

**Development of Value Added Opportunities from Recycled Cotton Mattress Fiber**

**Interim Report**

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## 1.0 Introduction and Background

Hennepin County Environmental Services is in the preliminary stages of developing a Twin Cities Metro Mattress Recycling Program in partnership with PPL Industries, a local non-profit organization located in south east Minneapolis. The recycling program is being modeled after the Goodwill Mattress Recycling program located in Duluth, Minnesota where over 43,841 mattresses and box springs have been dismantled and diverted from landfills. One of the unique challenges these recycling facilities face are finding and exploiting markets for the cotton based materials recovered from mattresses and box springs.

The Natural Resources Research Institute (NRRI) in cooperation with Hennepin County Environmental Services has researched some potential applications and markets where these recovered cotton materials can be utilized and or converted into other earth friendly products. This report provides an update on these applications and provides an additional market perspective where these materials can either be sold or converted to other earth friendly products.

PPL Industries has estimated that that in its first year of operation it will dismantle and recover 11,000 mattress units while ramping up to 40,000 units in year five. With each mattress containing as much as 9.24 lbs of recoverable cotton per unit, the annual generation rate of cotton is estimated at nearly 50 tons and ramping to 185 tons in year five. Therefore there is an immediate and impending need to find markets for these cotton based materials.

## 2.0 Program Challenges

Some of the challenges associated with finding market outlets or opportunities for these cotton based materials were found to be:

- Differences in cotton terminology across disciplines
- Perception issues associated with post-consumer-cotton
- Understanding how mattresses and box springs are initially constructed
- Cotton grading and sorting to meet quality and process specifications

*2.1 Cotton Terminology* – To successfully broker or find market outlets for reclaimed mattress cotton it is necessary to become familiar with the terminology used through out the cotton industry. There are several layers and types of cotton in a mattress. The mattress industry refers to the layer just above the steel springs as an “insulation pad.” This pad provides a protective barrier between the steel coils in a mattress and the loftier cotton materials above it. Some recyclers refer to this as “cotton-shoddy”. There is actually very little cotton in this material. This material is a needle punched non-woven mat composed mainly of synthetic, polyester and cotton fibers glued together with hot melt fibers. The loftier cotton layer above the insulation pad basically resembles what the industry refers to as “first-cut-cotton-linters”, an industrial by-product from the cotton oil seed industry. These linters are likely air layed into a batting before being placed into

mattresses. These terminology perspectives were gained through conversations with Buckeye Technologies, a world wide marketer of cellulose based absorbent products.

*2.2 Industrial Perception* - perception issues can render some application areas nearly impossible or very hard to exploit. For example, several states do not allow the use of post consumer cotton back into new consumer cotton products. In addition, when the NRRI initially researched the use of “post-consumer” cotton as a replacement for “post-industrial” cotton, it found the potential customer wanted some degree assurance of quality and an upfront inspection of the material. As a result, it was necessary to work with the customers to identify the quality considerations and provide samples for evaluation and testing. This was mostly an educational undertaking and was necessary to improve the marketability and perception aspects of the material. These evaluations aided acceptance in some applications and were helpful in brokering the materials.

*2.3 Mattress and Box Spring Construction* – several new mattress facilities were toured to better understand the unique materials and steps that go into the construction of a new mattress. Surprisingly, most manufacturers have shifted away from cotton based material for the loft layer and have made the switch to foam or latex products. Therefore, future recycling challenges are likely to include more foam and latex products – rather than cotton based products. This trend will likely start to appear in five to ten years.

*2.4 Grading and Sorting to Meet Quality and Process Specifications* – the grade, quality and age of the cotton recovered from mattresses can vary across mattress type. In addition, the nature, extent and volume of any synthetics or contaminants in the cotton, if properly removed or sorted can improve its value in the recycling market. A simple grading and sorting procedure was developed in which any netting, mesh or unusually longer fibered threaded materials are selectively removed from the cotton batting in a sorting procedure. This sorting procedure basically allows the recovered cotton to be reprocessed or air layed though conventional carding equipment commonly utilized throughout the non-wovens industry.

Another grading procedure for the cotton involves the use of UV black lighting to help grade the material into two streams - some having an acceptable (low) proportion of synthetics and those having unacceptable (high) proportions. Synthetics fluorescence easily under black light and is a simple means to grade the cotton into two separate streams.

### **3.0 Potential Market Applications for Recycled Cotton Fiber**

The application areas investigated for potentially utilizing the reclaimed cotton fiber included its use in:

- ceiling tiles
- filtration media substrate
- non-woven oil absorbent wiper
- bleached cellulose absorbent (grading method for potential use in this market)
- landscape products

### 3.1 Ceiling Tiles

A conventional ceiling tile formulary basically includes mineral wool fiber, perlite fines, starch, newsprint, a powdered clay filler and a surfactant. These materials are pulped, wetted, formed into a cake and then dried into light weight tiles. It was thought that cotton fiber could replace or supplement the mineral wool fraction in a conventional ceiling tile formulary. The NRRI conducted some preliminary technical feasibility investigations in which mineral wool was replaced with an equivalent amount of mattress cotton in a ceiling tile formulary. Although these investigations demonstrated technical feasibility, the difficulty by which the tile could be cut and its post press moisture content appeared marginal at best. Photographs of these prototype samples are provided as an Appendix to this document.

As a follow up to these investigations, the USG ceiling tile plant in Cloquet, Minnesota was then contacted and asked if they could initiate a test in which the performance aspects of a cotton based formulary was compared to a standard mineral wool formulary. Their preliminary assessment revealed the following:

- to replace mineral wool with cotton in the formulary would require about 7500 tons of cotton annually
- Current raw material pricing for mineral wool was in the nominal \$20 to \$40/ton range.
- Pulp testing revealed undesirable clumping and agglomeration of the cotton fiber.

It was concluded the potential cotton tonnages coming out of mattress recycling are too small, the value too low and more aggressive pulping would be required. Based on these findings, this application area was eliminated.

### 3.2 Filtration Media Substrate

Industry contacts were made on the use of cotton and wood fibers as a filtration media in oil filter applications. Leading manufacturers of gas fired engines have developed reliable methods to overcome the detrimental effects of high sulfur fuels. Depth type filters are a common choice for gas fired engines because of their large dirt holding capacity, good value and water removing properties. Water removal is important in these types of filters as water can combine with sulfur dioxide, and then react with oxygen to form sulfuric acid which can damage the additives package in the lube oil and over time diminish lubricity. The oleophilic cotton fiber when combined with the hydrophilic wood fibers offer:

- Excellent filtration of particulate from the oil
- Excellent throughput with low pressure drop
- Excellent water removal properties from the hydrophilic wood fibers

To evaluate the handle ability and forming characteristics of mattress cotton versus conventional cotton linters, Mat Inc., a local non-woven manufacturer, was contacted and asked to compare the forming characteristics of each on their fiber forming line. Mat, Inc. has been making natural fiber mats and blankets for 25 years in Floodwood, MN. selling a variety of products all over the world—from poultry floor liners to oil absorbent and filtration blankets. The company's main product line is a refined wood pulp used in hydro mulching and several filtration/absorbent blankets used in filtering applications. Mat Inc. agreed to evaluate the forming and handling characteristics of each and provided the following important findings:

- For mattress cotton to be properly carded, any stringy and longer fibers must be removed before it is accepted. In addition any mesh or netting attached to or inter bound with the cotton must be removed. These plug the carding machine and must be removed.
- The material was found to card as well as conventional first cut cotton linters if it is properly blended with wood fibers.
- Mat Inc. provided 400 lbs of the carded wood fiber/cotton blend to their customer.
- A comparative performance analysis conducted by the customer demonstrated equal performance to their current source of cotton supply.
- The value of the material was established at \$0.20/lb and there was a significant cost savings incurred by the customer.

Two full scale trial runs were completed at Mat Inc. demonstrating that mattress cotton was an effective alternative material to incorporate into their air layed filtration matting. These trials were successful as they helped to identify:

- Oil sorbency performance of mattress cotton was equal to industrial grade cotton linters.
- Handling and processing of the mattress cotton could be greatly improved with grading and sorting techniques.

As a result of these findings, a grading procedure was adopted at Goodwill Industries in which any unacceptable or uncardable materials are removed from the cotton prior to final baling.

This niche market application area is estimated to consume 50,000 to 60,000 lbs of recycled mattress cotton annually and save some 5400 to 6500 mattresses from going to landfills.

### 3.3 Non-woven Absorbent Wipe

The relative appearance and feel of the carded samples of wood fiber and cotton fiber obtained from Mat Inc. appeared to show potential as a general purpose oil absorbent wipe. As a result, two small trials were conducted at Mat Inc. in which the desired outcome was to produce:

- An acceptably dense non-woven cotton based wiper pad made from 96% mattress cotton.
- An acceptable dense non-woven cotton based wiper pad made from 60% cotton

These preliminary investigations revealed the following:

- Inconsistent density and non-uniform wiper density with the 96% cotton blend
- Better and more uniform density was achieved with 60 % cotton blend when supplemented with a filler fiber such as milled corn stover or sheared wood fiber.

Several rolls at the 60% blend ratio were produced and cut into 18 x 18 inch wipes. To gain a better understanding of the marketing and sales potential of these wipes, several samples were sent to the CPI Products Division in West Concord, Minnesota. CPI currently markets and sells a drip trap composite board made from 100 % ground corn stover designed to contain and manage oil spills beneath machinery, busses, trucks and other equipment and were looking for an earth friendly absorbent wipe. CPI offered to take a look at the wipers and provide an assessment of appearance, performance and sales potential. Their assessment indicated:

- Partial bleed out of loose fibers were evident in the samples they received
- Sorbency potential was excellent
- The strength and density of the mat needed to be improved for their application.

Further application in this area may show promise if the strength and density of the mat were improved with different filler fibers combined with increased dosage of a bi-component tackifier. Mat Inc. indicated these initial trials could be improved upon, but further trials would be necessary to identify the proper filler fiber to achieve the desired strength and density. A future business concept may involve the production of a master roll (60 inches wide x 100 ft long) containing 60% air layed mattress cotton. The master roll could then be cut into absorbent wipes measuring 18 x 18 inch, stacked and packaged for sale. A company like PPL Industries could possibly sell the mattress cotton fiber to a non-woven converter who could then provide master rolls back to PPL for cutting and packaging. The wipes may find application through GSA purchases or through state highway departments (MNDot). The preliminary development of this model appears to warrant further investigation. Discussions regarding additional trials are on going. Additional sales and test marketing of these wipes are ongoing with CPI Industries and will be reported on in a future report.

### 3.4 Bleached Cellulose Absorbent Applications

Buckeye Technologies takes first cut cotton linters, a by product from cotton seed refining, and bleaches the fibers white. The white fibers are then sold to secondary users who then make cotton balls from them. Buckeye Technologies was contacted to provide an assessment on the possible uses for reclaimed mattress cotton. After receiving several samples of the reclaimed cotton fiber, their findings indicate:

- Most of the samples they received closely resembled first cut cotton linters.
- Some of the cotton samples provide were heavily laden with synthetic fiber. Non bleachable synthetic fibers are not acceptable in their process.
- 17 out of 38 samples have negligible proportions of synthetic fiber and are likely to be acceptable in their process.
- Buckeye buys first cut cotton linters for \$0.30/lb delivered. Current supply is tight as previous prices were \$0.22 to \$0.25/lb.
- Buckeye processes over 200 metric tons/day of first cut cotton linters

Buckeye is currently running bleaching trials to determine acceptability in their process. These results are on-going and will be reported on in a future report.

### 3.5 Landscape Products

Two product configurations are currently in the early stages of evaluation at the NRRI – one as a geotextile stabilization mat and the other in a light weight turf application. Results from these applications will be reported on in future report.

#### 4.0 Brief Overview of Companies Contacted for mattress cotton utilization

Company Contacted	Application	Result
Mat Inc 12402 Hwy 2 Floodwood, MN 55736 Contact: Larry Heggedahl/Paul Karpik 888-477-3028	Reprocess mattress cotton into oil sorbent wipes and as filtration media substrate.	Several trial runs completed, grading implemented, transition to all mattress cotton imminent, nominal 60,000 lb/yr.
AirTex 150 Industrial Park Road Cokato, MN 55321 Contact: Greg Windsburger 800-851-8887	High loft waddings for bedding, upholstery and furnishings from cotton and polyester foam	State regulations do not allow post consumer cotton back into new consumer products.
USG Interiors 35 Arch Street Cloquet, MN 55720-1599	Incorporate cotton or cotton shoddy into ceiling tiles	Conical or plug and shell pulpers likely required, not technically feasible with current pulpers, cutting and contamination are issues.
Buckeye Lumberton 1000 Noir Street Lumberton, NC 28358 Contact: Chuck Oxendine 910-737-3231	Value added cellulose based specialty products	Applied grading procedure for separating cotton into acceptable and non-acceptable streams via black lighting, bleaching tests are on-going.
Sustainable Solutions 300 SE 15 <sup>th</sup> Street Wagoner, OK 74467 Contact: Brock Nunn 918-485-1755	SSI's mission is to utilize post-industrial waste streams (SmartStream™) to create profitable products with improved features in order to make our World more sustainable	Out sourcing the materials into their current client base and looking for exchange opportunities. Results pending and on going.
White Felt 810 West 6 <sup>th</sup> St. Rushville, IN 46173 Contact: Leo Griffin 765-932-2555.	air lays it into a batting and sells into the Fouton and mattress market.	State regulations do not allow post consumer cotton back into new consumer products.
St. Joseph Heating Solutions 10645 Hall School Rd Owebsboro, KY 42301 Contact: Rick Jones 270-929-7419	Manufacturer of briquetting machines	Samples of cotton shoddy sent for briquette assessment – materials must be torn up first and blended with other materials to make it viable.
CPI Plus/CPI Divisions PO Box 678/138 E. Main St. West Concord, MN 55985 Contact: George Coy 507-527-2233	Manufacturers soap products, sorbent products and Drip Trap Sorbents from corn stover	Air layed, reprocessed cotton fiber was provided for test marketing. Further results pending.
Miller Waste Mills, Inc. 580 Front Street Winona, MN 55987 Contact: Paul Gleeson 507-454-6906	Manufacturers fiber based filtration media using wood, polyester and cotton. Sells to filter manufacturers who roll and make up the final filter.	May be more applications here beyond that which has already been identified.
Leigh Fibers PO Box 1132 Spartanburg, SC 29304-1132 Contact: Tony Tamboro 864-949-5659 Contact: Paris Hicstures 864-949-5615	World class recycler of all types of textile and fiber waste.	Quoted value of cotton Shoddy (insulator pad) is 0.04 to 0.08 /lb on a good year and zero value in a bad year. Applications heavily tied to the housing industry.

## Appendix



**Figure 1.** Oil absorbent wipes made recycled mattress cotton.



**Figure 2.** Cutting deficiency of ceiling tiles formulated with mattress cotton.



**Figure 3.** Agglomeration deficiency of pulped cotton fiber.



**Figure 4.** Ceiling tile formulations using recycled mattress cotton.



**Figure 5.** Artificial Shod Turf.