Glass Clean-up Systems in MRFs

APRIL 2017
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Overview of Study
Is there a productive and cost-effective way to increase the reuse of glass from material recovery facilities (MRFs)?
Answering the Question

• Study conducted with support from HEINEKEN USA

• Interviewed industry stakeholders including MRF operators, equipment providers, consultants, glass processors, end users etc.

• Industry data and research obtained from the Glass Packaging Institute, RRS, and Governmental Advisory Associates

• Intended audiences: municipalities, MRF operators, glass industry, and investors
Current systems can produce higher quality cullet and generate significant savings for MRFs; under current conditions, glass may still be a cost to MRFs

- **Context**: Many MRF’s disposing of glass, processors want the material and have capacity, cost effective and productive systems have been developed to clean the glass for processors to use
- **Cost**: Effective clean-up systems can range from $350,000 to $1M+ for larger installations
- **Who**: MRFs generating/paying to dispose 10K+ tons of glass/yr, located < 100 miles of a processor; 50-100 MRFs would benefit

- **Current Adoption**: MRFs, such as Casella, ReCommunity, Republic, and WM, are actively pursuing new systems for their facilities to achieve greater savings

- **Further Levers for Profitability**:
  - Keep glass in recycling programs
  - Negotiate fair contracts, pay for sort
  - Increase willingness to pay for higher quality cullet
  - Establish alternative end markets
The ROI on improving glass clean-up (1)

15,000+ TPY of SS glass
- Installed Cost of Clean-up System: $350K - $1M (2)
- System: adjustable sizing screens, closed air separation
- Design: glass removed at presort, NGR reintroduced to main line, protected storage bunkers

MRF savings: + $25/ton
- 75+% yield for higher value glass cullet
- Marketable NGR commodities (1+%) (1)
- Less fines (< 10%), residue (< 15%)

Disposal: - $35/ton
- Discounted landfill tip fees
- Transportation

Higher quality feedstock
- 7-8% energy savings and GHG emissions reductions
- Less contamination

More glass is recycled

More end markets
- Additional opportunities to create value in established and emerging markets

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

<table>
<thead>
<tr>
<th>For Single Stream MRFs</th>
<th>For Municipalities</th>
<th>For Processors</th>
<th>For End Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue from glass stream</td>
<td>Sustainable home for a key commodity</td>
<td>Lower capex, operating costs</td>
<td>Lower capex, operating cost to get/use higher quality feedstock</td>
</tr>
<tr>
<td>More volume</td>
<td>Supports zero waste goals</td>
<td>Increased productivity</td>
<td>More secure and sustainable supply</td>
</tr>
<tr>
<td>Marketing advantage</td>
<td>Convenience for residents</td>
<td>Lower disposal costs</td>
<td>Greater yield from feedstock – competes better with virgin material</td>
</tr>
<tr>
<td>Secure markets for material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation (T&amp;D) savings</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*In addition to potential MRF benefits…*
Background Context
• 9M tons of glass containers generated as MSW each year

• <3M tons (33%) recovered for reuse, largely as a result of residential single stream recycling programs

• 6M (67%) tons go to landfill

• Up to 95% could be reused in containers

• The infrastructure and need exists to reuse substantially more glass

Additional yield data available from Glass Recycling Coalition, RRS: http://www.glassrecycles.org/glassrecyclingbenefits
Evolution of Material

• Over the last 15 years, with the implementation of single stream and carts, the volume of glass in MRFs has increased.

• Many systems were not designed to clean up large volumes of single stream glass. Those that did were inefficient.

• As a result, the glass stream has become more contaminated. This has made MRF glass more difficult for glass processors to use.

• As a result, glass prices are lower, and glass is less profitable for MRFs.
Inefficient Equipment

Due to poor performance of older glass clean-up systems, the non-glass content (NGR) can be as high as 50%
Glass Stream Contaminants

- **Organics**
- **Aluminum Cans**
- **Metal**
- **Shredded paper**
- **Plastic containers**
- **Ceramic, stone, porcelain**
- **Miscellaneous residue**
- **Paper**
Costs

• Poor glass quality has limited the options for MRFs. Many are utilizing outlets with a lower quality standard, such as landfill cover or even disposal.

Financial costs to the system are more than $150M per year

MRFs pay disposal and transportation costs

Municipalities pay processing and disposal costs
Recent Response

Setbacks

• **MRF operators** and **processors** are increasingly putting pressure on glass recycling, citing cost and contamination.

• **Municipalities** recently pulled glass from recycling programs, e.g.,
  • DeKalb County, GA
  • New Orleans, LA
  • Houston, TX
  • Knoxville, TN
  • Spartanburg, SC

• At this rate, the recovery rate could fall 1-4% each year.

Progress

• Other MRF operators and processors are investing in better clean-up systems, e.g.,
  • Casella
  • ReCommunity
  • Recology
  • Republic
  • Rumpke Glass
  • WM

• Industry is taking collective action to improve glass recycling infrastructure, e.g., **Glass Recycling Coalition**
Latest Technology and Results
Summary

Although every case is different,

- Glass clean-up technology has advanced and is now effective at producing a clean, usable product at the MRF

- A simple market and economic analysis will determine if an investment is justified

- In many cases, MRFs can realize significant savings under current market conditions

- MRFs may be able to realize further savings or revenue by pursuing other market levers
Clean Up Process

Feeding of material from wherever glass is removed via trommel, disc screen, glass breaker etc.

Size separation Using a vibratory deck or trommel screen

- Paper, bottles, cans, etc.
- Glass pieces, ceramic, stone etc.

Density separation Using air vacuum and / or blower

- Fines, small shredded paper
- Shredded paper, plastic, etc.

Heavies

2" to ¼ - 1/8” (1)

Lights

2”+

¼ - 1/8” minus

The best-performing systems:
1. Can be adjusted to differing conditions of glass material
2. Are designed to allow for a longer retention time of the material in the air separation stream

(1) Typical minimum size today is ¼”. ISRI 3-mix standard specifications define fines as smaller than 1/8”, which may change minimum size over time. http://www.isri.org/docs/default-source/random/mrf-glass-specifications-11-7-16-(002).pdf
Clean-Up Systems

- Both of these recent installations use similar principles
- Both systems have significantly improved the glass quality enabling MRF’s to utilize alternative, more cost-effective, outlets
- For mid-sized MRFs, capital costs can run between $350,000 to $1M for new equipment installed; costs will depend on capacity and support equipment

Note: 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.
Results

Glass

• The glass stream quality has been significantly improved

NGR

• Commodities recovered from the glass clean up system include paper, aluminum cans, plastic bottles, etc.
• Depending on quality, this material may have a market value ranging from $50/ton to $1,000+/ton
Example #1 – MRF in the Northeast

Before:

• A large single stream MRF generating over 40,000 tpy of glass, paying for glass to go to glass processor at a significant cost
• First generation clean-up system from 2008

After:

• A $600,000 total investment – vibratory double screen deck, zig-zag air separation, conveyors, platforms, controls, etc.
• Installed in 2016
• Glass going to same processor (< 50 miles)
• Fines going to alternative aggregate use
• NGR (paper, bottles, cans) going back to system for recovery and commodity value
• MRF saw an increase in cullet pricing; payback period of less than 2 years
Example #2 – Results

Composition of the clean glass stream:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass (¼” – 2”)</td>
<td>93.3%</td>
<td></td>
</tr>
<tr>
<td>Fines (&lt; ¼”)</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>NGR</td>
<td>5.8%</td>
<td>Non glass residue</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Composition of the NGR:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSP</td>
<td>3.2%</td>
<td>Ceramic, stone, porcelain</td>
</tr>
<tr>
<td>Organics</td>
<td>1.1%</td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>1.0%</td>
<td></td>
</tr>
<tr>
<td>Residue</td>
<td>0.6%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5.8%</td>
<td>Of the total stream</td>
</tr>
</tbody>
</table>

Note: Results from audit conducted in mid-2016 reflect standard specifications (“Fines = ¼” or less”) prior to recent update from ISRI (Nov 2016)
## Glass Stream Value

### 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

<table>
<thead>
<tr>
<th>Case Results</th>
<th>Processor’s target specification</th>
<th>Undersize</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0% 1.0% 5.0% 10.0% 15.0% 20.0% 25.0% 30.0% 35.0% 40.0%</td>
<td></td>
</tr>
<tr>
<td>NGR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.0%</td>
<td>$ (3.20) $ (3.44) $ (4.40) $ (6.60) $ (6.80) $ (8.00) $ (9.20) $ (10.40) $ (11.60) $ (12.80)</td>
<td></td>
</tr>
<tr>
<td>25.0%</td>
<td>$ (9.20) $ (9.44) $ (10.40) $ (11.60) $ (12.80) $ (14.00) $ (15.20) $ (16.40) $ (17.60) $ (18.80)</td>
<td></td>
</tr>
<tr>
<td>30.0%</td>
<td>$ (16.20) $ (16.44) $ (17.40) $ (18.60) $ (19.80) $ (21.00) $ (22.20) $ (23.40) $ (24.60) $ (25.80)</td>
<td></td>
</tr>
<tr>
<td>35.0%</td>
<td>$ (23.40) $ (23.64) $ (24.60) $ (25.80) $ (27.00) $ (28.20) $ (29.40) $ (30.60) $ (31.80) $ (33.00)</td>
<td></td>
</tr>
<tr>
<td>40.0%</td>
<td>$ (31.40) $ (31.64) $ (32.60) $ (33.80) $ (35.00) $ (36.00) $ (37.40) $ (38.60) $ (39.80) $ (41.00)</td>
<td></td>
</tr>
<tr>
<td>45.0%</td>
<td>$ (37.00) $ (37.24) $ (38.20) $ (39.40) $ (40.60) $ (41.80) $ (43.00) $ (44.20) $ (45.40) $ (46.60)</td>
<td></td>
</tr>
</tbody>
</table>

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).
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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Tons</th>
<th>$/ton</th>
<th>Total/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposal</td>
<td>15,000</td>
<td>($ 22.00)</td>
<td>($ 330,000)</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td>($ 10.00)</td>
<td>($ 150,000)</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td>($ 3.00)</td>
<td>($ 45,000)</td>
</tr>
<tr>
<td>Total annual cost</td>
<td></td>
<td>($ 35.00)</td>
<td>($ 525,000)</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Tons</th>
<th>$/ton</th>
<th>Total/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketable glass (2)</td>
<td>11,250</td>
<td>$ 12.40</td>
<td>$ 156,240</td>
</tr>
<tr>
<td>Fines (3)</td>
<td>1,350</td>
<td>-0-</td>
<td>-0-</td>
</tr>
<tr>
<td>NGR commodities</td>
<td>150</td>
<td>$ 150.00</td>
<td>$ 22,500</td>
</tr>
<tr>
<td>Residue disposal</td>
<td>2,250</td>
<td>($ 37.00)</td>
<td>($ 83,250)</td>
</tr>
<tr>
<td>Transportation</td>
<td>15,000</td>
<td>($ 10.00)</td>
<td>($ 150,000)</td>
</tr>
<tr>
<td>Maintenance (4)</td>
<td></td>
<td>($ 4.00)</td>
<td>($ 60,000)</td>
</tr>
<tr>
<td>Total cost (before financing)</td>
<td>($ 7.63)</td>
<td>($ 114,510)</td>
<td></td>
</tr>
</tbody>
</table>

**NET SAVINGS**

$27.37  $411,510

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(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.
Other Levers and Success Drivers

New equipment alone will not ensure benefits to MRFs and municipalities

- Municipalities and MRFs must continue to accept glass
- Municipalities and MRFs should negotiate fair contracts that reflect true costs/value of glass and minimize volatility
- Processors and manufacturers must be willing to pay for higher quality cullet in established markets (i.e., move up the price matrix)
- MRFs need access to alternative end markets (e.g., abrasives, aggregates) that are willing to pay for cullet and fines, and will scale over time
Market Landscape
End Markets

End markets can generate $75+ in revenue per ton, creating opportunities to increase value from glass.

The **bottle & fiberglass** manufacturing markets are well established.

- **Abrasives** and **water filtration** are gaining momentum as alternative uses.
- The first **light weight aggregates** facility in the US opened in March 2017.
- The use of **Pozzolan** (glass) in concrete exists in Canada and is developing in the US.
Operators | Container & Fiberglass Manufacturers, Processors

- 45 Container manufacturers (e.g., O-I, Ardagh, Anchor)
- 29 Fiberglass and other manufacturers (e.g., Owens-Corning, Johns Manville)
- 60 Processors; Strategic Materials Inc. (SMI) operates more than 30 plants in the US

Note: Emerging alternative end-market manufacturers are not listed
Source: GPI (2016).
Infrastructure Gaps

- **25% of MRFs** (133) handle single stream material in sufficient volumes (60,000+ TPY) to justify an investment in a new glass clean-up system
  - 83% (110) are within 100 mi. from nearest processor and manufacturer
- MRFs that are located within 100 mi. of a processor or manufacturer still may not have opportunity to market their glass, if they are not aware of local customers or if local customers are already at capacity
Opportunity for Impact

With $25M investment, we can:

- Improve glass clean-up systems in **50 mid- to large-sized MRFs**

- Increase volume of glass recycled for best use by 33% to **1M tons annually**, and **5M tons** over 5 years

- Increase savings to municipalities and MRF profitability by **$100M+** over 5 years

- Decrease energy costs and GHG emissions for glass container manufacturers by **7-8%**
Appendix
General Guidelines for Glass Clean-up Operations

• **Best** practices
  – Remove glass at first screen (typically OCC screen) in sortation process and 1-2x more times throughout (news screens and/or at polishing screen)
    • Best accomplished with glass crushing screens below OCC/news/polishing screens
  – Maintain glass crushing screens’ disks
  – IFO spacing for glass crushing screens less than 2 inches
  – Tilt and speed should be optimized based on MRF throughput and material mix
  – Install aspirator/vacuum to remove loose paper
  – Install shaker screen to remove <3/8 inch glass (non-sortable at glass processor)

• **Worst** practices
  – Removing glass later (i.e., after all screens) in the sortation process
  – Not maintaining glass crushing screens
  – Lack of aspirator/vacuum and shaker screen
  – Mismatch of throughput between overall MRF system and glass cleanup system

Source: Closed Loop Foundation, September 2015; see also Glass Recycling Coalition publication on MRF Best Practices: http://media.wix.com/ugd/161462_8188f343c3f049558d08dcc00f76ad4d.pdf
Economic Analysis – Key Drivers

1. Volumes
2. Operations
3. Markets
4. Transportation
5. Financing Terms

Refer to Calculator Tool for details
Glass represents a significant cost for MRFs

<table>
<thead>
<tr>
<th>% of Ton by Volume</th>
<th>3-yr Average $ Value/ton</th>
<th>Feb 2017 $ Value/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Paper</td>
<td>9.80%</td>
<td>$60.00</td>
</tr>
<tr>
<td>Newspaper (ONP)</td>
<td>39.90%</td>
<td>$72.43</td>
</tr>
<tr>
<td>Cardboard (OCC)</td>
<td>13.10%</td>
<td>$98.32</td>
</tr>
<tr>
<td>Aseptic and Gable Top Container</td>
<td>0.60%</td>
<td>$98.33</td>
</tr>
<tr>
<td><strong>Mixed Glass</strong></td>
<td><strong>27.10%</strong></td>
<td><strong>($14.50)</strong></td>
</tr>
<tr>
<td>Aluminum Cans</td>
<td>1.10%</td>
<td>$1,261.82</td>
</tr>
<tr>
<td>Steel Cans</td>
<td>2.90%</td>
<td>$101.72</td>
</tr>
<tr>
<td>PET #1</td>
<td>2.00%</td>
<td>$276.00</td>
</tr>
<tr>
<td>Natural HDPE #2</td>
<td>1.30%</td>
<td>$671.54</td>
</tr>
<tr>
<td>Colored HDPE #2</td>
<td>1.10%</td>
<td>$446.36</td>
</tr>
<tr>
<td>#3-7 Mixed Plastic</td>
<td>1.20%</td>
<td>$19.17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00%</strong></td>
<td><strong>$80.55</strong></td>
</tr>
</tbody>
</table>

Source: RRS
Note: In some markets, MRFs may find cost of glass is $30+/ton.
### Economic Analysis – Before (CLF Portfolio)

<table>
<thead>
<tr>
<th></th>
<th>MRF A</th>
<th>MRF B</th>
<th>MRF C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Volume</strong></td>
<td>12,000 tons (~12% of total volume)</td>
<td>650 tons (3) (~ 7% of total volume)</td>
<td>12,500 tons (13% of total volume)</td>
</tr>
<tr>
<td><strong>Disposal cost</strong></td>
<td>$ (18.53) (1)</td>
<td>-0-</td>
<td>$ (40.90) (1)</td>
</tr>
<tr>
<td><strong>Transportation cost</strong></td>
<td>$ (12.50) (2)</td>
<td>$ (20.00)</td>
<td>$ (22.00)</td>
</tr>
<tr>
<td><strong>FOB Revenue/ton</strong></td>
<td>$ (5.00)</td>
<td>$ 10.00</td>
<td>-0-</td>
</tr>
</tbody>
</table>

(1) Based on 5-mth average, all non-glass residue
(2) 9-mth average
(3) 6-mth average
Sample Economic Analysis – Before

**Current Scenario:** This scenario assumes an average size MRF with a total in-bound volume of 60,000 tons/year producing **15,000 tons/year of a glass stream**

<table>
<thead>
<tr>
<th>Description</th>
<th>Tons</th>
<th>$/ton</th>
<th>Total per year</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposal</td>
<td>15,000</td>
<td>($ 22.00)</td>
<td>($ 330,000)</td>
<td>Assumes disposal in a landfill as alternate daily cover at a reduced rate (avg. range: $20-25/ton)</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td>($ 10.00)</td>
<td>($ 150,000)</td>
<td>Trucking to disposal site (avg. range: $7-12/ton)</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td>($ 3.00)</td>
<td>($ 45,000)</td>
<td>Incremental maintenance associated with glass</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td></td>
<td>($ 35.00)</td>
<td>($ 525,000)</td>
<td><strong>Annual cost of glass stream</strong></td>
</tr>
</tbody>
</table>

Source: MRF interviews, RRS
Sample Economic Analysis – After

Potential scenario (1) with the installation of an effective glass clean-up system:

<table>
<thead>
<tr>
<th>Description</th>
<th>Tons</th>
<th>$/ton</th>
<th>Total per year</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketable glass (2)</td>
<td>11,250</td>
<td>$12.40</td>
<td>$156,240</td>
<td>Assumes 75% yield from glass stream</td>
</tr>
<tr>
<td>Fines (3)</td>
<td>1,350</td>
<td>-0-</td>
<td>-0-</td>
<td>Assumes 9% fines sent with glass to processor</td>
</tr>
<tr>
<td>NGR commodities value</td>
<td>150</td>
<td>$150.00</td>
<td>$22,500</td>
<td>Assumes 1% mixed metals in NGR</td>
</tr>
<tr>
<td>Residue</td>
<td>2,250</td>
<td>($37.00)</td>
<td>($83,250)</td>
<td>Assumes 15% residue, MRF negotiated tip fee</td>
</tr>
<tr>
<td>Transportation</td>
<td>15,000</td>
<td>($10.00)</td>
<td>($150,000)</td>
<td>Actual $/ton will vary depending on destination</td>
</tr>
<tr>
<td>Maintenance (4)</td>
<td></td>
<td>($4.00)</td>
<td>($60,000)</td>
<td>Assumes + $1/ton in incremental maintenance cost</td>
</tr>
<tr>
<td><strong>Total cost (before financing)</strong></td>
<td></td>
<td>($7.63)</td>
<td>($114,510)</td>
<td><strong>NET SAVINGS ~$410,000/yr, or $27/ton</strong></td>
</tr>
</tbody>
</table>

Most equipment loans could be paid back from realized savings within 2 years

(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
Strategic Materials Footprint (2016)

- Established in 1896, SMI is the largest glass recycler in the U.S.
- Operates over 40 glass recycling plants across North America; 20 plants receive MRF mixed glass
- Recycling approx. 3 million inbound tons of glass each year

Largest Network of Glass Recycling Plants in North America