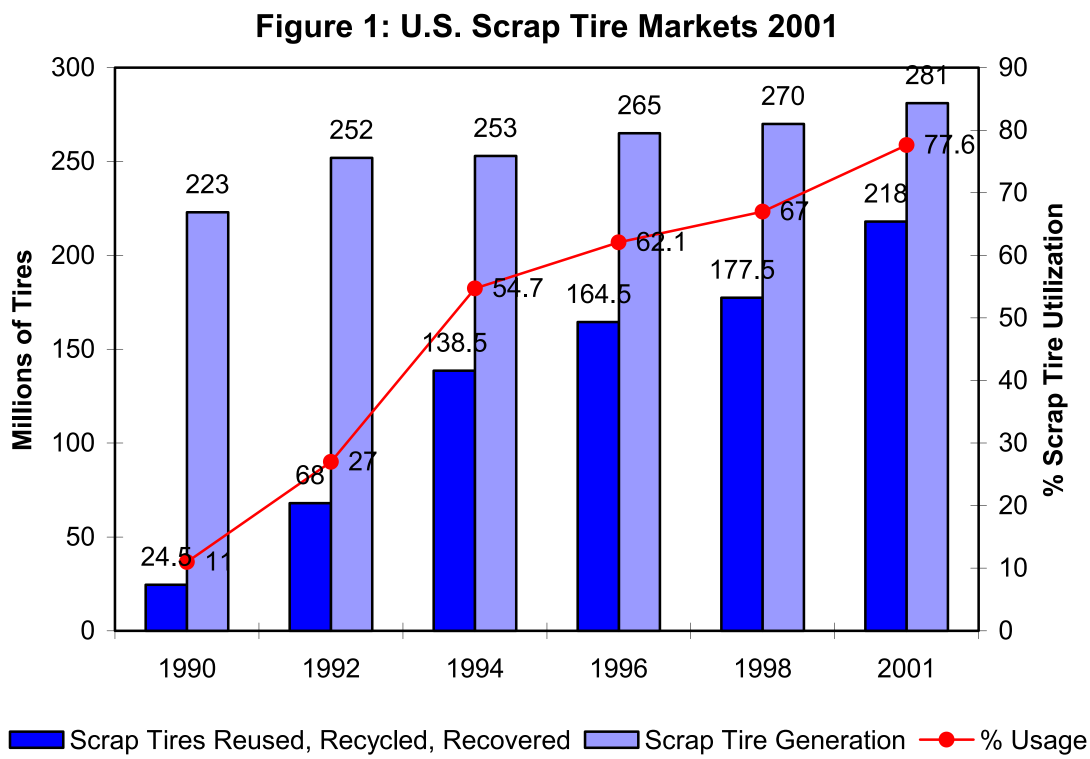
U.S. SCRAP TIRE MARKETS 2001

December 2002



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This is the sixth biannual report on scrap tire markets researched and published by or on behalf of the Rubber Manufacturers Association (RMA). This report, like all previous reports, provides a "snapshot in time" of the status, progress and challenges of the scrap tire industry in the United States (U.S.). The report also offers commentary on certain factors that have, are, or could impact the markets and management of scrap tires.

The information provided in this report is based on several sources. RMA sent a questionnaire to all state scrap tire regulators, the responses to which provide the basis for the market and stockpile inventory data contained in this report. Additionally, RMA staff conducted an extensive telephone survey with state scrap tire regulators and industry sources. This survey was used to gain insight into certain aspects of the market dynamics and trends affecting scrap tire markets, as well as to verify data collected elsewhere.

I. About the Rubber Manufacturers Association

RMA is the national trade association in the U.S. for the rubber products manufacturing industry. RMA members include all the major tire manufacturers with operations in the U.S. and about 100 manufacturers of engineered rubber products, including belts, hoses, seals, and other molded rubber goods. In 1989, the RMA member tire manufacturers created the Scrap Tire Management Council (STMC), a non-profit advocacy organization that operated as part of RMA. In October 2001, RMA realigned management of its activities. Today, RMA scrap tire-related activities are directed by the RMA Scrap Tire Committee, comprised of representatives of the seven major tire manufacturers, and managed by the RMA Environment and Resource Recovery Department.

The RMA Scrap Tire Committee provides policy direction and guidance for RMA activities regarding scrap tire management. The Committee's mission is to promote the environmentally and economically sound management and use of scrap tires. The Committee's strategic goals are to promote the elimination of all scrap tire piles; promote sound management of all annually generated scrap tires; seek public awareness of scrap tire management successes; and advocate for a legislative and regulatory environment that is conducive and supportive of its mission.

The tire industry is sensitive to the need to assist in promoting environmentally and economically sound end-of-life management, reutilization and disposal practices for its products. To promote the development of appropriate markets for scrap tires, RMA provides technical and policy information regarding several areas of scrap tire management, hosts national and regional scrap tire conferences for state and federal regulators, and advocates for sound state programs to address scrap tire issues.
RMA does not represent nor have any vested interest in the processing of scrap tires or in any product derived from scrap tires. RMA promotes the concept that scrap tires are a resource that can be used in a wide array of applications.

II. 2001 Scrap Tire Market Highlights

- **Total number of scrap tires going to an end use market reached 218 million**
- **77.6% of all scrap tires generated in 2001 went to an end use market**
- **Tire-derived fuel markets remained stable and showed clear signs of further expansion**
- **40 million scrap tires used in civil engineering applications in 2001, double the amount consumed by this market in 1998, the last time RMA surveyed scrap tire markets**
- **Scrap tire shreds were widely accepted and used in beneficial landfill applications**
- **Use of tire chips in septic system field drain fields continued to expand**
- **New market applications for larger-sized ground rubber increased consumption to 33 million scrap tires**
- **More states had better data on number of tires in stockpiles**
- **Millions of tires were eliminated from stockpiles across the U.S.**

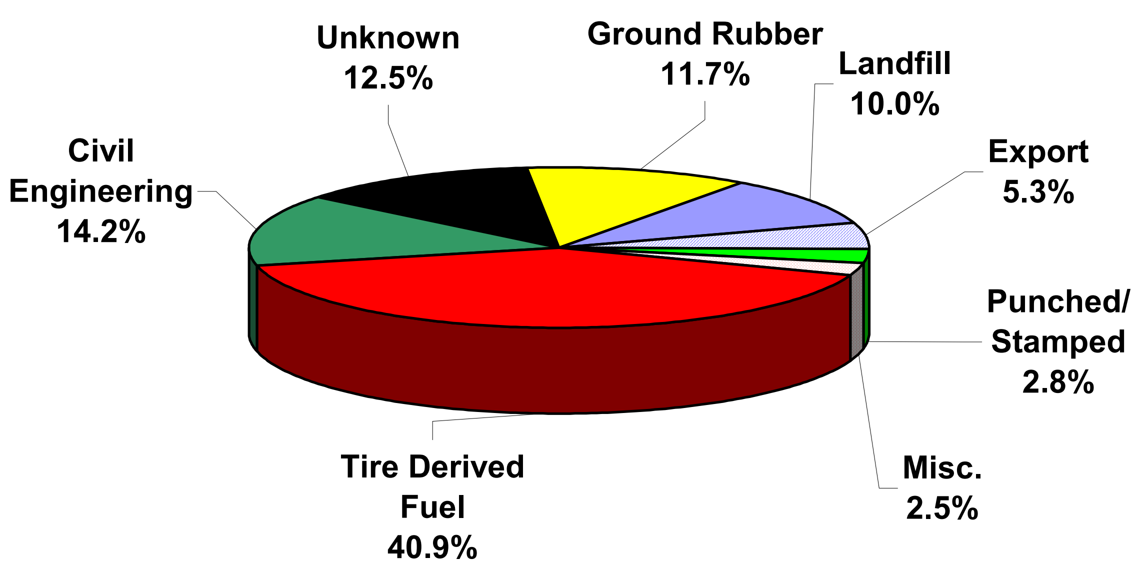

Figure 2: Scrap Tire Utilization 2001

III. A Historical Perspective of the Modern Scrap Tire Market

Typical scrap tire management before 1985 consisted of sending whole scrap tires to landfills for burial. Another means of managing scrap tires was for someone to collect scrap tires from retailers and place them onto a pile. Since there were no laws restricting how scrap tires could be managed or any programs seeking to encourage other uses for scrap tires, these two management practices were used because they were the lowest cost management practices available.

In 1985, Minnesota enacted the first legislation specific to scrap tires. At that point, states began to look into the possibility of changing the way scrap tires were being managed. In 1986, Oregon was the second state to enact scrap tire legislation and regulations. By 1990, all but two states (Alaska and Delaware) had enacted regulations and/or developed a specific management program.

In 1979, Waste Recovery, Inc. (WRI) began processing and selling tire derived fuel (TDF) to the pulp and paper industry in Washington State in the first commercial use of scrap tires. Up to that time, the uses for scrap tires basically were limited to dock bumpers, swings and assorted functions on farms. TDF use in the cement industry began in Germany in 1975, in response to the spike in energy prices caused by the embargo of petroleum by Organization of Petroleum Exporting Countries (OPEC) countries. Japan also used TDF in cement kilns beginning in the 1970's.

From 1979 to 1992, TDF was the dominant market application for scrap tires. From 1979 to 1985, WRI remained the only substantial commercial processor of scrap tires. WRI expanded its operations during that period to include a facility in Texas. In 1985, Oxford Energy, Inc. entered the scrap tire business to construct dedicated tire-to-energy power plants. By 1991, Oxford Energy had constructed two such facilities (Sterling, Connecticut and Westley, California).

In 1990, 25 million tires were consumed as fuel. In addition to the pulp and paper mills that WRI supplied and the tires-to-energy facilities developed by Oxford Energy, cement kilns began to use scrap tires as a supplemental fuel. By 1992, some 57 million of the 68 million scrap tires that went to an end use market were consumed as TDF.

In 1991, the U.S. Congress enacted the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which contained a provision mandating the use of ground tire rubber in a prescribed percentage of highways that were funded by the federal government. ISTEA required that, starting in 1993, five percent of all federally funded highways needed to contain 20 pounds of scrap tire rubber per ton of hot mix asphalt laid. ISTEA also mandated that by 1994, ten percent of all federally funded highways needed to contain 20 pounds of scrap tire rubber per ton of hot mix asphalt laid. The ISTEA mandate further required that the rates be increased to fifteen percent in 1995 and ultimately twenty percent in 1996 and thereafter. ISTEA mandated that any state that did not meet these goals would lose a corresponding amount of federal funds for any given year.

The mandate caused angst and exuberant optimism in the paving and scrap tire industries, respectively. In general, state departments of transportation and the paving industry were opposed to this unfunded mandate, while entrepreneurs and scrap tire processors were talking about how the demand for ground rubber had the potential to consume every scrap tire in the U.S.

In 1991, the demand for ground rubber was still being met, almost exclusively, by tire buffings, the part of the tire that is removed when tires are being prepared for a new tread (hence the term "retreading," also referred to as "recapping"). Tire buffings were collected, cleaned and shipped to specialized grinding facilities that processed these long, tubular particles into smaller-sized particles. At this point, the ground rubber market supplied several ground rubber applications, including asphalt rubber, bound rubber products and brake liners. No whole tires were being processed into ground rubber, not only because of the supply of buffings, but also because the equipment to process whole tires into ground rubber was in its developmental stages.

Still, from 1992 through 1995, a surge of companies entered the business of processing scrap tires into ground rubber in hope of capturing a share of the anticipated demand caused by ISTEA. Additionally, several states conducted asphalt rubber testing programs that led to an increase in activity and perhaps a false sense of market potential among some ground rubber producers. Meanwhile, most states refused to comply with the mandate, and the Federal Highway Administration (FHWA) issued a memo, which indicated that it was unlikely to monitor or punish states that did not comply with the mandate. Consequently, very little tire rubber was used in highway paving as a result of the ISTEA mandate. In 1993, Congress repealed the section of ISTEA referring to the use of tire rubber in highway paving.

The results of the FHWA memo and later the Congressional action were immediate, permanent and devastating to ground rubber producers. The rush to build processing capacity coupled with virtually no increase in demand not only caused the marginal ground rubber producers to go out of business, but weakened the larger, more established producers. This was a direct result of the downward price pressure caused by the over-supply of ground rubber. In the period of 1994 to 1996, some twenty ground rubber operations were either sold or closed.

1992 also marked the beginning of the use of tires in civil engineering applications. For civil engineering applications, scrap tires usually are shredded during scrap tire processing and used in lieu of a conventional construction material (i.e., sand, rock, or stone) in civil engineering projects such as landfill, septic system drain field, embankment, retaining wall, bridge abutment and road construction. To be sure, scrap tires had been used in an array of uses, ranging from swings to dock bumpers to floats to playground castles. Yet, these varied uses were too small to be considered concentrated uses or markets for scrap tires.

One of the seemingly inadvertent side effects of ISTEA was a focus on other uses of scrap tires in highway applications. Scrap tires were the subjects of experiments at several universities in the early 1990's. These experiments typically were designed to test the properties of tires. In particular, tire shreds were use-tested in road embankments, as a lightweight backfill and as a road base foundation material. These studies generated other questions, such as concerns about chemicals leaching from tires placed in the environment. Consequently, several states began testing the leachate from scrap tires. Yet, these studies were laboratory studies, designed for specific parameters. It was not until 1996 that the first field study of tire leachate was implemented.

Thus, in 1992 a shift began, albeit small, in the markets for scrap tires. TDF was no longer the only end use market. In 1992, civil engineering applications consumed about 5 million tires, and some 5 million whole tires were processed and used as ground rubber.

From 1993 to 1994, all three major markets for scrap tires increased, including TDF, ground rubber markets and civil engineering applications. By the end of 1994, market demand for scrap tires had reached 138.5 million, with 101 million going to TDF, 9 million going to civil engineering applications and 4.5 million being processed into ground rubber (3 million tires were used in asphalt rubber applications and 1.5 million tires in other ground rubber applications). Export, agricultural and miscellaneous applications accounted for the remainder of the market uses.

In December 1995, two large-scale road embankments built with scrap tire shreds in Washington State developed “hot spots” and began to heat. These incidents cast civil engineering applications in an unfavorable light. FHWA immediately distributed a memorandum to all of its field offices stating that they should not engage in new projects using tire shreds as a fill material. This action caused all ongoing and planned scrap tire civil engineering application to be halted. There were even some concerns that the asphalt road itself caught fire, but that was not the case.

RMA/STMC, in cooperation with the FHWA, provided technical assistance during and after the heating incidences. In addition, STMC convened an industry *Ad hoc* committee to determine the factors that led to the heating, as well as to develop construction guidelines to prevent any further self-heating episodes. The Committee concluded that the two embankments at issue were significantly deeper than any previous embankment project. Embankments with tire shreds less than 15 feet deep had never developed heating situations.

The *Ad hoc* committee’s recommendations, which were accepted and distributed by the FHWA, stated that no tire shred fill should be greater than 10 feet and listed a series of other construction guidelines as well. Once the FHWA accepted these guidelines, its restrictions on using tire shreds in civil engineering applications were lifted. While lifting the restrictions allowed this market niche to continue, it took several years before state agencies and the industry began using tire shreds at a significant level.

From 1996 through 1998, the majority of tires used in civil engineering applications were limited to alternative daily cover in landfills. During this time frame, TDF and ground rubber markets increased dramatically. By the end of 1998, end use markets for scrap tires had reached 177.5 million, with 114 million used as TDF, 20 million used in civil engineering applications and 7 million for ground rubber. Once again, export, agricultural and miscellaneous applications rounded out the field.

The TDF market, while remaining the largest single market for scrap tires, has been subject to a series of changes. From 1990 through 1996 the use of TDF expanded at a steady rate. TDF had become widely accepted in the cement and pulp and paper mill industries, and several large-scale and several small-scale power plants had also begun using this material.

In 1996, the cement industry began a six-year period of heightened demand caused by the economic boom the country was experiencing. Most kilns were operating in a sold-out condition, and those kilns that were using TDF as a supplemental fuel reduced or discontinued use of TDF. It was believed that using TDF, while helping to reduce their costs of production, also slightly reduced cement-making capacity.

At the same time, several pulp and paper companies stopped using TDF as well. In this case, a combination of poor quality material, pending changes to air permit requirements and company policies on reducing all discharges from their mills led to the decline. In pulp and paper mills that use wet scrubbers to remove sulfur from the gas stream, TDF use causes zinc effluent levels to increase. While the presence of zinc did not cause these mills to exceed any permit limits, it was contrary to some company policies. Consequently, several mills stopped using TDF.

The beginning of deregulation in the utility industry followed similar trends. From 1992 through 1996, several utility boilers had begun using TDF or were in the midst of completing testing of the material. Once utilities began considering selling their power generating plants, many of these companies stopped using TDF, due to concerns that an alternative fuels program would create a disincentive to a perspective buyer. The combination of all these factors caused the number of facilities using TDF to decrease. Furthermore, many facilities that were about to begin using TDF or that were in the permitting or testing process also stopped.

Nevertheless, from 1998 through 2001, all three major markets for scrap tires experienced further expansion. TDF use increased with the addition of several co-generation boilers and several cement kilns, while civil engineering applications expanded beyond road embankments. Tire shreds were widely used in various landfill construction applications. The use of ground rubber increased dramatically, beyond the historical markets of asphalt rubber, tire manufacturing and mold/extruded products. New applications, such as playground surfaces, soil amendments, horticultural applications and horse arena flooring combined to push the demand for ground rubber to new heights. These markets are more fully explained in the text ahead.

IV. Scrap Tire Disposition in 2001

The scrap tire challenge consists of two main components: tires that reach the end of their useful life (scrap tires, also referred to as end-of-life tires) and those tires that are in stockpiles. Each component of the scrap tire challenge has its own issues and solution scenarios. In this report, these two components will be discussed separately.

At the end of 2001, collected data showed that markets for scrap tires consumed 218 million, or about 77.6 percent, of the 281 million scrap tires generated annually. RMA estimates that 281 million tires are discarded each year, based on U.S. Census data, assuming one tire is discarded annually per person. RMA recently reaffirmed the validity of this ratio by adding the replacement tire shipments in all tire categories and the tires on scrapped vehicles and calculating the ratio of that sum to the total U.S. population. The calculations are shown in Table 1. 1999 tire data were used in all situations except farm and industrial tire shipments, since RMA stopped collecting that data in 1995. 1999 data is the most current data available for the number of vehicles scrapped. 2000 U.S. Census data was used to reflect the total U.S. population.

Table 1: Annual Scrap Tire Generation as a function of U.S. Population (in 1000's*)

Passenger tire replacements**	191,903
Light truck tire replacements**	33,798
Medium, wide base, heavy & OTR tires replacements**	12,951
Farm tire replacements***	2,461
Industrial tire replacements***	4,527
Tires from Scrapped Vehicles****	46,656
Total Scrapped Tires	292,296
U.S. Population – 2000 Census data	281,422
# tires scrapped per person	1.038639

* All units represented in table are in 1000's, except for # of tires per person, which is in actual units.
** 1999 RMA Data Total Replacement Shipments
*** 1995 RMA Data - RMA stopped collecting data for these categories after 1995
**** 1999 data compiled by in the Ward's Motor Vehicle Fact Book reflecting the number of vehicle registrations not renewed. Includes car/light truck, truck and bus data. This is the same source as previous Census data. However, in the 2001 Statistical Abstract, the relevant table was deleted. In the 2000 Statistical Abstract, this data was cited as from the Motor Vehicle Fact Book, then produced by the American Automobile Manufacturers Association, but now compiled by Ward's.

RMA estimates that another 25 million tires at a minimum are being legally managed by placement in a landfill or a monofill, adding another 10 percent to the known disposition.

In Europe and Japan, retreading and the used tire market are included in scrap tire market estimates. However, RMA makes a distinction among retreadable casings, used tires and scrap tires. All RMA reports have excluded retreading from estimates of scrap tire markets. Since retreadable casings can still be used for their original intended purpose, RMA does not consider them scrap tires and does not include them in scrap tire estimates. RMA does view retreading as a viable alternative that prolongs tire life and makes a positive contribution toward decreasing scrap tire disposal.

Used tires and retreadable casings usually are handled through the same collection system that collects all other worn tires when they are first removed from vehicles. Consequently, it is common for states and non-tire industry concerns to consider these tires as part of the "scrap tire" flow. RMA estimates that 16.4 million retreadable tire casings were retreaded in the U.S. in 2001 and were used by commercial aircraft, commercial trucks, school buses, and off-the-road vehicles such as industrial, agricultural and mining equipment. Several RMA member companies have significant retread businesses.

Used tires are defined as those tires that are still usable on vehicles after they are removed from initial service. Used tires are often resold in the U.S. and exported for sale in other countries. While no extensive market data are available on the used tire market, it is not unreasonable to believe that the used tire market might be around 10 to 12 percent of the total number of worn tires initially removed from vehicles, or around 30 million units. While RMA does not consider used tires that are resold in the U.S. in its scrap tire figures, as will be discussed later, about half of those units are exported from the U.S. and are counted as a scrap tire market.

Table 2 below shows the estimated total U.S. scrap tire market for 2001. In addition, Figure 1 on the cover of this report shows historical trends in the U.S. scrap tire markets, tracking scrap tire generation, utilization, and usage rates over time. The data in Figure 1 represent the historical data collected by RMA since the inception of its scrap tire activities. Appendix B at the end of this report contains additional data showing the historical trends of scrap tire utilization across the various markets, from 1990 through 2001.

Table 2: Estimated Total U.S. Scrap Tire Market: 2001
(in millions of tires)

Tire Derived Fuel (TDF)	
Cement kilns	53
Pulp/Paper mills	19
Dedicated tires to energy	14
Electric Utilities	18
Industrial boilers	11
Total Fuel Use	115
Products	41
Ground Rubber	33
Cut/Punched/Stamped	8
Civil Engineering	40
Miscellaneous/Agriculture	7
Export	15
TOTAL USE	218
TOTAL GENERATION	281
Use as % of total generation	**77.6%**

A. Scrap Tire Market Overview: 1998 - 2001

From 1998 through the end of 2001, the total number of scrap tires going to a market increased from 177.5 million tires (66 percent of the 270 million generated) to 218 million (77.6% of the 281 million generated). There were increases in all three of the major markets: TDF, civil engineering and ground rubber applications.

In the TDF market, the increase was a function of three factors: a decreased demand for cement, an increase in energy prices and an improvement in the quality and consistency of TDF.

In the ground rubber market there are two classes of particle sizes: "ground" rubber (10 mesh and smaller) and "coarse" rubber (10 mesh and larger, with a maximum size of one-half inch). Each of these size ranges has distinct market applications. Over the course of the last two years the greater growth in market share has been with the “coarse” sized particles. This particle range is used in playground surfacing, running track material, soil amendments and some bound rubber products. The smaller particle sizes are used for the more traditional applications (asphalt rubber and molded and extruded rubber products).

The use of scrap tires in civil engineering applications increased significantly during this period. In 1998, some 20 million scrap tires were used. The 2001 data indicated that 40 million scrap tires were used, doubling the use of tire shreds in civil engineering applications. Three large-scale applications for tire shreds accounted for most of the markets: landfill construction applications, use as a septic system drain field medium and road construction. The increase is a function of three factors: (1) cost competitiveness of tire shreds, compared to traditional construction materials, (2) increased acceptance by regulatory agencies and (3) increased recognition by scrap tire processors of market opportunities available in civil engineering applications.

Punched and stamped products, export, agricultural and miscellaneous uses either remained the same or increased slightly.

1. Tire Derived Fuel

At the end of 2001, 80 separate facilities used TDF on a regular basis. The total annual consumption of TDF was 115 million scrap tires. The permitted capacity of all facilities in 2001 was actually higher, but few facilities permitted to use TDF actually use the maximum permitted capacity.

As reported in the last market survey, the end-use market for processed TDF (fuel chips) has changed over time. Facilities that once accepted two to three inch rubber chips have generally shifted to smaller, typically two by two inch, fuel chips. A number of companies are producing two inch minus chips, which typically are no larger than two inches by one and one half inches. These smaller fuel chips also contain less steel than larger fuel chips, which can reduce problems associated with handling and ash disposal. Production of fuel chips smaller than one and one half inch minus, while technologically feasible, is not economically viable. In addition, several TDF applications continue to use whole tires as TDF.

The recent development of American Society for Testing and Materials (ASTM) standards for TDF must be recognized as another step toward making tire-derived materials a commodity (ASTM Standard D-6700-01 “Standard Practice for Use of Scrap Tire-Derived Fuel). The great advantage in this effort is that end users and potential end users now have an industry-accepted standard against which to compare all tire chips. The other benefit to the industry is the development of a single sampling and testing protocol.

Overall, combustion industries will be facing a number of significant issues in the near-term. A combination of a potential increase in energy costs, the implementation of new EPA air emission standards and an uncertain economy could cause significant changes. Whether these changes will have a positive or negative impact on alternative fuels programs remains to be seen. What follows is a discussion of each of the market sectors for TDF – the cement industry, pulp and paper mills, utility boilers, industrial boilers, and dedicated scrap tire-to-energy facilities.

a. The Cement Industry

Just as this sector experienced a dramatic decrease in TDF consumption in the period from 1996 to 1998, this sector experienced a dramatic increase in TDF consumption over the last three years. At the end of 1998, 30 kilns were using TDF, consuming 38 million tires. At the end of 2001, there were 39 facilities (62 kilns) using 53 million scrap tires. Table 3 lists the cement kilns in the U.S. that utilize scrap tires as fuel.

The increase in TDF consumption was due to several factors, including consolidation in the cement industry, reduced demand for cement, and environmental considerations. In the area of consolidation, Cementos Mexicanos (Cemex) purchased the assets of Southdown Corporation and is now the largest producer of cement in the U.S. Cemex has taken an aggressive approach to using TDF in their kilns, which was facilitated by the fact that several of the Southdown kilns were permitted to use tires or had actually used tires. In addition, LaFarge Cement bought Blue Circle Cement. Both companies were experienced with using TDF, and kilns now owned by LaFarge Cement continue to use and expand use of TDF.

The recent downturn in the U.S. economy has reduced the demand for cement, as construction and other uses of cement have declined. In addition, an increase in domestic cement production capacity and imported cement, have created an excess of production capacity available to the U.S. market. Most kilns are not operating at full capacity, as they were in the 1996 to 1998 period. In periods of lower production, kiln managers often seek ways to reduce costs. The cost of energy for kilns represents one-third of the total cost of production. Using TDF reduces the cost of energy and typically helps the kiln to run more smoothly.

Environmental considerations continue to play a key role in the use of TDF in cement kilns. For example, in 1998, the EPA issued a call for states to develop State Implementation Plans (SIPs) for the reduction of nitrogen oxides (NO_x) emissions from fuel combustion, which required some cement kilns to make significant NO_x reductions. The use of TDF is a low cost NO_x reduction option, encouraging the use of TDF in the cement industry.

Table 3: U.S. Cement Kilns Utilizing Scrap Tires as Fuel

Company	*Plant*	*Location*	*Whole Tires?*	*Kiln Type*	*No. Of Kilns*
Allentown (Lehigh)	Blandon	PA	WT	LSD	2
Ashgrove	Durkee	OR	WT	PHPC	1
Ashgrove	Foreman	AR	WT	LSW	3
Ashgrove	Incom	ID	WT	LSW	2
Ashgrove	Seattle	WA	WT	PHPC	1
Blue Circle (LaFarge)	Atlanta	GA	WT	LSW	2
Blue Circle (LaFarge)	Haryleyville	SC	WT	PHPC	1

Table 3: U.S. Cement Kilns Utilizing Scrap Tires as Fuel, *continued*

Company	*Plant*	*Location*	*Whole Tires?*	*Kiln Type*	*No. of Kilns*
Blue Circle (LaFarge)	Tulsa	OK	WT	LSD	2
California Portland	Colton	CA	WT	LSD	2
Calveras (Lehigh)	Redding	CA	WT	PHPC	1
Capital Aggregates	San Antonio	TX	WT	LSW	1
Capitol Chemical	Martinsburg	WV	WT	LSW	2
Cemex	Clinchfield	GA	WT	SPH	1
Cemex	Knoxville	TN	WT	PHPC	1
Cemex	Odessa	TX	WT	SPH	2
Cemex	Brooksville	FL	WT	SPH	1
ESSROC	Bessemer	PA	WT	LSW	2
ESSROC	Fredrick	MD	WT	LSW	2
FL Crushed St. (ESSROC)	Brooksville	FL	WT	PHPC	1
Holcim	Ada	OK	WT	LSW	2
Holcim	Artesia	MS	PT	LSW	1
Holcim	Clarksville	MO	PT	LSW	1
Holcim	Devils Slide	UT	PT	PHPC	1
Holcim	Mason City	IA	PT	LSW	2
Holcim	Midlothian	TX	PT	PHPC	2
Holcim	Portland	CO	PT	LSD	2
Holcim	Theodore	AL	PT	PHPC	1
Holcim	Dundee	MI	WT	PHPC	1
Holcim	Portland	CO	PT	PHPC	1
LaFarge	Seattle	WA	PT	LSW	1
LaFarge	Whitehall	PA	WT	SPH	2
Lehigh	Leeds	AL	WT	SPH	1
Lehigh	Union Bridge	MD	WT	LSD	4
Lone Star	Cape Girardeau	MO	PT	PHPC	1
Mitsubushi	Ontario	CA	WT	PHPC	1
Monarch	Humboldt	KS	WT	PHPC	2
N Texas Cement	Midlothian	TX	WT	LSW	3
Texas Lehigh	Buda	TX	WT	PHPC	1
Texas Industries	Hunter	TX	PT	SPH	1
Totals:	**39**				**62**

WT whole tires | **LSW** Long straight wet
PT processed tires | **LSD** Long straight dry
PHPC Preheater/precalciner | **SPH** Short Preheater

b. Pulp and Paper Mills

At the end of 1998, 18 pulp and paper mill boilers were consuming 20 million scrap tires. By the end of 2001, 14 mill boilers consumed 19 million scrap tires. Several factors contributed to this decrease. First, several mills using TDF were closed due to excess manufacturing capacity in the paper industry. Second, several mills ended their use of TDF due to poor TDF quality. Excess wire caused slag build up, which increased maintenance costs. Third, during consolidation new parent companies had no experience using TDF and ended its use. Table 4 lists the pulp and paper mills in the U.S. that utilized TDF in 2001.

Still, there were some bright spots for TDF in this market sector. In 2000, natural gas prices rose to approximately $10 per million BTUs, which made TDF a very attractive alternative fuel. The mills using natural gas and TDF increased their rate of TDF usage dramatically, and others quickly began TDF programs. Natural gas prices have declined, but not to the previous level. Should another surge in energy prices occur, mill managers could quickly increase the use of TDF. However, if a mill uses natural gas and no solid fuels, then TDF is not an option, due to emission considerations.

Table 4: U.S. Pulp and Paper Mills Utilizing Scrap Tires as Fuel

Name	*City*	*State*
Bowater	Calhoun	TN
Bowater	Catawba	SC
Abitibi	Sheldon	TX
Georgia Pacific	Woodland	ME
International Paper	Cortland	AL
International Paper	Bastrup	LA
International Paper	Natchez	MS
International Paper	Bucksport	ME
International Paper	Manesfield	LA
Jackson Paper	Jackson	NC
Mead Container	Stevenson	AL
Mead Paper	Rumford	ME
Smart Paper	Hamilton	OH
Southern Paper	Newberg	OR

c. Utility Boilers

The use of TDF in electric utility boilers decreased relative to the rate of usage in 1998. At the end of 1998, there were 11 facilities using TDF, consuming 25 million tires. In 2001, nine utility boilers consumed approximately 18 million scrap tires. Even so, the utility market remains a significant end user of TDF and retains a potential to consume significant amounts of TDF in the future. While a promising market opportunity, recent events in the utility industry suggest that it may take several more years before this market sector enters a period of stability that fosters the full potential of the market. The issues at hand are the reevaluation of the trend towards deregulating the utility industry and potential federal air emission regulations. Table 5 lists the utility boilers in the U.S. that utilized TDF in 2001.

The issues relative to the deregulation of this industry remain the same as previously reported. As the industry reorganizes into a delivery side and a generation side, many production facilities have been put up for sale. Many older, less efficient facilities have been closed. Older facilities, with less efficient power producing systems, have benefited most from the use of TDF. Newer utility boilers either use pulverized coal or have entered into long-term contracts to purchase low-sulfur coal. The use of TDF is incompatible with pulverized coal boilers due to the differences between the two fuels, both in terms of fuel size and in terms of the necessary residence time in the combustion zone. While the sulfur content of TDF is relatively low and stable, low sulfur coal contains less sulfur than TDF and typically is used to comply with stringent sulfur emission requirements. Few boilers will accept any fuel that contains more sulfur than contained in their current fuel.

Energy deregulation also offers a possible opportunity for the TDF market. Once the buying and selling process subsides, the new owners of producing operations likely will seek ways to lower the costs of generating electricity. TDF, with its higher heating value, lower NO_x emissions and competitive cost as compared to coal, may see increased usage rates. Recent experience in California with surging energy prices suggests that the utility industry will seek a period of stability, which is likely to preclude switching to alternative fuels or reopening permits for review and modification.

In regard to climate change issues, it appears fairly certain that U.S. President George W. Bush is unlikely to sign any international accord on this issue. Similarly, Congress appears equally unlikely to initiate any programs to address climate change issues any time soon. Instead, industries are devising their own responses to this issue. Some individual companies are setting voluntary targets for lowering greenhouse gas emissions. The likely impact of these programs on the use of TDF appears to be negative, suggesting that certain companies are seeking alternative fuels and/or increased emission control systems. In doing so, the tendency is to move away from solid fuels and/or limit the use of perceived “dirty” fuels (i.e., coal). Unfortunately, TDF is often associated with coal, and thus is tainted by the same biases.

As reported in the 1998/99 report, the EPA’s determination on the classification of TDF as a solid waste, rather than as a fuel, for hazardous air emission permitting purposes, is still pending. This classification has the potential to significantly impact the use of TDF. If TDF were classified as a fuel, implementing the use of TDF would not cause a combustion facility to be required to comply with any new or additional air permitting requirements. Clearly, the facility still would be required to comply with the appropriate environmental regulations. However, if TDF were classified as a solid waste, the combustion facility would be subject to additional and more stringent permitting requirements that apply to waste disposal/combustion facilities. Such a change would severely curtail, if not end, the use of TDF. At present, EPA is expected to classify TDF as a fuel.

Table 5: U.S. Utility Boilers Utilizing Scrap Tires as Fuel

Name	*City*	*State*	*Boiler Type*
Ameron	Port du Sioux	MO	Power Utility Boiler
LFC Power Systems (Hillman Power Co.)	Hilman	MI	Wood Fired Utility Boiler
Otter Tail Utilities	Big Stone	SD	Power Utility Boiler
Owensboro Municipal Utility	Owensboro	KY	Power Utility Boiler
Tennessee Valley Authority (Allen Plant)	Memphis	TN	Power Utility Boiler
Utilicorp United	Silbey	MO	Power Utility Boiler
Wisconsin Power & Light (Alliant Energy)	Beliot	WI	Power Utility Boiler
Grayling Power	Grayling	MI	Power Utility Boiler
Wyndotte Power	Wyndotte	MI	Power Utility Boiler

d. Industrial Boilers

This segment has experienced minor changes over the last three years. Nineteen facilities used TDF in 1998, consuming around 15 million scrap tires. By the end of 2001, 16 facilities consumed approximately 11 million tires. Since industrial boilers are smaller than utility boilers, they can react more quickly to market changes and government incentives. These facilities use a variety of fuels, but typically not low sulfur coal. In the case of wood-fired boilers, TDF offers a significant increase in heating value and a reduction in moisture content and ash generation. The limiting factors, however, are sulfur and zinc. Each facility must evaluate the impact of TDF on emissions of sulfur oxides (SO_x) and ash disposal. If an evaluation of these impacts is favorable, then the use of TDF becomes a matter of the permitting process. Table 6 lists the industrial boilers in the U.S. that utilized TDF in 2001.

Most resource recovery facilities allow tires to be used, although it is usually to a limited degree, which limits their impact on the end-use markets. In this market segment, the use of TDF primarily is a function of the amount of solid waste the facility consumes. In general, the use of TDF in resource recovery facilities still represents only two to five percent of a facility's fuel supply. This typically translates into the consumption of 500,000 tires per facility per year. When tires are allowed into a facility, the tip fee and heating value from TDF provide a net benefit that more than compensates for any capacity reduction from the facility.

Table 6: U.S. Industrial Boilers Utilizing Scrap Tires as Fuel

Name	*City*	*State*	*Boiler Type*
AES	Oahu	HI	Industrial Boiler
Air Products	Stockerton	CA	Co-Generation Boiler
Archer Daniels Midland	Decatur	IL	Industrial Boiler
Cogentrix	Richmond	VA	Cogeneration
Hartford County Resource Recovery	Aberdeen	MD	Resource Recovery Facility
Iowa State University	Ames	IA	Industrial Boiler
Ridge Energy	Auburndale	FL	Industrial Boiler
Southeastern Public Service Authority	Norfolk	VA	Resource Recovery Facility
Adirondack Resource Recovery	Hudson Falls	NY	Resource Recovery Facility
University of Missouri	Columbia	MO	Industrial Boiler
Viking Energy	Lincoln	MI	Industrial Boiler
Viking Energy	McBain	MI	Industrial Boiler
Waste Energy Partners	Joppa	MD	Industrial Boiler
Purdue University	West Lafayette	IN	Industrial Boiler
Dravo	Butler	KY	Lime Kiln
TES Tondu Energy	Filler City	MI	Industrial Boiler

e. Dedicated Scrap Tire-to-Energy Facilities

The use of whole and/or processed tires in dedicated scrap tire-to-energy facilities has remained consistent over the past two years. In 1998, there were two such facilities using some 16 million scrap tires annually. Today there are two dedicated tire-to-energy facilities consuming some 14 million scrap tires. However, in that time one of the dedicated facilities closed while another one opened. Table 7 lists the dedicated tire-to-energy facilities in the U.S. that utilized TDF in 2001.

The Modesto Energy Limited Partnership (MELP, Westly, California) closed in 1999, due to the change in rates the facility received for the power it generated. Pacific Gas & Electric (PG&E) wanted to bring down the cost of electricity, so it opened the power contract for renegotiation. MELP's operating costs necessitated a higher rate than PG&E was willing to offer. The end result was the closure of MELP. The irony was that the facility closed just before the energy crisis occurred in California, and was unable to take advantage of those temporary market conditions.

During the same period, the Ford Heights, Illinois facility reopened after Rubber Technology Group (RTG) purchased it. This plant was built by Browning-Ferris Industries in the mid 1990's, but was shut down soon after its completion due to the termination of the Illinois Retail Rate Law. The Retail Rate Law extended favorable rates for electricity to alternative fuel-fired utilities. It is now fully operational and consuming some three million scrap tires a year. In addition, a lawsuit against the State of Illinois for terminating the Illinois Retail Rate Law is progressing.

The Exeter Energy Limited Partnership facility, located in Sterling, Connecticut is a 25-megawatt electric generating facility. Built in 1991, Exeter consumes 10 to 11 million scrap tires a year, providing the only large-scale end-use market for scrap tires in the lower New England area. This facility also serves as a major market for scrap tires in New York and Northern New Jersey.

Table 7: U.S. Dedicated Tire-to-Energy Facilities 2001

Name	***City***	***State***
Ford Heights	Ford Heights	IL
Exeter Energy	Sterling	CT

f. Tire Derived Fuel: Market Outlook

Overall, the market outlook for the TDF market is optimistic over the next two years. However, the various market segments will face different market challenges and opportunities. Table 8 shows market trends for TDF in the U.S., projected through 2003.

Table 8: U.S. Tire Derived Fuel Market Trends (millions of tires)

	Cement	***Pulp/ Paper***	***Utility***	***Industrial***	***Dedicated***
1998	38	20	25	15	16
2001	53	19	18	11	14
2003 *(projected)*	65	19	18	16	14

The Cement Industry

In the cement industry, the demand for TDF should continue to increase for three reasons: (1) kilns that reduced TDF consumption are returning to previous levels of consumption; (2) at least 10 kilns are actively seeking to implement the use of TDF in the next 12 months and another four to six additional kilns are likely to pursue TDF use in the next two years; and (3) the continued importance of NO_x emission reductions will keep TDF levels constant once they are established.

Given the present conditions in the cement industry, the use of TDF is expected to increase by 10 to 20 million scrap tires within the next year. Additional demand of 6 to 10 million scrap tires within three years is likely. By 2005 there could be 50 facilities (75 kilns) using TDF. While this should be considered extremely positive, it must also be recognized that this may be reaching the upper limit of the total demand in this market sector.

Pulp and Paper Mills

In the pulp and paper industry, TDF consumption in mill boilers appears to be reasonably stable. The mills that are using TDF are expected to continue its use. Expanded use of TDF in this market sector will be a function of the location and equipment composition of the mill. While no further expansion in the use of TDF is expected in New England, the Mid Atlantic states or the Northwest, some expansion may be possible in the Southeast, depending on regulatory hurdles. Additionally, energy prices, availability of quality TDF and new EPA air emission requirements could impact the use of TDF in this market.

However, TDF prices and availability relative to other fuels may stimulate market growth in the pulp and paper market segment. The market value of bark, for example, a major fuel source for many mill boilers, has increased to a point where TDF is now competitive. Furthermore, the supply of bark that once was available on the open market is diminishing, due to increased demand and greater return on investments when selling bark into horticultural markets. However, the downturn in the economy, which has affected the pulp and paper industry particularly, may continue to dampen TDF markets in this area, as mergers, acquisitions, and mill closings continue.

Consequently, it is very difficult to predict what will happen in this market sector over the next two years. While it is possible that several mill boilers may begin or increase TDF use, it is equally possible that several mills could end use of TDF. Therefore, no increase in the use of TDF is anticipated in this market sector.

Utility Boilers

In the utility industry, due to continued industry restructuring and uncertainty about upcoming air emission requirements, it appears that this market sector will not present many, if any, market opportunities within the next two years. Indications are that the majority of facilities using TDF will continue to do so, which should provide stability for the TDF producers that service these contracts.

Industrial Boilers

In the industrial boiler market segment, a modest increase in the use of TDF is possible. Several industrial boilers in California have indicated interest in using TDF. One or more of these facilities could begin using TDF within the next 18 months. Issues that could delay these projects include the permitting process and obtaining an adequate supply and quality of TDF.

Dedicated Scrap Tire-to-Energy Facilities

In the dedicated tire-to-energy market segment, there are no known facilities under construction or consideration. As RMA reported in 1999, the combination of the cost of construction, the length of time needed to complete a project of this nature and the deregulation of the utility industry lead to the conclusion that there will not be another attempt in the near-term to construct one of these plants.

2. Ground Rubber Applications

The market for size-reduced rubber (ground rubber, also referred to as crumb rubber or rubber particles) continues to grow, although there has been a shift in the distribution of market share for the various ground rubber applications. There are two sources for tire derived size-reduced rubber: tire buffings and processed whole scrap tires. In 1998, the overall market demand for size-reduced rubber in the U.S. was approximately 460 million pounds.

At of the end of 2001, the total market volume for all sources of ground rubber was 650 million pounds. 400 million pounds of that total were generated from whole scrap tires, which equates to approximately 33 million scrap tires (12 million in asphalt rubber and 21 million in other ground rubber applications), assuming that approximately twelve pounds of ground rubber is produced per scrap tire. The remaining 250 million pounds (38% of the total) were generated from tire buffings, a by-product of the retread industry. In this report, no attempt is made to differentiate between retread buffings and scrap tire rubber in identifying markets, or to differentiate between cryogenically produced or ambiently ground scrap tire rubber. Table 9 shows the U.S. ground rubber market as a function of particle size and related market.

There were several major developments that occurred since the last market report. This sector of the industry has witnessed several new trends that are likely to have an impact in the foreseeable future. One of the more noticeable trends is a shift in end-use markets for ground rubber. The use of scrap tire rubber as an asphalt modifier remains the largest single application.

Another relatively new and fast growing market application is the use of tire-derived material as a ground cover material under playground equipment. In this application, tire rubber can be used as a loose fill material, as a molded brick or as part of a pour-in-place system. The size range for these playground applications varies according to the product application. Loose fill ranges from one-half inch to one-quarter inch pieces. Molded/extruded tiles or bricks and pour-in-place applications use 10 – 40 mesh rubber. The industry currently is discussing what to call these larger-sized particles, since this size of material is not defined in the ASTM specifications for ground rubber (D5644-01 "Standard Test Method for Rubber Compounding Materials – Determination of Particle Size Distribution of Vulcanized Particulate Rubber" and D5603-01 "Standard Classification for Rubber Compounding Materials – Recycled Vulcanizate Particulate Rubber"). For lack of a better term, we shall refer to the 10 mesh to one-half inch size range as "coarse" rubber.

Field applications, above or below the ground, are closely related to playground surfacing applications. While this particular application uses a smaller-sized particle, it appears that the same properties that make rubber so efficient under playground equipment have advantages in this market as well. Consequently, there has been a surge in the amount of tire-generated rubber in field turf and loose fill products, particularly in playground applications.

Another major issue in this market sector is the production capacity for ground rubber. In some parts of the U.S., demand is equal to the amount generated, while other parts of the country must still contend with excess capacity, a situation often exacerbated by the entry of new ground rubber producers. Another complicating factor is the ground rubber that is imported from Canada. Several Canadian Provinces have scrap tire management programs that encourage the production of ground rubber through economic incentives, which is then exported into the U.S.

The other major trend in this market sector has been the realignment of ground rubber producers. The 15 largest ground rubber producers (from whole scrap tires) generate more than 90 percent of the total ground rubber sales in the U.S. However, over the last two years there has been a series of buyouts, mergers and acquisitions within the scrap tire processing industry that has dramatically changed the composition of the major ground rubber producers in the U.S.

Table 9: U.S. Ground Rubber Markets by Application and Particle Size

Application	*Size Range*	*Estimated Poundage**
Asphalt rubber	16 – 40 mesh	220 million pounds
Athletic/field turf applications	¼ inch to 20 mesh	50 million pounds
Loose cover	$^1/_2$ – $^1/_4$ inch	30 million pounds
Tire manufacturing	80 –400 mesh	50 million pounds
Molded/extruded products	4 – 100 mesh	50 million pounds

*Whole tire generated ground rubber only

a. Asphalt Rubber

Ground tire rubber can be blended with asphalt to modify the properties of the asphalt in highway construction. Size-reduced scrap tire rubber can be used either as part of the asphalt rubber binder (generally referred to as asphalt rubber), seal coat, cap seal spray or joint and crack sealant, or as an aggregate substitution (rubber modified asphalt concrete, or RUMAC). Interestingly, when tire rubber was first incorporated into asphalt binder (circa 1963), it was done as a means to enhance the properties and characteristics of the asphalt binder. Even though these experiments were successful, no one ever envisioned asphalt rubber as a major market for the scrap tires generated in the U.S.

Asphalt rubber remains the largest single market for ground rubber, consuming an estimated 220 million pounds, or approximately 12 million tires. Of note, 180 million pounds of rubber is used in asphalt projects in California and Arizona. An additional 20 million pounds of tire rubber is used in the Florida asphalt market. This data supports the belief that the use of asphalt rubber is limited to certain regions of the U.S. It should be noted, however, that asphalt rubber is being used in greater amounts in Texas and Nebraska, and in 2002/2003 New Mexico will undertake its first large-scale asphalt rubber project. Furthermore, the Asphalt Rubber Technology Service in South Carolina is facilitating the use of asphalt rubber in county and state roads. It appears that state agencies are beginning to recognize the long-established benefits of asphalt rubber: longer lasting road surfaces, reduced road maintenance, cost effective over the long term, lower road noise and shorter braking distances.

The major obstacles to increased use of rubber in this market are varied. To a large extent, any large-scale increase in the use of asphalt rubber depends on the level of interest and commitment by the state Departments of Transportation (DOT). There simply must be a willingness to accept this technology and make its use routine. In order for such a paradigm shift to occur, a number of obstacles would have to be addressed. In some cases a top-down decision process could achieve this. Accordingly, a state governor could initiate such a program (e.g., Florida). If this does not occur, continuous training programs would have to be offered to and accepted by the state DOT's, paving contractors and/or the state legislature. This latter approach appears more likely, since few governors appear ready to order their DOT's to initiate this program. At this writing, several states have indicated an interest in pursuing an asphalt rubber program. While this is encouraging, it must be recognized that asphalt rubber programs take considerable time and resources to implement.

b. Athletic and Recreational Applications

Athletic and recreational applications have been fast growing markets for ground rubber over the last two years, consuming 80 million pounds of scrap tire rubber in 2001 (50 million pounds for athletic/field turf applications and 30 million for loose cover). The size particle used in these markets ranges from the 10 – 20 mesh range up to one-half inch pieces. Examples of this market segment include, but are not limited to, the use of rubber in playground surfaces, running track material, grass-surfaced playing areas, and stadium playing surfaces.

The main benefit of tire-generated material is its resiliency. In the case of playground cover, all three playground cover systems offer the highest level of impact attenuation (ability to absorb the energy from falling children and objects) of any available playground cover materials. In other words, tire floor cover is the most effective material to break a fall. In running tracks, the addition of rubber particles increases a track's resiliency, decreasing stress on runners' legs. In sports surfaces, once again the addition of rubber increases the resiliency (bounce) of the field. Decreased injuries, better grass root structure and improved drainage all contribute to longer lasting fields and better playing surfaces. In the recent past, larger mesh size rubber has been added with sand to form the support for artificial grass surfaces. These artificial grass applications are common practice on European practice soccer fields (European football), and are now becoming known in the U.S.

Not all niche markets are faring as well. The market for tire chips as a mulch material in horticultural applications is running into fierce competition from an increased presence of bark. As cited in the TDF section of this report, pulp and paper mill boilers are encountering a shortage of bark on the market. The reason for this shortage is that these mills have recognized that they can obtain a greater return on investment when selling bark into the horticultural market.

c. Bound Rubber Products

Ground scrap tire rubber is formed into a set shape, usually held together by an adhesive material (typically urethane or epoxy) to make bound rubber products. These products include, but are not limited to carpet underlay, flooring material, dock bumpers, patio floor material, railroad crossing blocks, and roof walkway pads. Improving sales of bricks and tiles made from rubber are advancing this market niche. While a considerable amount of tire buffings and non-tire rubber is used in these products, ground rubber from whole tires is being used in ever-increasing amounts due to the finite supply of tire buffings. No market data is available for this market segment.

d. New Tire Manufacturing

Tire manufacturers must balance a number of factors in tire design, including safety, traction, handling, speed rating, temperature resistance, rolling resistance and tire life when contemplating the use of recycled content in new tires. Finely ground (powdered) scrap tire rubber can be and is used as a low volume filler material in several components of a tire. This market consumed approximately 50 million pounds of scrap tire rubber in 2001.

Until recently, it was generally understood that ground rubber use in new tires was limited to a one-to-three percent level. As cited in the last market study, Michelin North America produced an original equipment tire for the Ford Windstar in which five percent of the rubber component consisted of recycled tire rubber. Continental Tire is about to conclude a multi-year research program on the use of recycled rubber material in new tire construction, funded through a grant from the state of North Carolina, which was designed to investigate the incorporation of recycled products at up to 25 percent in new tires.

The use of recycled content in new tire construction likely will continue. The use of recycled content or additional use of recycled rubber in new tire construction will be a function of several factors, including but not limited to advances in tire construction technology and the impacts of new federal regulations affecting tire performance and testing.

e. Friction Material

Friction brake material uses particulate rubber in brake pads and brake shoes. This is a mature industry with little to no growth expected. No market data is available for this market segment.

f. Molded & Extruded Plastics/Rubber

Particulate rubber can be added to other polymers (rubber or plastic) to extend or modify properties of thermoplastic polymeric materials. Examples of this application are injection molded products and extruded goods. There appears to be significant market potential for this application due to the continuing research and development in the area of surface modified rubber, in which a rubber surface is modified to enhance its tackiness and adhesion properties. This market segment consumed approximately 50 million pounds of scrap tire rubber in 2001.

g. Automotive Parts

The automotive industry has expressed strong interest in recycled content in rubber automotive parts. Given the long lead time on qualifying new parts for installation as original equipment on new cars, it is unlikely that this application will result in any substantial ground rubber consumption in the near future. Current consumption is limited to those few parts already qualified and being used, and to rubber parts manufacturers engaged in testing and development. No market data is available for this market segment.

h. Ground Rubber Applications: Market Outlook

The overall consumption of size-reduced rubber from 1998 through 2001 increased at a much higher than anticipated rate. RMA projected an increase of 10 to 15 percent annually. In fact, there was an increase of 80 percent over that period. At this time, the outlook for the ground rubber segment suggests a relatively stable market condition. Still, there are several possible factors that could disrupt market stability.

At present, several new ground rubber processing facilities are under construction, with several more being planned. Should these facilities take a predatory approach to marketing their product, the impact on the ground rubber infrastructure could be destructive. If, however, these new production facilities focus on new market niches, it could improve the market dynamics significantly.

The growth in the ground rubber market appears to be in areas of molded/extruded products, playground and sport surfing applications. This is not to suggest or rule out any other applications as potential areas of growth. Rather, it appears that these applications are becoming more accepted by the marketplace and that the producers of the respective tire particle sizes are becoming more proficient.

To a certain extent, the growth potential for the ground rubber market also may be impacted by state policies. Some states are looking to support the construction of additional production capacity, while other states still subsidize the purchase of ground rubber products. The impacts could become destabilizing if state funding programs end, if the industry becomes too dependent upon subsidized programs or if additional production capacity cannot be moved into new markets.

Another factor that could have an impact on the number of tires going into ground rubber production is the importation of ground rubber from Canada. Conceivably, increased demand for ground rubber in the U.S. markets could be met by supply from Canada. Although a concern, the production capacity in Canada is limited: Canada only generates 26 million scrap tires a year; not all of which are made into ground rubber.

3. Cut, Punched and Stamped Rubber Products

There has been no change in this market segment over the past several years. The process of cutting, punching or stamping products from scrap tire carcasses is one of the oldest methods of reusing of old tires. This market encompasses several dozen, if not hundreds of products, all of which take advantage of the toughness and durability of tire carcass material. The basic process uses the tire carcass as a raw material. Small parts are then die-cut or stamped, or strips or other shapes are cut from the tires. This market consumed approximately 8 million scrap tires in 2001.

A limitation of this market is that it generally uses only bias ply tires or fabric bodied radial tires. Historically, this market has consumed primarily medium truck tires. However, the steel belts and body plies in an increasing percentage of medium truck radial tires are not desirable in these applications. Larger bias ply tires may provide another possible raw material for this market, which could offset some of the decrease in supply for this market caused by the trend towards steel belted radial medium truck tires. Thus it may provide a reuse opportunity for some of the large off-the-road tires that otherwise pose waste management challenges.

Because of the consistent demand in this market, virtually all of the scrap bias ply medium truck tires that are collected by major truck casing dealers find their way to a cutting or stamping operation. The estimated size of this market is eight million tires.

This demand is expected to remain constant, since there is a limited number of bias ply tires. If no new supply of bias ply tires can be secured, it is likely that this market segment will decrease slightly over the next two years as the supply of bias ply tires diminishes.

4. Civil Engineering Applications

The civil engineering market encompasses a wide range of uses for scrap tires and scrap tire-derived material. In virtually all applications, scrap tire material replaces some other material currently used in construction (e.g., soil, clean fill, drainage aggregate, and lightweight fill materials such as expanded shale or polystyrene insulation blocks). This segment of the scrap tire market has shown dynamic growth over the last two years. Overall, use of tires in civil engineering applications doubled from the 20 million used in 1998 to 40 million by the end of 2001. To place this market in perspective, in 1996 approximately ten million scrap tires were used in this application. Today it is the second largest market for scrap tires.

Several factors contributed to the dynamic growth of this market application. In general, the end user community has accepted many civil engineering applications, particularly in the area of landfill construction, based on proven performance and economic benefits. To be sure, in virtually all civil engineering applications, tire shreds only will be used if and when there is an economic benefit.

There are two other major factors at play as well. First, a considerable amount of tire shreds for civil engineering applications come from stockpile abatement projects. This has a significant impact on the economics, as well as the application itself. Abatement tires are typically dirtier than other sources of tires, and as such typically are rough shredded. These rough shreds are a good source of material for embankment fill, alternate daily cover or landfill closure projects.

The second factor is that there is more information available on the various applications than at any previous time. This information includes the expanding availability of the ASTM specifications for tire shreds in civil engineering applications (ASTM D6270-98, “Standard Practice for Use of Scrap Tires in Civil Engineering Applications”), individual engineering reports, leachate data and training courses on highway and landfill applications. Of note, a field study released in 2002 examined the effects of chemicals leaching from tire shreds when placed below the groundwater table in a civil engineering application. The study showed negligible impact on the environment caused by the tire shreds. Table 10 shows properties of tire rubber used in civil engineering applications.

While RMA did not collect market information specific to each segment in the civil engineering market in this study, RMA intends to seek that type of data for the next scrap tire market report. However, this report does provide a qualitative discussion of the various market segments that comprise the civil engineering market for scrap tires.

Table 10: Properties of Tire Rubber Used in Civil Engineering Applications

Size	2 to 12 inches
Weight	1/3 to 1/2 weight of soil
Volume	1 cubic yard = 75 tires
Drainage	10 times better than well graded soil
Insulation	8 times better than gravel
Lateral Foundation Wall Pressure	1/2 that of soil

a. Landfill Construction and Operation

Of all the uses for tires shreds, this is the fastest growing market application. Overall, there are five applications for tire shreds in landfill construction. These applications are for the use of tire shreds in cap closures, as a lightweight backfill in gas venting systems, as a material for daily cover, in leachate collection systems and in operational liners. It must be noted that the use of scrap tires in landfill construction must not be considered as a disposal option. Rather, it is a beneficial use of the properties of processed scrap tires. Scrap tire shreds can replace other construction materials that would have to be purchased.

Cap closures: Tire shreds are being used in lieu of clean fill in the three feet of cover material placed between the upper most geotextile covering municipal solid waste and geotextile under the final cover material (typically soil). In this application, rough shreds, often taken from abatement sites replace the middle portion of the three feet of fill material.

Gas venting systems: A more refined tire shred, typically a clean cut four inch square shred is placed inside the trench in which the gas venting equipment is located. The lightweight nature of tire shreds, relative to conventional fill materials, allows tire shreds to exert less pressure against the gas venting equipment. This prevents shifting or damage to the gas venting system.

Alternate daily cover: Rough shreds are mixed with clean fill (dirt) to comprise the six inches of cover material every landfill must spread across the work area of an active landfill cell at the end of the day. This application, while a very low value added application, is utilizing large-scale amounts of abatement tires, as well as residual tire material from TDF processing. This application is proving beneficial in areas where clean fill is expensive. In this application, tire shreds prove effective in keeping the municipal waste in the landfill and preventing birds or rodents from entering the landfill. Tire shreds, however, have no ability to control odor emanating from the landfill. Consequently, landfill operators are combining dirt with tires in a 50-50 mixture.

Leachate collection systems: This appears to be the most widely used application for tire shreds in landfills. The use of a relatively clean-cut four-inch square shred is replacing the middle foot of the three feet of sand that is required in a leachate collection system. Tire shreds are not used in the sections of the collection system that touch the geotextile that separates the collection system from the municipal solid waste due to concerns that tire wire would puncture the geotextile and cause leakage.

The main benefit of using tires in this application, aside from economic considerations is that tire shreds appear to better allow the flow of leachate through the collection system, since once in place, tire shreds compact less than sand. Additionally, since there is more void space, the clogging potential of the leachate system is reduced. Finally, the presence of tire shreds has not been associated with any environmental stress or thermal degradation.

Operational liners: Operational layers separate municipal solid waste from landfill containment systems. Containment systems are typically a geosynthetic membrane, a geosynthetic clay liner or a compacted clay liner. Tire shreds are used in lieu of conventional material (sand or clean fill), but are not typically placed directly against the geosynthetic membranes.

b. Septic System Drain Fields

Tire shreds are used in several states to construct drain fields for septic systems. The lower density of the shredded tire material greatly reduces the expense and the labor to construct these drain fields, while the material provides equal performance of the traditional stone backfill material. Arkansas, Florida, Georgia, South Carolina and Virginia allow this application.

There is a series of reasons why tire shreds are fast becoming accepted by the septic field construction industry. Tire shreds have a greater void space percentage compared to stone. Tire chips contain 62 percent void space, as compared to 44 percent with stone. This allows tire chips to hold more water than stone. Furthermore, tire chips are lighter than stone, which makes moving tire chips easier than moving stone during construction. While gaining favor in certain parts of the country, the acceptance of tire chips is also a function of quality. Tire chips must be clean cut and have uniform size. While tire shreds have clearly demonstrated that they can be used in these applications, further expansion will be a function of two factors: approval from appropriate state agencies and economics. Where and when tire shreds are less expensive than stone and where state regulations do not restrict this application, it is expected that this market niche will expand.

c. Subgrade Fill and Embankments

Maine, Minnesota, North Carolina, Vermont and Virginia have used tire shreds as a subgrade fill in the construction of highway embankments and other fill projects. The principal engineering advantage that tire shreds bring to these projects is lighter weight (one-third to one-half of conventional soil fill). Use of tire shreds allows construction of embankments on weak, compressible foundation soils. For most projects, the use of tire shreds as a lightweight fill material is significantly cheaper than alternatives, such as use of expanded shale aggregate or polystyrene insulation blocks.

Projects featuring this use of scrap tires include: the construction of two highway embankments on weak clay in Portland, Maine; construction of an interstate ramp across a closed landfill in Colorado; construction of mine access roads across bogs in Minnesota; stabilization of a highway embankment in Topsham, Maine; and reconstruction of a highway shoulder in a slide prone area in Oregon. Scrap tire material also has been used to retain forest roads, protect coastal roads from erosion, enhance the stability of steep slopes along highways and reinforce shoulder areas.

d. Backfill for Walls and Bridge Abutments

Tire shreds can be used in small-scale, homeowner level civil engineering applications. Shredded tires have been used in some areas as a drainage medium around house foundations. In addition, several projects have been constructed using tire shreds as backfill for walls and bridge abutments. The weight of the tire shreds produces lower horizontal pressure on the wall, allowing for construction of thinner, less expensive walls. In addition, tire shreds are free draining and provide good thermal insulation, eliminating problems with water and frost buildup behind the walls. The benefits of this application were demonstrated by a full-scale test wall constructed at the University of Maine and a bridge abutment built by Maine DOT. Recent research conducted in Maine and South Dakota also shows that the compressibility provided by a thin layer of tire shreds placed directly against a bridge abutment can significantly reduce horizontal pressures.

e. Subgrade Insulation for Roads

One of the problems plaguing roads in northern climates is the excess water that is released when the subgrade soils thaw during the spring melt. To prevent this, tire shreds have been used as subgrade insulation on projects in Maine, Vermont, and Quebec. The insulation that is provided by a 6 to 12-inch thick tire shred layer keeps the subgrade soils from freezing throughout the winter. In addition, the very high permeability of tire shreds allows excess water to drain from beneath the roads, which prevents damage to road surfaces.

f. Civil Engineering Applications: Market Outlook

It is expected that the acceptance and use of scrap tires in civil engineering applications will continue to increase steadily over the next two years. Significant annual growth in the market is anticipated, likely in the 20 to 50 percent range. Septic tank drain fields and landfill leachate collection systems seem to be the market segments with the largest growth potentials. Additionally, tire shreds in other landfill applications appear to have potential for growth.

One of the factors that could limit the use of tire shreds in civil engineering applications and in landfill applications in particular is the inability to store tire shreds on the site of a construction job. Some states have strict regulations on how many tires can be stored at a location without obtaining a permit, even for processed tires. Compounding the problem is that some states still consider processed tires, even those that have been sold and being used in construction applications, as a solid waste. Thus, the need to store large-scale numbers of tire shreds as landfill construction materials could pose problems for landfill operators.

Finally, expansion of virtually all civil engineering applications will be a function of economics. Where and when tire shreds are cost competitive with construction materials currently being used, market expansion is likely. While this is an unfortunate reality, these large-scale applications do provide a beneficial outlet when other markets are limited, particularly for excess material and abatement tires.

5. Export of Tires

Export of sound used tires constitutes a distinct market for tires removed from initial service in the U.S. Used tires have ready markets domestically, in North America and in many other parts of the world. The export market routinely ships slightly more than one million units per month, or more than 15 million tires per year, based on the estimates of participants in those markets. This constitutes about five percent of the annual volume of discarded tires in the U.S.

6. Agricultural and Miscellaneous Uses

Scrap tires are regularly used in a variety of agricultural applications. Used tires not legally fit for highways sometimes may be used on low speed farm equipment. Tires are also used to weigh down covers on haystacks, over silage, or for other purposes where an easily handled weight is needed. Tires can be used to construct livestock feeding stations or to protect fence posts and other structures from wear and damage by livestock. Tires may also be used in erosion control and other land retention projects. There also is a wide variety of uses for scrap tires which do not fit neatly into any of the preceding categories, which ranges from one of the most popular uses as a scrap tire swing, to more exotic uses, limited only by imagination and necessity. We estimate the combined use in agricultural and miscellaneous uses consume some seven million tires annually.

B. Land Disposal Issues

In many states, the management portfolio for scrap tires includes an option to place whole and/or processed scrap tires into landfills. In some states, landfilling scrap tires is the only viable option. Certain aspects of landfilling scrap tires must be recognized. First and foremost, landfilling tires has a profound impact upon the end use markets for scrap tires. The cost to landfill a tire restricts the tip fees (fees paid to dispose of material at a landfill) that tire processors can charge for processing tires as well as the supply of scrap tires available to them. Second, landfilling scrap tires is not a market; it is a disposal option. Many factors, including transportation costs and limited scrap tire volumes, may make it impracticable to have substantial scrap tire markets in some locations. Where this is the case, it is understandable that landfilling may be the most reasonable and cost-efficient management option.

Since 1996, the placement of shredded scrap tires in monofills (a landfill, or portion thereof, that is dedicated to one type of material) has become more prominent in some locations as a means of managing scrap tires. In some cases, monofills are being used where no other markets are available and municipal solid waste landfills are not accepting or are not allowed to accept tires. In other cases, monofills are portrayed as a management system that allows long-term storage of scrap tires without the problems associated with above ground storage. In theory, monofilled processed scrap tires can be harvested when markets for scrap tire material improve. In practice, however, the economics of retrieving this material relative to the value this material can yield makes it unlikely that such actions will occur. Still, placing scrap tires into monofills is preferable to above ground storage in piles, especially if the piles are not well managed.

C. Scrap Tire Stockpiles

The issues associated with and management practices for scrap tires in stockpiles are different than those for annually generated scrap tires. Stockpiles are the residue of past (and some current, usually illegal) methods of handling scrap tires. While its owner sometimes considers a scrap tire stockpile to be an asset, scrap tire stockpiles truly are liabilities. Another major distinction between annually generated tires and stockpiled tires is a matter of economics. Generally, the collection, flow and processing of annually generated scrap tires are aided by the fees often assessed at the retail level. Typically, stockpile sites are managed such that the fees used to place tires onto stockpiles are not available to facilitate handling, processing or other remediation. Consequently, stockpiled tires tend to remain in place until state-initiated abatement programs can be implemented.

Another major issue in managing scrap tire stockpiles is developing an accurate assessment of the actual number of scrap tires in stockpiles. Since 1994, many state scrap tire management programs have focused on stockpile abatement. In 1994, following a survey of the states, the estimated number of scrap tires in stockpiles in the U.S. was 700 to 800 million, considerably fewer than earlier estimates.

Based on the latest RMA survey of state agencies, RMA estimates that around 300 million tires were in stockpiles in the U.S. at the end of 2001. This number is the same as the estimate in 1999. In actuality, there were millions of tires removed from stockpiles during this time period. Two main factors caused the estimate to remain the same since 1999. First, two states (Colorado and Connecticut) have begun to count some existing scrap tire storage sites as abandoned stockpiles. Second, some other relatively large-scale collection operations have closed.

From the information RMA collected in its survey of state agencies, it is apparent that stockpiled scrap tires are concentrated in a relatively small number of states. Eighty-five percent of all stockpiled tires in the U.S. are in the following nine states: Alabama, Colorado, Connecticut, Michigan, New York, Ohio, Pennsylvania, Texas, and West Virginia.

Of these states, Ohio, Pennsylvania and West Virginia have active stockpile abatement programs. These states expect to reduce their stockpile inventories. Of the remaining states with large-scale stockpile inventories, Massachusetts and New York are considering legislation that could reduce these piles. Alabama, Michigan and Texas either have inadequate or nonexistent programs to address their stockpiles.

Beyond these nine states, California, Florida, Georgia, Illinois, Iowa, Maine, Missouri and Virginia are still continuing active stockpile abatement programs. Consequently, there is an expectation that some 15 to 30 million tires could be abated over the next two years.

Table 11 shows RMA estimates, based on data from State regulators, of the numbers of tires remaining in stockpiles in the U.S. Estimates for each reporting state are displayed, organized by regions of the U.S. Environmental Protection Agency (EPA).

Table 11: Estimates of U.S. Scrap Tire Stockpiles: 2001

State	*# Stockpiled*	*Comments*	*Clean up Program Status*
EPA Region 1			
Connecticut	**20,000,000**	1 pile/Tire Pond	None
Maine	1,000,000	Tremendous progress	Active
Massachusetts	**10,000,000**	No program	None
New Hampshire	750,000	No program	None
Rhode Island	None reported	No program	None
Vermont	200,000	No program	None
EPA Region 2			
New Jersey	**7,000,000**		Grants to counties for some clean up
New York	**40,000,000**	No program	None
EPA Region 3			
Delaware	**3,500,000**	Looking to develop program	
Maryland	None reported		
Pennsylvania	**13,000,000**		
Virginia	**7,500,000**		None
West Virginia	**12,000,000**		Active
			Active
EPA Region 4			
Alabama	**25,000,000**	Regional dumping area	Active
Florida	DNR		Active
Georgia	250,000		
Kentucky	500,000		None
Mississippi	35,000		Active
North Carolina	100,000		Active
South Carolina	145,000		Limited
Tennessee	Unknown		Active
			Active
EPA Region 5			
Illinois	1,800,000		Active
Indiana	1,500,000		Limited
Michigan	**25,000,000**		
Minnesota	None reported		Active
Ohio	**40,000,000**		Limited
Wisconsin	None reported	3 processors w/large accumulations & limited markets	None

Table 11: Estimates of U.S. Scrap Tire Stockpiles: 2001 *(continued)*

State	***# Stockpiled***	***Comments***	***Clean up Program Status***
EPA Region 6			Ended
Arkansas	None reported		Moderately Active
Louisiana	35,000		None
New Mexico	240,000		
Oklahoma	560,000		Limited
Texas	**58,000,000**	Largest pile being bid out	Limited
EPA Region 7			None
Iowa	1,750,000		Moderately Active
Kansas	100,000		Limited
Missouri	3,600,000	Program might end in 2004	
Nebraska	1,200,000	8 million on site at EnTire	Active
EPA Region 8			None
Colorado	**28,000,000**		Active
Montana	None reported		None
North Dakota	200,000		
South Dakota	50,000		Limited
Utah	300,000		None
Wyoming	None reported	No program; nearly all landfilled	None
EPA Region 9			Active
Arizona	0		None
California	2,000,000		None
Hawaii	2,000,000		
Nevada	230,000		None
EPA Region 10			Active
Alaska	None reported		Active
Idaho	500,000		None
Oregon	100,000		
Washington	300,000		None

DNR: Did not report
Bolded stockpile numbers: Largest stockpile states

V. Conclusions

At the end of 2001, markets for scrap tires were consuming approximately 218 million, or about 77.6 percent, of the 281 million annually generated scrap tires. This represents an increase of 11.2 percent from the number of scrap tires used in market applications in 1998. In addition to the number of tires going to a market, this study indicates that another 25 million tires were legally managed through placement in a landfill or a monofill. This raises the number of managed scrap tires to 86.5 percent of the total scrap tires generated annually.

Overall, there were increases in all three of the major market sectors (TDF, civil engineering and ground rubber), even though certain TDF market niches saw reductions in the number of tires used. Many of the conditions and possibilities discussed in the 1998/1999 Market Survey actually did occur.

In the TDF market, increased use in the cement industry offset decreases in other market segments. It appears that the growth in TDF use in the cement industry will continue to increase for the next two years. TDF faces a less optimistic future in other market sectors.

In the pulp and paper industry, there appear to be mixed signals. In some cases, increasing energy costs and a shortage of bark present opportunities for TDF use to expand. On the other side are mill closings, a depressed pulp market and uncertainty over EPA programs. It seems reasonable that if energy savings obtained by using TDF become significant, this may provide the incentive necessary for mill operators to use TDF, regardless of certain other factors. Given the uncertainty in this market sector, it is difficult to predict the near-term changes in TDF use in the paper industry.

The industrial and utility boiler sectors present a contrast in their situations. Due to recent events in the utility market, implementation of new alternative fuel programs, including those using TDF, seem unlikely at this time. The industrial boiler sector seems to be better situated relative to alternative fuel programs. The possibility of increasing energy costs and a focus on reducing NO_x emissions could provide a window of opportunity for TDF. Still much will depend upon new EPA air emission regulations.

The growth in the use of tire shreds in civil engineering applications was phenomenal – over the last two years the market doubled. These applications offer the possibility of large-scale usage for relatively large-sized tire shreds. While these shreds do offer certain advantages and benefits for engineering purposes, their acceptance and use is normally a function of economics, which is a concern to the processing sector of the industry. While processing costs for this material are relatively low, so is the return on investment, which makes it difficult for most processors to adequately fund their operations and remain financially solvent.

State regulations also have potential to impact the economic stability of the civil engineering market for scrap tires. In situations where tire shreds are a marginal material and the landfill or construction manager is faced with an increased regulatory burden, tire shreds will typically not be considered. State regulatory agencies should facilitate the process that would allow tire shreds to be stored and used at these construction sites.

The ground rubber market also showed a very significant increase over the past few years, increasing consumption by 50 percent. Of particular importance, the major increase occurred in those markets that were just taking hold a few years ago. The use of ground rubber in asphalt rubber will likely remain the largest single end use. However, the use of tire rubber in athletic/sport surfacing, playgrounds and as a soil amendment appears to offer dynamic growth potential for the next two years. However, state policies that subsidize ground rubber producers and competition from Canadian ground rubber producers could negatively impact the ground rubber market.

Significant progress continued toward the remediation of scrap tire stockpiles. While the overall number of scrap tires in stockpiles appears to have remained the same over the last two years, in reality, some 50 to 60 million tires were permanently removed from piles. The closing of some relatively large-scale collection operations and the reclassification of some older storage sites from operational to abandoned stockpiles caused the overall number to remain constant.

Many states still are actively abating stockpiles. Several states, including California, Florida, Georgia, Illinois, Iowa, Maine, Missouri, Ohio, Pennsylvania, Virginia and West Virginia, are expected to make significant progress toward total elimination of stockpiles. Unfortunately, many of the states with large numbers of stockpiled tires either have no comprehensive scrap tire management program or are not focusing current programs towards stockpile abatement, including Alabama, Colorado, Michigan, New York and Texas.

The growth potential for scrap tire-derived materials appears to be, overall, positive for the next two years. As stated in previous reports, the ability to maintain and increase markets for scrap tires requires a concerted effort sustained by all involved. The forces of competition, government programs and changing technology will continue to challenge this industry for the foreseeable future.

Appendix A contains an outline of the factors influencing the major markets for scrap tires, including TDF, civil engineering applications, and ground rubber applications. Appendix B contains scrap tire market data for 1990 through 2001.

Appendix A: Factors Impacting the Major Scrap Tire Markets

Tire Derived Fuel:

Positive Factors

- Development of ASTM specifications
- Increased importance of NO_x reduction
- Cost competitiveness
- Increasing energy prices

Challenges

- New EPA air emission regulations
- Changing to natural gas

Civil Engineering Applications:

Positive Factors

- Acceptance by regulatory agencies & industry on use of tire chips in septic fields
- Acceptance by regulatory agencies & industry on use of tire chips in landfills
- Cost competitiveness
- Development of ASTM specifications
- Increased information in the public domain
- Long-term field studies of leachate

Challenges

- State regulations
- Abundance of competing materials

Ground Rubber Applications:

Positive Factors

- Expanding use of rubber-modified asphalt
- Safety advantages when rubber is used as playground cover
- Better availability of information on playground issues

Challenges

- Supply/demand imbalances

Appendix B: Scrap Tire Market Data 1990 - 2001

SCRAP TIRE USES (Millions of Tires)

	1990	1992	1994	1996*	1998	**2001**
Type of Fuel use:						
cement kilns	6.0	7.0	37.0	34.0	38.0	**53.0**
pulp/paper	13.0	14.0	27.0	26.0	20.0	**19.0**
Utility/industrial boilers	1.0	21.0	22.0	39.0	40.0	**29.0**
dedicated scrap tire-to-energy	4.5	15.0	15.0	16.0	16.0	**14.0**
Total fuel	24.5	57.0	101.0	115.0	114.0	**115.0**
Ground rubber	0.0	5.0	1.5	7.5	7.0	**21.0**
Asphalt rubber	N/A	N/A	3.0	5.0	8.0	**12.0**
Cut/punched/stamped products	N/A	N/A	8.0	8.0	8.0	**8.0**
Civil engineering	N/A	5.0	9.0	10.0	20.0	**40.0**
Export			12.5	15.0	15.0	**15.0**
Agricultural use and miscellaneous	N/A	1.0	3.5	4.0	5.5	**7.0**
Total scrap tire markets	**24.5**	**68.0**	**138.5**	**164.5**	**177.5**	**218.0**

* 1996 fuel use estimates vary from those previously reported. Previous 1996 estimates were based on permitted levels, rather than actual usage. The 1996 numbers reported here are based on actual fuel use, consistent with the data reported for all other years.