

NEW RESEARCH

Investing in glass clean-up systems at MRFs offers higher value commodities and significant savings for the entire system.



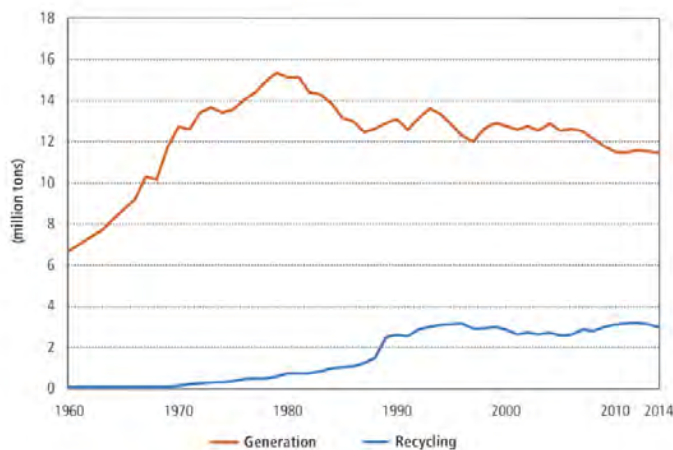
THE CURRENT STATE OF GLASS RECYCLING

As more municipalities transition to single-stream recycling, glass is arriving at recycling facilities (MRFs) in larger volumes, taxing the limits of aging equipment. The resulting material is more contaminated, making it difficult for downstream processors and manufacturers to use. Glass prices are lower too, driving down profitability and offering few downstream options for MRFs. As a result, more glass ends up in landfills.

Across the country, municipalities and MRFs are spending more than \$150M a year to dispose of single-stream glass.

The problem is likely to get worse as markets continue to decline. As a result, more municipalities and MRFs have chosen to remove glass from their recycling programs in recent months. If the trend continues, the system will recover less and less of the glass generated each year, despite the fact that manufacturers can save significant costs and energy using recycled glass. All stakeholders – from municipalities and MRFs to processors, manufacturers, and brand owners – need a more efficient and cost-effective solution to handle single-stream glass.

EPA: Glass Generation and Recycling, 1960-2014



GLASS IN MRFs: TECHNOLOGY AND ECONOMICS

Under current conditions, MRFs have few choices for single-stream glass. If the material is of acceptable quality, a MRF can pay to transport the glass to the nearest processor; if not, it may pay a discounted disposal fee at a landfill, where the glass will be used as alternative daily cover. Regardless, the MRF will lose money. For a MRF that generates 15,000 tons of glass per year, **the economic impact of accepting glass at its front door can approach \$500,000 in annual costs** (\$35/ton, including discounted disposal fees and transportation). From an environmental perspective, every ton of glass that is not recycled results in increased greenhouse gas emissions from transportation and virgin glass production.

New **technology** can clean single-stream glass to a higher quality cullet and separate out non-glass residue (NGR), including marketable commodities. For mid- to large-sized MRFs handling 10,000+ tons of glass per year, the capital cost of investing in a contemporary glass clean-up system ranges from \$350,000 to \$1,000,000. Recently, several MRF operators, including Casella, Recology, and ReCommunity, have invested in better glass clean-up systems, demonstrating that an investment can meet ROI requirements, and glass can be productively addressed in the material stream. In our study, the following practices yielded the best results:

¹ Cleaned glass typically sized between ¼" and 2" in diameter.

- 1 Glass should be removed from the stream early, via glass breaker, trommel or disc screen.
- 2 Size separation occurs using a vibratory deck or trommel screen. Adjustable screens allow for variation in material, e.g., different environmental conditions or source of material.
- 3 Density separation occurs using an air vacuum and/or blower. A system might use a zigzag design or air drum separator to remove NGR. Closed loop systems designed to retain the material in air separation for a longer amount of time performed particularly well. The resulting 3-mix glass (generally between ¼" and 2" in diameter) can be 95%+ "clean" (i.e., containing 5% or less NGR).
- 4 NGR can be run through the system again to capture all commodities of value, including fibers, metals, and plastics.
- 5 Glass should be stored under a covering or roof, in a bunker or container isolated from other materials, such as fiber, which could result in contamination.
- 6 Equipment should be maintained to ensure high performance, minimal downtime.



Markets for glass vary by region, but the largest customer by far nationally is Strategic Materials Inc. (SMI), where a majority of MRF glass goes. SMI has published a pricing matrix for the industry, and has committed to paying for higher quality material where available. As a result, MRFs can now be rewarded for sorting glass and providing higher quality glass.

Sample 2016 pricing (1)

More than 40% of current 3-mix supply falls within this range
New industry specifications have narrowed tolerances for NGR and undersize material

Case Results	Processor's target specification					Undersize				
	0.0%	1.0%	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%	35.0%	40.0%
0.0%	\$20.80	\$20.56	\$19.60	\$18.40	\$17.20	\$16.00	\$14.80	\$13.60	\$12.40	\$11.20
1.0%	\$19.60	\$19.36	\$18.40	\$17.20	\$16.00	\$14.80	\$13.60	\$12.40	\$11.20	\$10.00
5.0%	\$14.80	\$14.56	\$13.60	\$12.40	\$11.20	\$10.00	\$8.80	\$7.60	\$6.40	\$5.20
10.0%	\$6.80	\$6.56	\$5.60	\$4.40	\$3.20	\$2.00	\$0.80	\$(0.40)	\$(1.60)	\$(2.80)
15.0%	\$2.80	\$2.56	\$1.60	\$0.40	\$(0.80)	\$(2.00)	\$(3.20)	\$(4.40)	\$(5.60)	\$(6.80)
NGR	20.0%	25.0%	30.0%	35.0%	40.0%	45.0%				
	\$(3.20)	\$(3.44)	\$(4.40)	\$(6.80)	\$(8.80)	\$(8.00)	\$(9.20)	\$(10.40)	\$(11.60)	\$(12.80)
	\$(9.20)	\$(9.44)	\$(10.40)	\$(11.80)	\$(12.80)	\$(14.00)	\$(15.20)	\$(16.40)	\$(17.60)	\$(18.80)
	\$(16.20)	\$(16.44)	\$(17.40)	\$(18.60)	\$(19.80)	\$(21.00)	\$(22.20)	\$(23.40)	\$(24.60)	\$(25.80)
	\$(23.40)	\$(23.64)	\$(24.60)	\$(25.80)	\$(27.00)	\$(28.20)	\$(29.40)	\$(30.60)	\$(31.80)	\$(33.00)
	\$(31.40)	\$(31.64)	\$(32.60)	\$(33.80)	\$(35.00)	\$(36.00)	\$(37.40)	\$(38.60)	\$(39.80)	\$(41.00)
	\$(37.00)	\$(37.24)	\$(38.20)	\$(39.40)	\$(40.60)	\$(41.80)	\$(43.00)	\$(44.20)	\$(45.40)	\$(46.60)

Source: Leading glass processor, May 2016 (1) Pricing is delivered to the facility; "NGR" – Non Glass Residue; "Undersize" – Particle size less than 3/8", per processor. New ISRI standard specifications define undersize as 1/8" or less (Nov 2016).

² Volume equivalent to amount of MSW glass generated by a city the size of San Diego (CA), or the larger metropolitan areas around and including smaller cities such as Rochester (NY), Grand Rapids (MI), Tucson (AZ), or Honolulu (HI). ³ Installed costs. For smaller MRFs, SMI has consulted with operators to help them identify less capital-intensive investments that can support cleaner MRF glass at lower volumes.

In our study, MRFs interviewed were also paying to dispose of fines (undersize glass), by either taking it to the landfill or reintroducing it into the cullet sent to SMI. For most, there were no other customers to market this material to. However, emerging alternative end-markets, such as abrasives, water filtration media, aggregate, and pozzolan, are becoming an option in select US markets.

Transportation costs for glass also vary, but are significant because of the weight of glass and **distance** to customers. It was often cheaper to transport glass to local landfills than to processors, which might be farther away and still charge MRFs to take the material. For example, multiple MRFs interviewed paid \$20 or more per ton for transportation to facilities located more than 50 to 100 miles away.

For a MRF located in the Northeastern United States, the business case was clear.

BEFORE:

- A large single stream MRF generating over 40,000 tpy of glass
- First generation clean-up system from 2008
- Paying for glass to go to glass processor (<50 miles away) at a significant cost

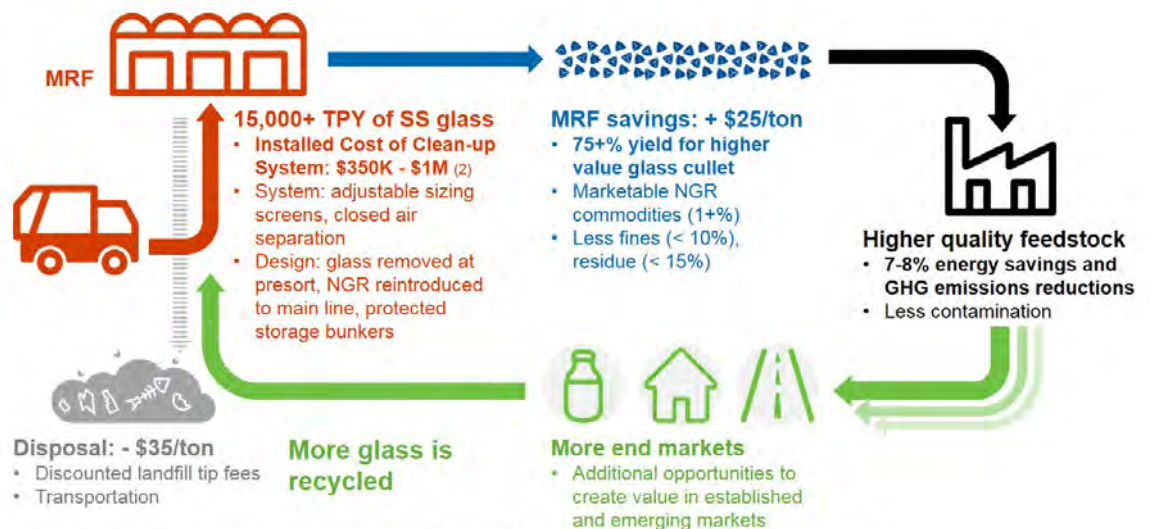
AFTER:

- A \$600,000 total investment in a full system, including vibratory double screen deck, zig-zag air separation system, conveyors, platforms, and controls, was installed in 2016
- Glass was separated, cleaned to 5% NGR, 1-2% undersize (tested in a follow-up audit)
- Glass is sold to same processor (< 50 miles) at an increased price
- Fines now going to alternative aggregate use
- NGR (paper, bottles, cans) going back into the system for recovery and commodity value
- ROI: Significant savings realized; payback period of less than 2 years

RESULTS

Given the above variables, the **-\$35/ton in annual costs for a MRF can be reduced significantly, generating savings of \$25/ton or more.** Results will vary depending on the quality of the material coming into the system, transportation costs, and the environmental conditions.

ROI on improving glass clean-up (1)



(1) Actual results will vary depending on MRF and local market. (2) Does not include cost of downtime at MRF to install new equipment

OPPORTUNITY FOR IMPACT AND THE PATH FORWARD

This model is starting to be replicated by MRFs in markets across the country, as operators act on this opportunity to improve diversion and profitability. Although new equipment alone does not yet turn the -\$35/ton cost to a positive, significant savings can be achieved. In order for MRFs to see a return on investment in a new glass clean-up system, two critical factors must be true:

- More municipalities accept (or continue to accept) glass – rather than remove it – in their recycling programs.
- Processors commit and follow-through on commitments to pay for higher quality cullet. SMI, for example, has made a [public commitment](#) to price incoming glass based on quality.

The economics can be further improved if:

- MRFs can increase volumes of glass generated, allowing MRFs to benefit from economies of scale, reduce overall costs and be more competitive in the market.
- MRFs can market fines, as well as cullet.
- Better contracts can be negotiated by municipalities, MRFs and processors, reflecting true costs/value and minimizing market volatility.
- Infrastructure is scaled, so that more MRFs are in closer proximity to customers. This would reduce transportation costs and increase competition for feedstock.

Scaled across the country, improved glass clean-up systems could have significant impact:

- More than \$100M saved by MRFs and municipalities over 5 years
- Greenhouse gas emission reductions of more than 1.4 million metric tons, in addition to reductions of 7-8% seen at manufacturing plants, over 5 years
- Energy savings of 7-8% at manufacturing plants



Nationally, at least 50 MRFs⁴ could benefit from new glass clean-up systems, increasing supply of recycled glass by 33%, or 1 million tons a year, and 5 million tons over 5 years. This material would otherwise go to landfill or continue to be a burden on the rest of the system.

Existing infrastructure includes 60 Processors, 70+ Container and Fiberglass Manufacturers

⁴ Based on Closed Loop Foundation analysis

Better performing glass clean-up systems would yield benefits not only for MRFs, but for each participant across the system.

FOR MUNICIPALITIES

- Sustainable home for a key commodity
- Supports zero waste goals
- Convenient for residents

FOR PROCESSORS

- Lower capex, operating costs
- Increased productivity
- Lower disposal costs

FOR END-MARKETS

- Lower capex, operating cost to get/use higher quality feedstock
- More secure and sustainable supply
- Greater yield from feedstock

In order to create this infrastructure opportunity and increase supply of recycled glass, the system needs to find ways to create more value for MRFs, municipalities, processors, and end-markets.

SMI's pricing transparency is a first step in this direction. Ultimately, brand owners must also play a role in increasing demand for recycled glass. Greater demand would set the necessary investments into motion.

FOR MORE INFORMATION

Further detail from our study and analysis can be found in this presentation ► [VIEW PRESENTATION](#). For MRF operators and municipalities, the authors have created a tool to calculate the potential costs and benefits of investing in a glass clean-up system ► [VIEW CALCULATOR](#)

If you'd like to contact Closed Loop Foundation to discuss our findings and applicability to glass recycling in your market, please contact Ellen Martin at ellen@closedloopfoundation.org.

ABOUT THE STUDY

Closed Loop Foundation's study was conducted with support from HEINEKEN USA in July through December, 2016. Our research team interviewed industry stakeholders, including MRF operators, equipment providers, consultants, glass processors, and end users. Additional data and research included in this report was obtained from interviewees, Glass Packaging Institute, RRS, and US EPA. Data on MRFs provided by Governmental Advisory Associates, Inc., *2016-2017 Database on Material Recovery Facilities and Mixed Waste Processing Facilities in the U.S.*, copyright 2016.

DISCLAIMER

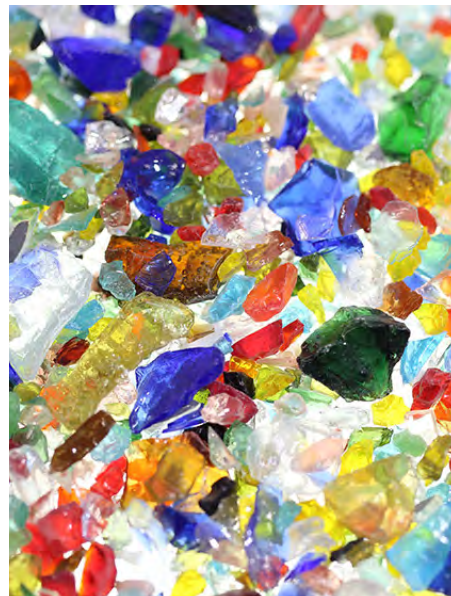
Closed Loop Foundation and Closed Loop Fund do not endorse any specific equipment manufacturer. The study reviewed equipment based on performance, with the aim of improving quality and increasing value at market. Although we gave our best effort to consider latest designs and technology available, not every manufacturers' product was reviewed.

[▶ VIEW CALCULATOR](#)

MRFs can add value with glass if they optimize the following key variables:

1. VOLUME: How much glass is generated at your facility each year? MRFs handling 10,000 tpy's or more are more likely to see significant savings and return on investment; however, these recommendations may be applicable to smaller MRFs depending on the local glass market.

- What is/are the source/s? Single-stream, dual stream?
- Do you expect this amount to increase or decrease (e.g., because a contract is ending or is vulnerable)? By how much? Some municipalities are considering taking glass out of their recycling programs as a reaction to the current costs. Other municipalities expect to add or increase glass as part of expanded curbside collection or more commercial material.
- Have any audits/analysis been done on the material composition? A composition study will help determine level of fines and organic residue, and help establish a baseline for yield.



2. OPERATIONS: How do you currently remove glass from the system?

- What type/components of glass clean-up and sizing equipment do you operate?
- Do you have any significant O&M costs associated with your current glass clean-up system? For most MRFs, a conservative estimate for incremental, glass-specific O&M is -\$3/ton; research indicates a modest increase (\$1/ton) may be necessary for maintenance of a new system.
- Are you reintroducing NGR into the line to capture additional commodities from residue? NGR commodities can bring an additional \$50-\$1000/ton, most commonly in the form of fiber, aluminum, or plastic.

3. MARKETS: Do you currently have a market for your glass?

If no, and material is going to landfill,

- How much do you pay per ton to dispose of glass? Many MRFs can receive a discounted disposal fee for glass because it can be used as alternative daily cover.
- Is/are there a processor/s within 100 miles? Although a processor may exist within 100 miles, MRFs may not be able to market their glass due to low quality/high contamination.
- Are there other alternative end-markets within 100 miles? Alternative end markets include abrasives, aggregates, filtration media.

If yes,

- What is/are existing market/s? SMI is the most likely processing customer, but it's also important to consider whether there are other MRFs in the area and what type of manufacturers are nearby. End markets can generate \$75+ in revenue/ton, but the specifications required will vary.
- How much do you earn/pay?

4. TRANSPORTATION: Do you pay to transport glass to landfill or processor?

- If yes, how much do you pay? MRFs in our study paid between \$4 and \$22 per ton.
- How far away? In our analysis, we identified more than 100 mid- to large-sized MRFs located within 100 miles of a processor and/or manufacturer (container or fiberglass). In some regions, MRFs haul glass to a processor located 500+ miles away.



5. FINANCING: Do you have access to financing for \$350K - \$1M clean-up system?

- If yes, what is the expected interest rate, term of loan? For the purposes of calculating expected savings, we use a generic 5-yr, 3% interest loan.

Sample Economic Analysis

Before

Average size MRF (60,000 TPY) sorts **15,000 TPY of SS glass** using minimal/outdated equipment. Glass goes to local landfill for use as alternative daily cover.

Description	Tons	\$/ton	Total/year
Disposal	15,000	(\$ 22.00)	(\$ 330,000)
Transportation		(\$ 10.00)	(\$ 150,000)
Maintenance		(\$ 3.00)	(\$ 45,000)
Total annual cost(\$ 35.00)	(\$ 525,000)

After ⁽¹⁾

MRF upgrades to **new glass clean-up system**. Same volume of glass is marketed to local processor, generating revenue from glass and NGR commodities.

Description	Tons	\$/ton	Total/year
Marketable glass ⁽²⁾	11,250	\$ 12.40	\$ 156,240
Fines ⁽³⁾	1,350	-0--	0-
NGR commodities	150	\$ 150.00	\$ 22,500
Residue disposal	2,250	(\$ 37.00)	(\$ 83,250)
Transportation	5,000	(\$ 10.00)	(\$ 150,000)
Maintenance ⁽⁴⁾		(\$ 4.00)	(\$ 60,000)
Total cost (before financing)		(\$ 7.63)	(\$ 114,510)
NET SAVINGS		\$27.37	\$ 411,510

(1) Scenario assumes no significant change in inbound materials or overall MRF operations; scenario does not include one-time costs, such as downtime during installation of a new glass clean-up system. (2) Assumes 75% glass yield (incl. 5% NGR, 9% undersize), 1% marketable NGR, 15% residue; actual price/ton may vary. (3) Additional savings could be gained by marketing fines; (4) based on MRF interviews