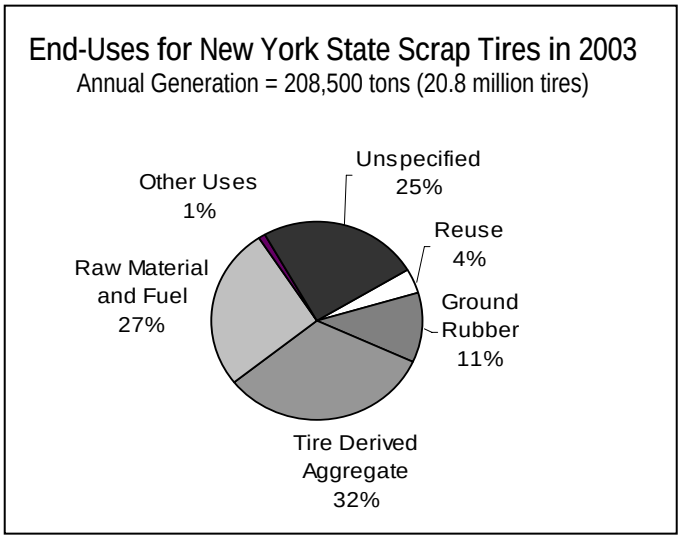
Final Report

Analysis of New York Scrap Tire Markets

Prepared for:
New York State Department of Economic Development



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R. W. BECK

ANALYSIS OF NEW YORK SCRAP TIRE MARKETS

New York State Department of Economic Development

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Background

This report provides a comprehensive snapshot and analysis of scrap tire supply and demand in New York State during the study year 2003, including a description of trends and factors affecting the market. On September 13, 2003, the New York Waste Tire Management and Recycling Act became effective. The Act instituted a $2.50 fee on each new tire purchased, to be placed in a Waste Tire Management and Recycling Fund. Fund uses include the abatement of 95 non-compliant waste[1] tire stockpiles containing an estimated 29 million waste tires. The Act also required the New York State Department of Economic Development (DED) to prepare an annual analysis of scrap tire markets and to implement a comprehensive program to expand markets in support of the following priorities:

1. Reduce the number of waste tires generated;
2. Remediate waste tire stockpiles in noncompliance;
3. Recycle waste tires into value-added products;
4. Beneficially use waste tires in an environmentally acceptable manner, including the beneficial use in civil engineering applications; and
5. Recover, in an environmentally acceptable manner consistent with the purpose of this chapter, energy from waste tires that cannot be economically recycled or otherwise beneficially used.

DED contracted with R.W. Beck to provide services that will support their effort to comply with the Act, via a 2-pronged project. This market analysis report represents the culmination of Phase One. Research for the report included detailed analysis of waste tire transporter data and other information provided by the New York Department of Environmental Conservation (DEC) and DED, supplemented by over 50 interviews and extensive review of written and online documents. This market analysis report presents a detailed analysis of how New York generated scrap tires flow from generator through processors and on to end use markets, including estimates of market disposition. Phase 2 of R.W. Beck's contract with DED involves preparation of a strategic plan for scrap tire market development covering the period of 2005 through 2010. The plan will include recommendations for state strategies to expand value added scrap tire markets related to financial and technical assistance, regulatory issues, technology, information and promotional efforts. The plan also will comprehensively evaluate and recommend new partnerships with entities positioned to

[1] In this report the terms *waste tire* and *scrap tire* are used synonymously. The Act defines *waste tire* as "any solid waste which consists of whole tires or portions of tires [including] tire casings separated for retreading and tires with sufficient tread for resale…"

assist DED in carrying out its market development strategies. As part of this effort, in March 2005, DED and R.W. Beck will host three workshops across the state, soliciting input from scrap tire market stakeholders. Phase 2 is expected to be completed in June 2005.

Annually Generated Scrap Tires – 2003 Market Disposition and Trends

R.W. Beck estimates that in 2003, 208,580 tons of scrap tires (20.9 million PTE[2]) were generated in New York State. Table ES-1 details the end uses to which these scrap tires flowed, along with key trends. The estimation methodology used is documented in detail in Appendix E of the report. Accurately estimating scrap tire supply and demand is complicated by numerous sources of uncertainty, including the need to deal with incomplete, inconsistent, inaccurate, and sometimes conflicting data and information. Because overcoming these data barriers is time consuming and challenging, these supply and demand estimates should be viewed as the best available approximations. R.W. Beck will seek to refine these estimates in annual updates to be prepared under contract to DED, beginning in early 2006.

Table ES-1
2003 Markets for NY Scrap Tires and Trends through 2005

Market Category	Submarket	2003 Use of NY Scrap Tires (Tons)	2003 Use of NY Scrap Tires (PTEs)	Percent of Total	Projected Key Trends Through 2005
Reuse	Partially Worn Reuse	4,138	413,800	2.0%	Amount expected to remain stable.
	Retread and Remanufactured	4,002	400,200	1.9%	Mostly stable. Some growth potential in remanufactured tires.
	Subtotal – Reuse	8,140	814,000	3.9%	
Ground Rubber	Roads	546	54,600	0.3%	Amount to remain negligible through 2005.
	New Tires	neg.	neg.	0.0%	Modest growth possible. Very competitive.
	Athletic Surfacing and Horticultural	12,083	1,208,300	5.8%	Sustained rapid growth in short term. Increasingly competitive market.
	Molded Products	1,495	149,500	0.7%	Amount will probably remain stable, with modest growth potential.
	Rubber-Plastic Compounds	neg.	neg.	0.0%	Potential for significant growth. Amount likely will remain low through 2005.
	Misc. Ground Rubber	9,814	981,400	4.7%	
	Subtotal - Ground Rubber	23,938	2,393,800	11.5%	
Tire Derived Aggregate	Roads	0	0	0.0%	One-time use of waste tires from non-compliant stockpiles will increase rapidly and dominate through 2005 at least.

[2] Passenger tire equivalent (PTE) is a common measure of scrap tire quantities. The measure is based on the assumption that one scrap passenger tire weighs 20 pounds.

Market Category	Submarket	2003 Use of NY Scrap Tires (Tons)	2003 Use of NY Scrap Tires (PTEs)	Percent of Total	Projected Key Trends Through 2005
	Landfill	67,883	6,788,302	32.5%	High sustained use through 2005; may taper in 2006.
	Septic	0	0	0.0%	New DOH policy may open market. Growth potential undetermined.
	Subtotal – Aggregate	67,883	6,788,302	32.5%	
Raw Material and Fuel	Manufacturing Raw Material (Steel)	6,642	664,200	3.2%	Small increase in amount possible.
	Manufacturing Fuel (Cement and Pulp)	1,759	175,905	0.8%	Potential for significant growth at NYS cement and pulp production facilities.
	Electricity Generation Fuel	48,075	4,807,495	23.0%	Amount increasing due to NYS facility increasing use.
	Subtotal - Fuel and Raw Material	56,476	5,647,600	27.1%	
Other Recycling		975	97,470	0.5%	Will remain negligible through 2005.
Other Unspecified		52,143	5,214,257	25.0%	Significant portion of "unspecified" may go to out of state electricity generation.
Total		208,580	20,857,959	100.0%	

Source: R.W. Beck

Reuse markets include retreading and remanufacturing, and the use of partially worn tires domestically or internationally. R.W. Beck estimates that reuse accounted for about 3.9 percent of New York's annually generated scrap tires in 2003 (8,140 tons or 814,000 PTE), split roughly evenly between reuse of partially worn tires and retreading, primarily of truck and industrial tires. An undetermined portion of these reused tires were exported to markets around the world. Because of the large number of entities involved in tire reuse, and a lack of data, this estimate may be conservatively low. Reuse as a percentage of overall scrap tire supply is expected to remain relatively flat in coming years. Most analysts agree that retreading of passenger tires has essentially died, and remaining growth opportunities related to truck tires are probably limited. While reuse of partially worn tires has some room for growth, especially in developing countries, this growth is not expected to be significant. Growth in reuse could also be hampered over the long term as scrap tire processors not necessarily involved in reuse further develop national supply networks that bypass the traditional scrap tire sorters and resellers responsible for steering tires to reuse markets. One emerging technology, developed by Green Diamond Tires, holds potential for expanding remanufactured tire markets. However, again the amount of growth in proportion to overall flows is expected to be minimal.

Ground rubber markets accounted for about 11.5 percent of New York's annually generated scrap tires in 2003 (23,939 tons or 2.4 million PTE). In 2003, New York scrap tires were shipped to three in-state producers as well as four out-of-state ground rubber producers located in Massachusetts, Pennsylvania, New Jersey, and Quebec. These ground rubber producers sold their product to a wide range of firms, both inside and outside New York, including: new tire manufacturers; surfacing, and athletic product producers; molded product producers; rubber-plastic compound producers;

and road construction firms. In addition, a number of tire chippers and shredders are beginning to compete with ground rubber producers by offering ¾" and smaller chips for the playground market. The ground rubber market continues to go through a period of intense consolidation and vertical integration. Since 2003, one producer has changed ownership and at least one new producer has located in the state. Technologies and market operating standards are becoming increasingly efficient and could result in the closure of additional production facilities nationwide in coming years. Growth in some relatively high value markets, such as rubberized asphalt and rubber-plastic compounds, remains elusive. For these reasons, the percentage of New York generated scrap tires flowing to ground rubber producers are not expected to change significantly in the short term.

Tire derived aggregate (TDA) markets accounted for nearly 32.5 percent of New York's annually generated scrap tires (67,883 tons or 6.8 million PTE). This was the single largest market niche, and was dominated by the Seneca Meadows landfill in 2003, which will continue to use tire derived aggregate in landfill engineering applications through 2006. There was virtually no flow of scrap tires to the other two TDA markets (roads and septic applications) in 2003. However in the coming year, an unprecedented amount of stockpiled tires from the abatement of noncompliant waste tire stockpiles will flow to several identified Department of Transportation (DOT) and New York State Thruway road construction projects. (See discussion of stockpiled tire market disposition below.) Furthermore, the NYS Department of Health (DOH) is developing a new policy allowing use of TDA in septic system drainfields, and plans to jointly promote this use in concert with other state agencies. The potential for growth in this market has yet to be determined.

Other scrap tire recycling uses accounted for less than one percent of New York's annually generated scrap tires in 2003. They include a wide range of projects involving whole, baled, and cut scrap tires. Some of these uses, such as production of cut, punched, and stamped products or use of tire strips in railroad ties are value added markets that could potentially grow modestly in coming years. Many other of these uses are dependent on sponsorship (e.g., by local government agencies) and are not expected to grow. The portion of overall flow moving to these uses is expected to remain low in the foreseeable future.

Raw material and fuel markets accounted for 27.1 percent of New York's annually generated scrap tires (56,476 tons or 5.6 million PTE). This includes 6,642 tons (664,200 PTE) used at value-added manufacturing facilities for which scrap tires provide a raw material source (e.g., the Nucor Steel Mill in Auburn), and 1,759 tons (175,905 PTE) used by manufacturing facilities using scrap tires primarily as fuel (e.g., three cement kilns located in Pennsylvania and Indiana). This market category also includes 48,075 tons (4.8 million PTE) used by electricity generators. In 2003, the use of scrap tires by New York electricity generators was just beginning, but the amount used grew considerably in 2004. Scrap tires also flowed to several waste-to-energy facilities. In 2003, over 22 percent of New York's scrap tires were used by out of state electricity generation facilities, most at the nation's only dedicated tire-derived-fuel combustion facility, Exeter, Inc. in Sterling, CT. A relatively small amount (1,606 tons or 160,600 PTE) were also consumed by New York waste-to-

energy facilities. New York demand in this market is expected to increase in coming years. Several New York manufacturing and electricity generation facilities are pursuing permitting approval or otherwise investigating the use of scrap tires as fuel. The potential exists for these facilities to increase in-state use of scrap tires as fuel in manufacturing and electricity generation facilities by well over 100,000 tons (10 million PTE) per year.

Stockpiled Waste tires – 2003 Market Disposition and Trends

Only a small amount of New York generated stockpiled waste tires (probably less than 2,000 tons, or 200,000 PTE) were abated and used in markets in 2003. Chautauqua County, for example, baled tires from local stockpiles (as well as some annually generated tires) for use in road construction. Additionally, Seneca Meadows, which shreds tires and uses tire-derived aggregate in landfill construction, reports that they received some stockpiled tires from small New York remediation projects.

In 2004, however, the clean up of stockpiled waste tires is expected to rapidly and significantly increase. As the result of a partnership among the DOT, Thruway Authority, DEC and the Office of General Services (OGS) in implementing the DEC's 2004 *New York State Waste Tire Stockpile Abatement Plan*, tires in noncompliant waste tire stockpiles in New York will be fast-tracked into civil engineering highway projects over the next six years. Twelve specific road construction projects scheduled for that time frame have been identified that are expected to consume an estimated 27 million waste tires (270,000 tons) out of the total estimated 29 million stockpiled tires (290,000 tons). As of January 2004, eight contracts, valued at over $50 million, have already been signed to abate eight of the highest-priority noncompliant waste tire stockpiles, containing a total of approximately 24.8 million tires (248,000 tons).

Market Analysis Synopsis

In 2003, R.W. Beck estimates that approximately 208,580 tons of scrap tires (20.9 million PTE) were generated in New York State. This report documents that, of this total amount, at least 75% (157,411 tons or 15.7 million PTE) flowed to an end use market, either in or out of state, for reuse, recycling, energy recovery or other beneficial use. The fate of the remaining 25% was not able to be documented in this study.

The New York scrap tire market is in a period of rapid transition and in-state demand is growing rapidly. Throughout the 1990s, New York scrap tire demand was limited to traditional retread and reuse markets, along with a fledgling ground rubber production industry. However in 2003, in-state value-added demand for scrap tires and intermediate products reached at least 84,271 tons (8.5 million PTE or 40.4 percent of total generation). This includes at least 8,140 tons (814,000 PTE) sent to New York retreaders and reused tire distribution firms, 67,883 tons (6.8 million PTE) used as tire derived aggregate in New York landfill construction projects, and 6,642 tons (664,200 PTE) used as raw material by a New York steel manufacturer and about 1,606 tons (160,600 PTE) used by in-state waste-to-energy facilities. In addition, approximately 17,378 tons (1.7 million PTE) were sent to New York based ground

rubber producers who shipped their product to a wide range of value-added manufacturing markets both inside and outside New York State.

As documented in this report, this market expansion trend is continuing and broadening. Several in state scrap tire markets grew significantly in 2004, and this trend appears likely to continue into 2005. The highest growth markets that would offer a positive value for processed scrap tires include ground rubber production (especially for sale into athletic surfacing and horticultural markets) and electricity production (requiring scrap tire chips). Additionally, at least one New York state pulp producer is pursuing permitting or otherwise investigating the use of significant quantities of scrap tires. Growth is possible but less certain in several other markets, including relatively high value ones like remanufactured tires and rubber-plastic compounds, and relatively low value ones like use of TDA in septic systems. Furthermore, while they are not value-added markets, demand by two major end-use outlets may increase significantly in the coming year: use of waste tires from noncompliant waste tire stockpiles in specific State road construction projects and use of whole scrap tires by New York cement kilns (using whole scrap tires subject to a tip fee). Finally, a range of intriguing emerging technologies for scrap tire recycling are under development, some of which appear promising.

Conclusions and Next Steps

Given this rapidly evolving landscape, DED is well positioned to successfully execute its legislative mandate to strengthen New York scrap tire markets by increasing the value of, and demand for, New York generated scrap tires. In Phase 2 of its contract with DED, R.W. Beck will prepare a strategic plan for scrap tire market development, covering the period of 2005 through 2010. The plan will include recommendations related to financial and technical assistance; regulatory adjustments; and information, education, and outreach efforts. In addition, the plan will evaluate and recommend means of building partnerships with various entities positioned to assist DED's market development efforts. As part of this effort, in March 2005, DED and R.W. Beck will host three workshops across the state, soliciting input from scrap tire market stakeholders.

Chapter 1

INTRODUCTION

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1.1 Background

Each year in New York, approximately 208,580 tons of scrap tires[1] are discarded, or about 20.8 million passenger tire equivalents (PTE).[2] Proper tire disposal is costly, and historically the demand for scrap tires by value-adding end markets has been insufficient to drive economic tire reuse and recycling. Over time, this contributed to the accumulation of approximately 29 million tires (290,000 tons) in 95 waste tire stockpiles that are not in compliance with New York State environmental regulations. The five largest sites are quite large, containing over 85 percent of the total number of stockpiled tires.

Scrap tires are a potentially valuable product that can serve as raw material for reuse and recycling businesses, provide a low cost fuel alternative to manufacturers and utilities, or provide other beneficial uses. In fact, scrap tire markets have been growing slowly, if sometimes turbulently, in the Northeast and nationwide for over a decade. In contrast, disposing tires wastes their value. Stockpiled tires in particular present a substantial environmental and public health hazard. Not only are they are a persistent breeding ground for mosquitoes and rodents, they can also result in dangerous and difficult-to-extinguish fires that can burn for long periods of time. Tire fires can result in contamination of groundwater and surrounding surface water. Additionally, air contamination from tire fires can be significant and widespread, affecting human health and industrial and commercial activities for long periods of time.

To address the public health and safety hazards of scrap tire generation and stockpiling, and to promote environmentally and economically sound scrap tire management practices, the New York State Legislature adopted the Waste Tire Management and Recycling Act of 2003 (the Act). The Act requires the New York State Department of Environmental Conservation (DEC) to prepare a comprehensive plan for abatement of all non-compliant waste tire stockpiles. DEC, in partnership with the Office of General Services (OGS) has begun executing contracts to abate an estimated 24.8 million tires (248,000 tons), well on the way towards its mandate to abate all 29 million stockpiled tires (290,000 tons) by December 31, 2010.

[1] In this report the terms *waste tire* and *scrap tire* are used synonymously. The Act defines *waste tire* as "any solid waste which consists of whole tires or portions of tires [including] tire casings separated for retreading and tires with sufficient tread for resale…"

[2] Passenger tire equivalent (PTE) is a common measure of scrap tire quantities. The measure is based on the assumption that one scrap passenger tire weighs 20 pounds.

The DEC's abatement plan involves processing the waste tires and using them in specific DOT and Thruway road construction projects, consistent with the following waste tire management priorities established in the Act:

a) First, to reduce the number of waste tires generated;

b) Second, to remediate waste tire stockpiles in noncompliance;

c) Third, to recycle waste tires into value-added products;

d) Fourth, to beneficially use waste tires in an environmentally acceptable manner, including the beneficial use in civil engineering applications; and

e) Fifth, to recover, in an environmentally acceptable manner consistent with the purpose of this chapter, energy from waste tires that cannot be economically recycled or otherwise beneficially used.

The Act assigns the State Department of Economic Development (DED) responsibility for tracking and developing scrap tire markets. Specifically, DED is directed to:

- Assist private market development with new technologies for waste tire reuse and recycling with an emphasis on higher-value end uses in order to further create and enhance sustainable markets;
- Provide industrial and consumer education on other benefits of recycled waste tire products; and
- Prepare an annual summary report and analysis of markets and disposition of both New York State stockpiled tires and New York State annually generated waste tires.

DED is also authorized under the Act to conduct an analysis of market outlets for waste tires and to establish a program that leads to increased markets for waste tires.

In response, DED contracted with R. W. Beck to prepare a scrap tire recycling market analysis for New York State (Phase I) and to prepare a strategic plan for scrap tire market development providing guidance through 2010 (Phase II). R.W. Beck's contract also includes preparation of annual updates to the market analysis report. The Results of Phase I are summarized in this report. Phase II will build on the Phase I research and findings.

DED and R. W. Beck will invite private and public sector stakeholders to learn about Phase I findings, and provide input to the strategic planning process via three regional discussion forums to be held in March. R.W. Beck will then develop recommended strategies aimed at overcoming market development barriers and stimulating scrap tire market development. The final strategic plan will be completed in June 2005, and will serve as the blueprint for State action to enhance markets for New York's continuous and growing supply of tires.

1.2 Research Methodology

R.W. Beck's Project Team included individuals with recycling market development, economic development, and solid waste management qualifications, plus broad

knowledge about scrap tire supply and demand. In developing this report, the Beck Project Team relied on this experience and expertise. In addition, Project Team members:

- Compiled and analyzed substantial tire- related data and information supplied by DED;
- Reviewed and analyzed waste tire transporter data and stockpiled waste tire information available from DEC and the New York State Department of Transportation;
- Conducted over 60 interviews with New York tire market participants and industry experts; and
- Reviewed numerous reports, articles, and web sites.

During the literature review, R.W. Beck, drew in particular from three sources: 1) The *Report of the New York State Council on Scrap Tire Management and Recycling* (June 2002), which served as a starting point for research on New York markets 2) *U.S. Scrap Tire Markets 2003 Edition* (RMA, July 2004), which provided a national comparative context; and 3) *Scrap Tire News*, which provided up-to-date information on scrap tire management trends nationwide.

Appendix E describes in detail R.W. Beck's methodology for estimating New York's 2003 scrap tire supply and demand. Summarized in Chapter 2 and cited throughout the report, these estimates are central to the report's overall market analysis. Their calculation involved detailed analysis of waste tire transporter data provided by DEC, supplemented by data from interviews and other sources.

Accurately estimating scrap tire supply and demand is complicated by numerous sources of uncertainty, including the need to deal with incomplete, inconsistent, inaccurate, and sometimes conflicting data and information. Overcoming these data barriers is time consuming and challenging. For these reasons, the supply and demand estimates provided in this report should be viewed as approximations. R.W. Beck will seek to refine these estimates in its annual updates to the market analysis.

1.3 Market Assessment Report Organization

This report provides a comprehensive snapshot and analysis of New York State's scrap tire market place. The report quantifies scrap tire supply and demand during the study year of 2003, and describes trends related to 2004 and beyond. Chapter 2 provides an overview, including estimates of supply and demand and a description of key market players. Chapter 3 describes New York's supply infrastructure for scrap tires and intermediate raw material products derived from scrap tires. Chapters 4 through 8 describe the primary end uses for New York State scrap tires: reuse, ground rubber, tire-derived aggregate, other recycling uses and raw material and fuel markets. Finally, Chapter 9 presents conclusions and discusses next steps for preparation of the strategic plan during Phase 2 of R.W. Beck's contract with DED. The appendices provide more detailed background and supporting information.

Chapter 2

OVERVIEW OF SCRAP TIRE SUPPLY AND DEMAND

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Chapter 2
OVERVIEW OF SCRAP TIRE SUPPLY AND DEMAND

This chapter broadly summarizes the flow of New York scrap tires from source to final destination, described in detail in subsequent chapters. The first section describes the characteristics of scrap tires that influence its market value. The second section estimates the quantity of tires flowing to different markets. The third section presents a flow diagram and describes the role of key players in both the private and public sectors with respect to scrap tire supply, transportation, processing and end use demand. And the last section describes how the New York scrap tire market interacts with the regional, North American and global markets.

2.1 Scrap Tire Characteristics

Scrap tires are tires that have been discarded by their owners. In this report, unlike some past studies, scrap tires is defined consistently with New York legislation to include casings separated for retreading and tires with sufficient tread for resale.

Scrap tire market values are ultimately determined by a tire's weight and inherent composition and physical properties. These vary by tire type, as described below.

Types of Tires

The U.S. Rubber Manufacturing Association (RMA) identifies three types of tires:[1]

- ***Passenger tires*** have rim diameters of less than 18 inches and are for use on cars only. In 2003, 54.5 million passenger tires were shipped as original equipment on new cars (5.6 percent of which were non-radial tires with no steel belt) and 193.6 million tires were shipped into the replacement market (only 0.4 percent of replacement tires are non-radials).
- ***Light truck tires*** have a rim diameter of 16 to 19.5 inches, and are manufactured specifically for light truck use. In 2003, nationwide, 7.9 million light truck tires were shipped as original equipment (of which 0.7 percent were non-radials) and 34.5 million light truck tires were shipped to the replacement market (of which 3.9 percent were non-radials).
- ***Other truck tires*** include medium commercial truck tires (rim diameter from 19.5 to 24.5 inches), wide base commercial truck tires (which can replace two medium commercial truck tires), heavy truck tires (rim diameters up to 25 inches) and large off-road tires.

[1] Statistics in this section are from: *Factbook 2004: US Tire Shipment Activity Report for Statistical Year 2003*, Rubber Manufacturers Association.

According to the Rubber Manufacturers Association, on average, about 84 percent of scrap tires are passenger car tires, about 15 percent are light and heavy truck tires, and about 1 percent are heavy equipment, aircraft and other off-the-road vehicle tires.

Tire Weight

Tires weights vary tremendously. While heavy truck tires may weigh as much as 10,000 pounds, following are typical weights of different tire types[2]:

- Passenger tire 20 lbs.
- Lightweight truck tire 35 lbs.
- Semi-truck tire (medium truck tire) 100 lbs.
- Tractor tire 147 lbs

Tire weight variation is a critical factor in analyzing scrap tire supply and demand statistics. This is discussed further in relation to estimating annual scrap tire generation (Section 3.1) and in relation to estimating supply and demand (in Appendix E).

Tire Composition

Table 2-1 summarizes typical tire composition, which is critical to determining potential market uses. Reuse markets use the entire tire casing. Ground rubber and tire derived aggregate markets make use primarily of the rubber component of tires. There are about 2.5 pounds of steel belt and bead wire in a passenger car tire which are engineered, high tensile strength steel made from a number of heavy metals and chemical treatments. The steel can be problematic for some scrap tire uses (e.g., playground applications), but it is a valuable raw material for others (e.g., steel mills using electric arc furnaces). Depending on the technologies they employ, ground rubber producers may view separated steel as a secondary revenue source (via sale to steel recycling markets), or may view it as a waste that must be managed, along with the fiber and other non-rubber components. Tires are also a valuable fuel source, particularly as an alternative to coal. Tires typically contain about 15,000 Btu per pound.[3]

[2] *Guidance Document for Measuring and Tracking Recyclables and Organic Wastes.* Nebraska Department of Environmental Quality. 1996.
[3] Rubber Manufacturers Association.

Table 2-1
Scrap Tire Composition

Material	Passenger Tires (percent by weight)	Truck Tires (percent by weight)
Natural rubber	14%	27%
Synthetic rubber	27%	14%
Carbon black	28%	28%
Steel	15%	15%
Miscellaneous (fabric, fillers accelerators, antiozonants)	17%	16%

Source: Rubber Manufacturers Association

Annually Generated vs. Stockpiled Tires

The market value of scrap tires depends heavily on their ability to satisfy the specifications of end users, and there are important differences in this respect between annually generated and stockpiled scrap tires. In general, stockpiled scrap tires are very dirty, charred and/or otherwise contaminated. As a result, processing may be more difficult and costly, and potential end use markets are far more limited. DEC's waste tire stockpile abatement plan emphasizes their use in road construction as tire derived aggregate.

2.2 Scrap Tire Market Disposition

The following two sections summarize the flow of annually generated scrap tires and stockpiled waste tires, respectively.

Market Disposition – Annually Generated Scrap Tires

Table 2-2 summarizes R. W. Beck's estimates of the quantities of annually generated New York scrap tires entering specific markets in 2003, along with key market trends associated with these markets.

Two scrap tire markets dominated the flow of New York tires in 2003: use of tire-derived-aggregate (TDA) in landfill construction applications (35.2 percent) and use of scrap tires as raw materials or fuel in manufacturing and electricity generation facilities (27.1 percent). While the dominance of these two markets may continue in the near term, there is the potential for steady growth in relatively high value tire reuse and ground rubber markets. Some significant changes have already occurred since 2003 with respect to tire derived fuel markets. In 2003 two New York utilities began consuming New York originating tire derived fuel. And, several New York cement kilns and at least one pulp mill are pursuing permitting and otherwise investigating the use of scrap tires as fuel and/or manufacturing raw material. Furthermore, major

changes in TDA markets may be in the offing over the coming years. The New York State Department of Health's recently announced policy to begin allowing use of TDA in septic drain fields could open that relatively low value added market. Offsetting these potential increases in demand is the expected decline in very low value demand for TDA in landfill applications in 2006, as the Seneca Meadows long standing landfill expansion project is completed.

Table 2-2
2003 Markets for NY Scrap Tires and Trends through 2005

Market Category	Submarket	2003 Use of NY Scrap Tires (Tons)	2003 Use of NY Scrap Tires (PTEs)	Percent of Total	Projected Key Trends Through 2005
Reuse	Partially Worn Reuse	4,138	413,800	2.0%	Amount expected to remain stable.
	Retread and Remanufactured	4,002	400,200	1.9%	Mostly stable. Some growth potential in remanufactured tires.
	Subtotal – Reuse	8,140	814,000	3.9%	
Ground Rubber	Roads	546	54,600	0.3%	Amount to remain negligible through 2005.
	New Tires	neg.	neg.	0.0%	Modest growth possible. Very competitive.
	Athletic Surfacing and Horticultural	12,083	1,208,300	5.8%	Sustained rapid growth in short term. Increasingly competitive market.
	Molded Products	1,495	149,500	0.7%	Amount will probably remain stable, with modest growth potential.
	Rubber-Plastic Compounds	neg.	neg.	0.0%	Potential for significant growth. Amount likely will remain low through 2005.
	Misc. Ground Rubber	9,814	981,400	4.7%	
	Subtotal - Ground Rubber	23,938	2,393,800	11.5%	
Tire Derived Aggregate	Roads	0	0	0.0%	One-time use of waste tires from non-compliant stockpiles will increase rapidly and dominate through 2005 at least.
	Landfill	67,883	6,788,302	32.5%	High sustained use through 2005; may taper in 2006.
	Septic	0	0	0.0%	New DOH policy may open market. Growth potential undetermined.
	Subtotal – Aggregate	67,883	6,788,302	32.5%	
Raw Material and Fuel	Manufacturing Raw Material (Steel)	6,642	664,200	3.2%	Small increase in amount possible.
	Manufacturing Fuel (Cement and Pulp)	1,759	175,905	0.8%	Potential for significant growth at NYS cement and pulp production facilities.
	Electricity Generation Fuel	48,075	4,807,495	23.0%	Amount increasing due to NYS facility increasing use.
	Subtotal - Fuel and Raw Material	56,476	5,647,600	27.1%	
Other Recycling		975	97,470	0.5%	Will remain negligible through 2005.
Other Unspecified		52,143	5,214,257	25.0%	Significant portion of "unspecified" may go to out of state electricity generation.
Total		208,580	20,857,959	100.0%	

Source: R.W. Beck

The statistics presented in Table 2-2 are based on a detailed analysis of waste transporter data provided by DEC, supplemented by data from interviews and other sources. As mentioned in Chapter 1, accurately estimating scrap tire supply and demand is complicated by numerous sources of uncertainty, including the need to deal with incomplete, inconsistent, inaccurate, and sometimes conflicting data and information. Overcoming these data barriers is time consuming and challenging. For these reasons, the supply and demand estimates provided in this report should be viewed as approximations. These challenges also are responsible for the fairly large quantity of "unspecified" scrap tires flow, at 25.0 percent of the total. These are scrap tires that R.W. Beck estimates were generated in New York State, but for which we were unable to assign an end-use. R.W. Beck will seek to refine these estimates in its annual updates to the market analysis. The methodology for estimating these flows is documented in detail in Appendix E. Alternative means of estimating total scrap tire generation are discussed in Section 3.1.

Market Disposition – Stockpiled Waste Tires

As indicated in Table 2-3, in 2003 only a very small amount of New York-generated stockpiled waste tires were abated and used in markets. Chautauqua County, for example, baled tires from local stockpiles (as well as some annually generated tires) for use in road construction. Seneca Meadows, which shreds tires and uses tire-derived aggregate in landfill construction, reports that they received some tires from small remediation projects as well as some stockpiled tires from Pennsylvania remediation projects. As described in Chapter Three, in 2004 OGS, on behalf of DEC, began executing a series of large scale contracts expected to produce tire derived aggregate meeting DOT specifications from nearly all of New York's estimated 29 million stockpiled waste tires. This material is expected to subsequently be used in specific DOT and Thruway roads projects.

Table 2-3
2003 Identified Uses of Stockpiled Waste Tires

End User	2003 Use (tons)	Notes
Seneca Meadows (Waterloo, NY)	"Some"	TDA - landfill project. Some stockpiled tires from PA and small NY projects.
Chautauqua County	1,293	Use of whole tires in road applications. Will Continue to use in near term.

Source: R.W. Beck

2.3 NY Scrap Tires Flow and Key Players

Figure 2-1 illustrates the flow of New York generated scrap tires from their source to final disposition. Key players involved in the supply, transportation, processing and end use chain as well as government agencies with responsibilities related to scrap tire supply and demand are described after the figure.

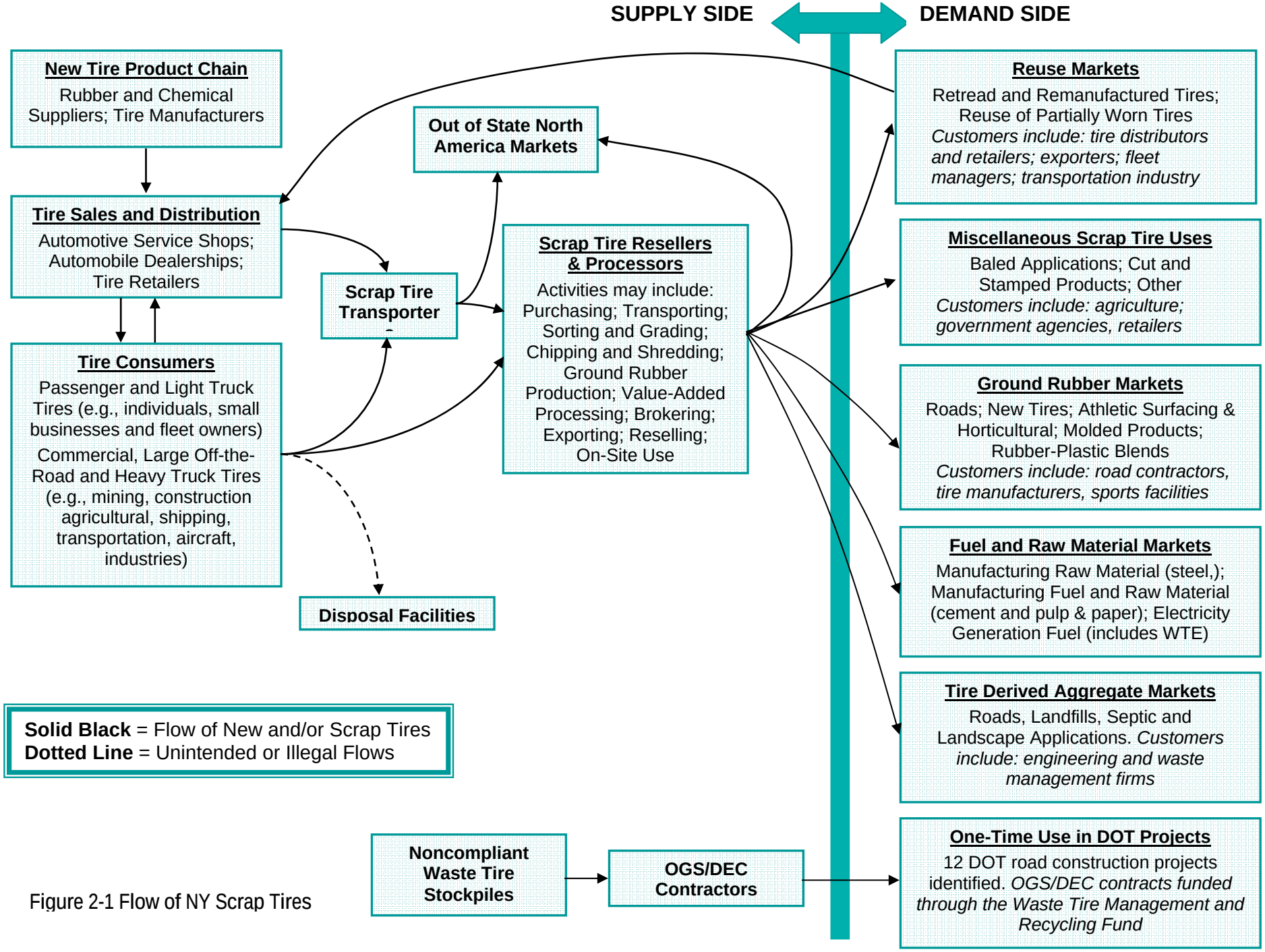


Figure 2-1 Flow of NY Scrap Tires

Key Market Players

The new tire product chain includes suppliers of rubber and chemicals and tire manufacturers. Nationwide, 41 percent of rubber used in tire manufacture is natural and 59 percent is synthetic.[4] Up to 5 percent recycled tire rubber can be used in making new tires. Nationwide in 2003, about 25,000 tons of recycled rubber went to this use. The nation's 51 tire production plants are predominately located in the South and Mid-West. New York is home to one tire production plant (Goodyear Dunlop Tire North America, Ltd., in Buffalo).

The tire sales and distribution chain includes wholesalers, automotive service centers, car dealerships and tire stores. In addition to selling new tires, distributors and retailers may also offer reused, retread, and remanufactured tires. Distributors and retailers also are major sources of scrap tires, since scrap tires are often exchanged for new tires. They typically sell scrap tires to transporters, but are increasingly entering into contractual supply agreements directly with scrap tire processors. Retailers also are responsible for collecting the $2.50 per tire Waste Tire Management and Recycling Fee and transferring funds (less $0.25 per tire for administration) to the Department of Taxation and Finance. The fee system is part of the Waste Tire Management and Recycling Act of 2003, which expires on December 31, 2010.

Tire consumers can be broken into two groups: buyers of passenger car and light truck tires and buyers of other truck tires. Tire consumers pay distributors and retailers the Waste Tire Management and Recycling Fee of $2.50 per tire, $2.25 of which is remitted to the State by the retailer. A few types of consumers, notably government agencies, are exempt from paying the fee.

Disposal facilities reportedly receive some incidental scrap tires from the public and in mixed solid waste loads, and may accept scrap tires for storage or processing separately from mixed solid waste under permit from the DEC. Section S 27-1911 of the Waste Tire Management and Recycling Act prohibits landfill disposal of waste tires.

Scrap tire resellers and processors include a wide range of diverse firms that purchase scrap tires from distributors, retailers, tire consumers and from other resellers and processors. Some may act as brokers without handling tires, but they often engage in one or more of the following activities: transportation, sorting, selling reusable tires domestically or internationally, producing and selling tire chips, shreds or ground rubber, or on-site use of whole or processed scrap tires. Major tire resellers and processors in New York include Casings (Catskill), Modern Recycling (Model City) and Integrated Tire (Buffalo). New York's supply infrastructure is described in Chapter Three.

Waste tire transporters may simply transport tires under contract, may broker tires between suppliers and buyers, and may undertake some of the activities listed under resellers and processors. New York State law requires that anyone engaged in the

[4] *Factbook 2004: US Tire Shipment Activity Report for Statistical Year 2003.* Rubber Manufacturers Association. 2004.

transportation of regulated waste (including waste tires) generated or disposed within New York State must possess a valid New York State Part 364 Waste Transporter Permit and must submit an annual report of waste transported. As discussed in Appendix E, R.W. Beck drew upon these reports in estimating scrap tire supply and demand for this report. There are currently approximately 300 waste transporters permitted to transport waste tires; however, less than half of these appear to be actively transporting waste tires, based on 2003 reported data.

Out-of-state North American markets include markets in neighboring states (e.g., Exeter, a major tire-derived-fuel market in Connecticut), neighboring Canadian provinces (e.g., ground rubber producers in Quebec) and global markets. Additionally, some finished products made with ground rubber and potentially some other scrap tire-derived products have global markets, but are not explicitly shown in this diagram. New York's scrap tire markets are discussed in the context of the broader geographic market in Section 2.4.

Noncompliant waste tire stockpiles include 95 sites with approximately 29 million waste tires (290,000 tons) identified by the DEC. They are currently being abated through an unprecedented, five-year initiative, as described in Chapter Three. In 2003, only about 150,000 stockpiled tires were abated and sent to an end use.

Stockpiled waste tire abatement contractors include seven firms that have thus far been awarded contracts by OGS (in partnership with DEC), valued at approximately $50 million, to abate an estimated 25 million stockpiled waste tires (250,000 tons). These contractors are firms with a history of large scale construction or supplying materials and services to the DOT, and do not generally include firms with an established presence in the scrap tire reselling and processing market.

Reuse markets include retreading and remanufacturing, and the use of partially worn tires domestically or internationally. Reuse accounted for about 5 percent of New York's annually generated scrap tires in 2003.

Ground rubber markets accounted for 11.5 percent of New York's annually generated scrap tires in 2003. In 2003, New York scrap tires were shipped to 5 in-state producers as well as 4 out of state ground rubber producers located in Massachusetts, Pennsylvania, New Jersey and Quebec. These ground rubber producers sold their product to a wide range of firms, both inside and outside New York, including: new tire manufacturers; surfacing and athletic product producers; molded product producers; rubber-plastic compound producers; and road construction firms.

Tire derived aggregate (TDA) markets accounted for nearly 32.5 percent of New York's annually generated scrap tires – the single highest use. This market was dominated by the Seneca Meadows landfill in 2003, which will continue to use large quantities of scrap tires in landfill engineering applications through 2006. There was virtually no flow of scrap tires to the other two TDA markets (roads and septic applications) in 2003. However in the coming year, an unprecedented amount of stockpiled waste tires will flow to specific DOT and Thruway Authority road construction projects involving use of tire derived aggregate in road construction applications.

Other recycling uses accounted for less than one percent of New York's annually generated scrap tires in 2003. They include scrap tire bale projects, use of scrap tires in agricultural applications and use of cut tires in landfill construction.

Raw material and fuel markets accounted for 27.1 percent of New York's annually generated scrap tires (56,476 tons or 5.6 million PTE). This includes 6,642 tons (664,200 PTE) used at value-added manufacturing facilities for which scrap tires provide a raw material source (e.g., the Nucor Steel Mill in Auburn), and 1,759 tons (175,905 PTE) used by manufacturing facilities using scrap tires primarily as fuel (e.g., three cement kilns located in Pennsylvania and Indiana). This market category also includes 48,075 tons (4.8 million PTE) used by electricity generators. In 2003, the use of scrap tires by New York electricity generators was just beginning, but the amount used grew considerably in 2004. Scrap tires also flowed to several waste-to-energy facilities. In 2003, over 22 percent of New York's scrap tires were used by out of state electricity generation facilities, most at the nation's only dedicated tire-derived-fuel combustion facility, Exeter, Inc. in Sterling, CT. A relatively small amount (1,606 tons or 160,600 PTE) were also consumed by New York waste-to-energy facilities. New York demand in this market is expected to increase in coming years. Several New York manufacturing and electricity generation facilities are pursuing permitting approval or otherwise investigating the use of scrap tires as fuel. The potential exists for these facilities to increase in-state use of scrap tires as fuel in manufacturing and electricity generation facilities by well over 100,000 tons (10 million PTE) per year.

Government Agencies with a Role in NY Tire Marketplace

Several government agencies either play a direct role in, or indirectly influence, the New York State scrap tire market place. These include the following:

The ***NYS Department of Economic Development (DED)*** is responsible for documenting the annual flow and market disposition of scrap tires. In addition, DED is responsible for assisting private companies with new technologies for scrap tire reuse and recycling, with an emphasis on higher value uses, in order to further create and enhance sustainable markets. They are also required to provide industrial and consumer education on the benefits of scrap tire derived products, and for preparing an annual market analysis report.

The ***NYS Department of Environmental Conservation (DEC)*** is responsible for regulating waste tire transporters, storage facilities, disposal facilities and the abatement of noncompliant waste tire stockpiles. DEC has helped to coordinate contracting by the Office of General Services for stockpiled abatement services, and commitments by the Department of Transportation to use abated tires in beneficial uses involving road construction. The DEC also issues case specific Beneficial Use Determinations (BUDs), which define the conditions under which a material used for a beneficial use is no longer considered a solid waste.

The ***NYS Department of Taxation and Finance***, under Section 27-1913 of the Environmental Conservation Law, is responsible for administering the collection of the Waste Tire Management and Recycling Fee.

The ***NYS Department of Transportation*** *(DOT)*, in coordination with DEC, has committed to use waste tires abated from noncompliant waste tire stockpiles, shredded by OGS contractors to meet established performance criteria, in specific road construction projects. DOT has conducted performance tests of rubber modified asphalt products, and has adopted a specification for asphalt binders modified with ground rubber (or polymers) to meet established performance criteria. DOT is also a leader in the Superpave program, a national effort to research and implement innovative paving designs, and is a partner in a national study of permeable friction courses sponsored by the US Transportation Research Board that could lead to increased use of rubberized asphalt.

The ***NYS Office of General Services' (OGS)*** is responsible for contracting with firms to abate New York State's noncompliant waste tire stockpiles. Additionally, each year OGS awards thousands of diverse, competitively bid contracts for use by State agencies, political subdivisions, and other organizations authorized by law to purchase from State contracts. These contracts offer commodities (materials, equipment, supplies, and printing); services; and technology, including telecommunications. The Group also establishes "Preferred Source Guidelines," which render certain groups of providers exempt from statutory competitive procurement requirements.

The ***NYS Office of Parks, Recreation and Historical Preservation*** is involved with procurement projects that potentially could use significant quantities of scrap tire derived products, for example, use of tire derived aggregate in septic systems, and use of rubberized asphalt in path paving efforts designed to comply with the American Disabilities Act. To date, no actual purchases of scrap tire derived products are known to have occurred.

The ***NYS Department of Health*** is involved in monitoring and regulating health and safety concerns related to stockpiled tires. The Department is developing a new policy that will allow the use of tire derived aggregate in septic leachate systems. This market has grown rapidly in some southern states.

Local government agencies are responsible for enforcing local waste management regulations and permits, and ensuring the sound management of scrap tires in their jurisdiction. Local agencies have the potential to purchase and promote the use of scrap tire derived products such as rubberized asphalt and TDA applications, as well as to develop beneficial uses for scrap tires. To date, for example, Chautauqua and Washington counties have sought BUDs to use baled tires in road construction. Local government agencies also play a role in overseeing the design and construction of septic systems.

The ***NYS Energy Research and Development Authority (NYSERDA)*** has a research and development program that supports the development and commercialization of innovative energy and environmental products, technologies, and processes that improve the quality of life for New York's citizens and help New York businesses to compete and grow in the global economy.

2.4 New York in the Broader Market Context

The New York State Context

In 2003, R.W. Beck estimates that approximately 208,580 tons of scrap tires (20.9 million PTE) were generated in New York State. This report documents that, of this total amount, at least 75% (157,411 tons or 15.7 million PTE) flowed to an end use market, either in or out of state, for reuse, recycling, energy recovery or other beneficial use. The fate of the remaining 25% was not able to be documented in this study.

The New York scrap tire market is in a period of rapid transition and in-state demand is growing rapidly. Throughout the 1990s, New York scrap tire demand was limited to traditional retread and reuse markets, along with a fledgling ground rubber production industry. However in 2003, in-state value-added demand for scrap tires and intermediate products reached at least 84,271 tons (8.5 million PTE or 40.4 percent of total generation). This includes at least 8,140 tons (814,000 PTE) sent to New York retreaders and reused tire distribution firms, 67,883 tons (6.8 million PTE) used as tire derived aggregate in New York landfill construction projects, and 6,642 tons (664,200 PTE) used as raw material by a New York steel manufacturer and about 1,606 tons (160,600 PTE) used by in-state waste-to-energy facilities. In addition, approximately 17,378 tons (1.7 million PTE) were sent to New York based ground rubber producers who shipped their product to a wide range of value-added manufacturing markets both inside and outside New York State.

As documented in this report, this market expansion trend is continuing and broadening. Several in state scrap tire markets grew significantly in 2004, and this trend appears likely to continue into 2005. The highest growth markets that would offer a positive value for processed scrap tires include ground rubber production (especially for sale into athletic surfacing and horticultural markets) and electricity production (requiring scrap tire chips). Additionally, at least one New York state pulp producer is pursuing permitting or otherwise investigating the use of significant quantities of scrap tires. Growth is possible but less certain in several other markets, including relatively high value ones like remanufactured tires and rubber-plastic compounds, and relatively low value ones like use of TDA in septic systems. Furthermore, while they are not value-added markets, demand by two major end-use outlets may increase significantly in the coming year: use of waste tires from noncompliant waste tire stockpiles in specific State road construction projects and use of whole scrap tires by New York cement kilns (using whole scrap tires subject to a tip fee). Finally, a range of intriguing emerging technologies for scrap tire recycling are under development, some of which appear promising.

The Regional Context

Many elements of the scrap tire market place are highly local. For example, although some high value end uses may attract supplies from several hundred miles away, according to the Rubber Manufacturers Association, most scrap tire transporters often restrict themselves to about a 150-mile radius. As a result, scrap tires and tire shreds

and chips originating in New York rarely are shipped beyond the adjacent states and provinces. Because of their higher value, reused tires, ground rubber, and products manufactured with scrap tires as raw material are often shipped internationally.

Whole and processed scrap tires from New York flow into several regional markets. In 2003, the second largest user of New York scrap tires was the Exeter tire burning facility in Sterling Connecticut. Small amounts of whole tires and tire shreds and chips were also sold to ground rubber producers in New Jersey, Pennsylvania, Massachusetts and Quebec. A much smaller quantity of tires was sold to alternative markets in Pennsylvania and as far away as South Dakota.

Neighboring states are pursuing similar market development goals as New York. Pennsylvania is establishing a new Recycling Markets Center to promote a range of recycling markets, and neighboring states have a range of recycling market development programs under way, paired with efforts to clean up stockpiled tires. Because scrap tires generally flow on a regional basis, New York and neighboring states will mutually benefit from recycling market development efforts.

The National Context

Table 2-4 shows New York's 2003 end uses for scrap tires, relative to the national averages. New York mirrored the nation in that relatively low value TDA and TDF markets dominate use. However, New York's market in 2003 showed a higher percentage use of tire-derived aggregate than is the national percentage. In New York, landfill applications dominated tire-derived-aggregate uses, while nationally road applications were more prevalent. Consistent with the national trend toward using tire-derived-fuel in value-added manufacturing facilities, New York has several cement kilns and one paper mill that potentially could expand use considerably in coming years. One utility, WPS Niagara, has already expanded use since 2003 and will likely be a major user of New York scrap tires for some time to come.

Table 2-4
Comparison of National and New York Scrap Tire Markets (2003)

Category	New York	U.S.
Reuse Markets	3.9%	N/A
Ground Rubber Markets	11.5%	9.7%
Tire Derived Aggregate Markets	32.5%	19.4%
Fuel and Raw Material Markets	27.1%	44.9%
Other Recycling	0.5%	3.7%
Disposal	N/A	9.3%
Unspecified	25%	10.3%
Export	N/A	3.1%

Sources: R.W. Beck (New York estimates); Rubber Manufacturers Association (U.S. estimates).

The North America Context

Markets in neighboring Canadian provinces are similar to neighboring U.S. states. The North American Free Trade Agreement has streamlined and reduced the cost of shipping scrap tires across the border. Canadian provinces have generally established more aggressive programs for market development, including subsidies for annually generated scrap tires and product stewardship requirements. As a result, some market players in the U.S., including New York market participants, have noted that, for example, Canadian ground rubber may out-compete U.S.-produced ground rubber in some markets due to a subsidy advantage. Canada's subsidies also have the potential to benefit New York, and some New York generated scrap tires flow to Canadian end use markets.

Canadian recycling market development programs can also benefit New York by providing valuable research and experience in the rubberized asphalt applications in cold-weather climates. Extensive testing and pilot tests are underway in Alberta and British Columbia. Combined with expected test results from the U.S. FHWA, this information and experience may help to expand the road application markets for ground rubber in the Northeast.

The International Context

Reused tires, ground rubber and products made from ground rubber are all shipped globally, though the primary markets for New York producers are generally in North America.

Producer responsibility policies in the EU, Canada and elsewhere may assist New York's market development efforts by involving tire and auto manufacturers in addressing end-of-life tire management issues, and by demonstrating successful market expansion technologies and policies.

Chapter 3

SUPPLY ANALYSIS

Chapter 3
SUPPLY ANALYSIS

This chapter describes New York's supply infrastructure for scrap tires and intermediate raw material products derived from scrap tires (i.e., chips, shreds and ground rubber). Section 3.1 covers the amount of scrap tires generated annually. Section 3.2 presents an overview of how annually generated scrap tires enter the market place. Sections 3.3 and 3.4 describe in more detail the two principal intermediate raw material supply products derived from scrap tires: tire shreds and chips, and ground rubber, respectively. Section 3.5 describes the supply of stockpiled waste tires. Stockpiled waste tires are treated separately since they flow through an entirely different supply infrastructure than annually generated scrap tires. Finally, Section 3.6 summarizes supply related trends and factors affecting supply.

3.1 Annual Scrap Tire Generation

This section summarizes R.W. Beck's analysis of annual scrap tire generation in New York. Information on generation trends helps analysts to project the availability of supplies for different end use markets. This could be especially important if increasing demand results in increased competition over supply. Also, combined with estimates of market disposition, generation statistics help decision makers to track progress towards the goal of developing high value end markets for all scrap tires. But while understanding scrap tire generation is important, it is also challenging. Due to resource and data constraints, analysts must make do with the best available estimates, given the range of data sources available.

Scrap tires are generated when they are discarded by their original owner at the end of their intended use.[1] R.W. Beck's analysis of scrap tire flows in New York State indicates that approximately 208,580 tons (20.8 million PTE) were generated in the state of New York in 2003, equivalent to 1.08 passenger tire equivalents per person. This estimate was derived from detailed analysis of waste tire transporter data supplemented by interviews and data from other sources, as presented in Section 2.2 and explained in detail in Appendix E. This estimate is subject to significant sources of uncertainty, and will be refined in subsequent annual updates to this market analysis report. However, R.W. Beck believes it is the best estimate available at this time.

To validate this estimate of scrap tire generation, the estimate was compared to two alternative calculation methods. As described in the following two sections, R.W. Beck's estimated scrap tire generation rate of 20.8 million tons, or 1.08 PTE per capita, is within about 5 percent of the generation rate predicted by both the RMA

[1] Unlike many previous studies, in this report the terms scrap tires and waste tires are defined consistently with New York legislation to include tire casings destined for reuse.

method and by analyzing Waste Tire Management and Recycling Fee receipts, suggesting it is reasonable.

Rubber Manufacturers Association Method

For over a decade, tire recycling analysts have typically assumed a national generation rate of one scrap tire per person. This assumption was most recently verified by the Rubber Manufacturers Association in its 2003 market analysis, based on two methods:

1. The sum of reported replacement tire shipments and tires on scrapped vehicles; and
2. Total reported scrap tire generation by State officials.

Table 3-1 below presents RMA's calculation based on shipment data.

Table 3-1
Annual Scrap Tire Generation as a Function of U.S. Population
(All figures in millions except for scrap tires per person)

Tire Type	Annual Generation
Passenger tire replacements	194.4
Light truck tire replacements	34.3
Medium, wide base, heavy and OTR tire replacements	15.7
Farm tire replacements	2.5
Industrial tire replacements	4.5
Tires from scrapped vehicles	53.2
Total scrapped tires	300.0[2]
US population	290.8
Number of scrap tires per person	1.03

Source: *US Scrap Tire Markets, 2003 Edition.* Rubber Manufacturers Association, July 2004.

R.W. Beck's estimated New York generation of 1.08 PTE per capita is less than 5 percent higher than RMA's national generation estimate of 1.03 tires per person.

Analysis of Waste Tire Management and Recycling Fee Receipts

Another way of estimating scrap tire generation is to analyze revenues raised by the Waste Tire Management and Recycling Fee. For the period of September 2003 through August 2004, the fee raised approximately $25 million. At $2.25 received per tire, this suggests that 11.1 million new tires were sold in the state (for use on new vehicles and as replacements), equivalent to a rate of 0.58 tires per capita. New tire sales on new vehicles do not necessarily equate directly to scrapped tires, since new

[2] Note: RMA's table apparently includes a summation error. The total generation sums to 304.6 million tons, resulting in a slightly higher annual generation rate of 1.05 tires per person. This difference is ignored in this report's discussion of generation rates.

car purchasers presumably sell their old car along with its used tires. This means that this may over estimate scrap tire generation. However, two additional adjustments can be made to this estimate.

First, this calculation does not take into account new tire sales that are exempt from the fee program (e.g., retreads or Internet sales). Assuming tires on exempt-registration vehicles are replaced at the same rate as non-exempt vehicles, R.W. Beck estimates exempt vehicles would generate an additional 352,894 tires per year. Second, the estimate does not account for scrap tire generation from scrapped vehicles. RMA estimates that, nationally, 17.5 percent of all annually generated scrap tires are from scrapped vehicles. Applying this ratio to New York yields an estimated 2,431,758 tires from scrapped vehicles. Combining the effect of these two adjustments results in a total statewide generation rate of 13,895,763 tires, or 0.72 tires per capita, nearly 30 percent lower than R.W. Beck's estimated generation.

This calculation, however, is based on actual tire sales, while R.W. Beck's and RMA's per capita estimates are for passenger tire equivalents. Passenger tire equivalents assume all scrap tires weigh 20 pounds. Some analysts suggest the actual, average weight of a scrapped passenger tire is greater than this. RMA reports that new passenger tires weigh, on average, 25 pounds and scrap tires weigh, on average, 20 pounds. At least one other source indicates the average scrap tire weighs 21 pounds. [3] And, as discussed in Section 2.1, RMA estimates that passenger tires account for only 84 percent of all sales, with 15 percent of sales being light and heavy truck tires and one percent heavy equipment, aircraft and other off-the-road vehicles. Assuming the average weight of scrap tires in these three categories is 20 pounds, 70 pounds and 140 pounds, this results in an average weighted new tire weight of 28.7 pounds. Dividing R.W. Beck's estimate of 20.8 million tons (derived from analysis of scrap tire flows by weight) by this weighted average scrap tire yields a generation rate of about 14.5 million weighted average scrap tires, or about 0.76 weighted scrap tires per person, about 5% higher than the rate predicted by analysis of Waste Tire Management and Recycling Fee receipts.

3.2 Overview of the Supply Infrastructure for Annually Generated Scrap Tires

Key Players

Scrap tire transporters, resellers and processors are the firms responsible for supplying annually generated scrap tires and processed raw materials to end markets. As used in this report, *resellers and processors* is a catch-all category including companies that sort, broker and/or process scrap tires (including the production of chips, shreds and ground rubber) for sale to end users or other companies in the supply chain. These companies receive scrap tires from transporters.

[3] *Standard Weight to Volume Conversion Factors.* US EPA, Available at http://www.epa.gov/recycle.measure/docs/guide_b.pdf.

Table 3-2 identifies the key resellers and processors handling New York generated scrap tires. The top four suppliers, Casings, Inc., Modern Recycling, Integrated Tire and Lakin Tire East, together accounted for about two-thirds of all shipments of scrap tires to end-users in 2003.

Table 3-2
Key Resellers and Processors Handling NYS Scrap Tires

Company	Location
Casings, Inc.	Catskill, NY
Modern Recycling	Model City, NY
Integrated Tire	Buffalo, NY
Lakin Tire East	West Haven, CT
Huron Recovery of New York	Buffalo, NY
Don Stevens Tire	Southington, CT
Meridian Tire	Plainfield, CT
Tire Trader	Long Beach, NY

Supply Infrastructure Economics

New York's supply infrastructure is the engine that drives the flow of scrap tires to end use markets. The business is generally one of high volumes and low margins. Due to a lack of high value markets, companies involved in the scrap tire supply chain rely upon disposal fee revenue to remain solvent.

The tight margins involved in scrap tire collection and processing can be illustrated by considering a typical *tire shed*, the geographic radius from which a facility sources scrap tires. Transportation is one of the largest tire recycling costs, averaging about $1.00 per mile, regardless of the size of the truck load. Assuming a typical truck load of 1,200 tires, a revenue stream of $0.75 per scrap tire, and an industry average processing cost of $0.50 per tire, a tire chipper would just break even at a maximum transportation distance of 150 miles.[4] Even state of the art, high value added ground rubber facilities may have a supply radius limited to no more than 250 miles.[5] On the other hand, some ground rubber producers dependent upon large truck or other specific tire types may import a portion of their supply from as far away as several hundreds of miles.

In New York, the disposal fee charged to generators (e.g., retail stores and fleet managers) ranges from about $0.45 to $2.00 per tire for passenger tire collection. Trailer loads of 1,100 to 1,200 tires may be collected at a cost of approximately $900

[4] *Considerations for Starting a Scrap Tire Company: A Blueprint for Planning a Business Strategy*. Rubber Manufacturers Association, 2004.
[5] For example, this is the supply radius of the new State Rubber & Environmental Solutions facility in Denver City, TX. *West Texas Town Boasts Newest Crumb Rubber Facility.* Scrap Tire News, October 2004.

to $1,400 per load, and an additional fee is typically charged for handling larger tires. Increasingly, tire processors are entering into long-term contracts with commercial scrap tire generators like tire dealerships, retail stores and fleet owners, bypassing the traditional waste tire transporters and/or resellers. Such arrangements can reportedly result in savings of approximately $0.50 per tire collected.

Table 3-3 presents typical market specifications and prices for scrap tires and intermediate processed products. (These markets are discussed in Chapters 4 through 8.) The cost of processing scrap tires to meet the specifications of the higher value markets (e.g., finely ground rubber) is greater than for low value markets (e.g., TDA used in landfill applications), and may require processors to invest in new equipment. This fact, along with high transportation cost as described above, is helping to drive a long term trend towards integration and consolidation among scrap tire supply companies. This trend may be exacerbated as demand increases drive increased competition over scrap tire supply.

Table 3-3
Typical Specifications and Value of Scrap Tire Supplies

Market	Specification	Product Examples	Price Received by Supplier	Source
Whole Tires Suitable for Reuse	Reusable passenger tires	Graded partially worn tires	$2 to $20 each	1
	Reusable medium truck tires	Graded partially worn tires; Retreaded or remanufactured tires	$5 to $50 each	1
	Reusable OTR tires		$50 to $200 each	1
Ground Rubber	Raw Retreader Buffings	Molded products	$125 to $212 per ton	2
	Reprocessed Retreader Buffings	Rubberized asphalt	$226 to $407 per ton	2
	¼”	Horticultural uses	$140 to $432 per ton	2
	3/8” (no wire)	Horticultural uses; cow mattresses	$140 to 240 per ton	1
	10 to 40 mesh	Molded products; horse arenas; rubberized asphalt	$200 to $402 per ton	2
	40 to 200+ mesh	Tire manufacturers	$280 to $1,500 per ton	2
Tire Derived Aggregate	3” – 6” chip, minimal wire	Landfill construction	$4 to $10 per ton	1
	1” to 3” chip, minimal wire	Road construction	N/A	
	2” chip	Septic drainage	$15 to $20 per ton	1
	3/4 “ chip, no wire protruding	Landscape/ playgrounds	$50 to $60 per ton bulk; Black: $200 to $300 per ton retail bags; Colored: $400 + per ton	1

Market	Specification	Product Examples	Price Received by Supplier	Source
Raw Material and Fuel	Whole Tires	TDF facilities; steel mills; cement kilns	$50 to - $55 per ton (i.e., a tip fee)	1
	2" Minus Chip, 90 percent wire free	Electric utilities using circulating fluidized bed combustors	$17 to $25 per ton	1
	¾ " minus	Pulp and paper mills using wood burning stoker combustor	$60 to $73 per ton	1

Sources: 1) R.W. Beck Interviews; 2) Recycling Research Institute

Ultimately, DED's goal of increasing demand for New York generated scrap tires by high-value markets is intended to move towards a situation where the market value of processed scrap tires is sufficient to cover the entire system cost, so that there is no "disposal cost" associated with scrap tire management. This is often the situation, for example, with recyclable high-grade waste paper, aluminum, steel and other recyclable commodities. R.W. Beck's strategic plan for scrap tire market development, to be developed in Phase 2 of this project, will analyze and recommend strategies to achieve this goal.

3.3 Scrap Tire Shred and Chip Supply

Quantity Processed

A large percentage of New York scrap tires generated annually is shred and/or chipped on its way to end users. In 2003, nearly 68,000 tons of New York annually generated scrap tires (6.8 million PTE) were shred and/or chipped and used in landfill construction applications; an additional 23,938 tons (2.4 million PTE) were chipped and shred, then further processed into ground rubber; and a small, but undetermined, percent of the 56,476 tons of scrap tires (5.6 million PTE) flowing to raw material and fuel markets was shred and/or chipped. Beginning in 2004 and over several years, this flow will be augmented by about 290,000 tons of processed stockpiled scrap tires intended for use in roads applications.

Specifications of Tire Shreds and chips

Tire shreds are 4 to 9 inches wide and can be up to 18 inches in length, still containing some fiber and steel. Tire chips are generally one-half to 3 inches wide. Tire shreds are an intermediate state in the production of chips, and have very limited markets. When produced to meet appropriate specifications and sold into the civil engineering applications (described later in this chapter and in more detail in Chapter 6), they are referred to as "tire-derived aggregate," since they replace natural rock and other aggregate materials. Newer uses of tire chips, such as rail line vibration damping and foundation support on poor soil, are competing with other, more expensive engineered aggregates or systems. Tire chips are sold into some fuel and manufacturing raw material markets, as discussed briefly below, and more in-depth in Chapter 8.

Market specifications for tire shreds and chips vary significantly depending on their end use. TDA for use in landfill construction is the least stringent specification. Chip sizes can be on the large side, and the existence of wire is not problematic, as long as it does not protrude more than 0.25 inches. Some tire-derived fuel specifications, however, demand a 1- inch sized chip, which is considerably more time consuming to manufacture. Material quality, and therefore the ability of a processor to enter additional and higher-value markets, increases as chip size and amount of retained steel and fiber decrease. Uniformity of chip size, also desirable for higher value applications, also increases with further processing.

Scrap Tire Chipping and Shredding Process

Tire chipping and shredding is a multi-step process, and equipment requirements vary with the size and quality of product needed. The first step is the primary shredder, also called a "chopper." Capable of handling whole tires, these machines typically use a series of oscillating or reciprocating cutting edges, moving back and forth in opposite directions to create a shearing motion that effectively cuts or shreds the tires as they are fed into the machine. The whole tires may first have the wire bead removed. Depending on the particular machine and its condition, shredders produce flat, irregularly shaped chunks as large as 12" to 18" long and 4" to 9" wide. The shreds will normally have protruding steel belt wire fragments and pieces of synthetic fiber on the edges.

Tire chips are produced by passing tire shreds either through the same equipment a second time, or through a second shredder. Using a second shredder produces more uniformly sized, cubical pieces; but they still contain steel belt wire and fibrous material.

A variety of machines can be added to the scrap tire processing line, each with a function that reduces the size of the chip and/or removes the steel and fiber. These include a primary granulator (known by such trade names as "grizzly," "rasper," or "liberator") that strips the steel from the tire chips using special knives mounted on a low-speed horizontal rotor. The material produced from this processing step is usually described as "ground rubber," with particle sizes ranging from ¾" to as small as 100-mesh (the particles fall through holes sized at 100 holes per square inch).

3.4 Ground Rubber Supply

Key Players and Quantities Processed

Table 3-4 lists ground rubber producers in New York and adjacent states and provinces that receive New York scrap tires. In addition to the ground rubber producers listed in Table 3-4, some New York shredders and chippers have sold coarse grind material, such as ¾" chips, to playground and mulch markets, classified in this report as ground rubber. One additional company, Tire Solutions (Elmira) was in operation in 2003, but this company has since closed and was purchased by Fennel Recycling. Other companies have developed or sought to develop ground rubber

production capabilities (some with support from NY DED), but they are not documented to have handled a significant flow of tires in the study year 2003.

Table 3-4
Ground Rubber Producers
Accepting New York Generated Scrap Tires

Company	Location
Fennel Recycling	Elmira, NY
High Tread International	Lockport, NY
New York Rubber Recycling	Rotterdam, NY
Omni of Babylon	West Babylon, NY
Toms River Rubber Recyclers	Guttenberg, NJ
F&B	New Bedford, MA
Chatham Rubber Co.	Chatham, ON
Rubber Recycle, Inc.	Lakewood, NJ

Source: R.W. Beck

R.W. Beck estimates that in 2003, approximately 23,938 tons (2.4 million PTE), or 11.5 percent of all scrap tires generated in New York, were converted to ground rubber and sold into one of the markets described in Chapter 5. Of this amount, about 17,358 tons (1.7 million PTE) were used by New York producers, with the remainder used by ground rubber manufacturers locate in Massachusetts, New Jersey, Pennsylvania, and Quebec. Because rubber constitutes only about 70 to 75 percent of total tire composition, the amount of ground rubber produced and marketed is significantly less than the tons input. In addition to this ground rubber production, New York retreaders also generated an undetermined quantity of buffing dust which was sold into ground rubber markets. Retreaders are described in Chapter 4. Nationwide in 2003, about 125,000 tons of buffing dust (12.5 million PTE) and 168,000 tons (16.8 million PTE) of scrap tire derived ground rubber were produced.

New York has experienced a consolidation trend similar to that affecting the nationwide ground rubber industry. At least one ground rubber operation in New York has changed hands in the past two years, and several small producers have closed over the past decade. This trend is driven by tight economics, highly competitive markets, and the fact that long awaited growth in relatively high value markets like rubberized asphalt has yet to materialize. Recent growth in the industry has been almost entirely in the coarse, relatively low value ground rubber markets such as horse arenas, sports turf and other athletic and horticultural markets.

Ground Rubber Specifications

Table 3-3 (in Section 3.2) lists the range of typical ground rubber specifications and prices. In this report, ground rubber is defined to include sizes as large as ¾” chips,

with virtually no wire protruding that is produced by some shredders and chippers and sold in to similar markets. This very coarse material requires relatively inexpensive equipment to produce, and is increasingly manufactured by both ground rubber producers as well as shredders and chippers. It is classified along with ground rubber in this report because it is increasingly sold into the growing athletic surfacing and horticultural markets and because ground rubber producers are key players in this market. Ground rubber of approximately 10 to 40 mesh is used to produce rubberized asphalt as well as a range of molded products. Very fine ground rubber of 80 to 200 mesh is used in tire manufacturing, in plastic-rubber compounds, and in other high end uses.

Production Process

Ground rubber production begins with the production of tire chips, as described in Section 3.3. Producers typically purchase whole scrap tires and do this first stage of shredding and chipping on site, though they may also purchase tire chips from other suppliers. They then continue processing the material to achieve specifications needed for different markets. The process for producing crumb rubber can be divided into two categories: ambient grinding and cryogenic grinding. Currently in New York, all ground rubber produced is ambient grind, although cryogenic capacity could potentially be installed if demand warranted it. One New York producer suggested that his firm had plans to move cryogenic production equipment from an out-of-state facility to its New York facility in the coming year. While producers often use proprietary equipment, it is generally based on similar principles and concepts.

Ambient Grinding

Ambient grinding is performed at room temperature, using either a granulator or a crackermill. Granulators employ a cutting and shearing action to reduce the size of tire chips, using screens to control the product size. Ground rubber produced via the ambient process generally has a rough texture with sides of relatively consistent dimensions. Crackermills are also referred to as primary, secondary and finishing mills, and generally use two large rotating rollers with blades, oriented in opposing directions. Product size in a crackermill is determined by the distance between the opposing rollers. Rubber may be passed through more than one crackermill to achieve desired particle size and to liberate steel and fiber materials from the rubber. Ground rubber produced in crackermills is generally long and narrow in shape, with a relatively high surface area.

Cryogenic Grinding

Cryogenic processing is conducted at very low temperatures as low as -80 degrees Fahrenheit. Liquid nitrogen is employed to achieve these temperature levels, greatly facilitating the size reduction process and the removal of steel and fiber components. At low temperatures, the tires become brittle and glass like. The incoming tire chips are typically cooled in a bath of liquid nitrogen and then run through a grinding machine, usually a hammer mill. This process produces particles ranging in size from about ¼” to 30 mesh. Ground rubber produced cryogenically is clean, with shiny fractured surfaces and relatively low steel and fiber content. When crumb finer than 30

mesh is needed, cryogenic grinding is generally used. Although ambient grinding can also produce smaller particles, they tend to be somewhat jagged and are inconsistent in size. An emerging cryogenic granulating technology is being developed by a company called Super Cool LLC, and may hold potential to reduce grinding costs. The technology is designed to be co-located with liquefied natural gas terminals to reduce cooling costs. Super Cool was issued a patent for its new process in December 2003.

Managing By Products

Most tires are only about 70 to 75 percent rubber by weight, and it is necessary to remove the remaining material, principally fiber and steel. After being processed into ground rubber via the ambient or cryogenic process, the product is typically passed through a magnetic separation system to remove the majority of belt wire steel. An air gravity separation table is used to remove the majority of fiber, and a second separation of belt wire steel and fiber is completed following the milling process. While these materials can technically be recovered, markets are weak. New technologies for recovering steel from tires in marketable form are growing, but their use is not yet widespread. The steel portion, in particular, represents a drag on profitability that can potentially be turned into a new source of revenue if it can be successfully marketed. At least one New York ground rubber producer intends to invest in equipment to render its residual steel marketable during 2005. However, the degree to which residual fiber and steel from ground rubber production is being recovered in New York was not determined.

Production of Fine Ground Rubber

In addition to the conventional ground rubber technologies, several proprietary systems exist for producing fine (i.e., 40 to 60 mesh) and superfine (i.e., 60+ mesh) grades of ground rubber. One example is micro milling, also called wet-grinding, in which rubber particulates are further reduced in size by grinding them in a liquid medium, usually water.

Emerging Ground Rubber Technologies

There are a number of emerging technologies being researched or under development for either treating ground rubber in the production process, and/or new markets. For example, ground rubber producers can treat their product through devulcanization, by producing compounds of rubber and polymers, or through other processes. This report does not attempt to comprehensively identify or analyze the range of new technologies under development. However, Section 5.6 discusses rubber-plastic compounds, and Section 5.7 briefly discusses other emerging technologies.

3.5 Stockpiled Waste Tires Supply

In 2004, New York State launched an unprecedented effort to abate its noncompliant waste tire stockpiles. The effort is leading to a new, one-time supply of approximately 29 million scrap tires that will be spread out over several years. The project is being

coordinated by DEC, with plans for OGS contractors to process the waste tires to DOT specifications, and use by the DOT and the Thruway Authority in road construction projects through 2010. These supply contracts are described below.

Noncompliant Waste Tire Stockpile Inventory

The DEC performed a survey of noncompliant waste tire stockpiles beginning in July, 2004. The survey identified 95 noncompliant waste tire stockpiles containing approximately 29 million scrap tires (290,000 tons) in New York. As shown in Table 3-5, the five largest stockpiles contain approximately 85 percent of these tires, ranging from 1.2 to 10 million tires (12,000 to 100,000 tons) per site. Accurately estimating the size of scrap tire stockpiles is difficult, and these estimates may not reflect the actual quantity of tires requiring abatement. One industry expert suggested the actual number of tires stockpiled in New York may be as high as 50 million (500,000 tons).

Table 3-5
Five Largest New York State Scrap Tire Stockpiles

Site	Location	Estimated Number of Tires
Fortino Site	West Monroe, NY	10 million
Mohawk Tire Recycling	Waterford, NY	8 million
Hornburg Tire	Sinclairville, NY	3.5 million
New York Tire/Izzo	Smithtown, NY	2 million
Cycletech	Hudson, NY	1.2 million
TOTAL		24.7 million

Source: NY DEC

Remediation Priority

Using ranking factors such as the number of tires per site, environmental, and other considerations described in the New York State Waste Tire Stockpile Abatement Plan, the DEC targeted twelve priority sites for initial clean-up and abatement. These sites, listed in Table 3-6, contain approximately 27 million tires.

Table 3-6
Top Priority Stockpile Abatement Efforts

Site	Location	Priority Score	Number of Tires
Fortino Site	West Monroe, NY	10	10 million
Mohawk Tire Recycling	Waterford, NY	9	8 million
New York Tire/Izzo	Smithtown, NY	9	2 million
Cycletech	Hudson, NY	8	1.2 million
Clarence Auto Parts	Newstead, NY	8	650,000
Hornburg Tire	Sinclairville, NY	7	3.5 million

Site	Location	Priority Score	Number of Tires
U Save Tire Company	Plattsburgh, NY	4	200,000
Hutchings Automotive	Plymouth, NY	6	800,000
Southern Tier Tire	Persia, NY	6	350,000
Tire Recycling, Inc.	Saugerties, NY	5	300,000
Coletta Recycling	Queens, NY	5	20,000
Doc's Trucking & Auto Parts	Verona, NY	5	10,000
TOTAL			27,030,000

Source: NY DEC

The DEC and OGS are expediting the contract process so that stockpile abatement may begin as soon as possible. The abatement process may be lengthy due to the condition of the tires and inaccessibility of some sites. As listed in Table 3-7, OGS, on behalf of DEC, has already issued eight contracts with construction firms for specific site abatement projects. DEC has expressed confidence that it can meet the legislative mandate to abate all noncompliant stockpiles by December 31, 2010.

Table 3-7
Scrap Tire Stockpile Site Remediation Contracts (as of February, 2005)

Site	Remediation Contractor	Contract Amount	Number of Tires
Mohawk Tire Recycling	U.W. Marx, Troy, NY	$13,014,611	8,000,000
Cycletech	Rifenburg Contracting, Troy, NY	$2,082,174	1,200,000
Tire Recycling, Inc.	Tulley Environmental, Flushing, NY	$836,095	300,000
Hornburg Tire	Ontario Specialty Contractor, Buffalo, NY	$8,387,158	3,500,000
Clarence Auto Parts	DEMCO, West Seneca, NY	$2,751,000	650,000
Hutchings Automotive	Rifenburg Contracting, Troy, NY	$1,911,168	800,000
Fortino	Delaney Construction, Gloversville, NY	$17,596,290	10,000,000
Southern Tier	Pike Company, Rochester, NY	$2,736,559	350,000
TOTALS		$49.3 million	24,800,000

Source: NY DEC

End-Uses for Abated Tires from Noncompliant Stockpiles

The DEC, in cooperation with DOT and the New York State Thruway Authority, plan to direct noncompliant stockpiled waste tires into beneficial uses in accordance with the Waste Tire Management and Recycling Act. The highest feasible beneficial use

has been determined to be engineering applications in road construction, such as embankments. The cost of site remediation, including tire processing, is covered by funds generated by fees levied by the Waste Tire Management and Recycling Act of 2003. Quality assurance and environmental monitoring of these projects, where needed, will also be paid for from the Waste Tire Management and Recycling Fund.

For the sites identified above, the OGS/DEC contractors are responsible for shredding the stockpiled tires on-site and processing them into tire derived aggregate satisfying DOT's revised specifications for use in road and embankment construction. The shredded tires will be stored in specially constructed piles that are to be inspected by certified, DOT-trained inspectors to ensure the quality of the shreds is suitable for use in planned road construction projects. Tire shreds satisfying the specification will be transported to road construction projects on an as-needed basis. DOT and the Thruway Authority have identified 12 planned projects for 2004 to 2007 that are projected to use more than 20 million tires.

Potential Market Disruption

As described above, most abated stockpiled waste tires are intended to flow into specific DOT and Thruway Authority road construction projects. Since the stockpiled tire shreds will not enter the open market, they are not expected to negatively impact the viability of existing shredders and chippers.

DEC's efforts to minimize the risk of market disruptions include quickly contracting for the abatement of nearly 90% of all waste tires in noncompliant stockpiles, and using the tires completely outside of the existing New York State scrap tire market. It is possible, however, that some stockpiled tires (especially those from some of the smaller sites being remediated directly by site owners) may enter the established market for shreds and chips. It is expected that most of the off-specification material from abatement activities will be directed to the landfill market, which is currently the only active market for TDA in New York State.

3.6 Trends and Factors Affecting Supply

Trends in Annual Scrap Tire Generation

Per capita annual scrap tire generation is expected to remain relatively stable. While there are factors that tend to increase scrap tire generation, they are roughly canceled out by other factors that tend to decrease scrap tire generation.

Factors that tend to decrease generation include:

- New tire technologies and materials are yielding increasingly long-lasting steel-belted radial tires, which have come to dominate the passenger and light truck tire market place. When maintained correctly, new tires may now be rated to last up to 80,000 miles.

- Some emerging technologies have the potential to significantly reduce scrap tire generation over the long term. One example is the *tweel.*[6] Developed by Michelin's American Technology Center, the tweel is a single-piece tire and wheel assembly that could potentially be used extensively on passenger cars and eventually construction equipment and aircraft. These tires could last two-to-three times as long as today's radial tires, and could lend themselves to highly economical retreading. The tweel is a long-term market prospect, however. The technology is being refined to address barriers such as higher production costs, greater road friction, noise and a less comfortable ride. Tweels are therefore not anticipated to enter the consumer automobile tire market place for several years.

Factors that tend to increase generation include:

- Tire sales are projected to grow nationwide at a rate of 2 percent per year through 2009, and are tied to gross domestic product and industrial production indices.7 This growth rate is roughly commensurate with projected New York population growth of 3 percent.
- Passenger car tire retreading has virtually disappeared as a result of lower cost imported new tires of high quality resulting in higher consumption of new, replacement tires.
- Many consumers do not adequately maintain new tires (e.g., tire pressure, wheel alignment, speed and rotation), and consequently new tires are often replaced far sooner than their guaranteed, rated number of miles.
- Some consumers choose to replace two or four tires at a time, even though only a single tire may fail.

Trends in Annually Generated Scrap Tire Supply

There is a move toward vertical integration and consolidation in the scrap tire supply chain. Increasingly, processors are establishing nationwide supply contracts with large generators such as retail chains and fleet managers, by passing traditional transporters and tire jockeys. Suppliers are also moving towards forward integration by investigating in investments in the production of finished products. The number of processors is also declining through consolidation.

Factors driving this trend include:

- Larger, vertically-integrated firms are better prepared to withstand tight profit margins and to attract the capital required to invest in new technologies that reduce unit costs and open access higher value end markets.
- Slowly but steadily increasing demand for scrap tires and intermediate products is resulting in increased competition for tire supplies, and more efficient operations are required to withstand this increased competitive pressure.

[6] *Technology: Reinventing the Wheel (And the Tire Too).* New York Times, January 3, 2005.
[7] *Factbook 2004: US Tire Shipment Activity Report for Statistical Year 2003*. RMA, 2004.

- This increasing competition has been exacerbated by newly developed technologies that have opened up new markets for coarse ground rubber (e.g., in playgrounds) to both traditional shredders and chippers and ground rubber producers.
- New competition from companies involved in stockpiled tire abatement contracts may further exacerbate this trend.

Trends in Stockpiled Waste Tire Supply

Between 2005 and 2010, OGS/DEC contracts will yield an unprecedented one-time supply of abated noncompliant stockpiled waste tires. Contracts already signed involve approximately 25 million tires (250,000 tons), over 85 percent of the total stockpiled amount. The supply of shreds and chips flowing to DOT and Thruway Authority road construction projects will grow in New York for the next 6 years as the numerous noncompliant waste tire stockpiles around the state are cleaned up according to DEC's Waste Tire Stockpile Abatement Plan.

Factors driving this trend include the New York Waste Tire Management and Recycling Act of 2003, which requires DEC to work with other State agencies to comprehensively abate identified non-compliant waste tire stockpiles by December 31, 2010.

Trends and Factors Affecting Ground Rubber Supply

Ground rubber production is experiencing a wave of consolidation, and companies are increasingly integrating vertically. This trend is resulting in fewer companies that must aggressively compete for limited markets. Ground rubber producers are also integrating backwards by establishing supplier networks (bypassing some traditional scrap tire suppliers) and also forwardly integrating by beginning to produce new products. Viewed optimistically, the net result of this trend may be fewer, stronger ground rubber producers. Viewed negatively, the industry may take longer to grow, if higher value ground rubber markets begin to grow as has long been anticipated.

Factors affecting this trend include:

- There is continued over capacity of ground rubber production compared to market demand, especially for lower value, coarse ground material;
- New production technologies have facilitated the emergence into the coarse ground rubber markets by new players;
- Market growth has been limited primarily to expansion in the use of coarse ground rubber in athletic surfacing and horticultural markets. A wide range of ground rubber suppliers are capable of meeting these market specifications, including some traditional shredders and chippers that have not previously competed directly with ground rubber producers; and
- The higher value ground rubber markets, including new tires, rubberized asphalt and rubber-plastic compounds, have not grown significantly in the Northeast.

While they each hold promise of growth, they are not expected to grow considerably in the near term.

Chapter 4

TIRE REUSE

Chapter 4
TIRE REUSE

4.1 Overview of Tire Reuse Markets

This chapter describes markets involving the reuse of scrap tires. In 2003, R.W. Beck estimates that approximately 8,140 tons of scrap tires (814,000 PTE) were reused in New York, divided roughly equally between retreading and reuse and constituting 3.9 percent of the total flow. Because of the many firms involved, and the fact that tires are often bought and sold across state lines, this estimate may be low. The following two sections summarize these markets. Section 4.2 describes partially worn tires that are suitable for reuse without further processing. Section 4.3 covers retreading and remanufacturing scrap tires. Section 4.4 discusses emerging technologies related to tire reuse.

4.2 Partially Worn Tire Reuse

R.W. Beck estimates that in 2003 approximately 4,138 tons of scrap tires (410,380 PTE) were sold by resellers as reusable, partially worn tires. These tires were sold to distributors, tire retailers, individuals, fleet managers and other consumers. An undetermined portion of these entered export markets.

As described in Chapter Three, tire resellers and processors purchase used tires, including passenger tires, light truck tires, medium truck tires, and specialty tires such as off-the road (OTR) tires from auto shops, auto dealers, and auctions. Some of these resellers cull through them to sort out reusable tires. Tires are visually inspected, and in some cases inspected using air equipment. The treads are measured, and they are assigned a rating. For example:

- A1, A2, and A3: Excellent condition
- B1, B2, and B3: Still have some good use
- C1, C2, and C3: Usable for a short period of time

Used passenger and light truck tires are often sold in pairs or quads. Depending on the source, resellers indicate that about half of the tires they receive are reusable or able to be reused if retreaded. The remaining tires received are not usable and must flow into one of the other end markets described in this report.[1]

[1] Unlike scrap tire studies conducted by RMA and others, in this report the term scrap tires is defined consistent with New York legislation to include tire casings destined for reuse.

The tires identified as reusable are sorted by size and quality. Some tires are delivered to local shops for resale, in the case of passenger and light truck tires. All types of tires are sold on the Internet for reuse. Generally a digital photo is taken of the tires, and posted on an Internet site, or emailed to potential customers (in the case of specialty and OTR tires). The customer pays shipping. Some worn tires, especially specialty, unique sizes, and truck and OTR tires, are sold to retread shops. The retread market is discussed in more detail below. Some partially worn tires are exported. One trader indicated that many of his tires go to Canada. It is difficult to know what percentage of scrap tires exported in bulk is ultimately reused. Definitions for Used tire specifications are provided in Table 4-1.

Table 4-1
Used Tire Specifications

Specification	Definition
Number 1 Used Passenger Tire	▪ Minimum of 7/32' tread depth straight across ▪ Must be 'Air Tested' and Ready to be mounted
Number 2 Used Passenger Tire	▪ Minimum of 5/32' tread depth straight across ▪ Must be 'Air Tested' and Ready to be mounted
Number 3 Used Passenger Tire	▪ Minimum of 4/32' tread depth straight across ▪ Must be 'Air Tested' and Ready to be mounted
Number 4 Used Passenger Tire	▪ Minimum of 3/32' tread depth at any point ▪ Visually inspected but not necessarily 'air tested'
Number 5 Used Passenger Tire	▪ Assorted Used Passenger Tires ▪ Minimum tread depth & grading specifications, to be agreed to by both buyer & seller ▪ Visually inspected but not necessarily 'air tested'
Repairable Passenger Tires	▪ Minimum of 5/32" tread depth straight across ▪ Injury repairable by Vulcanizing(Hot Patch) ▪ The injury not more than 3 cords in width and at least 2" above the bead
Used Light Truck Tires	▪ Mount ready used 16', 16.5, or LT designated tires ▪ Tread depth shall be determined between the buyer and seller
Repairable Used Light Truck Tires	▪ Damaged high tread LT tires that are repairable by vulcanizing (hot repair) ▪ Exact specifications of acceptable tire to be determined between buyer and seller

Specification	Definition
Used Heavy Truck Tires	▪ Inspected used heavy truck & bus tires that are mount ready ▪ Grade, tread depth, make, model and sizes to be specified and agreed upon between the buyer & seller
Repairable Heavy Truck Tires	▪ Graded, inspected heavy truck and bus tires that can be repaired by vulcanizing (hot repair) section work ▪ Exact specifications to be set by the buyer
Used Industrial Tires	▪ Assorted "Industrial Solid pneumatic," "Solid Press-on," and "Industrial Pneumatic" that have been inspected and are in reusable condition ▪ Acceptable sizes, brands and models are subject to agreement between the buyer & seller
Used Oversized Tires	▪ Assorted agricultural, industrial and OTR (Off The Road) tires that have been inspected and are in reusable condition ▪ Acceptable sizes, brands and models are subject to agreement between the buyer & seller
Other Used Tires	▪ Any other assorted used tires not included in the listed grades

Source: The Recycler's Exchange at http://www.recycle.net/Rubber/used/index.html

Key Players

Table 4-2 lists businesses known to be participating in the tire reuse market in New York. Each of these businesses also moves scrap tires to other end use markets, as described elsewhere in this report.

Table 4-2
Key Players in New York State Tire Reuse

Entity	Location
Casings, Inc.	Catskill, NY
Tire Trader	Deer Park, NY
Border Tire	Spencerport, NY
Meridian Tire	Plainfield, CT
Don Stevens Tire	Southington, CT
Lakin Tire East	West Haven, CT

Supply Considerations

Traders indicate that there is a strong supply of reusable tires that are discarded. Many people purchase tires in pairs or quads, when one or more of the existing tires are still in good condition. Used tires are received for little or no money by the tire dealers interviewed. One respondent indicated that he could probably be paid to take the tires, but he didn't want them to be considered a waste material, so he did not accept payment for taking delivery of them. One interviewee indicated that he purchased a significant number of tires from fleets, such as police departments and the government, who tend to discard tires before they are fully worn. One reseller indicated that he imports a significant number of specialty tires.

Tire reuse companies generally accept all tires from their suppliers. (However, stockpiled tires are not suitable for reuse markets.) The suppliers simply do not want to spend the resources to cull through tires, and prefer to let others do so. One trader indicated that he imports containers of used tires for resale, often reselling them to buyers in foreign countries, or out-of-state.

Large-scale resellers tend to have their own transportation network in place, and may have contracts with suppliers, such as auto repair shops and car dealerships. Sometimes the resellers have several locations where they resell tires. Several interviewees indicated that the reuse tire market is strong in inner-city locations.

Payment arrangements vary depending on the source, quality of tires, and other terms. One reseller indicates that he pays nothing or very little for the tires he receives. Another indicates that he pays nothing for the tires, and collects them for no fee. Others, however, collect large quantities of unsorted tires from generators and, as described in Chapter 3, receive a fee of up to $1.50 per tire, with an additional fee charged for handling larger tires.

Demand Considerations

Demand for used tires that are still reusable is strong in New York and in other markets. Traders indicate that their products are sold nationally and, in some cases, internationally. Specialty and odd-sized tires are especially likely to be shipped for reuse. Anecdotally, some markets will specifically request used tires with virgin casings (i.e., those that have never been retreaded) that have no structural casing damage or weather cracking. These tires, once fully worn, are the best candidates for successful retreading and therefore provide the best value to the consumer. Recycle.net, a web site sponsored by Recycler's World, a worldwide business-to-business Internet marketplace, is one forum in which buyers and sellers can post tires needed or wanted. According to the site, international markets for reusable tires include: Ireland, United Arab Emirates, Trinidad/Tobago, Russia, India and Brazil, Malaysia, Poland and Romania.

In New York, interviewees indicate that passenger and light truck tires sell for $40 or less for a set of four (generally $2 to $5 each). Medium truck tires sell for $5 to $50 each, and specialty and OTR tires sell for $50 to $200 each. Used tires compete directly with new tires. They offer a lower quality tire for a lower price, therefore markets are generally stronger for more costly tires, specialty tires, and hard-to-find

sizes. Markets also are generally stronger in lower income regions, such as domestic inner-cities and developing countries. Lower grade passenger tires and medium and heavy truck tires are often used for retreading.

Trends and Factors Affecting the Market

The demand for used tires is increasing. Industry experts indicate the following factors driving this trend:

- The relative cost advantage of used tires compared to new tires is becoming more favorable, as new tire prices increase along with the price of oil.
- Due to a tight economy, consumers are seeking cost-cutting measures.
- Automobile leasing is increasing, and leasers sometimes seek the lowest cost, acceptable tires to replace worn tires at the end of their lease.
- There is a growing use of all types of tires in developing countries.
- The use of the Internet and trading sites (such as Ebay) have made selling tires more efficient and broadened the market nationally and internationally, particularly in the case of specialty tires and hard-to-find sizes.

Competition over the supply of scrap tires may hamper increased reuse. Factors driving this trend include:

- Even though reusable tires have much higher value than most other end uses, some shredders, chippers and ground rubber producers are competing for supplies, especially for large truck and OTR tires that may otherwise be reused. These processors are increasingly establishing national supply networks, often by passing tire resellers that currently sort and grade tires for reuse.

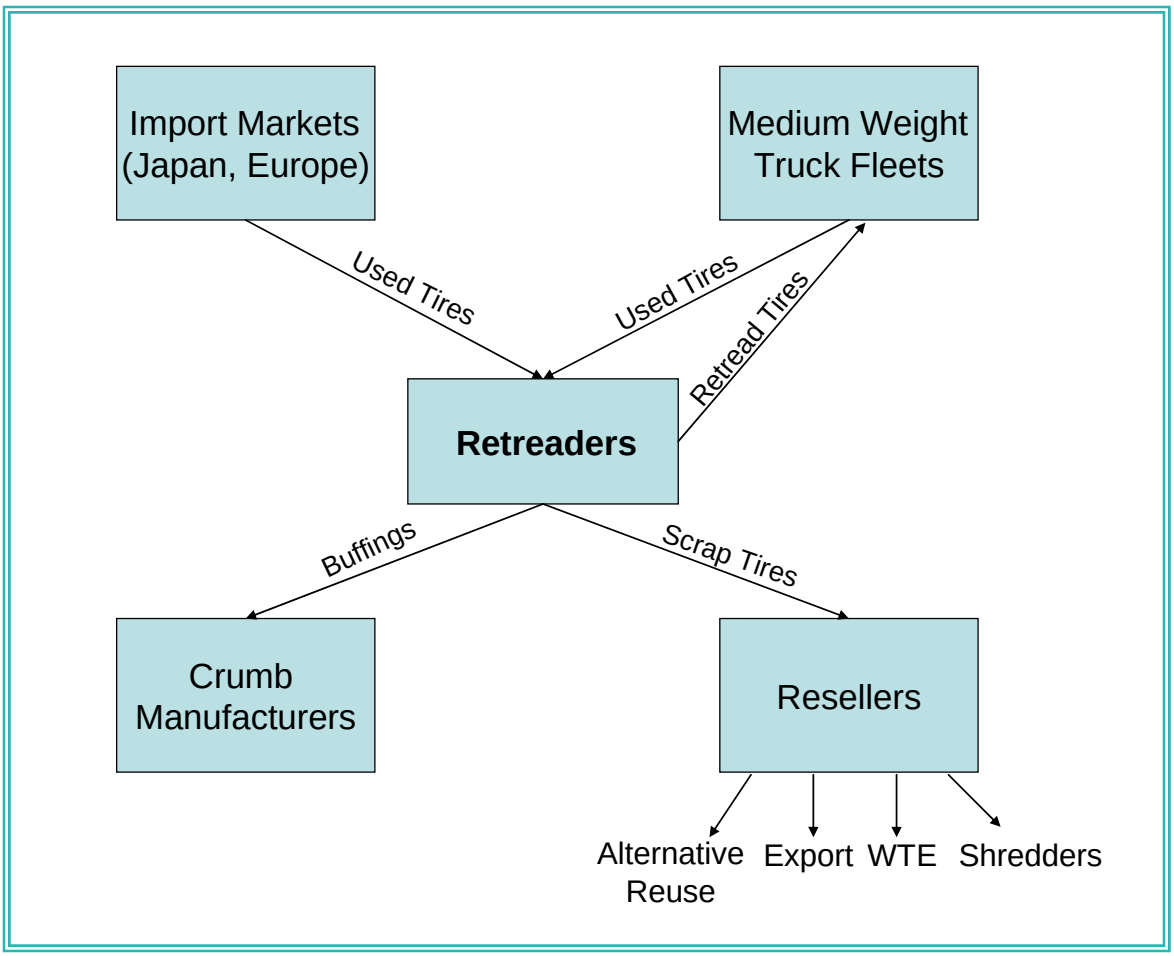
4.3 Retread Tires

R.W. Beck estimates that just over 4,000 tons of New York-generated scrap tires (400,000 PTE) were retreaded in 2003. However, there are a relatively large number of companies involved in retread markets, some of which are dealers and do not actually process tires. Appendix D lists 42 companies involved with retreading. Furthermore, many retread operations buy and sell tire casings across state lines. For these reasons, estimating tire flows is difficult, and R.W. Beck's estimate may be low. Nationwide, a total of 16.5 million retread tires (165,000 tons) were shipped in 2003, of which 94 percent were medium truck tires. Only 775,000 retread passenger and light truck tires (7,750 tons) were shipped (less than 0.3 percent of total shipments). Retreading is far more common for commercial and heavy off-the-road tires.[2] Nationwide, retreading increased sharply in 2003, possibly spurred by cost-saving measures implemented to counteract increased fuel prices.

[2] *Statistics in this paragraph are from Factbook 2004: U.S. Tire Shipment Activity Report for Statistical Year 2003*, Rubber Manufacturers Association.

Tire retreading involves removing the tread of a worn tire, and affixing a new tread to the tire to extend its life. The flow of tires for the medium-weight retread market is illustrated in Figure 4-1.

Figure 4-1
Materials Flow of Retread Market



For most passenger tires, retreading is no longer considered to be cost-effective, as passenger tires have actually become relatively less expensive to manufacture and purchase than retreads over the past thirty years. An exception is fleets owned by governments and other large institutions, which sometimes contract for retread tires. Retreading remains highly economical to truck and industrial tire consumers. Tires that are partially worn, especially airplane tires, medium truck tires and OTR tires, are frequently retread. To be retread, the tire casing must be in good condition and the tread worn down but intact. According to the Tire Retread Information Bureau (TRIB):

- Retreaded truck tires represent a savings of over $2 billion dollars annually for truckers and trucking companies in North America.
- Of the nearly 34 million replacement tires (340,000 tons) purchased by fleets in 2003, more than half were retreads.

- Nearly 100 percent of the world's airlines use retreaded tires, and 80 percent of the tires used by the commercial aviation industry are retreaded tires.
- Nearly 100 percent of off-the-road, heavy duty vehicles use retreaded tires.
- In addition, retreaded tires are commonly used by school buses, municipal vehicles, federal and military vehicles, including U.S. Postal Service vehicles, trucking fleets, fire trucks, taxi fleets, race car drivers, and farm vehicles.
- Passenger car owners also use retreaded tires.

Some scrap tire dealers interviewed for this project indicate that passenger tires with intact casings that are shipped to Canada and Central America may be retread, as opposed to reused. One trader estimated that 20 percent of the tires exported, at most, are retreaded.

The Retreading Process

The retreading process entails inspecting a tire casing to insure that it is still usable, and adding a new tread to the tire to extend its life. Used tires are visually inspected, placed on a buffing machine and inflated. The tire is rotated while an operator uses a buffing rasp, a lathe-type instrument, to scrape existing tread off of the tire. Next, any needed repairs to the casing are made. A new tread is then affixed to the buffed surface, using heat and pressure. The process produces buffings as a by-product, which are commonly blown into a tractor trailer, and sold to ground rubber markets (as described in Chapter 5). Retread buffing dust competes with the material produced by ground rubber producers who process whole tires. The casing is shaped to specified dimensions, and those with reusable casings are selected for retreading.

There are several different manufacturing techniques, which are generally franchised technologies. In general, however, there are two types of processes: the mold cure process and the pre-cure process. The mold cure process involves adhering uncured tread to the tire via heat application during a curing process that takes place in a mold. The pre-cure process involves adhering a pre-cured tread to the tire using adhesives, then curing the gummy adhesive layer via heat and pressure in a chamber.

After the tires are retread, they are inspected. If they pass inspection, they can be painted and labeled for resale. Retread tires are labeled with serial numbers that make them traceable to the manufacturer.

Supply Considerations

In general, the supply of tires to be retread is large, as most medium-weight truck tires with sufficient casing are retread, and most aircraft tires are retread. This is because there is financial incentive to do so. The federal government issued 40 CFR Part 253 in 1998, which states that all federal, state, county, and municipal agencies that receive federal dollars must use retreaded tires on their vehicles, however very few passenger and lightweight truck tires are actually retread in this country, even government vehicles. That is because passenger tires are relatively inexpensive, and tire manufacturers have programs in which they sell to government entities at below-retail prices. This results in these tires being relatively less costly to replace than retread. It

also results in partially worn tires being reused domestically, or exported to Canada, Central America, Mexico, or other countries for retreading, remanufacturing, or reuse.

Retreaders in New York indicate that most of their supply of tire casings is sourced regionally, up to about 250 miles. Because tires are bulky, it is generally not cost-effective to transport tires long distances to retread them. Many retreaders have franchise agreements that limit their operations to a specific geographic region for the franchise. Franchises often obtain national accounts with trucking fleets. Some retreaders do apparently import casings from Europe and Japan, where retreading is more limited.

Demand Considerations

The retread industry is unique in that the same market participant – trucking and commercial vehicle fleet managers, are on both the supply-side and demand-side of the equation. The market is self-equalizing, in this sense. Typically a fleet manager will contract with a local retreader or a national franchise for service. The retreader will service the tires, selling used non-retreadable tires and buffings to other market participants. Tires that are not suitable for retreading are generally not suitable for reuse, either, and are sold to shredders or chippers or waste-to-energy applications. In some cases these tires are culled for export to Mexico, Central America, or other nations.

The demand for retreading services, however, is generally stronger when fleet managers are faced with increasing budgetary constraints. In fact retreading is considered one of the most important steps a fleet manager can take to reduce fleet management costs. Increasing oil prices also spur demand for retreading, as retreading consumes far less oil than new tire production (it takes seven to eight gallons of oil to manufacture a new passenger tire, but only two gallons to retread it. Manufacturing a new commercial truck tire requires 22 gallons of oil, but retreading it requires only seven gallons).[3]

Retread tires compete with new tires and reusable used tires. Retreads are most cost competitive for higher value, specialized tires such as OTR, aviation, and medium weight truck tires. A retread tire costs 30 to 50 percent of what a new tire would cost. Medium-weight truck tires can cost in the $300-$350 range, and retreads can cost as little as $100 - $150. The trucking industry saves $2 billion per year by using retread tires.[4] Depending on mileage and casing wear, tires can be retread two or three times, on average. Vehicles that tend to drive straight highway miles, with little in-town turning, may be able to be retread up to eight times.[5] Retread tires are usually placed on the trailer, and the driving (or cab) tires are replaced.

Trends and Factors Affecting the Market

The retread market, like other scrap tire management sectors, is becoming increasingly consolidated and vertically integrated. Some of the most efficient retreading systems

[3] Ibid. P. 5.
[4] "Understanding Retreading," International Tire and Rubber Association Foundation, Inc. 2001, p.5.
[5] Telephone interview with Harvey Brodsky of the Tire Retread Information Bureau, November 18, 2004.

are owned by tire manufacturers or other national firms. Through franchise agreements, these technologies are licensed to firms that tend to out-compete independent, local retreaders.

The number of tires being retread in New York may be expanding. Increasing oil prices are driving increasing rubber and fuel costs, both of which encourage fleet managers to be creative in cutting costs. The majority of fleets utilizing medium truck tires currently do retread tires as a best management practice; however some fleet managers may have been hesitant in the past to use retreads, fearing that they were inferior in some way.

4.4 Tire Reuse Emerging Technologies

The Tweel

The *tweel* technology described in Chapter 3, if widely adopted in the future, could potentially lead to a resurgence of passenger and light-truck tire retreading in the mass market. The technology combines the wheel and rubber tire and, because it is airless, eliminates the possibility of flat tires. According to its developer, because of the way it is manufactured, it can be retreaded many times and restored to a like-new condition. Its widespread commercial application is many years off, however.

Green Diamond Tires

A new technology, currently being used to remanufacture passenger and light-weight truck tires in Canada, is soon to be operational in New York. Twin Tier Tire of Horseheads, New York has established Green Diamond Company, having been granted a license for using this technology, which was originally developed in Iceland. In the patented Green Diamond process, Twin Tier will take in worn tires, remove the outer rubber from both sidewall and tread (this ground rubber is resold), inspect the inner structure or core for integrity, apply new sidewall and tread, and remold the tire, using a similar process to making new tires. The remanufactured tires are unique due to the application of carbide granules in the tread, allowing for significantly added traction as the tread wears. As these tires are discarded, if wearable tread remains, they will not be suitable for shred and chip operations. Green Diamond expects to begin manufacturing at the New York plant in early February 2005, and reach full production by April. This business will also increase demand for used tires in New York.

Chapter 5

MARKETS FOR GROUND RUBBER

Chapter 5
MARKETS FOR GROUND RUBBER

5.1 Overview of Ground Rubber Markets

Ground rubber (or crumb rubber) is particulate rubber derived from scrap tires. It is used to make a variety of products. R.W. Beck estimates that, in 2003, approximately 23,938 tons of New York generated scrap tires (2.4 million PTE) were used to produce ground rubber, representing about 11.5 percent of the total amount generated. Table 5-1 summarizes the markets for this material and presents rough estimates for the breakdown of markets in 2003. Gathering detailed market statistics for New York is difficult because ground rubber producers are reluctant to discuss customers due to the highly competitive nature of the industry. Furthermore, ground rubber is sold into a large number of end use markets, and contacting all known markets was not possible given the time and resources available for this project. The ground rubber market in the Northeast is currently dominated by athletic surfacing and horticultural uses, which have experienced relatively strong growth in recent years. The second largest market is the wide range of molded products produced. Three relatively high value markets have the potential for long term growth, but this growth has so far remained elusive. These include road construction applications, like rubberized asphalt, use of ground rubber in new tire manufacture, and rubber-plastic compounding. R.W. Beck estimates that in 2003, none of these relatively high value markets constituted more than 3 percent of total ground rubber production derived from New York scrap tires.

Nationally, the market breakdown looks somewhat different, in part because it is influenced by comparatively large use of rubberized asphalt in such states as California, Arizona, and Florida. According to the Rubber Manufacturers Association, in 2003 about 20 percent of all ground rubber was used in asphalt and sealant markets (classified as road construction applications in this report), about 35 percent in molded products, about 30 percent in sports surfacing and horticultural, about 2 percent in surface modification (classified as rubber-plastic compounds in this report), and about 4 percent in animal bedding products (which are classified as either molded products or horticultural in this report, depending on how they are produced).

Table 5-1
Overview of Markets for Ground Rubber Derived from New York Scrap Tires

Market Category	Approximate 2003 Market Share (Total = 23,938 tons)	Market Activity in New York State	Outlook
Road Construction	< 3%	Limited demonstration projects conducted by DOT.	Continued zero to very low level use in New England markets. Potentially large growth remains at least 1 to 2 years away.
New Tires	< 3%	Goodyear Dunlop tire manufacturing facility in Buffalo probably uses some recycled rubber (not more than 5%). No New York based producers currently supply the plant.	National demand stable at very low level.
Athletic Surfacing and Horticultural	60% to 90%	Growing demand by local governments and private sports facilities, and horse arenas.	Continued moderate to rapid growth.
Molded Products	10% to 30%	Stable demand by a range of manufacturing facilities.	Continued moderate growth expected.
Rubber and Plastic Compounding	< 3%	Limited activity by compounders.	Steady demand at this level. Large growth potential remains elusive.

Source: R.W. Beck

The remainder of this Chapter summarizes these markets for ground rubber. Sections 5.2 through 5.6 cover each major market category: road construction, new tire manufacture, molded products, sports surfacing, and horticultural and rubber-plastic compounds, respectively. Section 5.7 discusses emerging technologies related to ground rubber markets.

5.2 Road Construction Applications

Overview

Tire recycling advocates have long championed the use of crumb rubber in road construction projects, especially in asphalt paving mixtures. Ground rubber can be used in a variety of rubberized asphalt applications. Additionally, other potential uses are under development, such as spray products, sealants, and highway sound barriers.

If economic and other barriers can be overcome, the market potentially holds the promise of creating strong demand for relatively high value ground rubber in the 40 mesh range.

After years of very slow growth, the road construction market for ground rubber has seen some success in a few warm weather states like California, Arizona and Florida. Unlike cold weather states like New York, these warm weather states primarily use open-graded pavement mixtures, for which use of recycled rubber is relatively well developed. For example, the California Department of Transportation used over 6 million PTE in rubberized asphalt concrete projects between 2000 and 2004, including nearly 2.7 million PTE in 2000 alone.[1] The Arizona Department of Transportation has used over 15 million PTE in rubberized asphalt projects since 1988,[2] and has recently launched a three-year program to surface all continuously reinforced concrete expressways in the Phoenix area with asphalt-rubber open-graded asphalt pavement. And Florida, the only state specifying rubber modified asphalt for friction course pavement in state maintained roads, uses about 1.5 million PTE annually.[3] Nationwide, the Rubber Manufacturers Association estimates that about 59,000 tons of ground rubber (5.9 million PTE, or 20 percent of total ground rubber production) were sold into road applications markets in 2003.

Production Process

As illustrated in Figure 5-1, scrap tire-derived ground rubber is used in asphalt products in two very different ways. In the wet process, ground rubber is incorporated into the asphalt binder itself prior to being mixed with aggregate to form road surface. The wet process is used extensively in some states and appears to have the highest potential as a consistent market for scrap tire derived ground rubber. In the dry process, ground rubber is combined with, or used in place of, dry aggregate stone immediately prior to being mixed with asphalt binder to form hot mix asphalt concrete. The NYS DOT experimented with the dry process, and like many other states, results were not successful.

At least two Northeast asphalt contractors, Citgo Refining, Inc. (NJ) and Hudson Asphalt (RI) have the capacity to supply performance grade binders containing recycled tire rubber, satisfying NYS DOT's established specifications.

[1] California Department of Transportation.
[2] Rubber Pavements Association.
[3] Florida Department of Environmental Protection.

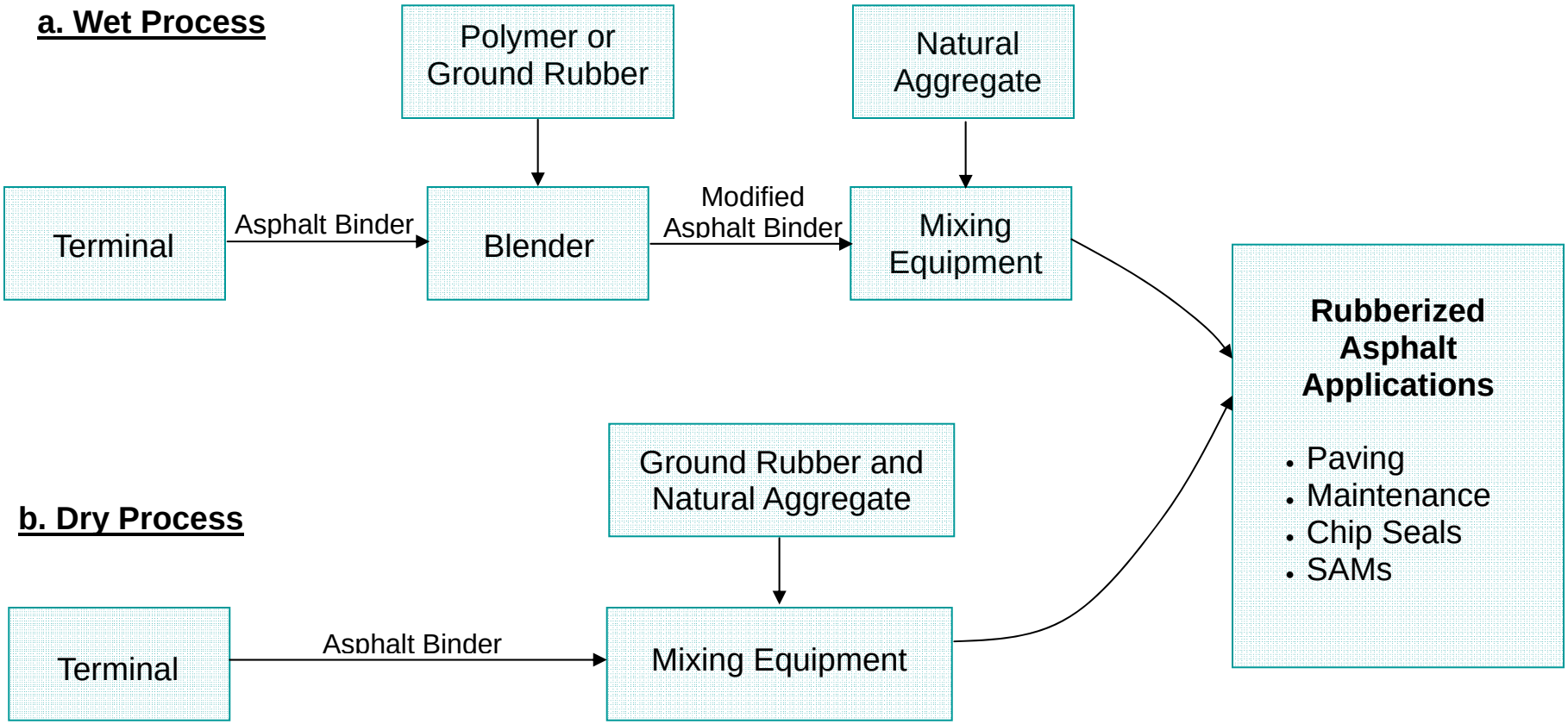


Figure 5-1 – Rubberized Asphalt Flow Diagram

Supply Considerations

Ground rubber destined for use in road construction applications must satisfy stringent specifications. It must be approximately 40 mesh and be consistently free of metal and fiber. One New York ground rubber producer reports that it is currently selling small quantities of ground rubber into the asphalt market in Rhode Island. New York's other ground rubber producers could potentially compete for supply contracts to fuel this market, should it grow. Several other regional ground rubber suppliers could also compete for such supply contracts.

Demand Considerations

Like many states, relatively little rubber modified asphalt has been used in New York to date. However, the NYS DOT has been and is engaged in activity that could help to grow the market in the future. (Also, as discussed in Chapters 3 and 6, NYS DOT is poised to use large quantities of shredded, stockpiled waste tires as light weight aggregate in road construction projects.)

Between 1989 and 1994, DOT experimented with four dry process installations, all of which failed, and one wet process installation. The wet process installation was successful, and by far the easiest for producers and contractors to deal with. This test pavement was constructed with 10% recycled tire rubber in the base, intermediate and top course.

New York's standard specifications allow the use of recycled tire rubber in any of the performance grade (PG) binders used in the state. Performance grade binders containing recycled rubber do provide benefits; however, the main barrier to increased use of recycled rubber is that it is currently more expensive than PG binders made with polymers, which provide similar benefits. A Canadian supplier provided PG binders for a project in northern New York containing recycled tire rubber, and after 5 years the pavement is performing well.

Use of rubber modified asphalt in New York is constrained, as in other cold weather states, by the fact that open-graded paving mixtures are rarely used. This means that the state cannot use the rubberized asphalt products and specifications that are most common in California, Arizona and Florida, the three largest consumers of rubberized asphalt. No cold weather state is known to have used rubberized asphalt extensively, although an aggressive program of testing and market development is underway in Alberta, Canada that could help inform New York's efforts.

Also, New York is participating in a project sponsored by the National Cooperative Highway Research Program of the US Transportation Research Board, with the objective of recommending design, construction, and maintenance guidelines that will maximize the advantages and minimize the disadvantages associated with permeable friction course (PFC) use. A PFC is a highly permeable mix containing polymer-modified asphalt or asphalt-rubber, and fibers--alone or in combination. The project is still pending as of January, 2005 and is expected to be completed in 16 months. If successful, this research project could give a boost to the use of recycled tire rubber in cold weather paving environments like New York. NYS DOT has expressed an

interest in conducting additional tests of pavement mixtures containing recycled tire rubber.

Trends and Factors Affecting the Market

Demand for New York generated ground rubber in road construction applications is not expected to grow substantially in the short run, although there is modest potential in the long term.

Factors moderating the use of ground rubber in road construction projects include:

- The results of the national Transportation Research Board project, which New York is participating in, may facilitate the use of recycled tire rubber in paving projects in cold weather states. The project is expected to be complete in 2007.
- Performance grade binders made with recycled tire rubber are currently comparatively expensive compared to those made with polymers. This may change if oil and polymer prices continue to rise.
- The performance benefits, concerns and long-term economics of using paving mixtures made with recycled tire rubber are still under investigation, especially for those mixtures most commonly used in cold weather states like New York. If performance and economic benefits are well documented, use of rubber modified asphalt may grow in the state.

5.3 New Tire Manufacture

Overview

Ground rubber is currently used in relatively small quantities in the production of new tires. Because it is not devulcanized (see Section 5.7 below), the recycled rubber is used as filler, and not as a direct substitute for virgin synthetic or natural rubber. Only one tire manufacture is located in New York, Goodyear Dunlop Tire North America, Ltd., a subsidiary of the Goodyear Tire and Rubber Co., located near Buffalo in Tonawanda. This plant produces passenger, light truck, bus, and motorcycle tires. According to company representatives, the plant probably consumes some ground rubber, but the exact quantity is not available. Neither could the company identify sources of recycled rubber used at this plant. However, no New York ground rubber supplier is known to sell to tire manufacturers at this time. A small quantity of New York generated tires sold to out-of-state ground rubber producers may find its way to this or other tire manufacturing plants, but this amount is probably less than 3 percent of the total amount of ground rubber produced from New York generated scrap tires. A representative of Goodyear stated that recycled rubber can account for up to 5 percent of total raw materials use in their value line tires (those that are not marketed with high mileage warranties). However, in higher performance tires the amount of recycled rubber is much less than 1 percent. Nationally, according to the Rubber Manufacturers Association, the amount of ground rubber used in new tire manufacture has increased from about 0.5 percent to about 5 percent of rubber raw materials. In

2003, RMA reports that about 9 percent of all ground rubber produced nationally flowed into this market, or about 26,000 tons (2.6 million PTE).

Two recent studies have examined the potential for using recycled rubber in new tire manufacture. First, Continental Tire North America, Inc. participated in a project conducted in conjunction with the North Carolina Department of Environment and Natural Resources. The study examined the feasibility of using up to 13 percent recycled content in tires (including recycled rubber from scrap tires, pre-consumer industrial scrap rubber, and other non-rubber recycled materials like recycled steel). The study found that recycled rubber can technically be used at levels of up to 13 percent, but that there is a direct relationship between increasing recycled content and reduced performance (e.g., increased rolling resistance and reduced tire life). According to a representative of Goodyear Dunlop, for every 1 percent of content used, there is a corresponding approximate 1 percent reduction in performance. The Continental Tire study also found that additional concerns further complicate the commercial viability of increasing recycled content, including reduced tread life and wet traction, as well as higher rolling resistance. These are the primary reasons recycled content is often restricted to the value line tires with relatively low mileage ratings. Another concern expressed by tire manufacturing companies is the ability to secure sufficient quantities of high quality ground rubber meeting their stringent specifications consistently over time. One broker commented that he could probably increase his sales of ground rubber to tire manufacturers if more high quality ground rubber was consistently available on the market.

The second recent study on using recycled rubber in new tire manufacturing was released by the California Integrated Waste Management Board in May 2004. The study was conducted by the Nevada Automotive Test Center. One finding is that it was very difficult to document the actual amount of scrap tire-derived ground rubber used in new tire production. This is partly because manufacturers are reluctant to disclose details of their production process, and also because it is difficult to know when reported recycled content was ground rubber and when it was other materials, such as pre-consumer industrial scrap or recycled steel used in wire and belts.

The study included a cost-benefit analysis that found there are wide variations in the cost, quality, and supply of fine ground rubber of the type needed in new tire manufacture (i.e., at least 80 mesh). Furthermore, the study confirmed the technological and economic barriers to increased recycled content use in new tire manufacture, both on the supply and demand side. The study concluded that, to increase the use of recycled content rubber in new-tire production, extensive efforts would be required to standardize, improve the quality of, and streamline recycling processes. Furthermore, the study states that, while isolated technological advances in processing methods do exist that may help increase the recycled content of new tires, most remain at a research and developmental stage, and there is little confirmed information on their commercial feasibility.

Supply Considerations

Ensuring an adequate supply of high quality ground rubber is an important concern related to increasing recycled content in new tires. Suppliers must be able to provide

at least 80 mesh product, and even as high as 200 mesh or higher, with strict limitations on contaminants. Very few suppliers can currently achieve this level. Furthermore, in the future suppliers wishing to sell raw materials to tire manufacturers may need to be certified according to the ISO 9000:2000 standards for quality control and management. According to *Scrap Tire News*, so far only two U.S. ground rubber suppliers have achieved this certification: PolyVulc USA Inc. (Vicksburg, MS) and Edge Rubber Pennsylvania L.S.C. This requirement stems in part from tire manufacturers concern over quality supplies and also from their concern over potential liability costs.

Demand Considerations

The main considerations pertaining to demand by tire manufacturers are related to supply (discussed above) plus cost, performance, and liability issues related to using recycled rubber feedstock. There is apparently very little cost advantage to using recycled rubber, since the rubber constitutes a relatively small percentage of overall tire production costs. This may change, however, if oil prices continue to rise and are sustained at high levels. Performance has been documented to decline with increasing recycled content, at least using current technologies. And finally, tire manufacturers are very sensitive to anything that could potentially expose them to liability or customer concerns over safety. While there has been no evidence that increased recycled content make tires less safe, the mere fact that recycled content is a new innovation makes risk adverse tire manufacturers cautious about its use. This is especially true in the wake of the major recalls that rocked the tire industry several years ago. A final issue related to performance is that, as recycled content increases, the rolling resistance of the tire may also increase. This results in less fuel economy and reduced tire life time.

Trends and Factors Affecting the Market

Use of ground rubber in new tire manufacture is expected to remain steady at its relatively low level. This is due to the factors discussed above, including poor economics, poor performance, and concerns over adequate supply and potential liability issues. Nevertheless, there may be room for high value ground rubber producers to increase their sales to tire manufacturers and to secure a niche in this potentially lucrative market. Since New York is not currently home to any producers of super fine ground rubber, new investments would be required to seek entry into the new tire market.

5.4 Athletic Surfacing and Horticultural Applications

Overview

In this report, this market category is broadly defined to include a wide range of ground rubber products and applications, including sports fields, turf dressing, playgrounds, outdoor surfaces, horse arenas, and landscape applications such as mulch. This is the fastest growing ground rubber market sector. R.W. Beck estimates

that it currently accounts for about 60 to 90 percent of all ground rubber produced from New York generated scrap tires. Some products in this sector, for example mulch and playground bark, may have specifications as large as ¾", and a number of shredders and chippers are competing with ground rubber producers to supply this product.

Perhaps even more than other ground rubber market sectors, this market is highly competitive and producers are reluctant to discuss specifics regarding their product specifications and customers. Several market players interviewed stated that there are some suppliers who are purporting to provide a product of a much higher quality than they are actually able to, and that this has the potential to negatively impact the overall market prospects, including those of higher end producers.

Nationally, the Rubber Manufacturers Association estimates that about 26 percent of all ground rubber produced in 2003 (76,000 tons or 7.7 million PTE) was sold to sports surfacing markets, and that an additional 4 percent (11,500 tons or 1.1 million PTE) of production was sold to horticultural markets. Examples of products in this broad market category include:

- **Playground surfacing**. This product can be applied in three ways. The first is as loose material with a specification of ¼" to ¾" that may be sold in black or other colors. The second is coagulated rubber emulsion that is poured in place in a similar manner to concrete. Pour in place products use finer ground rubber and are combined with a binder, usually a safe inert polyurethane liquid. The third way is as a pre-formed tile. The material is used in place of natural bark and other surfaces in children's playgrounds. It has been documented to provide superior safety and longevity characteristics, and can increase access to playgrounds during rainy periods.
- **Running track surfacing**. Similar to playground surfacing, in this application ground rubber provides increased resiliency and increases impact attenuation.
- **Mulch**. This product may have similar specifications as playground bark, and is sold to landscapers to replace a range of natural mulches. Like playground material, it can be dyed to virtually any color, including wood like colors. Two factors are driving use of ground rubber mulch. First, demand for wood chips (the traditional mulch material) as fuel in pulp and paper mills and other combustion facilities is growing. Second, ground rubber mulch lasts much longer, since it does not degrade.
- **Sports turf dressing**. This product may have specifications of 10 to 30 mesh. The dressing is added to artificial turf fields to decrease compaction and increase safety, and to natural turf fields to enhance performance in wet weather and to protect grass crowns.
- **Horse arena footing**. This product may have specifications of about 10 mesh. The superior safety and cushioning properties of ground rubber are a major advantage in this market.

New York companies involved in installation and sales of these products include:

- **Child Safe Products Inc.** (Amityville, NY) manufactures and distributes playgrounds and running track surfaces.
- **North Brook, Inc.** (Weedsport, NY) manufactures playground surfaces, horse arena footing, running tracks and cow mattresses. (Much of their rubber raw material is not derived from scrap tires.)
- **Safeguard Surfacing** (St. James, NY) manufactures pour in place and loose playground surfaces and exercise mats.
- **Surface America** (Williamsville, NY) is a subsidiary of Dodge Regupol. The company sells pour in place rubber surface systems.

Supply Considerations

The products in this market category have relatively forgiving specifications compared to other ground rubber markets. They also represent the largest growing market sector for ground rubber. Consequently, there is strong competition in these markets, including in some cases by tire shredders and chippers who do not have the capacity to produce a finer ground rubber product. While the market is growing, there is apparently an oversupply of product. This is likely to change in coming years as the number of producers declines through consolidation, and as the market becomes more mature.

Demand Considerations

Many of the products in this category have distinct performance advantages over their competing non-recycled products. In many cases, this fact has a greater influence on customers than the potentially higher prices. A key consideration in boosting demand is the need to educate potential customers about these new products, especially about their potential benefits. Customers may have reservations about potential negative environmental consequences of using scrap tire products. No environmental health concerns have been documented to date, however.

According to the New York State Council on Scrap Tire Management and Recycling, there are 712 local school districts in the state that could potentially become a customer for rubber playground products, in addition to numerous local parks, colleges and universities and other sporting facilities. In some states, state grants to purchasers have largely contributed to growth in this market. Ford Motor Company has provided $10,000 grants to schools and parks for artificial turf produced with ground rubber, including to several handicap-accessible parks in and near New York City.

Trends and Factors Affecting the Market

This broad market category is expected to continue to grow moderately to rapidly in coming years. Producers will continue to compete over this market share fiercely. Factors driving this trend include the superior safety and functional performance of rubber products over competing products, and an oversupplied marketplace that is driving aggressive price and marketing competition.

5.5 Molded Products

Overview

Like athletic surfacing and horticultural products, the molded products market category is broadly defined. It includes a wide range of products made in molds that incorporate a portion of ground rubber as raw material. R.W. Beck estimates that this is the second largest ground rubber market in the Northeast, accounting for about 10 to 30 percent of all ground rubber produced from New York scrap tires. Nationwide, the Rubber Manufacturers Association estimates that in 2003, molded products accounted for about 35 percent of all ground rubber produced (102,000 tons or 10.2 million PTE).

Molded products are made by forming ground rubber (along with other raw materials) into a given shape, typically bound by an adhesive material like urethane or epoxy. Examples of molded products produced with ground rubber include:

- Wheel chocks,
- Speed bumps,
- Traffic cone base,
- Roofing tiles,
- Carpet underlay,
- Flooring material,
- Mats,
- Dock bumpers,
- Railroad crossing blocks, and
- Roof walkway pads.

As discussed in Section 5.6, ground rubber can also be formed into compounds with polymers to further expand the range of products that can be produced, including a number of molded and extruded products.

New York companies involved in molded product production that use recycled ground rubber include:

- Enviroform (Geneva, NY) produces a range of molded products including wheel stops, speed bumps, wheel chocks, dock bumpers, playground mats, brick mats and others.
- Unity Creations, Inc. designs and manufactures safety surfacing products from tire-derived rubber and a urethane binder. Although Unity also resells some tire crumb, the majority of their stated demand of 100,000 pounds per year tire crumb is used to manufacture surfacing products. Unity Creations has received funding support from DED.

- Buffalo Polymer Processors, Inc. has innovated various rubber plastic compounds (discussed in Section 5.6 below) and also has developed the capacity to produce a line of slate roofing tiles made with rubber, plastic, and wood blends as well as interlocking floor tiles. Buffalo Polymer has also received funding support from DED.
- Rubber Sidewalks, Inc. is headquartered in California, but is currently investigating siting a facility in Elmira, NY. The company is part of a consortium that produces rubber sidewalks, a modular, rubberized asphalt paving tile that can be lifted and replaced as needed, as well as other molded products.

Supply Considerations

Many molded product manufacturers require ground rubber of about 10 to 20 mesh, with quality specifications that are easier to achieve than those of finer ground rubber markets like rubberized asphalt or new tire manufacture. Nevertheless, quality and consistency are hugely important and, as with other ground rubber markets, are an ongoing concern to molded product producers. Some New York molded product producers indicated they do not currently purchase supply from New York sources due to quality concerns. Some also prefer to use post industrial scrap since it is a more consistently high quality material. New York ground rubber producers, however, are able to meet these specifications and do sell into this market, and would probably be able to increase their supply significantly should this market sector grow.

Demand Considerations

Growth in demand for ground rubber by molded product manufacturers has remained stagnant for several years. The primary considerations in increasing demand involve the lack of a strong economic incentive to switch from virgin rubber raw material, concerns over supply quality and consistency, lack of understanding and familiarity over ground rubber, and concerns over performance and customer acceptance. According to the report of the Council on Scrap Tire Management and Recycling, there are about 303 rubber product manufacturers in the state that may be candidates for using recycled ground rubber. Only a very small fraction of these would be expected to be able to convert to using ground rubber as feedstock.

Trends and Factors Affecting the Market

Demand for ground rubber by molded product manufacturers is expected to grow modestly in coming years. This modest growth will be driven by ground rubber producers' marketing efforts, and tempered by a lack of understanding about ground rubber by molded product manufactures, as well as concerns over supply quality and consistency, performance, and price.

5.6 Rubber and Plastic Compounds

Overview

Ground rubber can be combined with polymers to form thermoplastic elastomers (TPEs), a raw material with many unique and valuable properties. TPEs are combinations of single plastic resins such as polypropylene, polyethylene, polystyrene, nylons, polyurethanes, and polyesters, with natural or synthetic rubbers. These rubber-like materials were initially developed in the 1960s and 1970s, refined since then, and are now one of the highest growth segments in the plastics industry. Recent estimates of the size of the 2004 North American market are $1.06 billion per year.

TPEs have displaced traditional materials, such as natural rubber, largely because of easier processing and exceptional properties that can be tailored for many applications by adjusting the ingredients or formulation. The resulting combination maximizes the synergy between the strength and processing characteristics of plastics and the ductility of rubber. Markets for TPEs include automotive, industrial, household appliance, lawn and garden, electronics, hand and power tools, and sporting goods components.

To this point, the dominant rubber constituent has been synthetic materials such as ethylene propylene dimer (EPDM) and styrene-butadiene (SBR). However, the use of tire-derived crumb rubber in plastic products is an emerging and proven market offering value-added opportunities for crumb rubber. Recent developments in the plastics industry also bode well for using tire-derived crumb rubber – new rubber like materials called thermoplastic vulcanizates (TPVs), which favor the use of vulcanized rubbers.

While considered a market for ground rubber in this report, compounders may also act as ground rubber producers. Two New York-based companies were identified as players in the plastic-rubber compounding or TPE market. Alternative Rubber & Plastics, Inc. (Amherst, NY) is a grinder and distributor of scrap plastics and rubber. Buffalo Polymer Processors, Inc. (Holland, NY) purchases, formulates, and compounds scrap rubber and plastics and also manufactures imitation slate roofing tiles. The current demand for tire-derived crumb at these companies is less than 250,000 pounds annually, or well under 1 percent of total New York scrap tire generation. There are some barriers, to be discussed later, that have inhibited growth. Two other New York compounders potentially involved in scrap tire recycling were also identified. One, Polyblends of Brooklyn, is believed to be out of business. The other is H. Heller & Co. of White Plains.

There are a number of other companies outside New York that either make TPE compounds or directly manufacture products incorporating rubber into thermoplastics. For example, Advac Elastomers, Inc., in Brookfield, WI is a fully integrated producer of both treated rubber crumb and rubber-plastic compounds. Ten additional companies were identified nationwide, including:

- Schulman in Akron, OH;
- Advanced Elastomeric Systems, L.P., Detroit, MI;
- Dupont Dow Elastomers, Midland, MI;
- GLS Corporation, McHenry, IL;
- Kraton Polymers, Houston, TX;
- PolyOne Corporation, Cleveland, OH;
- RTP Corporation, Winona, MN;
- Solvay Engineered Polymers, Auburn Hills, MI; and
- Teknor Apex Company, Pawtucket, RI.

Depending on their level of integration, companies in this business will either produce a refined ground rubber and/or recycled plastic, a rubber-plastic compound, or a manufactured product. The ground rubber is specified to meet a certain particle size specification and is usually surface-coated to improve its processing. Compounds of rubber and plastic are sold in pellet form. They are produced by melt mixing a tailored formulation in an extruder. There are numerous finished products that can be manufactured from rubber/plastic combinations, such as the roofing tiles made by Buffalo Polymer Processors, Inc.

Surface coatings are generally applied in a high intensity mixer to ensure uniform application on particle surfaces. High intensity mixers are industrial strength and sized versions of counter top kitchen mixers. In some instances, coatings are sprayed onto the tire crumb particles. Extruders are used to produce both pellets and finished products. The most common type is a single screw design where a flighted screw rotates inside an enclosed barrel. The combination of conductive heat from outside heater bands and frictional heat melts and mixes the plastic-rubber feed and additives that make up the formulation. If the product has a shape conducive to extrusion (a long simple profile, such as sheet, hose, or lawn edging), it is directly produced. If not, the extruder output is forced through a strand die, cooled, and chopped or cut into 3/8” pellets for use in other manufacturing processes. In cases where extensive mixing is required from the extruder or for heat sensitive materials like polyvinyl chloride, dual or twin-screw extruders are used to either produce a product or pellets.

Supply Considerations

Compounders have expressed concern about the ability of ground rubber producers to consistently meet their specifications at an acceptable price. Currently ground rubber sold into the TPE market must be fine particle size, no greater that 20 mesh and, in some cases, finer than 80 mesh. The need for fine particle size is because plastic manufacturing equipment is not designed to handle large particles (20 mesh size is 0.0331”) and many manufactured parts are quite thin. Particle size distribution must also be uniform to ensure consistency of properties in the rubber-plastic compound or finished part. Ambient ground tire crumb is generally unacceptable for this market due to the jagged particles and wide particle size distribution.

Another supply side quality issue in this marketplace is variability of the rubber material in tire-derived ground rubber. Buffalo Polymer Processing indicated that the quality of ground rubber has improved but they still use a synthetic rubber (EPDM) because its properties are more consistent. The different formulations used in passenger tires vs. light-duty truck tires vs. industrial tires were a major factor in its decision to use the synthetic rubber. It illustrates the point that for certain markets there will have to be better separation of tire types and/or components prior to grinding, as well as better separation of the fabric and steel belts.

Demand Considerations

Rubber-plastic compounds most often compete with natural rubber and other "soft" or elastomeric plastic compounds tailored for durable applications where ductility, flexibility, and impact resistance are major attributes. The types of competing products are thermoplastic polyolefins (TPOs), thermoplastic polyurethanes (TPUs), very low molecular weight polyethylenes and ethylene copolymers, polyester elastomers, and styrenic elastomers. Each of these product types has unique sets of properties and can compete in limited markets. Most are niche applications, so the availability of recycled forms of these elastomers is quite limited. In some cases, the competition is 100 percent rubber compounds, which may contain recycled rubber as a component. Most Rubber/plastics compounds have a market value of $0.75 - $1.00 per pound, some specialized grades are higher. Market values went above this range in 2004, due to crude oil price increases, but are expected to return to the above level (or slightly higher) within the next 6-12 months. Buffalo Polymer Processing's imitation roofing tiles compete with tiles made from other synthetic materials: primarily asphalt, clay, and concrete.

The types of products within these markets are landscape edging, composting bins, automotive bumper strips and bumper pads, automotive interior trim parts, truck/SUV step pads, "soft-feel" surfaces for tool handles, office supplies, and lawn and garden equipment, caster wheels, tool/tackle boxes, equipment housings, soft toy components, and components in household appliances, such as floor/carpet cleaning products and kitchen counter top appliances.

The demand for and production of these products tend to be regionalized and centralized around an original equipment manufacturer, such as an automotive assembly plant or household appliance assembly operation. This minimizes freight costs and promotes just-in-time deliveries. In many cases, distances are 100 miles or less. If the finished product is a rubber/plastic compound or a highly nestable product, then customer locations can range widely. For instance, it is not unusual to ship rubber-plastic compounds to niche markets that are 500 to 1000 miles distant.

The price of high quality ground rubber sold into these applications as an impact modifier is about $0.25 -$0.30 per pound in truckload quantities, depending on quality (uniformity, cleanliness, and particle size distribution). This price assumes that the grade of ground rubber is pure enough to act as an impact modifier and, as a result, add value to the compound or product. If the properties of the crumb rubber are such that it acts solely as a filler, the market value falls below $0.20 per pound.

Key Trends and Factors Affecting the Market

Demand for finely ground rubber by rubber-plastic compounders is expected to remain relatively low, although there is the potential for strong growth in the long term. Factors affecting the market include:

- Crude oil prices are increasing. As indicated by Buffalo Polymers Processing and Alternative Plastics and Rubber, the cost of synthetic rubbers, such as EPDM and SBR, have risen significantly this year, anywhere from 50 percent higher to double the price in mid 2003. This can provide a wide cost advantage to tire-derived ground rubber if the material meets the required fine particle size and quality needs. Many analysts expect crude oil prices to remain above $40 per barrel at least through the end of 2005.
- Demand for TPEs is growing strongly. Over the past 10 to 15 years, as other markets matured, plastic resin companies and compounders began developing and improving resin chemistry and compound formulations to manufacture very soft, ductile materials. Their thermoplastic nature lent itself to very efficient processing into new products. In other cases, their cost, performance, and processing advantages over thermoset elastomers has provided a market advantage. Ground rubber of sufficient quality may be able to find niches within many TPE markets.
- A new series of products, thermoplastic vulcanizates (TPVs), are being introduced by several plastic companies to compete with virgin, vulcanized rubber in markets not currently reachable by TPEs. This would appear to be an additional value-added market for tire-derived ground rubber. These markets include under-the-hood automotive components requiring high temperature stability.

5.7 Ground Rubber Emerging Technologies

As described in this chapter, there are some potentially high value, high growth markets for finely ground rubber meeting strict specifications. Because of this promise, a considerable amount of effort is being expended in the development of new technologies with the objective of expanding these markets. This report does not attempt to comprehensively identify and characterize the range of technologies under development. However, the following sections briefly describe two technologies to illustrate the range of activity. The first, *Vestanamer* is a new product developed by a particular company, Degussa that may have a promising future in increasing the use of rubberized asphalt. The second, *Devulcanization*, is a process for altering the chemical properties of ground rubber in a way that facilitates its use in many applications, including the production of new tires. However, devulcanization has long eluded commercial success.

Vestanamer

Vestenamer is a semi-crystalline rubber developed by Degussa, a multinational chemical company. According to the company's web site, Vestenamer is a polymeric processing aid that can act as a plasticizer of rubber compounds in mixing and

manufacturing processes. Properties that make it a beneficial additive in rubber compounds include a low melting point, low viscosity, and the fact that it is cross linkable and facilitates vulcanization. The product is used as a processing aid in the manufacture of tires, profiles, tubes and other molded rubber products. It is also used to improve the properties of rubber plastic compounds.

One application of Vestanamer may prove particularly important to scrap tire recycling. It can be used in ground rubber mixes with asphalt at as little as 4.5 percent by weight. According to the Company's web site, Vestanamer can enhance rubberized asphalt by dispersing fillers efficiently, and by promoting compatibility and cross linking in the mixture. In addition, it reportedly reduces tackiness, allowing for earlier compaction of asphalt concrete with steel and rubber rollers at higher temperatures, saving time and money. These qualities can further improve the beneficial performance characteristics of rubberized asphalt, such as reduced cracking, rutting, and shoving.

Vestanamer has yet to be commercially adopted in rubberized asphalt applications in the U.S.

Devulcanization

All transportation tires are vulcanized – a process of treating rubber compounds with a cross linking agent (usually sulfur) to create permanent chemical bonds. These bonds or crosslinks result in a thermoset rubber product with enhanced elasticity, strength, thermal stability, and long life.

The development of devulcanizing technology has been ongoing for at least 25-30 years without commercial success. Earlier techniques involved pyrolysis, chemical and solvent treatments, and various combinations of temperature, pressure, and/or high shear mixing. More recently, ultrasound, microwave, "supercritical" gas and "organic" additive technologies have been explored.

The fundamental problem with devulcanization is that the task is very difficult and complex. The technology must not only break extremely strong chemical bonds, but it must do so selectively to be commercially viable. Other main barriers to the technology include:

1. **Feedstock variability**. Four or five types of rubber are used in each tire; car tires, truck tires, and industrial tires are not the same; and each manufacturer has preferred formulations.
2. **Product quality**. Tire formulations contain 8 to 12 different ingredients, each of which can interfere with the devulcanization process and/or interact with devulcanization products.

The end product of devulcanization is a non-homogeneous mixture of rubbers and chemicals that may require further separation. Operating cost data is difficult to obtain for these technologies, although some sources indicate the range is 40 to 50 cents per pound.

New York's experience with devulcanized rubber, although limited to a de-linking additive developed by a Canadian company, bear out some of the technological

hurdles. Tire Recycling Technologies, Ltd. in Lockport, NY considered licensing this technology in 2001. However, the treated crumb rubber was too sticky and had a large number of hardened particles that kept the material from being molded into products that require a smooth surface. It was also determined that the de-linking process created significant levels of air pollutants, hence commercialization would require costly air pollution control devices.

Based on R.W. Beck's analysis, industry and New York experience, devulcanization is, at best, a long-term technology. It is not yet commercially viable because the production of a homogeneous high-valued product has yet to be demonstrated.

Chapter 6

MARKETS FOR TIRE-DERIVED AGGREGATE

R·W·BECK

Chapter 6
MARKETS FOR TIRE-DERIVED AGGREGATE

6.1 Overview of Tire Derived Aggregate Markets

As the use of tire shreds and chips in engineering applications grows nationwide, the term *tire-derived aggregate* or *TDA* is increasingly being used to emphasize that this scrap tire material is a direct substitute for rock and other natural aggregate materials. This chapter provides a broad overview of tire derived aggregate markets. Following this overview, three sections describe the primary uses for TDA – in landfill, roads and septic tank applications, respectively. Tire derived aggregate is also used in a fourth market, landscaping applications such as mulch and playgrounds. This market is covered in Chapter 5 along with other markets for ground rubber, since ground rubber producers often sell into this market.

Beck estimates that in 2003 a total of 67,883 tons of TDA (6.7 million PTE) produced from New York generated scrap tires were used in civil engineering applications, the single largest use for scrap tires in the state. This accounts for about 32.5 percent of all New York scrap tires generated in 2003, compared to 19.4 percent of scrap tires used in engineering applications nationally (based on Rubber Manufacturers Association estimates). New York's TDA use was dominated by landfill applications due to one large ongoing project at the Seneca Meadows landfill. This project is expected to begin to taper after 2005 and end in 2006. No TDA use in 2003 was attributed to roads and septic applications. However, this will likely change in the coming year due to a newly adopted DOH policy allowing, for the first time, TDA in septic drainage fields, and the launching of large OGS/DEC waste tire stockpile abatement contracts involving the use of waste tires in DOT and Thruway Authority road construction projects.

Civil engineering applications involve the use of processed scrap tires in place of a conventional construction aggregate such as gravel, stone, and sand. However, in many areas of the country, including most of New York, the availability, inert character, and low cost of natural aggregate constrain the economic use of tire-derived aggregate as a substitute. The use of TDA is more cost effective in civil engineering uses in which the competing materials are more expensive engineered materials such as expanded foams.

Tire derived aggregate has several properties that make it a good technical candidate for civil engineering uses in conjunction with landfills, roads and septic system drainage fields. It has a low dry unit weight, on the order of 45 to 58 pounds per cubic foot as opposed to 100 to 125 pounds per cubic foot for natural soil aggregates. It is compressible under loaded conditions, which helps where lateral loadings need to be minimized; and it has excellent thermal insulation properties – about seven to eight

times better than soils. This is beneficial in New York, for example, where regulations require a landfill's primary leachate recovery system to be protected against frost.

Producers of lower-quality chip that contains significant amounts of protruding metal are limited to the local landfill market. For example, the only New York market for 4" tire shreds is currently landfill TDA applications, at a price of approximately $4 to $10 per ton. As quality increases, other markets open up and distance to markets can increase as margins can absorb shipping costs. One producer of landfill-grade chips in New York also sells landscape material to users in Ohio and Pennsylvania. Two inch chips that have had the metal removed might find uses in septic systems when and if that market opens in New York, or they may be sold as tire-derived fuel (TDF) for $17 to $25 per ton. If the smaller chips, ¼" to ¾", have all of the protruding metal removed and are graded to be consistent in size, they may be sold into the landscape chip market at around $200 per ton.

Numerous studies and demonstration projects have shown that TDA, when processed according to a strict specification and installed properly, has a minimal negative effect on the local environment. Most guidelines advise against placing TDA in a water saturated zone, to avoid possible water contamination with iron oxide and other metals and compounds found in tires. DOT plans to be very conservative in this respect with their use of TDA in road construction projects.

6.2 Tire Derived Aggregate in Landfill Applications

Overview

R.W. Beck estimates that nearly 32.5 percent of New York generated scrap tires (67,883 tons or 6.8 million PTE) were used as aggregate in landfill applications in 2003. Nationally, according to the Rubber Manufacturers Association, the amount of shredded tires going to the landfill market declined slightly from 10 percent in 2001 to 9.3 percent in 2003. As the overall number of landfills declines and larger, often out-of-state regional landfills become more common, the ability of local TDA processors to supply the landfill market may decline. This market may be replaced by new in-state markets if septic and/or road construction markets for annually generated scrap tire chips expand, or in the newly expanded New York TDF market. As stated above, currently in New York, the landfill TDA market is dominated by one major landfill construction project at the Seneca Meadows landfill that is expected to continue through 2006.

New York State encourages the use of TDA for use in landfill construction and operation projects through the provisions of DEC Regulations. This "equivalent design" provision states that waste materials used as "individual components of a landfill's liner and final cover systems" are allowed where they are documented to perform in the same manner as traditional materials and are within the landfill's environmental containment system. This provision thus grants these waste materials a "Beneficial Use Determination" (BUD), consistent with DEC Regulations, avoiding special permitting processes. The use of waste materials must be addressed in the landfill design process according to DEC guidelines, which stress compliance with

ASTM D 6270, Standard Practice for Use of Scrap Tires in Civil Engineering Applications.

The TDA used in landfill applications must satisfy relatively forgiving specifications. The material is typically either primary or secondary shredded material, and larger shreds can be mixed with chips. For some uses, the amount of bead wire protruding from the section is a concern, but mostly the steel and fiber are not prohibitive. The main concern is that steel pieces not protrude more than ½", a specification that can be met simply by keeping the shredder knives sharp. Landfill uses also limit the amount of ground rubber and fines that can be included. The specifications are designed to prevent possible combustion of layered shreds and chips, and allow for optimal drainage.

Tire shreds and chips have four specific uses in New York MSW landfill construction and operation: as components of the leachate collection and recirculation system (LCRS), the gas venting system, the final cover foundation layer, and as alternative daily cover. Additionally, TDA could potentially be used in the operations/select fill layer, but this is not currently covered under DEC BUD determinations. Except for alternative daily cover, which eventually becomes assimilated into the landfill waste, the shredded tires remain in place as components of the system in which they are installed. Additionally, shredded tires may be used at landfills as road surfacing, erosion control, embankments, and retaining walls; however, these are small-volume uses. These specific uses are described in more detail below.

Leachate Collection and Recirculation System (LCRS)

Tire shreds may be used as leachate drainage material provided they do not compromise the stability of the landfill. Compressibility is an issue here as well, since this material is at the bottom of the landfill system. The design engineer must work with DEC to ensure that the drainage layer is thick enough to endure compression by the waste load and still perform as well as natural aggregate. A typical leachate drainage layer is 12" to 18" thick.

Landfill Gas Collection and Venting

A landfill gas (LFG) collection system at a MSW landfill, if used, serves to collect landfill gases and to convey them to an outside location. Typically, LFG is collected and conveyed by means of horizontal layers, horizontal trenches, and vertical boreholes filled with granular material such as gravel, rock, sand, etc. The collection layer, trench or borehole may include a perforated pipe to enhance gas removal.

Tire shreds have a high value of hydraulic conductivity so that, when used as LFG collection material, a layer of shredded tires may allow landfill gas to reach the gas collection and removal system more quickly as compared to a typical soil (i.e., sand or gravel). The shreds may be mixed with natural aggregates to optimize the system performance.

Landfill Final Cover

Landfill final covers may use shredded tires in the foundation layer. A typical foundation layer thickness is on the order of 12" to 24". Tire shreds with bead wires

should not be used as foundation layer material if the overlying barrier layer is a flexible geomembrane or geosynthetic clay liner (GCL). They should be mixed with soil before being applied.

Alternative Daily Cover

Tire shreds as alternative daily cover (ADC) must perform as any other cover material in controlling disease vectors, fires, odors, blowing litter, and scavenging. The maximum size for these shreds is 12" long, with half to be less than 6", and with no U-shaped pieces. The shreds should be placed in 12" layers. Tire shreds used alone have greater permeability than soil, and can be combustible under some circumstances. Therefore, guidelines suggest that tire shreds be used as ADC only during dry weather, and otherwise should be mixed with 30 to 50 percent soil.

New York Landfills Using TDF

According to DEC waste transporter data, in 2003 fourteen New York landfills received tires for disposal from New York suppliers for a variety of uses not specifically identified. Table 6-1 lists nine of these landfills that use TDA as part of their leachate collection and/or gas venting systems. With the exception of Chautauqua County, which used whole tire bales to construct the road leading into the landfill, landfills are assumed to use the chips in their operations. R.W. Beck estimates that 66,388 tons of scrap tires were used as tire-derived aggregate in New York landfills in 2003. Seneca Meadows accounts for the majority of TDA used in landfills.

Table 6-1
Examples of New York Landfills Using TDA in Engineering Applications

Landfill	DEC Region	TDA Use
Modern Landfill	9	LCRS
Seneca Meadows Landfill	8	Upper 12" of LCRS, Gas collection system
High Acres Landfill	8	Upper portion of primary LCRS
Madison County LF	7	Upper layer of primary LCRS, saving $120,000 in construction costs for 7-acre cell
Broome County LF	7	Component of LCRS for new 12-acre cell, saving $300,000 in construction costs
Albany County LF	4	Drainage medium in gas extraction system
Delaware County LF	4	Primary LCRS
Colonie Landfill	4	Drainage medium in gas collection system trenches for cover system
Hudson Landfill	4	Part of gas venting layer in trial to investigate feasibility of compacting clay barrier layer over TDA

Source: NY DEC

Supply Considerations

Landfills that use whole tires and shred them to meet their needs source the tires from the supply network described in Chapter 3, including retailers, fleets, government agencies, solid waste disposal facilities, and to some degree local tire pile clean-ups. They usually rely on small collectors to deliver tires, except for Modern Landfill, which also has its own network of trucks. Disposal fees at Seneca Meadows range from $55 to $65 per ton for car tires to $75 per ton for commercial truck tires, and are considerably higher than the normal $35 per ton tipping fee for MSW. Seneca and the Modern landfill produce a portion of their shreds and chips onsite; however, most tire shreds or chips for landfill use are produced by a number of shredders located in New York State, with some amount of supply entering from out of state suppliers. When the need for TDA exceeds the landfills' on-site shredding capacity, they purchase TDA at about $5 to $10 per ton.

In landfill applications, TDA competes with naturally-occurring aggregate of various sizes (stone, gravel, and sand). The degree of competition is mostly dependent on the cost of the competing material and the distance to haul it. Natural aggregate is plentiful in New York. DEC documents that New York is 15th in the U.S. in the value of its mineral resource, and 90 percent of the mining in New York produces sand, gravel, and limestone, the common construction aggregates. For non-engineered landfill TDA uses, the competing materials may be other wastes (i.e., crushed contaminated glass cullet, asphalt shingles), wood chips, soil borrow, or other materials permitted for such uses.

Demand Considerations

Landfill demand for TDA is contingent on their continued operations and expansion. Seneca Meadows has indicated that its current expansion project will near completion in 2006, and its continued demand for TDA is uncertain beyond that time. It has been documented by the DEC that landfills can save money on construction costs by using TDA in place of natural aggregate. The Madison County and Broome County landfills have saved a total of $420,000.

Trends and Factors Affecting Landfill TDA Markets

For the next two years, use of TDA in New York landfills at the current high rate is expected to continue. However, in the long term, the use of TDA at New York landfills is uncertain.

Factors that tend to increase demand for TDA at New York landfills include:

- The stated plans by Seneca Meadows landfill to continue its large expansion project for two more years, through 2006;

- The potential for large, regional landfills to be cited in New York or in nearby areas of adjacent states and provinces. The state is currently home to 27 sanitary landfills.[1] Estimates of the number and size of expansion projects were not available for this report.

Factors that may tend to decrease demand for TDA at New York landfills include:

- Potential competition for supply by higher value end uses such as some TDF applications and use of TDA in septic drain fields;
- Uncertain level of demand by New York landfills other than Seneca Meadows;
- The continuing trend for small, local landfills to close; and
- The inability of New York tire chip suppliers to ship TDA to landfills more than a very short distance away, due to the material's low market value.

6.3 Tire Derived Aggregate – Road Applications

Overview

Very few tires were used in civil engineering road applications until the 1990's, when uses in road embankments and wall backfills became chosen alternatives to the federal mandate for the use of rubberized asphalt. Both the mandate and the civil engineering alternatives were accepted slowly by the highway construction industry. Nonetheless, according to the Rubber Manufacturers Association, these uses were consuming around 10 million tires (100,000 tons) nationwide by 1995. In New York, successful demonstration projects were completed in Broome and Delaware Counties. Use of TDA in road projects is about to increase significantly, with the massive abatement the state's noncompliant waste tire stockpiles in coming years, as described in Chapter 3.

In 1995 and 1996, three widely publicized incidents of "burning roads" in Colorado and Washington almost completely ended the civil engineering uses of TDA. Two embankments and one backfill caught fire due to some factors that caused internal spontaneous combustion of the tire chips. The positive result of this near-disaster was that stakeholders in this burgeoning market came together to investigate the causes and put in place measures to mitigate future events. Investigators found that the fires were most likely caused by the tire fill layers being too deep (over 25 feet), the presence of crumb rubber particles and exposed steel belt wire, and the availability of oxygen to these tire chip layers.

Subsequently, the Federal Highway Administration (FHWA) adopted *Design Guidelines to Minimize Internal Heating of Tire Shred Fills* to address these issues. The American Society for Testing and Materials (ASTM) also issued new standard engineering guidelines for these uses: *Standard Practice for Use of Scrap Tires in Civil Engineering Applications* (ASTM D 6270-98).

[1] *Where Will the Garbage Go?* New York State Legislative Commission on Solid Waste Management. 2002.

Tire-derived aggregate offers a good solution for engineering uses in road project applications such as lightweight road embankment fill, retaining wall backfill, vibration damping for rail lines, and as an insulation layer for roadway frost heave protection.

According to processors interviewed for this report, the size and quality of tire chips for civil engineering uses depends on the properties needed for the end use. For uses in which light weight is the most important factor, such as embankments on poor soil or retaining wall backfill, a 2" to 3" shred is optimal. For uses in which compressibility is more important, such as vibration damping, insulation under roads, and embankments, a 1" to 2" chip is preferred. These applications are discussed in more detail below.

Light Weight Fill

Light weight fill applications take advantage of the fact that TDA is typically half as dense as soil or gravel, allowing structures to be placed on weak, compressible soils. Many areas with weak soil are impossible to develop using gravel or stone as fill, since it would just sink into the earth. For backfills against walls, tire chips reduce lateral loading, providing an additional margin of safety and/or allowing cost savings by reducing the wall thickness. Additionally, the cost of TDA is competitive with some lightweight fill materials such as expanded shale products.

Roadway Embankments

Roadway embankments use TDA as an inner layer, completely encased within a non-woven geotextile wrapping, surrounded on the sides by two feet of soil and covered by at least 3 feet of compacted earth. Chip layers should be no more than 10 feet deep, according to FWHA guidelines, to minimize combustion risk.

Vibration Damping

Vibration damping is important for rail lines being installed or reconstructed in urban areas. Federal guidelines issued in 1995 require that annoyance vibration in surrounding structures be minimized. Annoyance vibration occurs at much lower frequencies than frequencies that would cause building damage. Traditional ways to mitigate vibration impact are very expensive and include using rubber mats and/or isolation of the tracks using concrete pads and rubber bushings. Demonstration tests in California and Colorado have shown that tire chips, when placed in layers beneath the rail tracks, have been found to attenuate the low-frequency vibrations and reduce their impact to a significant degree. While future tests are necessary to confirm that a tire-constructed damping layer does not adversely affect the rail line operation, it is a promising new use for TDA. An ambitious transit construction project in Denver, CO known as "T-REX" plans to use TDA for vibration damping on 19 miles of light-rail installation.

Demonstration Projects

In the past, New York State has not used a great deal of waste tire TDA in road construction applications. To date such use has been limited to a few demonstration

projects, and in 2003 no roads uses for TDA were reported. The demonstration projects are discussed below.

In 1998, the DOT used TDA in an embankment construction project in Broome County. DOT engineers report that the shred fill performed exactly as expected, and the pavement surface over the shred fill is indistinguishable from other pavement on the project. The DOT is continuing to monitor the runoff water quality to establish a history for research purposes and to learn more about possible manganese and iron leaching. To date, levels of contaminants appear to be within levels of the surrounding soil.

In 2001, the Delaware County Public Works Department, with partial funding from New York State Empire State Development (ESD), obtained a BUD for a demonstration project to use tire chips as a sub base insulation layer for a public roadway that was chronically susceptible to frost heaving. A 3,810 foot length of County Road 20 in Delaware County was reconstructed using a 12" layer of insulating tire chips. Temperature monitoring equipment was installed to test the performance of the TDA. During sub-freezing temperatures in February 2003, thermistor data showed measurably warmer conditions within the insulated road than the adjacent non-insulated sections. Visual inspections over two winters showed no signs of frost damage.

Noncompliant Waste Tire Stockpile Abatement Contracts

The DEC, OGS, DOT and the New York State Thruway Authority are working in partnership to implement the DEC's *2004 New York State Waste Tire Stockpile Abatement Plan.* Under the plan, waste tires in noncompliant stockpiles will be fast-tracked into highway civil engineering projects over the next six years. Twelve specific road construction projects scheduled for that time frame have been identified for projects expected to consume an estimated 27 million waste tires (270,000 tons) out of the total estimated 29 million stockpiled tires (290,000 tons). Eight contracts have been issued to date to abate the eight highest-priority sites. These contracts are described more fully in Chapter Three.

Supply Considerations

Producing scrap tire shreds to meet DOT specifications should not pose a technical problem to the OGS/DEC contractors responsible for processing waste tires from noncompliant stockpiles. However, due to safety issues and the strict quality control necessary for these uses, suppliers should be prepared to provide a consistently high quality chip adhering strictly to the specifications for a particular use.

The continued use of scrap tire TDA in New York road construction projects beyond that funded by the OGS/DEC contracts is questionable. To continue, the price paid will need to be competitive with existing end users. Roads end users may be able to compete with landfill applications at a price of about $5 to $10 per ton, but may not be able to compete with some TDF markets at $17 to $25 per ton. Should the use of TDA in septic applications grow in New York, this market may out-compete roads applications. This is especially true given the low cost of natural aggregate available

for road projects in New York. For these reasons, future use of TDA in road projects in New York may be dependent on a strong government procurement policy.

Demand Considerations

The long-term demand for TDA in roads applications is dependent on performance, price, and other considerations. For uses where natural stone aggregate competes with shredded tires, the price is set by the price of the stone. According to a source at the DOT, tire chips have a significantly higher cost per ton than natural aggregate, especially considering additional costs such as environmental monitoring, manufacture, and storage of the TDA. TDA will be easier to justify in uses where the competing materials are other engineering materials as opposed to naturally-occurring aggregate. Competing materials for these uses include expanded polystyrene products for fill and insulation, and special rubber mats or isolation bushings for rail system vibration. One interviewee suggested the lower part of the Hudson River valley, in particular, exhibits soil characteristics that exclude natural aggregate as a fill material, and therefore may be a stronger marketplace for TDA for use in civil engineering applications.

A recent project in California sheds some light on the potentially positive economics of TDA use in engineering projects. The California Integrated Waste Management Board provided TDA for a rail vibration damping project in San Jose. Cost calculations assumed a cost for Type A chips of $20 to $25 per ton. The tire layer costs $150 per linear foot, while alternative methods such as a 1" thick ballast mat costs $200 per linear foot, and a spring or bushing isolation device cost around $500 per linear foot. (Note that the performance of each alternative product may vary.) The installation of the California rail line damping layer required a density of 50 to 55 lbs per cubic foot. A two-foot layer of chips, 1,500 feet long and 12 feet wide, would therefore require 1.8 million pounds of tire chips – roughly 90,000 tires. Given the relatively large rail mileage in New York and the proximity of much of it to populated areas, two or three large projects could consume a significant number of waste tires. If more chipping capacity did not come on line, supply might need to be sourced from outside the state.

Local departments of transportation and public works, and their contractors, are also potential customers, as are private companies involved in road construction. Large engineering and design consulting firms constitute another logical customer.

Trends and Factors Affecting the Market

New York's use of TDA in road construction projects will be dominated by the use of shredded stockpiled waste tires in DOT and Thruway Authority projects for the foreseeable future. The primary factor influencing this trend is the waste tire stockpile abatement plan prepared by DEC, which is being implemented in partnership with OGS and DOT. These projects will assist DOT and its contractors to gain experience and test the performance and application of TDA in roads applications, while simultaneously insulating the TDF market at large from becoming oversaturated with heavily subsidized stockpiled waste tire shreds which could negatively impact existing markets.

6.4 Tire-Derived Aggregate in Septic Applications

Overview

Use of TDA in place of natural aggregate for on-site waste treatment system leach fields is well documented and is encouraged in many states, including Florida, Texas, Arkansas, Virginia, and South Carolina. Tire chips have been found to exhibit performance characteristics equal to natural aggregate in this use. Tests have shown that environmental effects, such as groundwater leaching of minerals and compounds found in tires, are negligible as long as the groundwater pH is close to neutral. Technically speaking, there are no factors which should prohibit the use of TDA in properly designed septic system leach fields.

To date, use of TDA in septic applications in New York has been limited to one pilot project conducted by the State University of New York, Buffalo. However, the DOH is developing a new policy that, for the first time, will permit these uses. While the likelihood of this market expanding significantly is still unclear, the positive experience in other states indicates it is at least a good possibility.

The SUNY-Buffalo Demonstration Project

New York's new policy builds on experience gained from a demonstration project funded by DED. In 2000/2001, DED contracted with SUNY-Buffalo to install and evaluate a full-scale septic system using TDA at the Modern Landfill in Lewiston. The septic system serves the landfill's tire recycling facility, which employs 12 – 15 persons in two shifts. This usage is comparable to that of a 4-person household. The Niagara County Department of Health and the DOH were involved in the system design and approved it in May 2000.

Nine leachate trenches were constructed over soils with different percolation rates, and compared 1" chips, 2" chips, and natural #2 stone aggregate. The installation was monitored for two years to assess its performance. At the end of the test period, the project was deemed successful in that the TDA provided equally acceptable hydraulic performance as a leachfield media when compared to stone. The installation continues to function properly today.

Potential Users of TDA in Septic Systems

Potential users of TDA in septic systems include hundreds of local civil engineers, contractors and septic system design and installation firms. Additionally, state agencies such as the New York State Office of Parks, Recreation and Historical Preservation may be a potential purchaser via supply contracts for new buildings. The DED intends to contract with SUNY Buffalo to promote and provide technical assistance that will help develop this new market.

Supply Considerations

The TDA product used for septic systems must conform to a specification that is not technically difficult to achieve, but is critically important to guarantee proper system operation and minimize environmental contamination. The chip allowed by specs in

Virginia and the other states calls for a nominal 2" chip, with a maximum size of 4" and a minimum size of ½". Steel belt wire is not prohibited, but it may protrude no more than ½ inch from the chip. Fines, defined as material less than 2mm in sizes, are prohibited due to the potential for clogging the system. New York shredders, with the possible exception of one that is limited to producing a 4" chip, should be capable of manufacturing chips to meet the septic system specifications.

Since septic systems are commonly installed in rural areas, of which there are many in New York, obtaining adequate supply could be an issue in certain geographic portions of the state. Between Buffalo and Schenectady, and north of Schenectady, for example, there are currently no suppliers of TDA.

Supply was a concern even for the small installation at the Modern Landfill. The TDA used for that project was supplied by the landfill's tire recycling facility, which chips scrap tires for its own landfill uses as well as to sell as tire-derived fuel. If those tires had not been available, a local chip producer would have been used to supply the chips for the project. In the case of the Modern Landfill, even though it is located in the far western region of New York, two shredders are located in nearby Buffalo. A price survey done at the time indicated that chips were available from outside sources for about $2.50 per ton at the source. With shipping, the total cost of 16 tons of TDA for that project was calculated as $4.54 per ton. An average calculated cost from that study was $9.13 per installation in upstate New York.

Demand Considerations

TDA in septic applications will compete with natural aggregate, and in New York natural mineral aggregate is plentiful and inexpensive. Its performance characteristics are well known and it is environmentally benign. Thus septic system contractors in New York may be slow to experiment with TDA. In other states where clay or sandy soils are the norm and mined aggregate is scarce or not suitable for septic tank use, such as South Carolina, Florida and Texas, tire chips are an inexpensive way to save natural resources as well as provide an expansive outlet for scrap tires.

In some areas of New York, and in some applications, TDA as septic leach field aggregate may be able to save money in both transportation and installation costs over the use of natural aggregate. Because it is lighter than conventional aggregate, with a density of 45-50 pounds per cubic foot as opposed to 100 pounds per cubic foot for stone, a load of chips will fill more trench area than a load of stone. The greater permeability of TDA compared to stone also means that the drain field storage capacity can be increased up to 30 percent, again saving money on material. Installation contractors can reduce their costs, install systems in a shorter period of time, and possibly pass on savings to their customers.

Private homeowners in rural areas make up the bulk of potential markets for septic installations, but on-site wastewater treatment is also appropriate for public agencies, such as parks and recreation departments, that construct facilities in rural areas. Public agencies that install septic tanks can realize these cost savings as well.

One issue that could hamper development of septic TDA markets is concern over groundwater contamination from heavy metals. This issue has been addressed in

numerous studies. If the chips are relatively free of protruding steel wires and installed correctly, no adverse impacts have been noted. The State of Florida has a strict specification, due to water quality concerns, requiring that the bottom level of any leach field installation using tire chips be at least 24" above the highest water table level. Some states have expressed concern that septic tank installers must be precise about the amount of material they bring on-site. Extra stone can be left in a backyard and not pose a problem, but an extra pile of tire chips left after a job is unsightly and potentially could pose a safety hazard.

Trends and Factors Affecting the Market

Significant growth in the use of TDA in New York septic installations is possible, but uncertain. Factors that tend to drive growth in this market include:

- The new policy DOH is developing will allow the use of TDA in septic systems, combined with active promotion by DED and DEC, will help inform potential users about this new material and application;
- In some applications TDA may emerge as the most economical choice for septic applications; and
- State agencies such as the Department of Parks may help boost the market through affirmative procurement efforts.

Factors that may hamper growth in this market include:

- The circumstances under which TDA will emerge as an economic choice in New York septic installations is uncertain;
- Septic installations may need to compete for supply with other similarly or higher valued markets, such as TDA in landfills and certain TDF markets; and
- Concern over environmental risks, though addressed in existing research and demonstration projects, could slow adoption of TDA in septic applications.

Chapter 7

OTHER SCRAP TIRE USES

Chapter 7
OTHER SCRAP TIRE USES

7.1 Overview of Other Scrap Tire Uses

This section describes other uses for scrap tires not covered in previous chapters. These include uses for whole tires (e.g., in erosion control), uses for baled whole tires (e.g., road construction applications) and uses involving cut, stamped, and punched tires. In 2003, R.W. Beck estimated only 975 (97,500 PTE) tons of annually generated New York scrap tires went to such uses, plus an additional 1,297 tons (129,700 PTE) of stockpiled tires. However, many of these are difficult to document, and the actual number used is probably higher.

Table 7-1 summarizes the range of alternative scrap tire uses identified. Ultimately, the range of potential uses is bounded only by one's imagination (and subject to approval by the DEC through a beneficial use determination). Some uses described in this chapter involve value-added markets that could potentially grow in size. Others, however, are designed mainly as methods of managing scrap tires, and beyond occasional projects sponsored by municipalities or others, they do not have the potential to grow as a market per se. Following the table, the remainder of this section summarizes these uses. Section 7.2 describes an emerging technology for using baled scrap tires in road construction, called *Ecoflex*, that may have considerable market potential.

Table 7-1
Potential Alternative Uses for Scrap Tires

Form	Uses
Whole, unbaled scrap tires	• Agricultural uses such as grain storage structures, sapling protection, planters, weight covers on compost piles, silage piles, or plant covers • Boat and marina bumpers • Artificial reefs • Fencing and terracing • Recreational uses such as rifle range bullet stops, playgrounds, miniature golf courses, and paint ball courts • Engineering uses such as landfill construction (e.g., drainage layer over leachate collection system), bridge supports, dam construction, erosion control, and bank stabilization

Form	Uses
Whole, baled scrap tires	• Road sub base • Alternative lightweight fill in road construction • Retention wall backfill • Animal bedding • Erosion control • Stream bank stabilization
Cut scrap tires	• Cut, punched and stamped products • Strips used in farm equipment • Strips used in railroad tie production • Strips used in landfill construction applications • Cut tires used in playgrounds

Uses for Whole and Baled Tires

A major use for whole scrap tires is the agricultural applications listed in Table 7-1. R.W. Beck did not attempt to estimate the amount of New York scrap tires used in these applications. However, nationally in 2003, the Rubber Manufacturers Association estimates that about 3 million tires (300,000 PTE) went to such uses – about 1.7 percent of all U.S. generated scrap tires. The other whole tire uses listed in Table 7-1 can provide outlets for large quantities of tires, but only on a project-specific basis.

The DEC has granted at least 11 beneficial use determinations (BUDs) for whole tires. These BUDs were requested by either the private sector or governmental entities (i.e., counties and municipalities). Uses for which BUDs have been issued for whole tires in New York are summarized in Table 7-2.

Table 7-2
BUDs Issued for Scrap Tires in New York

BUD#	Reg.	County	Permitee	Use and Status
166-5-10	5	Clinton	Marina at Lighthouse Point, Inc.	Construct breakwater system (complete)
225-7-55	7	Tompkins	Sara Jones, Craig Dunn	Construct earth-filled walls for houses (unknown status)
235-6-23	6	Jefferson	Fort Drum	Construct tire house for army training (complete)
374-5-57	5	Warren	Chestertown Conservation Club	Construct backstop and berm at shooting range (operational)
493-3-56	3	Ulster	Town of Shawangunk	Create erosion control mat to substitute for large riprap in

BUD#	Reg.	County	Permitee	Use and Status
				drainage channel (operational)
499-6-22	6	Herkimer	Town of Webb	Erosion control at culvert crossings on town snowmobile trails (operational)
588-6-25	6	Lewis	Adirondack National Speedway	Tire bales, bound together, to construct barrier wall at speedway (operational)
609-4-01	4	Albany	Arthritis Foundation	Used with hay bales to construct barrier wall for temporary race track (operational)
764-9-07	9	Chautauqua	County DPW	Baled tires as an alternative for aggregate in construction of road sub base (operational)

The number of scrap tires used in these projects is undetermined. Most of the projects have completed their use of waste tires, with the exception of Chautauqua and Washington Counties, which are described in more detail below.

Chautauqua County Road Sub base

The Chautauqua County Public Facilities Department requested and received a BUD to use baled tires as a sub base in road construction. The County began researching alternative uses for waste tires after a waste tire pile caught fire in the County in 1995. The County was determined to develop a use for tires to avoid another unsafe tire pile. The baler manufacturer, Encore Systems, introduced the idea of using whole baled tires in road subgrade. The County hoped to improve road engineering by increasing drainage capability to roads that were prone to cracking due to moisture retention. They would also save money by not having to purchase traditional aggregate fill. The County has used tires in constructing portions of five roads. The first road in which baled tires were used for sub-base construction was a road leading into the County landfill. The County received a research demonstration and development permit in September 1998 to use baled scrap tires in road construction. Since then, tire bales have been used in the other projects summarized in Table 7-3.

Table 7-3
Summary of Chautauqua County Road Construction Projects Using Baled Tires

Road Name	Town	Year	Scrap Tire Use (PTE)	Scrap Tire Use (Tons)	Road Length	Benefit
Condin Road	Ellery	Summer 1999	120,000	1,200	928'	Improved drainage, held up to heavy trucks, reduced erosion and need for subsequent grading.
Kabob Road	Stockton	October 2000	30,000	300	200'	Improved previous situation -- poor soils (clay) in sub-base led to buckling of road after freezing/thawing.
East Road	Charlotte	June 2001	120,000	1,200	1,000'	Improved drainage for road built atop marshy soil.
Sanford Road	Cherry Creek	Summer 2002	150,000	1,500	1,500'	Improved drainage in low-lying road with poor soils in sub-base; Improved support for large vehicles.

In general, using baled tires as a sub base in road construction involves excavating the road surface, laying down a geo-fabric barrier, placing bales atop, and filling with sand to fill voids. A vibratory roller can be used to compact the sand, then 6" lifts of gravel are laid and compacted with the roller. The resulting road can be paved or left graveled. The benefits are:

- Improved drainage, particularly where sub base soils are poor (important to avoid buckling, pot holes, and cracks);
- Improved support for heavy truck traffic;
- The amount of sand and aggregate needed is reduced;
- An outlet for tires is provided.

The County has been able to reduce the $2.00 per tire fee that they normally charge at the landfill, to $0.40 per tire, to cover the costs of baling the tires. The County was able to obtain a state grant to purchase the $50,000 baler, and uses prison laborers to bale the tires. The $0.40 per tire covers the costs associated with the prison guard, baler operating costs, and baling wire. Residents, therefore, are saving $1.40 per tire that they recover. The County also estimates that between 1999 and 2001, they saved $819,176 in disposal costs. An additional $11,065 has been saved by using baled tires instead of stone in the four completed projects. Most importantly, the County has

cleaned up 253,782 tires from tire dumps and collected 258,200 tires from tire amnesty programs between 1999 and 2002.

The County operated under a three-year R&D permit, and now has a permanent BUD to continue to use baled tires in road construction. The County continues to hold an Amnesty Program each summer, collecting tires at the reduced rate. They baled over 500,000 tires in 2004, and will use the bales in upcoming road construction projects. The only noncompliant waste tire stockpile remaining in the County, however, is one that is to be remediated by the State. According to DEC waste transporter data, 1,293 tons of scrap tires (129,300 PTE) were used by the County in 2003.

Washington County – Alternative Lightweight Fill in Road Construction

Washington County received a BUD to use baled tires as lightweight fill for a road construction project adjacent to the Hudson River and the Champlain Canal. They plan to start the project in 2005. The County hopes that the tires will add stability, as historically soil has eroded from the embankment into the river consistently due to the lack of stability and heavy weight at the top of the slope.

The County estimates that it will use 35,000 passenger and light weight truck tires (350 tons). The County will use existing staff to make bales of 70 tires (1,400 pounds) each. Approximately 500 bales will be used to complete the project.

The project allows the County to use the used tires they collect (at a value of $1.50 per tire, which largely covers baling costs). Without this arrangement, the County estimates it would pay approximately $140 per ton to dispose of the tires ($49,000).

Uses for Cut Tires

Tires can also be applied in a variety of uses in which they are cut in various ways. For example, in 2003, about 231 tons of New York scrap tires (23,100 PTE) cut into strips were used in landfill construction applications at a Pennsylvania landfill. And an additional 741 tons (74,100 PTE) were shipped to South Dakota for use in agricultural equipment. (The specific application was not documented.)

Scrap tires can also be used to make a variety of cut, punched, and stamped rubber products, including gaskets, mats, safety cone bases, parking stops, and speed bumps. The Rubber Manufacturers Association estimates that in 2003, 65,000 tons of scrap tires (6.5 million PTE), down from 80,000 tons (8 million PTE) in 2001, went to this use. RMA states that the method of cutting, punching, and stamping products from scrap tire carcasses is one of the oldest methods of reusing scrap tires, and the products produce benefit from the strength and durability of tire rubber.

Two New York firms were identified that produce cut, punched and stamped products. Interstate Recycling Corporation of Auburn has historically produced speed bumps and parking curb stops. Recently, however, they developed and patented equipment to make railroad ties from used tires. Although the firm is not currently operating, management anticipates starting up again in 2005, with the capacity to process two tons of scrap tires per month. Tire Conversion Technologies of Niskayuna uses tire tread pieces to make rubber “planks.”

Supply Considerations

Whole tires are generally plentiful, and are collected by municipal governments as well as through large-scale generators, such as auto sellers, garages, and tire shops. Tires for many of the alternative uses described can be stockpiled as long as they are not heavily laden with dirt. Tires going to the cut, punched, and stamped rubber products market typically must be bias-ply tires or fabric bodied radial tires, which are largely from medium truck tires. Usually steel belts and body plies, which are increasingly present in medium weight tires, are not desirable in these markets. Larger bias ply tires, however, can be used in these applications.

Most alternative uses for whole tires are limited, and are typically of relatively low value. As such, alternative uses for whole tires, including baled tires, typically involves using locally generated tires, as the tires are of such low value, it is not cost-effective to transport them any considerable distances.

Demand Considerations

The uses described in this chapter are diverse. Some uses, such as cut, punched and stamped products, involve the production of value added products and therefore are driven by demand by their customers. Another example is Interstate Recycling Corporation's railroad tie product, which holds promise to create a sustained demand for a value added product. Anecdotally, several small "cottage industries" were also identified that potentially could evolve into thriving markets, for example, ones involving very small scale production of swings and mats. Other applications described in this chapter, such as the beneficial uses described above sponsored by government agencies, constitute an alternative to disposal and are not necessarily a potentially value added market. Collectively, these uses still represent a tiny percentage of overall New York scrap tire generation.

Trends and Factors Affecting the Market

The diverse scrap tire uses described in this Chapter will continue to account for a very small percentage of total scrap tire generation in the coming years. Factors driving this trend include low value and low demand for most of these products. Some cut products such as railroad ties have a higher value and potentially significant growth potential.

Beneficial use permits may continue in the future to consume a steady stream of stockpiled waste tires. Factors influencing this trend include the desire by local government agencies to use locally generated waste tires in local projects and owner initiated abatement efforts.

7.2 Emerging Technologies – Other Scrap Tire Uses

This section describes three emerging technologies for using scrap tires that do not neatly fit in previous chapters. The first section describes three different applications for a promising new technology for using baled, cut tires developed by Ecoflex. The

second section describes the use of scrap tires in dam construction, and the last section describes the use of scrap tires in home construction.

Ecoflex

Ecoflex (Australia) has developed a process for using "Ecoflex units" consisting of a tire with one sidewall removed, in several different applications. Three of these applications are described below: road construction, wall construction, and erosion control. The description below is based on an analysis of the technology performed by Dr. Dana Humphrey of the University of Maine.[1]

Road Construction

Ecoflex units reportedly can be used in temporary and permanent applications called the "E Pave System." For example, Ecoflex constructed an access road at Narara Creek, Gosford, where heavy equipment had to access the road. The road went through a wetland with water saturated soils. Conventional construction systems would have required substantial dewatering and importation of fill to a depth of 0.9 meters to support heavy equipment traffic. According to Dr. Humphrey's assessment, the use of the E Pave System enabled the fill material to be reduced by about half, and the footprint of the road to be limited to 6 meters. This project was temporary, and removal of the road showed no permanent impact. The reclaimed Ecoflex units were then reused in another project. Permanent projects often include the use of a geo-textile liner. Typical uses include the construction of access roads and parking lots over weak subgrade soils. The reported engineering benefits include:

- The relatively large contact area of the tire sidewall with the subgrade soil reduces the contact stresses with subgrade soil, improving road bearing capacity; and
- The confinement of the aggregate used provides for increased stiffness of the contained aggregates, limiting rutting within the aggregate layer, and helping distribute wheel load to the underlying subgrade soil.

Dr. Humphrey visited sites where this system was used and concluded it is a promising technology for construction for roads on weak subgrade soils. He further suggested that "engineering guidelines be developed to aid in the selection of one and two layer E Pave systems as a function of substrate strength, anticipated traffic loading, and allowable rut depths."[2]

Wall Construction

Ecoflex units have also been used to construct gravity retaining walls. The Ecoflex units are filled with stone or recycled concrete aggregate, about 3 inches in size. In some cases the units are faced with shotcrete, pressure treated wood, or sheet metal panels, such that tires are not visible when completed. Dr. Humphrey states, "E Wall Systems can be designed in accordance with typical U.S. practices. Moreover, it is my opinion that the E Wall System is a relatively mature technology as evidenced by a

[1] Letter from Dana N. Humphrey, Ph.D., P.E. (and Consulting Engineer) to Mr. Garry Callinan, Ecoflex Australia Pty Ltd, November 19, 2004.
[2] Ibid.

large number of successful field installations in addition to useful design aids…For cases when the E Wall System is founded on compressible soils, the inherent tolerance of the E Wall System for differential movement would be an important advantage."[3]

Erosion Control Systems

Ecoflex has installed several types of "E Rosion Control Systems." These projects can consist of:

- Ecoflex units filled with 3 to 6 inches of crushed stone or recycled concrete aggregate, in some cases covered by wire mesh;
- Medium weight batter protection units consisting of three units bolted together using tire tread, filled with tire side walls strapped together with UV resistant nylon strapping and coiled tire tread; bolted to the end tire units.
- Lightweight batter protection units consisting of overlapping elements of tire wall, interwoven with recycled conveyor belt straps.

The University of Queensland conducted flow tests on each of these designs, with satisfactory performance by each variation. Of this use, Dr. Humphrey commented that, "Properly designed and installed E Rosion Control Systems can be used for erosion protection in swales and scour protection at the outlets of culverts and bridge structures. Stone size should be elected as appropriate for anticipated flow velocities."[4]

Of the environmental considerations of the Ecoflex units, Dana Humphrey indicated that he has conducted studies of TDA placed both above and below the water table, with indicated that TDA releases negligible amounts of metals, including iron, and in some cases zinc. He indicates that the release of metals is due to exposed steel belts, and that because Ecoflex units have no exposed belts, their use would have a "negligible effect" on water quality when used in locations with near neutral pH. Applications where the Ecoflex units would be subjected to either highly acidic or basic conditions should be evaluated on a case by case basis for environmental compatibility."[5]

Dam Construction Using Whole Tires

A University of Arizona adjunct professor emeritus Stuart Hoenig, of the Department of Agriculture and Biosystems Engineering, has been working toward finding alternative uses for scrap tires that would offer less costly construction, and a solution to Arizona's scrap tire problem. Hoenig and his colleagues constructed a 30-foot long, 6-foot high tire dam at King's Anvil Ranch. They stacked and tied together tires with half-inch plastic straps, filled them with gravel, and covered them with chain-link mesh. They used free labor, probationers from Pima County, to construct the dam. It is estimated that the project cost $63,000 less than a comparable concrete dam, and is

[3] Ibid.
[4] Ibid.
[5] Ibid.

working well. Similarly, a 25-foot dam in Arkansas was constructed using more than 50,000 tires.

Baled Tires for Home Construction

New Mexico is in the forefront for using tires for home construction in the U.S. Tires are typically baled, filled with earth, and covered with stucco. Several companies in New Mexico exist that sell tire bales, and one that produces a square final product, which is ideal for building. Rammed Earth Works, of Napa, California provides seminars on how to construct homes made from scrap tires. Baled tire houses are reportedly well insulated and resistant to fire and insects.

Chapter 8

FUEL AND RAW MATERIAL MARKETS

R·W·BECK

Chapter 8
RAW MATERIAL AND FUEL MARKETS

8.1 Overview of Raw Material and Fuel Markets

This Chapter covers markets involving the consumption of scrap tires as raw material and/or fuel. In this report, this submarket is divided into three separate categories:

1. Use of scrap tires as raw material by value-added manufacturers (e.g., steel producers);
2. Use of scrap tires as fuel by value-added manufacturers (e.g., cement and pulp producers); and
3. Use of scrap tires as fuel by electricity producers (including waste to energy and dedicated tire-derived-fuel (TDF) users.

Table 8-1 lists facilities in this market niche that used New York generated scrap tires in 2003, along with several other potential users. In addition, it may be possible that additional out-of-state raw material and fuel end users consume New York generated scrap tires. However, R.W. Beck did not document this.

Table 8-1
Current and Potential Raw Material and Fuel End-Users

Facility	Market Sub Category
Raw Material for Value-Added Manufacturing	
Nucor Steel (Auburn, NY)	Steel Mill (electric arc furnace)
Fuel for Value-Added Manufacturing	
Systech Environmental (Whitehall, PA)	Cement Kiln
Lehigh Cement Co. (Michigan City, IN)	Cement Kiln
Lehigh Cement Co. (Bleandeau, PA)	Cement Kiln
Lafarge Cement (Ravena, NY)	Cement Kiln
St. Lawrence Cement Co. (Catskill, NY)_	Cement Kiln
Lehigh Cement Co. (Glens Falls, NY)	Cement Kiln
International Paper (Ticonderoga, NY)	Pulp Mill
Finch Pruyn & Company (Glens Falls, NY)	Pulp Mill

Facility	Market Sub Category
Fuel for Electricity Generation	
WPS Niagra Utility (Niagra Falls, NY)	Electricity Generation
Black River Generation (Fort Drum, NY)	Electricity Generation
Exeter Energy (Sterling, CT)	Dedicated TDF Facility
OCCRA Waste (Syracuse, NY)	Waste-to-Energy
Oswego County Energy Facility (NY)	Waste-to-Energy
Adirondak Resource Recovery (NY)	Waste-to-Energy

Table 8-2 summarizes estimates of current and potential use. R.W. Beck estimates that in 2003, 6,642 tons of New York generated scrap tires (664,200 PTE) were consumed as raw material for steel manufacturing (at the Nucor mill in Auburn), about 1,759 tons (175,900 PTE) were consumed as fuel (and to make use of a portion of tire material properties) by cement kilns outside of the state; and about 48,075 tons (4.8 million PTE) were consumed in electricity applications (primarily at the Exeter TDF facility in Sterling, CT). Nationwide in 2003, according to the Rubber Manufacturers Association, 91 facilities used TDF on a regular basis, accounting for nearly 1.3 million tons of scrap tires (100.3 million PTE).

Table 8-2
Current Use of New York Scrap Tires in Raw Material and Fuel Markets

Category	2003 Use (tons)	2003 Use (PTE)	Outlook
Raw Material for Value-Added Manufacturing	6,642	664,200	Potential increase currently limited to approximately 1,120 tons (112,000 PTE) with scrap tire handling upgrades.
Fuel for Value-Added Manufacturing	1,759	175,900	At least one New York State cement kiln and one New York State pulp mill pursuing permits and investigating use. Could potentially increase demand by up to 75,200 tons (7.5 million PTE).
Fuel for Electricity Generation (non-WTE)	98	9,800	Two New York State electricity generators report beginning use of over 50,000 tons per year scrap tires (5 million PTE) in 2004. This use expected to continue and possibly grow in 2005.
Fuel for Electricity Generation (WTE)	47,977	4,797,700	2003 dominance by Exeter Energy TDF facility in Sterling CT may decline as demand within New York State increases.
Totals	56,476	5,647,600	

Significant changes in this market have already occurred since 2003, with about 54,000 tons of New York scrap tires (5.4 million PTE) now being consumed by one New York electric power generator. Furthermore, there is the potential for additional large increases in demand in 2005 at New York cement mills, utilities, and pulp and paper manufacturers. This potential new demand could push in-state demand for scrap tire as manufacturing raw material or electricity generation fuel to more than 200,000 tons (20 million PTE), though both supply and demand side barriers will likely keep these potential new uses in New York far below this upper boundary.

The three raw material and fuel market sectors are discussed in more detail in the following two sections, followed by a section on emerging technologies.

8.2 Raw Material for Value-Added Manufacturing

Overview

Steel mills employing electric Arc Furnaces (EAF) produce batches of new steel using scrap steel. Whole tires, including rims (if lead weights are removed) can be consumed by these mills. In addition to their fuel value, the tires provide a source of carbon replacing coal, which is essential to the steel making process. Most of the energy required for the process comes from electricity; the balance comes from coal and tires. Scrap tires are also a source of scrap steel, since typically up to 15 percent of a tire's weight is steel. Since the steel and other materials in the tires are consumed, there is no ash or other waste. Due to the sulfur in tires, there are limits on air emissions which must be monitored. Electric arc furnaces are also used in other industrial processes, such as refractory production. However, these processes do not appear to be candidates for tire consumption because scrap tires would apparently contaminate the process.

Steel mills benefit from scrap tire consumption through reduced energy and raw material costs and through increased revenues from scrap tire tip fees provided by suppliers. Drawbacks include concerns over contaminating steel batches with lead weights not removed from tire rims and the need to satisfy stringent sulfur air emissions limits. (Similar to contamination concerns of all steel mills consuming scrap.) Furthermore, mills must limit scrap tire consumption to the production of lower quality steel products like reinforcing bar. Relatively minor plant modifications are required to accept and handle scrap tires, including the purchase of a grapple, used to handle scrap tires.

New York's one steelmaking plant using an electric arc furnace, Nucor Steel in Auburn, was the first in the nation to begin using TDF in 2002 and holds a patent on the process for using scrap tires. In 2003, this plant consumed 7,380 tons of scrap tires (738,000 PTE), of which about 90 percent, or 6,642 tons (664,200 PTE), is estimated to have originated in New York.

Supply Considerations

The Nucor steel mill uses whole tires, and consequently has been able to charge a tip fee for tires accepted. Tip fees for whole tires used as TDF in the Northeast are reported to be $50 to $55 per ton. While ample supply is likely to be available in the short run, as demand grows for scrap tires in New York and regionally, competition over supply may grow. It is possible that the Nucor mill may need to reduce the tip fee charged or, over the long term, even begin to pay for the scrap tires delivered to their facilities.

Demand Considerations

Demand for the steel products produced by Nucor is apparently strong, and this is helping to drive their interest in using scrap tires. However, demand for scrap tires by electric arc furnaces has apparently nearly peaked. New York's one facility, Nucor, has requested funding assistance from the DED to increase its use by about 1,100 tons per year by purchasing a second grapple to facilitate handling scrap tire supplies. However, there is no indication that their scrap tire demand could grow beyond this level.

Trends and Factors Affecting the Market

The consumption of scrap tires at New York's one EAF steel mill may grow slightly, but will then remain flat. The main factor influencing this trend is that New York is home to only one candidate facility, and it is in the process of maximizing its TDF use.

8.3 Fuel for Value-Added Manufacturing

Overview

Scrap tires can be used by manufacturing facilities as a fuel source in the production of value added products. The main candidates are steel mills using electric arc furnaces and cement kilns (both of which use TDF for fuel and also for the material's intrinsic properties) and pulp and paper mills (which use TDF for fuel value only). These are discussed further below.

Cement Kilns

A Cement kiln is a large inclined rotating furnace which converts limestone, clay, and shale into stone sized lumps of cement clinker. Clinker is then ground together with gypsum to make Portland cement. Portland cement is the active ingredient in concrete, the most widely used construction material in the world. Cement kilns operate at around 3,400 degrees F, and are generally fueled by fossil fuel combustion (e.g., coal or gas). Whole scrap tires can also be burned in the kiln as an alternative fuel.

In addition to the fuel value, cement kilns make use of the chemical properties of scrap tires in manufacturing their product. The clinker process does not appear to be

susceptible to contamination by the use of stockpiled tires. The very high combustion temperatures in the kiln provides for complete combustion of the tires. Relatively minor improvements are required at a cement kiln in order to handle tires -- namely a storage area and a conveyer.

Substituting scrap tires for solid fossil fuels such as coal or petroleum coke can potentially lower NOx emissions, but can also raise CO emissions. Tires have approximately half of the sulfur content than the coal consumed at New York's three cement kiln facilities. Any sulfur that is released during combustion is absorbed into the lime, capturing these potential air emissions.

Although none of New York's three cement kilns currently consume scrap tires, one has air quality and waste tire storage permits pending and, pending permit approvals, intends to begin scrap tire use over the next year. Another New York cement company is permitted to use TDF, but representatives report they do not currently, mainly because of lack of public support. Representatives of a third New York cement company report they have investigated, but are not currently pursuing the use of TDF. Together, these plants could have the potential to use over 70,000 tons of scrap tires (7 million PTE), equal to about one-third of New York's annual scrap tire supply.

Nationwide, the cement industry has been a growing user of scrap tires for some time. In 2003, 43 facilities (with 65 kilns) consumed about 530,000 tons of scrap tires (53 million PTE).

Pulp and Paper Mills

Pulp and paper mills use circulating fluidized bed combustors or stoker furnace boilers to generate electricity and steam for their production processes. (These combustors are described in Section 8.3 below.) New York is home to at least two operating pulp and paper mills that are candidates to consume scrap tires. While to date no New York producer is known to have used scrap tires, one company is pursuing it. The company has applied for a permit that would allow a two-week pilot project. Representatives of a second New York pulp mill reports they are monitoring the other pulp mill project to learn from its experience.

Nationwide use of scrap tires in pulp and paper mill boilers in growing. In 2003, 17 pulp and paper mill boilers consumed about 260,000 tons of scrap tires (26 million PTE), up from 14 boilers consuming 190,000 tons (19 million PTE) in 2001.

Supply Considerations

Supply considerations vary among the manufacturing markets described. Cement kilns can use whole tires; consequently, they can expect to charge a tip fee. Tip fees for whole tires used as TDF in the Northeast are reported to be $50 to $55 per ton.

In contrast, should pulp and paper mills begin use of scrap tires, their circulating fluidized bed combustors and stoker boilers could require TDF chips processed to a size of ¾" that are 98 percent wire free. Prices for such a chip are likely to range from $60 to $73 per ton. The cost implications of switching to TDF depend on a number of factors, including current fuels and prices, the specific combustor technology used,

supply sources and transportation costs. Representatives of at least one New York mill state they are interested in replacing up to 10% of its oil fuel use by consuming up to 25,000 tons of scrap tires (2.5 million PTE) per year.

While ample supply is likely to be available in the short run, as demand grows for scrap tires in New York and regionally, competition over supply may grow. It is possible that the cement kilns may need to reduce the tip fee charged or, over the long term, even begin to pay for the scrap tires delivered to their facilities.

Demand Considerations

Demand for the products produced by cement and pulp manufacturers is apparently strong, and this is helping to drive their interest in using scrap tires. The largest potential growth in manufacturer demand for scrap tires is from cement kilns. One New York producer with permits pending to consume scrap tires as fuel is the Lafarge cement kiln in Ravena. This facility is part of a national firm with a long and successful track record of using scrap tires in other facilities around the country. A representative of another New York cement kiln stated his firm did not move forward consuming scrap tires as fuel due to public opposition. Public opposition to consumption of scrap tire fuel by the International Paper mill in Ticonderoga recently led to a public request by a Vermont Senator that this not be allowed. The firm currently has permits pending with the DEC.

Statewide, there are numerous other industrial boilers that might be candidates for using scrap tires as fuel. Nationwide in 2003, 17 pulp and paper mill boilers consumed about 260,000 tons of scrap tires (26 million PTE), up from 14 boilers consuming 190,000 tons (19 million PTE) in 2001.

Trends and Factors Affecting the Market

The use of TDF in New York cement kilns may grow substantially in 2005. The main factors influencing this trend are favorable economics, an apparent lack of significant permitting barriers, growing national experience with TDF by one of New York's three mills, and good progress shown in permitting these mills. A factor that could slow this trend is the potential for strong public opposition, which has played a factor in at least one New York cement kiln's decision not to use TDF, even though it is permitted to do so.

The use of TDF in industrial boilers, like pulp and paper mills, is not likely to grow substantially in the short term. The main factors influencing this trend are the relatively high cost of suitable scrap tire chips, potentially strong public opposition, and a relative lack of experience in New York. National experience suggests, however, that it may be possible to overcome these barriers.

8.4 Fuel for Electricity Generation

Overview

This section covers use of TDF in non-manufacturing environments to generate electricity. The two primary applications, electricity generation boilers and waste-to-energy plants, are described below.

Electricity Generation Boilers

Many independent power producers, electric utilities and some industrial facilities use circulating fluidized bed (CFB) combustors. CFBs burn solid fuel by circulating large amounts of ash or other inert material, effectively suspending the fuel in the upwardly moving stream of air and ash. This process promotes complete combustion, under conditions of high heat transfer at relatively low combustion temperatures (approximately 1600 degrees F). Sorbents such as limestone can be used to absorb certain potential air emissions, namely sulfur, forming calcium sulfate. The hot gases pass over heat transfer surfaces (boiler and superheater tubes) to produce steam, which can be used to generate electricity in steam turbines, or for process heat. The benefits of CFBs over other solid fuel combustors include flexibility in fuel selection and reduced air emissions.

CFB combustors can generally burn tires efficiently, due to the inherent fuel flexibility of their design. Tires need to be chipped typically into 2-inch minus size in order to fluidize in the combustor. CFB's afford good control of air emissions, namely NOx, CO, and SOx due to the combustion temperatures, completeness of combustion, and use of sorbent (typically limestone). Since CFB plants already require sophisticated particulate removal equipment for their principal fuel, additional flyash collection components are not typically needed.

One drawback is that the steel belts, while they can be handled in the combustion process, represent a waste product that may actually complicate existing ash management strategies. This drawback may be hampering increased TDF demand by at least one New York facility, Black River Generation (Fort Drum). Another drawback is that, during combustion, the steel from the tires' belts can agglomerate into wads of materials like "steel wool" or into very dense balls[1], to the point which it no longer fluidizes and drops to the bottom of the bed. Careful monitoring is required to insure that the agglomerated steel does not plug the fluidizing air supply. Under bed drain systems are typically used to remove oversized ash and foreign materials from the bed; these systems require review to evaluate whether they can adequately handle the size and quantity of steel belt debris.

Some utilities and industrial boilers use stoker combustors. Generally, stoker boilers represent older units with lower output and efficiency. While stoker boilers can technically handle TDF, in some cases they could have difficulty achieving air quality requirements since they do not provide the favorable conditions for controlling NOx,

[1] *Fluidized-Bed Combustion of* Tires, D. L. Kraft, P.E., 1994 TAPPI Engineering Conference.

SOx, and CO that are found in CFB units. However, in some cases using TDF in stoker combustors may actually result in an environmental benefit. This may be the case for those stoker combustors currently burning coal that is 2 percent sulfur. In this situation, TDF, which is only about 1 percent sulfur, may provide an environmental advantage.

In 2003, the use of New York generated scrap tires at electric utility facilities was minimal. However, two New York plants began using over 50,000 tons (5 million PTE) of New York generated scrap tires in 2004. Representatives of these facilities indicate this use will likely continue, though in one case further expansion may be hampered by a need to find cost effective ash disposal options.

The likelihood of additional utility or industrial facilities to begin consumption of TDF is difficult to gauge. Statewide, 49 CFB or stoker boilers at 15 New York facilities are permitted to burn coal, and therefore are candidates for switching to TDF. There are also 56 wood burning units at 28 New York facilities, which may have less potential to switch to TDF. However, none of these facilities is known currently to be actively investigating TDF use.

Nationally in 2003, 11 utility boilers were known to use TDF, consuming about 250,000 tons (25 million PTE). This was up from 9 boilers consuming 180,000 tons (18 million PTE) in 2001.

Waste to Energy Plants

Waste to energy plants include several facilities in New York and neighboring states that combust municipal solid waste to generate electricity, as well as the nation's only remaining, dedicated tire-to-fuel facility, Exeter Energy in Sterling, CT.

According to DEC waste transporter records, in 2003, 46,469 tons of New York generated scrap tires (4.6 million PTE) were consumed by Exeter Energy, with an additional 1,508 tons (150,800 PTE) consumed at three New York based waste-to-energy facilities: OCCRA Waste (Syracuse), Oswego County Energy Facility (Oswego), and Adirondak Resource Recovery (Hudson Falls).

Supply Considerations

Unlike cement kilns and the Nucor steel facility's electric arc furnace, some independent power producers, electric utilities and industrial facilities using TDF must use scrap tire chips processed to 2" minus. Tire chips meeting this specification typically are traded in the Northeast at prices of $17 to $25 per ton. Waste to energy plants on the other hand, including the Exeter facility in Sterling CT, generally consume whole tires, and therefore receive a tip fee from suppliers. Current tip fees in the Northeast range from $50 to $55. As with the manufacturing TDF markets described in Section 8.2, increasing demand for scrap tires could result in increased competition over supply, potentially driving the cost of tire chips up, and/or driving tip fees down.

Demand Considerations

Demand for the electricity produced by independent power producers, electric utilities and waste-to-energy facilities is strong. Moreover, increasing fuel costs are driving continued interest in using TDF. Already since 2003, two New York utilities have begun to use large quantities of scrap tires as fuel. However, a barrier to this is the need to identify appropriate methods of managing the ash, which is contaminated due to the steel involved in TDF use.

Trends and Factors Affecting the Market

Use of TDF in utility boilers has grown considerably since 2003 and may continue to grow in the near future. Factors influencing this trend include favorable economics, growing experience in New York State and elsewhere, and the ability of facilities to obtain permits. A factor that might slow this trend is the need to manage boiler ash containing steel contaminants.

Use of TDF in waste-to-energy facilities will stay flat, or may decline. Factors influencing this trend include the unlikelihood of additional WTE capacity being sited and growing competition for scrap tires that may potentially reduce the flow of New York scrap tires to the Exeter TDF facility in Sterling, CT.

8.5 Emerging Technologies – Pyrolysis

Although pyrolysis has had many proponents and many incarnations over the past decade, it remains an emerging technology. The most recently developed technologies are variations on the older versions that proved unsuccessful. The key barrier to success to these operations continues to be the need for consistent, sufficiently priced markets for the primary products produced: carbon products, oil and gas. There is also a related need to demonstrate that these products can be produced in consistent quantities and specifications over time. One new innovation is to produce a range of carbon products rather than being rigidly dependent on recovering carbon black and oil as separate products. For example, one supplier has proposed to completely gasify tires and produce several standard commodity chemical products with ready markets. While improvements have been made, it remains unclear whether any of these technologies is ready for large scale commercial development in the U.S.

The remainder of this section briefly reviews previous pyrolysis technologies and describes four of the most recently developed pyrolysis technologies: Earth First Technologies; Integrated Resource Recovery; Metso Minerals, and Solvent Green, Inc. Each of these four technologies is at different stages of development and look at the products in a different light.

Previous Technologies

Previous tire pyrolysis technologies (e.g., Conrad Industries, SMS technology, and Wind Gap) concentrated on converting tire chips to the three typical products (oil, gas, and carbon) in indirectly heated retorts. A majority of the produced gas was used to operate the process and operating revenue was derived from the sale of oil (typically a

medium sulfur diesel grade fuel oil), the sale of steel and of carbon. The carbon product was claimed to be the most valuable—purported to have the high quality specifications of standard carbon black. Typically the market for this carbon was not fully developed and the technologies were never implemented at a commercial scale.

Earth First Technologies

According to the information made available to R.W. Beck, the Earth First Catalytically Activated Vacuum Distillation (CAVD) tire pyrolysis technology processes 1" minus tire chips in an externally heated continuous retort under vacuum conditions. The CAVD retort converts the tire chips to oil, a gas, and a carbon product. After heating, the vapor (consisting of oil vapors and gas) is removed from the retort and cooled to separate the oils from the gases. As reported by Earth First, the following are approximate percentages of the primary products that the unit produces (note that they do sum to 100 percent):

Carbon Product:	42.5 percent
Oil:	43.2 percent
Gas:	9.5 percent
Steel:	1.8 percent

The gas product is used to power the operation. The oil is to be sold as a heavy fuel oil and the carbon is to be sold as a high value additive to non tire applications that can use a carbon black type of product. Earth First has a 24 ton per day demonstration unit in Alabama. The unit currently is in the initial shakedown and operations phase. Earth First reports that the unit is operating one shift per day since the spring of 2004

The propriety technology appears to be a modification of the previous tire pyrolysis technologies that uses a catalyst (and vacuum operation) to enhance the production of the carbon product. The current 24 ton per day module is a half size unit. Earth First intends to offer 48 ton per day units. Earth First claims that the scale up to the larger size should be straight forward. Scale up will be accomplished by just increasing the length of the current module.

The economics of the process is highly dependent on the price received for the carbon product. This is similar to previous tire pyrolysis technologies. Earth First claims that they have gained acceptance of their carbon product from potential customers. However, the customer's names were not disclosed.

Metso Minerals

Metso Minerals is a manufacturer of heat treating equipment that has developed a tire pyrolysis system based on their externally heated rotary kiln technology. In contrast to other tire pyrolysis developers, Mesto only supplies the equipment and depends on others to develop facilities. At this time, Metso has worked with two developers (one in Canada and one in the US); however neither has been able to finance the equipment. Metso claims that they will provide typical warranties.

The Metso technology also produces the typical tire pyrolysis products (oil, gas, and carbon) along with steel and fiber. Metso stated that the developers that they have

worked with understand that the economics of the process depends on the sale of the carbon black. Metso reports that there has been some interest in the carbon; however, users need a continuous supply of product to confirm the quality over time. As of this time no Metso units have been built.

The Metso's unique reactor design uses the rotary action of the kiln to move tire chips from the feed end to the exit end of the reactor. In a mechanical sense, the separation of the steel, fiber, and char is key. The oil and gas collection systems are standard. However, care must be taken to keep solids out of the vapor stream. Operational conditions and product yields are typical of other processes. Metso reports the following product yields:

Steel:	15 percent
Oil:	28 percent
Gas:	29 percent
Carbon:	28 percent

Metso also reports that the gas contains some sulfur and may need to be cleaned prior to sale, and that the oil is salable as a moderate sulfur fuel oil in the commodity markets. The steel is saleable as recovered, and the carbon is a mixed carbon black that is potentially usable in lower grade applications. The demonstration plant contains all equipment, and operates at 200 to 300 pounds per hour. The full scale module is sized to operate at 100 tons per day -- approximately 30 times larger than the demonstration plant.

Integrated Resources Recovery (IRR)

IRR has developed a whole tire batch pyrolysis technology. IRR is currently operating a single module of the technology at a landfill in Idaho. The unit is indirectly heated using the produced gas to provide the heat for pyrolysis. The pilot unit uses 25 tires per batch (500 pounds) and operates at approximately 800 degrees F. The basic technology is from Japan.

Although limited information is available from IRR, it appears that this type of unit should produce the three typical tire pyrolysis products (oil, gas, and carbon). IRR claims that the value of the products is worth approximately $4 per tire. This implies a high value for the carbon product. IRR did not report any data with respect to operations or marketing of the products.

Solvent Green

Solvent Green takes a different approach to the pyrolysis of tires. The technology is a three step process. The first step is a traditional pyrolysis of three inch tire chips in an indirectly heated retort which produces the typical tire pyrolysis products (oil, gas, and carbon). Solvent Green reports a typical slate of products within the following ranges:

Oil:	38 to 55 percent
Gas:	10 to 30 percent
Char:	33 to 38 percent

The carbon products from this step are then directed to a second higher temperature step in which the char is converted into additional gases. At this point the gases are cleaned of contaminates such as sulfurs, chlorine and remaining solids. The gaseous products are then reformed and shifted to a synthetic gas consisting primarily of hydrogen, carbon dioxide, with small amounts of methane and carbon monoxide. Further processing results in a mixture of hydrogen and carbon dioxide with a small amount of argon. There products can be separated into their marketable components. This technology was developed in Byelorussia and is licensed by Solvent Green. The remaining parts of the process appear to be standard petrochemical processing techniques which should not present a large scale-up risk.

This is a unique approach which produces well-recognized commodity products that can be more easily sold into the market place than the carbon products produced by the previously mentioned tire pyrolysis technologies. The technology also benefits from a higher degree of flexibility in the products produced. This allows the process to be tailored to different end use markets.

Although Solvent Green does not have an operating facility in the United States, the basic retort design has been operated in Byelorussia. Solvent Green reports that tires are only one of the materials that can be processed in their system. Different materials would require modifications to portions of the design.

Chapter 9

CONCLUSIONS AND NEXT STEPS

Chapter 9
CONCLUSIONS AND NEXT STEPS

As the final product of Phase 1 of R.W. Beck's contract with DED, this report has analyzed supply and demand for New York scrap tires during the study year 2003, including identification of key trends and factors affecting the market place.

As documented in this report, the New York scrap tire market is in a period of rapid transition and in-state demand is growing rapidly. Throughout the 1990s, New York scrap tire demand was limited to traditional retread and reuse markets, along with a fledgling ground rubber production industry. However in 2003, value-added demand for scrap tires by end-use facilities located within the state reached at least 84,271 tons (8.5 million PTE or 40.4 percent of total generation). In addition, approximately 17,378 tons (1.7 million PTE) were sent to New York based ground rubber producers who shipped their product to a wide range of value-added manufacturing markets both inside and outside New York State.

This market expansion trend is continuing and broadening. Several in state scrap tire markets grew significantly in 2004, and this trend appears likely to continue into 2005. Furthermore, a range of intriguing emerging technologies for scrap tire recycling are under development, some of which appear promising.

Given this rapidly evolving landscape, DED is well positioned to successfully execute its legislative mandate to strengthen New York scrap tire markets by increasing the value of, and demand for, New York generated scrap tires. In Phase 2 of its contract with DED, R.W. Beck will prepare a strategic plan for scrap tire market development, covering the period of 2005 through 2010. The plan will include recommendations related to financial and technical assistance; regulatory adjustments; and information, education, and outreach efforts. In addition, the plan will evaluate and recommend means of building partnerships with various entities positioned to assist DED's market development efforts. In March 2005, DED and R.W. Beck will host three workshops across the state, soliciting input from scrap tire market stakeholders.

Scrap tire reuse and recycling can be advanced by a wide range of private companies and government agencies throughout New York. Together, their combined efforts have built a solid foundation for increasing success in the coming years.

Appendix A

GLOSSARY OF KEY TERMS

Appendix A
GLOSSARY OF KEY TERMS

Select Terms Defined in New York State Legislation[1]

Abatement: The removal of waste tires from a noncompliant waste tire stockpile and restoration of the site to a condition that is in substantial compliance with the rules and regulations administered by the department for waste tire storage facilities.

Beneficial use: The use of solid waste material, which would otherwise need to be placed in a landfill or disposed of through alternative means, in such a manner that the nature of the use of the material constitutes a reuse rather than disposal. Beneficial uses include incorporation of a solid waste material, which is a legitimate substitute for a raw material into a product marketable to an end user. Waste tires which are burned as a fuel for the purposes of recovering useable energy are considered to be beneficially used only at the point at which they are burned.

End use: A product that requires no further processing or manufacturing and is used by a consumer for the product's intended application.

End user: The ultimate customer of a finished product.

New tires: Tires that have never been placed on a motor vehicle wheel rim or tires placed on a motor vehicle prior to its original retail sale. It does not include recapped or resold tires.

Recycle: The use of recyclables in manufacturing a product for an end use other than burning for recovery of useable energy.

Recyclables: Solid waste materials that exhibit the potential to be used to make marketable products for end users.

Tire service: Any person or business in New York State who sells or installs new tires for use on any vehicle and any person or business who engages in the retail sale of new motor vehicles. A person who is not the end point of sale and any governmental agency or political subdivision is excluded from this term.

[1] As defined in the Waste Tire Management and Recycling Act of 2003, Title 19, Section 27-1901.

Waste tire[2]: Any solid waste which consists of whole tires or portions of tires. Tire casings separated for rereading and tires with sufficient tread for resale shall be included under this term, however crumb rubber shall not be considered a solid waste.

Waste tire storage facility: A facility at which waste tires are stored and for which a permit or registration has been issued.

Additional Select Terms[3]

AASHTO: American Association of State Highway and Transportation Officials.

Aggregate: Rock or stone of uniform size or a range of sizes from either naturally occurring deposits or from artificially prepared materials.

Altered tire: A scrap tire which has been modified so that it is no longer capable of holding or retaining air, water or being used on a vehicle.

Asphalt: A dark brown to black cement-like material in which the predominant constituents are bitumens which occur in nature or are obtained from petroleum processing.

Asphalt binder: The asphalt-cement portion of an asphalt concrete mixture.

Asphalt cement: A fluxed or unfluxed asphalt specially prepared as to quality and consistency for direct use in the manufacture of bituminous pavements.

Asphalt concrete: An aggregate mixture with an asphalt cement binder.

Asphalt rubber: A blend of asphalt cement, ground tire rubber, and certain additives in which the rubber component is at least 15 percent by weight of the total blend and has reacted in the hot mix asphalt cement sufficiently to cause swelling of the rubber particles.

Asphalt rubber chip seal: A thin layer of crumb rubber-modified asphalt used to bind an aggregate wearing course to a roadway surface.

Bagel cut: Cutting the tire in half along its circumference.

[2] In this report the terms *waste tire* and *scrap tire* are used synonymously.
[3] These term definitions are drawn in part from two sources: a) *Glossary of Scrap Tire Terminology*, Scrap Tire Manufacturing Council, April 1994, https://www.rma.org/publications/scrap_tires/index.cfm?PublicationID=11003; and b) *The NYS Roundtable for Consensus on Tire Management.* Rubber Manufacturers Association, March 2000.

Batch plant: A manufacturing facility for producing bituminous paving mixtures that proportion the aggregate constituents into the mix by weighted batches and adds bituminous material by either weight or volume.

Bead: The anchoring part of the tire which is shaped to fit the rim. The bead is constructed of high tensile steel wires scrapped by the piles.

Bead wire: A high tensile steel wire, surrounded by rubber, which forms the bead of a tire that provides a firm contact to the rim.

Bead-to-bead retreading: A retreading process which includes veneering of the sidewall from the shoulder to the bead.

Belt: An assembly of rubber coated fabric or wire used to reinforce a tire's tread area. In radial tires, it also constrains the outside diameter against inflation pressure and centrifugal force.

Bias Ply Tire: A tire built with two or more casing plies which cross each other in the crown at an angle of 30 to 45 degrees to the tread centerline.

Buffer: The equipment used to remove the old tread from the tire that is to be retreaded. A powerful rotary rasp that provides a rough, clean, even surface to which new rubber readily adheres. A flexible shaft buffer is used for preparing a small area for repairing.

Buffing: The process or removing worn/used tread from a tire to be retreaded. A rotating rap that provides a rough, clean, even surface to which new rubber readily adheres. A flexible shaft buffer used for preparing a small area for repairing. Buffings can also be produced during the manufacturing of a tire by grinding to expose white rubber on a finished tire, creating a white sidewall or raised white letters.

Buffing rubber: A term used by ASTM D11, Rubber Committee. Particulate rubber produced as a byproduct of the buffing operation in the carcass preparation stage of tire retreading; characterized by a wide range of particulate sizes which are predominately elongated or acicular in shape. The appearance of the unique shape of the particles of this material is only apparent in finished goods or products which contain particles having a dimension greater in size then 30 mesh.

Buffings: Vulcanized rubber usually obtained from a worn/used tire in the process of removing the old tread in preparation for retreading.

Carbon black: A material used in tires that provides strength to rubber compounds. This material consists essentially of elemental carbon in the form of near spherical colloidal particles and aggregates. Carbon black is obtained by partial combustion or thermal decomposition of hydrocarbons.

Casing: The basic tire structure excluding the tread (also referred to as a carcass).

Casing jockey: An individual or an independent business that collects used or scrap tires from tire vendors or automotive disassembly facilities and transports them to another location (also referred to as a tire jockey).

Chipped Tire: Pieces of scrap tires that have a basic geometrical shape and generally smaller than 6 inches by 8 inches in size (also referred to as a tire chip).

Chopped Tire: A scrap tire that is cut into relatively large pieces of unspecified dimensions.

Civil engineering application: The use of scrap tires in lieu of natural occurring materials (i.e., rock, sand, dirt, gravel) in construction.

Compound: A mixture of blending chemicals specifically tailored to the needs of the specific components of the tire.

Combustion: The chemical reaction of a material through rapid oxidation with the evolution of heat and light.

Concrete: A composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregate; in hydraulic cement concrete, the binder is formed from a mixture of hydraulic cement and water.

Continuous mix plant: A manufacturing facility for producing bituminous paving mixtures that proportions the aggregate and bituminous constituents into the mix by a contiguous volumetric proportioning system without definite batch intervals.

Converted tire: A scrap tire which has been processed into a usable commodity other than a tire.

Crumb rubber: See ground rubber.

Crumb rubber modified asphalt concrete: A general term used to identify a group of processes which incorporate crumb rubber modifiers into asphalt paving materials.

Crumb rubber modifier: A general term used by the FHWA to identify a group of processes and concepts which incorporate scrap tire rubber into asphalt paving materials.

Cryogenics: A crumb rubber modifier production process in which scrap tire rubber is frozen using liquid nitrogen or commercial refrigeration methods to embrittle the rubber. In the cryogenic process, the embrittled rubber is crushed in a hammer mill to the desired particle size.

Curing: Process of heating or otherwise treating a rubber or plastic compound to convert it from a thermoplastic or fluid material into the solid, relatively heat resistant state desired in commercial products. When heating is employed, the process is also called vulcanization.

DEC: New York State Department of Environmental Conservation.

DED: New York State Department of Economic Development.

Dense graded aggregate: An aggregate that has a particle size distribution such that when it is compacted, the resulting voids between the aggregate particles, expressed as a percentage of the total space occupied by the material, are relatively small.

Devulcanization: A process in which there is substantial regeneration of the rubber compound to its original plastic state, thus permitting the product to be processed, compounded or vulcanized. Combined sulfur is not affected. True devulcanization of vulcanized rubber regeneration of the original rubber and removal of combined sulfur has not been accomplished. The term is synonymous with reclaiming of vulcanized scrap rubber. It is primarily a depolymerization accompanied by some oxidation.

Discarded tire: A worn or damaged tire which has been removed from a vehicle.

DOH: New York State Department of Health.

DOT: New York State Department of Transportation.

Dry process: A paving product made with ground rubber as an aggregate component. The rubber is mixed with the aggregate prior to blending in the asphalt cement in quantities ranging up to three percent rubber. This process is also referred to as rubber modified asphalt concrete.

Granulated rubber: A term defined by ASTM D11, Rubber Committee as particulate rubber composed of mainly non-spherical particles that span a broad range of maximum particle dimension, from below 40 mesh to 0.47 inches. The key feature of this type of particular rubber is the fraction of the material in the greater than 0.08 inch up to 0.47 inch maximum particulate dimension range.

Granulator: A machine that shears apart scrap tire rubber with revolving plates and produces ground particles, generally ¾ inch to 200 mesh.

Ground Rubber: Particulate rubber composed of mainly non spherical particles that span a range of maximum particulate dimension, from well below 40- mesh to 0.08 inches, conforming to ASTM specifications D5644-96 and D5603-96. (Also referred to as crumb rubber.)

Heavy-Duty Tires: Tires weighing more than 40 pounds, used on truck, buses and off-the-road vehicles in heavy duty applications.

Hot mix asphalt: A composition consisting primarily of graded aggregate and asphalt cement widely used for paving.

ISTEA: Intermodal Surface Transportation Efficiency Act.

Light duty tires: Tires weighing less than 40 pounds, used on passenger cars and light trucks.

Light Truck Tires: Tires with a rim diameter of 16 to 19.5 inches, manufactured specifically for light truck use.

Logger tire: A special tire designed for the logging industry.

Mold cure: A retreading process using uncured tread compounds, where the vulcanization take place in molds.

NAPA: National Asphalt Paving Association

New Tire: A tire which has never been mounted on a rim, or which has only been mounted on the rim of a new, never-before sold automobile.

NTDRA: National Tire Dealers and Retreaders Association.

OGS: New York State Office of General Services

Open Graded Aggregate: An aggregate that has a particle size distribution such that when compacted, the voids between the aggregate particles, expressed as percentage of the total space occupied by the material, remain relatively large.

Original equipment tire: The tires supplied with new vehicles from vehicle manufacturers.

OTR: Off the road tire; tire designed primarily for use on unpaved roads or where no roads exist. Built for ruggedness and traction rather than speed.

Passenger car tire: A tire with less than an 18 inch rim diameter for use on cars only.

Processed tire: A scrap tire which has been altered, converted or size reduced.

PTE: Passenger tire equivalent; a measurement of mixed passenger and truck tires where five passenger tires are equal to one truck tire.

Recapping: An improper term for retreading. Often, this term refers to the process of top capping, in which rubber is applied to the tread surface only.

Reclaimed asphalt pavement, RAP: Asphalt pavement or paving mixture removed form its original location for use in recycled asphalt pavement mixtures.

Recycled Asphalt Paving Mixture: A mixture or reclaimed asphalt pavement (RAP) with the inclusion, if required, of asphalt cement, emulsified asphalt, cut back asphalt, recycling aggregate, mineral aggregate and mineral filler.

Remanufactured Tire: A worn tire than has been properly inspected and/or repaired and has had new rubber applied bead-to-bead to extend its serviceable life (also referred to as a remolded tire).

Repaired tire: A tire that has been damaged by cuts, puncture or breaks and which has been reconditioned to restore its strength for additional service.

Retreaded tire: A casing to which a new tread rubber and sometimes a shoulder and sidewall rubber has been vulcanized to extend the usable life of the tire.

RMA: Rubber Manufacturers Association; the trade association which represents the United States tire manufacturers and the United States based manufactures of non-tire rubber products.

Rough shred: A piece of a shredded tire that is larger than 2”x2”x2”, but smaller than 30”x2”x4”.

RPA: Rubber Pavement Association.

Rubber: An elastomer, generally implying natural rubber, but used loosely to mean any elastomer, vulcanized or not. By definition, rubber is a material that is capable of recovering from large deformations quickly and forcibly and can be, or already is modified to a state in which it is essentially insoluble in a boiling solvent.

Rubber modified asphalt: A general terms used to identify the incorporation of scrap tire rubber into asphalt paving materials (also referred to as crumb rubber modified asphalt concrete).

Rubber modified asphalt concrete: A pavement product made with rubber. The rubber acts as an aggregate, and is blended into asphalt cement along with the aggregate in quantities ranging up to three percent rubber. This process is also referred to as the dry process.

SAM: Stress absorbing membrane; a rubberized asphalt layer applied over an existing pavement to retard fatigue cracking.

SAMI: Stress absorbing membrane inter-layers; a rubberized asphalt layer applied over an existing surface before application of a surface asphalt concrete, used to retard reflective cracking.

Scrap Tire: Defined synonymously with "waste tire" as in New York legislation (see above).

Shredded Tire: A size reduced scrap tire. The reduction in size was accomplished by a mechanical processing device, commonly referred to as a shredder.

Sidewall: The side of a tire between the tread shoulder and the rim bead.

Source reduction: Any of a series of practices which act to reduce the number of scrap tires generated annually. These practices include but are not limited to using longer mileage tires, maintaining proper inflation, rotating tires, balancing tires, maintaining alignment repairing tires and retreaded tires.

STMC: Scrap Tire Management Council.

Synthetic rubber: Rubber that is obtained by polymerizing petrochemical based monomers.

Tire derived fuel: A uniformly shredded product obtained form whole tires, used as fuel.

Tire jockey: An independent business that hauls scrap tires fore a fee from retail tire vendors to another location. Also known as a casing jockey.

TISC: Tire industry safety council

Vulcanization: An irreversible process in which the chemical structure of rubber is changed (cross linked) to become elastic plastic (sticky, putty –like) and more elastic (bouncy).

Vulcanized rubber: The product of vulcanization in which rubber which has been chemically reacted with sulfur and accelerators (or other acceptable materials) under suitable conditions to achieve modified physical properties over a wide range of temperatures.

Wet process: Any method that blends ground rubber with the asphalt cement prior to incorporating the binder in the asphalt paving project.

Worn tire: Any tire which has been removed from a vehicle because of wear or damage. Worn tires can be retreaded, repaired or scrapped.

Appendix B

LIST OF PERSONS INTERVIEWED

Appendix B
LIST OF PERSONS INTERVIEWED

- Amirkhanian, Serji
  Clemson University Asphalt Rubber Technology Service
- Anderson, Jim
  RTG, Cambridge, ON
- Andrews, Marion
  Border Tire
- Barlow, Jeff
  Twin Tier Tire Corporation
- Bartz, Charles
  Earth First Technology
- Bates, RL.
  Enviroform
- Belaval, Judy
  CT DEP Waste Planning & Standards
- Benameur, Fariel
  Environmental Manager, Lafarge, Ravena, Cement Plant
- Bischoff, Jack
  Belting Associates
- Bhavani, Giri
  Environmental Manager, St. Lawrence Cement Company, Catskill Facility
- Blumenthal, Mike
  Senior Technical Director, Rubber Manufacturers Association
- Branson, Steve
  Product Specialist for Tire Recycling Equipment, Wendt Corporation
- Brodsky, Harvey
  Tire Retread Information Bureau
- Buss, Tim
  Buffalo Fuel Company
- Butindari, Rocco
  Sales, Child Safe Products
- DeVanney, Paul
  Business Development Representative, Seneca Meadows
- Duran, Joe
  O&M Manager, WPS Niagara

- Dwyer, Don
  New York State Department of Transportation
- Farris, Richard
  UMass AMherst
- Fasolino, Jerry Sr.
  Alternative Rubber & Plastics Inc.
- Fennell, Tom
  Fennell Recycling LLC
- Fromnick, Steve
  Solvent Green, Inc.
- Fulton, Mark
  Oswego County, NY
- Hassan, Morris
  Rubber Recycle
- Gardener, Kenneth L.
  Metso Minerals Industries
- Green, Stephen
  Environmental Manager, Nucor Steel Auburn, Inc.
- Greenstein, David
  Lakin Tire East
- Grimmke, Willy
  Washington County
- Hassan, Morris
  Rubber Recycle
- Heck, Mike
  Alberta Recycling/Canadian Tire Recycling Association
- Honer, Mike
  President, Huron Recovery of NY
- Hudson, Charlie
  Vice President, BCD Tire Chip Manufacturing
- Humphrey, Dana
  University of Maine
- Johnson, Rick
  General Manager, High Tread International
- Kauffman, Sam
  Plant Manager, Edge Rubber
- Kelly, Rick
  RTG
- Kyle, Peter
  North Brook Farms, Inc.

- Laporte, Misty
  Meridian Inc.
- Malkins, Amanda
  Ontario Ministry of Environment; Waste Management Policy Branch
- McCall, Steve
  Plant Engineer & Environmental Manager, Black River Generation LLC
- Melendez, Tony
  New York State Thruway Authority
- Mellot, Bruce
  Safety Engineer, Glens Falls Lehigh Cement Company
- Moreland, Alan
  Rubber Recycling Associates
- Murphy, Roseann
  New York City Department of Environmental Protection
- Pacifio, Tom
  Surface America, Inc.
- Prinz, George
  Unity Creations, Inc.
- Redanz, Brian
  Recycling Director, Modern Recycling, Inc.
- Riely, Pat
  Integrated Resource Recovery
- Robbins, Joel
  Process Engineer, Finch Pruyn & Company
- Saolon, Joseph
  Owner, Interstate Recycling Corporation
- Sears, Rachel
  Tire Conversion and Technologies
- Sessamen, Rachel
  Integrated Tire.
- Shatten, Bob
  SuperCool.
- Sikora, Mary
  Recycling Research Institute/Scrap Tire News
- Smith, Ken
  Chautauqua County
- Smith, Lindsay
  CEO/Owner, Rubber Sidewalks
- Staroba, Edwin
  Buffalo Polymer Processors Inc.

- Staroba, Miro
  Buffalo Polymer Processors Inc.
- Styk, Mike
  Environmental Engineer, New York State Division of Air Resources
- Terry, Tom
  Co-owner, Terry Haggerty Tire
- Thielke, Russ
  New York State Department of Transportation
- Wadsworth, Donna
  Communications Manager, International Paper, Ticonderoga Mill
- Walker, Gene
  Premier Rubber
- Warrener, Dan
  Chatham Rubber, Ontario CA
- Weinstein, Mel
  Tire Trader

Appendix C

BIBLIOGRAPHY

Appendix C
BIBLIOGRAPHY

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Canadian Association of Tire Recycling Agencies http://www.catraonline.ca/

Clean Washington Center http://www.cw.org/tires.htm

New York State Department of Conservation
http://www.dce.state.ny.us/website/dshm/redrecy/wstires.htm

Rubber Manufacturers Association http://www.rma.org

Scrap Tire News http://www.scraptirenews.com

United States Environmental Protection Division (US EPA)
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Appendix D

LIST OF SCRAP TIRE MARKET FACILITIES

R·W·BECK

Appendix D
LIST OF SCRAP TIRE MARKET FACILITIES

Appendix D lists facilities located in New York State that are involved in scrap tire management, as well as a limited number of facilities located outside of the state that handles New York generated scrap tires. As summarized in Table D-1, each facility was classified according to their market role (e.g., supplier or end-user), by category (based on the activities they are involved in) and by product (based on the type of product they sell or handle). This classification scheme is consistent with that used throughout this report. Table D-2 lists the market facilities.

Table D-1
Market Facility Classification Scheme

Market Role	Category	Product
Supplier	▪ Reseller/Processor ▪ Transporter ▪ Dealer/Broker ▪ Other	• Whole Tires • Shreds/Chips • Ground Rubber • Other
End User	▪ Reuse	• Partially worn reuse • Retread/Remanufacture • Other
	▪ Other Recycling Uses	• Whole Tire Uses • Baled Tire Uses • Cut, Punched and Stamped • Other
	▪ Ground Rubber	• Roads • New Tire Manufacture • Athletic Surfacing and Horticultural • Molded Products • Rubber/Plastic Compounds • Other
	▪ Tire Derived Aggregate	• Landfill • Transportation • Septic • Other
	▪ Raw Material and Fuel	• Steel • Cement • Pulp and Paper • Utility • WTE • Other

Table D-2
New York State Scrap Tire Market Facilities

Company Name	City	State Or Province	Market Role	Category	Product
Action Tire Retreaders, Inc.	Deer Park	NY	End User	Reuse	Retread/Remanufacture
Advac Elastomers	Evanston	IL	Supplier	Ground Rubber	Ground Rubber
AJ Tire Repair	Staten Island	NY	End User	Reuse	Retread/Remanufacture
All States Asphalt	Holliston	MA	End-User	Ground Rubber	Roads
Alternative Rubber & Plastics, Inc.	Amherst	NY	End User	Ground Rubber	Rubber/Plastic Compounds
American Rubbertech	Forest Hills	NY	End User	Ground Rubber	Molded Products
American Waste Control of NY, Inc.	Pine Island	NY	Supplier	Transporter	Whole Tires
Armstrong World	Lancaster	PA	Reuse	Ground Rubber	Ground Rubber
Bandag Tire of Buffalo	Buffalo	NY	End User	Reuse	Retread/Remanufacture
Barmore-Sellstrom Tires, Inc.	Jamestown	NY	End User	Reuse	Retread/Remanufacture
BCD Tire Chip Manufacturing	Glenville	NY	Supplier	Reseller/Processor	Whole Tires, shreds/chips
Belting Associates, Inc.	Hicksville	NY	Other - Distributor	Dealer/Broker	Molded Products
Black River Power Electric Generating (Black River Generation LLC)	Fort Drum	NY	End User	Raw Material and Fuel	Utility
Blue Circle Cement	Marietta	GA	End User	Raw Material and Fuel	Cement
Border Tire	Spencerport	NY	Supplier	Reseller/Processor	Whole Tires, Partially Worn Reuse
Briggs Tire Service, Inc.	Livonia	NY	End User	Reuse	Retread/Remanufacture
Buffalo Polymer Processors, Inc. (a.k.a. Staroba Plastics and Metals	Holland	NY	End User	Reseller/Processor	Rubber/Plastic Compounds, Molded Products
Carlisle Syntech	Carlisle	PA	End-User	Ground Rubber	Ground Rubber
Casings, Inc.	Catskill	NY	Supplier	Reseller/Processor	Whole Tires, Shreds/chips

Company Name	City	State Or Province	Market Role	Category	Product
Champion International	Jamaica	NY	End User	Reuse	Partially Worn Reuse
Chautauqua County Department of Public Facilities (Public Works)	Falconer	NY	End User	Other Recycling Uses	Baled Tire Uses
Child Safe Products	Amityville	NY	Other - Distributor	Broker/Dealer	Athletic Surfacing and Horticulture
Chriskar Inc.	Walton	NY	End User	Tire Derived Aggregate	Other - Industrial Applications
Cline Retreading Co., Inc.	Wellsville	NY	End User	Reuse	Retread/Remanufacture
Columbus McKinnon Corporation	Amherst	NY	Supplier	Other	Equipment
Commercial Truck Tire Retreaders, Inc.	East Syracuse	NY	End User	Reuse	Retread/Remanufacture
CRAFCO, Inc.	Latham	NY	End User	Ground Rubber	Roads
Crumb Rubber Technology, Inc.	Hollis	NY	Other - Distributor	Ground Rubber	Other – Equipment
D.J. Tire Works, Inc.	Brooklyn	NY	End User	Reuse	Retread/Remanufacture
Delaware County Department of Public Works	Delhi	NY	End User	Tire Derived Aggregate	Roads
Dodge Regupol, Inc.	Lancaster	PA	End User	Ground Rubber	Molded Products
Doino's Tire Service, Inc.	Hicksville	NY	End User	Reuse	Retread/Remanufacture
Don Stevens Tire	Southington	CT	Supplier	Reseller/Processor	Whole Tires
Dunrite Systems Corp.	Ronkonkoma	NY	Supplier	Reseller/Processor	Ground Rubber
Earth First Technology	Tampa	FL	End User	Raw Material and Fuel	Other – Pyrolysis
Edge Rubber	Chamberburg	PA	Supplier	Reseller/Processor	Shreds/chips, Ground Rubber
Edward Arnold Scrap Processors, Inc.	Corfu	NY	Supplier	Reseller/Processor	Whole Tires
Eggers, Caryl & Corrigan, Inc.	Utica	NY	End User	Reuse	Retread/Remanufacture
Empire Reclaim Service, Inc.	Niagara Falls	NY	Supplier	Reseller/Processor	Whole Tires

Company Name	City	State Or Province	Market Role	Category	Product
Enviroform Products (Division of R.L. Bates & Associates, Inc.)	Geneva	NY	End User	Ground Rubber	Molded Products
Environment Services Group, Inc.	New York	NY	Supplier	Reseller/Processor	Whole Tires
Environmental Process Systems (EPS)	Mineola	NY	Supplier	Reseller/Processor	Ground Rubber
Exclusive Repairs / Tire Service	West Babylon	NY	End User	Reuse	Retread/Remanufacture
Fennell Recycling, LLC	Elmira	NY	Supplier	Reseller/Processor	Shreds/chips, Ground Rubber
Finch Pruyn & Company	Glens Falls	NY	End User	Raw Material and Fuel	Pulp
Five County Truck Tire Service	Westbury	NY	End User	Reuse	Retread/Remanufacture
Floroseal	Allentown	PA	End Users	Ground Rubber	Ground Rubber
Fox Tire Company	Buffalo	NY	Supplier	Transporter	Whole Tires
G&C Tire Co.	Plattsburgh	NY	End User	Reuse	Retread/Remanufacture
Garlock Valves and Industrial Plastics Division	Camden	NJ	Supplier	Reseller/Processor	N/A
GCR Truck Tire Center	Albany	NY	End User	Reuse	Retread/Remanufacture
Glens Falls Lehigh Cement Company	Glens Falls	NY	End User	Raw Material and Fuel	Cement
Gotham Bandag Corp.	Bronx	NY	End User	Reuse	Retread/Remanufacture
Harvey Brothers, Inc.	Newburgh	NY	End User	Reuse	Retread/Remanufacture
High Tread International, LTD a.k.a. Tire Recycling Technologies	Lockport	NY	Supplier	Reseller/Processor	Ground Rubber
Huron Recovery of New York, Inc.	Buffalo	NY	Supplier	Reseller/Processor	Whole Tires, Shreds/chips
Huron Recovery of New York, Inc.	Buffalo	NY	Supplier	Reseller/Processor	Whole Tires, Partially worn reuse, Shreds/chips
Hurtubise Truck Tire Sales & Service	North Tonawanda	NY	End User	Reuse	Retread/Remanufacture

Company Name	City	State Or Province	Market Role	Category	Product
Industrial Recycling Systems, Inc.	Croton-on-Hudson	NY	N/A	N/A	N/A
Industrial Tire	Buffalo	NY	End User	Reuse	Retread/Remanufacture
Integrated Resource Recovery		ID	End User	Raw Material and Fuel	Other – Pyrolysis
Integrated Tire	Buffalo	NY	Supplier	Reseller/Processor	Shreds/chips, Raw Material and Fuel
International Paper, Ticonderoga Mill	Ticonderoga	NY	End User	Raw Material and Fuel	Pulp and Paper
Interstate Recycling Corporation	Auburn	NY	End User	Other Recycling Uses	Cut, Punched, and Stamped
ITR Recycling, Inc.	Dobbs Ferry	NY	Other - Distributor	Ground Rubber	Other – Equipment
JAR Rubber dba Ranger Tires	Farmingdale	NY	End User	Reuse	Retread/Remanufacture
JBH Tire Recycling	Yapank	NY	Supplier	Transporter	Whole Tires
Jim's Mobile Tire Service	North Tonawanda	NY	End User	Reuse	Retread/Remanufacture
JP Byrne & Co., Inc.	Syracuse	NY	End User	Reuse	Retread/Remanufacture
JP Tires	St. James	NY	Supplier	Reseller/Processor	Whole Tires, Shreds/chips
K&S Tire Company	Williamstown	NY	Supplier	Reseller/Processor	Partially Worn Reuse
KES - Kenetech Energy Systems	Chateaugay	NY	Supplier	Transporter	Shreds/chips
Lafarge, Ravena Cement Plant	Ravena	NY	End User	Raw Material and Fuel	Cement
Lakin Tire East	West Haven	CT	Supplier	Reseller/Processor	Whole Tires, Shreds/chips
Lewis General Tires, Inc.	Rochester	NY	End User	Reuse	Retreat/Remanufacture
Long Park Tire, Inc.	Watertown	NY	End User	Reuse	Retreat/Remanufacture
Madison County Landfill	Wampsville	NY	End User	Tire Derived Aggregate	Landfill

Company Name	City	State Or Province	Market Role	Category	Product
Main Tire Exchange	Dansville	NY	Supplier, End User	Reseller/Processor, Reuse	Whole Tires, Retreat/Remanufacture, Partially Worn Reuse
Mazco Tire Recycling	Commack	NY	Supplier	Transporter	Whole Tires
Meridian, Inc.	Plainfield	CT	Supplier	Reseller/Processor	Whole Tires, Shreds/chips
Metro Truck Tire Services	Bronx	NY	End User	Reuse	Retread/Remanufacture
Metso Minerals Industries	Danville	PA	End User	Raw Material and Fuel	Other – Pyrolysis
Miller, Jack Tire Co. Inc.	Bronx	NY	End User	Reuse	Retread/Remanufacture
Modern Recycling, Inc.	Model City	NY	Supplier, End User	Reseller/Processor, Tire Derived Aggregate	Whole Tires, Shreds/chips, Landfill Applications
Modern Recycling, Inc.	Model City	NY	Supplier, End User	Reseller/Processor, Tire Derived Aggregate	Landfill, Septic
Mohawk Tire Recycling	Waterford	NY	End User	Reuse	Retread/Remanufacture
National Tire Shop	Corona	NY	End User	Reuse	Retread/Remanufacture
New York Rubber Recyclers LLC	Rotterdam	NY	Supplier	Reseller/Processor	Ground Rubber
New York Tire Processing, Inc.	Deer Park	NY	Supplier	Reseller/Processor	Shreds/chips, Whole Tires
North Brook Farms, Inc.	Weedsport	NY	End User	Ground Rubber	Molded Products, Athletic Surfacing and Horticulture
Northeastern Tire Retreaders, Inc.	Albany	NY	End User	Reuse	Retread/Remanufacture
Nucor Steel Auburn, Inc.	Auburn	NY	End User	Raw Material and Fuel	Steel
Omni of Babylon	W. Babylon	NY	Supplier	Reseller/Processor	Shreds/chips, Ground Rubber
Outlet Tire Sales	Geneva	NY	End User	Reuse	Retread/Remanufacture
PPG Adhesives	Pittsburg	PA	End-User	Reuse	Ground Rubber
Pat's Tire Service	Rome	NY	End User	Reuse	Retread/Remanufacture

Company Name	City	State Or Province	Market Role	Category	Product
Pawling Rubber Corporation	Pawling	NY	End User	Ground Rubber	Athletic Surfacing
PharGo LLC DBA Buffalo Weaving and Belting	Buffalo	NY	End User	Ground Rubber	Molded Products
Polyblends, Inc.	Brooklyn	NY	End User	Ground Rubber	Rubber/Plastic Compounds
Premier Rubber Co.	Massapequa	NY	Supplier	Dealer/Broker	Shreds/chips, Ground Rubber
Recoverers of Manufactured Products	Middletown	NY	Supplier	Transporter	N/A
Renu Industrial Tire Corp.	Freeport	NY	End User	Reuse	Retread/Remanufacture
RMA Asphalt Producers			End User	Ground Rubber	Road Construction
Roli Retreads, Inc.	Farmingdale	NY	End User	Reuse	Retread/Remanufacture
Ron Parmenter Motors, Inc.	Odessa	NY	End User	Reuse	Retread/Remanufacture
Rua & Sons, Inc.	Cobleskill	NY	End User	Reuse	Retread/Remanufacture
Rubber Sidewalks	Gardena	CA	End User	Ground Rubber	molded Products
Rubberman Tire Removal	Monroe Township	NJ	Supplier	Transporter	Whole Tires
RubberRecycle, Inc.	Lakewood	NJ	Supplier	Reseller/Processor	Ground Rubber
Safe Guard Surfacing	St. James	NY	End User	Ground Rubber	Athletic Surfacing and Horticulture
Safe Landings, Inc.	Kingston	NY	Supplier	Dealer/Broker	Ground Rubber
Scrap Tire Broker			Other - Distributor	Broker/Dealer	whole tires
Seneca Meadows, Inc.	Waterloo	NY	Supplier, End User	Reseller/Processor, Tire Derived Aggregate	Landfill Applications
SMI Waste Tire Facility	Seneca Falls	NY	N/A	N/A	N/A
Smith's Commercial Tire Service	Hudson	NY	End User	Reuse	Retread/Remanufacture
Solvent Green, Inc.	West Chester	PA	End User	Raw Material and Fuel	Other – Pyrolysis

Company Name	City	State Or Province	Market Role	Category	Product
St. Lawrence Cement Company, Catskill Facility	Catskill	NY	End User	Raw Material and Fuel	Cement
SuperCool LLC	Arlington	MD	Supplier	Ground Rubber	Ground Rubber
Surface America	Williamsville	NY	End User	Ground Rubber	Athletic Surfacing and Horticulture
Target Compaction	Oneida	NY	End User	Other Recycling Uses	Baled Tire Uses
Terry-Haggerty Tire Co., Inc.	Albany	NY	End User	Reuse	Retread/Remanufacture
The Goodyear Tire and Rubber Co.	Akron	OH	End User	Ground Rubber	New Tire Manufacture
The John Rossi Company, Inc.	Ossing	NY	End User	N/A	N/A
The Tire Shredder, Inc.	Central Bridge	NY	Supplier	Transporter	Whole Tires, Shreds/chips
Tire Conversion Technologies, Inc.	Niskayuna	NY	End User	Other Recycling Uses	Cut, Punched, and Stamped
Tire Traders, Inc.	Deer Park	NY	Supplier	Transporter	Whole Tires
Toms River Rubber Recycling LLC	Guttenburg	NJ	Supplier	Reseller/Processor	Ground Rubber
TR Treading	Akron	NY	End User	Reuse	Retread/Remanufacture
Transinternational Tire Recycling and Energy	Brooklyn	NY	Supplier	Transporter	Whole Tires, Partially Worn Reuse
Tri-State Tire	Mount Vernon	NY	End User	Reuse	Retread/Remanufacture
Twin Tier Tire Corporation	Elmira	NY	End User	Reuse	Retread/Remanufacture
U Save Tire Company	Plattsburgh	NY	End User	Other Recycling Uses	Cut, Punched, and Stamped
Unifuse Plastics, Division of B&R Specialties, Inc.	Staatsburg	NY	End User	Ground Rubber	Rubber/Plastic Compounds
Unity Creations	Saugeries	NY	End User	Ground Rubber	Athletic Surfacing and Horticulture

Company Name	City	State Or Province	Market Role	Category	Product
Unity Surfacing Systems	Hicksville	NY	End User	Ground Rubber	Rubber-Plastics Compounds, Molded Products
Ursula Products, Inc.	Brooklyn	NY	Supplier	Dealer/Broker	Whole Tires
Valley Tire Co., Inc.	Tonawanda	NY	End User	Reuse	Retread/Remanufacture
Washington County	Fort Edward	NY	End User	Other Recycling Uses	Baled Tire Uses
Wendt Corporation	Tonawanda	NY	Other - Distributor	Ground Rubber	Other – Equipment
Winans and Sadecki, Inc.	Hallstead	PA	Other - Distributor	Ground Rubber	Other – Equipment
WPS Niagara Generation, LLC	Niagara Falls	NY	End User	Raw Material and Fuel	Electricity Generation

Appendix E

METHODOLOGY FOR ESTIMATING 2003 SUPPLY AND DEMAND

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Appendix E
METHODOLOGY FOR ESTIMATING 2003 SUPPLY AND DEMAND

Objectives

This appendix describes R.W. Beck's methodology for estimating New York scrap tire supply and demand in the study year 2003. The main objective of this initial analysis was to estimate 2003 market disposition estimates and identify key trends (especially information describing 2004 changes and projections for 2005). The Project Team worked to validate data, reconcile conflicting information, and fill gaps in order to develop as accurate a portrayal of the supply and demand of scrap tires originating in New York as possible, given data, time and resource limitations. Because of the many challenges involved, R.W. Beck will seek to refine these estimates in future annual updates. The following sections summarize the methodology, sources of error and degree of confidence in results.

Methodology

R.W. Beck undertook the following steps to estimate the supply and demand of New York generated scrap tires in 2003:

1. Obtained and compiled data from Part 364 waste transporter annual reports from DEC for calendar years 2002 and 2003. Year 2003 data became fully available in January 2005. Each form shows the waste transporter, amount shipped, and "disposal facility" (which often is a recycling facility). These data were entered in to an Excel spreadsheet and sorted separately by transporter and by disposal facility. Since the units for amount of tires vary, all were converted to tons using the conversion factors listed in Appendix F. Data from the 18 largest disposal facilities were moved to a separate spreadsheet for analysis. Each was telephoned and interviewed. These facilities accounted for over 95% of total flow.
2. Additional interviews were conducted with select companies known to be active in each of the major end use markets identified in the report. Contact information and information on products produced were obtained from DED.
3. Additional sources of information included information on scrap tire BUDs and noncompliant waste tire stockpile abatement contracts from OGS/DEC, state environmental agencies in Connecticut and New Jersey, a NEWMOA report on scrap tire flows in 2000, the Rubber Manufacturers Association, and

the report prepared by the New York Council on Scrap Tire Management and Scrap Tire News (a monthly publication dedicated to scrap tire management).

4. A spreadsheet was developed listing separately suppliers and end-users of scrap tires, defined strictly according to the system used throughout this report. Each identified facility for which flow data were available was assigned either as supply, demand, or both (if they both supply material and use on site). Suppliers include any facility producing a whole tire, tire shred or chip, or ground rubber for sale directly to an end-use market, or that engaged in end-use activities on site.
5. Suppliers were scrutinized in an effort to eliminate double-counting, and to list only those suppliers shipping directly to an end-use market. Where information was available to document shipments between suppliers, quantities for some suppliers were reduced to compensate. This process yielded a first-order estimate of supply for the year.
6. The estimates were adjusted for each market sector to balance supply and demand. For example, demand estimates were adjusted by entering estimates for unidentified purchasers (where information about supplies moving to a particular market sector was available, but not on the specific end user). Supply estimates for some market sectors were adjusted allocating a portion of supply not previously allocated to a specific end use (where information on an end use was available, but no on the particular supplier). For example, tire resellers indicated in interviews that they sold approximately 4,138 tons of scrap tires into reuse markets. Yet due to resource limitations, R.W. Beck did not attempt to identify the purchasers of these reused tires. Rather, demand was adjusted to reflect 4,138 tons purchased by "miscellaneous end users." Similar balances were performed for each market sector. This process required careful scrutiny of all data from interviews and other sources. In several cases, additional phone interviews were conducted to verify or clarify data. All adjustments were documented clearly.
7. The total supply of New York scrap tires was compared to other estimates of scrap tire generation (as discussed in Section 3.2), and found to be reasonably within the boundaries of expected values.
8. Information from interviews pertaining to 2004 and expected trends was also captured in the spreadsheet for each facility.

Data Limitations and Sources of Error

Following are the major potential sources of error in this analysis, and the steps R.W. Beck took in an attempt to reduce error:

- The potential exists to double-count tires (transported once as whole tires, for example, and again as shreds). R. W. Beck worked to mitigate this impact using information obtained from interviews. This factor may cause R.W. Beck's estimate of total flow to be over estimated somewhat.

- Only a portion of identified Retreaders in New York were contacted for information. It is possible that quantities of scrap tires flowing to these facilities were not counted. This factor may cause R.W. Beck's estimate of total flow to be under estimated somewhat.
- Waste transporter data does not distinguish between the amount of tires generated out-of-state vs. in-state. Again, Beck supplemented transporter data wherever possible with information obtained through interviews and other sources.
- New York State law exempts waste transporters hauling less than 500 pounds (25 passenger tires) of non-hazardous waste in any single shipment from having to be permitted. Additionally, those transporting via rail, water, and air are exempt from waste transporter permitting. Although Beck does not believe these exemptions are a large source of error, it is impossible to document this with certainty.
- The potential exists for waste transporters, located both in-state and out-of-state, to not obtain a permit. According to ECL 27-0303, Chapter 226, "Waste Tires shall mean waste tires transported for a fee for the purpose of reuse, recycling or disposal, except those tires collected and transported incidental to the collection and transportation of solid waste." Some haulers have indicated that they are not transporting for a fee, therefore they do not have to be permitted. The extent to which this is occurring, or what impact this would have on overall market numbers is unknown.
- Some waste transporters/processors receive stockpiled tires from smaller, locally managed cleanup projects. Beck attempted to identify the number of stockpiled tires received vs. annually generated through the interview process; however some respondents did not know the portion, and some smaller entities were not interviewed.
- It is impossible to know the final disposition of some tires. Some resellers, for example, indicate that a portion of their tires go to Canada, but they can only speculate what is done with them there. Similarly, some respondents were unwilling or unable to share information regarding final disposition, and not every processor and producer in the State was interviewed.
- Waste transporter data was not provided in consistent units. In some cases, Beck had to convert cubic yards or tire volumes to tons using estimates of the type and density of the waste tires transported.
- In some cases, waste transporter data may be reported incorrectly due to waste transporter errors in completing the form, or data entry errors by DEC or R.W. Beck staff.
- Ground rubber is specifically exempt from the reporting process, so no information on it is captured in waste transporter reports.

Degree of Confidence in Results

Despite the above data limitations and other sources of error, R.W. Beck believes these supply and demand estimates are the best available covering New York, and the best possible, given the study's available time and resources. Beck believes that they accurately indicate the relative flow of scrap tires in 2003 to broad market categories. However, the breakdown of flows to narrow sub markets within broad market categories may be less accurate. R.W. Beck will seek to refine these estimates in annual updates, beginning in March 2006.