WASTE TIRE UTILIZATION

by

Dr. Robert L. Hershey
Martin D. Waugh
EveLynn J. Hanny

April 30, 1987

Work Performed Under Contract No. AC01-84CE40714

for

U.S. Department of Energy
Office of Industrial Programs
Washington, D.C.

by

Science Management Corporation
Washington, D.C.

DISCLAIMER

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Prepared for:

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PREFACE

The Department of Energy's Office of Industrial Programs has sponsored a number of projects focused on utilization of waste tires and other waste products. This report discusses various technological options for dealing with the waste tire accumulation problem, with an emphasis on those systems where the tires are used for fuel. The report is intended to be useful to a wide audience including citizens, business people, and officials of state and local governments.

In preparing this report, we were provided helpful guidance by Messrs. Jerome Collins, Stuart Natof, and James Demetrops of the Office of Industrial Programs. We also received useful inputs from the tire industry and the entrepreneurs who are implementing new technologies to deal with the waste tire problem. In particular we appreciate the participation of the National Tire Dealers and Retreaders Association who provided data to us.

Dr. Robert L. Hershey, P.E.
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I. INTRODUCTION

Waste tire accumulations have become an increasingly important problem in recent years. This is of interest to DOE because the scrapped tires represent a large energy resource, and many requests for information have been received. Therefore, this report has been prepared to help in implementing waste tire utilization technologies.

1. GENERATION OF WASTE TIRES

At the present time approximately 200 million tires are scrapped annually in the United States. Estimates vary from 170 million to 240 million. The rule of thumb is that 1 waste tire per person per year is generated.

The large majority of these waste tires will join the expanding accumulation of 2 billion tires that continues to build up throughout the country. The tires tend to be moved around until they end up in one of the hundreds of tire piles that are scattered throughout the nation. These tire piles have begun to become a concern to the communities where they are located, because of possible problems from mosquitoes or fire hazards. Because of these potential problems there has been an increasing need to get rid of the tires once and for all -- either by utilizing them or by disposing of them in landfills.

In analyzing the waste tire problem, there are various types of tires that must be considered.

- Approximately 85% of the waste tires are automobile tires. Each automobile tire weighs approximately 20 lb. Thus, the rule of thumb is that there are approximately 100 automobile tires per ton. The smallest tires may weigh as little as 12 lb, and the largest are about 28 lb. Automobile tire diameters run from 18 to 30 inches. Besides the rubber in the tire, there will also be some steel for the bead and some rayon or steel for the belt. If a tire is burned, the fuel value is slightly higher than that of coal, about 12,000 to 16,000 Btu/lb. Therefore, for 200 million tires at 15,000 Btu/lb there are approximately .06 quadrillion Btu/yr of potential energy value.

- Approximately 15% of the waste tires are truck tires. Tires from trucks come in various sizes and weights. Typical weights are from 30 to 90 lb, and typical diameters are 30 to 48 inches. Generally truck tires can be handled by the same means as automobile tires, adapted for the greater weight and larger diameter.

- Less than 1% of the waste tires are special tires for construction equipment, aircraft, or military vehicles. The few very large tires that are from heavy construction equipment may weigh hundreds of pounds and require special handling.

During its lifetime, a tire may be handled by various participants in the tire industry, all of whom are generating scrap tires. These include manufacturers, retailers, casing jockeys, and retreaders.

(1) Manufacturers

There are several large tire manufacturing companies in the United States. They manufacturer new tires which enter the tire distribution network, and they also generate scrap tires from their production line defects. Several of the manufacturers currently burn their scrap tires for fuel, producing process heat for their manufacturing operations.

(2) Retailers

Typically customers drop off their old tires when they purchase new ones. Some retreaders cull these tires to recover salable used tires or ones that can be retreaded. The retailers also accumulate some scrap tires from the few defective tires shipped to them from the manufacturers. Each tire dealer must find a way to get the scrap tires removed from his property, or he will face a continuing accumulation which may become a cause of community concern.

(3) Casing Jockeys

Often the waste tires are removed from the retailer's lot by a casing jockey. The casing jockey takes the tires away to some location where they can be sorted. Many of the tires have good carcasses and can be recapped. Some tires are good enough to be resold as is. The vast majority of them are scrap and must be transported to a tire pile or landfill. The casing jockeys have agreements with the retailers on the frequency of pickups, the pickup fee per tire, and the degree of "cherry picking" allowed the retailers.

(4) Retreaders

The retreaders take tire carcasses and run them through a recapping process to put new tread on them. The retreaders generate scrap tires from incoming carcasses which they reject, as well as manufacturing defects.

As described above, all four participants in the tire industry are continually generating scrap tires. Any one of them who is not moving the scrap tires off his property on a regular basis will soon generate a substantial tire pile.

2. TIRE DISPOSAL PROBLEMS

Waste tires have various characteristics which make them hard to dispose of.

(1) Difficulties of Disposal in Landfills

Unless waste tires are buried very carefully in landfills they tend to rise up through the soil and become uncovered again. The landfill management techniques to avoid this problem are time consuming and burdensome, and they involve deeper burial, mixing with other wastes, or burying at widely spaced intervals. Even after ideal burying the landfill will not normally be able to support structures taller than one story. This will relegate the reclaimed land to uses such as golf courses. Because of this problem many landfills will not accept tires. Since there is a general landfill availability problem in the heavily populated areas of the nation, there is a critical shortage of landfills available for tires. This has resulted in tipping fees at the landfills, ranging from $.05 to $1.00 per passenger tire.

(2) Mosquitoes

Tire piles are excellent breeding grounds for mosquitoes. The shallow pools of water that collect in the tires after a rain are ideal for the adult female mosquitoes' egg laying. Since tires are dark in color, they readily absorb energy from sunlight, creating a hospitable warm environment for the mosquito eggs. This is especially the case in warm humid parts of the country, such as the Gulf Coast.

(3) Fire Hazard

Tire piles are basically accumulations of combustible material, similar to coal piles. If fires get started in tire piles, they are hard to extinguish, and the uncontrolled burning gives rise to smoke and noxious emissions. The tire fires also leave behind hazardous liquids formed through pyrolysis that must be cleaned up to safeguard groundwater and restore the site. To minimize the fire hazard, communities sometimes insist that the tire piles have fire lanes between the pile segments to provide access for fire control vehicles and retard the spread of a potential fire. The better managed tire stockpiles have surveillance systems and emergency water supplies for firefighting.

Because of the problems associated with tire disposal, getting rid of waste tires involves considerable expense and logistic difficulties. As a result, some unscrupulous businesses and car owners have resorted to illegal dumping. It is difficult to estimate how many waste tires have wound up in ravines, woods, deserts, or empty lots through illegal dumping.

3. ALTERNATIVES

There are a limited number of alternatives for utilizing or disposing of waste tires.

(1) Landfills

Currently the main method used in the United States for permanent disposal of scrap tires is by landfilling. Because of the problem of whole tires rising up in landfills, the generally accepted procedure is to shred or split the tires first. Landfilling the tires solves the main problems associated with tire piles -- mosquitoes and fire hazards. However, there are two major disadvantages associated with landfilling:

- Landfill capacity is limited. There is currently a shortage of landfills in metropolitan areas. As the shortage gets worse, tires have to be transported longer distances to reach landfills with space.

- The fuel value of the tire is lost. Burying a tire in a landfill will probably prevent its use as fuel in the future. Landfilling mixes the tires with other wastes and contaminates them with earth, making it much more difficult to retrieve and burn them in the future.

Several years ago, landfilling was the only viable option. But recently new technologies have been developed for combustion and other utilization alternatives.

(2) Combustion

The controlled combustion of tires using environmentally acceptable technologies is very different from uncontrolled open burning. People who are not familiar with the newer tire combustion technologies usually visualize open burning when they think of tire combustion -- with black smoke and a noxious odor of burning rubber. However, this image is no longer correct. At the much higher temperatures of today's technologies, the combustion is complete and the environmental cleanup technologies will take care of the pollutants. Several tire combustion technologies are available for various uses:

- Reciprocating Stoker Grate System

  This system uses a grate composed of bars of temperature resistant material arranged in a configuration that allows air flow. This system has been used commercially for twelve years at the Gummi Mayer tire facility in West Germany. It is now being installed in a power plant in Modesto, California by

Oxford Energy. This system will be discussed in detail in Chapter III.

- Pulsing Floor Furnace

  A heat-recovery steam generator system using a pulsing floor furnace has been developed by Basic Environmental Engineering, Inc. of Glen Ellyn, Illinois. A plant of Firestone Tire & Rubber Company in Decatur, Illinois is currently using this system to burn waste tires along with other solid wastes. The tire combustion system produces 23,000 lb/hr of process steam for the plant.

- Combustion in Cement Kilns

  Kilns used in the cement industry have temperatures hot enough to give complete combustion of tires in an environmentally acceptable manner. This technology is widely used in Europe. However, in the U.S. only one cement maker is currently using shredded tires as fuel on a commercial basis. This company is Genstar in Redding, California. Combustion of tires in cement kilns will be discussed further in Chapter IV.

- Small Package Steam Generators

  Several small package steam generator units have been produced by foreign manufacturers and operated in various installations abroad. As of this date only one is in operation in the United States.

  - Tsurusaki Sealand markets a small package system manufactured in Japan by Nippo. The unit can burn 24-25 tires/hr, producing 100 psig process steam with the heat. The draft configuration allows the tires to burn at 2000°F, greatly reducing the emission problem. There are over 20 of these small incinerators now operating in Japan. The first U.S. unit was recently installed and has been in operation for the past two months. It is at Les Schwab Tires, a retreader in Prinesville, Oregon. The unit has a Cleaver Brooks waste heat recovery boiler and a bag filter. The unit has been fitted with an automatic feed system that loads whole tires, both automobile tires and light truck tires. The system was approved by the Department of Environmental Quality of the State of Oregon, and it is apparently working well.

- Bartech Inc. of New Canaan, Connecticut markets a Japanese patented system which will convert 900 tires per day to a gas which can be used to produce process steam. They plan to start their first U.S. installation by the end of the year.

- Eneal Alternative Energy of Milan, Italy has a waste tire package plant to produce process steam. It consumes approximately 200 tires per hour and produces 22,000 lb/hr of process steam. None of these Eneal plants are currently in operation in the U.S.

As discussed above, there are several viable clean combustion technologies which can derive fuel value from waste tires.

(3) Road Surfacing

By combining crumb rubber from waste tires with asphalt, a road surfacing material can be produced. Several installations of this road surface have been done by firms such as Asphalt Rubber Systems of Rhode Island. They have observed extended pavement life for the large majority of these installations. However, the first cost of asphalt rubber is approximately twice that of conventional paving. Since the adoption of the rubber asphalt system by state highway departments remains controversial, there is no current indication that a large volume of waste tires will be going to this use.

(4) Manufactured Products

It is possible to produce various manufactured products using crumb rubber from waste tires as opposed to virgin rubber. The question remains as to the properties of rubber in the recycled product and its market acceptance. Recently Rubber Research Elastomerics, Inc. of Minneapolis dedicated a plant in Babbitt, Minnesota to produce articles from recycled crumb rubber from waste tires. Their Tirecycle® operation will use their proprietary process to make products from ground scrap rubber, which include mats and powdered compound. These are, in turn, used by other firms in the manufacture of other products such as liners for use in the automotive industry. Data from Rubber Research Elastomerics indicate small changes of properties compared to virgin rubber. It remains to be seen whether there will be sufficient market acceptance of recycled rubber products to make this a substantial user of waste tires.

(5) Pyrolysis

Using a pyrolysis process, it is possible to convert scrap tires into a liquid fuel. The economics of pyrolysis is dependent on the price of oil, which has recently been relatively low, as well as on the sale of the char byproducts. Until a more economical pyrolysis process is developed, such as by upgrading of char, there is no indication that a substantial number of waste tires are likely to be utilized in this manner.

(6) Artificial Reefs

There has been a substantial amount of publicity given to the few examples of artificial reefs constructed from waste tires. These reefs are environmentally benign, protecting the shoreline and improving the offshore area. However, the reefs are expensive to install, and the areas where they can be used to advantage are limited. Thus, they are expected to have a negligible effect on the problem of utilizing waste tires. The same is true for other low volume uses, such as boat docks, highway safety barriers, soil erosion control, and backyard swings.

(7) Pond Storage

One way of allieviating the problems associated with tire piles is to store them underwater. There is currently one such tire pond in the United States at the site of an abandoned quarry in North Haven, Connecticut. However, it is doubtful if this solution to the tire problem can be repeated at many locations.

* * * * *

In summary, there are several alternatives for dealing with the waste tire problem. The current high volume approaches appear to be combustion and landfilling. The combustion alternatives are discussed in the following chapters:

- III. Free Standing New Power Plant
- IV. Cement Kilns
- V. Tire-Derived Fuel.

Landfilling is discussed further in Chapter VI. Enviro. :ental Considerations.

II. TIRE SUPPLY CONSIDERATIONS

II. TIRE SUPPLY CONSIDERATIONS

The tire supply situation is a critical consideration for any entrepreneur thinking of setting up a power plant to burn waste tires. Similarly, it enters into the economics of producing tire-derived fuels or using waste tires as fuel in cement kilns. To make good economic sense, the waste tires must be available at a near-zero or negative cost over the long term. These conditions tend to be site-specific and depend on setting up long term contracts.

1. TIPPING FEES

Since waste tires are an unwanted commodity, disposing of them requires payment of a tipping fee in most locations. The amount charged for the tipping fee by the operator of the landfill or tire pile will vary with supply and demand. Depending on the local situation, the tipping fees are anywhere from 5 cents a tire to $1.00 per passenger tire. Tipping fees for truck tires may be higher, going up to as high as $3.00 per tire. The tipping fee will vary depending on:

- o state and local regulations
- o availability of competing landfills or other places to dispose of tires
- o degree of enforcement against illegal dumping of tires.

In some unusual cases, there may be the opposite of a tipping fee -- a tire bounty. This may occur in a community where people want to gather waste tires and discourage illegal dumping. Conceivably it could occur in the private sector if a tire-burning power plant needed fuel. Presently no companies in the U.S. are paying tire bounties.

2. LONG TERM CONTRACTS

In order to assure a supply of fuel for a tire-burning power plant, the operator of the plant will generally need long term contracts with suppliers of waste tires. These contracts assure the power plant operator that the suppliers of waste tires will not demand a lower tipping fee once the plant goes on line and their waste tires are needed. The long term contracts, in turn, assure the waste tire sources that they can plan to dispose of their tires without increasing tipping fees in the future or trucking the tires long distances.

Operators of tire-burning power plants can write long term contracts with manufacturers, retailers, casing jockeys, or retreaders. In dealing with casing jockeys, the entrepreneur can plan that the casing jockey will be the one who transports the tires. In dealing with other parties, the entrepreneur may have to supply the transportation.

In obtaining a long term contract, an entrepreneur may have to assure his suppliers of a way to dispose of tires until the plant comes on line. In the case of Oxford Energy Company's proposed Connecticut plant, they are providing shredding and landfilling services to their suppliers until the plant comes on line.

The long term contract situation will be influenced by other potential disposal sites for tires in the area. For instance, if there is already a tire-burning power plant in an area, it would be difficult for a second plant to obtain an adequate supply of tires.

3. TRANSPORTATION

Almost all waste tires are moved by truck in the United States today. A typical truck used for this haulage will hold 12 tons of whole tires -- about 1200 tires. If the tires have been shredded into 2-inch chunks, the truck will hold twice as much -- 25 tons. The transportation charge for the 25-ton load of 2-inch chunks may be approximately $250. For a 100-mile run this would be approximately $.10 per ton mile or 1 mill per tire mile. Generally, the rule of thumb is that it does not pay to move tires more than 150 miles. The rule of thumb is subject to change, however, as the need for tire disposal becomes more severe, or as rail and barge service becomes available for tires.

4. TIRE ACCUMULATION

A tire-burning power plant will need a tire pile nearby as a source of fuel. This is necessary as a buffer against supply disruptions, even if suppliers continue to bring enough waste tires for current needs. Thus, the most likely siting for a tire-burning power plant is at an existing tire pile. This was the case for siting the Oxford Energy tire plant in Modesto, California which is sited at the largest tire pile in the U.S. -- 35 million tires.

5. STANDBY FUEL

For a power plant to continue to supply power, it must have a backup fuel supply. Often power plants have a backup supply of one month of fuel or more. For a tire-burning power plant, the most likely backup power supply is a tire pile. If it appears that the tire pile has a chance of becoming exhausted, then additional supplies such as oil or natural gas will be necessary.

6. STATE ACTIONS

The development of a tire-burning power plant can be encouraged or inhibited by governmental actions in the host state or the surrounding states. One of the actions that will encourage a tire-burning power plant is to enforce the laws against illegal tire dumping in the surrounding area. This will encourage the tires to flow toward legal utilization at the power plant rather than illegal dumping.

On the other hand, state actions in neighboring states can be detrimental to the operation of a tire-burning power plant if they draw off the waste tire supply. For instance, Minnesota has subsidized the tire recycling manufacturing plant at Babbitt, Minnesota. This allows the plant to accept waste tires without a tipping fee. This encourages the waste tire suppliers to bring their tires to Babbitt, and it discourages them from dropping off their tires at a competing location where they might have to pay a tipping fee.

* * * * *

In conclusion, the waste tire supply situation for tire-burning power plants is highly site-specific. To be successful, an entrepreneur must find a situation where the economics of the supply situation favor the establishment of a plant.

III. FREE STANDING NEW POWER PLANT FUELED BY WASTE TIRES

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Currently, the major alternative to landfilling of waste tires is burning them in a free standing new power plant. This chapter presents the current status of this alternative and discusses the economics of power plant operation.

1. DESCRIPTION OF TECHNOLOGY

The first U.S. tire-burning power plant is currently under construction in Modesto, California, and it is slated for testing in the next few months. A photograph of the plant is shown in Exhibit III-1. Oxford Energy is the developer, with General Electric providing construction services for the plant on a turnkey contract basis. GE has also chosen to participate in the venture as a limited partner.

The plant is designed to produce 12.9 MW of power and to operate all year, 24 hours per day, 7 days per week. The design feed capacity of the unit is 5.6 tons/hr. This is equivalent to approximately 700 tires/hr. Thus, the facility will consume approximately 4.5 million tires per year. Since the tire pile at Modesto has 35 million tires, the plant will have enough fuel to operate for 8 years even if additional tires do not arrive. However, tires are continuing to accumulate at a rate of 4-5 million per year, and the pile is not likely to shrink rapidly.

A schematic drawing of the tire incineration process is shown in Exhibit III-2. The plant has two tire incinerators, each with an associated boiler. The combustion of tires takes place at temperatures above $1800^{o}F$. During the burning, the tires are supported on a reciprocating stoker grate. The grate is made from material which can survive the high temperatures of incinerator service. The grates have metal bar configurations that allow for air flow above and below. This aids in combustion and helps to cool the grate. The grate also allows the slag and ash to filter down to a conveyor system which takes them to a hopper for off-site disposal. This type of grate system has operated successfully for 12 years in burning tires at the Gummi Mayer tire facility in West Germany. Because of the experience record of the reciprocating grate technology, Oxford Energy, the developers of the Modesto plant, chose it over competing technologies, such as rotary kiln or fluidized bed.

The heat from the grate area rises to enter the boiler where superheated steam is produced. Each of the two boilers produces steam, and they both feed a single turbine generator. The system produces 100 million kilowatt hours of electrical power per year. The pollution control system includes a flue gas desulfurization system and a fabric filter baghouse. The baghouse will remove

EXHIBIT III-1

PHOTOGRAPH OF THE MODESTO TIRE-FUELED POWER PLANT UNDER CONSTRUCTION (3/30/87)

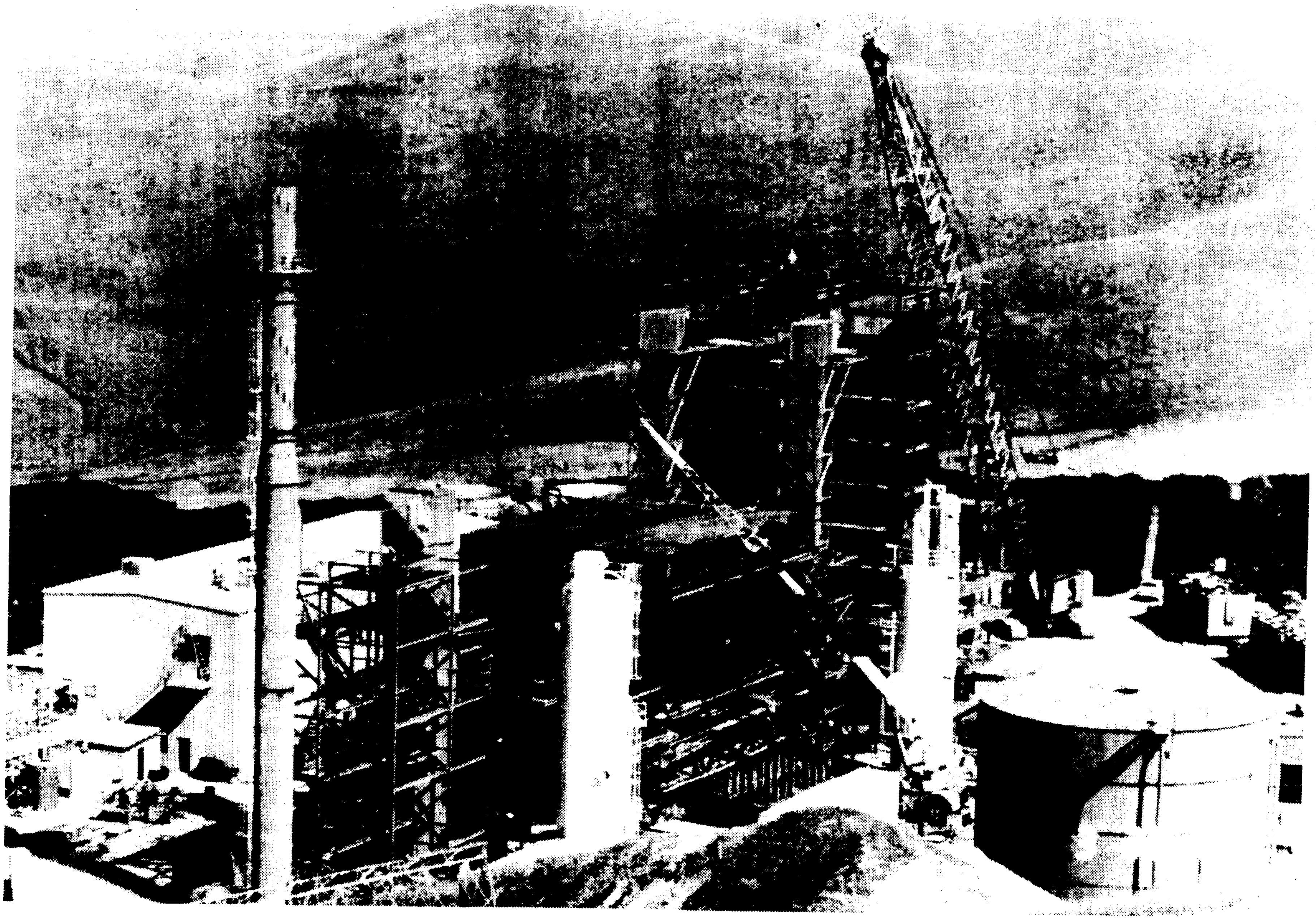
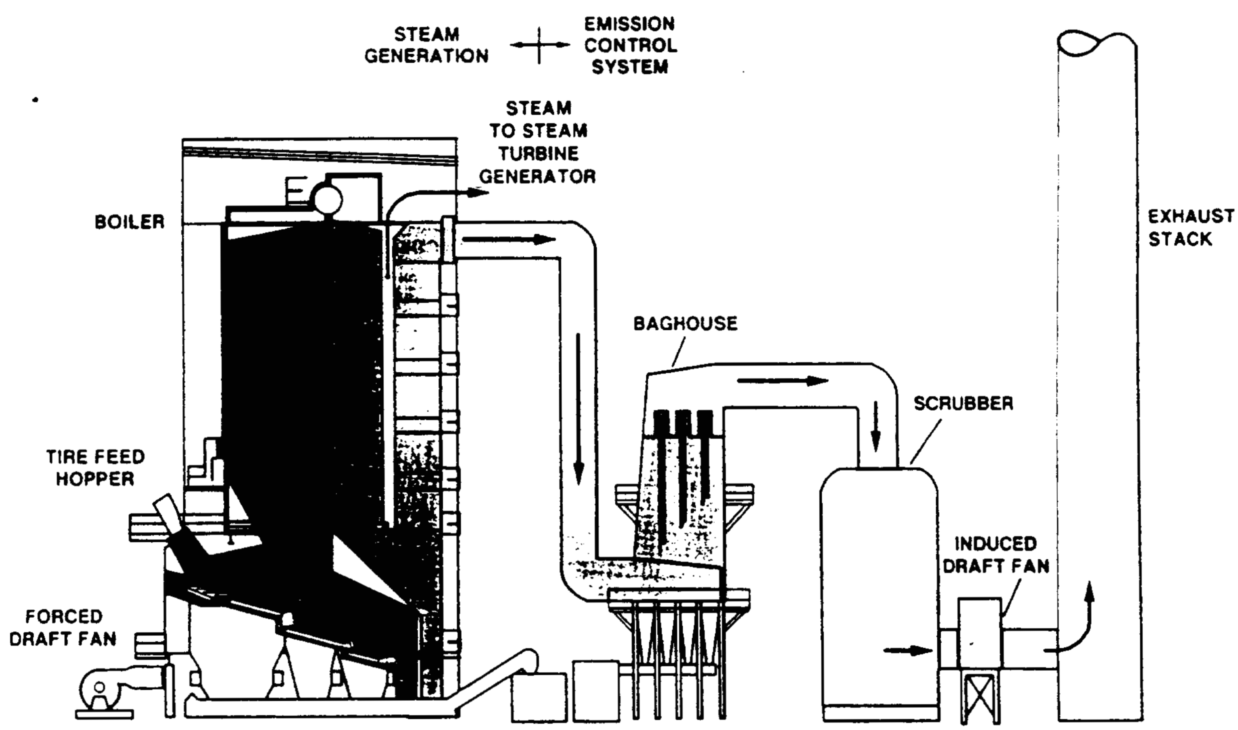


EXHIBIT III-2

SCHEMATIC: TIRE INCINERATION PROJECT



over 99% of the particulate that is generated. The system specifications for removal of pollutants are shown in Exhibit III-3.

2. STATUS OF FACILITY

At the present time, the Modesto, California facility of Oxford Energy is still under construction. As shown in the photograph of Exhibit III-1, almost all the structures have been erected. The boilers, structural steel, and superheaters are in place. As of the end of March, the developers indicated that the facility was 80% complete. As of then, the refractory still needed to be bricked up, and the cables and pipes still needed to be installed. The startup is slated for mid-summer.

Besides the Modesto facility, Oxford Energy is in the planning stages on three similar plants.

- New Hampshire Tire Incineration Project

  A 14 MW waste tire generating facility is being planned for a site in the State of New Hampshire. It is expected to cost $45 million to build. Work is expected to start this year and to be completed in 1988. Oxford plans to sell the power to UNITIL Power Corporation, a New Hampshire utility. Air quality and waste management permits have already been received from the State of New Hampshire.

- Connecticut Tire Incineration Project

  This 27 MW tire-burning power plant will be located in the town of Sterling in northeastern Connecticut. Oxford Energy has obtained options to acquire two sites. The power plant is expected to cost $70 million. Construction is slated to begin this year and be completed in 1989. A power sales agreement has been negotiated with Connecticut Power and Light. The Connecticut Department of Public Utilities Control has issued a final order approving the contract.

- New Jersey Tire Incineration Project

  This unit is planned to be a 27 MW electrical generation facility with an estimated cost of $72 million. Oxford Energy has obtained options on two potential sites, and they are negotiating an electric power sales agreement with Atlantic Electric Company, which is subject to review by the New Jersey Board of Public Utility Control.

As discussed above, Oxford Energy is in the midst of building one power plant and planning at least three more. All their plants are planned to use the reciprocating grate technology, which has been successfully used by Gummi Mayer in West Germany.

EXHIBIT III-3

ENVIRONMENTAL SPECIFICATIONS OF THE MODESTO POWER PLANT

Emissions	Maximum lb/day	Maximum PPMV Dry
SO_x	250.0	16.86
NO_x	500.0	46.58
CO	346.4	84.5
UHC	148.4	33.72
HCL	56.2	6.65
TSP	113.0	N/A

All emissions performance standards are measured at 12% CO_2 (dry).

Stack temperature 180°F.

Source: Oxford Energy Company

3. ECONOMICS OF A FACILITY

The main factor driving any potential waste tire utilization venture is the economics. The basic question any entrepreneur will ask is about the profit per tire. Only those proposed ventures with a large enough profit per tire will be accomplished.

The profit earned per tire may be computed from the equation shown below.

$$P = F + R - C - T - D$$

where

P is the **profit** per tire

F is the tipping **fee** collected per tire

R is the **revenue** per tire received from power generation

C is the processing **cost** per tire for operation of the facility

T is the **transportation** cost to bring in tires

D is the **disposal** cost for waste products

For an example of how the profit per tire is calculated, consider a rough analysis* of the profit per tire from the Modesto facility:

F = 0, since the tires are obtained from the on-site tire pile without charge.

R = $1.84, the sales price of the electricity generated per tire at a utility buyback rate of 8.3 cents per kilowatt hour.

C = $.50, an estimate of the operating cost per tire for operations and maintenance, labor, and materials.

T = 0, since the tires are already on site there is no transportation cost.

* SMC's estimates have been neither confirmed nor denied by Oxford Energy. A formal return-on-investment analysis would be necessary to be really accurate. This would include the financing structure of the venture, interest rates, depreciation, and tax considerations.

D = \$.08, an estimate of the net disposal cost for the total fly ash and bottom ash per tire.

Substituting these numbers in the equation yields a profit of \$1.26 per tire. Thus, the annual gross profit for the operation is \$1.26 x 4.5 million tires = \$5.7 million/yr.

One rough measure of the economic viability of a venture is the simple payback period obtained by dividing the capital value by the gross profit per year. For this project, the estimated capital cost is \$38 million.

$$\text{Payback Period} = \frac{\$38 \text{ million}}{\$5.7 \text{ million}} = 7 \text{ years}$$

This seems like an acceptable payback period, since investors in similar power plants generally want payback periods of 7 years or less. Our rough analysis is just a preliminary look at the overall economics, showing that the venture is viable.

Note the importance of the buyback rate in the above example. If it had been 4 cents per kilowatt hour instead of 8.3 cents, then the profit per tire would have been only \$.31 per tire. Then the payback period would be 28 years, and the investment would no longer be attractive. For the first 10 years, Oxford has been granted an average annual escalation rate of 9%. The price per kilowatt hour paid in the second ten years is expected to be significantly lower.

4. ADVANTAGES OF THE TECHNOLOGY

As discussed above, the production of electricity through tire combustion appears to offer various advantages. It does indeed dispose of the waste tires once and for all while producing electrical energy. The particular advantages of the Gummi Mayer reciprocating grate technology are its long history of 12 years of successful operation and its environmentally clean operation. The system also has the advantage of being able to use whole tires without shredding.

5. CONSTRAINTS OF THE TECHNOLOGY

The motivation to siting a tire-burning power plant will be a high enough buyback rate for electric power or a long term customer for steam. The main constraint limiting the applicability of this technology is acceptance by the host community. This was somewhat easier than usual for the Modesto facility since the pile of 35 million tires had already accustomed the community to seeing the transport and storage of tires. Similarly, the Modesto facility demanded no further land requirements besides that already occupied. From the point of view of Oxford Energy, the Modesto facility is ideal because the supply requirements can be met by using the existing tire pile.

IV. BURNING WASTE TIRES IN CEMENT KILNS

IV. BURNING WASTE TIRES IN CEMENT KILNS

Because of the high temperatures involved in cement kilns, they make ideal furnaces for the complete combustion of tires. Unfortunately, this technology has hardly been utilized in the United States, with the first such system in operation only a few months. In Europe, however, the technology has been widely used for several years.

1. DESCRIPTION OF TECHNOLOGY

The process of cement manufacturing is shown schematically in Exhibit IV-1. The drawing shows a typical U.S. cement kiln which has no suspension preheater. In the rotary kiln, limestone and clay are heated to produce the clinker. This is later ground with gypsum to produce cement. Generally, the fuels used in the kiln are coal or natural gas. The kiln temperature is typically around 2600^{o}F, and it is hot enough for complete combustion of waste tires, including the steel, if they are used as a fuel. Thus, the waste tires are combusted in an environmentally acceptable manner, and the cement producer realizes some cost savings on fuel.

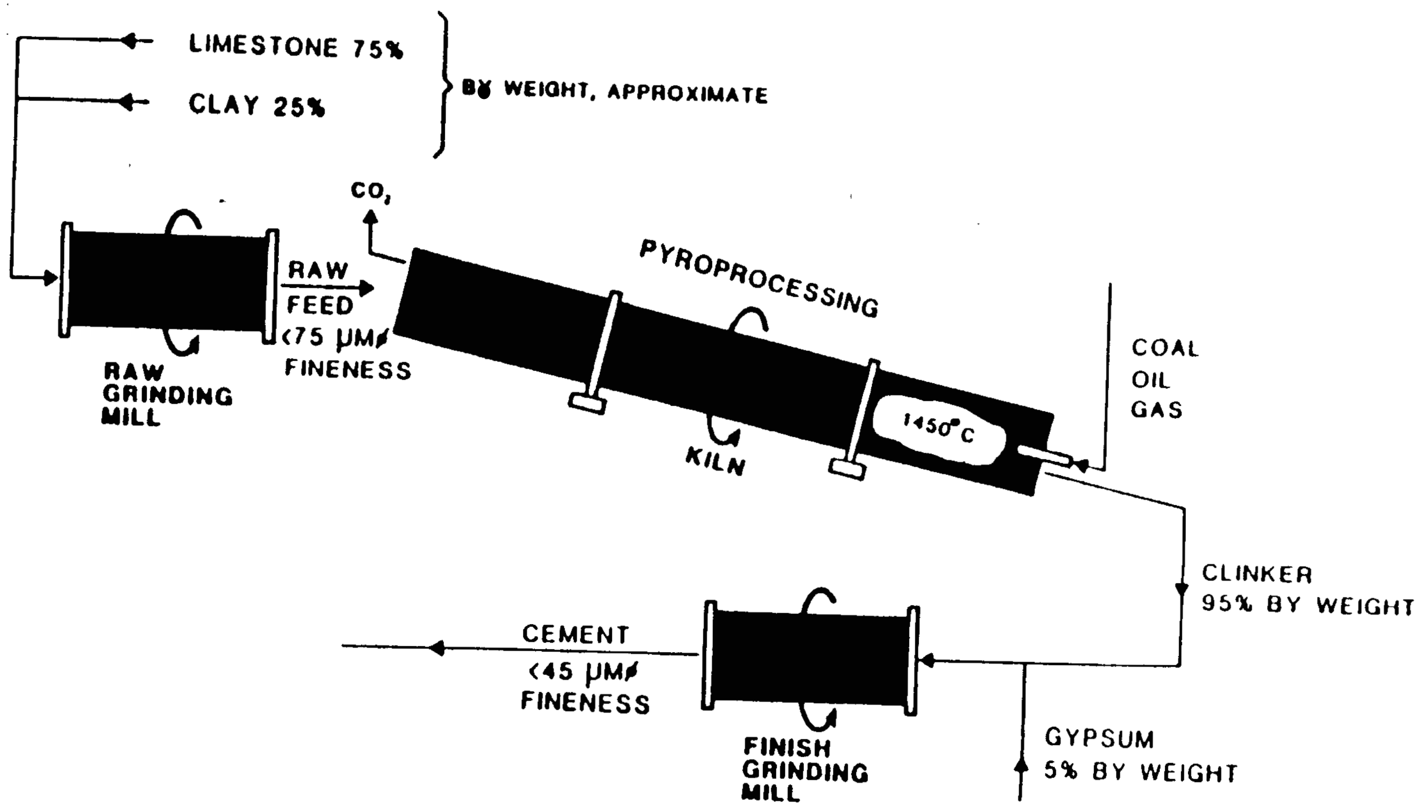
Combustion of tires in cement kilns has been done commercially at several cement plants in Europe for many years, particularly in West Germany, Austria, and France. Most of these plants feed whole tires directly into the kilns. However, it is easier to economically justify the technology in Europe, since fuel prices are higher and labor costs are lower. For example, Heidelberger Zement in West Germany has been burning tires in cement kilns since 1978. They have utilized as much as 50,000 metric tons per year in 6 plants. Generally, the proportion of tires is kept below 20% of the Btu input of fuel to each plant. Improvement in kiln performance has been observed with more stable operation. Monitoring of air pollution from the kilns indicated there was no problem. DOE held an exchange meeting on the use of scrap tire fuel for cement kilns in Chicago in 1984, which discussed cement producers' experiences up to that time (item 7 in Bibliography).

2. STATUS OF IMPLEMENTATION

In the United States there are currently only two cement plants which are burning waste tires in their kilns. The Genstar Cement plant in Redding, California started test burns of tire chips in 1983. In 1986, the plant began burning tire-derived fuel on a commercial basis. The Arizona Portland plant in Rillito, Arizona is currently perfecting their tire fuel feeding system in a series of trials. These plants' operations are described below.

EXHIBIT IV-1

CEMENT MANUFACTURE



(1) Genstar

Genstar Cement Company's Calaveras cement plant is located in Redding, California, north of Sacramento. They are currently burning 1 ton per hour of tire-derived fuel in their kiln. The waste tire fuel they buy consists of 2-inch chunks which are shipped to them by truck. These chunks still contain the steel from the tire beads and belts, which are beneficial to the kiln operation. Most truckloads of 2-inch pieces weigh approximately 25 tons. They obtain the tire-derived fuel from the Sacramento area, and the trucks pick up lumber in the Redding area to haul back.

In the present arrangement, the Genstar kiln gets 10% of its Btu input from the tire-derived fuel. The tire pieces are fed into the lower end of the kiln (the hot end). The remaining 90% of the fuel value is natural gas, which is fed into the upper end of the kiln (the cold end). Genstar has developed an auger feeder arrangement to feed the tire pieces into the kiln. It utilizes a variable speed screw and an elevator.

Before Genstar burned tires, they used to burn 10% coal and 90% natural gas. With the auger arrangement, Genstar has found that feeding tire pieces to the kiln is easier than feeding coal. Genstar prefers the tire pieces to whole tires because it would require an expensive handling system to accommodate whole tires.

One advantage found by Genstar in burning tires is that they no longer have to add iron ore to their cement. The tire pieces contain iron from the steel beads and steel belts. This iron accomplishes the same purpose as the iron they would have added, and their iron ore consumption has been cut in half. They would have had to pay $18/ton for adding the iron ore. Not having to purchase the iron ore has saved approximately $50,000 per year. In summary, Genstar has been pleased with the results of using tire-derived fuel and plans to continue using it.

(2) Arizona Portland

Arizona Portland's cement plant is located in Rillito, Arizona near Tucson. They have recently begun trials of burning tire chips in their cement kiln. The configuration they tried is different from Genstar's. They feed tire pieces into the calciner using an air lock mechanism. They tried feeding 4 tons/hr of tire pieces into the kiln or approximately 100 tons per day. In some test runs they successfully fed the tire pieces for up to 3 days. However, they had problems with tire pieces jamming the air lock. They have been able to alleviate the problem somewhat by using 2" x 2" tire pieces instead of 4" x 4". They also plan to try the air lock with rubber edges to see if this prevents the pieces from getting caught in the air lock. They plan to make trial runs with this modified configuration in May 1987. If it works well, they plan to burn 100 tons/day of tire pieces in their kiln.

In their most recent trials of the system, Arizona Portland has obtained 300 tons of tire pieces from the City of Tucson, which operates a nearby landfill. The City of Tucson has a shredder which produces 2" x 2" pieces. To dispose of the shredded pieces, the City of Tucson provides them to Arizona Portland at the cost of freight, without charging for the pieces themselves. This is likely to be a continuing supply because the City of Tucson has 10,000 tons of tires. In earlier test runs Arizona Portland had also acquired 2,000 tons of tire pieces from the City of Phoenix.

Before the trials of tire burning, the Arizona Portland plant had been burning coal to get 90% of their Btu value. The remaining 10% comes from natural gas which tends to stabilize the combustion. In making cement they have been adding iron ore. The trial runs with tire pieces have not indicated any differences in the cement produced.

As discussed above, the burning of waste tires in American cement kilns has just begun in recent years. The U.S. installations to date have both used tire pieces rather than whole tires. This has simplified the handling situation at the cement kilns and obviated the need for a capital investment in expensive whole tire handling equipment. Both cement producers who have tried tires have realized a substantial cost savings per ton over using coal. The early results from Genstar and Arizona Portland seem promising, and further growth of cement kiln utilization would appear likely.

3. ECONOMICS OF A FACILITY

The economic feasibility of burning waste tires in cement kilns depends on replacing coal at a much lower cost per ton. Only this substantial cost savings will justify a cement producer's installation of tire fuel handling equipment and performing the test burns necessary to make a successful adjustment of his operating parameters.

As in all tire utilization ventures, we can get a rough idea of the economics by looking at the equation for the profit per tire. In this case, we will look at it from the point of view of a cement producer contemplating whether to use tire fuel instead of coal.

$$P = F + R - C - T - D$$

In a typical case of a cement plant using tire chips:

F = 0, the tipping fee, since both U.S. cement plants that have tried tires have the tire pieces trucked to them.

R = \$.30. If coal costs \$30/ton, and the tire fuel is provided without charge, the revenue is in the form of a saved cost. **R** is the cost saving per tire from burning tires instead of coal, which is \$.30 per tire, from the rule of thumb of 100 tires per ton.

C = 0. Generally, it is about as difficult to feed coal as tire pieces, in terms of the commitments of labor and materials. Some operators think that tire pieces are easier.

T = \$.01, the transportation charge. **T** will vary greatly depending on the distance, the type of carrier, and the local supply and demand. With the rule of thumb of 1 mill per tire mile and an assumed distance of 10 miles, T = \$.01.

D = 0, typically for a cement kiln. There is no waste product. The tire is consumed completely -- bead, steel belts, and all. The solids wind up in the cement clinker.

Substituting these values in the tire profit equation, we have

$$\mathbf{P} = 0 + \$.30 - 0 - \$.01 - 0 = \$.29$$

In this case, the cement maker would realize a profit of \$.29 per tire. If he burned 100 tons of tires per day, he would have an annual profit of about \$1 million.

If the cement maker had to spend \$2 million for modifications to his plant to burn tires, the payback period would be

$$\text{Payback Period} = \frac{\$2 \text{ million}}{\$1 \text{ million}} = 2 \text{ years}$$

This is a short payback period, and a cement maker would be inclined to make the capital investment.

However, if the supply and demand situation were different, and the cement maker had to pay \$28/ton for tire-derived fuel, the economics would be changed. In this case R would be only \$.02 per tire. This would make the profit per tire \$.01 and the annual profit \$37,000.

For this second case of \$28/ton tire-derived fuel, the payback period is

$$\text{Payback Period} = \frac{\$1{,}000{,}000}{\$37{,}000} = 27 \text{ years}$$

In this case, the payback period is far too long and no cement maker would make modifications to his plant with the expectation of this little profit per tire.

In summary, the economics of burning tires in cement kilns depends on the price of tire-derived fuel (unless the kiln can burn whole tires), the price of the competing fuel (usually coal), and the capital investment needed to modify the cement kiln feed system. This again shows the importance of long-term supply contracts to obtain tire fuel at a suitably low price for a long period of time.

4. ADVANTAGES

As discussed above, there are various advantages to burning waste tires in cement kilns. The main advantage is the environmentally safe disposal of the tires. The temperatures in cement kilns are hot enough to give complete combustion of the tire without harmful emissions. The cement kiln combustion also eliminates any solid ash constituents that would be left over, since they are absorbed in the cement instead. The extra advantage for the cement operations that would normally be adding iron ore is that the tires already contain iron from the beads and steel belts. As far as the cement producer is concerned, the main advantage is that tires are a less expensive fuel than coal.

5. CONSTRAINTS

The main constraint to implementing the burning of tires in cement kilns is the economics. If a cement plan can already obtain coal very cheaply and if the transportation costs for obtaining tire-derived fuel are very high, then the plant will probably continue to burn coal. The situation is very site-specific.

The cement plants vary widely in the amount of capital investment necessary to modify the handling equipment for tires. If the plant is already set up to burn coal, the modifications to burn tire-derived fuel may be of the order of several hundred thousand dollars. If a plant installs a whole tire handling system, the cost will be well over a million dollars. Whole tire burning is more difficult in U.S. kilns than in Europe, where suspension preheater kilns are often used. Approximately 10% of U.S. cement kilns have suspension preheaters. Many U.S. cement firms have suffered losses in recent years and are not planning to make any capital investments in the near future. Only those cement plants that are running profitably and can foresee short payback periods are likely to make the investments.

The siting of many tire utilization facilities is difficult, because the entrepreneur must gain the acceptance of the community around the plant. This is generally easier for a cement plant which is generally located in an industrial area. The burning of tire-derived fuel to replace some of the coal is unlikely to cause any noticeable effect on the surrounding community.

VI. ENVIRONMENTAL CONSIDERATIONS

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In conclusion, the use of waste tires as a fuel for cement kilns appears promising. This has been done for many years in Europe, and the techniques are starting to be adopted in the U.S. The penetration of tire utilization in the cement industry is likely to be driven by site-specific economics with tires used as a supplemental fuel.

V. TIRE-DERIVED FUELS

V. TIRE-DERIVED FUELS

One possibility for utilizing scrap tires is the procedure which transforms the waste tires into tire-derived fuel (TDF). Briefly, TDF is used as a supplemental fuel in boiler operations, and it burns very much like coal. (It actually has a higher Btu/lb value than coal.)

1. DESCRIPTION OF TECHNOLOGY

A basic definition of TDF is scrap tire rubber which is ground into small rubber chips suitable for incineration processes. The exact size of the chips, as well as whether bead and radial wire are removed, are decisions based on the user's needs. The category of user which is most receptive to using TDF is an industry that operates a boiler that uses lump coal on a grate. The user should also be equipped to deal with the steel fragments which TDF may contain. Steel content can be an asset in cement kilns (see Part IV), but this is not necessarily the case for other end users. Industrial consumers that burn lump coal are already well equipped with pollution control devices. Industries which have used TDF in the past include the pulp and paper and the cement industries. Another identified user group is institutional boilers such as universities which use TDF to supplement heating fuels.

Even when TDF customers have been identified and persuaded to purchase TDF, a major portion of a TDF producer's profitability will depend on the tipping fee received on tires collected. Thus, a successful TDF firm must be in an area where TDF is marketable and where tipping fees are at adequate levels.

2. ECONOMICS OF A FACILITY

(1) Marketability

There does exist a significant potential market for TDF. The success or failure of a TDF producer obviously depends on the ability to reach that market as well as having an adequate supply of tires with which this demand can be met. There are several key factors which have a tremendous impact on the marketability of TDF.

- Adequate Supply

  Clearly, no TDF business can be considered viable if it lacks an adequate supply stream of waste tires. Furthermore, end users of TDF will require some assurance that the supply is adequate before retrofitting their equipment to burn TDF. Early users of TDF were frustrated by occasional supply constraints.

- Price Competitiveness

  The price of TDF must be far enough below that of the existing fuels, such as coal, in order to induce users to take the necessary steps for the burning of TDF. Some retrofitting will usually be required. A significent price difference will be required to justify any capital investment.

- Environmental Controls

  A TDF producer should identify potential customers as industrial consumers of fuels, such as coal, that have boilers already equipped with pollution controls. The extent to which pollution protection devices exist is directly related to the proportion of TDF which can safely be included in the fuel mixture. The most promising potential customer is one that burns lump coal on a grate.

- Quality of Product

  A successful TDF producer must have the ability to tailor his product to meet the customer's requirements. That is, once adequate supply and demand are present, the TDF must be in a form which is useful to the user. This might include the ability to remove all non-rubber elements from the tire as well as the ability to grind the rubber into chips of an appropriate size for a particular boiler operation.

(2) Profitability

Once the presence of a market has been identified, and assuming that market can be tapped, the income/expense framework would include the items listed below. Obviously, if this income/expense framework fails to provide adequate profits, no entrepreneur will start a TDF venture.

The equation below may be used to estimate the profitability of a TDF business venture.

$$\mathbf{P = F + R - C - T - D}$$

where

P is the **profit** per tire

F is the tipping **fee** collected per tire

R is the **revenue** per tire received from TDF customers

C is the processing **cost** for producing TDF and general plant overhead

T is the **transportation** cost per tire to bring in tires when necessary

D is the **disposal** cost for waste products

Outlined below is an example of how profit per tire would be calculated. Assumptions are based on a hypothetical TDF plant processing 1 million tires per year.

F = \$.75, an estimate of tipping fees. The actual tipping fee will depend on the operating environment, such as how many other processors are accepting tires in the area.

R = \$.25, based on a TDF sales price of \$25 per ton.

C = \$.40, an estimate of cost per tire for operations, maintenance, and labor.

T = \$.05, in order to ensure a steady flow of tires it may be necessary occasionally to transport tires into the facility.

D = \$.10, some end-users require their TDF to be free of all non-rubber parts such as radial cord. These materials must be disposed of in some way such as burial.

This example would result in a profit of \$.45 per tire. Thus, for a 1 million tire per year facility, this comes to \$450,000 per year. The payback period on this project, assuming an initial capital investment of \$1 million, is calculated below.

$$\text{Payback Period} = \frac{\$1 \text{ million}}{\$.45 \text{ million}} = 2.22 \text{ years}$$

A payback of 2.22 years is attractive. But note that the riskiness with regard to the cash inflows somewhat taints the attractive payback. First, 75% of the revenues in this analysis are from tipping fees; these are often called "front end" revenues, whereas the actual sales of TDF are "back end" revenues. Therefore, one would want to examine the waste tire accumulation rates in an area to be reasonably assured of future tire inflows. Furthermore, TDF marketability is determined by the market price for more conventional fuels, such as coal. Thus, the profitability of a TDF operation is rather suseptible to the market swings in prices of the competing fuels.

It should also be noted, however, that the prices of shredding machinery used in a TDF plant cover a rather wide range. Mobile tire shredders can be obtained for under $10,000. Larger commercial shredders, applicable to the scenario described above, can range from $200,000 to $500,000, depending on the rate of throughput desired. Thus, the revenue risks could be significantly hedged by going with a lower-end machine. The above example used a mid-range machine cost of $300,000.

3. ADVANTAGES OF TDF

The advantages of TDF are similar to those in any waste-to-energy operation. The process eliminates an unwanted accumulation and produces a benefit simultaneously. TDF, as well as other tire-burning technologies, holds an advantage over rubber recycling in terms of the quality of the end product. Up until now, recycled rubber has possessed somewhat inferior physical properties, whereas the heat value a tire possesses is more generic. The steam produced by burning tires works just as well as steam from burning coal. When the user of TDF is already equipped to burn lump coal, the initial investment to burn TDF is at or near zero.

4. CONSTRAINTS OF TDF

There are various site-specific constraints on the TDF business, both for the TDF producer and the user. These must be taken into account in assessing the viability of a potential TDF operation.

(1) Siting

As described in the section on TDF's economics, siting is crucial to the success of a TDF operation. The cost of real estate for the site, proximity of TDF customers, and local availability of waste tires all weigh heavily in the success or failure of a TDF business.

(2) Community Acceptance

As with any technology which burns tires, community acceptance can be problematic. The notion of TDF conjures a mental picture of the open burning of a tire in the minds of many, with the associated smoke and odor. In the case of TDF, the task of gaining community acceptance falls mostly upon the TDF customers.

*   *   *   *   *

In summary, TDF is one of the ways to put waste tires to productive use. As with any business venture, however, the relevant factors must be researched thoroughly. This is particularly true with TDF as there can be a great deal of variance within these factors since so many are site-specific. It is estimated that 50,000 tons of TDF are now sold annually, generally as a substitute for coal or wood fuels.

VI. ENVIRONMENTAL CONSIDERATIONS

There are various environmental considerations that are part of the waste tire situation. Probably the most severe environmental impact is associated with the status quo, as waste tires continue to accumulate around the nation year by year. Each tire utilization method has its own environmental parameters. In general, these utilization options will improve the environment by reducing the waste tire buildup.

1. ROLE OF EPA

Waste tires are a nonhazardous waste. As such, they are covered under Subtitle D of the Resource Conservation and Recovery Act (RCRA). According to 40CFR Part 257, Criteria for Classification of Solid Waste, Disposal Facilities and Practices, the operators of waste tire stockpiles, as well as other nonhazardous waste facilities, are responsible for taking proper precautions to prevent fires and to control infestations of mosquitoes or rodents.

As one would expect, the nonhazardous wastes, such as tires, have had a lower priority within EPA than the hazardous wastes. In 1984, the Hazardous and Solid Waste Amendments to RCRA were enacted, which require EPA to submit a report to Congress examining the adequacy of the criteria for nonhazardous wastes. A section on waste tires will be included in this Subtitle D Report which EPA will submit to Congress in November.

2. LANDFILL RESTRICTIONS

EPA's Phase 1 Report under Subtitle D was published in 1986. The report discussed the general situation on disposal of nonhazardous waste, without particular attention to waste tires. The report noted that a critical landfill shortage is developing in the U.S., especially for metropolitan areas on the east coast.

Because of the landfill shortage, many landfills will no longer accept waste tires unless they have been split or shredded. Those landfills that do accept waste tires are likely to charge a higher tipping fee for them because they are classed as a "hard-to-handle" waste.

For instance, the Los Angeles landfill charges $7/ton as the tipping fee for ordinary refuse, but they charge $10/ton as the tipping fee for whole tires. If the tires are split or shredded, the tipping fee is reduced back down to $7. The higher tipping fee for whole tires compensates the landfill operator for the additional work that must be done in burying whole tires so that they don't rise up again. This requires distributing the load of tires throughout the landfill, mixing them with other wastes, and covering them over. Even with all this extra care, the tires still occasionally work their way up through the landfill because of buoyant forces and then become uncovered again. Even if the tires stay buried, they do not biochemically degrade much.

3. PREVENTION OF TIRE FIRES

In recent years there have been fires at large tire stockpiles near metropolitan areas in the states of Florida, Texas, Virginia, and Washington. These fires were very hard to extinguish and burned for several months causing large volumes of noxious black smoke. Tire fires generally leave behind toxic oils caused by the pyrolysis of the tires. Tire fires may require millions of dollars for preventing groundwater contamination and restoring the site.

Clearly, the operators of tire stockpiles must take proper precautions to prevent tire fires. Generally, this involves providing fire lanes between the segments of the tire pile. It is also necessary to provide surveillance to keep sources of flames away from the tires, particularly guarding against arsonous intruders. Operators of tire stockpiles often provide security measures such as watchman, guard dogs, chain link fences, and bright lighting at night. Operators have also considered the possibility of watch towers with infrared observation equipment.

Some of the better prepared tire piles have also provided emergency water supplies for fighting potential fires. Fire hydrants have been provided at strategic locations, connected to the emergency water supplies.

4. CONTROL OF MOSQUITO PROBLEMS

Waste tire piles can serve as habitats for mosquitoes or rodents. The former is a much more severe problem.

Tires which are piled outdoors will collect rain water. Because of the shape of the tires this tends to happen no matter what orientation the tire has in the pile — vertical, horizontal, or angled. These small ponds are ideal places for mosquitoes to lay their eggs. If plant material, such as leaves or grass, blow onto the surface of these small ponds they provide nutrients for the mosquito larvae ("wrigglers") that hatch from the eggs. The dark color of the tire absorbs sunlight and provides warmth for rapid development. After a cocoon-like pupa stage, the mosquitoes emerge as adults, capable of carrying diseases and biting humans.

The U.S. Public Health Service's Center for Desease Control (CDC) has made extensive studies for mosquito-borne diseases. They have found four tire-breeding mosquito species to be of importance.

- Culex pipiens transmits the St. Louis encephalitis virus.
- Aedes triseriatus transmits LaCrosse encephalitis, a neurological disease especially affecting children.
- Aedes aegypti transmits dengue fever, also known as "breakbone fever".
- Aedes albopictus is called the Asian tiger mosquito because of its aggressiveness in attacking humans. CDC's surveillance indicates that this mosquito has recently come to the U.S. and was possibly imported in shipments of used truck tires from the Orient. The Asian tiger mosquito carries both LaCross encephalitis and breakbone fever. It also carries other dengue viruses that were heretofore only prevalent in Asia, including the one that causes dengue hemoragic fever.

Because of the mosquito infestation problem and the mosquito-borne diseases, it is essential that proper actions are taken on the waste tire problem. Three types of actions would appear to deter the mosquito problem.

- Utilize or Landfill the Tires

  These would appear to be the only long term solutions.

- Keep the Tire Stockpiles in Appropriate Areas

  The tire pond storage area in the abandoned quarry would appear to offer full protection against mosquito infestation. Similarly, the storage of tires in arid areas, such as deserts, where they would be unlikely to accumulate rain water would be helpful.

- Treat the Tire Piles with Insecticides

  EPA has developed a list of insecticides which would be appropriate against mosquitoes. This list is presented in Exhibit VI-1. Unfortunately, the effective application of insecticides is expensive and labor intensive.

The mosquito problem is one of the main environmental considerations in dealing with waste tire problems.

5. AIR POLLUTION REQUIREMENTS

Those tire utilization systems that involve combustion generally have to meet air pollution limits of both U.S. EPA and the particular state's

EXHIBIT VI-1

COMMONLY USED MOSQUITO CONTROL MATERIALS

MATERIAL	QUANTITY USED* (approx.)	USE**
Oils (GB, Flit MLO, etc.)	338,300	L
Bti	237,200	L
Dursban (chlorpyrifos)	231,800	L some A
Abate (temephos)	182,400	L
Malathion	152,900	A some L
Altosid (methoprene)	146,900	L
Baygon (propoxur)	61,000	A
Dibrom (naled)	26,900	A
Baytex (fenthion)	17,200	A some L
Pyrethrins	12,500	L & A
Pyrethroids	7,800	A
Methoxychlor	1,200	L
Parathion	800	L
M-parathion	100	L

These are 1984 data from the Vector Control Information Network, a nationwide survey of mosquito/vector control agencies. It should be recognized that there is considerable variation in the relative amounts used in different parts of the country. California, for example uses more m-parathion that parathion, naled, methoprene, pyrethrins, pyrethroids, or temephos. There are a number of other materials listed in EPA files for mosquito control, but they are no longer used or there use is very minor.

* Oils in gallons; Bti in biological unites; other insecticides are in pounds active ingredient.

** L = larvicide, A = adulticide

environmental regulations. Usually these require that the tires be burned at high temperatures above 1800°F to get complete combustion and destroy various noxious effluents.

Generally the criteria for pollutant levels apply to five main effluents:

- sulfur dioxide
- oxides of nitrogen
- carbon monoxide
- unburned hydrocarbons
- particulate

The emissions from the Modesto tire-fired power plant are expected to meet all pollutant limits, based on the experience with the same technology in West Germany. The environmental specifications of the Modesto plant were presented in Exhibit III-3.

6. ASH PROCESSING

A tire-fired power plant such as the Modesto facility will typically give rise to four kinds of solid waste products -- fly ash, gypsum, slag, and bottom ash. The methods of dealing with these four products will be discussed below.

(1) Fly Ash

The incinerator of the Modesto unit is being equipped with a fabric filter unit to remove particulate generated from the combustion process. The fabric filter will collect a fly ash which is expected to contain a large percentage of zinc oxide. Since zinc is valuable, it is expected that the fly ash can be sold as a byproduct. If it cannot be sold, it will have to be sent to an appropriate facility.

(2) Gypsum

The scrubber for the Modesto plant will utilize a forced oxidation system. Such a system produces gypsum as a final product instead of scrubber sludge. The gypsum is stable and easily handled. It can be sold as an ingredient for manufacturing wallboard. If no suitable buyers can be found, the gypsum can be landfilled.

(3) Metal/Ash

The metal/ash from the incinerator will contain the steel from the tire beads and belts as well as other non-combustible material. About 4,000 cubic yards of metal/ash per year are expected to come from the Modesto plant. It is expected that the metal/ash will be sold or landfilled.

(4) Bottom Ash

Very little bottom ash will be generated by the Modesto incinerator. It is planned that the bottom ash will be reinjected into the furnace, where it may burn or come out as slag or fly ash.

As discussed above, the Modesto power plant has methods for dealing with the four kinds of solid waste byproducts. Any combustion technology for waste tires should have similar plans.

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Environmental considerations must be taken into account when dealing with the waste tire problem. These concerns must be addressed whether the tires are utilized or continue to accumulate.

VII. SITING CONDITIONS IN THE STATES/REGIONAL CONSIDERATIONS

Generally, the states are well aware of, and quite concerned about, the accumulation of scrap tires in their respective domains. This concern encompasses both illegal dump sites and legal stockpiles. There has been wide press coverage of various fires at waste tire stockpiles. There has also been concern over mosquito proliferation. These have sparked widespread state interest in waste tires, particularly within those states with direct experience with these sorts of unfortunate occurrences. However, for the most part, the states are in the research stage.

The typical state approach has been to study the problem while the search for an adequate solution continues. The solution most eagerly awaited is for a commercially viable, environmentally safe industry (or industries) to emerge that can eliminate an environmental danger while increasing economic activity in the state at the same time. Until these industries prove themselves viable, most states confine their activities to identifying and cleaning up illegal stockpiles and regulating known stockpiles to safeguard against catastrophic accidents.

1. STATE INITIATIVES

There have been two notable leaders among the states -- New Jersey and Minnesota. They have sought to meet the waste tire challenge head on. Many of the other states remain in their "wait and see" posture, keenly watching what occurs in these pioneer states.

(1) New Jersey

New Jersey has been a front runner in the area of solid waste recycling, used tires being a significant portion of their general solid waste problem. Faced with an increasingly limited landfill capacity, the state opted to reduce its levels of solid waste via recycling rather than seek out new landfill sites. In 1981, the state implemented the New Jersey Recycling Act. The Act established a fund to provide grants to municipalities and non-profit groups to start recycling programs. It also provides low-interest loans to new recycling business ventures. The fund is financed through a surcharge placed on all solid waste dumped at New Jersey landfills. The amount of the surcharge is currently at $0.46 per ton of solid waste; it will increase to $1.50 per ton on July 1, 1987.

The surcharge serves a dual purpose. On the one hand the money collected is channeled to set up new recycling centers. Once these recycling centers are in place, the surcharge will serve as a disincentive to dumping recyclable solid wastes at landfills.

The New Jersey Department of Environmental Protection's Office of Recycling has been meeting extensively with companies proposing start-up operations in New Jersey. Given New Jersey's commitment to initiate recycling programs as well as the high number of scrap tires generated there, tire utilization businesses should find New Jersey to be an attractive site for their plants.

The first major example that New Jersey's positive steps are attracting these new businesses has appeared. Oxford Energy, the leading U.S. developer of tire-to-electricity projects, has announced plans to build a tire incineration project in New Jersey. The facility will be able to generate 27 MW of electric power by incinerating scrap tires. Oxford has options to obtain two potential locations for the facility and is currently negotiating a power sales agreement with Atlantic Electric Company. Construction is expected to begin as early as 1988.

(2) Minnesota

Minnesota was one of the first states to recognize the tire disposal problem and to take steps toward curbing it. In July 1985, the state legislature passed a ban on landfilling of tires. In addition, stockpilers with inventories in excess of 500 tires were required to obtain permits as a means of control. Recently, there have been moves to extend the permitting program to include all players in the waste tire arena. Sometime this year it is expected that a state law will be passed requiring transporters and processors of waste tires to have permits as well.

The Minnesota program first sought to identify the waste tire stockpiles. Second, the identified stockpiles were prioritized in order of greatest potential hazard. As of the date of this report, legal actions have been taken against the top 14 stockpiles, which account for 3.7 million tires, on the list. The owners of the stockpiles must submit a plan or schedule for clean-up. As most piles were in existence prior to the date the law was passed, November 21, 1985, Minnesota will usually partially reimburse stockpile owners for the clean-up cost. Generally, the state pays for transportation and any tipping fees applicable while the stockpile owners are responsible for loading and unloading.

One of Minnesota's initiatives was in the form of a user-tax to finance the tire program. A tax of $4.00 is assessed to the transfer of a vehicle title. Part of the funds collected are channeled to the researching of possible solutions. In addition, some of these funds are loaned to new business ventures that utilize technologies that process scrap tires. These loans carry below-market interest rates to reduce the risks associated with a brand new industry.

Not surprisingly, some of the most closely watched start-ups are centered in Minnesota. Of particular interest are the efforts of Rubber Research Elastomerics, Inc. (RRE). RRE was the recipient of a half million dollar award from the Minnesota Waste Management Board to be put toward a tire processing plant in Babbitt, Minnesota. The facility could potentially process 3 million tires per year.

The facility utilizes RRE's patented Tirecycle® technology. Basically, Tirecycle® refers to the process of specially treating ground scrap rubber obtained from old tires. According to RRE, the special treatment gives the scrap rubber improved physical properties which have been lacking in prior recycled rubber applications. The treated scrap rubber is then mixed with rubber compounds in varying proportions depending on what the needs of the particular end product are.

In conjunction with the new plant, RRE has been promoting their "Home on the Range" ad campaign. The "Home" in this case refers to a resting place for discarded tires. Whereas most disposal centers assess a fee for accepting people's old tires, RRE is accepting tires free of charge. Currently, those who wish to avail themselves of this outlet must first arrange for an appointment. To date, the stockpile has accumulated amounts of 40-50,000 tires.

2. OTHER CONSIDERATIONS

The environmental problems which tire stockpiles represent are sufficient incentive for adopting state initiatives to deal with the problem. However, the tire problem is a unique situation in that it offers the possibility for a "win-win" solution from the legislator's point of view. That is, the tire disposal problem can be eliminated without a cost to taxpayers if viable waste tire businesses get started. Furthermore, successful new businesses represent new sources of tax revenue for states that host them.

The potential benefits do not end there. There is a "multiplier effect" of sorts at work here. The new businesses create new jobs, which create more tax revenues, more economic activity, and an increase in disposable income.

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If the progressive programs being initiated in these states prove successful in terms of eliminating waste tires while generating business activity, there will be many other states eager to implement similar programs.

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