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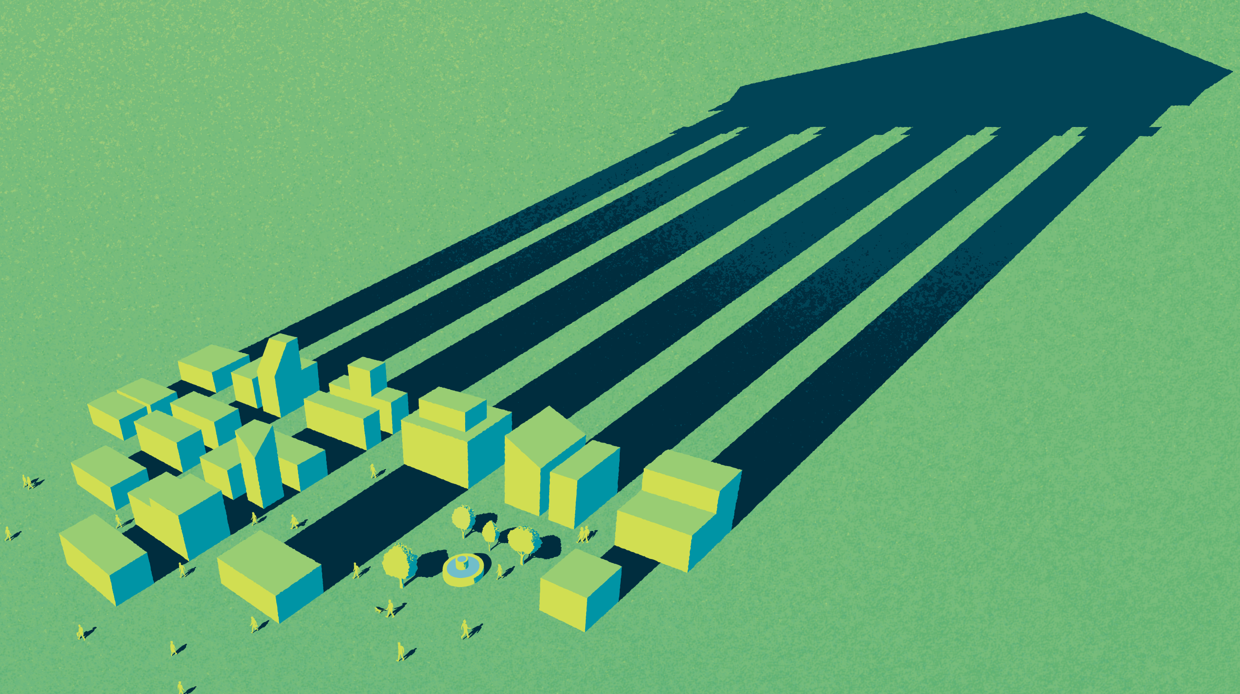

RESEARCH

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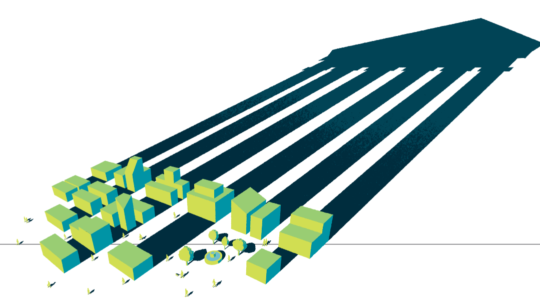

RESEARCH

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TO INCREASE THE USE OF RECYCLED CONTENT IN BUILDING PRODUCTS: REDUCE HEALTH HAZARDS & IMPROVE FEEDSTOCK QUALITY

TO INCREASE THE USE OF RECYCLED CONTENT IN BUILDING PRODUCTS: REDUCE HEALTH HAZARDS & IMPROVE FEEDSTOCK QUALITY

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ABSTRACT:

The recycling industry has made significant strides toward a closed loop material system in which the materials that make up new products today will become the raw material used to manufacture products in the future. However, contamination in some sources of recycled content raw material ("feedstock") contain potentially toxic substances that can devalue feedstocks, impede growth of recycling markets, and harm human and environmental health. Since May 2014, the Healthy Building Network, in collaboration with StopWaste and the San Francisco Department of Environment, has been evaluating 11 common post-consumer recycled-content feedstocks used in the manufacturing of building products. This paper is a distillation of that larger effort, and provides analysis on two major feedstocks found in building products: recycled PVC and glass cullet. This research partnership seeks to provide manufacturers, purchasers, government agencies, and the recycling industry with recommendations for optimizing the use of recycled content feedstocks in building products in order to increase their value, marketability and safety.

(Keywords: green building, health, recycling, feedstock, purchasing, PVC, glass, cullet, policy, hazards)

INTRODUCTION

In California and other states where green building is increasingly becoming standard practice, demand for recycled-content building products has never been higher. These products perform as well as, and are generally priced competitively with, their non-recycled counterparts. Products with post-consumer content change the conventional linear model of make-use-discard to a more virtuous closed loop model of make-use-remake. For these reasons, recycling and recycled content products are an important attribute that should be encouraged and celebrated within the building products industry.

However, concurrent with this growing demand for recycled-content building products is growing scrutiny of environmental and human health issues associated with building products. Increasingly, owners and occupants want assurances that the carpet, furniture, paint, glues, fabrics, plastics and other materials in their buildings are healthy and safe now, and that they won't burden future generations with a legacy of pollution and toxic waste later. In addition, designing products and building projects with healthy materials today fosters a healthy closed loop economy for these materials in the future.

To this end, this Greenbuild 2015 research paper presents a new framework for evaluating recycled feedstocks used in building materials. It focuses on two materials – glass cullet and recycled PVC – as examples of how this framework can be applied.* These evaluations identify pathways for reducing health hazards in recycled feedstocks, protecting human and environmental health, increasing the economic value of these feedstocks, creating green jobs, and maximizing the use of feedstocks that otherwise go to waste.

The target audiences of this research are building product manufacturers, architects, designers, specifiers, building owners, purchasers, government agencies, and the recycling industry as a whole. Each has a role to play in ensuring recycled feedstocks are optimized for their highest, healthiest, and best use.

METHODS

The scope of the investigation was limited to the state of the feedstock as it is typically delivered to manufacturers for inclusion in building products sold within California's San Francisco and Alameda counties. Where possible, investigations included California Bay Area-specific data, though some sources of information were only as specific as the West Coast region. Research methods included literature review, interviews with recycling industry experts, and communication with building product manufacturers. Specific lines of inquiry included:

- Examination of shipping records and other trade data to identify the companies and countries through which feedstocks move
- Exploration of regulation/policy addressing contaminants in recycled materials
- Review of screening protocols used by recyclers and manufacturers to remove contaminants

Four criteria were developed by which the feedstocks would be investigated and rated:

1. Environmental and health impacts
   a. Does the recycled material contain contaminants of concern for human health and the environment?
   b. Does the recycled material processor screen for and/or eliminate contaminants of concern?
   c. Does processing recycled material into feedstock for building products require the use of chemicals or technologies that are potentially hazardous to ecosystems, workers, and surrounding residents?
2. Supply chain quality control and transparency
   a. Is information about potential feedstock contamination communicated throughout the supply chains of the products in which it is incorporated?
   b. Do feedstock processors publish content specifications for their end products that are protective of human health and the environment?
   c. Do manufacturers disclose the origins of the recycled content used in their products?
3. Green jobs and other local economic impacts
   a. Where does feedstock recovery and recycling take place? Are quality jobs created as a result?
   b. What are the economic impacts for feedstock collection, processing, and remanufacture for California?
4. Room to grow
   a. What is the potential for increasing recycling rates of the feedstock?
   b. Can local demand for feedstock reprocessing and remanufacturing be increased?
   c. Is the feedstock's economic value and potential for reuse being maximized through the use of screening practices to remove hazardous content?

RESULTS

This paper presents an application of these evaluation criteria against two very different recycled feedstocks for comparison: PVC and glass cullet. Table 1 summarizes the evaluation results, followed by an explanation of each metric.

Table 1 PVC & Glass Cullet Feedstock Evaluation Summary

	Evaluation Criteria			
Recycled Feedstock	Environ-mental & Health Impacts	Supply Chain Control	Green Jobs	Room to Grow
Polyvinyl Chloride	Red	Red	Red	Yellow
Glass Cullet	Green	Yellow	Green	Green

Key:

Green: ***Very good:*** Feedstocks are superior to comparable virgin or pre-consumer feedstocks, or pose minimal risks to human health and the environment.

Yellow: ***Room for improvement:*** Feedstocks are frequently better options than using similar virgin or pre-consumer materials, but may not be the best choice in all instances.

Red: ***Significant concerns:*** Feedstocks showed potentially higher levels of concern than their virgin or pre-consumer counterparts, and should be prioritized for supply chain improvements.

Post-Consumer Polyvinyl Chloride (PVC)

Red: *Environmental Health Impacts*

PVC is produced by polymerizing vinyl chloride monomer. The resulting material is hard and resinous, and requires additives to achieve key performance characteristics, such as flexibility or protection from ultraviolet degradation. These additives can include lead, cadmium, and phthalate plasticizers, all of which have known serious effects on the human body. [1,2] U.S. and European manufacturers have replaced many of these additives with safer alternatives in many— but not all — applications. [3]

As PVC products made prior to the use of safer alternatives enter into the waste stream, legacy contaminants such as lead, cadmium, and phthalates come with them. When captured for recycling, PVC thereby becomes an avenue by which the same problematic additives being purposefully removed from virgin PVC are reintroduced to the marketplace.

Testing by the Ecology Center in late 2014/early 2015 revealed how old PVC additives are reintroduced into building products through recycled content. It identified the composition of 74 PVC floors (representing eight manufacturers and collected from six leading retailers) using X-ray fluorescence (XRF). The top layers of the floors were made with virgin PVC while the inner core contained recycled PVC. The composition of the recycled content showed higher amounts than the virgin content of several elements that have historically been used in PVC products other than floors.

Element	Recycled PVC		Virgin PVC
	Average	Maximum	Average
Gold	107	225	2
Bromine	194	2,328	10
Cadmium	1,846	22,974	0
Lead	1,144	10,608	5
Copper	1,343	2,260	183

Table 2: Selection of Contamination Found in Recycled PVC Flooring (parts per million (ppm)) [4]

Supply Chain Control

A globalized recycling economy sometimes seeks the lowest-cost processing operations, which do not always adequately protect environmental or occupational health. This can lead to the reintroduction of hazardous substances into the environment, workers, and building products, such as those using recycled PVC.

The leading recycling processor in the world is China, which handles an estimated 82% of the United States' PVC waste scrap exports. [5] The dominant method for sorting and extracting PVC is known as "mechanical recycling," but it is not, as the name implies, machine-based. It requires workers, often poorly trained and given low wages and minimal protective equipment, to hand-sort the waste in small batches, sometimes disassembling products, stripping wires and cables by hand, or burning plastics in open pits in order to extract precious metals. [6]

A wide variety of PVC scrap products are comingled in this process. The product survey summarized in Table 2 confirms this: bromine, gold and copper are common elements in PVC product formulations used in applications other than resilient flooring. They are common in electronic waste, for example, but are not standard additives in resilient flooring. Their presence in the recycled portion of a resilient floor signals that the recycled content in those floors came from a waste stream of PVC from multiple sources, including jacketing from wire and cable scrap. [7] PVC jacketing is a particularly problematic e-waste input to the recycling waste stream. In addition to cadmium and lead additives, polychlorinated biphenyls (PCBs) were also common PVC jacketing components until the 1970s. [8]

PVC receives a Red/Significant Concerns for Supply Chain Control.

Green Jobs

According to the Institute for Local Self-Reliance, recycling-based plastic manufacturers create 93 jobs per 10,000 tons per year of plastics recycled. [9] However, far more PVC scrap generated from the US is being recycled and incorporated into new products overseas than domestically: PVC waste or scrap exports from the US grew from 13,339 metric tons in 1993 to 228,747 tons in 2013 — a 1,715% increase in 20 years. [10] PVC feedstock therefore receives Red/Significant Concerns for Green Jobs.

Room to Grow

Recycling rates for PVC are very low compared to other plastics (far less than 1%). [11,12] In the short term, growing public awareness about contamination in recycled PVC may cause more building product manufacturers to refrain from using the feedstock, especially in interior products. However, in the longer term, the outlook is a bit brighter. Reformulated PVC products that do not contain hazardous additives will eventually enter the waste stream, making the feedstock cleaner and healthier. For this reason, PVC receives Yellow/Room for Improvement for the Room To Grow evaluation criterion.

Glass Cullet

Environmental Health Impacts

Cullet, defined as waste or broken glass destined for re-melting, has many end uses in building and construction. [13] Insulation is the second largest consumer of glass cullet. [14] Preferred sources of cullet used in insulation are bottle glass and float glass (used to make windows). Other types of glass, particularly leaded cathode ray tubes from old computer monitors and television sets, can contaminate cullet supplies without adequate separation and screening. [15]

Because there is a significant statewide glass cullet recycling economy in California, and this system is exemplary, this analysis looks at the use of glass cullet in the manufacture of fiber glass insulation in California. Cullet used in California fiber glass manufacturing is reliably low in hazardous content due to state regulations that ensure a clean, source-separated glass supply; and proactive practices by the sole cullet supplier to the state's insulation factories (Strategic Materials) ensure that its output complies with these regulations.

California is one of 19 states that have enacted a Toxics in Packaging law [16] limiting the presence of lead and select other heavy metals in bottle glass, to 100 ppm. [17] 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. [18] According to communications with Curt Bucey of Strategic Materials, a single supplier processes container and float glass into Toxics in Packaging-compliant cullet. It supplies the same cullet to both bottle and fiber glass manufacturers in California. As a result, the glass 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. This finding does not apply nationwide.

Supply Chain Control

Standard glass cullet scrap is sorted and washed multiple times, mainly to remove dirt, paper and plastic, which, according to Curt Bucey, can represent up to 50% of the weight of collected material. [19] As previously noted, a single supplier provides all cullet used in California and it complies with the 100 ppm threshold set by the Toxics in Packaging law.

The lack of contamination of California cullet is due to state regulations on container glass and compliance to that standard by the sole supplier to insulation. The United States fiber glass insulation industry's ASTM standards for cullet cap heavy metal oxides at 0.1%, or 1,000 ppm. [20] This allows heavy metal content ten times higher than the Toxics in Packaging law requires. 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. [21] Further, insulation manufacturers in the United States do not publicly disclose the sources of their cullet. Glass cullet therefore receives a Yellow/Room for Improvement rating for Supply Chain Control.

Green Jobs

Glass recycling creates many jobs, earning it a Green/Very Good evaluation for Green Jobs. A 2011 report prepared for the BlueGreen Alliance estimates that diverting 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). [22] According to a 2013 CalRecycle survey, "15 facilities [in California] use about 700,000 tons of cullet per year." [23] Applying the arithmetic of the BlueGreen Alliance estimates 7,700 jobs created.

Room To Grow

More glass containers are recycled in California than any other state; about 2.5 billion glass containers (80% of redeemable bottles sold per year) are recycled. [24] The state requires that fiber glass insulation contains at least 30% recycled glass. [25,26] But there is still room to grow. CalRecycle notes that those same 15 facilities leave some 100,000 tons of cullet unused each year. [27]

California's screening programs support the economic viability of the feedstock, as uncontaminated cullet supplies are worth more on the market than cullet from mixed streams. [28] Cullet earns Green/Very Good for Room to Grow.

FINDINGS AND RECOMMENDATIONS

Through review of these two important feedstocks, three major findings have emerged. Recommendations for improving the safety, quality, and marketability of recycled-content feedstocks in building products are also provided.

Finding 1

Contaminants reduce feedstock value. Product designers can eliminate or minimize problematic ingredients that can contaminate future recycled-content feedstocks.

Recommendations:

Products and building projects should be designed with deconstruction and reuse in mind. In a closed-loop economy, the materials of new products today will become feedstocks for products in the future. Designing new products that are free of problematic contaminants will reduce possible future harm and increase the quality and market value of future recovered feedstock.

For example, PVC flooring manufacturers today are producing products devoid of additives of concern, which means that floors made today are desirable feedstocks for future materials. [29]

Finding 2

Some feedstocks contain hazardous substances in quantities that exceed allowable limits for virgin feedstocks.

Recommendations:

The recycling industry should screen and remove these substances prior to selling the material for use in building products, especially where they come into contact with people or the environment. Through screening and extraction practices, it is possible to remove toxic content. For example, some glass cullet processors take great care in removing as many contaminants as possible. Several leading vinyl flooring manufacturers only incorporate post-consumer PVC where the source is known, contaminants are identified, and the incorporation of the feedstock does not elevate contamination levels in the final product above established thresholds of concern. [30] X-ray fluorescence and other techniques can effectively detect heavy metal contaminants, and the recycling industry has tools available to eject heavy metals from the waste stream.

The recycling industry, certifiers, consumers of recycled feedstocks, industry associations, and regulators all have roles to play in fostering a healthier recycled feedstock stream, that will enhance the value – and reuse – of these commodities.

Industry associations and regulators should establish limits on concentrations of toxic material in recycled content materials. Where thresholds exist for substances of concern in virgin materials, those same thresholds may be suitable for recycled content materials as well. Best practice guidelines for dealing with banned substances if found in feedstocks or products should also be established, as well as incentives for public and private investments in waste processing improvements.

Recyclers' screening protocols should be publicly available. Their end products should be third party certified as compliant with the established content thresholds protective of human health. Meanwhile, purchasers should prioritize manufacturers sourcing clean feedstocks.

In the absence of regulatory action on toxic content in feedstocks or final products, all parties should collaboratively develop unified voluntary thresholds and methodologies for screening and testing.

Finding 3

The risk of harm is highest where regulations are the most relaxed.

Recommendations:

The best way to ensure recycled content feedstocks are healthy is to process them where worker rights, labor laws, and environmental regulations are strong and enforced: domestically, and ideally within the same communities where the waste is produced. Both government agencies and the recycling industry should increase investments in domestic recycling capacity, through a combination of higher standards, procurement incentives, research and development, and investments in screening technologies.

Additionally, manufacturers should preferentially source recycled materials from domestic suppliers whenever possible, and seek suppliers in compliance with environmental and labor laws when domestic supplies are not available. They should also implement a company environmental management system to account for all ingredients within recycled content feedstock sources. Purchasers should give preference to products with recycled content sourced from places with high worker safety standards, and require annual sustainability reports or other documentation from manufacturers that explains how worker and environmental health is protected.

Glass cullet recycling in California contrasts sharply with PVC recycling in China; in California, where regulation exists to limit contamination from entering waste streams to begin with (the Toxic Packaging law), feedstocks emerging at the other end of processing are clean and healthy, and the workers handling the scrap have avoided exposure to harmful substances.

CONCLUSION

This report provides a snapshot of the work done by the authors and their organizations to illuminate the challenges of producing healthy building products through the use of recycled feedstocks, using PVC and glass cullet as examples. Much work remains to optimize recycled content products, but the future is promising: by identifying problems, we are also identifying solutions and pathways to ensure that materials are not wasted and that both human and environmental health are prioritized.

Further detailed findings and recommendations from this first phase of our collaboration to optimize recycling for use in building materials are available at: http://healthybuilding.net/content/optimize-recycling.

** Additional research on other feedstocks helped the authors understand the current reality of recycled materials used in building products. Feedstocks researched in our collaboration include Asphalt Shingles, Flexible Polyurethane Foam, Ground Tire Crumb Rubber, Nylon 6, Nylon 6,6, Polyethylene, Reclaimed Asphalt Pavement, Steel, and Wood Fiber.*

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