Carpet Recycling 101

Post Consumer Carpet Recycling in North America
The Participant will gain knowledge in the following:

- Drivers for Carpet Recycling
- General Categories of carpet recycling
- Differences in Various types of recycling
- Market Values of Various Recycled Products
- Demand for Recycled materials from Carpet
- Understanding Capital needs of Recycling
- Present & Anticipated recycling capacities
- Present & New Recycling technologies
- Challenges & Opportunities
Post Consumer Carpet Drivers

Factors driving Recycling of Post Consumer carpet
Post Consumer Carpet Recycling Drivers

Broad List of Drivers:

- Carpet Manufacturers
  - LEED building Standards – Need P. Consumer for high value/Specifications
  - NSF 140
    - High value of P.C. content
    - Platinum Level highly prized: Requires Min. Post consumer content.
    - Platinum Level requires P.C. Carpet recycling at CARE Goal levels – Escalate every year.
- Professional Specifying Commercial Community demands Sustainability
  - Reward most Sustainable companies with increased business: or NO business
  - Recycling and P. Consumer recycled content is large factor
- Large National Accounts demanding sustainable initiatives:
  - Wal-Mart, Home Depot, etc.
- Good Old healthy competition.
Post Consumer Carpet Recycling Drivers

Broad List of Drivers:

- Entrepreneurs:
  - Willing to risk Capital for carpet recycling
  - They are beginning to see fairly good business model
  - Beginning to make money from carpet recycling
  - They are essential link in the value chain of processing

- High Oil prices
  - Keeps Virgin Nylon very expensive
  - Cost Spread between virgin and P. Consumer is wide
  - Makes P. Consumer very attractive for cost savings.

- Post Industrial Feedstocks are rapidly diminishing
  - P. I. Nylons have been standard product in plastics compounding for decades
  - Hundreds of millions of pounds have disappeared from the marketplace
  - Post Consumer Products are beginning to fill the large gap.
  - Nylon 6.6 in critically short supply

- New Recycling technologies: Produce Higher value products
Recycling Processes
Classification of Discrete recycling processes
General Categories of Carpet recycling & Diversion

- **Broad Recycling Types/Classifications:**
  - Chemical Recycling
  - Mechanical Recycling – Dry Systems
  - Mechanical Recycling – Wet/Dry Systems
  - Mechanical Recycling – Skiving Systems
  - Commercial Carpet Recycling – General Information
  - Hybrid System – Kela Synthetic Fuel Pellet
  - CAAF: Carpet as Alternate Fuel
  - WTE: Waste to Energy
Chemical Capet Recycling

Available systems in North America
Chemical Recycling Systems in Operation

  - Capped at Approx. 100 million lb capacity
  - Depolymerizes Face Fiber to Caprolactam: building block of Nylon 6.
  - Processes Nylon 6 only.
  - All output used for carpet fibers.
  - Used as Post Consumer content in nylon 6 carpet fibers
  - Non Carpet components recycled into beneficial applications
Chemical Recycling Systems in Operation

- Nylon Depolymerization - Canada
  - Approx. 5 million lb capacity - Can be expanded.
  - Depolymerizes Carpet to Caprolactam: building block of Nylon 6.
  - Process for Nylon 6 only.
  - All output used internally and/or sold to outside Companies.
  - Used as Post Consumer content in nylon 6 carpet fibers
  - Leaves all non-nylon components as Sludge.
Chemical Recycling Systems in Operation

- Formic Acid Dissolution - Delaware
  - Operations begin July 2010.
  - Raw material input: Baled nylon fibers: Various sources
  - Dissolution of Nylon in formic acid.
  - Precipitates almost pure nylon.
  - Can process both Nylon 6 and Nylon 6.6.
  - Presently 1 site – 5 million Lbs. Going to 15 million w/Expansion.
  - Plans to expand regionally in various parts of the country.
  - Leaves small amount of Non-Nylon components
Common Elements of all Chemical Recycling

- All use *some* mechanical Pre-processing prior to Chemical process
  - Performed either on site or outside Pre-processor
  - Includes, but not limited to:
    - Size reduction – Shredding
    - Calcium Carbonate Reduction – Hammer mills or Textile Tearing.
  - Leaves Non-Nylon components to be recycled via some other method.
  - Extremely Expensive capital requirements w/exception of MCR
Advantages/Disadvantages

- **Advantages De-Poly systems**
  - Purest nylon output of any carpet recycling system.
  - Virtually no contaminants.
  - No degradation in properties.
  - Perfect for new nylon fiber (fiber to fiber).

- **Disadvantages De-Poly systems**
  - Extremely expensive capital outlay
  - Limited to Nylon 6
  - Single site exists in U.S. – Capacity limited to one site
  - High cost logistics – Carpet trucked all over U.S.
  - Costs are higher than virgin nylon.
Advantages/Disadvantages

**Advantages Formic Acid system**

- Nylon Purity 2nd only to Depoly. Processes.
- Very little contaminants.
- Suitable for Plastics Market & Fiber
- Can process both nylon 6 & 6.6.
- Multiple site can be built Economically
- Cost effective nylon fiber source from Post Consumer carpet.

**Disadvantages Formic Acid system**

- Not all color is removed from nylon as with De-poly systems
- Leaves non-nylon for other form of recycling
Mechanical Carpet Recycling

Dry Recycling Systems
Dry Systems

Dry Systems & Types

- Very prevalent and broad based
- Mechanically processes carpet
- Two types of Mechanical Processing
  - **Process 1 – Beating process**
    - Size Reduction – Shredding
    - Sequential steps of step cleaning and Hammer mills to remove ash.
  - **Process 2 – Textile Process**
    - Size Reduction
    - Sequential opening and combing to remove ash.
System Outputs

**Dry Systems Outputs**

- Co-mingled carpet fibers (face/back)
- No Separation of face & backing components
- Desired Final product Ash content can vary dramatically
  - Depends on no. of cleaning steps
  - Depends on needs of End markets
  - Ash content varies – 25% down to 5%.
Dry System Uses and Markets

- **Input material for low value plastics:**
  - Typical market is China
  - Requires very low processing & Wage markets.

- **Input material for further mechanically processed products**
  - Fiber carpet underlayment – Great for mixed polymers
  - Geo Hay type materials.
  - Plastic Lumber Composites – Decking, Sound Barriers, Rail Ties, etc.

- **Input Materials for higher Value Output recycling systems**
  - Input for De-Poly operations – Lower Contaminants improve efficiencies of next process.
  - Input for Wet/Dry Recycling systems
Advantages/Disadvantages

**Dry System Advantages**

- Low cost process
- High Volume, High Speed process
  - Multiple lines in single facility
  - Can produce various grades in one facility
- Liberates Calcium fillers (40% to 50% of carpet weight)
  - Allows calcium to be reclaimed into new products
- Low cost Input for Higher Value Recycling processes & Recycled products
  - Wet/Dry
  - Depoly
  - Underlayment
Advantages/Disadvantages

- **Dry System Disadvantages**
  - Low Value product Output
  - Very sensitive to costs
  - High Yield losses – Typical losses of 50% to 60%.
  - Process Cannot Separate carpet Polymers
  - Large Volume operation requires millions of dollars Capital
Mechanical Carpet Recycling

Wet/Dry Recycling Systems
Wet/Dry Systems

Wet/Dry Systems & Types

- Only 3 Facilities Exist in U.S.
- Material Input comes from Dry System output – Mixed polymers
- Combines Several processes: Described Below
- Economically feasible only for Nylon Post consumer carpets.
  - Process 1 – Very fine particle size reduction
    - Mechanical systems
  - Process 2 – Polymer Separation
    - Wet Separation of Polymers
    - Separate backing from Face components
  - Process 3 – Polymer Continuous Drying
  - Process 4 – Densification of Each polymer Stream
    - Several densified physical forms
Wet/Dry System Outputs

- Separated Nylon Face & Backing components.
  - Nylon Face.
  - Polypropylene Back.
- Relatively Pure Nylon Pellets - 95% pure.
  - Some Residual P.P. in Nylon
  - Calcium constitutes most of contamination – Cannot be totally removed
End Uses & Markets

Wet/Dry System Uses and Markets

> What Industry
  * Plastics Industry
  * Engineered Resins: (Definition)
  * Nylon 6 & Nylon 6.6 used extensively

> Who are the Plastics Industry Customers.
  * Compounders: (Definition)
  * End Users w/compounding capabilities
  * End users who specify Post Consumer plastics

> What are some of the Plastics Industry sectors
  * Automotive - Largest
  * Small Appliances
  * Lawn & Garden
  * Commercial – Furniture Industry
Wet/Dry System Advantages

- Achieve Relatively High purity levels: *Can be melt filtered to some degree thru extruder, but costs increase & loose polymer.*
- Good Costs vs. Performance for Plastics Industry
  - Lower costs vs. Post Industrial Nylons
  - Do not perform as well as P.I, but cost/Performance curve favorable.
- Product increasingly accepted in Plastics
  - Relatively new product Category
  - Experience, exposure needed for further acceptance
- High Value output goes directly to Plastics compounding
Advantages/Disadvantages

- **Wet/Dry System Disadvantages**
  
  - Only 3 systems exist
    - 1 site - Tennessee
    - 1 site - S. Carolina
    - 1 site - Georgia
  
  - Limited availability
    - Not likely to expand in the short term
    - Relatively high capital requirements: *Highly skilled workforce needed*
    - Total Capacity: Approx. **50 MM to 60 MM pounds/Yr. output.**
    - However: P.C. Carpet needed to produce output is: **160 MM to 200 MM Lbs/Yr.**
  
  - Quality of input material is key for Purity levels.
Mechanical Carpet Recycling
Skiving or Shearing
What are they? What do they do?

> Removal of face yarn from carpet via. Lateral Cutting action.
> Shaves carpet face from rest of carpet.
> Origination of Equipment
  * Converted “Leather Slitting” machines
  * New Machines being built specifically for Carpet Shearing.
  * They take into account the uniqueness of Post Consumer carpet
    * Metal contamination
    * Variations in pile heights
    * Density of carpet materials
Shearing System Outputs

- Concentration on Nylon Post Consumer Carpets
- Face fiber Output
  - Still in Yarn form
  - Nylon is preferred: Nylon 6 & Nylon 6.6
  - Fiber typically baled
- Output is Very Pure Nylon
  - Typical 99% purity
  - Commands good value in Market.
  - Misc debris constitutes contamination: Approx. 1%
- Carpet “Carcass”.
  - Left over carpet from Shearing:
  - Much is landfilled today: 60% to 75% of Carpet weight left.
  - Technology developing to harvest high Value from Carcass Recycling
  - Some Carcass will go to CAAF, but needs better answer.
Sheared Nylon End Uses and Markets

- Same Industry as Wet/Dry nylon Output.
  - Plastics Industry
  - Engineered Resins
  - Nylon 6 & Nylon 6.6 used extensively

- Who buys these products in the Plastics Industry.
  - Compounders
  - End Users w/compounding capabilities
  - End users who specify Post Consumer plastics

- What are some of the Plastics Industry sectors
  - Automotive - Largest
  - Small Appliances
  - Lawn & Garden
  - Commercial – Furniture Industry
**End Uses & Markets**

**Sheared Nylon End Uses and Markets Con’t**

- **Carpet Industry**
- **Used for fiber extrusion, but:**
  - Must be further purified prior to extrusion
  - Nylon 6 & Nylon 6.6 are Prime Candidates
  - Produces Post Consumer Content for new Nylon fibers
- **New Applications for Fibers Developing**
  - First application: nylon 6.6
  - Nylon 6 beginning to be developed
**Shearing System Advantages**

- Very High Purity output
  - 99% Purity
- Relatively Small Capital outlay for business start up
  - Shearing Equipment: From $50K to $340K per machine
  - More costs for Auxiliary equipment: ID guns, balers, Material handling, etc.
- Carpet Fiber back to Carpet Fiber (Closed Loop)
- Local Processing Facilities Very easy
  - Install process where carpet is collected
- Very low footprint recycling
  - Reduced Logistics: Haul from small local Radius
  - Low Energy recycling
Shearing System Disadvantages

Low yield from Original carpet
- 60% to 75% of carpet not Harvested

Why:
- Purity of output must be maintained
- Cannot shear off entire face
- Varying face fiber heights: continual adjustments

Carcass Disposition
- Much goes to landfills today
- Out of 1MM lbs Post Consumer carpet sheared – 600K to 750K is Landfilled

Technology Developing to harvest Value from Carcass
- Includes Thermoplastic component
- Calcium
Mechanical Carpet Recycling

Calcium Carbonate fillers: Residential carpets
**Calcium Carbonate Recycling**

- **Filler represents large portion of carpet weight (40% to 50%)**
  - Process recycles filler into new carpet fillers
    - Combines recycled filler w/Virgin filler & other materials
    - Used as P. Consumer content in new carpet products
    - East cost Site and West Coast Site
    - Many carpet mills in trial phase. Some are already using.
  - Benefits
    - Keeps millions of pounds out of landfills
    - Reduces mining for virgin fillers
    - Fairly low cost P. Consumer content for new carpets.
    - Low impact recycling.
Commercial Carpet Recycling

Overview
Commercial Carpet Recycling

- **Due to the extremely varied nature of Commercial carpets, a variety of processes must be employed for recycling.**
- **Many products, especially tiles, contain backing pre-coats of chemistries that differ from the main backing coat.**
  - Must be segregated by face fiber and backing types
  - General backing chemistries - Broadloom
    - Latex
    - Polyurethane
    - PVC – 6 ft wide
  - Tiles
    - PVC
    - Thermoplastic Extruded
    - Polyurethane
  - Recycling uses one or several recycling processes already described. It is not in the scope of this presentation to describe commercial recycling in detail.
Synthetic Fuel System

- Synthetic Coal Bricket
- Constituents
  - Coal fines
  - Wood Dust
  - Post Consumer Carpet: Glue that holds it together
- Technology
  - Licensed to Utilities by Kela Energy
  - Carpet added at Plant sites
  - Carpet is Dry processed (Shredded) prior to insertion
- Sites
  - Several are planned in the next 5 years
- Start up
  - Projected for Late 2010
Advantages/Disadvantages

Kela System Advantages

› Outlet for Million of tons of Coal dust
› Uses million of Lbs. carpet of all types
› Beneficial use of Wood dust
› Lower Emissions than cleanest Stocker Grade coal
› Product manufactured at Coal fine locations
› Takes polluting Coal fines out of environment
› Reduces dependence on new coal mining
Carpet as Alternate Fuel
**Carpet Diversion Technology**

> Uses single source fuel
> Carpet is only fuel source
  > Carpet must be collected
  > Shipped
  > Dry processed prior to Fuel generation
> Technology
  > New Technology by Shaw
  > Start up in late 2010
  > Two phases are planned
> Benefits
  > Uses carpet that otherwise cannot be easily recycled
  > Could be very beneficial for some types of commercial carpets
Recycling capacities

Present Post Consumer Carpet Recycling capacities
Carpet Recycling Capacities

**2010 Estimated Utilization**

- Dry Recycling systems
  - 200 Million Lbs.
- Chemical Recycling systems
  - 85 Million Lbs.
- Wet/Dry Recycling systems
  - 30 Million Lbs.
- Shearing Systems
  - 30 million Lbs.
- Kela
  - 10 Million Lbs.
- WTE
  - 50 million Lbs.
- Misc:
  - 20 Million

**Total: 425 Million**

**2012 Estimated Utilization**

- Dry Recycling systems
  - 250 Million Lbs.
- Chemical Recycling systems
  - 150 Million Lbs.
- Wet/Dry Recycling systems
  - 40 Million Lbs.
- Shearing Systems
  - 200 million Lbs.
- Kela
  - 60 million Lbs.
- CAAF
  - 100 million Lbs.
- WTE
  - 60 Million Lbs.
- Misc:
  - 20 Million Lbs.

**Total: 860 Million**
Challenges & Opportunities

What does the future hold?
What are some of the hurdles that must be overcome

- Sound Economic Recycling Models: *Price/Performance Continuum*
- Discuss Values of P.C. Streams: vs. (Virg. P.I.) and vs. (various P.C. Streams)
- Carpets constructed for Recycling
- Commercial Carpet Diversity
- Patchwork of Regulatory rules
- New Recycling Technology advances: How can it be incentivized.
- Thermoplastic Purity
- Full acceptance of Post Consumer products in all Markets
- Purity of outputs
- As we mature: Collecting & Mining Enough carpet
- Polyester Value chain:
  - In 5 years, could be 1 Billion pounds of output
What is the Future Potential

- Great source of Material for Plastics
- Will replace P. Industrial as the source to the Marketplace
- Steady/Dependable pricing: Insulates marketplace from wild fluctuations
- De-couples plastic materials from the Oil well: Multiple lives
- Low Environmental impact vs. Virgin Plastic production
- Relieves landfill burdens Nationally
- Develops an entire new industry with jobs
- Projects carpet as more Sustainable product
- Purity of outputs
- As we mature: Collecting & Mining Enough carpet

Polyester Value chain:
  - In 5 years, could be 1 Billion pounds of output
Thank You

Questions