

# Carpet Recycling – Northwest Project Overview, July 2009

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## What's Been Happening:

In March of 2008, Seattle Public Utilities (SPU), with support from King County Solid Waste Division, convened a Forum of national carpet manufacturers and recyclers, local flooring sellers, local recyclers and related businesses, and local solid waste and economic development agencies. The Forum was the culmination of some months of building relationships in the carpet industry locally and nationally, and researching collection, processing, and end-market considerations.

For different types of carpet and types of fiber, we've learned of different "paths" for recovery/remanufacturing. In the Northwest, with many thousands of tons of various kinds of carpet currently going to landfill, we are interested in realizing as many of these paths as practical. There are many parties interested in carpet recycling of one type or another, and work continuing since the Forum supports multiple actions.

Since the Carpet Forum, most of these are ongoing and "evolving" activities:

1. Exploring siting of pre-processing and processing facilities in the Northwest with various companies.
2. Expanding collection/consolidation sites (such as flooring sellers and recyclers—companies that receive, sort, and ship recyclables, and may also conduct some material processing).
3. Published Life-Cycle study comparing impacts of carpet recycling to landfilling and burning. (Available.)
4. Researching intermediate and end products currently or potentially made of recovered nylons from carpet. (Summarized below.)
5. Providing information and presentations to green building, solid waste policy and other audiences.
6. Compiling feedback from western Washington flooring sellers, and providing them recycling contacts.
7. Expanding the network of businesses and others assessing potential for more carpet recycling in the Northwest (various business-to-business meetings, economic development assistance, etc.)
8. Contributing to C&D policy discussions in Seattle and King County to support/promote separation of carpet from non-recyclable debris loads, to include carpet recovery in deconstruction and salvage program development, and to initiate disposal restrictions on carpet to parallel infrastructure and market development.
9. Addressing asbestos contamination in inter-jurisdictional discussions with enforcement and other agencies; and scheduling presentations and publications to building owners/managers and project managers to promote job specs and execution that keeps carpet free of asbestos and other contamination.
10. Participating in government purchasing processes to increase provisions for recycled content in carpet and mandatory reclamation of carpet from local public facilities (State of Washington, Seattle, King County, etc.)

The above statements condense many, many actions and conversations, and I hope this conveys to you a "busy" level of incubating and cultivating that has propelled us to invest further in carpet recovery efforts!

Other findings that may be useful to you:

- It's practical to separate carpet from other materials, starting at the job site and from "clean" C&D loads.
- The carpet industry sees value in recovered nylon.

- Growth in green building as well as other factors have led to increasing investment in carpet recovery by the carpet industry.
- Several changes offer opportunities not present a few years ago: technologies “scalable” to smaller, decentralized processing facilities; the presence of end-markets outside the U.S. southeast; changes in global plastics markets and manufacturing affect recent developments.
- Local businesses have become more seriously interested in carpet recycling.
- Green jobs and climate change initiatives support these interests, too.

## Background:

### Who’s Recycling Carpet in the Northwest

To our knowledge at this time, a relatively small fraction of post-consumer carpet is recycled in the Northwest through manufacturer-sponsored “direct” arrangements on a job-by-job basis or through local recyclers (haulers and/or consolidators); through public agency contracts mandating reclamation (State of Washington contract used by numerous public agencies including City of Seattle and King County), or through a few sorting facilities. At times, these facilities have included East County Recycling in Portland, Ore.; Recovery One in Tacoma, Wash.; and Pacific Urethane in Kent, Wash. Various companies, both new and existing in the region, including recyclers, flooring sellers and manufacturers of carpet or other products, have reported some involvement in the past and/or expressed interest recently. Understandably, companies interested in carpet recycling do not always want their interest published.

### Description of Carpet Materials

This information was compiled to help us assess/understand factors affecting processing and re-manufacturing.

Carpet consists of face fiber, carpet backing, binders, and padding; approximately 250 different compositions of carpet are on the market.

**Face fiber** types include: nylon 6, nylon 6,6, PET, olefin, natural fibers, and bio-based plastic. Face fibers are about 50% by weight of the carpet.

Nylon 6,6 is a polyamide in a tighter, more compact structure than Nylon 6. Nylon 6,6 is the most prevalent yarn used at 45% of the carpet market.

Nylon 6 is a polyamide made by linking large numbers of molecules derived from a petroleum product called caprolactam. Manufacturing nylon 6 typically must take place at high temperatures and high pressures. Nylon 6 is the second most prevalent yarn at 30% of the carpet market.

Olefin fibers (polyalkenes). Only polypropylene (PP) is found in carpet face fiber. Polyethylene is found in carpet packaging or carpet protectors. Polyolefins have a nonpolar, nonporous, low-energy surface not receptive to inks or lacquers without pretreatment. Olefin has a very low melting point.

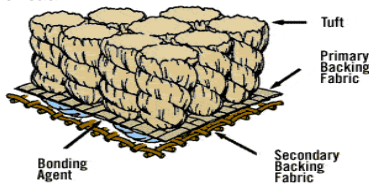
PET is polyethylene terephthalate, also known as *polyester* of terephthalic acid, the thermoplastic used for soda bottles. About 1 in 4 bottles recycled in the US are made into PET carpet fiber. PET has a low flash point, crushes and mats easily and typically oil stains are permanent. Polyesters thermoplastics may change shape after when heated, so PET carpet is not typically made back into PET carpet.

Bio-based and natural fibers are soy, corn sugar, or wool. Example bio-based brands are Sorona, SmartStrand, and Corterra.

**Carpet backing** contains a primary backing, a chemical adhesive, and a secondary backing, and makes up about 15% of the weight of the carpet. **Primary backing** is woven or non-woven fabric in which the yarn is inserted by the tufting needles. Most primary backings are made from woven polypropylene. **Secondary**

**backing** is fabric laminated to the back of the carpet to reinforce and increase dimensional stability. This is woven polypropylene, polyurethane or polyvinyl chloride (PVC). Jute is sometimes used.

#### Tufted



**Binders** (or bonding agents) hold the face fiber in place. Binders are usually latex or Styrene Butadiene Rubber (SBR latex), and make up 35% by weight of the carpet. Calcium carbonate is used as 'filler' in the latex, and does not contribute to the properties of the carpet. On curing, the SBR latex is cross-linked and hence becomes a thermoset. Thermosets do not re-melt; they disintegrate in the recycling process.

**Carpet Padding** is cushioned material placed underneath carpet for longevity, comfort, and noise absorption. The most common varieties are felt, rubber, and urethane. Carpet backing suppliers sometimes incorporate coal fly ash into polyurethane. "Cushion-backed" carpet incorporates the padding as an integral part of the backing.

## Description of Recycling Processes

**Recycling Issues:** A primary challenge to recycling carpet comes from composites of thermoplastics (any of the plastics #1-7), thermosets (cross-linked resins), engineered resins (e.g. nylon 6, or nylon 6,6), bio-plastics (based on biodegradable plants), stabilizers, fillers, and additives which vary by carpet brand and product.

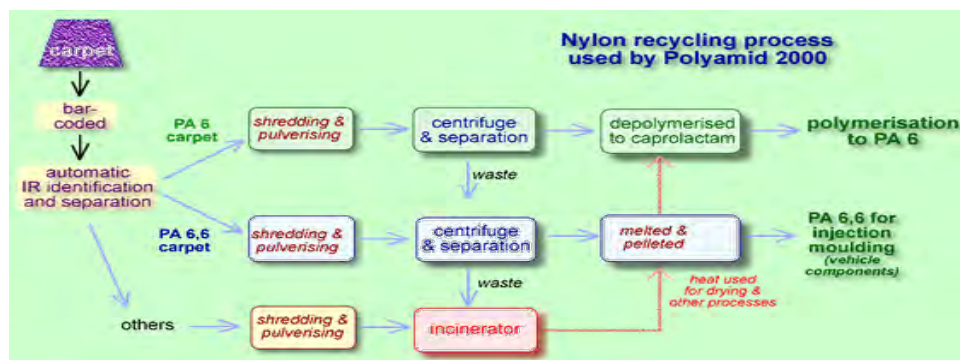
Segregating these materials to given specifications will make the material more marketable and of higher value.

New techniques and advancements in recycling infrastructure are making recycling carpet more viable. Petroleum costs affect the value of carpet recycle and thus of the end products.

### Nylon Recycling

Two types of recycling are used on nylon carpet: mechanical or heat-and-pressure to pelletize the nylon, or chemical processes.

**With mechanical recycling**, polymers are chopped into flakes and cleaned. Nylon 6,6 can be extracted from carpets by melting and forming pellets to be used for injection molding of engineering components. This type of recycling results in loss of quality, however, so such products would not be suitable for further recycling by this method. A diagram demonstrating the typical recycling pathways based on resin type is below.



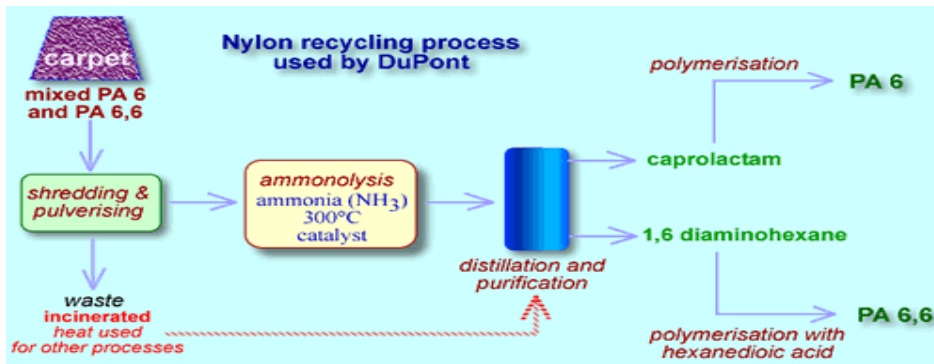
Source: from the German company, Polyamid 2000, [www.greener-industry.org/pages/nylon/8nylonPM3.htm](http://www.greener-industry.org/pages/nylon/8nylonPM3.htm)

**Chemical recycling** is sometimes called 'feedstock recycling'. There are four main methods.

- **Pyrolysis.** Plastics waste is heated in a vacuum producing a mixture of gaseous and liquid hydrocarbons not unlike petroleum.
- **Hydrogenation.** Plastics waste is heated with hydrogen; this "cracks" the polymers into a liquid hydrocarbon.
- **Gasification.** Plastics waste is heated in air producing a mixture of carbon monoxide and hydrogen gases. These are used to produce new raw materials such as methanol, which can also be used as a fuel.
- **Chemolysis.** Individual plastics are chemically treated, or de-polymerized, and turned back into monomers.

One process separates nylon 6 from its backing materials; it is then de-polymerized. This produces fresh caprolactam that can be used to manufacture nylon 6 with no loss in quality, and so is suitable for further recycling. The comparable process for nylon 6,6 is not as easy. A few companies, including DuPont, have

developed a process using ammonia to de-polymerize nylon 6,6 or any mixture of nylon 6 and 6,6. The result is fresh caprolactam and 1,6 diaminohexane for manufacture of nylon 6 and 6,6 respectively.



Source: [www.greener-industry.org/pages/nylon/8nylonPM3.htm](http://www.greener-industry.org/pages/nylon/8nylonPM3.htm)

Another new technology to reclaim nylon 6,6 has been developed in Italy by Sergio Dell'Orco and Frank J. Levy of Post Consumer Carpet Processing Technologies LLC (PCC). See *Carpet to Carpet Recycling Markets* under *Nylon 6,6 Face Fiber* below.

John D. Muzzy, a chemical engineer at the Georgia Institute of Technology in Atlanta, is working on a chemical reaction to melt nylon and cleave its long molecules using a liquid catalyst. He estimates that a single facility using this process to recycle nylon 6 would be able to recover about 90 percent of its caprolactam. It could generate more than 4,600 metric tons of an impure solution of caprolactam each year at a cost of about half the current market price. Source: Sid Perkins. "Polymer Breakdown" *Science News*. Washington: Jul 7, 2007. Vol. 172, Iss. 1; pg. 3

### PVC Recycling

PVC in carpet usually contains softeners and stabilizers to resist heat and UV light degradation. The list of other additive categories for PVC products may include: processing aids, impact modifiers, pigments, inert fillers such as chalk, lubricants that aid in extrusion, flame retardants, smoke suppressants, or biocides. These additives are generally used in much smaller quantities than the plasticizers and stabilizers. Recyclate from PVC applications which contain additives (but cannot be separated into pure PVC) is only suitable for use in mixed composition products such as railroad ties, blocks, or back into carpet tiles.

Sources: [www.mindfully.org/Plastic/Polyvinylchloride/PVC-Health-HazardPWG25oct01.htm](http://www.mindfully.org/Plastic/Polyvinylchloride/PVC-Health-HazardPWG25oct01.htm)

[www.ecvm.org/code/page.cfm?id\\_page=151](http://www.ecvm.org/code/page.cfm?id_page=151)

[www.dinp-facts.com/upload/documents/webpage/document2.pdf](http://www.dinp-facts.com/upload/documents/webpage/document2.pdf) [www.cpsc.gov/library/foia/foia01/os/dinp.pdf](http://www.cpsc.gov/library/foia/foia01/os/dinp.pdf)

[www.buildinggreen.com/auth/article.cfm?fileName=030101b.xml](http://www.buildinggreen.com/auth/article.cfm?fileName=030101b.xml)

## Carpet-to-Carpet Recycling Markets

Vertical integration and subsidiary relationships influence the technology and capacity for carpet to carpet recycling. Grouped by face fiber type, the section below approximately describes the current status of selected manufacturers' efforts to recycle and reclaim carpet for carpet manufacturing.

### Nylon 6 Face Fiber

The *Mohawk Group* has developed a mobile technology called „GreenWorks' which would develop regional reclamation capacity. Their demonstration facility is located in Chatsworth, Georgia. Currently one GreenWorks center can process 15 million lbs per year. The facility is scalable and the technology can be purchased. The GreenWorks model will partner with regional businesses to collect whole carpet, then segregate and pre-process nylon 6, nylon 6,6, and PP types of residential carpet for shipment to a GreenWorks facility. Mohawk consults with end-market experts to develop a customer base for their recycled content pellets.

Mohawk produces a non-PVC carpet tile product called „Encycle' RE with 35% pre-consumer recycled content and 2% bio-based content. Whole Encycle carpet that has reached the end of its useful life is melted down and made into new Encycle backing. Mohawk also makes „Ultra Performance System RE', with 35% post-consumer recycled content broadloom backing and 15% post-consumer windshield glass. Mohawk Industries offers recycling for over 500 products, (including post-industrial), operated through their ReCover program.

<http://www.mohawkflooring.com/green-flooring/default.aspx>; [www.mohawkgreenworks.com](http://www.mohawkgreenworks.com) Mohawk Aviation

*Group:* Similar to the recycling offered through its ReCover program, Mohawk Aviation Group offers recycling of airline carpet. Airline carpet is typically replaced every six weeks to every two years. Delta implemented a permanent recycling program in 2007, and diverted 12,080 square yards (48 tons) of material from Atlanta landfills. Source: [www.mohawkair.com/sitefiles/pages/co\\_info.asp](http://www.mohawkair.com/sitefiles/pages/co_info.asp)

*Aquafil USA*, Cartersville, Georgia, uses 'Lactam Direct Recycling' to put recycled nylon 6 into 15% of their new fiber, marketed to various carpet manufacturers. [www.aquafilusa.com/Home/OurCompany/USOperations/tabid/60/Default.aspx](http://www.aquafilusa.com/Home/OurCompany/USOperations/tabid/60/Default.aspx)

*Evergreen Nylon Recycling (Shaw):* This Augusta, Georgia facility was originally owned by AlliedSignal (Honeywell) and DSM, and produced a 25 percent recycled-content mix with virgin fiber, marketed as 'Infinity'. Descriptions of the process state the fiber could be made with up to 100% recycled content. The original Evergreen Nylon Recycling facility closed because pricing for recycled content material was too high to compete with the cost of virgin material. Shaw purchased the facility and re-opened in 2007. The Evergreen facility processed 100 million pounds of nylon 6 in 2007. Shaw, Inc. has capacity to recycle up to 300 million pounds there. They use 50 collection sites to gather carpet for the facility. [www.floortec.net/used\\_carpet\\_recycling.htm](http://www.floortec.net/used_carpet_recycling.htm)

Shaw produces three recycled content fibers for use in its carpet. A major advance in terms of sustainability was using polyolefin backing instead of PVC, reducing the weight of carpet tiles, thereby requiring less material and fuel to ship. [www.shawfloors.com/Shaw-Environmental/Sustainability](http://www.shawfloors.com/Shaw-Environmental/Sustainability) and Simpson, Robert "An Industry Poised for Vast Growth" *Flooring Magazine*, March 2000

*J&J / Invision* recovers nylon 6 fiber and extrudes it into 25% recycled content fiber at J&J / Invision's manufacturing plant in Dalton, Georgia, under their branded EnAct Initiative. All carpets made from this fiber with SBR latex backing are recyclable in this loop. They also accept other types of fiber and backing, using nylon 6,6 for waste to energy, "eko" backing to new carpet backing, and PVC backing to other products (via Mannington). Non-PVC backed tiles are recycled back into product. J&J / Invision participates in Partners for Renewal. Source: *Environmental Policy Fact Sheet of J&J / Invision* <http://www.jj-invision.com/default.aspx>

### **Nylon 6,6 Face Fiber**

*Invista:* Koch Industries purchased Invista and DuPont's nylon 6,6 fiber brand, Antron. Invista also markets the brands Lycra and StainMaster. Invista's Antron Reclamation Program processes reclaimed fiber into EcoSoft carpet cushion (50% PCC carpet), carpet backing (20% PCC carpet), and Antron carpet fiber (up to 90% recycled content). Source: *Antron Reclamation and Recycling Programs Flyer* <http://antron.net/>

*InterfaceFLOR's* recycling process is called 'ReEntry 2.0', in LaGrange, Georgia. It accepts both residential and commercial carpet, regardless of backing or face fiber. Post Consumer Carpet Processing Technologies (an Italian partnership of Stellamcor, Inc. and Dell'Orco) licensed their technology to Interface, which started using this new, scalable process at the LaGrange facility in 2007. In this process, nylon fibers are separated from polypropylene backing. New regional lines are planned for the future. About 9-10 million lbs of face fiber is recycled annually. The current ReEntry 2.0 program has capacity of 30 million lbs. InterfaceFLOR has identified streams of use for reclaimed nylon 6, polyester or polypropylene

Recovered nylon 6,6 fiber is sent to Universal Fibers, where it is chipped and incorporated into new nylon 6,6 for Interface, totaling about 12 to 25% recycled content depending on the color. Interface incorporates the recycled nylon 6,6 fiber into the first ever PCC nylon 6,6 carpet product called 'ReEntropy'. Universal Fibers is based in Virginia, with plants also in Thailand and China. Its fiber brands include 'Refresh' or 'EarthSmart'. Source: John Bradford. "An Acorn Becomes A Tree." *Environmental Design+Construction*. Nov'07, V.10, Is11, p16; Reuters, "Universal Fibers Launches EarthSmart Technology(SM)" Mar10,,08; [http://www.ifma.org/daily\\_articles/2007/jun/06\\_26.cfm](http://www.ifma.org/daily_articles/2007/jun/06_26.cfm); Janet Herlihy, "Commercial carpet fiber weakens" *Floor Covering Weekly*, Jun2-9 '08; <http://interfaceflor.com/default.aspx>

*Partners for Renewal (Solutia):* Solutia is an independent company that once was the chemical division of Monsanto. Beaulieu of America, Constantine, J & J / Invision, and Royalty Carpet Mills are associated with Solutia's Partners for Renewal program, which partners with recyclers and end markets such as LA Fibers, Nylon Board Manufacturing, US Plastic Lumber and Covanta Energy. Solutia Ultron fiber, called Renew, contains 95% pre-consumer nylon 6,6 recycled content. [www.ultron.com/socialResponsibility.aspx](http://www.ultron.com/socialResponsibility.aspx)

### **PVC Backed Carpet Tiles**



Mannington grinds up PVC backed tile in their LOOP process. Their „Infinity ReBacking’ product contains 10% post-consumer recycled content. Mannington is a 50% partner with J&J/ Invision to recycle PVC tiles at their facility in Tennessee. Source: [www.mannington.com/global/downloads/MG%20 LOOP flyer.pdf](http://www.mannington.com/global/downloads/MG%20 LOOP flyer.pdf)

Tandus’ three brands are C&A (Collins & Aikman), Monterey, and Crossley. C&A operates „FLOORE’ incentive program, part of their Infinity Initiative that purchases used PVC-backed tile (including other brands). The tiles are size-reduced, pelletized, heated, and extruded into a 100% recycled-content modular tile product called „Powerbond ER3’. Tandus also offers recycling of old C&A airline carpet. Texas Carpet Recycling, Corporate Floors, and Tandus recycled 280 tons of carpet from a 70,000 yard job at American Airlines. <http://www.tandus.com/sustainability/recycling.aspx>; [www.starnetflooring.com/news/display.php?id=60](http://www.starnetflooring.com/news/display.php?id=60)

Shaw uses third-party processors for PVC-backed products. [www.shawcontractgroup.com/html/html/capabilities/cap\\_sustain7.shtml](http://www.shawcontractgroup.com/html/html/capabilities/cap_sustain7.shtml)

InterfaceFLOR: Vinyl backing from reclaimed carpet is recycled into backing via a technology called „RePrise’. RePrise is composed of PVC backing and face fiber.

### Others

J & J / Invision participates in Partners for Renewal (the Solutia recycling program), the StarNet recycling network, and with flooring dealers to collect carpet. This company’s program called „R4’ takes back all samples and architect folders, regardless of manufacturer and brand. Folders are mailed back to Georgia, then disassembled for recycling. J&J produces a biobased and recycled-content backing for a modular tile product called „eKo’. Other modular tiles and SBR latex broadloom carpet are 10% PCC as of 2008. „Olefinic’ (PP) backing is “closed- loop” recycled back into modular carpet. J & J / Invision also uses recycled-content SBR latex. Source: [www.jjindustries.com/default.aspx?ID=45](http://www.jjindustries.com/default.aspx?ID=45) & [www.jjcommercial.com/default.aspx?id=15](http://www.jjcommercial.com/default.aspx?id=15) <http://jj-invision.ecoscorecard.com/> <http://www.jjindustries.com/Environmental.aspx>

Milliken Carpets, LaGrange, Georgia, is a division of Milliken and Co, which makes textiles, tires, and chemicals in 65 manufacturing plants worldwide. Milliken Carpets markets a service and product called „Earth Square’ to renew and reuses recovered tiles. The three-step process super-cleans, re-textures and updates designs via a dye injection process. Milliken’s standard modular carpets use their „Engineered towards Sustainability’ (ES) backing system which contains 35% recycled content and can be reused via the Earth Square process. They donate a portion of their modular tiles to a non-profit called „ReDO’ that donates carpet worldwide. Milliken’s face fiber is made of Stainmaster or Antron nylon 6,6 from Invista twisted together with New Zealand Wool. Source: [www.millikencarpet.com/Americas/Contract/Government/Performance/Pages/default.aspx](http://www.millikencarpet.com/Americas/Contract/Government/Performance/Pages/default.aspx)

Shaw Industries Group, a Berkshire Hathaway subsidiary, owns a cradle-to-cradle carpet recycling facility in Cartersville, Georgia called the „EcoWorx Recovery Technology’, which recycles polyolefin EcoWorx backing. The backing is separated from the nylon face through an elutriation process (separating the lighter particles of a powder from the heavier ones by means of an upward directed stream of gas or liquid. IUPAC Compendium of Chemical Terminology). The polyolefin from the backing is returned directly to the extrusion process to become more EcoWorx backing of equal quality. The nylon is sent on for recycling at the Evergreen Recycling facility, also owned by Shaw. Shaw will pick up EcoWorx product at no charge to the customer and recycle it into more EcoWorx. They also operate a free carpet samples recycling program. The New Patcraft and Designweave, a commercial division of Shaw Industries Group, participates actively in Shaw’s recycling programs. Source: <http://www.shawcontractgroup.com/Html/EnvironmentalReclamationRecycling>

### Major suppliers/ manufacturers of backing and fiber:

Several of the major mills extrude their own fibers. Others purchase fibers from plastics manufacturers or suppliers.

Carpet and Rug Backings and Supplies (CRB), Dalton, Georgia, is a vertically-integrated, longtime manufacturer and distributor of primary polypropylene and secondary backings to the industry. Source: [www.floordaily.net/FloorFocus/The Backing Business January 2008.aspx?print=TRUE](http://www.floordaily.net/FloorFocus/The Backing Business January 2008.aspx?print=TRUE)

Propex, Hazelhurst, Georgia, makes woven polypropylene fabric and fiber used in primary and secondary carpet backings. Besides U.S. production, Propex has plants in Germany, Hungary, Mexico and Brazil. Propex

products (Polybac, Actionbac, Gatormat, and Matrix) are in more than 50% of carpet produced worldwide. Carpet backings are about 40% of its sales. Other major products include geotextile and erosion control products. Source: [www.floordaily.net/FloorFocus/The\\_Backing\\_Business\\_January\\_2008.aspx?print=TRUE](http://www.floordaily.net/FloorFocus/The_Backing_Business_January_2008.aspx?print=TRUE)

*Mattex* started manufacturing in Jeddah, Saudi Arabia and added a second plant in Dubai. It produces mostly primary backings for residential markets in the U.S. The balance is in the commercial and artificial turf markets.: [www.floordaily.net/FloorFocus/The\\_Backing\\_Business\\_January\\_2008.aspx?print=TRUE](http://www.floordaily.net/FloorFocus/The_Backing_Business_January_2008.aspx?print=TRUE)

*Omnova*, in Calhoun, Georgia and Mogadore, Ohio, is a large latex (SBR) producer. [www.floordaily.net/FloorFocus/The\\_Backing\\_Business\\_January\\_2008.aspx?print=TRUE](http://www.floordaily.net/FloorFocus/The_Backing_Business_January_2008.aspx?print=TRUE)

Note that various carpet manufacturers are an end-market for millions of pounds of other recycled materials. Recovered glass, coal fly ash, plastics, and more are used in face fiber, backing systems, and as fillers.

## Carpet into Non-Carpet Recycling Markets

**Auto parts, straps, and fasteners; truck bumpers; step bars; pick up covers; ramps; louvers; mirror housings; wheel covers; engine fan shrouds; air intake manifolds; radiator end tanks.** Primarily, nylon 6,6; sometimes nylon 6. Auto sales directly affect demand for PCC carpet as feedstock. Approximately 25 lbs of nylon are used in each vehicle. The black color of auto parts lends itself well to recycled nylon. [http://www.carpetrecovery.org/pdf/annual\\_conference/2008\\_conference\\_pdfs/ECM\\_Plastics\\_Pilotti.pdf](http://www.carpetrecovery.org/pdf/annual_conference/2008_conference_pdfs/ECM_Plastics_Pilotti.pdf)

**Wood-plastic composites, paneling, and pallets.** Wood-plastic composites (WPC) are typically made from polyethylene (HDPE), polypropylene (PP), or PVC, but can be made with polyamides (nylon), ABS, polystyrene, or PLA (biobased plastic). Research from Georgia Tech shows that WPC can be made from pelletized carpet plastics. Adding glass fiber (30%) adds a great deal of structural stability that counteracts the poor properties of mixed plastic in carpet. One WPC application is nylon pallets used for shipping. Source: *Muzzy, John D., et al. Recycling of fibrous textile and carpet waste: Composites Derived from Post-Consumer Nylon 6 Carpet. May ,03*

**Resilient flooring.** Resilient flooring typically made of vinyl can be made from PCC carpet.

**Parking stops, signs and guardrails, sound barriers.** Granulated into regrind that is washed, dried and packaged for manufacturers of products such as drainage pipe, nursery containers, and plastic sheeting.

**Geotextiles, Nets, and Mats.** Hummer Grass Tiles are sod tiles with PCC carpet mixed with sand, soil and other nutrients. GeoHay erosion control blocks, mats, and filter socks, produced with post-industrial carpet and PCC nylon, polyester, polypropylene carpet fiber. .

### Carpet pads, insulation, and cushions.

LA Fibers, Los Angeles, California, makes synthetic carpet cushion (called „Reliance’) from 100% post-consumer carpet fibers. LA Fibers processes 20 million pounds of used carpet in 6 months. Employees hand sort and check the carpet with infrared technology to verify fiber type. Pieces are then put through machines to remove dirt and backing; then multiple times to break it apart into fiber strands. The resulting shoddy is made into carpet pads by adding latex and heating to melt the latex to bond the fibers together. LA Fibers also partners with carpet manufacturers supplying their reclamation programs. Source: [www.lafiber.com](http://www.lafiber.com)

Chamlan Enterprises in Fresno California makes nonwoven carpet underlay from recycled carpet fibers. The surface is treated with a specially formulated resin that stabilizes the cushion and adds tensile strength. The resin also adds a slick surface for ease of installation. [www.chamlan.com/Cushion.asp](http://www.chamlan.com/Cushion.asp)

### Concrete.

Carpet cut into molds can be incorporated with little cleaning or separation costs into concrete to help stabilize blocks in the event of an earthquake or sudden explosion. Source: *Miraftab, Mohsen. 4th Annual Conference on Recycling of Fibrous Textile and Carpet Waste : May 17-18, 1999 /: Novel Applications of Pre- and Post-Consumer Carpet.*

MDM Fiber of Langhorne, Philadelphia, uses post-consumer and post-industrial carpet to add to concrete products including site-cast and pre-cast; asphalt products including hot-mix, cold-mix and warm-mix; hydro-seeding products; soil stabilization; and plastic products and other thermo-set materials. *Source: CARE website*

**Drain pipes and filtration.** Pelletized nylon 6,6 PCC carpet can be made into septic system filtration pipe.

**Tire cords and bike tires** (potential market). Nylon 6 is used in tire cords. It is unclear if this might be a viable end market for recovered nylon 6.

**Engineered plastics.** There are several applications for glass fiber reinforced polyamide/polyolefin products. These products address the needs of the users in the automotive, appliance, liquid handling, power tool and industrial markets requiring minimized adverse effects of water absorption (which is commonly experienced with nylon molding compounds). This material offers stability in processing and physical properties in humid conditions. "Technyl XCell" is mineral filled plastic made from glass reinforced nylon 6,6 and 6, for example.

BASF signed an agreement to source adiponitrile from Invista and plans to close an outdated adiponitrile unit in 2009. BASF uses adiponitrile to make hexamethylenediamine (HMD), an intermediate used to make nylon 6,6. BASF also makes adipic acid, the other intermediate used to make nylon 6,6. HMD and adipic acid combine to make AH-salt. BASF has 670,000 m.t./year of nylon capacity and is the second-biggest producer after DuPont. The company recently reorganized its nylon business, part of which it acquired during the last few years. BASF bought Ticona's nylon 6,6 business in 2003, and Miramid (Leuna, Germany), a producer and compounder of nylon-6 and nylon 6,6, two years later. Its biggest nylon deal was a swap in 2003, under which BASF's nylon fiber business was exchanged for Honeywell's nylon 6 resins operation. *Source: Natasha Alperowicz. "... Puts Nylon Intermediates Project on Hold." Chemical Week. New York: Jul 25, 2007. Vol. 169, Iss. 25; pg. 15*

Cycle-Tex, Inc. is a Dalton, GA, based recycler of thermoplastic post-industrial waste. They re-pelletize polypropylene and polyethylene scraps for use by other manufacturers. Two extrusion facilities in North Georgia are capable of processing over 40 million lbs/year. The company has strong long-term relationships with many of the major carpet manufacturers, enabling Cycle-Tex to become a major thermoplastics recycler in the area.

### **Energy**

Plas2Fuel Corp, headquartered in Kelso, WA, has developed a full-scale, plastics-to-fuel unit currently operating under franchise in Brooks, Oregon (AgriPlas). The process can convert 16 g of waste plastic material to 12 g of synthetic crude oil. Plas2Fuel calls it ideal for undesirable or unmarketable thermoplastic resin flakes. Plas2Fuel Corp. was founded in 2004 by Kevin and Elisabeth DeWhitt; they plan to sell small-scale closed systems that recyclers can purchase or lease for their own premises. *Source: Becky Brun. "Do you take plastic?" Sustainable Industries Journal 11.29.06 [www.sustainableindustries.com/energy/4771436.html](http://www.sustainableindustries.com/energy/4771436.html) and <http://www.bizjournals.com/portland/stories/2006/10/09/story4.html>*

Past research shows that carpet might substitute for up to 15% of coal fuel in cement kilns. The highest concentration of energy is in the primary and secondary backing in the polypropylene at 38 million BTU per ton. PET is 20.45 million BTU per ton. Carpet in general is 20 million BTU per ton. The CaCO<sub>3</sub> (filler) is not combustible, but could be used in portland cement.

[http://crt.d.asme.org/btrd/imece2003/carpet\\_recycling\\_project.pdf](http://crt.d.asme.org/btrd/imece2003/carpet_recycling_project.pdf)  
and [www.eia.doe.gov/cneaf/solar.renewables/page/mswaste/mswtableb1.html](http://www.eia.doe.gov/cneaf/solar.renewables/page/mswaste/mswtableb1.html)

**Other potential end uses without further information at this writing:** Sound barriers, furniture, appliances, alloys with other plastics or other recycled materials.

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