SCRAP TIRE MANAGEMENT COUNCIL

Scrap Tire Use/Disposal Study 1992 Update

A.T. Kearney

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EXECUTIVE SUMMARY

Disposal of scrap tires is a serious national problem. Due to the large number of scrap tires generated annually and their long product life, tires pose a substantial waste management problem. Currently the majority of scrap tires are being landfilled or stockpiled, creating potentially serious health and environmental threats, as well as taking up rapidly shrinking landfill capacity.

The Federal government, state governments, and tire manufacturing industry are committed to investigating and developing alternative environmentally sound methods to landfilling and stockpiling. Many states have set mandatory recycling requirements that will increasingly affect the way in which scrap tires are managed. The Scrap Tire Management Council (STMC) has undertaken a strategic program to increase the environmentally sound reuse, recycling, energy recovery or disposal of scrap tires.

In 1990, the tire manufacturing industry retained A.T. Kearney to examine available methods for scrap tire management, including the environmental, economic and infrastructure/capacity for each alternative. The results of that study have been widely disseminated and provided the basis for many of the activities that have been undertaken since 1990 by all involved parties.

It is important to point out that the focus of this study is the examination of scrap tire management alternatives other than retreading. Essentially this means that A.T. Kearney examined scrap tire management methods for those tires that can no longer be used for their originally intended purpose. Retreading represents a management method that extends the useful life of a tire, thus it does not meet the study's definition of a scrap tire management method. Retreading does however represent a very important means of volume reduction for scrap tires, thus it warrants mention here. Approximately 30 million tires are retreaded or repaired annually and put back into use. Retreading processes have been in use almost as long as tires have existed. New retreading technologies continue to increase the useful life of tires, thereby ensuring fuller utilization of the resources built into the tire.

Purpose

This study is intended to be used as a companion document to the 1990 Scrap Tire Use/Disposal Study.

The purpose of this study is to :

- Identify and evaluate the level of progress made with the reuse, recycling and energy recovery of scrap tires since the 1990 report.
- Identify new methods which have emerged since the 1990 report
- Identify market, technical, institutional, and other barriers to the expanded use of these methods.

The results of this study are intended to help industry and the STMC evaluate the progress that has been made in the development and implementation of those scrap tire use or disposal methods which have the greatest promise for significantly reducing the number of tires going to landfills or stockpiles in the near future.

Background

The study is intended to be used as an updated reference to the 1990 study. The outline for the original study was replicated in this report for ease of cross-referencing.

Results

The following alternative scrap tire use or disposal methods were re-evaluated in this study:

- Use as a supplemental fuel in cement kilns
- Use as a supplemental fuel in pulp and paper mills
- Use as a supplemental fuel in electricity generating facilities
- Use as fuel in dedicated tire-to-energy facilities
- Use in asphalt/paving applications
- Use in civil engineering applications
- Product recovery via pyrolysis

Each of these alternatives is briefly discussed below. Note that all scrap tire materials are expressed in terms of "scrap tires". For the purposes of this study, one "scrap tire" is equal to 20 pounds of tire derived fuel or 10 pounds of crumb rubber (equal to approximately one passenger car tire). Based on our numerous conversations with industry experts, this ratio is generally considered to be the industry norm.

Use as a Supplemental Fuel in Cement Kilns

Either whole tires or tire-derived fuel (TDF) can be used as supplemental fuel in cement kilns, depending on kiln size and technology. The technology is proven and has been in operation in the U.S. for at least six years and longer in other countries. The number of kilns burning tires or TDF on an operational basis has increased from two to eleven, while an additional twelve kilns have submitted trial burn results and are awaiting state permits. Five kilns have scheduled trial burns for 1992 and another nine are seriously evaluating using scrap tire material as an supplemental fuel. Whole tires appear to be the preferred fuel alternative despite higher initial capital requirements.

Kilns currently burning scrap tire material have individual volume capacities ranging from 250,000 to 2.2 million scrap tires per year. One system not currently operating has the capacity to burn up to 5.3 million scrap tires. Total current permitted capacity is 14 million scrap tires. Current usage is approximately 7 million scrap tires, which is expected to grow to 60 million by 1997.

The principal barriers to the further use of tires as a supplemental fuel in U.S. cement kilns are:

- Availability and cost effectiveness of competing supplemental fuels such as solvents and hazardous waste. This procedure may be impacted by stricter BIF regulations
- Significant capital investment needed for installation/modification of feeding system
- High costs of conducting permit required tests
- Reliability of tire/TDF supply in isolated areas
- Local opposition to tire burning

Use as a Supplemental Fuel in Pulp and Paper Mills

Tire-derived fuel (TDF) can be used as supplemental fuel in pulp and paper mills. The technology is proven and has been in

It is difficult to predict the future potential capacity of U.S. pyrolysis facilities due to the highly uncertain economics of the process. If markets for products of pyrolysis (char, oil, steel) can be secured, consumption could approach 15 million scrap tires per year by 1997.

The principal barriers to the use of tires in pyrolysis plants in the U.S. are:

- Questionable process economics; high capital expenditures for plant construction and start-up.

- Uncertain demand for pyrolytic products, especially char. Product quality is questionable at present.

- Technology has yet to be proven over a long term basis.

<u>1990/1992 Scrap Tire Consumption/Projection Comparison</u>

The following section summarizes and explains the differences in current and projected scrap tire material consumption estimates between the 1990 and 1992 Scrap Tire Use/Disposal Studies:

<u>Current Consumption</u>

The most notable change in current consumption is seen among electricity generation facilities which increased their consumption of scrap tire materials more than 20 fold. Most of this can be attributed to a single facility, Archer Daniels Midland - Decatur, Illinois, which began burning tires in the fall of 1991. Utilities which began using scrap tire materials on a continuous basis during the last two years include Ohio Edison, Manitowoc Public Utilities, Wisconsin Power & Light, and The Nebraska Public Power District. Significant increases can be expected to continue in the near term as several additional facilities are currently in various stages of testing/permitting.

A large increase in scrap tire consumption was also noted among dedicated tire-to-energy facilities. This increase is due entirely to the start-up of a single new facility - Oxford Energy in Sterling, Connecticut.

Smaller increases were noted among the cement and paper segments. The smaller size of these increases are due, in large part, to the fact that the use of scrap tire materials is well established in both of these segments. However, significant growth opportunities continue to exist on a per kiln volume basis.

Five Year Projection

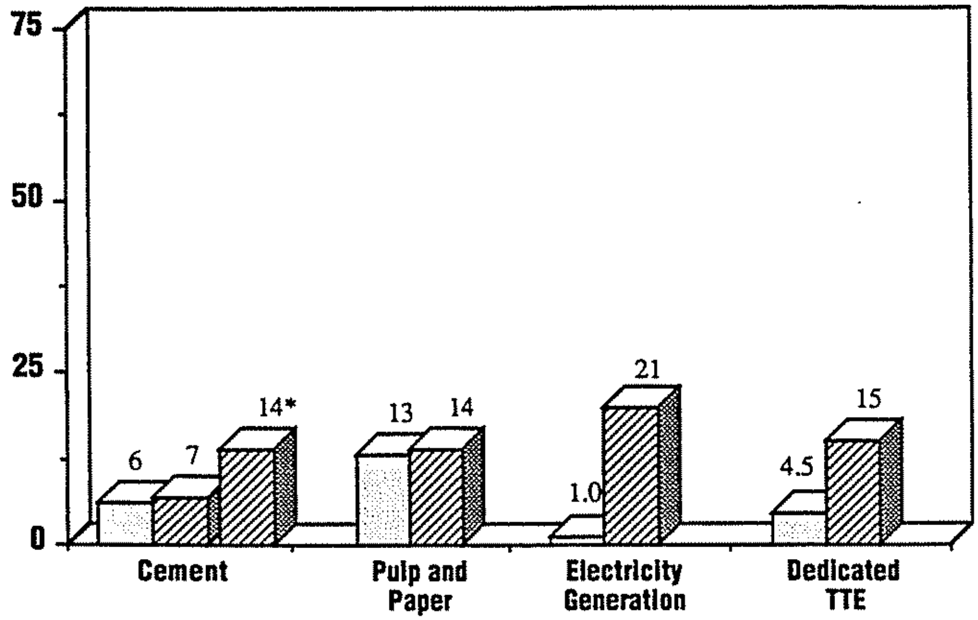
The most notable change between the 1990 and 1992 five year projections is associated with asphalt/paving applications. The 1992 five year projection is driven by the requirements of the Intermodal Surface Transportation Efficiency Act of 1991, whereas the 1990 estimate was based on growth projections associated with then current industry usage.

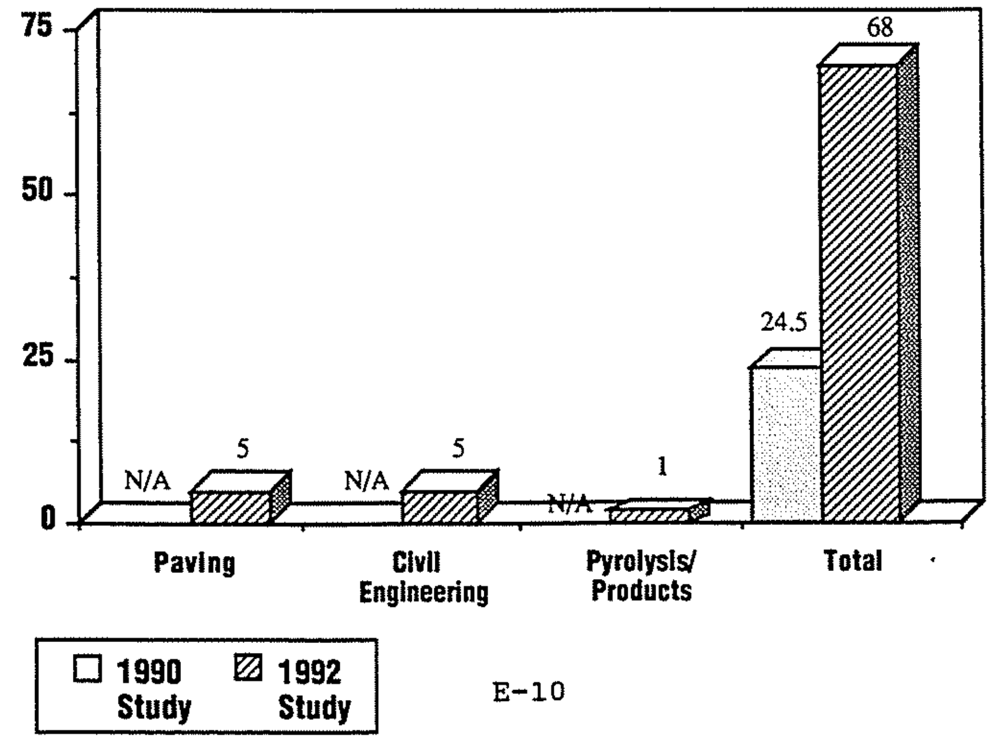
A second notable change is associated with the five year projection for usage in electricity generation facilities. This increase is driven by the emergence of non-utility electricity generation facilities as significant users of scrap tire materials.

Finally, the estimates for potential usage of scrap tire materials in civil engineering and asphalt/paving applications have been increased in response to escalating research and pilot testing activities in these areas.

Actual Consumption Of Scrap Tire Materials – 1990 Vs. 1992

(Million tires per year)





*1992 Permitted capacity. Information unavailable for 1990.

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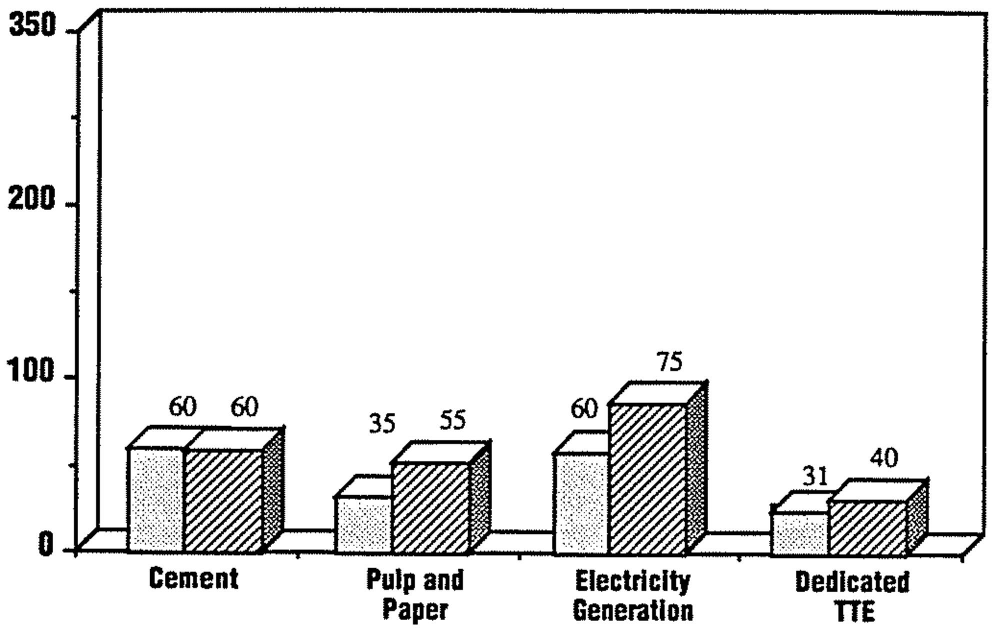
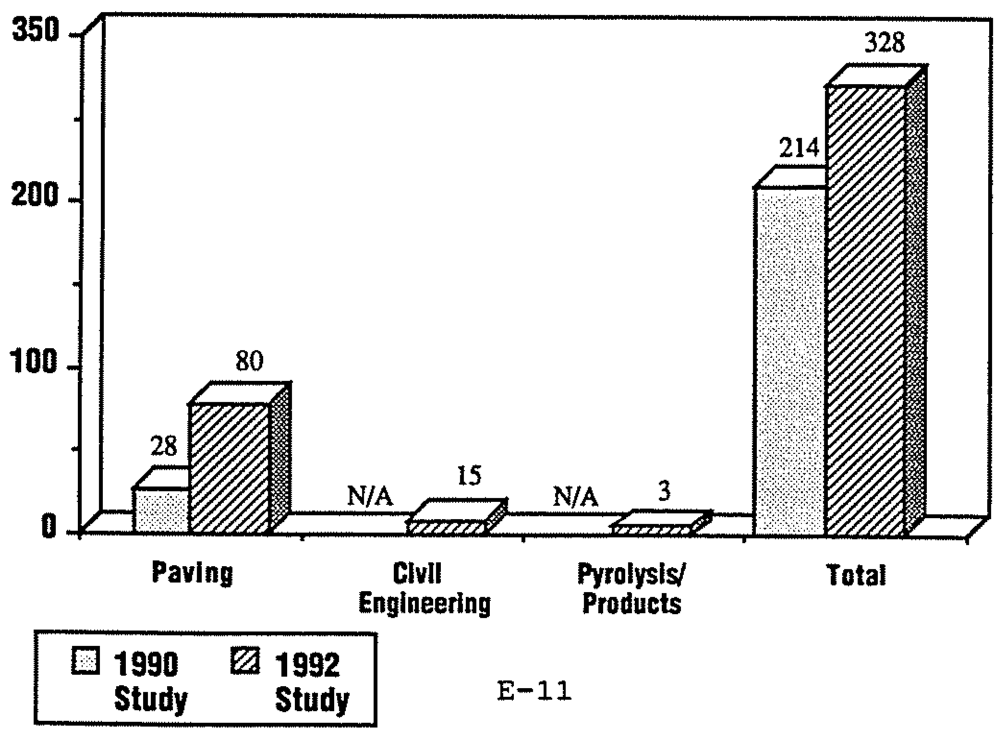
Five Year Consumption Projections – Base Year 1990 Vs. 1992

(Million tires per year)





**Potential usage for non-utility electricity generation was estimated to double within five years. Significant additional growth opportunities may exist in this area.*

1.0 INTRODUCTION

Disposal of scrap tires is a serious national problem. Due to the large number of scrap tires generated annually and their long product life, tires pose a substantial waste management problem. Currently the majority of scrap tires are being landfilled or stockpiled, creating serious health and environmental threats, as well as taking up rapidly shrinking landfill capacity.

The Federal government, state governments, and the tire manufacturing industry are committed to investigating and developing alternative methods to landfilling and stockpiling. Many states have set mandatory recycling requirements that will likely affect the way in which scrap tires are managed.

The Scrap Tire Management Council (STMC) has undertaken a strategic program to increase the environmentally sound reuse, recycling, or disposal of scrap tires. Scrap tires are defined as tires which can no longer be used for their original purpose. Hence, retreaded and repaired tires are not considered to be scrap tires in the scope of this study. This study will help the STMC evaluate the progress that has been made and focus on activities to increase the environmentally acceptable use or disposal of scrap tires with a relatively short time frame (e.g., five years.)

1.1 PURPOSE AND SCOPE

The purpose of this study is to :

- Identify and evaluate the level of progress made with the reuse, recycling, and energy recovery of scrap tires since the 1990 report.
- Identify new methods which have emerged since the 1990 report
- Identify market, technical, institutional, and other barriers to the expanded use of these methods.

The study is intended to be used as an updated reference to the 1990 study. The results are intended to help focus industry activities on furthering the development and implementation of those scrap tire use or disposal methods which have the greatest promise for significantly reducing the number of tires going to landfills or stockpiles in the near future.

The focus of this study is limited to methods of scrap tire use or disposal which will potentially meet the three baseline criteria specified below:

- Environmental acceptability
- Economic feasibility
- Volume capability within a two-to-five year timeframe

1.2 BACKGROUND

Scrap tire generation, reuse, and disposal have been the subject of numerous recent studies by Federal and state agencies. It is not the purpose of this study to repeat data readily available in these sources.

1.2.1 Generation

For the purpose of this report, data concerning generation rates of tires remains the same as described in the original report. Note that all scrap tire material quantities have been converted to "scrap tires". One "scrap tire" is equal to 20 pounds of tire derived fuel or 10 pounds of crumb rubber (equal to approximately one passenger car tire).

1.2.2 Management Methods

Identification of potential changes in scrap tire management methods was not included in the scope of this report.

1.3 METHODOLOGY

The basic methodology used to conduct this study coincides with the methodology followed in the 1990 study.

1.4 ORGANIZATION

This report is organized as follows:

- Chapter 2 - Updated profiles of methods which satisfied baseline criteria for environmental acceptability, economic feasibility, and volume capability. The methods profiles are:

- Use as a supplemental fuel in cement kilns
- Use as a supplemental fuel in pulp and paper mills
- Use as a supplemental fuel in electricity generating facilities
- Use as fuel in dedicated tire-to-energy facilities
- Use in asphalt/paving applications
- Use in civil engineering applications
- Product recovery via pyrolysis

- Chapter 3 - Conclusions
- Chapter 4 - Additional Sources

2.0 TECHNOLOGY PROFILES

This section provides technology profiles for those scrap tire use alternatives which were determined to meet study criteria. That is, the alternatives profiled in this section were determined to be potentially environmentally sound, economically feasible, and capable of utilizing a significant quantity of scrap tire material.

The technologies examined in this section are:

- Use as a Supplemental Fuel in Cement Kilns
- Use as a Supplemental Fuel in Pulp and Paper Mills
- Use as a Supplemental Fuel in Electricity Generating Facilities
- Use as Fuel in Dedicated Tire-to-Energy Projects
- Use in Asphalt/Paving Applications
- Use in Civil Engineering Applications
- Product Recovery Via Pyrolysis

2.1 USE AS A SUPPLEMENTAL FUEL IN CEMENT KILNS

Abstract. Either whole tires or tire-derived fuel (TDF) can be used as supplemental fuel in cement kilns, depending on kiln size and technology. The technology is proven and has been in operation for at least six years in the United States and longer in other countries. From 1990 to 1992, the number of kilns burning tires or TDF on an operational basis has increased from two to eleven, while an additional eleven kilns have submitted trial burn results and are awaiting state permits. Five kilns have scheduled trial burns for 1992 and another nine are seriously evaluating using scrap tire material.

Kilns currently burning scrap tire material have individual permitted volume capacities ranging from 250,000 to 2.2 million scrap tires per year. One system not currently operating has the capacity to burn up to 5.3 million scrap tires. Interviews with plant managers indicate that although feed systems for whole tire burning are more expensive than those needed for TDF, whole tire burning is the preferred and more cost effective system overall.

It is estimated that U.S. cement kilns could be consuming 60 million tires per year by 1997. This estimate is based on the assumption that 90% of the cement kilns with preheaters/precalciners, currently numbering 44, will use scrap tire material as an auxiliary fuel at an average rate of 1.5 million scrap tires per year.

The principal barriers to the further use of tires as an auxiliary fuel in U.S. cement kilns are:

- Significant capital investment needed for installation/modification of feeding system
- High costs of conducting permit required tests
- Reliability of tire/TDF supply in isolated areas
- Local opposition to tire burning
- Availability and cost effectiveness of competing supplemental fuels such as solvents and hazardous waste

2.1.1 Technology Description

There has been one major change since mid-1990 in the technology that uses scrap tire material as a supplemental fuel in cement kilns. Mid kiln injection systems for long kilns are now available and operating. The practicability of this technology opens a significant market for this segment of the cement industry. Due to their unusually high operating temperature and long exhaust gas residence times in the burning zone, cement kilns have the capacity to safely use a wide variety of fuels, including tires or tire-derived-fuel (TDF). Whole tires or TDF are a good auxiliary fuel for coal and oil burning cement kilns because their:

- British Thermal Unit (Btu) value is comparable or higher than typical coal used in making cement
- Nitrogen, Sulfur, and ash content is lower than typical values for coal
- Steel content provides supplemental iron for the cement

Installation of a fuel feeding system remains the most significant and costly modification necessary to burn scrap tire material. Whole tires are fed to kilns using a mechanical feed system designed for tire charging. TDF may be fed using either mechanical or pneumatic systems.

Typical feed rates vary from 0.5 - 3 tons of scrap tire material per hour, with tires providing 5-25 percent of the total fuel. Average annual tire consumption at a typical facility is about 1.5 - 3 million scrap tires. One kiln explored the possibility of burning up to 6 tons of tires per hour.

2.1.2 Environmental, Economic, and Volume Characteristics

The following section summarizes the changes found since mid-1990 in the environmental, economic and volume characteristics associated with burning tires or TDF in U.S. cement kilns.

Environmental Characteristics

From a technical standpoint, the environmental characteristics associated with burning scrap tire material in cement kilns have not changed since mid-1990. The regulatory environment, however, is more complex.

The strengthening of air pollution control regulatory requirements on the state and national level may have a two-fold effect on the use of tires and TDF as fuel in cement kilns. In particular, coal fired facilities will be evaluating available fuel alternatives to meet the more stringent requirements of the Clean Air Act of 1990. Since the use of tires as an auxiliary fuel in cement kilns (vs. 100% coal use) typically reduces the amount of nitrogen oxides released and does not adversely affect other components of kiln air emissions, this option will be evaluated closely. As over half the kilns in the United States currently rely on coal as their primary fuel, the potential for increased TDF use is substantial.

However, tougher air pollution control requirements necessitate additional complex and expensive tests. Although these tests may not be difficult to pass, their high costs could prove prohibitive for facilities considering burning TDF for the first time.

Over 10% of the cement companies interviewed indicated that environmental and community waste management concerns played a part in their decision to burn tires. They felt that by burning tires they helped alleviate a serious waste problem in their communities. Some companies, like Southwestern Cement in Victorville, CA, were approached by their communities to investigate the possibility of burning scrap tires.

Economic Characteristics

The economic characteristics associated with burning scrap tire material in cement kilns have not changed substantially since mid-1990.

The vast majority of plant officials interviewed stated that the decision to use tires as a fuel source was based primarily on economic considerations. Since coal, petroleum coke, and natural gas compete with tires as standard kiln fuels, the price of these fuels is an important factor in the decision to utilize tires. The economics of using tires as a supplemental fuel source are also contingent upon the process capabilities of the kiln and the availability and price of tires or TDF.

Generally, burning whole tires is more economical in the long run than burning TDF. Although the mechanical feeding system necessary for burning whole tires is initially more expensive than the pneumatic system for TDF use (mechanical system: $250,000 - $500,000 vs. pneumatic blower system: $60,000 - $100,000), whole tires can be procured at a lower cost than TDF. Depending upon landfill and regulatory conditions in the area, kilns may charge a tipping fee to tire disposers, making a profit through the use of tires as an auxiliary fuel.

The continued economic viability of using scrap tires as a supplemental fuel depends on several factors.

- Landfill disposal of scrap tires remains costly or is prohibited.

- State programs that help develop and subsidize non-landfill uses for scrap tires significantly increase the use of TDF. Maintenance of existing programs is important and the addition of programs in other states would be beneficial.

- Tire shredding costs remain substantial. Any technological advances in that area that reduce the price of TDF could stimulate usage.

The economic viability of using scrap tire material as fuel is heavily dependent upon its procurement price. Interviews with kiln operators nationwide revealed widely divergent procurement fees.

Examples of procurement fees:

- Holnam, Morgan, UT - TDF costs $15-25/ton. Price reflects the state of Utah's $20/ton rebate to users of scrap tires

- Hawaiian Cement, Oahu, HI - charged a nominal fee for shredding

- Kosmos Cement, Kosmosdale, KY - charges tip fee for scrap tires comparable to that charged by local landfill

- Medusa Cement, Clinchfield, GA - charges tip fee of $.05/tire

- Florida Crushed Stone, Brooksville, FL - has subsidiary that provides them with tires

<u>Volume Characteristics</u>

The following is an estimate of the potential usage of scrap tires by the U.S. cement industry:

- Within Five Years: 60 million scrap tires per year

- Within Two Years: 35 million scrap tires per year

- Current Permitted Capacity: 14 million scrap tires per year

- Current Usage: 7 million scrap tires per year

This estimate for potential usage within five years is based on the assumption that 90% of the cement kilns with preheaters/

precalciners, currently numbering 44, will use TDF as an auxiliary fuel at an average rate of 1.5 million scrap tires per year. The estimate for potential usage within two years is based on the following assumptions:

- All kilns currently burning tires will continue to do so at their maximum potential.

- All kilns which are awaiting permits will begin burning tires on a continuous basis at their estimated rate.

- All kilns which have successfully conducted trial burns but are not currently burning and those kilns that are conducting test burns in the immediate future will begin burning on a continuous basis at their estimated rate.

The estimate of current permitted capacity is based on maximum permitted consumption as dictated by individual permit levels. The estimate of current usage is based on the results of interviews with numerous industry, company, and facility representatives.

2.1.3 Usage of Scrap Tire Material in U.S. Cement Kilns in the First Quarter of 1992

As of the first quarter of 1992, there are eleven U.S. kilns burning whole tires or TDF on an operating basis. Additionally, eleven kilns have completed trial burns and are awaiting state permits to begin burning on an operational basis. Five kilns have planned trial burns for 1992 and near future use of scrap tire material is considered to be likely at nine facilities. Seven cement companies interviewed indicated that scrap tires use was unlikely at their facilities. Their responses are also included because they shed light on some of the barriers to further use of scrap tires as fuel. Exhibit 2.1 provides a summary of the use of scrap tire material in U.S. cement kilns.

U.S. Facilities Currently Burning Scrap Tire Material

- Arizona Portland Cement, Rillito AZ

  - Annual consumption: 720,000 scrap tires
  - 5% of Btu value is provided by 2" by 2" non-dewired chipped tires, permitted for up to 20%
  - Maximum consumption: 2.8 million scrap tires
  - Would increase to TDF use to 20% if price was right
  - Has used TDF for 5 years

- Ash Grove Cement West, Durkee, OR
  - Estimated annual consumption: 256,000-320,000 scrap tires
  - 5% of Btu value is provided by .5" by .5" non-dewired chipped tires, permitted for up to 10%
  - Maximum consumption: 640,000 scrap tires
  - Does not plan to increase TDF use
  - Has used TDF for 6 months

- Calaveras Cement, Redding, CA
  - Annual consumption: 1.7 million scrap tires
  - 20% of Btu value is provided by non-dewired chipped tires and whole tires (switched over September 1991), permitted for 25%
  - Maximum consumption: 2.1 million scrap tires
  - Plans to increase scrap tire use to 22%
  - Has used scrap tire material for 6 years
  - Tire supplier is aided by $20/ton rebate from the state of Oregon

- Essroc Materials, Frederick, MD
  - Estimated annual consumption: 1.1 million scrap tires
  - 15-20% of Btu value is provided by whole tires
  - Received permit summer 1992

- Hawaiian Cement, Ewa Beach, Oahu, HI
  - Estimated annual consumption: 800,000 scrap tires
  - 15% of Btu value is provided by non-dewired chipped tires, permitted for 20%
  - Maximum consumption: 1.1 million scrap tires
  - Testing completed early 1991, permit received March, 1992
  - Are working out start-up problems such as material handling difficulties

- Holnam Inc.- Ideal Basic Industries, Seattle, WA
  - Annual consumption: 900,000 scrap tires
  - 15% of Btu value is provided by dewired chipped tires, permitted for up to 20%
  - Maximum consumption: 1.2 million scrap tires
  - Does not plan to increase TDF use
  - Has used TDF for 3 years

- Lone Star Industries, Cape Girardeau, MO
  - Estimated annual consumption: 1 million scrap tires
  - Currently permitted to burn TDF and hazardous waste
  - Recently completed major adjustment to feeding system
  - Burning as of June 1992

- Medusa Cement, Clinchfield, GA
  - Annual consumption: 540,000 scrap tires
  - 10% of Btu value is provided by whole tires, permitted for up to 20%
  - Maximum consumption: 1.1 million scrap tires
  - Plans to increase scrap tire use
  - Has used scrap tire material for 1.5 years

- Monarch Cement, Humboldt, KS
  - Annual consumption: 600,000- 1,000,000 scrap tires
  - 15% of Btu value is provided by whole tires, permitted for up to 30%
  - Maximum consumption 2.0 million scrap tires
  - Does not plan to increase scrap tire use
  - Has used scrap tire material for 18 months, including the testing period

- National Cement, Raglin, AL
  - Estimated annual consumption: 530,000 scrap tires
  - Began burning in early 1992

- Southdown Inc., Lyons, CO
  - Annual consumption: 200,000 scrap tires
  - 2.7% of Btu value is provided by 2" by 2" non-dewired chipped tires, permitted for up to 14%
  - Maximum consumption: 1.0 million scrap tires
  - Had used TDF for 2 years but had been using a fixed amount of coal obtained at a below market price
  - Had to modify poor feeding system that got plugged up when tire chips were added at a fast rate
  - Burning as of June 1992

Facilities That Have Conducted Test Burns and Are Awaiting State Permits

- Florida Crushed Stone, Brooksville, FL
  - Estimated annual consumption: 1.0 million scrap tires
  - 15% of Btu value is provided by whole truck tires
  - Testing completed late 1991

- Holnam Inc.- Boxcrow Cement, Midlothian, TX
  - Estimated annual consumption: 1 million scrap tires
  - 12% of Btu value is provided by 3" non-dewired chipped tires
  - Does not plan to increase TDF use
  - Operating on a 6 month temporary permit

- Holnam, Inc, Morgan, UT
  - Estimated annual consumption of two kilns: 1.5 million scrap tires
  - 15% of Btu value is provided by 2" or smaller debeaded chipped tires, permitted for up to 20%
  - Maximum capacity: 2.0 million scrap tires
  - Does not plan to increase TDF use
  - Has used TDF since December, 1991, operating on a temporary permit
  - Aided by $20/ton rebate from state

- Illinois Cement, LaSalle, IL
  - Completed test burn of 2" tire chips in August 1991
  - Intends to switch to whole tires
  - State of Illinois has been supportive of tire burning but EPA Region V has presented obstacles

- Kosmos Cement, Kosmosdale, KY
  - Estimated annual consumption: 800,000 scrap tires
  - 12% of Btu value is provided by whole tires
  - Plans to try to increase scrap tires use to over 12%
  - Testing completed early 1991

- Lafarge Corp., New Braunfels, TX
  - Estimated annual consumption: 840,000 scrap tires
  - 10-20% of Btu value is provided by non-dewired chipped tires
  - Had temporary permit but state environmental department required further tests
  - Considering a switch to whole tires due to the high cost of shredded tires, but a significant one-time investment will be necessary
  - Last test completed November, 1991, anticipate burning scrap tire material again by mid-1992

- Lafarge, Whitehall, PA
  - Estimated annual consumption: 750,000 scrap tires
  - 15% of Btu value is provided by whole tires permitted up to 30%
  - Maximum consumption: 1.5 million scrap tires
  - Testing completed December 1991

- RMC Lonestar, Davenport, CA
  - Estimated annual consumption: 2.3 million scrap tires
  - 20% of Btu value is provided by TDF
  - Will evaluate potential benefits of burning whole tires
  - Would consider burning up to 5.3 million scrap tires per year
  - Trial burn using TDF completed December, 1990
  - Awaiting permit modification

- Southwestern Cement, Fairborn, OH
  - Estimated annual consumption: 300,000 - 400,000 scrap tires
  - 10-20% of Btu value is provided by whole tires
  - Had used TDF for 3 years, waiting for permit renewal

- Tarmac Cement, Roanoke, VA
  - One test burn completed, future test burns are scheduled in an attempt to meet stack test requirements

- Texas Lehigh Cement, Buda, TX
  - Completed test burn in 1990
  - State of Texas has put a hold on permitting TDF burning at this and several other facilities

Facilities That Are Planning Trial Burns In 1992

- Holnam Inc, Aida, OK
  - Estimated annual consumption: 1.4 million scrap tires
  - Anticipate 10-20% Btu value provided by debeaded chipped tires
  - 2 kilns in operation
  - Test burns planned for early 1992

- Independent Cement, Hagerstown, MD
  - Preparing for a test burn with 2" chips

- Lone Star Industries, Oglesby, IL
  - Estimated annual consumption: 500,000 scrap tires
  - Test burn to be conducted in early 1992
  - Tire chips will be insufflated

- Medusa Cement, Charlevoix, MI
  - Estimated annual consumption: 2.3 to 3.8 million scrap tires
  - Requested permit for trial burn of whole tires
  - Anticipate burning three to five tons an hour/20% of Btu value per year

- Rinker Materials, Dade County, FL
  - In process of conducting test burn in August 1992
  - Will install whole tire feeding system in 1992

Facilities Where Future Use of Scrap Tire Material is Likely

- Ash Grove Cement West, Inkom, ID
  - Estimated annual consumption: 600,000 - 750,000 scrap tires
  - Approached by the county to help them deal with scrap tire problem.
  - Have 2 kilns that would be suitable for whole tire consumption
  - Estimated that a tip fee/rebate of $20/ton would be necessary
  - Received permit early 1992

- Ash Grove Cement West, Seattle, WA
  - Plant not in operation yet
  - Will evaluate TDF option during 1992
- Blue Circle, Harleyville, SC
  - Estimated annual consumption: 800,000 to 1.2 million scrap tires
  - Testing completed late 1990
  - Burned whole tires at rate three tires per minute
  - Stack emissions testing results were better when burning scrap tires
  - Anticipate making a decision by late 1992
- California Portland Cement, Mojave, CA
  - Test burns of shredded tires conducted in late 1980's
  - Concluded that potential public negative reaction outweighed economic benefits
  - Currently re-evaluating use in light of potential CA Department of Health support of TDF use
- Lafarge, Davenport, IA
  - Have commissioned a market survey on suppliers or scrap tires
  - Scrap tire burning is a priority item on agenda
- Lafarge, Sugar Creek, MO
  - Will consider test burn of whole tires if test burn at White Hall plant is a success
- Lehigh Cement, Leeds, AL
  - Estimated annual consumption: 750,000 scrap tires
  - Anticipate 15-20% Btu value provided by whole tires
  - Concerned about public perception/criticism
  - Received permit for test burn
  - Began burning September 1992
- Phoenix Cement, Clarksdale, AZ
  - Seriously considering burning whole tires

- Southwestern Cement, Victorville, CA

  - Estimated annual consumption: 2.1 million
  - 20% of Btu value is provided by non-dewired chipped tires and whole tires, permitted up to 25%
  - Maximum consumption: 2.6 million scrap tires
  - Approached by county to help deal with scrap tire problem
  - Testing completed in December 1991, permit received March, 1992
  - Feeding system to be installed Spring, 1992
  - Began burning scrap tires August 1992

<u>Facilities Where Future Use of Scrap Tire Material is Unlikely</u>

- Ash Grove Cement West, Montana City, MT

  - Alternative fuel will most probably be hazardous waste

- Ash Grove Cement, Chanute, KS, Foreman, AR and Louisville, NE

  - Cited economic and supply factors as reasons why the burning of scrap tire material is not an option
  - Contended that hazardous waste is more cost-effective to burn
  - Cited the availability of scrap tire material as a concern

- Blue Circle Inc., Atlanta, GA

  - Completed testing of shredded tires November 1991
  - Determined that they could not burn scrap tire material efficiently with their conventional wet process kiln

- Giant Cement, Harleyville, SC

  - Has conducted two tests using quarter-inch shreds, largest size they can use in wet kiln
  - Cited the high cost of TDF as reason why they were not burning

- National Cement, Lebec, CA

  - Permitted to burn solvents up to 40% of Btu value
  - Estimates that the cost of obtaining a permit to burn TDF in CA would negate any cost savings

- Oldover Corp., Ashland, VA
  - Cited difficulty securing a supply of appropriately sized TDF chips as a cause
  - Test burn with debeaded TDF indicated that the remaining steel in the TDF negatively effected the product
  - Would reconsider TDF if quality and availability of TDF chips improve

- River Cement, Festus, MO
  - Conducted unsuccessful trial burn of whole tires in early 1980's
  - Determined that their long dry kiln could burn TDF if it was small enough to be blown in the front end of the kiln but that the economics were not good

Use Of Scrap Tire Material As A Supplemental Fuel In Cement Kilns

Company	Facility	Status	Potential Capacity (Million tires per year)
Arizona Portland	Rillito, AZ	●	2.8
Ash Grove Cement West	Durkee, OR	●	0.6
Ash Grove Cement West	Inkom, ID	○	0.8
Ash Grove Cement West	Seattle, WA	○	N/A
Blue Circle Inc.	Atlanta, GA	◒	0.0
Blue Circle Inc.	Harleyville, SC	◒	1.2
Calaveras Cement	Redding, CA	●	2.1
California Portland	Mojave, CA	○	N/A
Essroc Materials	Fredrick, MD	●	1.1
Florida Crushed Stone	Brooksville, FL	◒	1.0
Giant Cement	Harleyville, SC	◒	N/A
Hawaiian Cement	Oahu, HI	●	1.1
Holnam Inc. - Boxcrow Cement	Midlothian, TX	◒	1.0
Holnam Inc. - Ideal Basic Industries	Seattle, WA	●	1.2
Holnam Inc.	Aida, OK	○	1.4
Holnam Inc.	Morgan, UT	◒	2.0
Illinois Cement	LaSalle, IL	◒	N/A
Independent Cement	Hagerstown, MD	○	N/A

○ Considering Use of TDF or Whole Tires
◒ Test Burn Conducted
● Currently Burning TDF or Whole Tires

ATK1/2011/9 kp

Use Of Scrap Tire Material As A Supplemental Fuel In Cement Kilns (Cont'd)

Company	Facility	Status	Potential Capacity (Million tires per year)
Kosmos Cement	Kosmosdale, KY	◒	1.3
Lafarge Corporation	Davenport, IA	○	N/A
Lafarge Corporation	New Braunfels, TX	◒	1.5
Lafarge Corporation	Sugar Creek, MO	○	N/A
Lafarge Corporation	Whitehall, PA	◒	1.5
Lehigh Portland Cement	Leeds, AL	●	1.0
Lone Star Industries	Cape Girardeau, MO	●	1.5
Lone Star Industries	Oglesby, IL	○	0.8
Medusa Cement	Clinchfield, GA	●	1.1
Medusa Cement	Charlevoix, MI	○	3.8
Monarch Cement	Humboldt, KS	●	2.0
National Cement	Raglin, AL	●	0.5
Oldover Corporation	Ashland, VA	◒	N/A
Phoenix Cement	Clarkdale, AL	○	N/A
Rinker Materials	Dade County, FL	○	N/A
River Cement	Festus, MO	◒	0.0
RMC Lonestar	Davenport, CA	◒	5.3

○ Considering Use of TDF or Whole Tires
◒ Test Burn Conducted
● Currently Burning TDF or Whole Tires

ATK1/2011/9A kp

Use Of Scrap Tire Material As A Supplemental Fuel In Cement Kilns (Cont'd)

Company	Facility	Status	Potential Capacity (Million tires per year)
Southdown Inc.	Lyons, CO	●	1.0
Southwestern Cement	Fairborn, OH	●	0.6
Southwestern Cement	Victorville, CA	●	2.6
Tarmac Cement	Roanoke, VA	◒	N/A
Texas Lehigh	Buda, TX	◒	N/A

○ Considering Use of TDF or Whole Tires
◒ Test Burn Conducted
● Currently Burning TDF or Whole Tires

2.1.4 Information Sources

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Phone conversation with Randy Thompson, Florida Crushed Stone, Brooksville, FL.

Phone conversation with Scott Hoard, Ideal Basic Industries (Div. of Holnam), Seattle, WA.

Phone conversation with Randy Stillwell, General Mill and Kiln Supervisor- Medusa Corp., Clinchfield, GE.

Phone conversation with Tim Matz, Environmental Assistant- Lehigh Cement, Leeds, AL.

Phone conversation with Jim Post, Vice President of Technical Services- Ash Grove Cement West, Durkee, OR.

Phone conversation with Brad Phillips, Environmental Department- Southwestern Portland Cement, Fairborn, OH.

Phone conversation with Charles Parker and Patrick McKay, Plant Operations- Essroc Materials, Frederick, MD.

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Phone conversation with John Shin, Technical Services- Hawaiian Cement, Oahu, Hawaii.

Phone conversation with Gregg St. Clair, Lafarge Corp., New Braunfels, TX.

Phone conversation with Roy Owens, Plant Manager- Monarch Cement, Humboldt, Kansas.

Phone conversation with Dan Peterson, Plant Manager- Ash Grove Cement West, Montana City, MT.

Phone conversation with Jerry Hoyle, Production Supervisor- Southwestern Portland Cement, Vicorville, CA.

Phone conversation with Dennis Connolly, Quality Control Manager- National Cement, Lebec, CA.

Phone conversation with Tom Brosnan, Plant Manager- Arizona Portland Cement, Rillito, AZ.

Phone conversation with Terry Dengler, Purchasing Manager, LaFarge Corp., Whitehall, PA.

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Phone conversation with Pete Arnott, Control Room Supervisor- RMC Lonestar, Davenport, CA.

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2.2 USE OF SCRAP TIRE MATERIAL AS A SUPPLEMENTAL FUEL IN PULP AND PAPER MILLS

Abstract. Tire-derived fuel (TDF) can be used as supplemental fuel in pulp and paper mills. The technology is proven and has been in continuous use in the U.S. since the early 1980s. Consumption of TDF in U.S. pulp and paper mills has increased marginally since mid-1990 to approximately 14 million tires per year, an increase of about eight percent. There are currently nine mills known to be burning TDF on a continuous basis. Nine additional mills, with a combined potential capacity to burn approximately 10 million tires per year, could begin burning TDF on a continuous basis within the next two years.

Environmental constraints associated with burning TDF vary widely depending on facility characteristics (type, age, pollution control equipment, etc.) and the local regulatory climate. In general, interviews with mill managers and environmental professionals indicate that permitting processes have become less complicated as access to industry test burn data has increased. It is estimated that U.S. pulp and paper mills could be consuming 55 million tires per year by 1997. This estimate is based on the assumption that 40% of pulp and paper industry hog fuel boilers will switch their supplemental fuel to 10% TDF on a Btu basis.

The principal barriers to the further use of TDF in the U.S. pulp and paper industry are:

- Marginal cost advantage of TDF over typical mill fuels (coal, purchased hog fuel).
- Environmental permit modification requirements; inconsistent regulatory guidance in some states.
- Remote location of many mills (higher transportation costs).
- Lack of easy access to technical and environmental information regarding the use of TDF in U.S. pulp and paper mills.
- Reliability of TDF supply in remote locations.

2.2.1 Technology Description

Since mid-1990, there have been no major changes in the technology associated with burning TDF in pulp and paper mills. Installation of fuel feeding systems remains the most significant and costly modification necessary at most mills.

2.2.2 Environmental, Economic, and Volume Characteristics

The following section summarizes the changes found in the environmental, economic, and volume characteristics associated with burning TDF in U.S. pulp and paper mills.

Environmental Characteristics

From a technical standpoint, the environmental characteristics associated with burning TDF in pulp and paper mills have not changed since mid-1990. The regulatory environment, however, is more complex. Some states have streamlined permit modification processes by reducing test burning requirements while others have imposed more stringent requirements. Reportedly, the state of Oregon is likely to allow at least one mill to burn TDF without specific facility trial burn data, relying instead on data from trial burns conducted at other local mills. On the other hand, several mill representatives indicated that they have received inconsistent guidance from state environmental regulatory agencies. In some cases, solid waste regulators have reportedly been encouraging the use of TDF while air pollution regulators within the same agency have been discouraging it. Zinc fuming and zinc contamination of waste water and ash continues to be a concern for some facilities. At least two Washington state facilities have abandoned the use of scrap tire material due to regulatory complications associated with zinc contamination.

Economic Characteristics

The overall economic characteristics associated with burning TDF in U.S. pulp and paper mills have not changed significantly since mid-1990. The financial attractiveness of TDF to a pulp and paper mill is highly dependent on the cost of competing fuels in the region, tipping fees available to local shredders, and the resulting prices charged by shredders for TDF. While most mills currently burning or considering the use of TDF consider economics to be the main driving force, most report that the economic situation is marginal. Four of the nine mills currently burning TDF are receiving significant ($20 per ton) subsidies from their state governments. Other state subsidies currently under consideration should help to improve the economic outlook for burning TDF at other U.S. mills.

Volume Characteristics

The following is an estimate of the potential usage of scrap tires by the U.S. pulp and paper industry:

- Within Five Years: 55 million scrap tires per year.
- Within Two Years: 27 million scrap tires per year.
- Current Usage: 14 million scrap tires per year.

The estimate for potential usage within five years is based on the assumption that 40% of U.S. pulp and paper industry hog fuel boilers will switch their supplemental fuel to 10% TDF on a Btu basis. The estimate for potential usage within two years is based on the assumption that 70% (the approximate percentage of mills currently burning TDF which have the ability to do so) of those mills which have successfully burned TDF in the past or have conducted successful trial burns will begin burning TDF on a continuous basis. The estimate of current usage is based on the results of interviews with numerous industry, company, and facility representatives.

2.2.3 Usage of TDF in U.S. Pulp and Paper Mills in the First Quarter of 1992

In the first quarter of 1992, there were nine U.S. pulp and paper mills known to be burning TDF on a continuous basis. Combined TDF consumption at these facilities was equivalent to approximately 14 million scrap tires per year. There were 17 additional mills that had conducted TDF test burns or had used TDF in the past. Future use of TDF is considered to be possible at nine of these mills which represent an additional potential capacity of approximately 10 million scrap tires per year. Exhibit 2.2 provides of summary of the use of scrap tire materials as fuel in U.S. pulp and paper mills.

U.S. Facilities Currently Burning Tires or TDF

- Champion International, Bucksport, ME
  - Current capacity: 3,000,000 tires per year.
  - Currently burning 1"x 1" dewired TDF in a hog fuel boiler.
  - Has been burning TDF since November, 1990.
  - Initial trial burns were conducted in 1989.
  - Only using newly generated scrap tires.
  - Supply is a concern since the facility can burn twice as many tires as Maine generates in a year.

- Fort Howard Paper, Green Bay, WI
  - Current capacity: 1.1 million tires per year.
  - Burns dewired 1"x 1" TDF in a hog fuel boiler at approximately 10% of total Btu input.
  - Has been burning TDF since 1989.
  - Concerned that once Wisconsin tire piles are disposed of, there will not be enough TDF available to satisfy facility needs.
  - Aided by $20/ton subsidy from the state of Wisconsin.

- Georgia Pacific, Cedar Springs, GA
  - Current capacity: 3.2 million tires per year
  - Currently burns TDF in two hog fuel boilers at approximately 3% of total fuel weight.
  - No significant technical or environmental problems have been encountered
  - Has been burning TDF since 1988.

- Georgia Pacific, Big Island, VA
  - Current capacity: 720,000 tires per year.
  - Currently burns 2"x 2" dewired TDF in two hog fuel boilers at approximately 10% of total Btu input.
  - Has been burning TDF since 1983.
  - No significant technical or environmental problems have been encountered.
  - TDF supply is not considered to be a major concern.

- Inland Rome, Rome, GA
  - Current capacity: 1.8 million tires per year.
  - Currently burns dewired TDF in two hog fuel boilers at approximately 6% of total Btu input.
  - Has been burning TDF since 1986.
  - No significant technical or environmental problems have been encountered.
  - Economics is the main driving force behind the use of TDF.

- Jefferson Smurfit, Newberg, OR
  - Current capacity: 600,000 tires per year.
  - Currently burns TDF in a hog fuel boiler at approximately 4% of total Btu input.
  - Has been burning TDF since 1986.
  - No significant technical or environmental problems have been encountered.
  - Economics is the main driving force behind the use of TDF.
  - Wants to burn a higher percentage of TDF but is concerned about ash disposal - particularly zinc contamination problems.
  - Investigating the possibility of burning whole tires.
  - Aided by $20/ton subsidy from the state of Oregon.

- Packaging Corporation of America, Tomahawk, WI
  - Current capacity: 1.5 million tires per year.
  - Currently burning 2"x 2" TDF in a hog fuel boiler at approximately 5% of total Btu input.
  - No significant technical or environmental problems have been encountered.
  - Plant was previously owned by Great Northern Nekossa
  - Aided by $20/ton subsidy from the state of Wisconsin.

- Potlatch, Lewiston, ID
  - Current capacity: 1.9 million tires per year.
  - Currently burning partially dewired 2"x 2" TDF in hog fuel boiler at approximately 5% of total Btu input.
  - Has been burning TDF for since mid-1991. Has held permit for several years.
  - No significant technical or environmental problems have been encountered.

- Willamatte Industries, Albany, OR
  - Current capacity: 320,000 tires per year.
  - Currently burning dewired TDF in a hog fuel boiler at approximately 2% of total fuel weight.
  - Has been burning TDF since 1984
  - Some zinc contamination of scrubber water has been noted.
  - Expansion of TDF usage is unlikely due to environmental concerns.
  - Aided by $20/ton subsidy from the state of Oregon.

U.S. Facilities That Have Conducted Test Burns or Have Used TDF in the Past

- Boise Cascade, Deritter, LA
  - Potential capacity: Unknown
  - Was using TDF in hog fuel boiler prior to 1990.
  - Stopped in 1990 due to low cost of competing fuels.
  - Still holds permit to burn TDF.

- Boise Cascade, Wallula, WA
  - Potential capacity: 0 tires per year.
  - In 1988, conducted trial burns of 1"x 1" TDF in a hog fuel boiler and a lime kiln at up to 10% of total fuel weight.
  - Stack emissions from hog fuel boiler were unacceptable. Facility operates under very tight regulatory constraints.
  - Environmental problems in lime kiln were less significant. However, a chrome contamination problem was noted.
  - Does not anticipate using TDF in the future due to regulatory constraints.

- Champion International, Sartell, MN
  - Potential capacity: 500,000 tires per year.
  - In 1990 and 1987, conducted short trial burns of 2"x 2" TDF in a coal fired power boiler at approximately 6% of total fuel weight.
  - No significant technical or environmental problems were encountered. Some increase in ash zinc content was noted.
  - Currently in process of renewing its air permits. Expects to have permission to burn TDF on a continuous basis.
  - Does not expect to begin burning TDF right away due to capital requirements for feeding system. Project will get more attention as economy improves.

- Daishowa America, Port Angeles, WA
  - Potential capacity: 0 tires per year
  - In mid-1980s, conducted a test burn with TDF.
  - Clarifier contamination problems were unacceptable.
  - Plant was formerly owned by Crown Zellerbach Corp.

- Fort Howard Paper, Rincon, GA

  - Potential capacity: Unknown
  - In 1991, conducted trial burn of TDF in coal fired boiler unit. Testing was continuing as of 12/91.
  - No significant technical problems were encountered.
  - Has not completed review of emissions and economic data. These will be the deciding factor.

- Georgia Pacific, Bellingham, WA

  - Potential capacity: 450,000 tires per year
  - Conducted test burn with TDF in 1987 in a hog fuel boiler at up to 6% of total Btu input.
  - Processed all scrap tires at the facility with a chipping system purchased for the project.
  - Minor technical problems were encountered. It was difficult to accurately predict the correct feed ratio as hog fuel moisture content changed.
  - In addition to the technical problems, economics has been a major barrier.
  - More testing required to get permit.

- Georgia Pacific, Toledo, OR

  - Potential capacity: 400,000 tires per year
  - In mid-1990, conducted a trial burn of 1"x 1" TDF in a hog fuel boiler at approximately 2% of total fuel weight. Approximately 2,500 tire equivalents were burned during the test.
  - No significant technical problems were encountered during the test. However, an increase in waste water zinc content caused some concern.
  - In 1979, conducted a trial burn with TDF in the same hog fuel boiler.
  - Technical and environmental problems were prohibitive. Poorer quality TDF is believed to be the main difference between this test an the more recent one.
  - Anticipates conducting another trial burn in 1992.
  - Current economic situation is questionable. TDF is only slightly less expensive than competing fuels - hog fuel and natural gas.
  - Would be aided by $20/ton subsidy from the state of Oregon.

- James River, Clatskaine, OR
  - Potential capacity: 150,000 tires per year
  - Facility is currently undergoing permitting process to burn TDF in a fluidized bed combuster at up to 5% of total fuel weight.
  - State of Oregon did not require test burn. Relies on results from test burns at other facilities.
  - Does not plan to begin using TDF in the near future due to current economic situation.
  - Would be aided by $20/ton subsidy from the state of Oregon.

- Longview Fibre, Longview, WA
  - Potential capacity: 0 tires per year
  - In 1988, conducted a trial burn of TDF in a hog fuel boiler with approximately 5% of total fuel weight.
  - Environmental problems were prohibitive. Significant zinc fuming from plant scrubbers was noted.
  - Does not anticipate using TDF in the future.

- Louisiana Pacific, Samoa, CA
  - Potential capacity: Unknown
  - In 1990, conducted a test burn of TDF in a hog fuel boiler.
  - No significant technical or environmental problems were encountered.
  - Economic situation is unknown.

- Mead, Stevenson, AL
  - Potential capacity: 0 tires per year
  - In early 1991, conducted a test burn of TDF in a hog fuel boiler
  - Particulate control was not adequate.
  - Does not plan to reexamine use of TDF in current boilers.

- Port Townsend Paper, Port Townsend, WA
  - Potential capacity: 0 tires per year
  - Burned TDF in a hog fuel boiler at a rate of approximately 360,000 tires per year from 1981 until 1987.
  - Stopped burning TDF as the cost of emission control equipment required by the state became prohibitive.
  - Particulate control was the most serious problem. No other significant technical or environmental problems were encountered.
  - Does not anticipate using TDF again in the future.

- Scott Paper, Everett, WA
  - Potential capacity: 0 tires per year
  - Burned TDF in hog fuel boiler in early 1980s.
  - Was required by the state to stop due to problems associated with zinc contamination in facility waste water.
  - Does not anticipate using TDF in the future due to regulatory constraints.

- Sonoco Products, Harleyville, SC
  - Potential capacity: Unknown
  - Detailed information on the use of TDF at this facility was not available.

- Union Camp, Franklin, VA
  - Potential capacity: 4 million tires per year.
  - In 1990, conducted a trial burn with 1"x 1" TDF in hog fuel boiler.
  - Plant management has not yet finished reviewing all emissions data. Early indication is that no significant problems have been encountered.
  - Supply is a problem. Local suppliers are "unsophisticated."
  - Management expects to begin burning TDF by the last quarter of 1992.

- Westvaco, Covington, VA
  - Potential capacity: 250,000 tires per year.
  - Burned TDF on a continuous basis between 1989 and 1990.
  - Stopped burning because of supply problems and economic situation.
  - Plans to re-examine use of TDF only at State request.

- Willamette Industries, Campti, LA
  - Potential capacity: 900,000 tires per year.
  - Prior to 1983, burned 1"x 1" TDF in lime kiln.
  - No significant problems encountered in lime kiln.
  - Unable to burn TDF in power boiler due to stack emission problems. Problem can not be corrected without significant capital investment.
  - Stopped using TDF in lime kiln in 1983 due to economic situation - competing fuels, hog fuel and natural gas, were less expensive.
  - Facility permit still allows for the use of TDF and equipment is available.
  - Economics is main barrier to use of TDF. Will consider continuing use if economic situation changes.

Exhibit 2.2

Use Of Scrap Tire Material As A Supplemental Fuel In Pulp And Paper Mills

Company	Facility	Status	Potential Capacity (Million tires per year)
Boise Cascade	Deritter, LA	◒	N/A
Boise Cascade	Wallula, WA	○	0.0
Champion International	Bucksport, ME	●	3.0
Champion International	Sartell, MN	◒	0.5
Daishowa America	Port Angeles, WA	○	0.0
Fort Howard	Rincon, GA	◒	N/A
Fort Howard	Green Bay, WI	●	1.1
Georgia Pacific	Cedar Springs, GA	●	3.2
Georgia Pacific	Toledo, OR	◒	0.4
Georgia Pacific	Big Island, VA	●	0.7
Georgia Pacific	Bellingham, WA	◒	0.5
Inland Rome	Rome, GA	●	1.8
James River	Clatskaine, OR	○	0.2
Jefferson Smurfit	Newberg, OR	●	0.6
Longview Fibre	Longview, WA	○	0.0

○ Past use or trial burns - Future use unlikely
◒ Past use or trial burns - Future use possible
● Currently burning TDF

Use Of Scrap Tire Material As A Supplemental Fuel In Pulp And Paper Mills (Cont'd)

Company	Facility	Status	Potential Capacity (Million tires per year)
Louisiana Pacific	Samoa, Ca	◒	N/A
Mead	Stevenson, AL	○	0.0
Packaging Corporation of America	Tomahawk, WI	●	1.5
Port Townsend	Port Townsend, WA	○	0.0
Potlatch	Lewiston, ID	●	1.9
Scott Paper	Everett, WA	○	0.0
Sonoco Products	Harleyville, SC	N/A	N/A
Union Camp	Franklin, Va	◒	4.0
Weyerhauser	Longview, WA	○	0.0
Westvaco	Covington, VA	◒	0.3
Willamette	Campti, LA	◒	0.9
Willamette	Albany, OR	●	0.3

○ Past use or trial burns - Future use unlikely
◒ Past use or trial burns - Future use possible
● Currently burning TDF

2.2.4 Information Sources

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Phone conversation with Norm Shroyer, Union Camp Corporation, Franklin, VA

Phone conversation with Ed Hurley, Jefferson Smurfit, St. Louis, MO

Phone conversation with Liz Smith, Louisiana Pacific, Samoa, CA

Phone conversation with Ron Steward, Packaging Corporation of America, Tomahawk, WI

Phone conversation with Ron Reynolds, Packaging Corporation of America, Evanston, IL

Phone conversation with Ron Anderson, Procter & Gamble Pulp Products

Phone conversation with Dave Lutrick, Simpson Paper, Anderson, CA

Phone conversation with Fred Fenske, Simpson Paper, Tacoma, WA

Phone conversation with Curt Baron, Stone Container Corporation

Phone conversation with Willie Martin, Temple-Inland

Phone conversation with Ken Johnson, Weyerhauser Corporation, Tacoma, WA

Phone conversation with Chuck Hess, Williamette Industries, Portland, OR

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Phone conversation with Dave Baachman, James River Corporation, Camas, WA

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Phone conversation with Keith Sowada, Champion International, Sartell, MN

Phone conversation with Danny Young, Williamette Industries, Campti, LA

Phone conversation with Don Rundell, International Paper, Moss Point, AL

Phone conversation with Scott Ogglesvy, International Paper, Moss Point, AL

Phone conversation with Tom Jayne, International Paper, Karkauna, WI

Phone conversation with Bill Dameworth, Potlatch Corporation, Lewiston, ID

Phone conversation with O.B. Burns, Westvaco Corporation, New York, NY

Phone conversation with Manford Buder, Weyerhauser Corporation, Tacoma, WA

Phone conversation with Joanne Toban, Technical Association of the Pulp & Paper Industry, Atlanta, GA

Phone conversation with Joe Nicollo, American Paper Institute, New York, NY

Phone conversation with Bill Cobb, Jefferson Smurfit, Newburg, OR

Phone conversation with Chris Mygrin, Williamette Industries, Albany, OR

Phone conversation with Bill Martin, Fort Howard Paper, Green Bay, WI

Phone conversation with Tom Ryan, Boise Cascade Corporation, Deritter, LA

Phone conversation with Stan Cupp, Port Townsend Paper, Port Townsend, WA

Phone conversation with Dave Harris, Champion International, Bucksport, ME

Phone conversation with George Brown, Packaging Corporation of America, Tomahawk, WI

Phone conversation with J.R. Pitzing, Georgia Pacific, Cedar Springs, CA

Phone conversation with John Asmanson, Georgia Pacific, Bellingham, WA

Phone conversation with Bob Jones, Inland Rome, Rome, GA

Phone conversation with Bob Harley, Bowater, Inc., Catawton, SC

Phone conversation with Al Lindsey, International Paper, Memphis, TN

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Phone conversation with Alex Hood, Scott Paper, Everett, WA

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2.3 USE OF SCRAP TIRE MATERIAL AS A SUPPLEMENTAL FUEL IN ELECTRICITY GENERATING FACILITIES

Either whole tires or tire-derived fuel (TDF) can be used as supplemental fuel in electricity generating facilities. The technology for burning tire material in wet bottom, cyclone, stoker, and fluidized bed units is proven. At least four U.S. utility power plants, four industrial power plants, and one municipal resource recovery facility, are currently burning scrap tire material on a continuous basis with a combined capacity of approximately 21 million tires per year. Nine additional facilities have conducted TDF test burns. Seven of these, with a combined potential capacity to burn approximately 22 million tires per year, could begin burning TDF within the next two years.

Environmental constraints associated with burning scrap tire material vary widely depending on facility characteristics (type, age, pollution control equipment) and the local regulatory climate. In general, burning scrap tire material in electricity generating facilities does not adversely affect unit operations or environmental performance.

The economics associated with burning whole tires in wet bottom boilers is approaching the favorable economics of cement kilns, while the economics associated with burning TDF continues to be marginal. As subsidy programs are adopted around the country (such as the Oregon program and the program being considered in Illinois) the use of TDF will likely become more widespread.

We estimate that U.S. electricity generating facilities could be burning 75 million tires per year by 1997. This estimate is based on the assumption that 25 percent of boilers capable of burning whole tires or TDF will switch over to tire materials for five percent of their fuel requirements and usage in industrial furnaces will double.

The principle barriers to the further use of scrap tire material in electricity generating facilities are:

- Marginal cost advantage of scrap tire material over competing fuels; whole tire burning often requires separate equipment for fuel feeding, while TDF suitable for feeding into fluidized bed, stoker, and cyclone units is sometimes more expensive than coal.
- Environmental permit modification requirements; inconsistent regulatory guidance in some states.
- Reliability of TDF supply in remote locations.
- Conservative/risk averse nature of utility industry.

2.3.1 Technology Description

Since mid-1990, there have been no major changes in the technology associated with burning scrap tire material in electricity generating facilities. Wet bottom, stoker, cyclone, and fluidized bed units can burn tire material because their ash handling systems can accommodate slag formed by steel from tire beads and belts. In general, pulverized coal type units can not burn scrap tire material in an economically viable manner.

2.3.2 Environmental, Economic, and Volume Characteristics

The following section summarizes the changes found in the environmental, economic, and volume characteristics associated with burning TDF in electricity generating facilities.

Environmental Characteristics

From a technical standpoint, the environmental characteristics associated with burning scrap tire material in electricity generating facilities have not changed since mid-1990. In general, burning scrap tire material does not adversely affect unit operation. In fact, in some cases, the burning of scrap tire materials as supplemental fuel has been shown to decrease emissions of NO_x, SO_2, and particulate materials. Since mid-1990, permitting processes have become less complicated as access to industry test burn data has increased.

Economic Characteristics

The overall economic characteristics associated with burning scrap tire materials in U.S. electricity generating facilities have not changed significantly since mid-1990. The financial attractiveness of scrap tire materials to a coal fired power plant is highly dependent on the cost of coal in the region, tipping fees, and the characteristics of the facility itself. The economics associated with burning whole tires in wet bottom boilers is approaching the favorable economics of cement kilns, while the economics associated with burning TDF continues to be marginal. All three public utility facilities currently burning TDF receive at least part of their TDF from the state of Wisconsin, which provides a $20/ton subsidy.

Volume Characteristics

The following is an estimate of the potential usage of scrap tires by U.S. electricity generating facilities:

- Within Five Years: 75 million scrap tires per year.
- Within Two Years: 37 million scrap tires per year.
- Current Usage: 21 million scrap tires scrap tires per year.

The estimate for potential usage within five years is based on the assumption that 25 percent of public utility boilers capable of burning whole tires or TDF will switch over to tire materials for five percent of their fuel requirements and that usage in industrial furnaces will double. There are currently about 900 coal fired utility boilers in the U.S. which, together, account for approximately 700,000 MW of generating capacity. Approximately seven percent of these units are of a type capable of burning whole tires or TDF.

Assuming a total thermal efficiency of about 30 percent, these facilities require about 1.3×10^{15} Btu's per year in fuel input. If 25 percent of these units derived five percent of their energy input from whole tires or TDF, the industry would consume 52 million scrap tires per year. The estimate for potential usage within two years is based on the assumption that 80% of those facilities which have conducted successful trial burns will begin burning TDF on a continuous basis and that usage in industrial furnaces will remain constant. The estimate of current usage is based on the results of interviews with numerous industry, company, and facility representatives.

2.3.3 Usage of Scrap Tire Material in U.S. Electricity Generating Facilities in the First Quarter of 1992

In the first quarter of 1992, there were four U.S. utility power plants, four industrial power plants, and one municipal resource recovery facility, currently burning scrap tire material on a continuous basis with a combined capacity of approximately 18 million tires per year. Nine additional facilities have conducted TDF test burns. Exhibit 2.3.1 provides a summary of the use of scrap tire materials as a supplemental fuel in U.S. public utility electricity generating facilities. Exhibit 2.3.2 provides a summary of the use of scrap tire materials as a supplemental fuel in U.S. industrial and resource recovery facilities.

U.S. Public Utility Facilities Currently Burning Tires or TDF

- Manitowoc Public Utilities, Manitowoc, WI

  - Annual Consumption: 0.04 million tires.
  - Burns 1"x 1" TDF in two units; one fluidized bed and one stoker.
  - No major technical problems have been encountered.
  - Has been burning since summer 1990.
  - Can not burn during winter due to technical constraints of feeder and storage systems.
  - No immediate plans to expand usage.
  - Aided by $20/ton subsidy from state of Wisconsin.

- Ohio Edison, Toronto, OH

  - Annual Consumption: 3.0 million tires per year.
  - Burns whole tires in a wet bottom boiler at approximately 20% by weight with coal.
  - No major technical problems have been encountered.
  - Has been burning since October, 1991.
  - Tires accepted on a just-in-time basis. Receives a small tipping fee for accepting tires.

- Otter Tail Power, Big Stone, SD

  - Annual Consumption: 3.0 million tires per year.
  - Burns 2"x 2" TDF in a cyclone system at approximately 2% by weight with coal.
  - Some minor technical problems with feeder system.
  - TDF quality is difficult to control. Poor quality material disturbs feeder system.
  - Lack of stable/quality suppliers is main barrier to expansion.
  - Has been burning since 1989.
  - Aided by $20/ton subsidy for Wisconsin tires. TDF is beating price of coal even without subsidy.

- Wisconsin Power & Light, Beloit, WI

  - Annual Consumption: 1.2 million tires.
  - Burns 1"x 1" TDF in two cyclone units at approximately 5% by weight with coal.
  - Initial testing began in early 1990.
  - No major technical problems have been encountered.
  - Currently constructing an on-site shredding facility with a capacity of 1.2 million tire/per year.
  - Plans to burn primarily "fresh" tires in the future. Wants to get away from stockpile sources.
  - Aided by $20/ton subsidy from state of Wisconsin. Economics would be "questionable" otherwise.

U.S. Industrial Facilities Currently Burning Tires or TDF

- Archer Daniels Midland, Decatur, IL
  - Annual Consumption: 10 million tires (permitted), 3 million tires (current).
  - Burns 2"x 2" TDF in a fluidized bed unit at approximately 10% by weight with coal. Will eventually burn in six units.
  - No major technical problems have been encountered.
  - Has been burning since fall 1991.
  - May seek to expand permitted capacity to 20,000,000 tires per year.

- Firestone, Decatur, IL
  - Annual Consumption: 0.1 million tires.
  - Burns whole tires in a moving (pulsating) hearth furnace in a 50% blend with wood waste.
  - No major technical problems have been encountered.
  - Has been burning since 1984.

- Monsanto, Sauget, IL
  - Annual Consumption: 1.0 million tires.
  - Burns 2"x 2" TDF at approximately 10% by weight with coal.
  - No major technical problems have been encountered.
  - Has been burning since mid 1991.
  - TDF price reportedly 50% less than that for coal.

- Palm Beach County Resource Recovery, West Palm Beach, FL
  - Annual Consumption: 0.3 million tires.
  - Burns 2"x 2" TDF in 2 stoker units at approximately 0.5% by weight municipal refuse.
  - No major technical problems have been encountered.
  - Has been burning since 1989.
  - Only burns tire materials found in municipal waste stream - does not otherwise burn tire materials on a commercial basis.

- Uniroyal/Goodrich, Eau Claire, WI
  - Annual Consumption: 0.2 million tires.
  - Burns 6" square TDF in a stoker unit at approximately 5% by weight with coal.
  - Plant will permanently close in June, 1992.
  - Zinc contamination in fly and bottom ash reported.

U.S. Public Utility Facilities That Have Conducted Test Burns

- Commonwealth Edison, Springfield, IL
  - Potential capacity: 6.0 million tires per year.
  - In 1991, conducted trial burns of 1"x 1" TDF in two cyclone units at approximately 3% by weight with coal. Approximately 50,000 tire equivalents burned during test.
  - No major technical problems were encountered. Emission and ash analysis data not yet available.
  - Economics not yet clear. Will likely be effected by state's allocation of disposal incentive funds.

- Illinois Power, Baldwin, IL
  - Potential capacity: 3.5 million tires per year.
  - In 1991, conducted trial burns of 1"x 1" TDF in two cyclone units at approximately 2% by weight with coal. Approximately 50,000 tire equivalents burned during tests.
  - Plans to conduct additional tests with 600,000 tire equivalents during 1992.
  - Incomplete combustion of TDF is a major concern. Slag contaminated with unburned TDF can't be sold to current customers. Problem will have to be addressed before long-term use gets underway.
  - Received $100K from state of Illinois to subsidize testing and cost of TDF in 1991. Future incentives possible but not guaranteed. Plans to continue with program regardless.

- Nebraska Public Power District, Lincoln, NE
  - Potential capacity: 3.5 million tires per year.
  - In early 1992, conducted a trial burn of 1"x 1" TDF in a cyclone unit at up to 9% by weight with coal.
  - Has applied to conduct additional test burns.
  - No significant technical or environmental problems were encountered.
  - Supply situation has yet to be carefully examined.

- New York State Electric & Gas, Binghamton, NY

  - Potential capacity: 4.5 million tires per year.
  - In 1991, conducted trial burns of 1"x 1" TDF in a stoker fired unit at up to 10% by weight with coal. Approximately 130,000 tire equivalents were burned during the tests.
  - Applied for permit to burn TDF on a permanent basis at up to 10% by weight with coal.
  - New York's characterization of scrap tires as a "waste" or as "fuel" will be a major driver behind the final decision to burn TDF on a continuous basis.
  - Supply situation has yet to be carefully examined. Plans to wait for permit before a final decision is made.

- Northern Indiana Public Service, Hammond, IN

  - Potential capacity: 4.5 million tires per year.
  - In early 1991, conducted a trial burn of 1"x 1" TDF in a cyclone unit at approximately 5% by weight with coal. Approximately 150,000 tires burned during test.
  - No major technical difficulties encountered. Some increase in slag zinc content was noted.
  - Availability of quality TDF is main barrier to use. No source of supply has been found at a price lower than that of petroleum coke.
  - Will not seek permit to burn TDF until source is secured.
  - Will not accept TDF from tire piles.

- Northern States Power/Wisconsin, Ashland (Bayfront), WI

  - Potential capacity: 1.75 million tires.
  - In 1991, conducted a trial burn of 2"x 2" TDF in a waste wood fired stoker unit at approximately 10% by weight with waste wood. Approximately 10,000 tire equivalents were burned during the test.
  - No major technical difficulties were encountered.
  - Has applied for a permit to burn TDF on a permanent basis. Hopes to have permit and to begin continuous usage of TDF by late 1992.
  - Aided by $20/ton subsidy from state of Wisconsin.

- Traverse City Light & Power, Traverse City, MI

  - Potential capacity: 0 tires
  - In mid 1991, conducted a trial burn of 1"x 1" TDF in a stoker unit at approximately 2% by weight with coal. Approximately 600 tires were burned during the test.
  - Test results were unacceptable due to smoking.
  - Future use is highly unlikely since large capital modifications would be necessary to overcome smoking problems.

- United Power Association, Elk River, MN

  - Potential capacity: 0 tires.
  - In 1982, conducted a trial burn of 2"x 2" TDF in a stoker unit at approximately 50% by weight with coal.
  - Project was dropped due to economics.
  - Unit has since been converted to 100% refuse derived fuel. Future use of TDF is seen as highly unlikely.

<u>U.S. Industrial Facilities That Have Conducted Test Burns</u>

- Caterpillar, Decatur, IL

  - Potential capacity: 0.8 million tires per year.
  - In mid 1991, conducted two trial burn of 1.5"x 1.5" TDF in a cyclone unit at approximately 20% by weight with coal.
  - Significant feed system difficulties were encountered - project is on hold until completion of additional engineering studies.
  - Availability of quality TDF is main barrier to use.

- Dow Corning, Midland, MI

  - Potential capacity: 0.9 million tires per year.
  - In early 1989, conducted a trial burn of 1"x 1" TDF in a stoker fired unit at approximately 6% by weight with wood waste.
  - No major technical difficulties encountered. Slight increases in particulate and zinc emissions were noted.
  - Currently waiting for permit to burn.

Use Of Scrap Tire Material As A Supplemental Fuel In Electricity Generating Facilities: Non-Utilities

Company	Facility	Status	Potential Capacity (Million tires per year)
Archer Daniels Midland	Decatur, IL	●	10.0
Caterpillar	Mossville, IL	◒	0.8
Dow Corning	Midland, MI	◒	0.9
Firestone	Decatur, Il	●	0.1
Monsanto	Sauget, IL	●	1.0
Palm Beach Resource Recovery	West Palm Beach, FL	●	0.3
Uniroyal/Goodrich	Eau Claire, WI	●	0.0*

○ Past use or trial burns - Future use unlikely
◒ Past use or trial burns - Future use possible
● Currently burning TDF

* Facility is permanently closing in June, 1992. Current consumption is approximately 0.2 million tires per year.

Exhibit 2.3.1

Use Of Scrap Tire Material As A Supplemental Fuel In Electricity Generating Facilities: Utilities

Company	Facility	Status	Potential Capacity (Million tires per year)
Commonwealth Edison	Springfield, IL	◒	6.0
Illinois Power	Baldwin, IL	◒	3.5
Manitowoc Public Utilities	Manitowoc, WI	●	.04
Nebraska Public Power District	Lincoln, NE	◒	3.5
New York State Electric & Gas	Binghamton, NY	◒	4.5
Northern Indiana Public Service	Hammond, IN	◒	4.5
Northern States Power/ Wisconsin	Bayfront, WI	◒	1.8
Ohio Edison	Toronto, OH	●	3.0
Otter Tail Power	Big Stone, SD	●	3.0
Traverse City Light & Power	Traverse City, MI	○	0.0
United Power Association	Elk River, MN	○	0.0
Wisconsin Power & Light	Beloit, WI	●	1.2

○ Past use or trial burns - Future use unlikely
◒ Past use or trial burns - Future use possible
● Currently burning TDF

2.3.4 Information Sources

Phone conversation with David Richardson, Monsanto Corporation, Sauget, IL

Phone conversation with Terry Wells, Archer Daniels Midland, Decatur, IL

Phone conversation with Larry Frsch, Dow Corning, Midland, MI

Phone conversation with Bill Kosch, Nebraska Public Power District/Sheldon Station, Lincoln, NE

Phone conversation with Dave Welder & Don Freeman, Northern States Power/Bayfront Plant, Ashland, WI

Phone conversation with Peter Brinkoetter, Firestone, Decatur, IL

Phone conversation with Mike Horvath, Ohio Edison, Cleveland, Ohio

Phone conversation with Ray Sturzel, Monatowak Public Utilities, Manatowak, WI

Phone conversation with Chuck Kern, Northern Indiana Public Service, South Bend, IN

Phone conversation with Mark Rolfes, Otter Tail Power Company, Big Stone, SD

Phone conversation with Verlin Memze, Otter Tail Power Company, Souix City, SD

Phone conversation with Dave Stopek, Illinois Power

Phone conversation with Phil Murphy, New York State Electric & Gas (Jennison Station), Bainbridge, NY

Phone conversation with Greg Eirschele, Wisconsin Power & Light, Madison, WI

Phone conversation with Al Rinozzi, Commonwealth Edison (Kincaid Station), South Springfield, IL

Phone conversation with Frank Nemes, Commonwealth Edison, Chicago, IL

Phone conversation with Bob Beagle, Traverse City Power & Light, Traverse City, MI

Phone conversation with Mike Ricciardi, Madison Gas & Electric, Madison, WI

Phone conversation with Chris Bergenson, Utility Data Institute

Phone conversation with Wayne Hanson, United Power Association

Phone conversation with Chuck McGowin, EPRI, Palo Alto, CA

Phone conversation with Tom Johnson, Caterpillar Corporation, Mossville, IL.

Phone conversation with Gene Werner, Palm Beach Resource Recovery, West Palm Beach, FL.

Phone conversation with John Glenz, Uniroyal/Goodrich, Eau Claire, WI.

A.T. Kearney, Inc. "Scrap Tire Use/Disposal Study - Final Report." Scrap Tire Management Council. September, 1990.

Malcolm Pirnie, Inc. "Air Emissions Associated with the Combustion of Scrap Tires for Energy Recovery." Ohio Air Quality Development Authority. May, 1991.

Roy F. Weston, Inc. "Assessment of Scrap Tire Management Recovery Options and Opportunities." Georgia Power Company. Undated

<u>Energy Technology Handbook</u>. Douglas M. Considine, P.E., Editor-in-Chief. McGraw Hill Book Company, New York, New York.

2.4 USE OF SCRAP TIRE MATERIAL IN U.S. DEDICATED TIRE-TO-ENERGY FACILITIES

Abstract. Either whole tires or tire-derived fuel (TDF) can be used as fuel in dedicated tire-to-energy facilities; existing and planned facilities are designed to burn whole tires to minimize fuel costs. The technology has been proven in the U.S. and in Germany. There are two U.S. facilities, with a combined capacity to burn approximately 15 million tires per year, currently burning whole tires on a continuous basis. Both are owned and operated by the Oxford Energy Company. Two additional facilities, also to be owned and operated by Oxford Energy, are currently in the planning stage. If built, these facilities will have a combined capacity to burn approximately 25 million tires per year.

Environmental and economic constraints associated with burning whole tires in dedicated whole tire-to-energy facilities have not changed significantly since mid-1990. Capital costs per megawatt of generating capacity for these facilities run between 2 and 7 times more than those associated with more traditional electricity generating facilities. Because of these high capital costs, dedicated whole tire-to-energy facilities are only practical in those parts of the country with high electric rates and tipping fees.

We estimate that dedicated tire-to-energy facilities could be burning approximately 40 million scrap tires per year by 1997. This estimate is based on the assumption that two of the three Oxford Energy currently in the planning stage are completed and operational by that date.

The principle barriers to the further use of scrap tire material in dedicated tire-to-energy facilities are:

- High capital cost of facilities; dedicated tire-to-energy facilities cost between 2 and 7 times more to construct per megawatt than conventional coal power plants.
- Processing economics typically require some form of subsidy for costs to be favorable.
- Local opposition; both planned facilities may encounter local opposition, delaying or possibly cancelling construction.
- Environmental permitting for planned facilities.
- Reliability of fuel supply.

2.4.1 Technology Description

Since mid-1990, there have been no significant changes in the technology associated with burning whole tires in dedicated tire-to-energy facilities. Oxford's Modesto, California facility has experienced a variety of technical problems. However, according to facility representatives, most of these problems have been solved. In 1991, the facility was reportedly on line 84 percent of the time. Oxford's second facility located at Sterling, Connecticut started commercial operation in October 1991. It is twice as large as the Modesto plant allowing for significant economies of scale and a broader revenue base to adsorb the impact of maintenance outages. Other improvements at the Sterling facility include, a less complex/costly fuel feeding system; lower fire prevention costs since only a six month supply of tires is kept on site; and an enclosure protecting all major equipment from the elements. The Connecticut facility is reportedly on line 85 percent of the time, a rate consistent with the planned capacity of 10 million tires per year.

2.4.2 Environmental, Economic, and Volume Characteristics

The following section summarizes the changes found in the environmental, economic, and volume characteristics associated with burning TDF in power plants.

Environmental Characteristics

There have been no significant changes in the environmental characteristics associated with burning whole tires in dedicated tire-to-energy facilities since mid-1990. In general, emissions of SO_2 and NO_x are lower for tire-to-energy facilities than for traditional coal fired units. Particulate generation and zinc and chromium contamination of ash and wastewater appear to be the only environmental characteristics less favorable to dedicated tire-to-energy facilities than to traditional coal fired units.

Economic Characteristics

The overall economic constraints associated with burning whole tires in U.S. dedicated tire-to-energy facilities have not changed significantly since mid-1990. Capital costs per megawatt of generating capacity for these facilities run between 2 and 7 times more than those associated with more traditional electricity generating facilities. Because of these high capital costs, dedicated whole tire-to-energy facilities are only practical in those parts of the country with high electric rates and tipping fees.

Volume Characteristics

The following is an estimate of the potential usage of scrap tires by U.S. dedicated tire-to-energy facilities:

- Within Five Years: 40 million scrap tires per year.
- Within Two Years: 15 million scrap tires per year.
- Current Usage: 15 million scrap tires per year.

The estimate for potential usage within five years is based on the assumption that both of Oxford Energy's planned tire-to-energy facilities are completed and operational by 1997. The estimate for potential usage within two years is based on the assumption that no new dedicated tire-to-energy facilities are scheduled to come on line during this period. The estimate of current usage is based on the results of interviews with numerous industry, company, and facility representatives.

2.4.3 Usage of Scrap Tire Material in U.S. Dedicated Tire-To-Energy Facilities the First Quarter of 1992

In Quarter of 1992, there were two U.S. dedicated tire-to-energy facilities operating on a continuous basis with a combined capacity to burn approximately 15 million tires per year. Two additional facilities, representing a total combined capacity to burn approximately 25 million tires per year, are currently in the planning stage. There are no other companies known to be considering constructing dedicated tire-to-energy power plants in the U.S. Exhibit 2.4 provides a summary of the use of scrap tire materials as fuel in dedicated tire-to-energy facilities.

U.S. Facilities Currently Burning Tires

- Oxford Energy, Modesto, CA
  - Annual consumption: 4.5 million tires per year.
  - Electricity Output: 15 Megawatts.
  - Start up was in 1987.

- Oxford Energy, Sterling, CT

  - Annual consumption: 10 million tires per year.
  - Electricity Output: 15 Megawatts.
  - start-up was in 1991.

U.S. Facilities In Planning Stages

- Oxford Energy, MI

  - Planned capacity: 10 million tires per year
  - Electricity Output: 15 Megawatts

- Oxford Energy, Moapa, NV

  - Planned capacity: 15 million tires per year
  - Electricity Output: 49 Megawatts
  - Financing currently underway
  - Planned start-up in 1994.

Use Of Scrap Tire Material As Fuel In Dedicated Tire-To-Energy Facilities

Company	Facility	Status	Potential Capacity (Million tires per year)
Oxford Energy	Modesto, CA	●	4.5
Oxford Energy	Sterling, CT	●	10.0
Oxford Energy	Michigan	○	10.0
Oxford Energy	Moapa, NV	○	15.0

○ Facility in Planning Stages
◓ Facility Under Construction
● Facility in Operation

2.4.4 Information Sources

Phone conversation with Jack Roberts, Oxford Energy

Phone conversation with Bob Graulich, Oxford Energy

A.T. Kearney, Inc. "Scrap Tire Use/Disposal Study - Final Report." Scrap Tire Management Council. September, 1990.

Malcolm Pirnie, Inc. "Air Emissions Associated with the Combustion of Scrap Tires for Energy Recovery." Ohio Air Quality Development Authority. May, 1991.

Energy Technology Handbook. Douglas M. Considine, P.E., Editor-in-Chief. McGraw Hill Book Company, New York, New York.

Oxford Energy Company 1989 Annual Report.

Oxford Energy Company 1990 Annual Report.

The Exeter Energy Project - A Project of the Oxford Energy Company. Oxford Energy Company Brochure.

2.5 USE OF SCRAP TIRE MATERIAL IN ASPHALT/PAVING APPLICATIONS

Abstract. Since mid-1990, interest and experimentation with the use of scrap tire material in asphalt/paving applications have increased significantly. Scrap tire material can be used either as part of the asphalt rubber binder or seal coat (both uses known loosely as asphalt-rubber), or as aggregate (rubber modified asphalt concrete, or RUMAC). By the first quarter of 1992, most state transportation departments and many local agencies were conducting experimental programs with one or both of the major scrap tire applications. The principle driving force behind this interest is the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) which mandates the use of scrap tire material in all "federal aid" asphalt/paving projects beginning in 1994.

The technical, environmental, and economic constraints associated with the use of scrap tire material in asphalt/paving applications have not changed significantly since mid-1990. In general, asphalt-rubber, or the "wet process," has proven to be the most successful product from a technical performance standpoint. Several studies have shown enhanced de-icing properties and increased durability and longevity. Life-cycle cost effectiveness, however, has yet to be fully evaluated.

We estimate that the total U.S. consumption of scrap tire materials in asphalt/paving applications could reach 80 million scrap tires per year by 1997. This estimate is based on the assumption that the Intermodal Surface Efficiency Act of 1991 will be fully implemented.

The principle barriers to the further use of scrap tire material in asphalt/paving applications are:

- High initial costs. On a cost per ton basis, both asphalt-rubber and RUMAC have been reported to be twice as expensive as conventional asphalt.
- Inconsistent long-term performance data; long-term technical/economic benefits are difficult to predict.
- Lack of standardized long-term environmental testing protocols.
- The Federal Department of Transportation/Federal Highway Administration needs to provide state DOTs with more details and guidance concerning ISTEA.
- Unanswered questions regards the effect on recyclability of used asphalt pavement.

2.5.1 Technology Description

Since mid-1990, there have been no major changes in the technology associated with the use of scrap tire material in asphalt/paving applications. Tires can be utilized in asphalt in two ways: asphalt-rubber (also known as the Arizona or "wet" process), which is typically used as a sealant or as a relatively thin over-layer; and as rubber modified asphalt (also known as "RUMAC", the "dry" process, or PLUSRIDE™), in which rubber chips replace part of the aggregate in the paving mix. Asphalt Rubber is produced by one of two procedures. In the McDonald procedure kerosene is added to the hot blended mixture, while in the Arizona Refinery Procedure, an oil extender is added to the asphalt before heating and adding the rubber.

In general, asphalt-rubber has performed at least as well as traditional asphalt in test applications, although performance improvements have not been consistently shown to justify the added expense of the product. Performance results from the use of rubber modified asphalt have been varied but all the results have yet to come in. In both cases, enhanced performance and durability has been realized when proper application techniques and quality control procedures have been followed. As paving personnel gain experience using scrap tire material, overall performance of the product is expected to improve. Similarly, the economic attractiveness of asphalt paving applications is also expected to improve as experience levels increase and experimentation related activities and costs decline.

2.5.2 Environmental, Economic, and Volume Characteristics

The following section summarizes the changes found in the environmental, economic, and volume characteristics associated with the use of scrap tire materials in asphalt/paving applications.

Environmental Characteristics

As of the first quarter of 1992, conclusive information on the overall environmental impacts of the use of scrap tire material in asphalt/paving applications was not available. There are two areas of concern. First, there is some concern regarding the potential of constituent leaching where the road bed is below the water table. Yet, several studies have concluded that asphalt containing scrap tire material poses no threat to groundwater. Tests of groundwater at several sites were conducted and each sample passed EPA drinking water standards. Second, there has been limited study of the emission effects of scrap tire material in the application process. EPA is expected to release some findings on this issue in 1993. Environmental benefits include noise reduction and icing-resistance (e.g., less rock salt would be required).

Economic Characteristics

The economic characteristics associated with the use of scrap tire material in asphalt/paving applications have not changed significantly since mid-1990. The initial cost of asphalt-rubber and RUMAC has been reported to be twice the initial cost of the standard asphalt or aggregate they replace. Although several test applications have demonstrated that asphalt-rubber significantly extends the life of pavement, clear and consistent data on its overall life-cycle cost effectiveness is not yet available.

There are five significant factors which may impact the economics of using scrap tire materials in asphalt/paving applications:

- The patent for one of the asphalt-rubber technologies will expire in 1992, probably lowering its cost.

- Higher volume use is likely to lower the cost of asphalt-rubber as process optimization and economies of scale factors are realized.

- If fully implemented, the Intermodal Surface Transportation Efficiency Act of 1991 may create a temporary shortage of scrap tire materials by the late 1990's if increased production capacity is not available. Ultimately, this shortage will be remedied as new production capacity comes on line. However, the fundamental nature of the projects involved; the typical length of time from proposal submittal to contract around and then to project startup; and the lingering uncertainties due to the lack of empirical evidence as to asphalt/paving applications' performance; all represent key factors to consider in examining these applications.

- Second, research studies have not adequately addressed whether or not asphalt-rubber and/or rubber modified asphalt can be recycled in the same manner as traditional asphalt materials.

- Only 60-70 percent of the tire is used in the production of ground rubber. The remainder must be used efficiently or it will become part of the waste stream.

The potential impact of these factors is difficult to assess at the current time. The final implementation of the Intermodal Surface Transportation Efficiency Act of 1991 will be a major factor. There is a provision in the Act allowing other recycled or recyclable materials determined appropriate by EPA to be substituted for recycled rubber.

Volume Characteristics

The following is an estimate of the potential usage of scrap tires in asphalt/paving applications:

- Within Five Years: 80 million scrap tires per year.
- Within Two Years: 20 million scrap tires per year.
- Current Usage: Less than 5 million scrap tires per year.

The estimates for potential usage within two-to-five years are based on the assumption that the Intermodal Surface Transportation Efficiency Act of 1991 will be interpreted in a manner which will maximize the use of scrap tire materials in asphalt/paving applications. The Act requires that, beginning in 1994, five percent of all "federal aid" asphalt concrete laid in the U.S. contain 20 pounds of crumb rubber per ton of hot mix. The requirement increases by five percent each year after 1994 before leveling out at 20 percent in 1997. Total asphalt concrete laid in the U.S. is approximately 450 million tons, of which approximately 200 million tons is "federal aid" and subject to the provisions of the Act. Assuming 10 pounds of crumb rubber per tire (versus 20 pounds per tire for TDF), the Act will mandate the use of approximately 20 million scrap tires in 1994 and approximately 80 million in 1997. This estimate, however, is highly dependent upon both the amount of scrap tire materials reused/recycled through other technologies and the final interpretation of the Intermodal Surface Transportation Efficiency Act of 1991. There is a provision in the Act allowing individual state reductions and exemptions from the minimum usage requirements if "there is not a sufficient number of scrap tires available in the state prior to disposal...as the result of recycling or processing uses including retreading and energy recovery. The estimate of current usage is based upon interviews with representatives from industry and various state and federal agencies.

2.5.3 Usage of Scrap Tire Material in Paving/Asphalt Applications in the First Quarter of 1992

In the first quarter of 1992, most state transportation departments and many local agencies were conducting experimental programs designed to measure the technical and economic suitability of asphalt-rubber and/or RUMAC. Exhibit 2.5 provides a summary of states known to be testing and/or using one of these materials.

Use Of Scrap Tire Material In Asphalt/ Paving Applications

State	Usage
Alabama	
Alaska	○
Arizona	●
Arkansas	
California	○
Colorado	
Connecticut	
Delaware	○
District of Columbia	○
Florida	○
Georgia	○
Hawaii	
Idaho	○
Illinois	○
Indiana	○
Iowa	○
Kansas	○
Kentucky	
Louisiana	
Maine	○
Maryland	○
Massachusetts	○
Michigan	○
Minnesota	○
Mississippi	○
Missouri	○

State	Usage
Montana	○
Nebraska	○
Nevada	
New Hampshire	○
New Jersey	○
New Mexico	
New York	○
North Carolina	○
North Dakota	
Ohio	○
Oklahoma	○
Oregon	○
Pennsylvania	○
Rhode Island	
South Carolina	○
South Dakota	
Tennessee	
Texas	○
Utah	
Vermont	○
Virginia	○
Washington	○
West Virginia	
Wisconsin	
Wyoming	○

○ Current Testing/Limited Use
● Extensive Use

2.5.4 Information Sources

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Phone conversation with Dan Lakin, Lakin Corporation, Chicago, IL

Phone conversation with Bob Maust, Maust Tire Recycler Inc.

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Phone conversation with Adam Baker, Baker Rubber, South Bend, IN

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Phone conversation with Milt LaPanta, International Rubber, Inc., Changler, AZ

Phone conversation with Carol Brown, Envirotire, Seattle, WA

Phone conversation with Fernley Smith, Midwest Elastomers, Wapakoneta, OH

Phone conversation with Mike Hietzman, Federal Highway Administration, Washington, DC

Phone conversation with William Hamlin, Asphalt Rubber Systems, Riverside, RI

Phone conversation with Mickey Randall, Eagle Crest Construction Company, Arlington, WA

Phone conversation with Jeffrey Smith, International Surfacing, Inc. Phoenix, AZ

Phone conversation with John Corcoran, Manhole Adjsuting, Inc., Montery Park, CA

Phone conversation with Mike Anderson, Asphalt Institute, Lexington, KY

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Phone conversation with Ed Harrigan, Strategic Highway Research Program, Washington, D.C.

Phone conversation with Robert Winters, Atlos Rubber, Inc., Los Angeles, CA

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Phone conversation with Jack VanKirk, California Department of Transportation

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Phone conversation with Bill Lovell, Purdue University

Phone conversation with Don Fohs, Federal Highway Administration

Phone conversation with Tom Kissane, New York Department of Transportation

Phone conversation with Jim Keith, Alabama Department of Transportation

Phone conversation with Gerry Jaggers, City of Phoenix, Arizona: Street Maintenance Division

Phone conversation with Joe Cano, City of Phoenix, Arizona: Street Maintenance Division

Phone conversation with Equbalali Charania, City of Phoenix, Arizona: Street Maintenance Division

Phone conversation with Dan Anderson, Arizona Department of Transportation

Phone conversation with Dan Simpson, Arizona Department of Transportation

Phone conversation with Dave Ashley, Arizona Department of Transportation

Phone conversation with Joe Barela, New Mexico State Highway Department

Phone conversation with Michael Sock, Rhode Island Department of Transportation

Phone conversation with Dan Johnston, Rhode Island Department of Transportation

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2.6 USE OF SCRAP TIRE MATERIAL IN CIVIL ENGINEERING APPLICATIONS

Abstract. Since mid-1990, interest and experimentation with the use of scrap tire material in civil engineering applications have increased significantly. Either whole tires or shredded tires may be utilized in road base, embankments, artificial reefs, crash barriers, and a variety of other applications. In the first quarter of 1992, 25 states were known to have conducted experimental programs designed to measure the technical and economic suitability of at least one of these uses.

The technical, environmental, and economic constraints associated with the use of scrap tire material in civil engineering applications have not yet been fully evaluated. Early indications are that scrap tire material will prove to be suitable for a number of applications, particularly road embankments.

At this time, it is not possible to predict the total potential U.S. consumption of scrap tire materials in civil engineering applications. However, representatives from several state transportation departments believe that the potential consumption of scrap tires material in embankments alone is greater than that for asphalt/paving applications (predicted to consume as much as 80 million scrap tires per year by 1997).

The principle barriers to the further use of scrap tire material in civil engineering applications are:

- Unfavorable economics for some applications, particularly artificial reefs.
- Lack of sufficient long-term performance data.
- Unclear long-term environmental implications.
- Potential future supply shortages due to requirements of the Intermodal Surface Transportation Efficiency Act of 1991.

2.6.1 Technology Description

This section briefly describes the major potential uses of scrap tire material in civil engineering applications.

Use of Scrap Tire Material in Subgrade/Embankments

There are two principle uses for scrap tire material in subgrade/embankments: use of shredded tires as a lightweight fill material; and use of whole tires or their sidewalls for soil reinforcement in embankment construction. The use of shredded tires as a subgrade road bed has been tried in several states including Oregon, Vermont, Minnesota, and North Carolina. Shredded tires used as a substitute for traditional road fill such as gravel have been shown to enhance roadbed stability in soft soil areas. Scrap tire material has also been used to retain forest roads, protect coastal roads from erosion, enhance the stability of steep slopes along highways, and reinforce shoulder areas. The California Department of Transportation has found that the latter two applications to be both stable and economical.

Artificial Reefs and Breakwaters

Whole tires can be used in the construction of artificial reefs and breakwaters. Artificial reefs are designed to prevent scouring, protect coastal roads, and provide habitat to aquatic life. Tire reefs are made by bundling punctured tires weighed down with concrete and anchoring them to the ocean floor. The largest known scrap tire reef, comprised of approximately 12 million used tires, is located in Florida. Breakwaters are used to reduce shoreline erosion. Scrap tire breakwaters are made by tying together tires with rubber strips and nylon bolts. Georgia and New Jersey have both built scrap tire breakwaters and have reported no significant technical difficulties.

Crash Barriers and Railroad Crossings

Scrap tire material can be used in a variety of other civil engineering applications including roadway crash barriers and railway crossings. Texas, Alaska and Florida have each reported using scrap tires in such applications and have reported no significant technical difficulties.

2.6.2 Environmental, Economic, and Volume Characteristics

The following section summarizes the environmental, economic, and volume characteristics associated with the use of scrap tire materials in civil engineering applications.

Environmental Characteristics

The long-term environmental implications of using scrap tire materials in civil engineering applications are not documented at this time. Results from several studies indicate that leachate from tire materials would not likely threaten the environment. But further standardized testing is needed. One known study on the feasibility of using "Waste Tires in Subgrade Road Beds" (MCPA, 1990) was sponsored by the Minnesota Pollution Control Agency. In the study, a laboratory analysis was conducted to evaluate the compounds which are produced by exposure of tire and asphalt materials to different leachate environments. Yet it should be noted that the testing protocol used is not applicable to all situations. The following conclusions were reached (MCPA 1990):

- Co-disposal limits and EP Toxicity limits are not generally exceeded for the parameters of concern.
- Drinking water Recommended Allowance Limits (RALs) may be exceeded under "worst-case" conditions for certain parameters.
- Potential environmental impacts from the use of scrap tires can be minimized by placement of tire materials only in the unsaturated zone of the subgrade.

An extensive study was conducted by Radian Corporation (Radian 1991) to assess what level of chemicals, if any, are leached from scrap tire material. Radian based its evaluation on EPA's Toxicity Characterization Leaching Procedure (TCLP). The results of the study indicated that "none of the tire and other rubber products tested, cured or uncured, exceeded proposed TCLP regulatory levels. Most compounds detected were found at trace levels from ten to one hundred times less than TCLP Regulatory Limits and U.S. Drinking Water Standard MCL values." (Radian 1991)

Economic Characteristics

The economic characteristics associated with the use of scrap tire materials in subgrade/embankments appears to be promising. Scrap tire material is significantly less expensive than traditional fill material such as stone ($1.00 per cubic yard for shredded tires versus $9.00 - $12.00 per cubic yard for stone). In general, the installation of artificial tire reefs has not proven to be an economically feasible use for scrap tire materials.

Volume Characteristics

The following is an estimate of the potential usage of scrap tires in civil engineering applications:

- Within Five Years: 15 million scrap tires per year

- Within Two Years: 7 million scrap tires per year

- Current Usage: Less than 5 million scrap tires per year.

At this time, it is not possible to predict the total potential U.S. consumption of scrap tire materials in civil engineering applications. However, representatives from several state transportation departments believe that the potential consumption of scrap tire material in embankments is greater than that for asphalt/paving applications (predicted to consume as much as 80 million scrap tires per year by 1997). This estimate, however, is highly dependent upon both the amount of scrap tire material reused/recycled through other technologies and the final interpretation of the 1991 Federal Transportation Act. There is a provision it the Act allowing exemptions from asphalt/paving usage requirements if an equal amount of tire material is reused/recycled with other "acceptable" technologies. The potential consumption of scrap tire material in road embankments or other civil engineering applications will be limited if they are not considered to be "acceptable" technologies.

2.6.3 Usage of Scrap Tire Material in Civil Engineering Applications in the First Quarter of 1992

In first quarter of 1992, several states and local agencies had conducted experimental programs designed to measure the technical and economic suitability of using scrap tire materials in civil engineering applications. Exhibit 2.6 provides a summary of states known to be testing and/or using one of these materials.

Use Of Scrap Tire Material In Civil Engineering Applications

State	Usage
Alabama	○
Alaska	○
Arizona	
Arkansas	
California	●
Colorado	○
Connecticut	
Delaware	
District of Columbia	
Florida	○
Georgia	○
Hawaii	
Idaho	
Illinois	
Indiana	○
Iowa	○
Kansas	○
Kentucky	
Louisiana	
Maine	○
Maryland	○
Massachusetts	
Michigan	○
Minnesota	○
Mississippi	
Missouri	

State	Usage
Montana	
Nebraska	
Nevada	
New Hampshire	
New Jersey	○
New Mexico	
New York	○
North Carolina	○
North Dakota	
Ohio	●
Oklahoma	
Oregon	○
Pennsylvania	○
Rhode Island	
South Carolina	○
South Dakota	
Tennessee	
Texas	○
Utah	
Vermont	○
Virginia	○
Washington	○
West Virginia	○
Wisconsin	
Wyoming	

○ Current Testing/Limited Use
● Extensive Use

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2.6.4 Information Sources

Phone conversation with Pamela Harley, Colorado Department of Transportation

Phone conversation with Bob Clevenger, Colorado Department of Transportation

Phone conversation with David Nash, Connecticut Department of Transportation

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Phone conversation with Camron Peterson, Utah Department of Transportation

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2.7 PRODUCT RECOVERY VIA PYROLYSIS

Abstract The outlook for commercial pyrolysis is somewhat brighter than it was in mid-1990. Although no U.S. pyrolysis facility is currently known to be making a profit, the J.H. Beers Company appears close to being commercially operational. The future economic viability of the process will be closely tied to the price of its products, which are themselves highly dependent upon energy prices.

It is not currently possible to predict the future potential capacity of U.S. pyrolysis facilities due to the highly uncertain economics of the process. Currently, there is one operational U.S. pyrolysis facility with a capacity to process approximately 800,000 scrap tires per year.

The principal barriers to the use of tires in pyrolysis plants in the U.S. are:

- Questionable process economics; high capital expenditures for plant construction and start-up.
- Uncertain demand for pyrolytic products, especially char. Perception of product quality is negative at present.
- Technology has yet to be proven over a long-term basis.

2.7.1 Technology Description

There have been no major technological advances in pyrolysis technology since mid-1990. However, existing technologies have been continuously refined and optimized. Pyrolysis is the process of thermal degradation in the absence of oxygen. It is also know as gasification, liquification or destructive distillation. When scrap tire rubber is pyrolyzed, it decomposes into three recoverable constituents; char (with ash, fiber, and steel), pyrolytic oil and gas. The quantity and quality of the constituents can vary depending on the unit design and operation, and the desired end market.

2.7.2 Environmental, Economic, and Volume Characteristics

The following section summarizes the changes found in the environmental, economic, and volume characteristics associated with pyrolysis.

Environmental Characteristics

There is currently no significant data on the environmental characteristics associated with scrap tire pyrolysis. However, early indications are that well run pyrolysis facilities may present fewer environmental risks than other major uses of scrap tire material in terms of processing only.

Economic Characteristics

The economics associated with scrap tire pyrolysis remain questionable. As pyrolysis technology has been improved and refined, the possibility of pyrolysis becoming economically feasible has increased. Although no U.S. pyrolysis facility is currently known to be making a profit, the J.H. Beers Company claims to be close to achieving the break even point. The future economic viability of the process will be closely tied to the price of its products, which are themselves highly dependent upon energy prices, market demand, and perceived quality.

Potential markets for char have been hurt by the perception that refined char is vastly inferior to virgin carbon black. The quality of the carbon black obtained from pyrolysis is still questionable. Pyrolysis operators now claim that the process has been successfully refined so that high grades of carbon black are able to be produced.

- Potential existing markets for refined char include molded goods, shoe soles, and printing inks and pigments
- The pyrolytic oil can be used as a gasoline octane extender, blending stock, or boiler fuel
- There is a stable market for the steel recovered from scrap tires

Volume Characteristics

The following is an estimate of the potential usage of scrap tires by U.S. scrap tire pyrolysis facilities:

- Within Five Years: 3 million scrap tires per year.
- Within Two Years: 2 million scrap tires per year.
- Current Usage: 1 million scrap tires per year.

It is not currently possible to predict the future potential capacity of U.S. pyrolysis facilities due to the highly uncertain economics of the process. The estimate of current usage is based on the results of interviews with numerous industry, company, and facility representatives.

2.7.3 U.S. Pyrolysis Facilities in the First Quarter of 1992

In the first Quarter of 1992, there was one U.S. pyrolysis facility reported to be operating on a continuous basis with a capacity to process approximately 800,000 scrap tires per year. Three additional facilities, with a potential combined capacity to process approximately 7 million scrap tires per year, were reportedly close to operational status. Several smaller experimental units are scattered throughout the country.

U.S. Facilities Currently Operational

- J.M. Beers, Inc., Wind Gap, PA
  - Sources indicate that this company is committed to making this pyrolysis operation economically feasible
  - Significant amount of capital has been invested and most of the process variable have been figured out
  - The operation is reported to be at or above the break-even point
  - Capable of processing 800,000 tires per year
  - Receive a tip fee for the tires they receive from the tire distributor

U.S. Facilities Under Construction or Undergoing Testing

- Conrad Industries, Centralia, WA
  - Capable of pyrolyzing 2000 lbs of material (substances other than tire chips can be burned) per hour. Equivalent to one ton of tire chips per hour or 800,000 scrap tires annually
  - Claim that they can produce and market char/ recycled carbon black pure enough for almost any use
  - Unit used on a demonstration basis only

- RMAC Corporation, Troutsdale, OR
  - Claims to have been commercially operational in late 1991, but is currently shut down for minor process modifications with start-up set for late January, 1992
  - Capable of pyrolyzing 3 - 5 tons of dewired tire chips per hour. (3 million tires per year)
  - The pyrolytic oil is the most commercially viable product, equivalent to low-grade fuel oil
  - The gas is used in soil stripping operations
  - Char is sold mostly for its heat value

- Wolf Industries, Knightsville, IN
  - Capable of pyrolyzing 10,000 tires per day
  - Has been running 3 -4 days at a time at 1/4 production to study and evaluate the products
  - Claims to have secured small markets for all products contingent upon product quality
  - Has collection network of trailers at tire retailers to collect scrap tires

Product Recovery Via Pyrolysis

Company	Facility	Status	Potential Capacity (Million tires per year)
Conrad Industries	Centralia, WA	◒	0.8
J.M. Beers, Inc.	Wind Gap, PA	●	1.0
RMAC Corporation	Troutsdale, OR	◒	3.0
Wolf Industries	Knightsville, IN	◒	3.0

○ Facility in planning stages
◒ Facility under construction or undergoing testing
● Facility in operation

2.7.4 Information Sources

Phone conversation with Bob Zarriski, J.H. Beers, Wing Gap, PA

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3.0 CONCLUSION

Seven market alternatives for scrap tires were determined to meet or nearly meet study criteria for environmental acceptability, economic viability, and volume capability. We estimate that these methods combined have the potential to annually consume approximately 328 million scrap tires by 1997. This consumption rate will require the utilization of scrap tires from the existing stockpile of approximately two billion tires. Current consumption of scrap tires by these seven methods has increased significantly since 1990 to approximately 68 million scrap tires per year, or approximately 27 percent of the annual number of scrap tires generated in the U.S.

Each of the seven alternatives faces significant barriers to further implementation. These barriers include:

- Marginal cost advantage over other fuels or materials.
- Air permit modification requirements; inconsistent regulatory guidance in some states.
- Reliability and quality of tire/TDF/ground rubber supply.
- High capital or initial costs.
- Local opposition, particularly where method involves new facilities.
- Unclear long-term environmental implications of some uses, particularly asphalt/paving and civil engineering.
- Uncertainty on state DOT level about the implementation of the Intermodal Surface Transportation Efficiency Act.
- Insufficient long-term technical performance data for some applications.

The estimated potential annual scrap tire consumption by each method in 1997 is (based on scrap tires):

• Cement Kilns	-	60 Million
• Pulp and Paper Mills	-	55 Million
• Electricity Generating Facilities	-	75 Million
• Dedicated Tire-to-Energy Facilities	-	40 Million
• Asphalt/Paving Applications	-	80 Million
• Civil Engineering Applications	-	15 Million
• Pyrolysis	-	3 Million
		328 Million

It is important to note that the industries; regulatory agencies; legislatures; activists; federal, state and local governments; and others working to solve the scrap tire management problem in the U.S. have made significant progress. Since our original study in 1990, actual scrap tire consumption has increased more than two fold. In addition, two new scrap tire management alternatives have been shown to meet the study criteria for environmental acceptability, economic viability and volume capability. They are civil engineering applications and electricity generating facilities other than utilities.

Our 1990 study projected a more than eight fold increase in scrap tire consumption by 1995 to some 210 million scrap tires per year. Our 1992 data clearly indicates a five fold increase in annual scrap tire consumption by 1997 to some 328 million scrap tires per year. While the annual growth rate over five years would appear to be somewhat lower 1990 versus 1992, the important point here is that total annual consumption will have increased significantly, and the data upon which these projections are based has a much higher level of user confidence. This is due to the enormous strides that have been made in both developing the fact base on scrap tire issues, as well as significantly increasing scrap tire consumption over the last two years, particularly with respect to electrical generation facilities and asphalt/paving applications. Other alternatives also increased consumption, however the increase was less dramatic.

Finally, the quantity, quality and extent of dissemination of information regarding scrap tire management warrants further comment. In 1990, much of our original report was predicated

4.0 ADDITIONAL SOURCES

Phone conversation with Jay Ort, Pennsylvania Department of Environmental Resources

Phone conversation with Darren Hazlett, Texas Department of Health, Solid Waste Division

Phone conversation with Eldon Morrison, Vermont Agency of Natural Resources - Waste Management Division

Phone conversation with Lauren Brumberge, Wisconsin Department of Natural Resources

Phone conversation with Pat Crowley, Montana Department of Health & Environmental Sciences

Phone conversation with Joe Carpenter, New Jersey Department of Natural Resources

Phone conversation with David Bailey, Virginia Department of Waste Management

Phone conversation with Nat Palmer, Palmer Shredding, North Ferrisburg, VT

Phone conversation with Art Dodge, Dodge RegaPol, Lancaster, PA

Phone conversation with Jerry Goldberg, Terramat Corporation, Youngstown, OH

Phone conversation with Lawrence Tracy, Mates, Inc., New Fairfield, CT

Phone conversation with Don Kiselewski, Tire Log,Palm Beach Gardens, FL

Phone conversation with Allan McNish, Degussa Carbon Black, Akron, OH

Phone conversation with Pamela Harley, Colorado Department of Health

Phone conversation with Russell Kelly, Alabama Department of Environmental Management

Phone conversation with Dan Zeller, Arizona Department of Environmental Quality

Phone conversation with Marilyn G. Brown, New Mexico Health & Environmental Department

Phone conversation with George Beaumont, New Mexico Health & Environmental Department

Phone conversation with Chris Schaffer, Rhode Island Office of Environmental Coordination

Phone conversation with Mara Cherkowski, Rhode Island Office of Environmental Coordination

Phone conversation with Terry Keller, South Dakota Department of Water & Natural Resources

Phone conversation with Brad Gavin, Indiana Department of Environmental Management

Phone conversation with Herb Hicks, Louisiana Department of Environmental Quality

Phone conversation with Lisa Jenkens, Missouri Department of Natural Resources

Phone conversation with Bill Lee, Mississippi Department of Environmental Quality

Phone conversation with Kevin Solie, North Dakota State Department of Health

Phone conversation with Dorothy Adams, Salt Lake City County Health Department

Phone conversation with David Nash, Connecticut Department of Environmental Protection

Phone conversation with Richard Folmsbee, Delaware Department of Natural resources & Environmental Control

Phone conversation with Joe O'Donnel, District of Columbia Recycling Department

Phone conversation with Bill Parker, Florida Department of Environmental Regulation

Phone conversation with Charles Evans, Georgia Department of Natural Resources

Phone conversation with Russel Pack, Hawaii Department of Environmental Quality

Phone conversation with Teresa Hay, Iowa Department of Natural Resources

Phone conversation with Dottie Martin, South Carolina Department of Health