

SINGLE-ALLOY RESEALABLE BEVERAGE CAN

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Primary Topic

Recovery & Recycling of Packaging Materials

Secondary Topic

Building a Circular Economy for Products and Materials

ABSTRACT

Canovation has developed CanReseal®, the world's first all-metal, resealable can designed for seamless integration into existing food and beverage can manufacturing. CanReseal's beverage can design represents a transformative opportunity for U.S. recycling, energy efficiency, and supply chain resilience.

Today's beverage cans average ~71% recycled content in the US, limited by the 5xxx series alloy required for today's standard pop-top ends (The Aluminum Association, 2024). This design complicates recycling streams, lowers efficiency, and constrains secondary aluminum use. CanReseal's ring end design (CRE®) eliminates the need for ring pull tabs and scored opening, enabling can ends to be produced from a similar 3xxx series aluminum as the can body, creating a single-alloy beverage can capable of being made from 100% recycled content (International Aluminium, 2024).

A single-alloy beverage can simplifies material recovery, making U.S. recycling infrastructure more efficient and profitable. By raising the recycled content of cans, CanReseal reduces energy demand for primary smelting, aligning directly with U.S. energy-saving goals. Expanded domestic recycling capacity, incentivized by a consistent scrap stream, strengthens U.S. supply chains by reducing reliance on imported critical materials that are often subject to tariffs and geopolitical risk.

This shift has national security benefits as well. Aluminum is a critical material for both civilian and defense applications, and ensuring a robust, circular domestic supply reduces vulnerability to foreign supply disruptions. By keeping more economic value within U.S. borders, CanReseal supports domestic manufacturing competitiveness and reinforces long-term industrial resilience.

In addition to energy and security advantages, CanReseal supports sustainability objectives by lowering scope 1 and 2 emissions for manufacturers & suppliers, and scope 3 emissions for food and beverage brands. Replacing today's can ends made mostly from primary aluminum with an equally recyclable, 3xxx series aluminum solution strengthens the circular economy, enabling a true closed-loop, can-to-can recycling stream at higher volumes and efficiency.

CanReseal thus goes beyond packaging innovation: it delivers a material solution to enhance U.S. recycling, expands secondary aluminum production, and protects domestic supply chains. By unlocking the potential for beverage cans made entirely from recycled aluminum, CanReseal aligns with REMADE's mission to increase critical material supply, reduce energy usage, and strengthen U.S. manufacturing competitiveness.



Canreseal® Parts | Standard Can Body, Canreseal Ring End (CRE®), Canreseal Closure

INTRODUCTION AND MOTIVATION

Aluminum is one of the most widely used structural and packaging materials in the United States due to its low density, corrosion resistance, and ability to be recycled indefinitely without fundamental loss of properties. Aluminum packaging, and beverage cans in particular, represent one of the most successful examples of large-scale material recovery, with collection and recycling rates exceeding those of most other consumer packaging formats (The Aluminum Association, 2024). Despite these advantages, the aluminum beverage can has not yet achieved a fully closed-loop material cycle.

This limitation arises from the dual-alloy architecture used in conventional pop-top beverage cans. Modern cans utilize a 3xxx-series aluminum alloy for the can body, enabling deep drawing and wall ironing. The pop-top end, on the other hand, is manufactured from a 5xxx-series aluminum alloy, providing the necessary strength and functionality for scoring the tab and opening the can. While this configuration has been optimized for high-speed manufacturing and mechanical performance, the 5xxx series aluminum requires higher magnesium content than the 3xxx series aluminum. This composition differential limits the reuse of end stock material in new can end production, resulting from the oxidation of the magnesium during recycling, leading to significant yield loss of the 5xxx series aluminum. (Raabe, et al., 2022).

Consequently, due to this alloy mismatch and material composition requirements of the 5xxx series end stock, the recycled content of aluminum beverage cans in the United States has plateaued at ~71%, despite the technical feasibility of higher recycled content in can body stock (The Aluminum Association, 2024). This constraint has negative implications for energy consumption and emissions. Primary aluminum production is among the most energy-intensive industrial processes, whereas secondary aluminum production from scrap requires only a fraction of that energy (U.S. Geological Survey, 2023; International Aluminium Institute, 2024). Therefore, increasing recycled content represents one of the most direct pathways to reducing energy use and greenhouse gas emissions in aluminum packaging.

Beyond environmental considerations, aluminum is increasingly recognized as a strategic material with implications for domestic manufacturing competitiveness and national security. The United States remains partially dependent on imported primary aluminum, exposing downstream industries to supply disruptions, tariffs, and geopolitical risk (U.S. Geological Survey, 2023). Strengthening domestic recycling systems and improving the quality and value of post-consumer scrap can reduce reliance on primary imports while retaining more economic value within domestic manufacturing and recycling operations.

Recent research in sustainable alloy design emphasizes the importance of circular design approaches that consider alloy compatibility at the product design stage rather than relying solely on downstream sorting and processing (Raabe, et al., 2022). Within this context, re-examining the alloy architecture of high-volume products such as beverage cans presents a significant opportunity to improve circularity at scale. Prior technical work has demonstrated that 3xxx-series aluminum alloys used for beverage can bodies are capable of being produced from up to 100% recycled content while maintaining required forming and performance characteristics (Guiglionda, 2025).

By enabling the ring end and closure components of the proposed single-alloy beverage can to be produced from a 3xxx-series aluminum alloy like the can body, this approach creates a more homogenous alloy system that simplifies post-consumer recovery and improves remelting efficiency. The purpose of this paper is to examine how material design decisions can improve recycling efficiency, energy demand, and domestic supply-chain resilience in one of the largest aluminum product streams in the United States.

CURRENT STATE OF THE TECHNOLOGY

The dual-alloy beverage can configuration has been in place for decades, optimized primarily for mechanical performance and production efficiencies. The 3xxx series provides the formability required for deep drawing, whereas the 5xxx series offers the strength and flexibility needed for pop-top functionality. However, this pairing of alloys was developed long before circular manufacturing and materials optimization became industry priorities. According to the Aluminum Association, U.S. beverage cans average approximately 70%–73% recycled content, with the 5xxx series aluminum end-stock being the main limiting factor.

Today, 3xxx series can bodies are recycled together with the 5xxx series pop-top ends without introducing broad impurity incompatibilities. However, the primary metallurgical distinction between the two alloys is the magnesium content, which is significantly higher in the 5xxx series aluminum than in the 3xxx series ($\approx 4\%$ – 5% versus $\approx 1\%$ – 1.2%) (Raabe, et al., 2022). During the recycling process, magnesium oxidizes due to its higher chemical reactivity relative to aluminum. As a result, while 3xxx/5xxx scrap can be recycled together, magnesium losses reduce the overall material yield. These losses limit the efficient reuse of end-stock material in new can end production.

Introducing a single-alloy beverage can to the existing recycling stream of dual-alloy used beverage cans (UBCs) would not require new processes, given that the can bodies and ends are already being recycled together. Furthermore, a single-alloy beverage can made from 3xxx series aluminum would further enhance the recycling process by helping to reduce yield losses, enabling more efficient closed-loop recycling and improved material utilization within domestic secondary aluminum production.

While today's beverage can ends remain constrained by the metallurgical requirements of 5xxx series alloys and therefore cannot achieve higher recycled content, the 3xxx-series can body stock used for beverage cans can, in principle, be produced from 100% recycled aluminum. Technical evidence demonstrates that 3xxx series can body alloys can be manufactured with up to 100% recycled content while maintaining the required forming and performance properties. Recent industry developments further support this capability, including commercial announcements of 100% recycled aluminum beverage can body stock by major suppliers such as Constellium (Guiglionda, 2025; United States of America Patent No. WO2016191513A1, 2016).

Aluminum recycling consumes up to 95% less energy than primary smelting (U.S. Department of Energy, 2022). Yet the requirement for the 5xxx series alloy for today's can ends forces manufacturers to rely more heavily on primary aluminum, increasing both energy intensity and carbon emissions. The 5xxx series alloy is also less readily available from domestic rolling mills and is often imported, exposing U.S. manufacturers to tariffs, shipping costs, and geopolitical risks (U.S. Geological Survey, 2023). These inefficiencies negatively impact secondary aluminum recovery and discourage investment in domestic recycling infrastructure, representing a missed opportunity to strengthen national competitiveness in critical materials.

Despite remarkable advances in forming speed and cost efficiency, modern beverage can lines produce 2,000 to 3,000 cans per minute; the fundamental alloy architecture of the beverage can has remained unchanged for over half a century. The next leap forward in packaging innovation must address material compatibility and circularity, enabling higher recycled content, reduced energy intensity, and improved economic viability for domestic recycling.

TECHNOLOGY APPROACH

The proposed single-alloy beverage can technology is being engineered and designed to minimize disruption to the highly optimized can-making infrastructure. Aluminum beverage cans are one of the fastest manufactured products in the world, oftentimes being produced at speeds of 2,000-5,000 units per minute, depending on equipment condition and line configuration (Stueve, 2016). Because new can-making lines require an investment of hundreds of millions of dollars and often take up to a decade to realize returns, the optimal commercialization strategy centers on seamless integration into existing production assets rather than replacement (Grohowski & Higgins, 2022). The single-alloy beverage can's commercialization and global adoption is highly dependent on compatibility with today's can manufacturing and supply chain logistics. The investments needed from can makers to manufacture this new can technology will only be justified if the technology fits into today's existing lines with minimal modifications, considerably reducing the risk of the large investment(s) needed to introduce the technology.

With our partners, we anticipate finalizing the development of our minimum viable product (MVP) in the next 12-18 months. Through collaboration with Stolle Machinery, which supplies a majority of the world's can-making equipment, the threaded ring end and closure have been co-designed to fit within current press, conversion, and filling & seaming processes with only minor tooling modifications. Additionally, we are working closely with manufacturers of beverage filling equipment, cappers, and all other necessary entities to ensure compatibility with the full value chain. These relationships are critical to developing this new beverage can technology in a way that does not disrupt industry efficiencies when the technology is introduced and ready for commercialization. This approach substantially reduces capital risk for can manufacturers and ensures continuity in filling, seaming, and distribution operations. In addition to our development partners, we are working closely with beverage industry leaders, such as Coca-Cola and AB InBev, who have helped us establish our MVP. With these two large entities giving us the guardrails to meet their specifications and requirements, the rest of the industry will follow in their footsteps.

The single-alloy beverage cans development program follows a structured pathway from digital modeling to pilot-scale validation. Preliminary Finite Element Analysis (FEA) simulations conducted by Stolle and independent engineering partners indicate the current can design is able to withstand internal pressures of ≥ 100 psi, well above the

90psi minimum required for carbonated beverages and beer pasteurization cycles exceeding 100F°. Additionally, to quantify the environmental benefits of the proposed single-alloy beverage can design, [Life-Cycle Assessment \(LCA\) studies have been conducted comparing the 3xxx series beverage can with conventional dual-alloy beverage cans.](#) Preliminary analysis performed in collaboration with Silgan Containers indicates a meaningful reduction in life-cycle carbon intensity, driven by increased recycled content, projected to reach a minimum of 90%. While these results required various assumptions and are therefore not of publication quality, the findings provide strong confidence that the proposed design significantly reduces carbon emissions and energy requirements by eliminating the need for 5xxx series aluminum.

As of today, prototype components have been fabricated and successfully trialed on AB InBev's low-volume pilot filling line in St. Louis, Missouri, indicating the new can's compatibility with commercial filling systems. Upon the completion of the MVP, a dedicated pilot manufacturing line, operated in partnership with a major can maker, will then produce upwards of 10 million single-alloy beverage cans annually. These volumes are sufficient to support early market evaluations by leading beverage brands such as Coca-Cola and AB InBev. These pilot-scale trials will help validate manufacturability, performance, and consumer acceptance under real-world conditions. The proposed new can technology has already undergone proof of concept through consumer research and received very positive feedback across multiple sessions. Knowing the technology would be accepted by consumers was a critical step in development to understand the desirability of the technology once introduced. Given that the technology is competing with the highly efficient and optimized pop-top beverage cans we are all familiar with, the pilot line is a necessary next step to prove to the industry that the proposed new beverage can design is a scalable packaging solution because of its ability to integrate into existing systems.

DISCUSSION

The following content synthesizes established metallurgical literature with scenario-based engineering calculations to evaluate the potential impacts of a single-alloy beverage can. Where quantitative estimates are provided, they are derived from published energy- and emissions-intensity data and rely on stated assumptions regarding adoption and recycled content.

The U.S. beverage can industry currently requires approximately 1.4 million metric tons of aluminum each year. With today's aluminum cans containing an average of 71% recycled content, this demand translates to roughly 406,000 metric tons of primary aluminum supplied to the market annually (The Aluminum Association, 2025). Conventional 16oz cans weigh approximately 14 grams, while current estimates show the proposed single-alloy beverage can design weighs slightly more at around 16.5 grams with the additional threaded ring end and closure components. Even with this estimated increase in unit mass, the transition to a single-alloy design enabling $\geq 90\%$ recycled content fundamentally reshapes the industry's material and energy profile. Additionally, the current 16.5-gram proposed design can be optimized in the future to reduce the amount of aluminum used, hence reducing the overall weight and improving the energy, carbon emissions, and material efficiency further.

If the proposed single-alloy beverage can design fully replaced conventional pop-top cans in the U.S. beverage can market, total aluminum demand would increase modestly to 1.6 million metric tons due to the added weight of the ring end and closure configuration. However, the share of primary aluminum required would drop sharply, from 406,000 metric tons to just 160,000 metric tons, while secondary aluminum demand would rise from 994,000 metric tons to 1.44 million metric tons. This shift represents a structural improvement in U.S. aluminum circularity, redirecting demand toward domestically recoverable and energy-efficient secondary material.

Although the single-alloy design requires an additional 200,000 metric tons of aluminum, the dramatic reduction in primary material demand unlocks substantial energy savings. Primary aluminum production requires 14.82MWh per metric ton, compared to only 0.8MWh per metric ton for secondary production. Under a full conversion scenario, these dynamics result in an annual national energy reduction of more than 3TWh, driven by replacing energy-intensive primary smelting with low-carbon secondary remelting. These modeled outcomes are illustrated in Table 1 (The Aluminum Association, 2025).

Table 1: US Annual Energy Requirements Per Ton of Aluminum Production

Scenario	Total (Mt/yr)	Recycled Content	Primary	Secondary	Total required
Baseline	1,400,000.00	71%	14.82MWh	0.8MWh	6.8 TWh
CanReseal	1,600,000.00	90%	14.82MWh	0.8MWh	3.52 TWh
Net Savings	–	–	–	–	-3.28 TWh

Table 1 assumes all baseline cans are constructed of 71% recycled content and all CanReseal cans are made of 90% recycled content

Beyond energy savings, the emissions reductions associated with shifting away from primary aluminum production are equally meaningful. According to the Aluminum Association, depending on smelter type, primary aluminum production emits between 1.9 and 16 tons of CO₂ per ton of metal, with U.S. operations averaging around 11.05 tons. In contrast, secondary aluminum production emits approximately 0.5 tons of CO₂ per ton. Using these emissions intensities, a complete transition to the proposed single-alloy beverage can suggests a reduction in national CO₂ emissions from aluminum production by an estimated 2.5 million metric tons annually (Table 2). This represents a significant opportunity for the beverage-packaging sector to align with U.S. decarbonization goals and corporate net-zero pathways.

Table 2: US Annual Metric Tons of CO₂ Emissions per ton of Aluminum Smelting

Scenario	Primary 1.9tons CO ₂ per ton	Primary 16tons CO ₂ per ton	Average US 11.1tons CO ₂ per ton	Secondary 0.5tons CO ₂ per ton	BEST CASE CO ₂ per ton	US Average
Baseline	771,400.00	6,496,000.00	4,486,300.00	497,000.00	1,268,400.00	4,983,300.00
CanReseal	304,000.00	2,560,000.00	1,768,000.00	720,000.00	1,024,000.00	2,488,000.00
Net savings	–	–	–	–	244,400.00	2,495,300.00

Table 2 assumes total primary and secondary are a result of 71% (Baseline) and 90% (CanReseal) recycled content

In addition to the single-alloy beverage can's ability to cut down on energy usage and CO₂ emissions, an increased recycling rate would further enhance the United States' economic requirements for the entire aluminum industry. As stated by the Aluminum Association, to support the entire aluminum industry, the US imports over \$12 billion worth of primary aluminum and either landfills or exports \$6 billion worth of aluminum every year. With a recycling rate of 43%, aluminum beverage cans are a significant contributor to the overall aluminum scrap that is either landfilled or exported each year. Suppose only 43% of the 1.4 million metric tons of aluminum used for baseline

conventional beverage cans are recycled each year. In that case, the US is wasting 602 thousand metric tons of aluminum, equating to \$1.67 billion using the LME price of aluminum (\$2,780.00) (London Metal Exchange (LME), 2025).

Table 3: US Annual Economic Loss from Aluminum Imports & Exports/Landfilled

Scenario	Total US Aluminum Metric tons	Price (LME) / Mt	Total spent/lost
Primary Aluminum imports	4,400,000.00	\$2,780.00	\$(12,232,000,000.00)
Aluminum scrap landfilled/exports	2,400,000.00	\$2,780.00	\$(6,672,000,000.00)
Total	–	–	\$(18,904,000,000.00)

Table 3 assumes all aluminum costs the same amount of \$2,780.00 (LME), also assumes landfilled/exports are grouped due to limited information

With the US beverage can market requiring 406 thousand metric tons of primary aluminum every year, this equates to close to 9% of all primary aluminum imports. If we assume 9% of the 406 thousand metric tons of primary aluminum needed to supply the US beverage can market is imported, and using the standard LME price of aluminum (\$2,780/ton), then the US spends \$104 million on primary aluminum imports each year for beverage cans. Using these numbers, if all cans switched to the single-alloy beverage can, at 16.5 grams and constructed of 90% secondary aluminum (requiring 3% of primary imports), the US could save nearly \$90 million a year on primary aluminum imports (Table 4). It is important to note that the figures used in Table 4 do not include tariffs, which could nearly double the price of aluminum (LME) used to calculate the figures below. As reported by Oil Price, “the US all-in aluminum price hit a record \$4,816.00 per ton, nearly double its 2023 lows, as inventories tightened sharply,” (ZeroHedge, 2025).

Table 4: US Annual Spend on Primary Aluminum Imports for Beverage Cans

Scenario	Total Metal (Mt/yr)- Primary	Percentage of 4.4Mt Primary Imports	Spend on Imports for Beverage Cans
Baseline	406,000.00	9.23%	\$104,146,381.82
CanReseal	160,000.00	3.64%	\$16,174,545.45
Net Savings	–	–	\$87,971,836.36

Table 4 assumes 9% of primary used for baseline cans is imported, and 3% of primary used for CanReseal is imported

Furthermore, using these estimates and assumptions, a full replacement of conventional cans with the single-alloy beverage can and increasing the US recycling rate from 43% to 75% would increase the supply of secondary aluminum from 688 thousand metric tons per year to 1.2 million metric tons per year. The 1.2 million metric tons of secondary aluminum could then be used toward the 1.44 million metric tons of secondary aluminum needed for the proposed single-alloy beverage can design. The remaining 400,000 metric tons needed would need to come from alternative sources. At a 75% recycling rate, conventional cans would create a surplus of 56,000 metric tons of secondary aluminum. However, the 406,000 metric tons of primary aluminum needed for conventional cans would still need to be produced. Using the LME price of aluminum at \$2,780.00, the 6,000 metric ton difference at the increased 75% recycling rate would save the US as much as \$16.68 million annually by switching to a slightly heavier single-alloy beverage can (Table 5).

Table 5: Annual Savings from Increasing Beverage Can Recycling Rate

Scenario	Current RR (43%)	Proposed RR (75%)	Current Total Mt/yr	Primary Mt/yr	Secondary Mt/yr	Metal still needed
Baseline	602,000.00	1,050,000.00	1,400,000.00	406,000.00	994,000.00	406,000.00
CanReseal	688,000.00	1,200,000.00	1,600,000.00	160,000.00	1,440,000.00	400,000.00
Net Savings	–	–	–	–	–	\$16,680,000.00

Table 5 does not include the economic value (LME) of 56,000 metric tons surplus in secondary aluminum from baseline cans

In summary, the transition to a single-alloy resealable aluminum can system has the potential to deliver material, energy, economic, and emissions benefits simultaneously. As discussed in the *Current State of the Technology* section, the single alloy can architecture remains compatible with existing UBC recycling streams and does not require separate collection or sorting; rather, the material and energy benefits discussed above scale progressively as adoption increases. These outcomes directly support US national security and decarbonization priorities, particularly in strengthening domestic supply chains, improving materials circularity, reducing industrial energy consumption, and enabling economically competitive decarbonization pathways across U.S. manufacturing.

Conclusions & Recommendations

This work suggests that the proposed single-alloy aluminum beverage can architecture represents a transformative opportunity for advancing circular manufacturing and industrial decarbonization within the U.S. beverage-packaging sector. By eliminating the need for 5xxx series end stock and enabling a more homogeneous 3xxx series system, a single-alloy beverage can has the potential to resolve one of the most persistent inefficiencies in aluminum recycling, the alloy incompatibility between can bodies and ends. The result is consistent with a packaging format that can be produced entirely from recycled aluminum while maintaining compatibility with existing high-speed manufacturing infrastructure. This transition is indicative of significant economic benefits, including lower import costs, enhanced domestic scrap value, and reduced industrial energy expenditures. Beyond these measurable impacts, a single-alloy beverage can strengthens U.S. supply-chain resilience by incentivizing new domestic remelt and rolling-mill investment, enhancing material security for both civilian and defense applications, and reinforcing the long-term competitiveness of the U.S. aluminum industry.

To accelerate the transition toward large-scale implementation of single-alloy beverage-can systems, several actions are recommended:

1. **Expand Pilot-Scale Validation and Standardization.**
Continued collaboration with can-making equipment suppliers, manufacturers, fillers, and brand owners should focus on standardizing processes and confirming performance metrics.
2. **Advance Comprehensive Life-Cycle Assessment (LCA) Studies.**
Peer-reviewed LCAs comparing the single-alloy design to conventional two-alloy cans should be completed to quantify energy and emissions reductions. Such analyses can provide robust data for corporate sustainability reporting and national energy-efficiency metrics.
3. **Strengthen Domestic Recycling Infrastructure.**
Partnerships between the aluminum industry, policymakers, and REMADE's research community should target improved collection and segregation of used beverage cans (UBCs). A cleaner and more uniform scrap stream will amplify the benefits of single-alloy design and improve the economics of secondary-aluminum production.
4. **Develop Market and Policy Incentives for Circular Aluminum.**
Introducing mechanisms such as recycled-content targets, carbon-intensity labeling, or procurement preferences for single-alloy packaging would accelerate market pull and signal long-term policy alignment with U.S. decarbonization objectives.

A single-alloy beverage can illustrates how design innovation in one of the world's most ubiquitous packaging formats can deliver tangible gains in energy efficiency, materials recovery, and national resilience. By transforming the beverage can into a fully circular system, this technology provides a practical model for the type of improvements envisioned by the REMADE Institute, where engineering, policy, and market forces converge to build a stronger, cleaner, and more competitive U.S. manufacturing economy.

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Finally, the authors wish to recognize the broader Canovation team for its sustained dedication to developing technologies that advance sustainable packaging and support U.S. manufacturing competitiveness. Their collective efforts exemplify the collaborative spirit that underpins the REMADE mission to accelerate the nation's transition toward a more circular, energy-efficient economy.

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