

A Business Plan for the  
Production of Crumb Rubber  
by  
Solid-State Shear Extrusion

**EnPro 351**  
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## **Table of Contents**

Abstract	3
Introduction	4
Methodology	9
Market Characterization	13
Market Size and Growth	17
Financial Analysis	22
Next Steps	28

### Abstract

This Business Plan was developed by the EnPro Team to evaluate the market opportunities for the Solid-State Shear Extrusion (SSSE) process, a technology developed at IIT for the size reduction of rubber. The development of SSSE is in response to the failure of conventional rubber pulverization methods to preserve polymer carbon chain bonds while breaking cross-link bonds. By applying a combination of shear and compression forces at room temperature, the Solid-State Shear Extruder yields rubber granules with a higher level of cross-link reduction, low moisture content, and a high, irregular surface area.

The EnPro Team conducted interviews with manufacturers who use crumb rubber in their products, potential competitors who produce crumb rubber and a variety of rubber associations and other sources. It was determined that the primary applications potentially penetrable by SSSE crumb rubber are: Rubber Modified Asphalt, used to pave and patch roads; Molded and Extruded Products such as flooring and mats; Athletic Surfaces, including Playgrounds, growing applications of recycled rubber; and other Developing markets, such as paints, are opportunities for the future of SSSE.

A thorough financial analysis was conducted, including developing a market penetration estimate and a Profit and Loss Statement. It was determined that SSSE crumb rubber is competitively priced and with an investment of approximately \$3 million, can look forward to a 5-10% share of the crumb rubber market over the next five years (2002-2007). This penetration would produce the following Net Pre-Tax profitability:

Year	1	2	3	4	5
<b>Total Pounds (Millions)</b>	<b>13.2</b>	<b>28.4</b>	<b>45.8</b>	<b>69</b>	<b>97.8</b>
<b>Total Dollars (Millions)</b>	<b>1.5</b>	<b>3.4</b>	<b>5.5</b>	<b>8.2</b>	<b>11.6</b>
<b>Net Pre-tax Income (Thousands)</b>	<b>101</b>	<b>657</b>	<b>1341</b>	<b>2250</b>	<b>3409</b>

## **Introduction**

Recycling is a technological age solution to a consumer age problem. Paper, plastic, and glass are all familiar elements in the recycling industry. New developments in the field of recycling technology have led to the expansion of recycling into the realm of scrap tire rubber.

Scrap tire rubber is an ideal candidate for recycling because of the large waste stream associated with it. Each year, 283 million scrap tires are generated in the United States (Scrap Tire Users Directory), with 12 million scrap tires produced in the state of Ohio alone. (Scrap Tire News) Used passenger tires, used truck tires, defective tires from the manufacturing industry, and buffings (long, thin strips of rubber) from the tire retread industry are all plentiful sources of scrap tire rubber. Recent state-funded grants for the use of recycled rubber in playgrounds and roads in states such as California, Pennsylvania, and Florida have created a market for ground rubber.

Rubber, a thermoset polymer, is different from many thermoplastic polymers in the sense that it is vulcanized. The polymer chains are cross-linked in such a way that rubber cannot be melted for reuse. Plastics recycled in the more familiar fashion include polyethylene terephthalate (PETE), high and low density polyethylene (HDPE and LDPE), and vinyl. (American Plastics Council) These thermoplastic varieties are used in many food and beverage packaging applications, and can be melted for incorporation in new products. Instead of melting scrap rubber, it is ground into smaller pieces for integration into new products.

There are a few conventional methods to grinding rubber: ambient grinding, cryogenic grinding, and buffing. Each of these methods can produce rubber granules of varying sizes, but can pose problems in the end product of the rubber.

The ambient grinding method of rubber pulverization takes place at ambient temperature and higher, as the rubber is ground by shearing and tearing action. Particles have an irregular shape, with high surface area, but can experience thermal degradation due to high operating temperatures. Cryogenic pulverization starts with reducing the temperature of the rubber to below 90 degrees F, usually by contacting the rubber with liquid nitrogen. At these low temperatures, the material is very brittle, and can easily be shattered into small particles by hammermills. Cryogenic processing tends to result in smooth, regular granules of rubber. Either ambient grinding or cryogenic processes may be followed by a crackermill, where the rubber is passed through two large serrated rollers to cut the rubber into smaller pieces. (Scrap Tire News Online) Buffing is used to produce long, thin strips of scrap rubber. While tire buffings can be used in similar applications to rubber granules, it is most often a precursor to ambient and cryogenic grinding processes.

While conventional methods of recycling rubber yield possibilities for use in new products, there has yet to be a commercially implemented process that retains the chemical properties of virgin rubber. When scrap rubber is shredded and grinded, the long polymer chain bonds are broken with the same frequency as cross-link bonds. The Solid State Shear Extrusion (SSSE) process, being developed at the Illinois Institute of Technology (IIT), addresses this problem by selectively breaking cross-link bonds, a phenomenon called devulcanization. The particles produced in SSSE have a cross-link

density reduction of approximately one third that results in particles with chemical properties more similar to virgin rubber.

Since 1995, Dr. Hamid Arastoopour, the Chairman of the Chemical and Environmental Engineering Department at IIT, has been developing this new method of pulverizing rubber. This process reduces the size of rubber, or other solid material, into small granules without the high level of chemical degradation that can occur during other rubber grinding processes. The process was developed based on the strain energy storage theory, indicating that a combination of compressive and shear deformation can lead to breakage of chemical bonds within the rubber. (Pulverization of Low Density Polyethylene Under High Shear and Compression) Dr. Arastoopour has found a unique, low-energy method of reducing the scrap tire waste stream. Although this patented process is still in the laboratory stage, the EnPro Team believes it may be advantageous to invest in a full-scale production version of the machine for the manufacturing of crumb rubber.

This technology presents several marketing possibilities, including:

- Sales of the crumb rubber produced by SSSE
- Licensing of the SSSE technology
- Sales of SSSE crumb rubber manufacturing equipment

Therefore, the goal of this EnPRO is:

To develop a Business Plan for the Solid State Shear Extrusion method of producing pulverized rubber. The team has chosen to focus on the area of sales of crumb

rubber produced by SSSE, because of the more comprehensive nature of available information about the market for crumb rubber.

This Plan includes an analysis of:

- SSSE technology
- Crumb rubber market in North America
- Recommendations regarding the penetration of a series of applications, which would be served effectively through the SSSE Process.

Some of the steps the Team took to complete this task include:

- Studying the SSSE process
- Exploring initial pricing estimates for scale-up of the operation
- Conducting interviews with end-users of crumb rubber
- Conducting interviews with manufacturers of crumb rubber

After taking these preliminary steps, a Business Plan was constructed. Each section of this Business Plan is described below:

- **Methodology** defines the characteristics of rubber granules produced by several of the patented SSSE processes, and defines interviews accomplished with end-users and potential competitors.
- **Market Characterization** describes the applications and characteristics of crumb rubber from the end-user perspective, as well as an evaluation of the characteristics of SSSE through the eyes of its competitors, and provides a detailed description of the market environment.

- **Market Size and Growth** reviews information about the total crumb rubber market, characterized by application, and describes growth experienced during the last 5 years and growth expected over the next 5 years.
- **Financial Analysis** defines the SSSE technology's growth scenario, which the EnPro Team recommends when entering the crumb rubber market, supported by multiple market penetration scenarios, resulting in a five year Pro Forma Profit and Loss Statement.



## Methodology

### SSSE Particle Characteristics

The SSSE process creates pulverized crumb rubber with no chemical additives. This purely mechanical process also yields crumb rubber with no moisture. The rubber particles undergo a reduction in cross-link density and show a high surface area to assist in bonding. The exact values of these changes, as well as the size distribution, are specific to which SSSE process is used. The Team focused on the 5:1 screw 1SSSE and 2SSSE, as well as the 3:1 screw 1SSSE. The 5:1 screw has a higher compression ratio but lower output than the 3:1 screw. “1SSSE” signifies that the rubber was run through the extruder once, while “2SSSE” denotes twice.

5:1 Screw 1SSSE		
Mesh Size	Surface area	Cross-link Reduction
30-40	1600m <sup>2</sup> /g	21%
170-60	2800m <sup>2</sup> /g	34%
Mesh Size	Distribution (%)	Proposed Price (cents/lb)
150	6.7	49
70	12.7	22.5
40	13.4	14.4
30	23.9	13.5
25	25.4	12.5
20	13.4	12
10	4.5	9.5

5:1 Screw 2SSSE		
Mesh Size	Surface area	Cross-link Reduction
30-40	2200m <sup>2</sup> /g	28%
170-60	2300m <sup>2</sup> /g	33%
Mesh Size	Distribution (%)	Proposed Price (cents/lb)
150	4.6	No Data
70	19.1	
40	22.9	
30	29.8	
25	20.6	
20	3.1	

<b>3:1 Screw 1SSSE</b>		
<b>Mesh Size</b>	<b>Distribution (%)</b>	<b>Proposed Price (cents/lb)</b>
70	0.8	22.5
40	6	13.8
30	8.6	13.4
25	18.4	12.5
20	16.8	11.5
10	27.3	9.5
6	19.2	8
4	2.8	6.5

### **Interviews**

In the process of researching the crumb rubber market, **54** different companies in the rubber industry were interviewed, of which 17 were producers of crumb rubber producers. While these companies are not possible consumers for crumb rubber made by SSSE, they are potential users of the SSSE equipment. They also assisted in obtaining a more accurate assessment of the current crumb rubber market.

### **Producers of Crumb Rubber Interviewed**

Bridgestone Firestone  
Bristow Rubber  
CRM Co, LLC  
Edge Rubber  
Emert Grinding  
Environmental Recycling Technologies  
First National Recovery Inc.  
Goodyear Tire  
GreenMan Technologies of California  
GSR Recycling Inc  
Jai Tire Industries  
Northwest Rubber, Colorado  
Pheonix Recycled Products  
Rebound Rubber Recycling  
Rubber Technology International  
Uniroyal  
West Coast Rubber Recycling, LLC

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The remaining companies were end users in tire, flooring and surfaces, auto, asphalt, molding, paint, and roofing industries. These companies were interviewed to gauge the consumer market reaction to the new technology.

<b>Market Segment</b>	<b>Company</b>
N/A	Rubber Manufacturers Association
Asphalt	Advanced Recycling Services Crafco FNF Construction Manhole Adjusting Contractor Western States Surfacing
Auto	Amorium Industries Envirotech Extrusion Inc. Rubber Queen
Flooring and Surfaces	Advanced Rubber Surfacing Products Blacklidge Emulsions Centaur Floor Systems Dinoflex Manufacturing Ltd. Dodge Regupol No Fault Industries Playdek International Pro Tech Rubber RB Rubber Products Inc Roll-Tech Resilient Surface Supply RTH Safe Guard Surfaces America
Gaskets	Aero Rubber Gem Inc RFI Seals And Gaskets SCE Gaskets
Molded and Extruded Products	Carsonite International Concrete Precast Systems Rubber Materials Inc. Scientific Developments
Paint and Coatings	MD-Both PPG Wolstenholme
Roofing	Bridgestone Firestone Spech-Chem Inc.
Tire	Bridgestone Firestone Goodyear Tire Pomp's Tire Service Uniroyal Wingfoot
Tire Buffings	Premier Rubber

## Market Characterization

As indicated in the Methodology Section, the EnPro Team interviewed 33 end-users of crumb rubber, 17 producers of crumb rubber, and 7 other companies in the crumb rubber industry. The Team determined there are a large number of uses for ground rubber, characterized by the specific applications for crumb rubber. As this market is segmented into regions that are typically defined by state boundaries/financial support for the production of crumb rubber, the EnPro Team found this detailed assessment was beyond the scope of its capabilities. Thus, this Business Plan focuses on national market perspectives.

The market assessment concluded that there are two major types of applications for the crumb rubber produced through the SSSE process. The first type of applications includes:

- Injection Molding/Extruding - roof shingles, plastic/rubber blends, mats and sheeting, etc.
- Flooring – Interlocking anti-fatigue mats for use with people or livestock, anti-slip mats for use in the shipping industry, underlay mats for use under traditional flooring (e.g. carpet, hardwood, tile), and pour-in-place floors.
- Athletic Surfaces – Running tracks, basketball courts, tennis courts, etc.
- Playgrounds – The largest segment of the athletic surfaces type market for crumb rubber.

The use of crumb rubber in these products helps reduce fatigue, deaden vibrations, dampen sound, absorb impacts (such as falling children on a playground), is appealing to consumers because of its recycled nature, and is often cheaper than traditional materials used in these products. These applications typically use sizes of

crumb rubber that range from 20 mesh to 1"; the largest size our process produces is about  $\frac{1}{8}$ "

Our end-user interviews indicated that the unique characteristics of crumb rubber produced by SSSE would not have any effects (good or bad) on these products.

If the pricing of SSSE-produced crumb rubber on these sizes (20 mesh and larger) were competitive (between 9¢ and 20¢ / lb), it could successfully penetrate this sector of the crumb rubber market. The Team's price estimates have indicated that SSSE-produced crumb rubber could be profitably sold for between 9¢ and 17¢ / lb, with the wide variation being due to differences in raw material cost and availability of a market for all mesh sizes produced by the SSSE process (inability to sell certain mesh sizes would force increases in the selling price for other sizes). The market price ranges the Team found varied by state and even within specific states. For example, the range of 9-20¢ / lb for comparably sized crumb rubber was seen just in the state of California. A meaningful ingredient of this price difference was the raw material cost, which varies significantly by region (i.e. the state of California pays \$20/ton to companies that dispose of waste tires; one interviewed company in Colorado was paid \$1 per tire they took; a company in South Carolina reported paying up to 0.9¢ / lb for unground rubber).

The EnPro Team recommends that more market research be conducted to determine the reason for large price disparities across North America, to develop a sense of raw material price based on region, and to determine how this data would influence the SSSE technology's ability to compete in different areas of the country.

The second type of application for which SSSE-produced crumb rubber could be used is RMA.

- Rubber Modified Asphalt – Used in highways to help dampen sound and increase highway lifetime. While it is more expensive than traditional asphalt, its longer lifetime saves money in the long run and several states (notably Arizona, California, and Florida) invest heavily in RMA. RMA does not perform well in cold (i.e. northern) climates.

This application typically uses a government-specified distribution of sizes between 40 mesh and 20 mesh. The current crumb rubber price in the Arizona/California area for these size distributions is 11¢ / lb.

The unique characteristics of the SSSE-generated crumb attracted interest from RMA companies, but they would need good results from tests of RMA created with this crumb rubber before switching from their current suppliers.

The EnPro Team recommends that tests be performed to determine the:

- Reduction in cross-link density from tire rubber – currently devulcanization test results are limited to rubber that originally had much less cross-linking than tire rubber and thus is not directly comparable.
- Thermal conductivity of crumb rubber produced by this process as compared to currently used crumb rubber (higher conductivities are better).
- Heat generated, temperatures reached, and viscosity (lower is better) of asphalt mixed with our crumb rubber when processing into asphalt concrete (asphalt is the ‘oily’ part, asphalt concrete is what roads and parking lots are made out of) and how this compares to currently used processes.
- Estimates of noise reduction, reduction of wear on vehicle suspensions, and durability of RMA created with our crumb rubber as opposed to crumb rubber currently on the market.

There is apparently a market for devulcanized rubber (partial devulcanization is one of SSSE-generated crumb rubber’s main characteristics) in the tire industry – one of

the grinders we interviewed produced devulcanized rubber and sold it for use in tires.

The Team was unable to gather more information on this market segment.

There are also potential markets in future adhesive and paint products (one of the end-user companies we interviewed was researching use of ultra-fine rubber particles – around 10 microns in diameter – in these applications). The time periods necessary for these products to come to market – and the potential sizes of the markets – are uncertain at this time.



## Market Size and Growth

The crumb rubber market in North America is a growing market that consumed 996 million pounds of recycled rubber in 2002. Divided as follows:

Summary of Crumb Rubber Market	
Application	2002 Market Size
	(millions of pounds)
RMA	296
Molded Products	307
Sport Surfacing	141
a) Tracks	63
b) Playgrounds	80
Miscellaneous	43
Areas that are not applicable to SSSE	209
Total applicable market to SSSE	787

### **Rubber Modified Asphalt (RMA)**

Rubber modified asphalt is the second largest market for crumb rubber overall. However, it offers the largest market for SSSE rubber because of the SSSE characteristics. Generally about 30 lbs. of crumb rubber is used for every ton of asphalt. The rubber modified asphalt is only used in top layers of roads, but not in structural layers. Currently the U.S. uses about 550 million tons of asphalt per year. At most only ½ of all asphalt used would be RMA (due to the structural concerns).

The total RMA market is about 296 million pounds of crumb rubber. Since RMA is used in highway applications, its use must be approved by each state; use is limited to only 4 states at the present time. These states are California, Arizona, Texas and Florida. California uses only 15% RMA of its total asphalt usage compared to Arizona using 85%.

The growth is limited by climate, because RMA does not work well in cold climates.

Other states that are likely to use RMA by 2004 include those primarily in the sunbelt area:

Georgia	North Carolina
Maryland	Oklahoma
New Jersey	Pennsylvania
New York	South Carolina

Canada (Montreal)

Despite the addition of these states, the budgetary limitations of many of these states will place a short-term limit on the growth of the crumb rubber market. Without these budgetary restraints the RMA market could have grown to 500 million pounds per year by 2005. As such, the feeling in the marketplace is that crumb rubber used in the RMA applications will grow to 400 million pounds per year by 2005. This represents a growth of 10% per year. Presuming the budgetary dilemma is rectified the subsequent growth during 2006 and 2007 could be as high as 20% per year. Bringing the total in 2007 to just under 570 million pounds.

### **Molded Products**

The largest market for crumb rubber is in molded products. However it is difficult to assess what percent of the market is accessible to SSSE due to the wide range of products that fall within that category. The molded products that can utilize SSSE rubber are various types of rubber mats and molded roof shingles. The rubber mat market includes so many types of mats for so many uses that it was not possible to quantify the market size.

The roofing market is comprised of two major portions; asphalt shingles and all other shingles including wood shake, metal, and ceramic. Asphalt shingles comprise 80% of the market and everything else takes the remaining 20%. Rubber molded shingles generally replace wood shake or ceramic shingles and are therefore only a small niche market in the roof industry (likely less than 5%). However, asphalt shingles that are modified with crumb rubber for durability could claim a greater portion of the market. Last year 152 million squares of asphalt shingles were sold (1 square = 10' X 10' = 3 bundles of shingles containing 20 shingles each). Since asphalt shingles are 80% of the market the remaining market (wood shake, ceramic, rubber, metal) would be about 38 million squares. There is potential for growth in the roofing market because the life of rubber shingles far exceeds wood and is less expensive than ceramic.

The total market for molded products is 307 million pounds of crumb rubber per year and it is likely to grow at 3-5% (4% average) per year over the next 5 years, producing 375 million pounds per year, by 2007.

### **Sports Surfacing**

Sport surfacing, which includes any rubber track or tennis court and playgrounds that use rubber flooring, is a very accessible market for SSSE rubber. The majority of sports surfaces in the U.S. use recycled rubber. Running tracks and playgrounds use close to 100% recycled rubber.

There are approximately 800-1000 new running tracks built per year and about twice that number in old tracks resurfaced. Each new track uses 40,000 pounds of rubber and each resurfaced track uses 15,000 pounds. Tracks use close to 100% recycled rubber, but most of that rubber is not recycled tire rubber. The SSSE process can be used on

many types of rubber/plastic but that research was beyond the scope of this project. The industry cannot provide any approximation of the number of playgrounds in existence, but estimates that several thousand new playgrounds are built per year.

The running track market is very steady and probably will not grow or decline significantly in the long term. However, playgrounds are a fast growing market for crumb rubber, due to the added safety of rubber playground flooring. Lobbying and legislation are very supportive of using recycled rubber in playgrounds to replace existing wood chips or sand.

The market is 141 million pounds of crumb rubber; the expected growth rate is 6-8% (7% average) per year, reaching 200 million pounds per year.

### **Miscellaneous Recycled Rubber Products**

The remaining market of miscellaneous recycled rubber products is not very well defined. Many of these products do not use SSSE's characteristics or are small niche markets that still need to be explored. Out of the other markets, SSSE can be used in rubber plastic blends and tires. Rubber plastic blends include some roof shingles and false wood made of rubber, plastic, and sawdust that are more of a niche market.

Although tire manufacturers use large quantities of crumb rubber they produce virtually all of it internally (only 1 company we interviewed sells to tire manufacturers). The tire manufacturers may be interested in purchasing machinery to produce SSSE rubber but they are not worth pursuing as a possible market to sell rubber crumb directly. An opportunity may exist with these manufacturers because they use a significant number of byproducts either in their processes or in side businesses of the tire plants.

The miscellaneous market for crumb rubber accounts for 43 million pounds in 2002. It is expected to grow at the rate of 3-5% (4% average), reaching 55 million pounds per year by 2007.

**Summary**

The following table summarizes the growth forecast for each of the market segments within the crumb rubber industry.

**Summary of Crumb Rubber Market**

<b>Application</b>	<b>2002 Market Size (millions of pounds)</b>	<b>Est. Annual % Growth</b>	<b>Est. 2007 Market Size (millions of pounds)</b>
RMA	296	3yrs at 10% 2 yrs at 20%	570
Molded Products	307	4%	375
Sport Surfacing	141	7%	200
Miscellaneous	43	4%	55
Areas that are not applicable to SSSE	209	N/A	N/A
Total applicable market to SSSE	787	9%	1230

## **Financial Analysis**

The Market Penetration of the SSSE process:

### **RMA**

As stated in the market growth discussion, RMA is projected to be the most receptive marketplace for the SSSE process. As such, the market penetration would reach 10% by 2007, starting at 2% in the first year, gaining another 2% per year, through 2007.

### **Molded Products**

A more limited market penetration than RMA, molded products would likely see a penetration reaching 5% by the end of 2007. The initial penetration is estimated at 1%, gaining another 1% per year.

### **Sports Surfacing**

Factors contributing to the market penetration in this area are the fall rating and handicap accessibility factor. As such, market penetration for SSSE can be estimated at 10% by 2007, starting at 2% in the first year, gaining another 2% per year.

### **Miscellaneous**

Because of the diversity of products in this area SSSE will penetrate 5% of the market by 2007, starting at 1% in the first year, gaining another 1% per year.

### **Summary**

Based on the market growth and penetration forecasted above, the Team's calculation, and the market response, the crumb rubber produced by the SSSE process

can be sold for an average of 11.9 cents per pound. The table that follows produces a revenue stream for the SSSE process that begins at approximately **\$1.5 million in year one** growing to **\$11.6 million in year five**.

	2002	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Rubber Modified Asphalt Market</b>						
Market Size (Pounds)	296,000,000	325,600,000	358,160,000	393,976,000	472,771,200	567,325,440
Market Share		2%	4%	6%	8%	10%
Share of Market (Pounds)		6,512,000	14,326,400	23,638,560	37,821,696	56,732,544
Revenue (Average 11.9c/lb)		\$774,928	\$1,704,842	\$2,812,989	\$4,500,782	\$6,751,173

<b>Molded Products</b>						
Market Size (Pounds)	307,000,000	319,280,000	332,051,200	345,333,248	359,146,578	373,512,441
Market Share		1%	2%	3%	4%	5%
Share of Market (Pounds)		3,192,800	6,641,024	10,359,997	14,365,863	18,675,622
Revenue (Average 11.9c/lb)		\$379,943	\$790,282	\$1,232,840	\$1,709,538	\$2,222,399

<b>Sports Surfaces</b>						
Market Size (Pounds)	141,000,000	150,870,000	161,430,900	172,731,063	184,822,237	197,759,794
Market Share		2%	4%	6%	8%	10%
Share of Market (Pounds)		3,017,400	6,457,236	10,363,864	14,785,779	19,775,979
Revenue (Average 11.9c/lb)		\$359,071	\$768,411	\$1,233,300	\$1,759,508	\$2,353,342

<b>Misc</b>						
Market Size (Pounds)	43,000,000	44,720,000	46,508,800	48,369,152	50,303,918	52,316,075
Market Share		1%	2%	3%	4%	5%
Share of Market (Pounds)		447,200	930,176	1,451,075	2,012,157	2,615,804
Revenue (Average 11.9c/lb)		\$53,217	\$110,691	\$172,678	\$239,447	\$311,281

<b>Total Pounds</b>		<b>13,169,400</b>	<b>28,354,836</b>	<b>45,813,496</b>	<b>68,985,495</b>	<b>97,799,949</b>
<b>Total Dollars</b>		<b>\$1,567,159</b>	<b>\$3,374,225</b>	<b>\$5,451,806</b>	<b>\$8,209,274</b>	<b>\$11,638,194</b>



## **Profit and Loss Statement Assumptions**

### **Revenue**

- We will assume crumb rubber producing facilities will be running 365 days per year.
- Supplemental income will come in the form of compensation for taking scrap tires.
- In order to produce 13 Million pounds of crumb rubber the process requires 19 Million pounds of raw material because of the approximate 1/3 waste.
- At 25 pounds per tire this would require 760,000 tires.
- At 50 cents per tire this would produce \$380,000 of supplemental revenue.

### **Management Cost**

- Total management costs will start at \$180,000 per year.
- The president's responsibilities include sales and administration. President's salary will be \$100,000 per year plus a percentage of the profitability.
- To support the president the company will have two support staff who will be collectively paid \$80,000 per year.
- This number will increase at 4% annually to account for annual raises.

### **Rent**

- Rental of support facilities for the production of crumb rubber is estimated at \$15 per square foot.
- Rental space will be approximately 10,000 square feet.
- Total rental costs will be \$150,000.
- This number will increase at 4% annually to account for increases in rent.

### **Marketing expenses**

- The sales force will be commission based pay at a 5% commission on all sales.

- Out of pocket expense allocation of \$5,000 per sales representative.
- Five sales reps in year one, increase by one per year
- This number will be determined by the amount sold in any given year.
- Promotional costs including trade shows, advertising, etc. are estimated at \$100,000 beginning in year one and increase at \$50,000 per year thereafter.

**Production Costs** (estimated by IIT faculty)

- Electrical costs are estimated at 0.35 cents per pound of crumb produced.
- Labor is estimated at 3.95 cents per pound of crumb produced.
- Overhead is estimated at 80% of labor.
- Maintenance is estimated at 1.13 cents per pound of crumb produced.
- Taxes and Insurance are estimated at 1.13 cents per pound of crumb produced.

**Total production cost= \$1,281,000**

**Equipment Purchase/Depreciation**

- Each extruder produces an estimated 13 Million pounds of crumb rubber per year and costs \$280,000.
- Supporting each extruder will be a grinder, a shredder and a conveyor system which collectively will cost \$270,000.
- Depreciation will be based on a twenty year amortization schedule.

**Estimated Net Pre-tax Income**

- Based on the assumptions presented above the net pre-tax income for the SSSE process is as follows:

Year	1	2	3	4	5
Net Pre-tax Income	\$101,187	\$657,027	\$1,340,832	\$2,250,060	\$3,409,059

**Investment Required**

- Based on the assumed revenue stream, third party investment funding will be necessary for years 1, 2, and 3; the company should be able to support any further investment based on its own profitability.

- An investment of \$500,000 to support the development of the SSSE Process from a laboratory to an operating stage.
- Investment in year one is \$ 1 Million.
- Investment in year two is \$ 1 Million.
- Investment in year three is \$ 500,000.

**Total Investment Commitment = \$2.5 million**

### Profit and Loss Statement

Year	1	2	3	4	5
Share of Market (Pounds)	<b>13,169,400</b>	<b>28,354,836</b>	<b>45,813,496</b>	<b>68,985,495</b>	<b>97,799,949</b>
Revenue (Average 11.9c/lb)	\$1,567,159	\$3,374,225	\$5,451,806	\$8,209,274	\$11,638,194
Tire Income	\$376,269	\$810,138	\$1,308,957	\$1,971,014	\$2,794,284
Total Revenue	\$1,943,427	\$4,184,364	\$6,760,763	\$10,180,288	\$14,432,478
<b>Fixed Costs</b>					
Management Cost	\$180,000	\$187,200	\$194,688	\$202,476	\$210,575
Rent (10,000 sq ft at \$15 per)	\$150,000	\$150,000	\$150,000	\$150,000	\$150,000
<b>Variable Costs</b>					
Electrical	\$47,410	\$102,077	\$164,929	\$248,348	\$352,080
Labor	\$520,191	\$1,120,016	\$1,809,633	\$2,724,927	\$3,863,098
Overhead (80% labor)	\$416,153	\$896,013	\$1,447,706	\$2,179,942	\$3,090,478
Taxes & Insurance	\$148,814	\$320,410	\$517,693	\$779,536	\$1,105,139
Maintenance	\$148,814	\$320,410	\$517,693	\$779,536	\$1,105,139
Sales Expenses (\$5,000/rep)	\$25,000	\$30,000	\$35,000	\$40,000	\$45,000
Sales Team (5% commission)	\$78,358	\$168,711	\$272,590	\$410,464	\$581,910
Promotional Expenses	\$100,000	\$150,000	\$200,000	\$250,000	\$300,000
Depreciation	\$27,500	\$82,500	\$110,000	\$165,000	\$220,000
<b>Total Expenses</b>	\$1,842,241	\$3,527,337	\$5,419,931	\$7,930,228	\$11,023,419
<b>Net Pre-tax Income</b>	<b>\$101,187</b>	<b>\$657,027</b>	<b>\$1,340,832</b>	<b>\$2,250,060</b>	<b>\$3,409,059</b>
<b>Cumm Pre-tax Income</b>	<b>\$101,187</b>	<b>\$758,213</b>	<b>\$2,099,045</b>	<b>\$4,349,105</b>	<b>\$7,758,164</b>

## Next Steps

Considering the great potential for a viable business built around SSSE crumb rubber, it is the recommendation of this EnPRO Team that research should continue.

Further research should be conducted in the following areas:

- **Pricing research** to determine the reason for market price disparities, to develop a sense of raw material price based on region, and to determine how this data would influence the SSSE technology's ability to compete in different areas of the country
- **Particle Characteristic research** to find the cross-link reduction and thermal conductivity for SSSE crumb produced from scrap tire sources
- **Rubber Modified Asphalt research** to test the heat generation, viscosity, noise reduction, and durability of RMA made with crumb rubber produced by SSSE

Additionally, a scale-up of the SSSE technology must be undertaken. With a full-scale version of the extruder in place, production, energy consumption, and temperature estimates can be verified.

During the market analysis interviews, several interviewed parties expressed interest in being a part of the continuing development of SSSE:

**Rick Moore**  
**Phoenix Recycled Products, Inc.**  
**Batesburg, SC**  
**803-532-4425**  
**843-723-1625**

**Jerry Dodenhoff, President**  
**Greenman Technologies of California, Inc.**  
**Azusa, CA 91702**  
**626-633-1174**

**David Emert, Owner**  
**Emert Grinding**  
**Somerset, PA**  
**814-443-4853**  
**814-445-9886**

Aaron Lebedow and Bob Anderson will contact these companies to determine the depth of their interest in the SSSE Process.

