HEALTHY BUILDING NETWORK

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Post-Consumer Cullet in California

A Healthy Building Network Evaluation
for StopWaste and the Optimizing Recycling Collaboration

2015

Contents

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Acknowledgements: We are grateful to Curt Bucey, Joe Keating, Scott Miller, Jim Puckett, Lauren Roman, Gale Tedhams, Jerry Turner, and Stan Wolfersberger for their information and insights.

StopWaste provided funding for this research on post-consumer cullet, with additional support from the BlueGreen Alliance and donors to the Healthy Building Network (HBN). It was conducted using an evaluative framework developed by StopWaste, the San Francisco Department of the Environment, and HBN (the "Optimizing Recycling Collaboration").

The views expressed in this evaluation are those of the authors and do not necessarily reflect the position or policy of StopWaste, the BlueGreen Alliance, the San Francisco Department of the Environment, or donors to HBN.

About Optimizing Recycling Series

The Optimizing Recycling Series of reports is a collaboration between the Healthy Building Network, a non-profit organization whose mission is to protect health in the built environment, and StopWaste, a public agency responsible for reducing the waste stream in Alameda County, CA, with support from the San Francisco Department of the Environment. It examines the hazards, supply chains, and economic impacts of recycled feedstock streams found in building products.

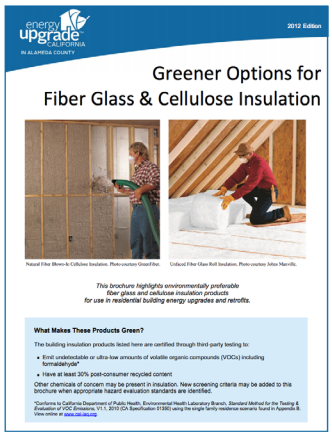
This briefing paper on post-consumer cullet in California is the second in a series of papers that examine ways to optimize recycled content feedstocks commonly used in building materials. The most common conditions of post-consumer feedstocks, as consumed in California, establish the baseline for assessments found in this report.

The recycling industry and building product manufacturers have made significant strides toward the vision of a closed loop material system, whereby materials produced today become the raw materials for their products in the future. Contamination of feedstocks with chemicals of concern, however, can reduce feedstock value, impede growth of recycling rates and potentially endanger human and ecosystem health.

We describe the framework for our evaluation of cullet and other feedstocks in our collaboration's overview report, *Optimizing Recycling: Criteria for Comparing and Improving Recycled Feedstocks in Building Products*. It describes how best practices for monitoring and improving the purity of recycled feedstocks in building materials can improve feedstock value, protect human health and dramatically increase recycling rates in North America.

The white paper and feedstock briefing papers can be found on HBN's website, at http://healthybuilding.net/content/optimize-recycling.

STOPWASTE'S GREENER INSULATION GUIDE



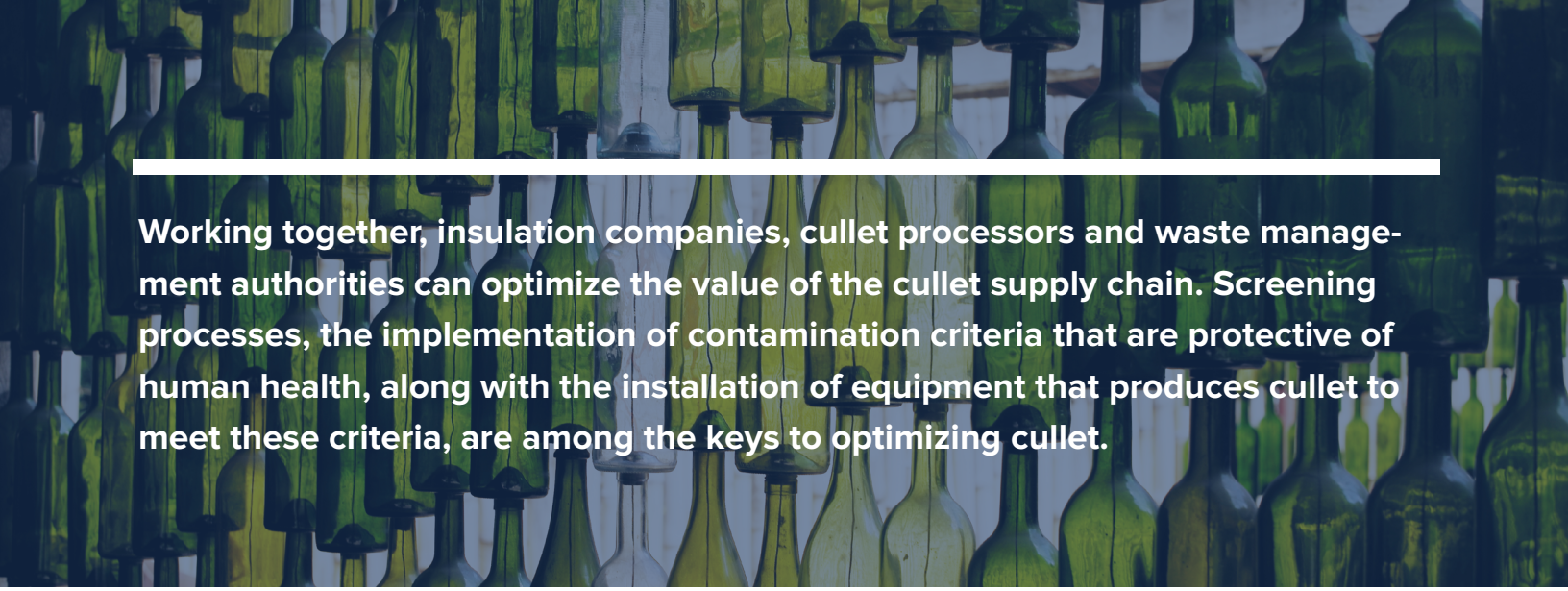
This Optimizing Recycling series examines ways to optimize recycled content feedstocks commonly found in building materials. When pieced together with systematic evaluation of a product's health and environmental attributes, this information can help consumers make more informed decisions about which products to purchase. One example of this is found by piecing together the information in this glass cullet report along with recommended best practices for selecting fiber glass building insulation products found in StopWaste's greener insulation brochure.

Greener Options for Fiber Glass & Cellulose Insulation highlights environmentally preferable fiber glass and cellulose insulation products for residential buildings. These insulation products are certified through third-party testing to:

- Emit zero or ultra-low amounts of volatile organic compounds (VOCs)
- Have a minimum of 30% post-consumer recycled content

As found in this glass cullet report, if the recycled product was manufactured in California, it has high likelihood of being among the safest options for insulation materials.

The brochure is available at www.stopwaste.org/insulation.



Working together, insulation companies, cullet processors and waste management authorities can optimize the value of the cullet supply chain. Screening processes, the implementation of contamination criteria that are protective of human health, along with the installation of equipment that produces cullet to meet these criteria, are among the keys to optimizing cullet.

A. Executive Summary

I. OVERALL EVALUATION

- Feedstock Health and Environmental Hazards
- Supply chain quality controls / Transparency
- Green Jobs & other local economic impacts
- Room To Grow

OVERALL: Cullet – that is, recycled glass waste processed for re-melting into new products – has many benefits including a constant supply, job creation, and reduced greenhouse gas emissions compared to virgin glass. Unfortunately, some types of post-consumer cullet that are used in building products can be contaminated with heavy metals like lead and mercury. In California, however, several existing conditions reduce concerns of heavy metal contamination in cullet feedstocks. First, state law restricts the toxic content of container glass that can legally be sold. Second, a strong bottle recycling bill effectively segregates bottle glass from cross-contamination with other types of post-consumer glass. Lastly, the sole cullet producer in California produces its cullet in compliance with the state's restrictions on toxics in bottles. Therefore, post-consumer recycled content cullet produced in California is generally of less concern than cullet produced in states without these protections. Cullet collected or processed outside of California does not necessarily meet these conditions.[a]

SUITABLE BUILDING APPLICATIONS: Cullet produced in compliance with California's Toxics in Packaging state law[1] is suitable for use in many building products, including fiber glass insulation, Type X (fire resistant) wallboard, fluorescent bulbs, window glass, concrete, pavement (glassphalt), construction fill, sandblasting, terrazzo floors, tiles, countertops, and carpet backings.

PATHWAYS FOR OPTIMIZATION: The condition of cullet delivered to California manufacturers demonstrates how recycled feedstocks can be optimized through a combination of best practices. Source materials are segregated at the point of generation through California's effective bottle bill, and the state's sole cullet processor identifies and eliminates contaminants

[a] Our research found that some factories outside California using standard cullet release more heavy metal pollution than comparable factories in California. The scope of this investigation did not allow full classification of feedstocks harvested or processed outside of California.

to comply with the Toxics in Packaging law.[2] Manufacturers of products that include recycled glass can replicate and even improve upon California's optimization nationwide by implementing and publicizing cullet specifications that limit heavy metal content accepted in cullet from suppliers, especially for products that can come into contact with people or the environment.

II. SCOPE OF EVALUATION

This evaluation of cullet focuses on feedstocks used in the manufacture of common building products sold in California. Fiber glass insulation[b] is the second most significant end use of cullet, after bottles.[c] Therefore, cullet processors and suppliers that sell to fiber glass insulation manufacturers were the main focus of this investigation. In particular, this evaluation focuses on the condition of cullet as delivered to manufacturers of insulation sold in the Bay Area of California.

Though this investigation was primarily based on fiber glass insulation manufacturers, many of the findings and recommendations are expected to be suitable for other building products that make use of cullet in California. These findings apply only to cullet derived from flat glass or container glass. Other cullet streams, such as cathode ray tubes (CRTs), contain levels of lead and heavy metals far higher than those present in the cullet delivered to California's fiber glass insulation manufacturers.

III. FINDINGS

a. General

- The life cycle benefits of using cullet are considerable, particularly in saving energy and minimizing resource extraction. For example, according to the US Environmental Protection Agency, "Making fiber glass insulation from recycled cullet requires less energy than making it from sand and other raw materials, since it avoids the energy needed to fuse the raw materials into glass. For every 10 percent of recycled content in fiber glass insulation, the manufacturing energy needs decrease by roughly 3.25 percent."[3]
- Despite the benefits of recycling glass, nearly 11.5 million tons of scrap glass enter the U.S. municipal waste stream each year. Only 27.5 percent of this glass is recovered for recycling, according to EPA data for the years 2010 to 2013.[4] In California, by contrast, over 75 percent of glass containers that fall under the bottle bill are recycled.[5] This is aided by a high collection rate for beverage containers: in 2014, over 912,535 tons of glass beverage containers were returned in California, up from 895,335 tons in 2011.[6] The drivers for this high recycling collection rate are a combination of the bottle bill price signal, as well as demand from the insulation industry for cullet.[7]

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[b] Fiber glass is also commonly called "glass wool" or "glass mineral wool" in insulation products. Insulation products include unbonded and bonded glass wool, batting, ceiling tiles, mats and pipe insulation. (Worrell, E. et. al. Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry: An ENERGY STAR® Guide for Energy and Plant Managers. Ernest Orlando Lawrence Berkeley National Laboratory. March 2008. http://china.lbl.gov/sites/all/files/guidebooks/Glass_Guidebook_EN_0.pdf)

[c] Two of the largest consumers of cullet produced insulation: Owens Corning is ranked as the third leading user (14.2%, 475,000 tons) and Johns Manville is ranked sixth (6.4%, 215,000 tons). (Cattaneo, J. Glass Bottles: Reaching 50% Recycled Content [Powerpoint slides]. Glass Packaging Institute. May 18, 2010. http://www.vrarecycles.org/LinkClick.aspx?fileticket=jP3bJ0xHPuo%3D&tabid=58)

- State regulations and incentives help to ensure clean, source separated supplies of glass. These drivers include:
    - The California Beverage Container Recycling and Litter Reduction Act, which helps to keep bottles separated from the waste stream and to prevent cross-contamination from problematic glass types, like compact fluorescent bulbs and CRTs, which contain mercury and lead, respectively.
    - The state's Toxics in Packaging law, which requires that container glass (including drinking bottles or other food grade containers) have fewer than 100 parts per million (ppm) of four key metals – lead, cadmium, mercury, and hexavalent chromium – combined. [8]
    - The California Department of Conservation's Quality Incentive Payment (QIP) Program, which pays curbside programs, drop-off or collection programs, and other certified entities to sort and clean material to QIP specifications.[9]

In summary, when glass recycling programs adhere to specifications protective of human health, the result is uncontaminated supplies of high value, high demand cullet derived from bottle and window[d] glass waste. These recycled content feedstocks have many benefits over virgin products, are reliably low in hazardous content, and should be suitable for many uses in building materials.

b. Fiber Glass Insulation Manufacturing in California

Within the building product industry, fiber glass insulation manufacturers represent the largest consumers of California cullet. In 2014, new fiber glass production in California consumed 168,933 tons of cullet, up from 131,050 tons in 2011. In 2014, new fiber glass insulation produced in California contained 50.7% recycled glass.[10]

Because of this, much of our research and the resulting findings for this paper are based on fiber glass manufacturing in California. Our evaluation has determined that:

- Cullet Used in California's Fiber Glass Insulation is Reliably Low in Hazardous Content

The cullet used to make fiber glass insulation in California is reliably low in hazardous content because the sole supplier of recycled glass to the state's insulation factories produces cullet in compliance with the state's Toxics in Packaging law. There are four insulation factories in California[e], and a single cullet supplier – Strategic Materials – supplies all of their cullet.[f] Strategic Materials' production lines create cullet both for container glass and fiber glass insulation companies. Quality controls designed for bottle producers have the incidental side benefit of providing insulation cullet that is compliant with packaging regulations.

Therefore, we have determined that cullet, as used in the majority of fiber glass insulation made in California, sold in the Bay Area, does not raise significant human health or environmental concerns.

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[d] Also known as sheet, flat, and float glass.

[e] There are four fiber glass insulation factories in California: Johns Manville in Willows, CertainTeed in Chowchilla, Owens Corning in Santa Clara, and Knauf Insulation in Shasta Lake.

[f] This and other information was obtained in personal communications with Curt Bucey, of Strategic Materials, on June 25, 2015.

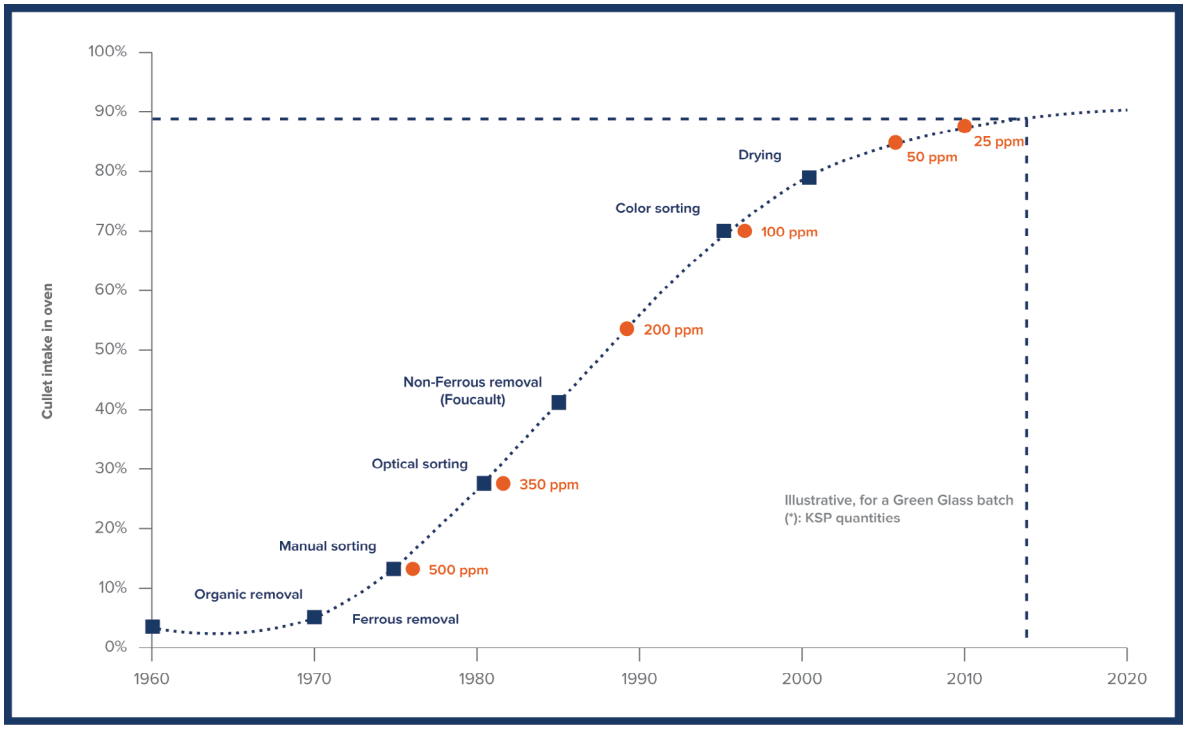
- California Leadership Does Not Necessarily Translate to Other States

The above findings do not apply nationwide. The national fiber glass insulation industry has not published health-based procurement specifications or chain of custody controls for cullet. Further, some cullet producers have demonstrated poor quality control practices.[9] Some fiber glass insulation factories obtain cullet from a company that the Occupational Health and Safety Administration has placed in its "Severe Violator Enforcement Program."[11] Some insulation factories have reported high amounts of lead (Pb) releases.[12] One insulation company attributed these lead releases to the cullet.[13] Further clarification on these issues is needed from fiber glass insulation manufacturers and cullet suppliers. The clean supply of cullet in California can be a model for other parts of the country.

- There are Opportunities to Increase Cullet Usage

Statewide, and nationally, more post-consumer glass is generated than is actually recycled in products. Higher recycled content rates in insulation are possible by lowering the contamination of cullet. As seen in the graph below, published by Ferver, the European Federation of Glass Recyclers, reductions in heavy metal content (particularly lead) directly correlate with increased usage of recycled glass. This graph illustrates clearly that as the sorting technology increased in effectiveness, the cullet intake also increased while the contamination (in ppm) decreased.

GRAPH 1. IMPROVEMENT IN GLASS RECYCLING QUANTITY & QUALITY IN EUROPE



Graphic reproduced from Glass recycling: years of improvement, Ferver (European Association of Glass Recyclers), presentation to Glassman Europe, May 6, 2015. http://www.glassmanevents.com/europe/content-images/misc/FERVER.pdf

[9] The second largest supplier of cullet to fiber glass insulation manufacturers, Dlubak Glass, has not responded to our requests for information, and has been named a serious repeat offender of environmental and occupational health laws for lead contamination.

> **"If we can find a way to get more supply in the right form, there's a lot more supply to be had."**
>
> **- Gale Tedhams of Owens Corning**
> (personal communication)

California is the national leader in recycling glass, but the state's fiber glass insulation manufacturers have room for even more recycled content than they averaged in 2014 (50.7%).[14] For example, two companies that manufacture fiber glass insulation in California have achieved much higher recycled glass content in their products that are manufactured and sold in Europe. Knauf Insulation's fiber glass insulation made in Belgium has an average of 71% recycled glass content, and its insulation made in the United Kingdom has reached as high as 82% cullet content.[15] And Saint-Gobain, parent company of Certainteed, uses up to 80% percent recycled glass in its European insulation.[16]

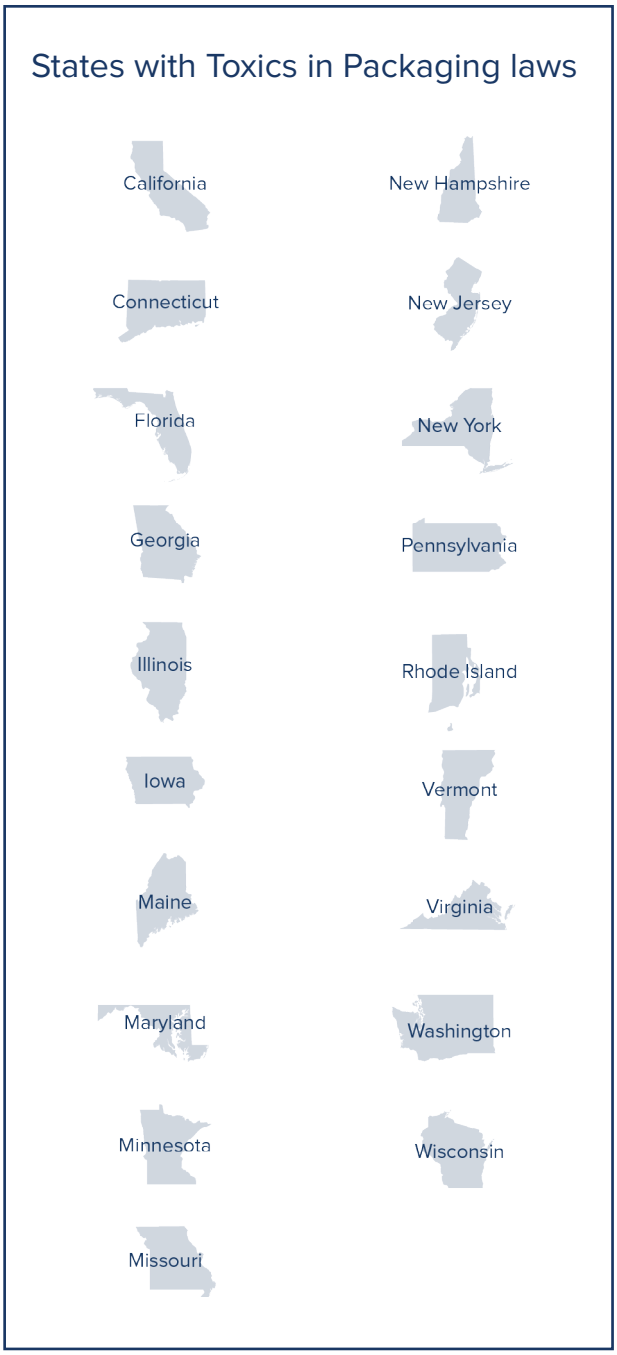
"Cullet use levels of 70 to 90 percent are commonplace in many European countries, particularly in Germany and Switzerland," according to a 2012 analysis by recycling specialist Joe Van Rossum. [17]

Quality control is essential for achieving higher cullet usage in fiber glass insulation. "In the U.S., lower cullet utilization rates of 10 to 40 percent are more common," said Van Rossum. "U.S. glass manufacturers point to a lack of consistent supplies of quality cullet as the reason for lower utilization rates. Contamination of recovered cullet is a major concern to manufacturers as many recycling programs have become unable or unwilling to carefully sort out unacceptable materials such as ceramics, heat-resistant cookware, light bulbs, metal rings and lids, porcelain, and non-container glass."

Europe recycles more glass because it more aggressively identifies and eliminates contaminants. European fiber glass insulation manufacturers severely restrict non-ferrous metal content, a contaminant frequently found in recycled glass. For their parts, European cullet processors have invested in sophisticated technologies to scan for and eliminate non-ferrous metals and other contaminants, a practice California could follow and again show domestic leadership in glass recycling.

Working together, insulation companies, cullet processors and waste management authorities can optimize the value of the cullet supply chain. Screening processes, the implementation of contamination criteria that are protective of human health, along with the installation of equipment that produces cullet to meet these criteria, are among the keys to optimizing cullet.

The fiber glass insulation industry has responded to environmental and health challenges before – it no longer uses asbestos or vermiculite fibers, and all of the California fiber glass insulation companies have eliminated formaldehyde-based binders from their standard products.[h] The industry can continue its arc toward sustainability by adopting stringent specifications for cullet, with the support of states (through "bottle bills" and other source separation incentives, and the adoption of restrictions on heavy metal content in container glass) and the recycling industry (by producing cullet with minimal heavy metal content).



[h] In the past few years, CertainTeed, Johns Manville, Knauf, and Owens Corning have eliminated formaldehyde-based binders from many types of fiber glass insulation. They have typically replaced them with polyol-polyacrylic acid copolymers in standard fiber glass batt insulation. (Johns Manville. (April 3, 2013.) Formaldehyde-free Fiber Glass Building and Flexible Duct Insulation [Material Safety Data Sheet].
http://cleancrawls.com/wpcontent/uploads/2015/07/jm_fiber_glass_insulation.pdf;
CertainTeed. Environmental Product Declaration: Sustainable Insulation® Unfaced and Kraft Faced Batts. June 25, 2013.
http://www.certainteed.com/resources/CertainTeed_Sustainable_Insulation_EPD.pdf;
Knauf Insulation. Environmental Product Declaration: EcoBatt Unfaced Insulation. November 8, 2013.
http://www.knaufinsulation.us/sites/us.knaufinsulation.com/files/EPD%201%20-%20EcoBatt.pdf;
Owens Corning. Environmental Product Declaration: EcoTouch® Foil Faced Insulation. June 13, 2014.
http://www.cavitycomplete.com/NetworkShare/Shared/10019221-EPD---EcoTouch-Foil-Faced-Insulation.pdf

IV. RECOMMENDATIONS:

For Cullet Processors:

Sell only cullet that complies with California's Toxics in Packaging laws or equivalent international standards. Restricting toxic content in building products is essential wherever manufacturing, installation, use or deconstruction may release these hazards into the environment. Publicly disclose sources of processed cullet. Publicly disclose testing procedures and results for heavy metal content (in parts per million) of cullet as delivered to building product manufacturers. Processors should clearly state the heavy metal content of the cullet they sell.

For Building Material Manufacturers in California:

Publicly certify the origins and heavy metals contents of cullet used in building products. California's Toxics in Packaging laws have a threshold of 100 ppm; however, Europe uses a standard of <20 ppm non-ferrous metals, total, in cullet.[26] Manufacturers should look to match Europe's standard.

For Manufacturers outside California:

Source recycled content from processors whose cullet contains less than 100 ppm lead and other heavy metals, in compliance with state Toxics in Packaging rules. Follow the above recommendation for manufacturers in California. Further, industry associations, such as the North American Insulation Manufacturers Association, should update their ASTM standards for cullet utilization.[i] Ideally, building product manufacturers will adopt the European standard for non-ferrous metal content. Europe's cullet standard is far more protective of human health, and, as a direct consequence, cullet produced to this standard can be incorporated at a much higher rate.

[i] One option is to revive and incorporate a proposed ASTM standard that would "allow end users to write specifications that limit the total heavy metal content of glass products, to ensure their workers' safety." (ASTM International, Subcommittee F40.01. "Work Item Summary: WK15289 New Test Methods for Analysis of Heavy Metals in Glass Using X-Ray Fluorescence (XRF). 2007." Retrieved via Internet Wayback Machine February 2015 from https://pharosproject.net/uploads/files/sources/1/3ab0ce84b93b165821949d66532b85051af47bf8.pdf)

For Consumers:

Consumers looking to specify products made from cullet, like fiber glass insulation, should seek high recycled content products made in California. Cullet supply chain controls are less clear outside California. In the meantime, if specifying fiber glass insulation made outside California, consumers should request that manufacturers fully disclose their ingredients, including their sources of recycled content. Seek products from companies that test recycled materials for toxic contents, including heavy metals. Look for manufacturers that ensure worker and environmental protection during processing stages.

For Certifiers:

Develop certifications that verify that cullet produced for products like fiber glass insulation complies, at minimum, with Toxics in Packaging rules and ideally also with the European non-ferrous metals limits.

For Regulators:

Update state and federal specifications to ensure that cullet used in building products, at minimum, does not exceed Toxics in Packaging restrictions on heavy metal content.[28] Ideally, California could update its law to require cullet producers to meet the European industry's standard, which limits this content to 20 parts per million total non-ferrous metal content. Government-funded building project specifications should also adopt these standards.

To encourage greater supply of quality feedstock, support bottle bills and other initiatives to keep bottles out of single stream recycling operations. See "Room To Grow" (Section B.iv) for further explanation of the challenges of glass recovery from single stream recycling.

B. Behind the Ratings

I. ■ FEEDSTOCK HEALTH AND ENVIRONMENTAL HAZARDS

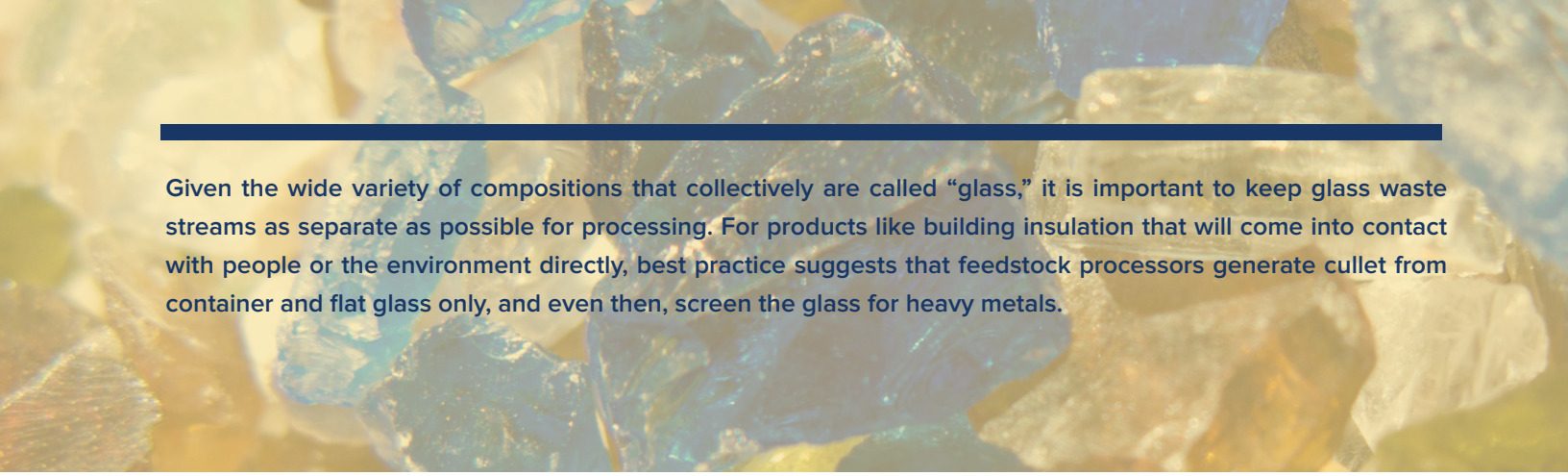
There are many different types of glass. Standard container (bottle) and window glass (also known as float or flat glass) are soda-lime compositions and are the preferred sources of cullet used in fiber glass insulation and other finished products. There are no significant health or environmental hazards associated with these types of glass as produced in California.

California is one of 19 states that have enacted Toxics in Packaging laws[20] limiting the presence of lead and select other heavy metals in bottle glass, to 100 ppm.[21] Float glass can generally be assumed to be relatively free of contaminants, because even minute amounts of metals or plastics in glass will cause distortions or other imperfections in the glass making them unsuitable for use as windows.[22]

One company – Strategic Materials – processes recycled container and float glass in California into cullet. It produces Toxics in Packaging-compliant cullet and supplies the same cullet to bottle and fiber glass manufacturers in California.[23] As Strategic Materials is the only Toxics in Packaging-compliant cullet producer in California, it is the sole supplier of recycled cullet to insulation manufacturing facilities in the state. As a result, the cullet used in the manufacture of insulation in California complies with the 100 ppm threshold, and receives a Green/Very Good rating for Environmental and Health Impacts of the feedstock.

This finding, however, does not apply nationwide. Some containers – especially those not produced to the specification of Toxics in Packaging laws – can exceed established thresholds of concern for heavy metal content. Further, some specialty glass, when commingled with standard bottle and float cullet, can contaminate the feedstock with toxic constituents, particularly lead oxide (funnel glass used in televisions can contain up to 20% lead oxide), mercury (from fluorescent glass lamps), and arsenic (a common refining agent).[24]

The relatively clean supply of cullet in California should be a model to others in other parts of the country that do not have the same regulations in place.



Given the wide variety of compositions that collectively are called "glass," it is important to keep glass waste streams as separate as possible for processing. For products like building insulation that will come into contact with people or the environment directly, best practice suggests that feedstock processors generate cullet from container and flat glass only, and even then, screen the glass for heavy metals.

a. Standard Content of Glass

Glass accounts for about five percent of municipal waste in the U.S.[25] Cullet — defined as waste or broken glass destined for remelting — has many forms. The largest stream is soda-lime glass used in packaging. Other types of cullet include flat or float (window) glass; cathode ray tubes and crystal glass (which contain lead oxide), fluorescent lamps (which contain mercury) and Pyrex (which contains boric oxide and sodium tetraborate[26]). Another potentially problematic ingredient in cullet is arsenic oxide (a common refining agent in glass).

There are many end uses for cullet in building and construction, such as insulation, fluorescent lights, window glass, flooring tiles, ceiling tiles, wallboard, asphalt, concrete, construction fill, and sand blasting. There are dozens of grades of cullet to consider in these potential uses.[27]

Bottles and windows (flat glass) are the most common sources of cullet used in fiber glass manufacturing.

According to a 2013 European Union analysis of best available techniques in glass manufacturing, heavy metals may be present as minor impurities in some raw materials, and the production of container glass and flat glass can release small amounts of lead[j] during production.[28]

However, not all container glass contains negligible amounts of lead. The Toxics in Packaging Clearinghouse (TPCH) recently screened glass wine bottles, and "found that approximately 19 percent of bottles tested exceeded allowable levels of lead in packaging. All bottles analyzed by TPCH that exceeded regulatory thresholds were green wine bottles originating from South America and Europe. In at least one case, the amount of lead in the wine bottle was 10 times greater than the regulatory threshold." [29]

[j] According to the EU analysis, without abatement, container glass production can emit up to 4 milligrams of lead per normal cubic meter of air (mg/Nm^3) and flat glass up to 1 mg lead/Nm^3. By contrast, lead crystal glass production releases up to 70 mg lead/Nm^3.

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b. Contaminants and Additives in Processing Glass Waste

Standard processing operations that turn glass waste into cullet are mechanical. According to Curt Bucey at Strategic Materials, broken glass is sorted and washed multiple times mainly to remove dirt, paper and plastic, which can represent up to 50 percent of the weight of collected material.[30]

In Europe, and to a lesser degree in the United States, cullet processors go beyond simple mechanical processes. Some use UV light and metal detectors to scan for other undesired contaminants, like ceramics, stones, porcelain, ferrous and non-ferrous metals, lead crystal, lead glass, and cathode ray tubes. Separators, vacuums, and magnets may be used to eject these materials.[31] To varying degrees, cullet processors also use X-Ray Fluorescence devices to test for heavy metals in their product before it is sold.

The most common health concerns in cullet processing operations are skin cuts and breathing glass dust during physical handling.[32] However, exposure to heavy metals such as lead can lead to health concerns for workers in processing plants, and even their families at home.[k]

Cullet processing can include decolorization, then the introduction of dyeing agents. First melted cullet is oxidized, then manganese oxide is mixed in to turn the cullet to a gray base color. Other agents are added to create desired colors, including, most commonly, borax, cobalt carbonate, erbium oxide, neodymium oxide, potassium permanganate, titanium dioxide, and zinc oxide.[33] Some colorants (erbium oxide[l], neodymium oxide) present minimal health hazards, some are respiratory hazards (titanium dioxide, zinc oxide) and some are developmental or reproductive toxicants (magnesium oxide, cobalt carbonate).[m]

Recycled glass used in a number of building products such as fiber glass insulation, however, does not need to be decolorized and dyed, as mixed cullet is commonly used.

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[k] In July 2015, a pediatrician at an Ohio children's hospital reported a case of lead poisoning of two young children to the Centers for Disease Control. The patients were "two children, ages 1 and 2, whose father worked at an e-scrap recycling company crushing cathode ray tubes (CRTs)," reported Cincinnati Children's Hospital Medical Center. The father apparently brought the lead home on his clothing. Dr. Nick Newman found levels of 18 micrograms per deciliter and 14 micrograms per deciliter in the children's blood. "Although no safe blood lead level in children has been identified, a reference level of 5 micrograms per deciliter is now used to identify children for whom parents, doctors and public health officials should take action to reduce exposure to lead," according to the Ohio hospital. Dr. Newman described CRT recycling as "emerging health concern." (Cincinnati Children's Hospital. "Doctor Warns About Lead Poisoning Risk From Recycling Older Electronic Equipment" [Press release]. July 27, 2015. http://www.cincinnatichildrens.org/news/release/2015/lead-poisoning-older-electronics/)

[l] Erbium oxide might be the best decolorization/dyeing option for processing cullet for use in window glass; it has no associated health hazards, and is used to clear all colors from the cullet. ("The Glass Recycle Process." All Recycling Facts. Last updated 2014. Retrieved February 2015 from http://www.all-recycling-facts.com/glass-recycle.html)

[m] Information on these chemicals is available through the Pharos Project database, maintained by the Healthy Building Network. www.pharosproject.net .

II. SUPPLY CHAIN QUALITY CONTROLS / TRANSPARENCY

States and the federal government, as well as third party certification bodies, have failed to consider health-based toxic heavy metal content restrictions in cullet that is used in construction (such as fill, aggregate and sandblasting) or in building products. Specifically, the fiber glass insulation industry in the United States has not published toxicology-based specifications for the allowable amount of heavy metals like mercury or lead in cullet used to manufacture its products.

The lack of contamination of California cullet that ends up in building products is due to factors external to product manufacturers: state regulations on container glass content, and compliance to that standard by Strategic Materials.

For example, the United States fiber glass insulation industry's ASTM standards for cullet cap heavy metal oxides at 0.1%, or 1,000 ppm.[34] This allows heavy metal content ten times higher than the limits set by the Toxics in Packaging law.

By comparison, European insulation manufacturers restrict non-ferrous metal content (including lead, mercury, and chromium) in cullet to a total of 20 parts per million, which is five times lower than the Toxics in Packaging law. (See Tables 1 and 2)

Further, insulation manufacturers in the United States do not publicly disclose the sources of their cullet. Cullet used in building products therefore receives a Yellow/Room for Improvement rating for Supply Chain Quality Control.

a. Industry Associations

There is no industry association of cullet manufacturers. The biggest suppliers of cullet to the fiber glass insulation industry are Strategic Materials of Houston, Texas, and Dlubak Glass Co. of Upper Sandusky, Ohio.[35] Neither Strategic Materials nor Dlubak Glass publish specifications, product declarations, or safety data sheets on their websites.

The website for the North American Insulation Manufacturers Association, naima.org, representing Owens Corning, CertainTeed, Johns Manville, and Knauf, does not publish specifications, product declarations or any other guidelines for identifying or limiting heavy metals in cullet feedstocks.

b. Certifications

No third party organizations have yet been employed to certify the heavy metal content in cullet used in building products, including fiber glass insulation.

c. State and Federal Law

State (but not federal) regulations have addressed heavy metal content in drinking bottles, but not yet for cullet for building products, at least from a toxicological viewpoint. The State of California has imposed certain standards on fiber glass insulation manufacturers, but these standards are not yet based upon human health protection.

Under public law (the Fiber Glass Recycled Content Act of 1991), the State of California requires fiber glass insulation manufacturers to use at least 30% cullet.[36] It also specifies maximum percentages of various oxides in this cullet. It limits heavy metal oxides, such as lead oxide, to under 0.1% (1000 ppm) of the cullet by weight (Table 1). The California standard mirrors the industry's ASTM standard for cullet used in insulation, which is based upon technical requirements.[37]

Ideally, these specifications would mirror the more restrictive "maximum permissible" levels of contamination allowed by the European insulation industry association, Eurima. According to a 2011 European Commission technical report, Eurima members[n] allow no more than 20 ppm non-ferrous metals (including lead) in cullet used in insulation (Table 2).[38] This is fifty times more restrictive than the 1000 ppm (0.1%) allowed in the ASTM and State of California specifications. It is also five times more restrictive than the state's Toxics in Packaging laws.

TABLE 1. NORTH AMERICAN INSULATION MANUFACTURING SPECIFICATIONS FOR CULLET

Oxides	State of California	ASTM - 0-5% cullet in batch	ASTM - 5-15% cullet in batch	ASTM - >15% cullet in batch
Silicon Dioxide	66-75%	68-77	68-77	68-77
Sodium Oxide	8-18%	8-18	8-18	8-18
Calcium Oxide (CaO)	5-15%	5-15	5-15	5-15
Magnesium Oxide (MgO)	0-5%	0-5	0-5	0-5
Aluminum Oxide	0-7%	0-7	0-7	0-7
Potassium Oxide	0-4%	0-4	0-4	0-4
Iron Oxide	<0.5%	<0.5	<0.5	<0.5
Sulfur Trioxide	<0.2%	<0.4	<0.3	<0.2
Chromium Oxide	<0.1%	<0.2	<0.15	<0.1
All other oxides (including lead oxide)	<0.1%	<0.5	<0.3	<0.1

Sources:
State of California. 2011 California Code Public Resources Code DIVISION 12.9. fiber glass RECYCLED CONTENT ACT OF 1991 [19500 - 19535] CHAPTER 3. Cullet Specifications for fiber glass Manufacturing Section 19515.5. http://law.justia.com/codes/california/2011/prc/division-12-9/19515-19519/19515.5
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TABLE 2. MAXIMUM PERMISSIBLE LEVELS OF TYPICAL CONTAMINATION OF CULLET, FOR THE PRODUCTION OF CONTAINER GLASS, FLAT GLASS, AND INSULATION MINERAL WOOL. (EUROPE)

Contamination	Particle weight / size	Container glass maximum (ppm)	Flat glass maximum (ppm)	Insulation mineral wool (fiber glass) (ppm)
Ferrous Metals	> 0.5 g	50	None (2 if <0.5 g)	10
Non-ferrous Metals	> 0.1 g	20	None (0.5 if <0.1 g)	20
Inorganics	> 0.2 mm	20	None	25
Organics	> 2 g	3000	None (45 if <2 g)	3000

Table reproduced from: Vieitez, E. R., Elder, P., Villanueva, A., & Saveyn, H. End-of-Waste Criteria for Cullet: Technical Proposals. Joint Research Center, Institute for Prospective Technological Studies. December 2011. Table data sources are Eurima (the European Insulation Manufacturers Association) and Glass for Europe http://ftp.jrc.es/EURdoc/JRC68281.pdf

[n] Eurima members include two manufacturers that also produce insulation in California: Knauf Insulation and Saint-Gobain (which owns CertainTeed).

d. Best Practices

Significant reductions in heavy metal content in cullet supplied to building products like fiber glass insulation are possible by preventing contaminated cullet from entering the factory. This can be accomplished through more restrictive specification criteria like the Toxics in Packaging laws. The best practices would meet the European insulation industry's 20 ppm non-ferrous metal standard.

A European Union analysis of best available technologies in glass manufacture lists raw material selection including "specifications on cullet quality…. to minimize contamination" as a key method of preventing heavy metal emissions.[40]

In 2007 an ASTM working group considered "New Test Methods for Analysis of Heavy Metals in Glass Using X-Ray Fluorescence (XRF)." An archive of that proposed standard reads:

> "Waste Glass is currently recycled into various products that can end up in consumer homes, worker lungs, and drinking water streams. Changes in the makeup of the glass that recyclers receive (old CRT tubes, leaded glass) has led to the need for a simple quick accurate method of sorting out incoming waste glass that has lead, arsenic and other heavy metals."[41]

Kristopher Davies of Potters Industries said the proposed standard would "ensure that products that could become hazardous to workers are not manufactured and it will also allow end users to write specifications that limit the total heavy metal content of glass products, to ensure their workers' safety."[42] The proposal has come and gone; ASTM's website no longer lists the work item.

e. Disclosure

Cullet processors in North American do not routinely publicize the heavy metal content of the cullet they sell, although they likely communicate this information to product manufacturers that they supply. Container glass manufacturers would need this information to ensure their products comply with Toxics in Packaging laws. The global automotive industry requires its suppliers to report lead and arsenic over 100 ppm.[43] However, data about these contents in cullet or building products that use cullet have not yet become public information.

f. Testing

Curt Bucey of Strategic Materials said his company has in-house practices in place to ensure that heavy metals do not contaminate their products. "We are light years ahead of our competition on quality," he said. This includes rejecting all CRT waste and adding testing procedures.

> **"Regulated ingredients such as lead oxide must also be avoided when using recycled cullet. Improved data, chemical analyses, and process control systems should overcome these and other quality issues."**
>
> **– Berkeley National Laboratory, 2008**

Strategic Materials' website states: "Strategic Materials has revolutionized the post-consumer cullet industry by implementing a continuous quality improvement program, based on ongoing samples and measurement of every batch."[44]

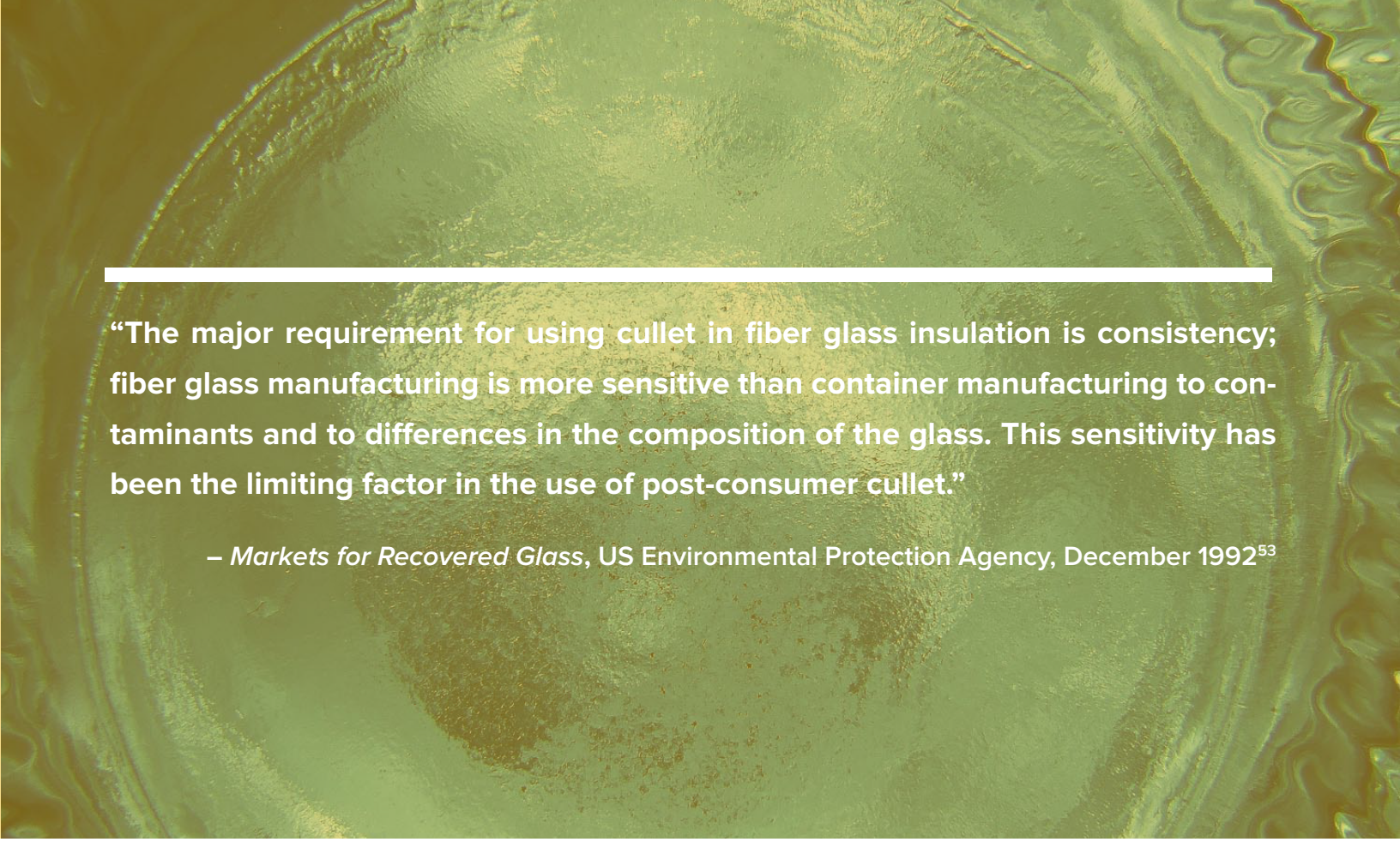
Strategic Materials is implementing handheld and/or stationary X-ray fluorescence testing procedures to detect leaded glass on all of its lines at all of its plants. It is also investing in optical sortation to separate glass by color in an effort to comply with container glass restrictions on heavy metal content. As previously noted, this compliance has the coincident benefit of cleaning up cullet supplies in general.

The XRF testing takes place on the outbound side, after the glass is processed, because what comes in can have a lot of unwanted materials that are ejected during the recycling process. Strategic Materials also inspects its final product with XRF devices. "If we start getting hits, we trace it back to the supplier, and we reject their loads until the supplier goes through a recertification process," Bucey explained.

A 2011 European Commission report shows how this system is working in Europe.

> *"The X-ray system is able to sort out undesired glass fractions that cannot be detected with infrared technique, like lead glass, refractory glass and glass ceramic. Within milliseconds, material with defined characteristics is blown out of the cullet, independent from the size, shape, or colour of the particle. Finally, automatic quality control is combined with manual quality control by qualified staff overseeing the final separation result. The outcome of these steps is cullet with a certain quality."*[45]

The Toxics in Packaging Clearinghouse (TPCH) also recommends the use of XRF testing, rather than an EPA testing procedure that uses leachate testing instead. "Some testing laboratories are using EPA Method 3050B, which is a sample preparation method intended to measure 'total recoverable metals' or leachable metals. This test method is inadequate in determining compliance with state toxics in packaging laws," said Alex Stone, Senior Chemist in the Washington State Department of Ecology. "Laboratories using this method – which was developed for detecting leachable metals in soil samples – failed to detect any lead in the glass samples."[46]



"The major requirement for using cullet in fiber glass insulation is consistency; fiber glass manufacturing is more sensitive than container manufacturing to contaminants and to differences in the composition of the glass. This sensitivity has been the limiting factor in the use of post-consumer cullet."

– *Markets for Recovered Glass*, US Environmental Protection Agency, December 1992[53]

III. ■ GREEN JOBS & OTHER LOCAL ECONOMIC IMPACTS

"On a per-ton basis, sorting and processing recyclables alone sustain 10 times more jobs than landfilling or incineration," says the Institute for Local Self-Reliance. "Making new products from the old offers the largest economic pay-off in the recycling loop."[47]

Glass recycling creates many jobs, especially in California, which has an aggressive glass collection program, incentives for color sorting, and recycled content requirements for end products like fiber glass insulation and glass containers. In 2006, the state had the country's highest glass container recycling rate, 58%.[48] California's glass container recycling rate (for those that have a California Refund Value) has continued to increase, and averaged over 80 percent between 2009 and 2014.[49]

A 2011 report prepared for the BlueGreen Alliance (BGA) estimates that the diversion of 1,000 tons of glass from the municipal waste stream generates about 11 jobs (1.67 collection jobs, 2 processing jobs, and 7.35 reuse/remanufacturing jobs).[50] Fifteen facilities in California use about 700,000 tons of cullet each year, according to a 2013 CalRecycle study.[51] That translates into an estimated 7,700 jobs.

The State of California's mandate to recycle 75 percent of its municipal waste by 2020 should also lead to growth in cullet use in new products. CalRecycle projects that 2,712 jobs will be added through increased use of glass recyclables by 2020.[52] Because of these strong job markets and projections, cullet receives a "green/good" rating.

IV. ■ ROOM TO GROW

The US generated 11.6 million tons of scrap glass in 2012. Only 28 percent of this glass was recovered for recycling, according to the EPA.[54] In some areas of the country, markets do not support the collection of glass, hence no scrap glass is collected for recycling.[55]

Nationally, the room for high value cullet recycling to grow is constrained where bottle bills or other source separation incentives are not in place. Post-consumer materials collection and processing has fundamentally changed in the short span of the new millennium. Source separation (where materials are collected separately and sent to distinct recycling facilities) has been replaced by single stream processing, in which all sorts of recyclables (and often, non-recyclables) are commingled, collected and processed together. In 2000, less than one quarter of municipal recycling volumes flowed through from single source systems; today, over 60% of these wastes are collected and processed in a single stream.[56] All but one of the ten largest cities in the U.S. collect recyclables in one bin systems.[57] The last holdout, New York City, plans to convert to single bins by 2020.[58]

Single stream systems are convenient and save consumers and municipalities the step of sorting various wastes. This space- and time-saving collection system is credited with increasing the volume of recycling overall, which reduces the amount of waste sent to landfills and incinerators. But while single stream systems increase waste material inputs into recycling processes, they generally reduce the quality of outputs.

Contamination and breakage in single sort systems particularly impacts the quality and supply of cullet. Due in part to single bin collection, good quality cullet is growing scarce, and market prices are rising. "Single-stream collection typically results in 15 to 20% of recyclables ending up as residual needing disposal. Why? Largely because of broken glass," says Neil Seldman, president of the Institute for Local Self-Reliance.[59] He adds, "The one bin system is not a strategy for conserving and recycling valuable material resources and getting them to markets."[60]

The Container Recycling Institute (a glass industry organization) noted in 2009,

> *"[O]n average, 40% of glass from single-stream collection winds up in landfills, while 20% is small broken glass (glass fines) used for low-end applications. Only 40% is recycled into containers and fiber glass. About one third of the non-recyclable glass is broken glass, too small to separate for recycling. Much of the breakage occurs during compaction in the single-stream truck or in the MRF [Materials Recovery Facility] separation process. In contrast, mixed glass from dual-stream systems yields an average of 90% being recycled into containers and fiber glass, with 10% glass fines used for low-end applications, and nearly nothing sent to landfill. In container-deposit systems, color-sorted material results in 98% being recycled and only 2% marketed as glass fines.*
>
> *"A system that reduces contamination and glass breakage to enable color sorting is a more effective way to recycle glass into high-value re-manufactured goods such as new glass bottles and fiber glass."*[61]

GRAPH 2: END-MARKETS FOR COLLECTED GLASS

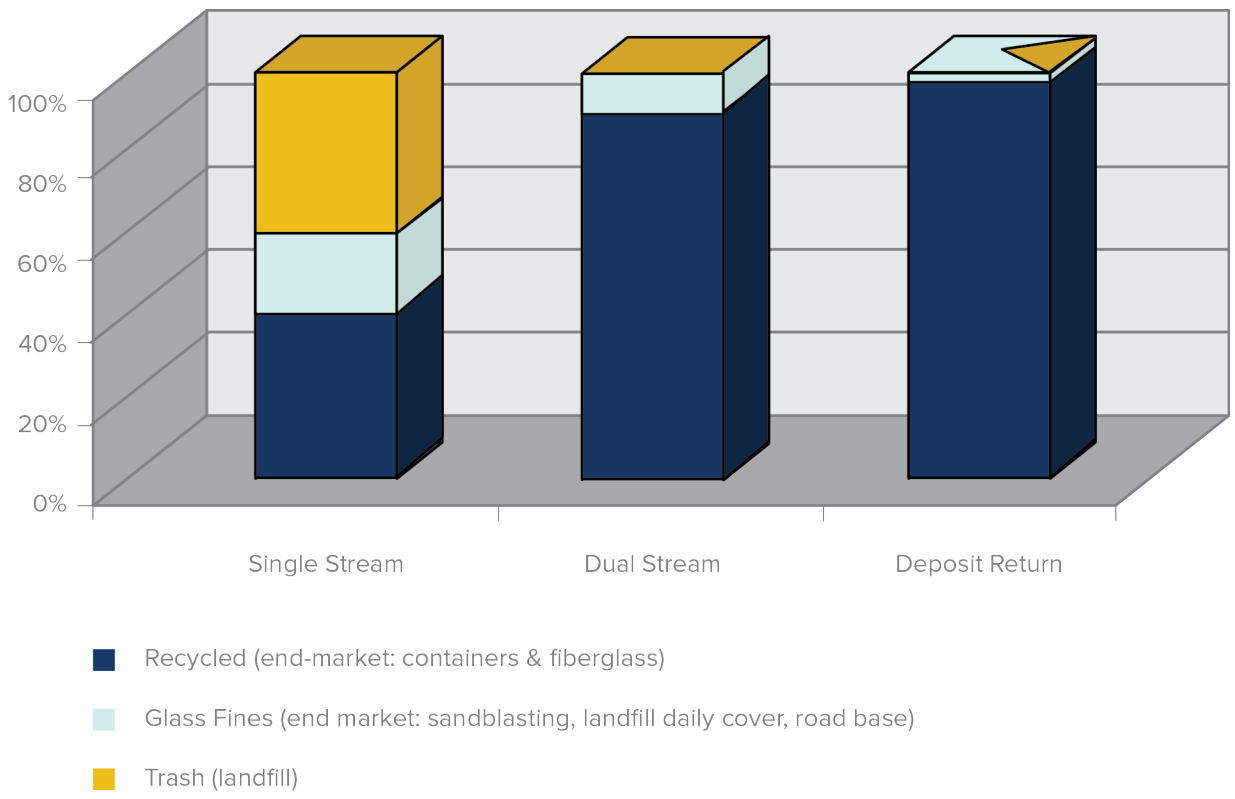
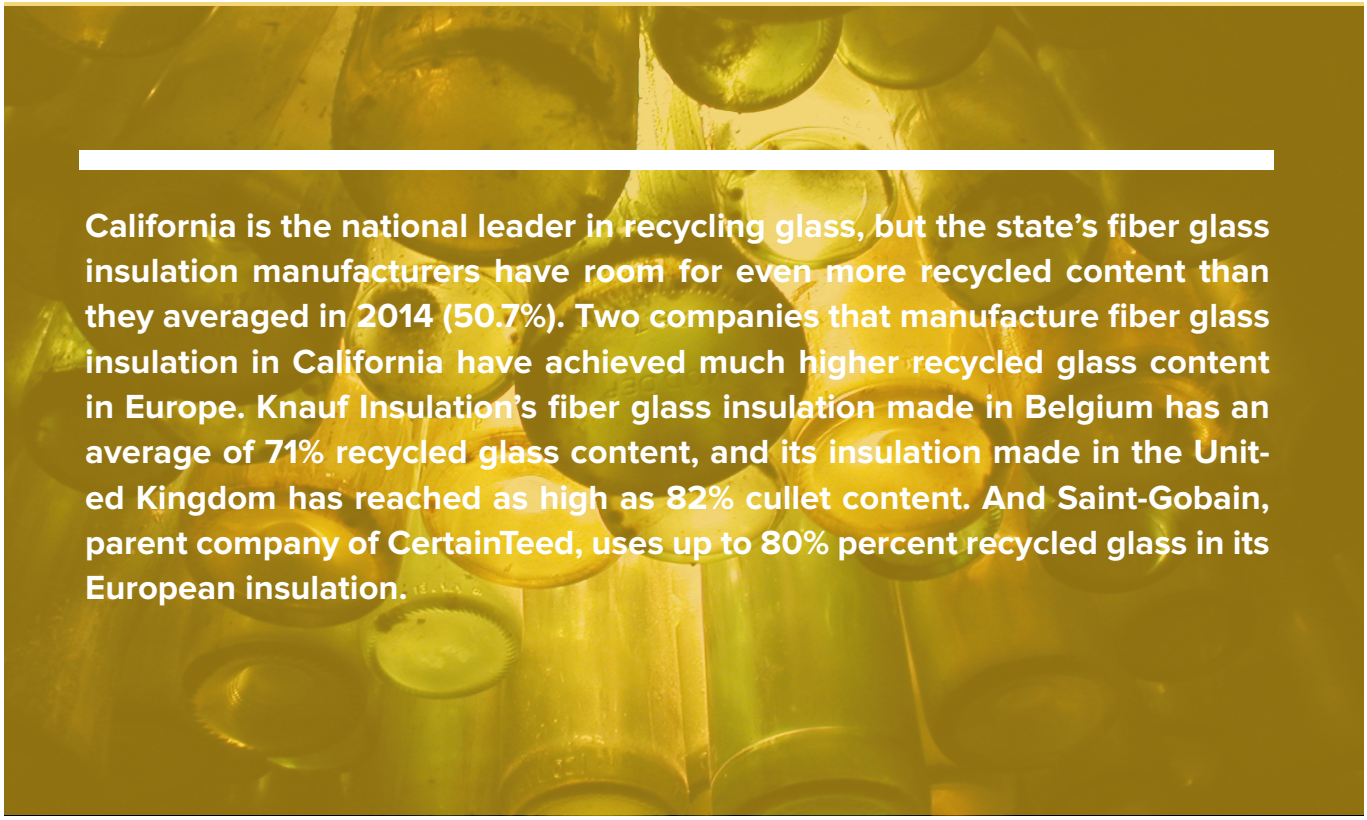


Figure reproduced from *Understanding economic and environmental impacts of single-stream collection systems*, Container Recycling Institute, December 2009, http://www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf.
Original source: Strategic Materials

"Our challenge is that the feedstock is always changing so we have to be adapting and changing," Curt Bucey of Strategic Materials told HBN. "Single sort has made it much much, much, harder. We can do it, we just need more equipment, more processes, and more quality control."

The most effective system for ensuring high quality cullet for broadest use in the market, studies have found, are container deposit systems. Fortunately, California and nine other states have enacted bottle bills,[o] which enhance the local quality of cullet. These states account for about half of all glass that is productively recycled in the United States.

The identification and elimination of contaminated wastes at each step of the process – from collection to processing to remanufacturing – is the most important strategy for maximizing the benefits of glass recycling. These steps will ensure a healthy supply of container cullet for recycling into many different products and end uses. Given the ample potential supply of glass, and the correlation between feedstock quality and use of cullet in high end products like building insulation, cullet used in building materials gets a green rating for its "Room to Grow."



[o] Bottle bills are state container deposit laws. Consumers pay a deposit on beverages sold in recyclable bottles and cans, and return them for redemption. In addition to California, Connecticut, Hawai'i, Iowa, Maine, Massachusetts, Michigan, New York, Oregon, Vermont, and the U.S. territory of Guam have bottle bills. http://www.bottlebill.org/legislation/usa.htm

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Post-Consumer Cullet in California

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