

# RECYCLING AS A SUSTAINABILITY PRACTICE IN THE NORTH AMERICAN VINYL INDUSTRY

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## Abstract:

Recycling of vinyl materials has been ongoing and robust for decades. As a result, several markets have developed for applications that consume these reclaimed materials. The Vinyl Institute contracted with Tarnell Company, LLC to survey recycling firms in North America and confirmed that some 1 billion pounds of vinyl materials were recycled in 2013. Increasing recycled content in vinyl products contributes to reducing the carbon footprint of vinyl products, which corresponds with the American Institute of Architects sustainability policy goal of carbon neutral buildings by 2030. A number of standards and eco-labels also require recycled content to claim credits. This paper was presented at the Society of Plastics Engineers Annual Technical Conference (SPE ANTEC) Vinyl Session, March 25, 2015 in Orlando, FL.

## Introduction: U.S. Vinyl Markets Perspective

Vinyl is one of the most versatile thermoplastics in use today. According to the American Chemistry Council 2014 Resin Report [1], some 10 billion pounds of vinyl resin was converted into vinyl products in North America. In addition to vinyl resin, additives such as impact modifiers, lubricants, stabilizers, fillers, process aids, pigment, and plasticizers (for flexible materials) will increase the overall amount of vinyl material on a compound basis by 25 to 40%. As depicted in Figure 1, some 90% of vinyl materials are used in durable end uses, the largest being building and construction. In the U.S., there are over 2,500 vinyl material processors that employ over 300,000 workers with a payroll contribution of greater than \$45 billion to the U.S. economy. [2]

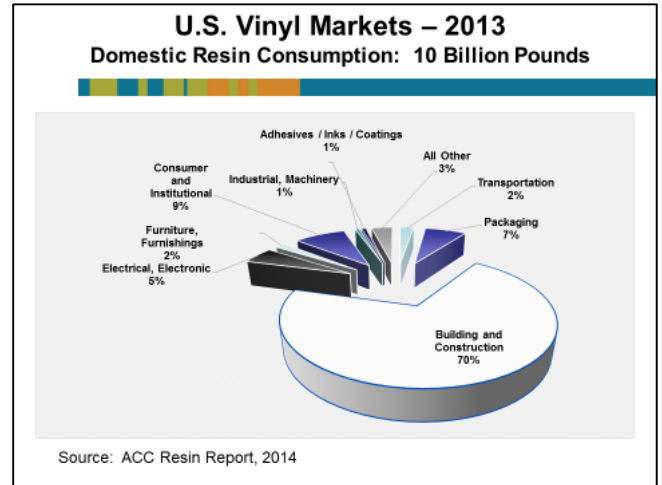


Figure 1: Vinyl Use by End Market, Ref. ACC 2014 Resin Report

## Characterizing Vinyl in the Waste Stream

The U.S. EPA performs an annual characterization of the amounts and types of wastes generated and eventually discarded in municipal solid waste (MSW) sites. According to EPA's 2012 MSW Characterization [3], plastics make up about 26% of the material discarded, or some 57,900 million pounds, (Figure 2).

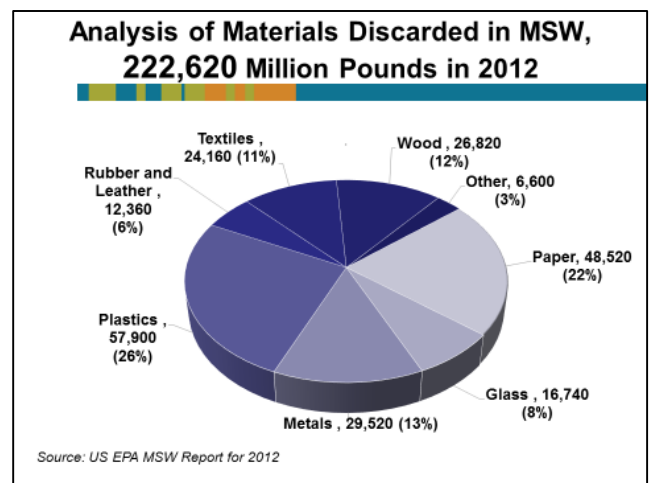


Figure 2: Materials Discarded in Municipal Solid Waste Stream

Using a material flow calculation method, which considers durable/non-durable uses by residential, commercial and industrial sources, EPA estimates that vinyl represents 3% of the plastics volume in MSW, as shown in Figure 3. Although vinyl is not a significant contributor to the plastics waste stream, it nevertheless provides an opportunity to further reclaim post-consumer vinyl materials.

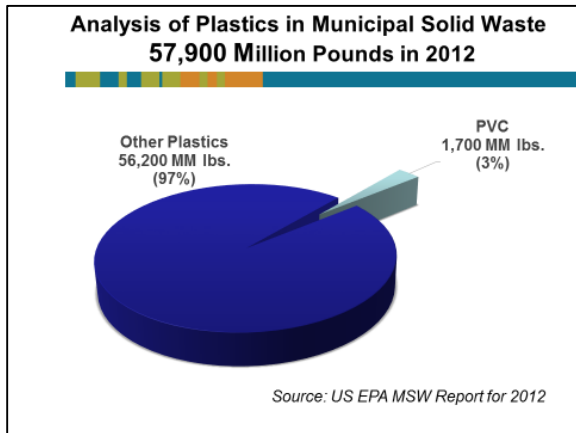


Figure 3: Vinyl Portion of Plastics in MSW

### Recycling Enhances Vinyl Sustainability

The International Standards Organization (ISO) standard 14021:1999 on Environmental labels and declarations- Self-declared environmental claims cautions against making sustainability claims, for example on the basis of a single environmental criteria such as recycled content, because there are no defined measures of how sustainable this practice is. [4] ISO 14021 goes on to require that self-declared environmental claims

“...shall take into consideration all relevant aspects of the product life cycle in order to identify the potential for one impact to be increased in the process of decreasing another”. [5]

But one of the key elements of sustainability is protection of the environment. [6] As depicted in Figure 4, when materials are recycled, not only are resources conserved, but emissions to the environment can be lowered. Vinyl compounds have demonstrated the ability to retain their physical properties without significant deterioration through several heat histories such as grinding, extruding, molding, or calendaring operations, which is necessary for a material to be recycled. [7]



Figure 4: Sustainability Considerations

To the extent that a product’s cradle to grave performance is a critical metric for measuring its sustainability, then life cycle assessments (LCA) are the best method of quantifying the likely cumulative impacts of any product on the environment. For example, the estimation of a product’s overall greenhouse gas emissions is a well-recognized method of determining its carbon footprint. Greenhouse gas emissions are found at practically every stage in a product’s life cycle. Estimates typically will include emissions from ancillary processes not directly involved in the manufacture of the product such as electrical power generation and transportation of materials.

Taking these factors into consideration, an LCA conducted by Sustainable Solutions Inc. in 2014 for a large diameter vinyl pipe concluded that the hypothetical use of 50% recycled content would reduce greenhouse gas (GHG) emissions by 30% (Figure 5). Additional LCA’s completed by Sustainable Solutions on other vinyl building products similarly confirmed reductions in GHG by incorporating recycle content. [8] The practical considerations of meeting demanding product performance requirements must be weighed when evaluating the use of recycled content. But in general, increasing recycled content in vinyl products contributes to reducing their carbon footprint, which corresponds with the American Institute of Architects sustainability policy goal of carbon neutral buildings by 2030. [9] Constructing buildings with materials that have lower carbon footprints and at the same time reduce energy consumption, such as vinyl products, can help achieve this AIA goal.

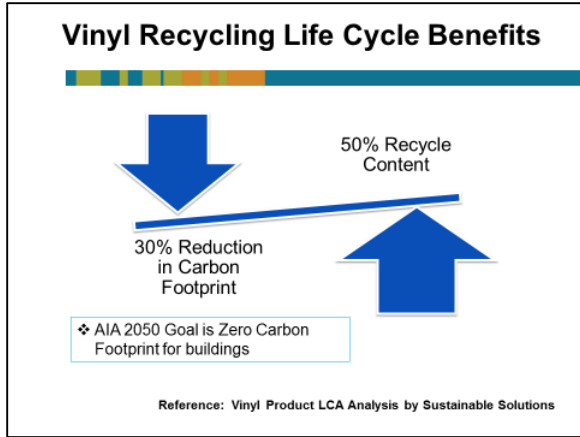


Figure 5: Sustainability Considerations

Several manufacturers offer commercial vinyl products that contain recycled content. The amounts of recycled content ranges from up to 5% in some single ply roofing membranes, up to 43% in some hotel room entry cards, and even as much as 60% in certain vinyl siding products, to name just a few. A number of vinyl flooring and wallcovering manufacturers offer take back of existing products, reprocess the reclaimed materials in their own plants, and incorporate high amounts of post-consumer recycle into some of their brands. In addition, there are many vinyl products that are made completely of recycled vinyl and sold into the flooring, automotive, plumbing, and building and construction markets, among others.

### Standards Driving Recycle Contents

Third-party standards, ecolabels and industry codes focused on enhancing sustainability are growing drivers of recycling in building and construction, one of the key markets for vinyl products. Examples of building rating systems that award credits for materials or products that contain recycled content or divert building materials from the waste stream are listed in Table 1.

Table 1: Building Rating System Examples That Include Recycling Criteria [10], [11]

<b>Standard</b>	<b>Sub-Category</b>	<b>Credit Levels</b>
GBI/ANSI 2010	R/M-10.1, -2 Materials Content	1% or more of building materials contain pre- and post-consumer recycled content
GBI/ANSI 2010	R/M-10.5 Reduction, Re-use, and Recycling of Waste	25% or more of construction and demolition waste must be diverted from landfill
LEED v.4	MR-2.1 Construction Waste Management	Divert 50 to 75% from landfill
LEED v.4	MR-4.1 Component Recycled Content	10 to 20% post-consumer + pre-consumer

Similarly, Table 2 identifies several certified sustainability standards that recognize manufacturers with solutions for end of life issues such as product take-back and reclamation programs. Some of these sustainability standards even award points for products that are designed for recycling, and thus simplifying reclamation at end of life.

Table 2: Sustainability Standards that Include End-of-Life Product Solutions [12]

<b>NSF/ANSI Standard</b>	<b>Product Area</b>
140	Carpet
332	Resilient Floor Covering
342	Wallcovering
347	Single Ply Roofing Membranes

Yet another example is the International Green Construction Code (IGCC), which was approved by the International Codes Council in 2011 for the 2012 code cycle, and has been adopted by several authorities having jurisdiction (AHJ). The relevant requirements for recycling in the IGCC are listed in Table 3.

Table 3: Recycling Criteria in the International Green Construction Code [13]

<b>IGCC Sub-Category</b>	<b>Requirement</b>
503.1 Construction Material and Waste Management Plan	Divert 50% of waste materials from landfill or incineration in accordance with recycling or salvage plan
505.2.2 Recycled Building Materials Content	Minimum of 55% shall contain 25% post-consumer and pre-consumer recovered material
505.2.3 Recyclable Building Materials	Material that contains recycle content must be able to be recovered and recycled at >30%

Recycled content credits for all building materials is an important objective in order to drive landfill avoidance, which contribute to the sustainability efforts in the building industry. But achievable thresholds for all types of building materials are necessary for this to be accomplished. In the case of plastics, certain products that contain as much recycled content as is practical may not be recognized for credit or possibly not even specified simply because of the manner in which the credit threshold was arbitrarily established. Indeed, ISO 14021 cautions that higher recycled content does not always imply lower environmental impact. [14] Specific requirements such as those embodied in the aforementioned product sustainability assessment standards in Table 2 offer a more representative method of accounting for recycle content.

### **Defining and Validating Recycled Content**

In its 2012 guideline for the use of environmental claims, the U.S. Federal Trade Commission (FTC) was clear that recycled materials are those that have been diverted from the solid waste stream. [15] The FTC purposely excluded those intermediate materials that are recovered at a facility and reused in the original process, such as regrinds, reworked materials, etc. from its definition of recycled content. While ISO 14021:1999 also excludes in-plant regrinds and rework material from being considered recycled

content, it does differentiate between pre- and post-consumer content in this manner [16]:

**ISO 14021 – Pre-Consumer Recycled Content** - is “material diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.”

Note that the term pre-consumer has replaced the often used and widely recognized term post-industrial.

**ISO 14021 – Post-Consumer Recycled Content** -is “material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.”

Proper classification of recycled content is needed for conformance with the aforementioned standards that award credits or as required to meet IGCC code. In order to assist in this effort, both ASTM and ULE have developed standards for validating recycled contents. ASTM 2129 was first published in March, 2001 [17] and provides a comprehensive assessment of the sustainability aspects of building materials, including identifying amounts of recycled material contents. UL 2809 was adopted in 2014 and provides a framework for evaluating the supply chain and validating recycled content calculations in a product. [18] Each of the NSF/ANSI standards listed in Table 2 provides for 3<sup>rd</sup> party validation of recycled contents.

### **Post-Consumer Vinyl Recycling**

The general material flows involved in recycling post-consumer building products are mapped out in figure 6 for rigid vinyl products and in Figure 7 for flexible vinyl products. These flows indicate the sources and uses of various vinyl products and the potential interchangeability of moving from one application to another. In the U.S., there are over 100 resin grades produced, tailored for specific processing and performance requirements needed to satisfy each end use application. It is important to understand which resin types can be used in the various applications in order to achieve the required properties in recycled products.

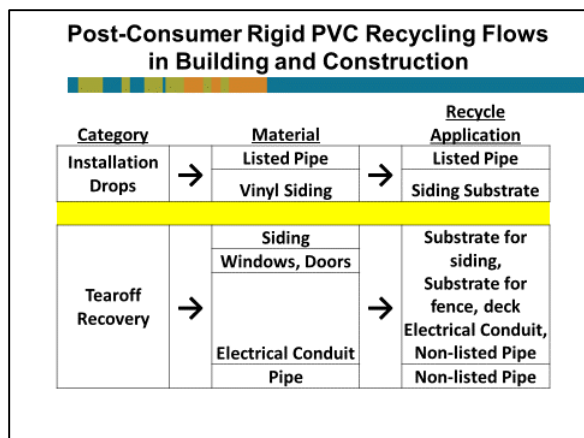


Figure 6: Material Flows for Rigid Post-Consumer Vinyl Materials

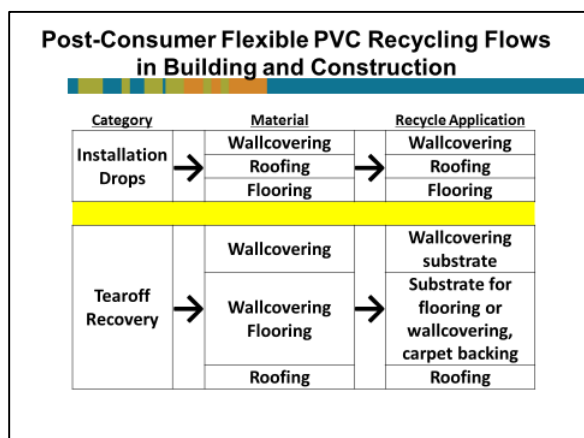


Figure 7: Material Flows for Flexible Post-Consumer Vinyl Materials

### Tarnell Recycling Survey

In 2014, The Vinyl Institute retained Tarnell Company, LLC to confirm the latest amounts of vinyl recycled in the U.S. and Canada.

The survey was conducted from August to October, 2014 for recycling activities during calendar year 2013. Companies that are known or believed to be vinyl recyclers and/or brokers were included in the survey along with those processing companies that include significant recyclate scrap or reprocessed materials in their finished products. The source for companies engaged in vinyl recycling came from VI's website which has maintained a list of recyclers since 1999 and from Tarnell's proprietary database of vinyl processors. Of 207 potential recyclers contacted, 101 U.S. and Canadian Companies were vetted as vinyl recyclers, brokers, or significant finished product manufacturers. Tarnell business analysts determined that representatives being surveyed at the recycler

were indeed qualified to respond to the interview questions. Qualified recycler representatives ranged from purchasing managers to engineers, and company principals. Information was obtained on recycled material amounts and types purchased/sold/landfilled, reprocessing capabilities, and markets served. To avoid any double counting, purchased volumes were compared to sold volumes, and broker volumes were identified. The data was then tabulated and summarized in Table 4 for review and discussion.

The data shows that over half (53%) of the amounts of pre- and post-consumer volumes are compounded and repelletized, while just under half (47%) are reground and blended after being diverted from the solid waste stream. A few observations can be made from this information. Materials that are compounded and repelletized are often used as 100% of the material for the new application, which requires significant knowledge of vinyl ingredient formulating and compounding. Repelletized recyclate is often used directly for profile extrusions, calendared sheets, or injection molded parts. Materials that are only ground and blended and do not go through a compounding and repelletizing step are usually processed simultaneously with virgin vinyl materials that can compensate for any deficiencies in the recyclate needed for the next application. Alternatively, ground and blended pre- and post-consumer materials can also be used 100% as a substrate where a virgin vinyl material is either capped over it or co-extruded with it to meet the performance needed in the finished application.

Table 4. U.S. and Canadian Vinyl Recyclers and 2013 Recycled Volumes

Type of Company	Number of Companies	Pre-Consumer Amount, MM lbs.	Post-Consumer Amount, MM lbs.	Landfill Amount, MM lbs.	Total Amount, MM lbs.	Total Amount, %
Broker	12	34.7	0.1	0.0	34.9	3%
Compounder/ Repelletizer & Other	37	475.1	53.6	0.2	528.8	53%
Grinder/ Blender & Other	52	389.8	47.2	0.1	437.1	44%
<b>Total</b>	<b>101</b>	<b>899.6</b>	<b>100.9</b>	<b>0.3</b>	<b>1,000.8</b>	<b>100%</b>

Detailed information was obtained in the survey to more fully characterize the capabilities of the vinyl recyclers. As shown in Figure 8, shredding and grinding are the most predominant processes at recyclers while other widely used practices include compounding and repelletizing. To clarify, recyclers are using combinations of these various technologies to process the material streams being reclaimed.

While more than half the volume is being compounded and repelletized as stated above, many of these facilities must shred, grind, and pulverize the recyclate prior to compounding.

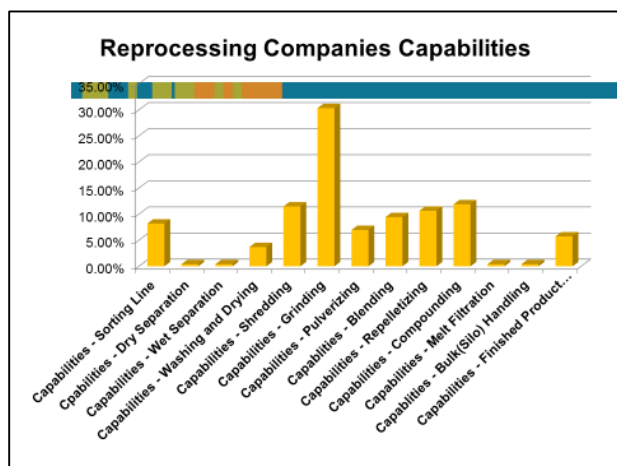


Figure 8: Vinyl Recyclers Processing Capabilities

Another aspect of the recycled market is to understand where the recycled material can be reutilized. Vinyl is one of the most versatile materials used today and the Tarnell survey confirmed that over thirty end market applications are incorporating recycled materials into their finished products. Table 5 lists the top 5 end markets using recycled vinyl materials.

Top 5 End Markets for Recycled Vinyl
1. Custom Extrusions
2. Interior Building Trim
3. Floor Coverings
4. Small Diameter (<4") Pipe
5. Siding, Soffits, and Exterior Trim

### Vinyl Landfill Amounts

A group of prime vinyl material compounders were surveyed separately by the Vinyl Institute to determine how much was being landfilled from their operations. Amounts ranged from 0 to 0.04% of incoming raw materials ended up being landfilled. This is comparable to the recycled amounts that are purchased and end up in a landfill at 0.03% as reported in the Tarnell Survey. This confirms that very little vinyl material is being landfilled from vinyl processors, since the compounds are able to be readily recycled.

### Conclusion

The vinyl recycling industry is robust, and pre- and post-consumer amounts are growing. Recycling vinyl

reduces the carbon footprint of finished products and enhances their ability to meet sustainability criteria in codes and standards. Recycled vinyl materials have diverse end use market applications.

### Acknowledgement

The authors wish to express their appreciation to the Vinyl Institute and its members for their support with preparing this paper, the Tarnell Company and its employees for the comprehensive market survey, and the important comments of Keller and Heckman.

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