

Increasing Sustainability in the Low-Slope Roof Market through PVC (Vinyl) Membrane Recycling

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TRIPLE BOTTOM LINE (TBL) accounting (people, planet, profit) was introduced in the mid-1990s. Since then, enterprises of all sizes across all industries have begun to analyze their company value not just from a financial position, but also from an environmental and social responsibility perspective. Resource conservation fits well with a TBL approach in the form of material recovery, including slowly decaying waste plastic such as polyvinyl chloride (PVC). Optimal value for PVC roof replacement can be enhanced by recycling “tear-off” waste, or old PVC membrane, at the end of its useful life. This article reviews potential environmental, social, and corporate governance (ESG) benefits of roof recycling; reviews the roof recycling process and options; and identifies steps for the roofing industry to scale up the practice.

In North America, postconsumer recycling of PVC roof membranes began in 1999. Working with a PVC membrane manufacturer, a Massachusetts recycling company produced a highway cold-patching material made from ground-up old PVC roofing membranes and other recovered plastics. As state-of-the-art recycling equipment evolved to size reduce and separate polyester scrim reinforcement and felt backing from the PVC polymer, retired roofing membrane became feedstock for new products, such as roofing walkway pads, commercial-grade flooring, and concrete expansion joints. While the production of walkway pads might consume a few hundred thousand pounds of product a year for any one manufacturer, now

more than a million pounds is being converted into new membrane annually as production lines are designed to blend granulated recycled PVC material with virgin feedstock.

Total net costs of postconsumer recycling depend on total roofing square footage, the distance the old roof must be shipped to be processed, and avoided landfill tipping fees. In some cases, the savings in disposal costs, the value of the full range of salvaged materials, and potential building appraisal appreciation for green building credits can offset the cost of the additional labor, shipping, and grinding fees involved to remove and reuse end-of-life (EoL) PVC roofing material. As a result, more active consideration is being given to making the commitment to incorporate a recycling strategy into a roof replacement project.

LANDFILL AVOIDANCE

While landfills can offer a convenient and in some cases a less costly disposal option for roof tear-offs, landfills in certain geographical regions that are reaching capacity limits may need to begin to be utilized for the more distressed materials that do not have any alternative (EoL) dispositions. This creates an opportunity to avoid the landfilling of materials with recycling options available, such as PVC single-ply membranes. Landfill avoidance for PVC single-ply roof membranes not only avoids disposal costs but can also drive several other positive-value generators for an enterprise or building owner.

PVC roof membranes at their EoL can be recovered for subsequent processing at a PVC recycler. PVC recycling capacity exists for a portion of the PVC membranes torn off, and if presented with continuing opportunities to process more tear-off material, PVC recyclers can plan capacity and technology additions to accommodate the additional material opportunity. This creates jobs and economic value in the recycling industry while preserving the PVC

molecule initially created in the resin production process. The overall environmental benefits and resource conservation accrued by recovering PVC materials are significant in the form of reduced greenhouse gas and other impacts and can be quantified using environmental product declarations (EPDs) based on the results of detailed life-cycle assessment (LCA) methods.¹

CARBON AVOIDANCE QUANTIFICATION

The increased global concern about greenhouse gas emissions (henceforth called “carbon”) and the industrywide efforts to curtail those emissions have led businesses to set carbon-reduction and “net-zero” goals. With many companies paying for carbon credits to meet their goals, carbon avoidance is leading to direct, and increasing, monetary value for businesses. Many commercial building owners and real estate companies have committed to reducing their carbon footprint and actively search for ways to reach reduction targets. Although carbon credits are a regulated market and typically not applicable to recycling in North America, quantifying carbon avoidance in roof recycling will benefit stakeholders when calculating their voluntary carbon reductions. Furthermore, such quantification will bring a new value proposition for roof recycling and incentivize building owners who drive the demand for it.

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Due to the importance of carbon avoidance in the industry, the National Institute of Standards and Technology (NIST) is working on methods to measure the carbon avoidance generated by recycling materials at the end of their service life. For specific industrial applications, such as roof recycling, consensus will be needed around key aspects of the measurement approach to create standards. Standards will support fair practices that can strengthen markets for these types of recycled materials.

The basic idea of carbon avoidance quantification is an estimation of the difference in carbon emissions between a typical practice, such as disposing of the EoL roof in a landfill, and an alternative approach, such as recycling. To use this information in a market setting, consideration needs to be given to the allocation of these savings across the value chain participants—building owners, converters, and PVC product manufacturers. The carbon avoided in different processing steps will need to be allocated among them equitably to avoid any double counting, while at the same time encouraging the formation of a market for the materials by crediting the roles of the different value chain participants. LCA literature provides different allocation methods that can be used.² A standard for accounting for these savings will need to guide the choice of the one appropriate to the situation.

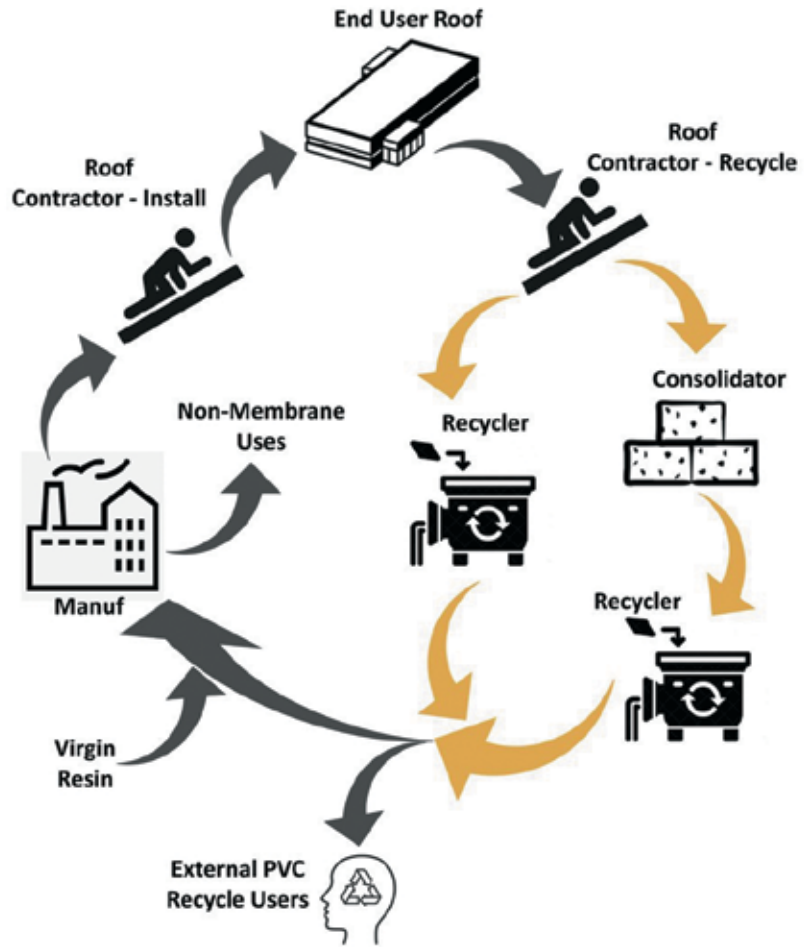


Figure 1. Recycled value stream and the role of each member of the process.

ESG COMMITMENTS

Green building rating certifications can be one aspect of an enterprise sustainability platform. Enterprises that are pursuing ESG framework reporting could include green building ratings as part of their sustainability-related opportunities. Roof recycling can be a tangible and measurable aspect of ESG metrics.

For buildings pursuing green rating certifications, credits are available from voluntary green building rating systems (Table 1) for diverting construction wastes from landfills.³⁻⁵ Recycling back to a PVC membrane manufacturer can also help that manufacturer reach some of

its sustainability targets, as prescribed in ANSI/ NSF 347, *Sustainability Assessment for Single Ply Roofing Membranes*.⁶

The benefits of recycling PVC single-ply roof membranes are numerous. How much value is realized for the building owner, whether

Table 1. Credits available for existing buildings from voluntary consensus type green building rating systems for diverting roof tear-off from landfills

Voluntary Rating System	Applicable Section	Credit Language
Green Building Initiative ³ (2021)	5.1.1.5 Waste Management for Cycle Renovations	Requires waste management policy, procedure, and plan for cycle renovations
U.S. Green Building Council ⁴ (2021)	MR Prerequisite—Facility Maintenance and Renovations—Waste Management Policy for Maintenance and Renovations	Establishes goals and strategies for renovation waste diversion
BREEAM ⁵ (2015)	11.0—Wst 01—Project Waste Management	Requires options and actions to reuse or recycle materials, reducing and diverting waste from landfill



Figure 2. Roofing contractor removing PVC roof membrane and prepping for recycling.

Source: Benchmark, Inc.

through higher asset value or higher occupancy rates or revenues, can depend on many factors. The Institute for Market Transformation and the Appraisal Institute concluded that "green building property performance and value can show up across the board in quantifiable property metrics and favorable adjustments made during appraisal and underwriting."⁷

THE ROOF RECYCLING PROCESS

A successful long-term roof recycling program requires an engaged roofing value chain (Fig. 1) with motivation to undertake the effort to recycle rather than dispose of EoL roofing membrane. Building owner/developer demand for recycling is fundamental to program success. The reroofing project is more likely to be pursued if the owner is aware of the option and has asked for it to be included in the reroofing project. Draft specification language should be added to the specification to ensure roofing contractors are aware of the request in the bidding process.

The roofing manufacturer, possibly with the assistance of an industry association, can fulfill the role of value chain educator. Working through marketing communication and sales force outreach, success in communicating the positive benefits of recycling is important to recycling success. Education throughout the value chain will create positive word of mouth and reduce barriers

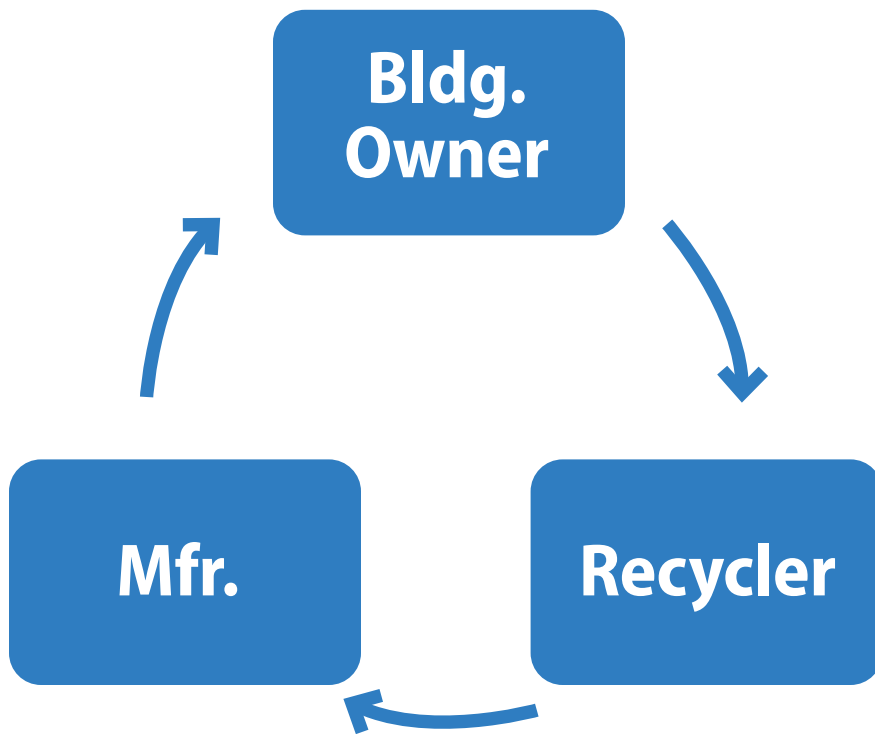


Figure 3. Closed-loop recycling. The PVC membrane manufacturer manages the process and recycles the material into new PVC membranes.



Figure 4. The Rogers Centre in Toronto, Canada.

Source: Sika Sarnafil.

to changes in behavior. The roofing specifier, contractor, and distributor all play important roles in the education process.

The first step in the process of roof recycling is matching supply and demand to ensure a viable market for any collected material. The next steps are securing the infrastructure necessary to carry out the reverse logistics of moving the material from the job site to the recycler and identifying a recycling site network capable of and interested in processing the materials.

A PVC roof recycling project candidate can be a roof of any age or size, but certain parameters increase the attractiveness of the material for recycling. Generally, roofs larger than 800 squares (80,000 ft² [7,400 m²]), are excellent candidates for recycling since the quantity allows for a full truckload of material, and roofs less than 20 years old have the benefit of modernized PVC formulations which



Figure 5. Open-loop recycling. The PVC membrane manufacturer specifies recycling with the owner. The recycler then sells to the open market.



Figure 6. Overhead view of the PVC membrane reroof project at Bishop Elementary School in Ypsilanti, Michigan.

Note: PVC = polyvinyl chloride.

Source: Duro-Last Inc.

Recyclers processed
 1.1 billion lb
 (5×10^8 kg)
 of vinyl comprising
 950 million lb
 (4.3×10^8 kg) of
 preconsumer scrap
 and 140 million lb
 (6.4×10^7 kg)
 of postconsumer
 material in 2019.

may be more desirable for the next use of the material.

Since the average-size low-slope commercial roof is 250 squares (25,000 ft² [2,300 m²]), a consolidation network may be needed to bring together enough material to avoid less-than-truckload shipping costs. Collecting a roof sample for lab analysis of physical properties will provide an indication of the viability of recycling and appropriate end dispositions. Some additives used 20 years ago are no longer used in today's modernized PVC roof formulations. Mechanically attached roofs are preferred; adhered roofs are problematic because of the facer material that is typically delaminated from the roof insulation or coverboard during the tear-off process, and this becomes challenging contamination to remove during the recycling process.

The roof removal process for recycling is very similar to removing the roof for disposal.

Removing debris from the roof with a leaf blower is a good first step to minimize foreign material. Typically, the pallets used for new material delivery are repurposed to hold the material removed from the roof. Instead of the membrane being tossed down a trash chute, it is rolled, ribbon folded, or cut into 10-ft (3-m) strips for loading on a pallet. The membrane is cut along the seams to ease removal and eliminate metal plates and fasteners (Fig. 2). These metallic parts can also be collected and recycled. Under ideal conditions, each pallet can hold 3,500 ft² (330 m²) of membrane. Metal or braided strapping is used to secure the membrane to the pallet.

RECYCLING OPTIONS

The PVC recycling industry in the US and Canada is robust, with over 100 recyclers handling mostly PVC preconsumer scrap; the volume of EoL PVC material has grown to about 13% of the total PVC recycled.⁸ Surveys conducted by Tarnell



Figure 7. PVC roofing membrane from roof tear-off transported from job site to recycling facility.

Photo courtesy of Duro-Last Inc.

Company and sponsored by the Vinyl Institute estimate these recyclers processed 1.1 billion lb (5×10^8 kg) of vinyl comprising 950 million lb (4.3×10^8 kg) of preconsumer scrap and 140 million lb (6.4×10^7 kg) of postconsumer material in 2019.⁹

The Chemical Fabrics and Film Association (CFFA) completed a survey of its Vinyl Roofing Division (VRD) members in 2022 and estimated that 19.1 million lb (8.7 Thousand Metric Tons) of preconsumer and over 1.0 million lb (0.5 Thousand Metric Tons) of postconsumer single-ply PVC roof membranes was recovered and recycled that year.¹⁰ The CFFA VRD also estimates that of the installed PVC roof membrane reaching its EoL this year, approximately 19 million lb (8.6 Thousand Metric Tons) may be available for recovery.

PVC recyclers are selective about what types of material they process and will specialize in either rigid or flexible PVC. Because PVC single-ply roofing contains plasticizers, it is categorized as flexible material and must be directed to a facility that processes this type of PVC. Several PVC product manufacturers also take their products back at their EoL and recycle the reclaimed materials back into new products.

The typical mechanical recycling process for EoL single-ply PVC roof membrane involves size reducing the tear-off rolls using shredders and then granulating the material. While low-speed shredders can accommodate a small amount of foreign material, higher-speed granulators have sharp blades and screens that must be protected from any foreign debris, such as wood, stones, and metal. Shaker tables and magnets can be employed to assist in separating this debris, but complete removal of highly contaminated materials is often infeasible. It is best to keep incoming material free of wood, stones, and metal. Once the membrane is granulated, aspirating the material to remove the fiber reinforcement is an option depending on the end-use disposition.

For closed-loop recycling (Fig. 3), where the material will be reprocessed back into single-ply roof membranes, the fiber must be removed. Further size reduction, including smaller granulation or pulverization, enables a more complete aspiration of fiber out of the material. Once the fiber is removed, this granular/pulverized material becomes feedstock for recompounding with specifically modified virgin blends of compounds that will meet the desired performance specification for that layer of the membrane roof.

The Rogers Centre (Fig. 4) in Toronto, Canada, case study provides more context on the closed-loop process.¹¹

For open-loop recycling (Fig. 5), where the material is used in a non-roof-membrane application, leaving the reinforcing fiber in the granulated material depends on the application. Significant amounts of pre- and postconsumer PVC roof membranes are recycled into flooring applications, where the fiber helps reinforce the flooring composition. Flooring applications using PVC roof membrane include calendared sheet flooring and molded interlocking tiles. In addition to flooring, use in concrete expansion joints and roof walkway pads presents a significant opportunity to consume large amounts of recycled PVC membranes. Other open-loop applications where more cosmetic surfaces are preferred, such as automotive floor mats, or where smooth surfaces are desired, such as hoses, may require substantial removal of the fiber.

The PVC membrane reroof project at Bishop Elementary School (Figs. 6 and 7) in Ypsilanti, Michigan, provides more context on the open-loop process.¹²

Advanced recycling alternatives to mechanical recycling are also being developed. Selective dissolution of the PVC molecule using specific solvents is progressing, since it can recover the PVC or compound ingredients with high purity without including any of the reinforcing fiber. Technology for selective dissolution and processes to handle composite PVC material, including roof membranes and fabric, are being developed by Polyloop in France¹³ and the Fraunhofer Institute in Germany. The German process called Creasolv¹⁴ can yield high-purity PVC for circular use. (Any mention of commercial products is for information only; it does not imply recommendation or endorsement by NIST, CFFA, or VI.) Fraunhofer is developing additional processes to further hydrogenate certain phthalate plasticizers to other ester forms for circular use. A pilot plant in Germany is nearing completion to demonstrate feasibility for recovered EoL PVC flooring and is being partially funded using EU grants.

INDUSTRY COLLABORATION

Postconsumer roof recycling has been practiced in the US for more than 20 years, but it still only touches a small fraction of the available roofing materials. Experience has shown that, to grow volumes significantly, broad industry collaboration will be required. Several procompetitive activities could be organized under an industry collaborative that would enhance the recycling process and encourage growth. Some examples include the following:

- Developing a network of regional material consolidators
- Establishing a joint education program to grow awareness of recycling as an option
- Developing recycled PVC material specifications to facilitate end-use markets

A sustainable recycling strategy requires high-quality reclamation in the tear-down, reprocessing efficiency, and a ready customer base for the recycled product. Keeping the firm commitment to evolving postconsumer recycling initiatives is key in limiting the environmental burden posed by construction materials. By collaborating, the industry can efficiently and effectively address the hurdles to expanding the volume of material recycled. Since recycling a roof must be decided before the project begins, the first step is to incorporate a recycling plan into the bid package on your next roof replacement project. One way to ensure this step is to complete a design review summary that includes a sustainability section discussing the EoL disposition of the torn-off roof. 

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