of this assessment.

Material Flow Analysis



Dynamic Model Scenarios

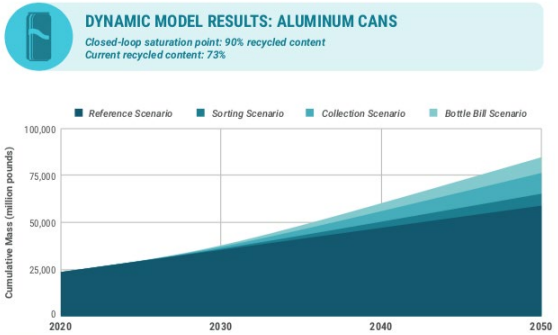


Fig. 13 **The cumulative amount of aluminum recovered (both open-loop and closed-loop) with each modeled scenario.** The bottle bill scenario provides an increase of 44% more material recovered within 30 years, compared to 29% for the collection scenario, and 11% for the sorting scenario.

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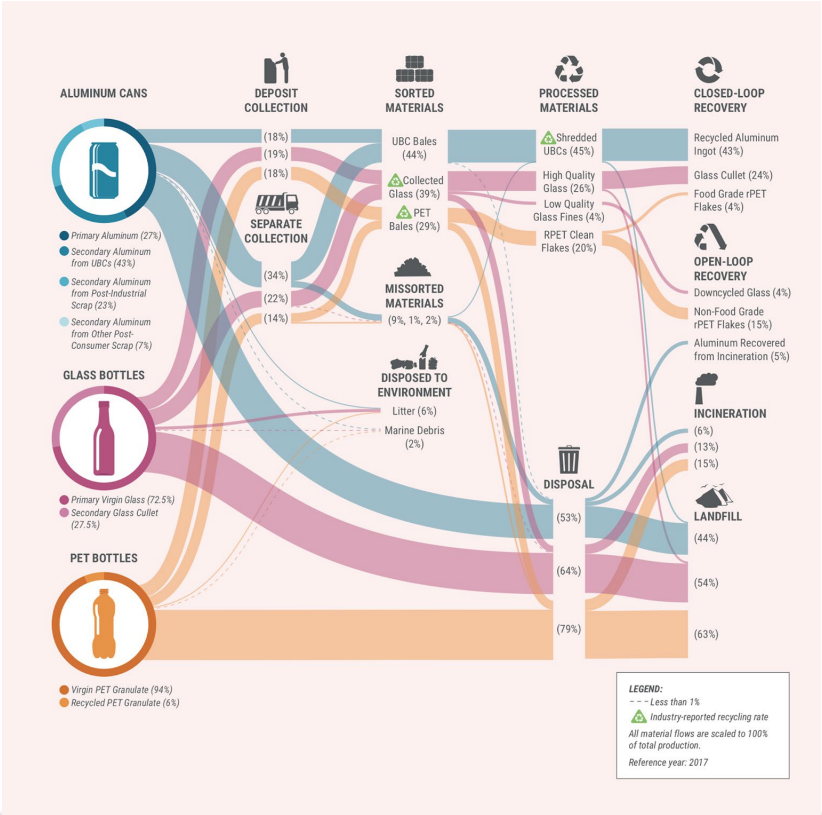
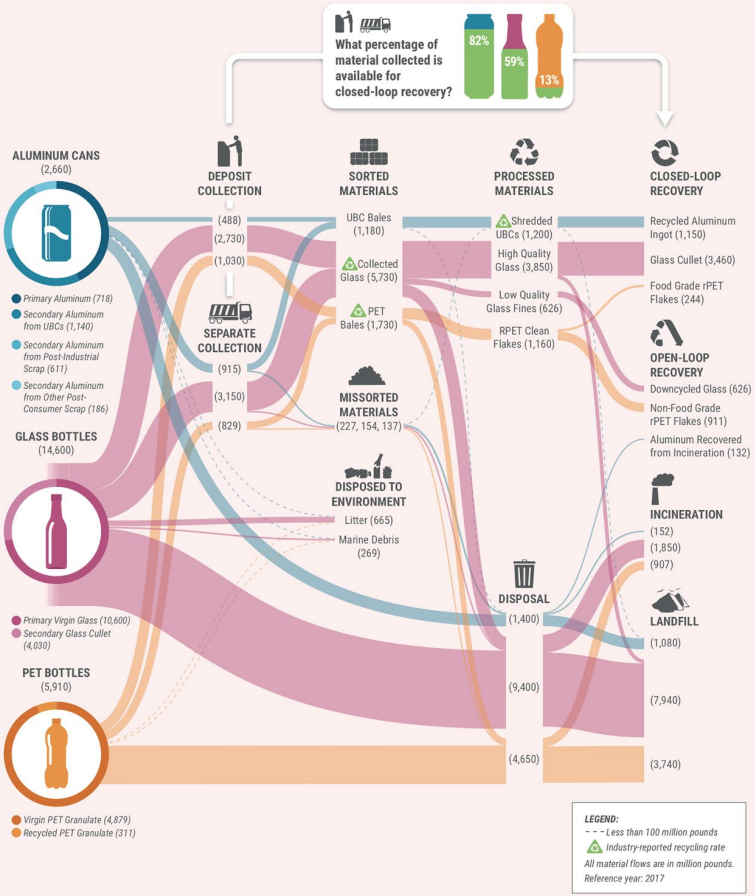
Material Flow Analysis Overview





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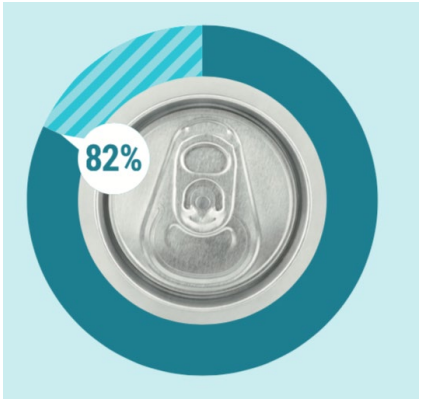
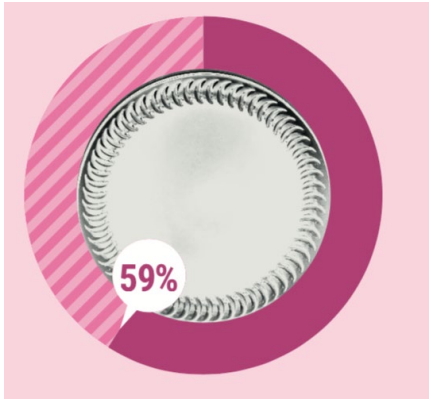
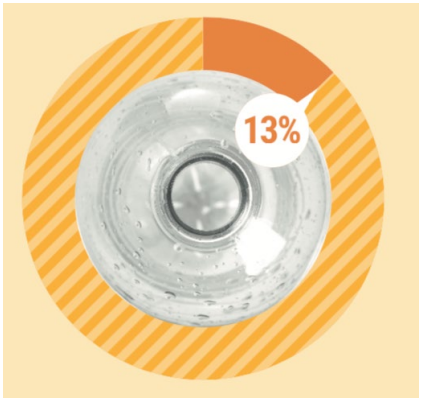
In the current system, aluminum cans perform highest on circularity.

More than 80 percent of beverage cans collected for recycling are recovered and turned back into new beverage containers, compared with 59 percent of glass bottles and 13 percent of plastic PET bottles.







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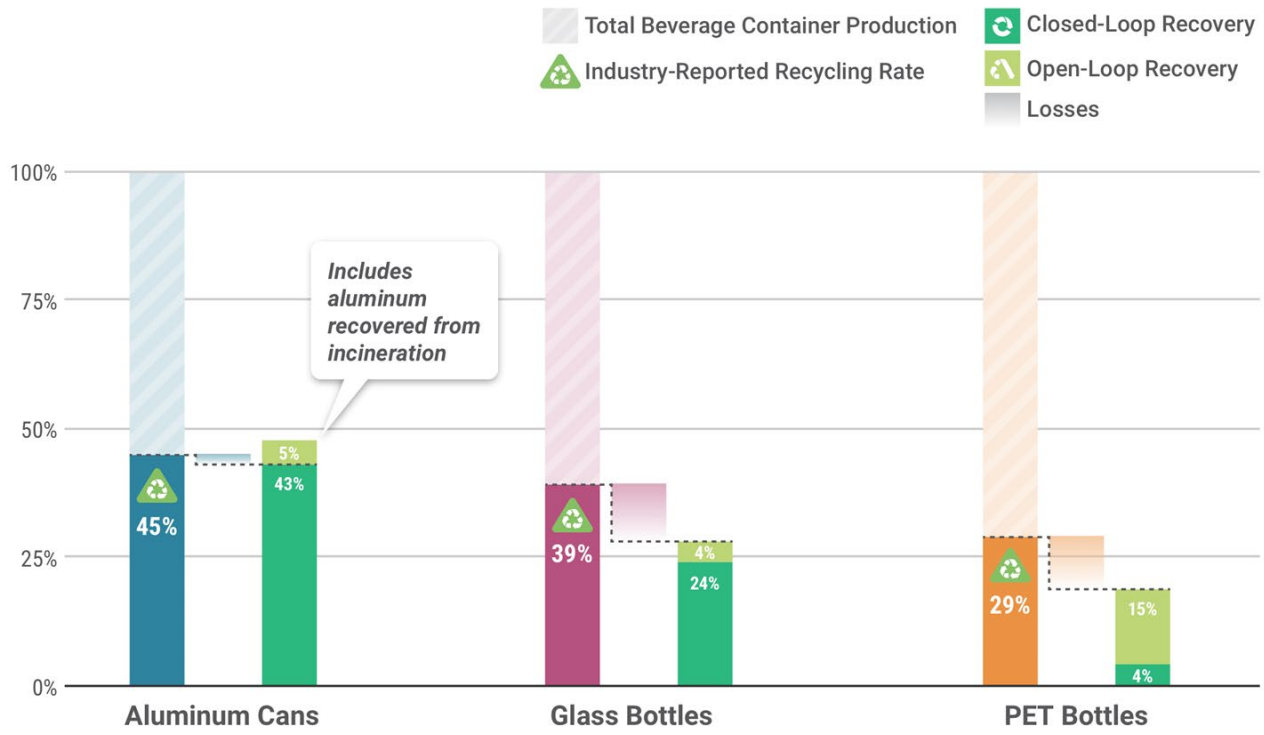
Aluminum cans show the highest processing efficiency for each packaging type, with most processed material available for high-value recovery.



Aluminum cans also show the highest impact reduction potential under all modeled scenarios, considering both open- and closed-loop material recovery.

1 TECHNOLOGY

Sorting scenario: Increase sorting efficiencies to improve material recovery yields (reaching 100% sorting efficiency by 2040)

2 BEHAVIOR

Collection scenario: Increase collection of materials through existing curbside recycling infrastructure (reaching 100% collection by 2040 through existing systems)

3 POLICY

Bottle bill scenario: Implement a national bottle bill to increase material collection and improve the quality of material streams (reaching 100% collection by 2040 through deposit systems)

Pack Type	Collection Scenario			Sorting Scenario			Bottle Bill Scenario		
	GWP	WDP	CED	GWP	WDP	CED	GWP	WDP	CED
Aluminum	-33%	-57%	-25%	-15%	-23%	-12%	-35%	-57%	-27%
PET	-2%	+3%	-1%	-1%	+1%	-1%	-26%	-1%	-26%
Glass	+2%	+14%	-1%	0%	0%	0%	-1%	+14%	-9%

GWP = Global Warming Potential; WDP = Water Depletion Potential; CED = Cumulative Energy Demand

Table 2 **Closed-loop production-related impact reduction potential** [% change from 2020 baseline]

Pack Type	Collection Scenario			Sorting Scenario			Bottle Bill Scenario		
	GWP	WDP	CED	GWP	WDP	CED	GWP	WDP	CED
Aluminum	-29%	-55%	-20%	-9%	-18%	-6%	-60%	-115%	-41%
PET	-12%	-5%	-15%	-1%	-1%	-1%	-1%	+1%	-1%
Glass	0%	0%	0%	0%	0%	0%	-10%	-3%	-9%

GWP = Global Warming Potential; WDP = Water Depletion Potential; CED = Cumulative Energy Demand

Table 3 **Open-loop impact reduction potential** [% change from 2020 baseline]

Tailored recommendations for each packaging type:

Aluminum cans perform well in the current recycling system, but collection rates need to increase to keep materials circulating at high value.

Glass bottles should be directed towards localized reuse systems to maximize impact reduction potential.

PET bottle producers should prioritize advocating for bottle deposit systems, while exploring energy-efficient chemical recycling opportunities for material that can no longer be mechanically recycled.

Rolling out bottle deposit collection systems across the United States would greatly improve the circular performance of all three packaging types.

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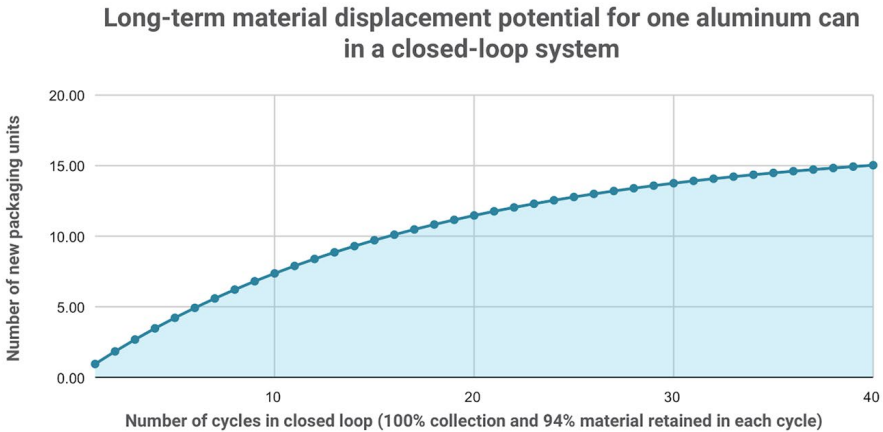
Aluminum cans are well positioned to remain the most circular beverage container in the long term, assuming circularity and impact reduction remain key objectives moving forward.

Why does aluminum perform so well in our assessment?

- High recycled content
- Minimal processing losses
- Hydropower-based electricity use
- Able to be recovered and put back into the system at a high value for multiple recycling loops



Aluminum cans are well positioned to remain the most circular beverage container in the long term, assuming circularity and impact reduction remain key objectives moving forward.

Opportunities for improvement:

- Built-in incentives for collection (i.e. through deposit systems)
- Improve sorting technologies at MRFs, install additional eddy currents
- Explore ways of separating the can body from the lid in the recycling process, and invest in alloy sorting technologies to maximize recycled content potential
- Maximize recycled content, eliminate or minimize the need for primary aluminum in the can
- Monitor material displacement rates from a system-wide perspective

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