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WASTE TIRE RECYCLING BY PYROLYSIS
Energy Task Force
Of the Urban Consortium
For Technology Initiatives

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PREFACE

YEAR 11 ETF PUBLICATION

The Urban Consortium for Technologies (UC) is composed of over forty of the largest cities and urban counties by population in the United States. The Consortium provides a unique forum to define urban problems common to its member governments and to develop, apply transfer and commercialize technologies and innovative management techniques to address those problems.

The Urban Consortium conducts its work program under the guidance of Task Forces structured according to the functions and concerns of local governments. The Urban Consortium Energy Task Force (UCETF), with a core membership of 20 large cities and counties, was formed in 1979 to help improve urban energy management decision-making through applied research and technology transfer. The UCETF focuses on developing and sharing new approaches and innovative solutions to energy management problems with interested local governments. Projects with similar subjects are organized into Units with each unit managed by a selected Task Force member.

A description of the Units and projects included in the 1990 program are as follows:

ALTERNATIVE VEHICLE FUELS

Alternative vehicle fuels offer a very strong potential to aid in the reduction of US dependence on foreign oil supplies, with the concomitant benefits of decreased air pollution in urban areas. Local governments can play an instrumental role in realizing this potential through practical applied research and highly visible demonstrations for alternative fuel and technology options. Projects in this topic area place a strong emphasis on the examination of all potential alternate fuels with support from teaming and partnership activities among cities and counties, utilities and other relevant private sector organizations that have matching interests. The 1990 Alternative Vehicle Fuels unit consists of:

Albuquerque, NM -- *Alternative Fuel Vehicles in Municipal Duty Cycles*
Broward County, FL -- *Dual Fuel Conversion Demonstration*
Detroit, MI -- *Assessment of AFV Availability to Meet Emergency Contingency Planning and Long Term Public Fleet Integration*
Denver, CO -- *Alternative Fuels and Transportation Management Associations*
Houston, TX -- *CNG Fueled Vehicle Comparison*
New York, NY -- *Alternative Transportation Fuels: Infrastructure Issues*
Pittsburgh, PA -- *Compressed Natural Gas as an Alternative Vehicle Fuel*
San Diego, CA -- *Siting Alternative Fuel Filling and Maintenance Stations*

ELECTRICITY MANAGEMENT

Energy costs can place a severe burden on residents and limit economic growth for both energy-intensive industries and the vital small business sector that provides the majority of today's employment opportunities. Urban governments, therefore, need to have the ability to manage both the use and demand for electricity supplies. The emphases on the 1990 electricity management projects include attention to broad issues of electricity cost as an economic factor in commercial development decisions, procedures for the design of major new public facilities, and the feasibility of emerging decentralized and/or alternative sources of electrical energy. This 1990 unit consists of:

Chicago, IL -- *Central Station DHC Phase I Feasibility Analysis*
Columbus, OH -- *Electricity Demand Impacts of New Indoor Air Quality Standards*
Dade County, FL -- *Global, Automated Urban Government Energy System (GAUGES)*
Detroit, MI -- *Hydraulic Waste Energy Recovery City of Detroit Water Distribution System*
Kansas City, MO --*Use of Cogeneration System to Control Electrical Demand*
Montgomery County, MD -- *Integrated Energy Planning for a New Detention Center*
New York, NY -- *Strategies to Reduce Electricity Cost in New Commercial Construction*

ENERGY, ENVIRONMENT AND ECONOMIC DEVELOPMENT

Today's urban centers face critical and continuing problems that constrain their ability to provide affordable housing, to reduce congested highways, and to improve air quality, waste management, and economic development. The efficient use of energy and the development of alternate, clean energy resources can help address these broad community problems and contribute significantly to achieve truly sustainable, environmentally responsible, and economically viable communities. This unit, therefore, deals with community problems, from affordable housing to alternate clean energy resources. Urban strategies to improve energy-sustainability will require attention to both broad based institutional changes, as well as specific projects designed to encourage the application of appropriate technology and community development practices. This 1990 unit consists of:

Phoenix, AZ -- *Impact of Heat Islands on Cooling and Environment*
Los Angeles, CA -- *Heat Island Mitigation*
Pima County, AZ -- *Tucson Solar Village*
Portland, OR -- *The Sustainable City: Phase II*
San Jose, CA -- *The Sustainable City: Phase II*
San Francisco, CA -- *The Sustainable City: Phase II*
St. Louis, MO -- *Pilot Program for Energy Efficient Mortgages*
Washington, DC -- *Energy Efficiency in Public Housing*

WASTE MANAGEMENT

Effective and environmentally sound waste management is a concern of local government that only promises to grow in its significance through the decade. Urban strategies for waste management are evolving into coherent approaches that integrate traditional collection and disposal practices with new emphases on waste source reduction, separation and isolation of hazardous wastes, and practical recycling procedures. This year's unit consists of:

Hennepin County, MN -- *Household Hazardous Waste Processing - Phase II*
Houston, TX -- *Solid Waste Integrated Cost Analysis Model: An Applied Decision Making Tool for Municipalities*
Memphis, TN -- *Sludge Storage Lagoon Biogas Recovery*
New Orleans, LA -- *Pyrolysis Disposal of Scrap Tires*
San Diego, CA -- *Mixed Plastics Recycling*
Seattle, WA -- *Evaluation of Hazardous Waste Management Programs*

Reports from each of these projects are specifically designed to aid the transfer of proven experience to other local governments. Readers interested in obtaining any of these reports or further information about the Energy Task Force and the Urban Consortium should contact:

Energy Program
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC 20004

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I. ABSTRACT

This project examines the City of New Orleans' waste tire problem. Louisiana State law, as of January 1, 1991, prohibits the knowing disposal of whole waste tires in landfills. Presently, the numerous waste tire stockpiles in New Orleans range in size from tens to hundreds of tires. New Orleans' waste tire problem will continue to increase until legal disposal facilities are made accessible and a waste tire tracking and regulatory system with enforcement provisions is in place. Tires purchased outside of the city of New Orleans may be discarded within the city's limits; therefore, as a practical matter this study analyzes the impact stemming from the entire New Orleans metropolitan area. Pyrolysis mass recovery (PMR), a tire reclamation process which produces gas, oil, carbon black and steel, is the primary focus of this report. The technical, legal and environmental aspects of various alternative technologies are examined. The feasibility of locating a hypothetical PMR operation within the city of New Orleans is analyzed based on the current economic, regulatory, and environmental climate in Louisiana.

A thorough analysis of active, abandoned, and proposed pyrolysis operations (both national and international) was conducted as part of this project. Siting a PMR plant in New Orleans at the present time is technically feasible and could solve the city's waste tire problem. Pending state legislation could improve the city's ability to guarantee a long term supply of waste tires to any large scale tire reclamation or recycling operation, but the local market for PMR end products is undefined. Before any large scale tire processing or reclamation operation will find it economically feasible to locate a plant in any state, the waste tire crisis needs to be addressed at the state level to provide such essentials as a reliable long-term supply, legal provisions for tire handling and storage, provisions for PMR plant siting and other logistical and economic factors.

II. INTRODUCTION

PROJECT PURPOSE

This project examines potential solutions to the waste tire situation in the New Orleans area and specifically developed a strategy for inclusion of a pyrolysis plant to produce recycled products from shredded tires. It is the result of work performed under a grant by the U.S. Department of Energy, administered by the Urban Consortium Energy Task Force. Responding to a national solicitation for energy-related proposals, the New Orleans proposal was the only one selected to evaluate pyrolysis as a potential solution for a local problem, transferrable to municipalities across the country. The following tasks were accomplished as part of this project:

1. Evaluate and discuss the alternative technologies for tire recycling and reclamation as applied to the New Orleans metropolitan area.
2. Evaluate supply and collection issues and methodology.
3. Research existing tire pyrolysis plants in the United States and abroad.
4. Develop site options for a pyrolysis plant.
5. Compute transportation means and costs to sites.
6. Solicit regional/industrial participation through the University of New Orleans Urban Waste Management and Research Foundation.
7. Examine market potential for pyrolysis end products.
8. Specify the operations of a pyrolysis plant.
9. Review potential environmental impacts.
10. Examine state and local waste laws.
11. Determine federal, state and local permit requirements.
12. Deliver final report to City Administration, City Council and Urban Consortium Energy Task Force.
13. Examine future evaluation and monitoring.

Working through these tasks has allowed the City to evaluate what can be accomplished at the local level and what should be addressed at the regional and state levels.

In Louisiana, the uncertain regulatory climate improved during the course of this project in response to legislative action in 1990 which led to development of draft regulations by the state Department of Environmental Quality. As an outgrowth of this project, staff and other city personnel joined the private sector in contributing to the state's process. A valuable transferable lesson stemming from this work is to cities located in states lacking comprehensive tire management plans. The importance of early participation in the creation of a state program by local officials should not be underestimated.

REPORT ORGANIZATION

This report is divided into the following sections:

<u>Section I</u>	Overview. This section discusses the national and local problems associated with waste tire disposal, and briefly summarizes the more acceptable solutions.
<u>Section II</u>	Local waste tire situation. The distribution and volume of waste tires are described. Local health problems are presented and the efforts - thus far - to eliminate waste tires are discussed. State legislation and regulation development are discussed.
<u>Section III</u>	Proposed state and national waste tire legislation.
<u>Section IV</u>	Scrap tire collection, storage and shredding. Site plant and associated economic data is provided.
<u>Section V</u>	Pyrolysis processes and site planning. Types of processes and reactors are discussed. A selected process is discussed in detail as are siting considerations.

Section VI Pyrolysis products and their markets. An economic feasibility analysis is given for the selected operation and a _pro forma_ developed for decision makers.

Section VII Summary. Actions taken to date are presented in the project summary. The summary highlights the accomplishments of this project and describes the major impediments to future progress.

Section VIII Recommendations.

Section IX Appendices.

SECTION I: OVERVIEW

A. GENERAL BACKGROUND

Mountains of tires of all types and sizes from many sources are looming all across America. Tires are not being recycled because the law of supply and demand makes disposal cheap and recycling expensive. Approximately 295 million tires are produced annually in the United States which must be disposed of in some manner or another. While this represents only 1% to 1.2% (by weight) of the total solid waste stream, used tires pose special disposal and reuse problems because of their size, shape and physical and chemical nature. It is uncertain exactly what percentage of landfill volume (space) these waste tires occupy, but since 74% of the existing landfills will close by the year 2000, we are obliged to begin conserving the precious space that remains. Unfortunately, almost 85% of the used tires generated annually in the United States are either stockpiled, landfilled, or illegally dumped and added to the two and a half to three billion tires presently blighting our landscape. Unless physically broken or shredded, tires cannot be reduced in size.

Tires from automobiles, and light and heavy trucks are the ones most frequently discarded and compose the vast majority of illegal stockpiles. Therefore, this study focuses on the options for legally disposing of scrap automobile and light and heavy truck tires.

Existing tire stockpiles represent significant threats to the environment and public health. Tires, when exposed to the elements, collect water regardless of the position in which they are placed. The black color increases a tire's heat storing capacity and makes an excellent incubator for mosquito larvae. Studies have indicated that mosquitos can breed up to 4,000 times faster in tires than in natural settings. Rats, water snakes, and other pests seek refuge in abandoned tire piles.

Landfilling is not a reasonable option for the capacity reasons described above but also because no matter how much the tires are compressed or compacted, tires eventually return to their original shape, float back to the surface and may disrupt or pierce the landfill cover, or become vector breeding grounds. The structure of a tire and its incompressibility causes it to occupy a great amount of space and further jeopardizes future use of landfill sites.

There is also a significant threat of fire from tire stockpiles. Waste tire piles often contain hundreds of thousands of tires. These piles catches fire it is almost impossible to extinguish the flames. When burned, each tire releases approximately 2.5 gallons of petroleum products. The trapped air pockets in waste tire piles allow them to burn for months, releasing a thick oil. This oil is considered a hazardous waste and may flow into nearby waterways and contaminate groundwater. The millions of dollars required to clean up a fire's aftermath can be another real concern for a state such as Louisiana with many waterways and shallow aquifers. Many states have already enacted legislation aimed at averting the tire crisis, while other states like Louisiana are just beginning to formulate regulations and recognize the extent of their tire disposal problem.

Traditionally, tire dealerships have accepted used tires from customers to build and maintain customer goodwill. Decreasing profit margins and fewer local disposal facilities have, however disrupted this practice. Tire dealers want to dispose of their tires at the least possible cost, and usually do not ask where the tire scrapper takes the tire for disposal. Moreover, the increased presence of low priced imported tires on the market and their longevity have decreased the number of new tires being sold.

Options do exist for the reuse of scrap tires, e.g., retreading, processed tire products, tire derived fuel, whole tire product uses, incineration and recycling through use of pyrolysis (advantages and disadvantages of the various waste tire options are presented in

Table 1. Recycling options other than pyrolysis represent uses that presently consume approximately 15.4% of the scrap tires generated in the United States. Figure 1 presents the current distribution of waste tires excluding tires diverted for the retread market. In this study, disposal through the use of pyrolysis technology will be explored as an avenue for addressing waste tire disposal in the New Orleans regional area. Pyrolysis technology was chosen because: (1) pyrolysis consumes a large amount of waste tires that meet the waste tire supply in Louisiana, (2) has claims of minimal adverse environmental effects, (3) results in a variety of end products.

Key Points Of Investigation:

A waste tire disposal method must not only remove waste tires from the refuse stream, but must also be compatible with the geography, economics and environmental concerns of an area. The following characteristics are key points to investigate when waste tire disposal alternatives are being explored:[1]

1. No adverse environmental effects.
2. Conservation of natural resources by recovery or replacement of non-renewable resources.
3. Minimum adverse affect on established industries, being consistent with reliable and ethical disposal objectives.
4. The commercial marketability of the end products.
5. Competitive economics requiring user disposal fee so that public support will not be necessary.

The universally favored methods of waste tire recycling are resale as used tires and the recapping of waste tires. However, for the purposes of this study a waste tire is defined as a tire which cannot be resold or recapped. The waste tire disposal problem is growing, in part, because fewer automobile tires are being recapped. The current distribution of waste tire inventory is presented in Figure I.

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[1] Report to the Minnesota Pollution Control Agency on "Scrap Tires in Minnesota", October 1985, p. 202, by Waste Recovery Inc., Portland, Oregon.

Figure 1

Current Distribution of Waste Tire Inventory

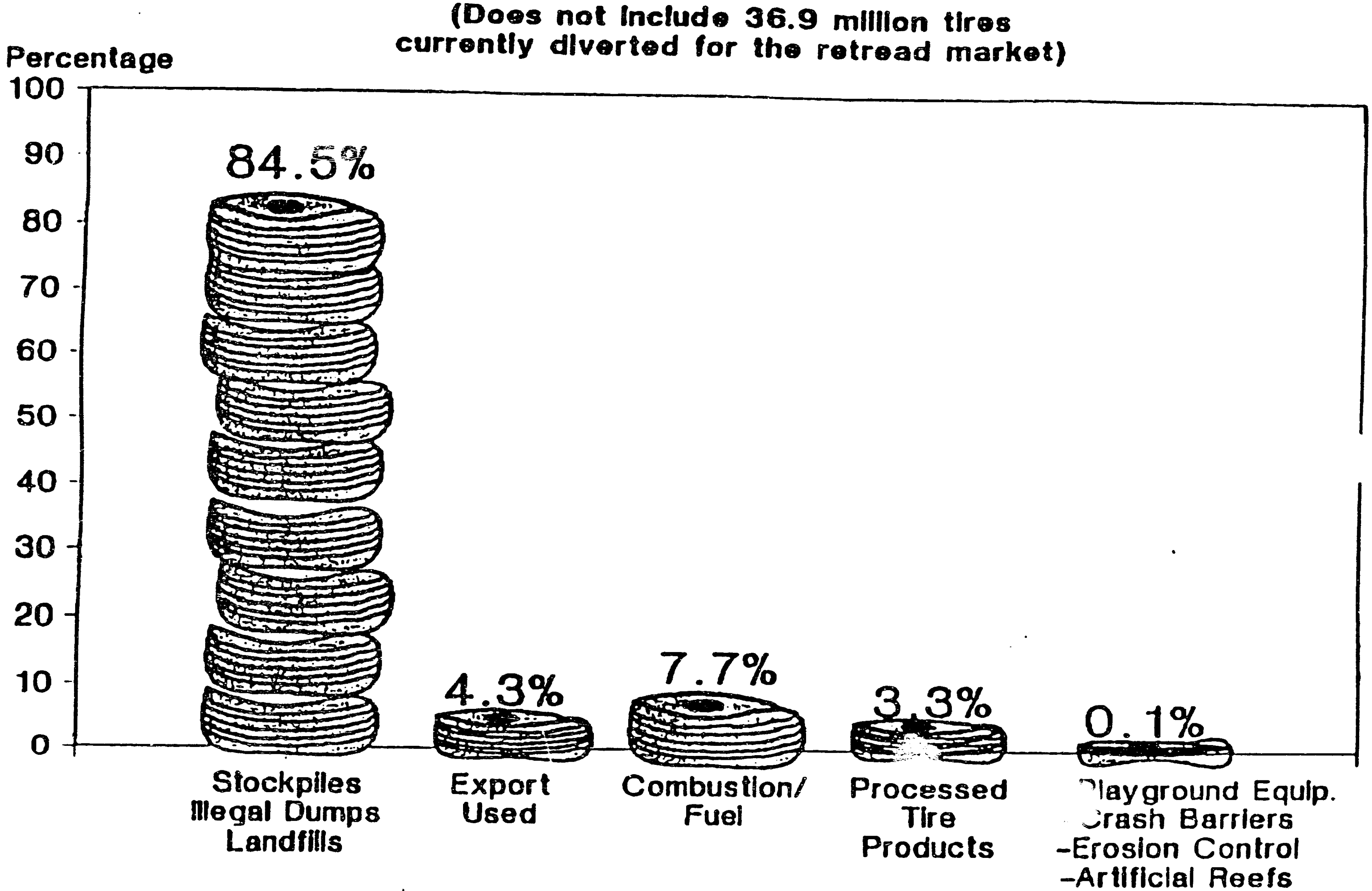

TABLE 1

Tire Recycling Options

OPTION	ADVANTAGES	LIMITATIONS
Retreading	Reduce source of pollution. Truck tires can be retreaded 7 to 9 times.	Easier to retread non-radial tires. Tires must be inspected carefully. Automobile tires are often too worn to be retreaded.
Processed tire products (Asphalt additives)	Extend life of roads; life cycle costs may make it more economical in the long run.	Patented processes have high costs. Lack of widespread experience with the products.
Whole Tire (Pier bumpers, Erosion protection mats)	Higher level of use. Rubber can be reused.	Supply far exceeds the potential use for entire, unserviceable tires.
Tire derived fuel	Can use up to 4.5 million tires per year. Supplemental fuel source.	Requires a continuous supply of tires and many communities resist new stockpiles of tires for feedstock. Potential air pollution problems. Economically viable only under certain circumstances.

Source: Tire Recycling Incentives Act. Congressman Esteban E. Torres.

B. ALTERNATIVE USES OF SCRAP TIRES

Recycling and Reuse:

Waste tires have various uses ranging from household garden planter boxes to artificial offshore reefs. Because the uses are so wide-ranging, this report will describe a sampling of the various waste tire recycling technologies and those companies marketing unique waste tire products.

Highway Lane Dividers

Mates Tire System, a Fairfield, Connecticut firm, licenses different technical waste tire applications for processes including sewage treatment, road culverts and drains, irrigation, hydroponics, aquaculture and agriculture. One particularly interesting design involves using waste tires inside large cement highway lane dividers. The hollow center provides a space to run water and gas pipes during road construction so the pipe is not exposed or does not have to be buried. Additionally, the tires provide cushioning support to protect the pipes from impact or movement.

Earthship: Waste Tires in Home Construction

Earthship is a new habitat design that creates a self-contained independent and ecologically sound living system. The design calls for beverage containers and waste tires to be recycled as building materials. Support walls are constructed by stacking earth-filled tires; non-support walls are made from aluminum cans. The finished home has an adobe look, but with all the benefits of alternative technology, durability and energy efficiency.[2]

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2 "Earthship" is published by High Mesa Foundation Press and can be obtained through Michael Reynolds, Solar Survival Architecture, Box 1041, Taos, NM 87571, (505) 758-8769.

Tires as a Bulking Agent in Sewage Sludge Composting

Adding tire chips as a bulking agent in sewage sludge composting maximizes air flow through the compost pile, and allows the amount of wood chips that are traditionally mixed with sewage sludge to be reduced. Tire chips are more expensive than wood chips, but 25 to 35 percent of the wood chips used in each batch degrade. The rubber chips are removed from the compost and can be reused. It was found that using tire chips increased the heavy metal content of the compost and high levels of zinc and iron were noticed, but these decreased each time the chips were reused.[3]

Another use is to add tire chips before yard compost is spread on garden beds to serve as subsoil drainage. Tire rubber has also been tested successfully as an absorbent for toxic materials such as lead, cadmium, zinc, and mercury from aqueous solutions.[4]

Terra Mat

Terra Mat is a method developed by the Terra Mat Corp. of Youngstown, Ohio for linking together waste tires to make road sub-base, temporary roadways, and earth reinforcement. Circular pieces of tire are overlaid and linked with metal fasteners. Terra Mat primarily uses 18 wheeler truck tires. Large truck tires do not easily fit into the traditional disposal options since shredding is difficult and tipping fees are much higher. This is, therefore, a good option to investigate for disposal

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3 Higgins, Andrew J., et. al., Shredded Rubber Tires as a Bulking Agent for Composting Sewage Sludge, EPA, May 1987, EPA/600/S2-87/026.

Pillsbury, Hope and Beachey, Jacob E., Markets for Scrap Tires, Presented at the First U.S. Conference on Municipal Solid Waste Management, p. 14, June 13-16, 1990.

4 Rowley, A.G. et. al., "Mechanisms of Metal Absorption From Aqueous Solutions by Waste Tire Rubber", Water, Res. vol 18, no. 8 pp. 981-984, 1984.

of large truck tires. Terra Mat was originally developed as a construction aid to help traverse swamp lands. Thus, this could be a possible aid in roadway construction in low lying areas such as Louisiana.[5]

Cryogenic Processing

Cryogenics is a reclamation process in which a material is frozen with liquid nitrogen. When using cryogenics with waste tires, the tires are first shredded into 4" to 6" pieces, then frozen and further shredded to separate the rubber, fiber, and steel. The large quantities of liquid nitrogen required to produce fine crumb rubber make the process prohibitively expensive at this time.

The uses for the almost pure rubber are many. Finely ground rubber dust is used to control oil spills on water. The rubber can also be further separated into carbon black and oils.[6] Osaka Gas Co. has developed a room temperature crushing and low temperature pulverizing method. This allows a pure product to be produced at low cost.

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5 Terra Mat Corporation
462 Arbor Circle
Youngstown, Ohio 44505
(216) 759-9412

Local Representative
Donald Lup
(318) 984-3556

6 Powell, Jerry, "Tire Recycling: Proven Solutions and New Ideas", Resource Recycling, Jan/Feb 1987.

Norman R., "Cryogenic Recycling and Processing", 1980, ISBN 0-8493-5779-9.

Typlax Polymer

R W Technology Inc., of Chesire, CT. [7] has developed a tire reclamation system which recaptures the three component parts of waste tires, rubber, fiber, and steel. The technology involves a series of size reductions. The surface of the reclaimed rubber is chemically altered and through a patented process blended with plastic to form Typlax Polymer, a thermoplastic polymer blend that is also recyclable. Typlax can be used for such things as shoe soles, carpet backing, containers, flexible mats and building materials.

Tirecycle

Tirecycle of Babbit, MN, is the name of a patented technology that molecularly binds crumb rubber with a polymer. Rubber Research Elastomerics Inc., in Babbit, Minnesota, produces Tirecycle. One hundred percent of the financing for the tire recycling plant which produces the crumb rubber was financed by state and county sources. The company insists that the crumb rubber, once treated to produce Tirecycle, results in a substance that is stronger and technically superior to virgin rubber. Despite this, the company declared bankruptcy in 1990.

Waste Tires as Roadbed Fill

Using tire chips as roadbed fill seems particularly appropriate for Louisiana. The shells that have been historically used for roadbed fill compact easily, allowing individual repairs to erode quickly. When used for the entire subgrade the road becomes uneven as the shell or gravel compacts. Tires chips are resilient and do not compact over time as does gravel. This helps distribute weight evenly. Tire chips are light weight, weighing only 540 pounds per cubic yard, and the porosity

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[7] John Minicucci President
R W Technology, Inc.
691 Business Park
611 West Johnson Ave.
Chesire, CT 06410

created by a mass of chips increases drainage. Further, tires do not easily biodegrade even in aqueous salty conditions.[8]

The leaching effects of using asphalt rubber and tire chips for roadbed fill in wet and/or marshy areas was tested. It was found that in highly organic and highly basic soils, tires leach both heavy metals and polyaromatic hydrocarbons. The leaching occurred only in extreme soil conditions. If the tire chips were not in direct contact with the soil or are used above the water line there appeared to be no leaching problem. If road construction or test projects are to be developed, reference should be made to the Soil Survey of Orleans Parish by the U.S. Dept. of Agriculture in September 1989. In assessing soil compatibility with tire chips as roadbed fill, questions to ask are:

1. The type of soil, organic or inorganic, and the soil PH
2. The salinity; fresh or brackish water
3. Water infiltration rate
4. Level of ground water
5. Type of use roadway will receive

Generally, the benefits of tire chips as fill outweigh the disadvantages. The possible leaching is a problem for the New Orleans area, but only when the roadway would be placed directly in a marshy area with extreme PH conditions and near a sensitive watershed or preserve. If construction was to occur some distance from a protected zone, even though there was a high water table and past roadway sublimation, tire chips can provide a safe and long lasting road base. Conversations with the New Orleans Department of Streets indicate an interest in the option but a need to perform tests under the area's unique ground/subsurface conditions.

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8 Geisler, Eric, et. al., "Tires for Subgrade Support", written for presentation at the 1989 International Winter Meeting sponsored by the American Society of Agricultural Engineers, New Orleans, LA, Dec. 12-15, 1989.

Tire chips are also used as an aggregate in road and arena surfaces. The tire chips are cut to size specification and used in place of gravel, stone or shell.

Asphalt Rubber

One of the fastest growing uses of waste tires is as a component in asphalt rubber. It is only infrequently used in many areas of the country. This is due in major part to the high cost, sometimes double that of traditional asphalt, as well as to the need to use specialized equipment to apply some of these forms of asphalt rubber. The high cost can be partially attributed to royalty fees for patented processes. However, some of those patented processes have expired, and the use of asphalt rubber is expected to greatly increase in the future.

Asphalt rubber has been applied in several locations and in various ways. Phoenix, Arizona has an extensive network of streets. As a result of heavy traffic and weather conditions, these streets suffer deterioration. The timely maintenance of these street pavements is given a high priority by the City. The form of surface treatment is critical as the process has to be both economical and durable. In its attempts to extend the life of a given pavement at economic costs, the City used various types of surface treatments. They have used asphalt rubber for more than twenty-five years. Phoenix has placed over 1000 miles of asphalt rubber chip seals on the city's streets since 1967, a testimonial to the progressive attitude taken by that city toward innovation.

The process used by Phoenix consisted of applying hot asphalt rubber followed by an application of hot precoated chips. The asphalt rubber provides elasticity which prevents reflection cracking and helps to stabilize the badly cracked pavement. This extends the life of the pavement.

New Jersey found another use for asphalt rubber. In northern New

Jersey, an industrial site was contaminated with a high concentration of toxic heavy metals. The New Jersey Environmental Protection Agency wanted the fill removed. The estimated removal and disposal cost of the fill was $6 million. Instead, the fill was left in place and asphalt rubber was used as an interlayer to seal the landfill. After scaling, the landfill was used as a parking lot. The final cost of the clean-up was $140,000.

Another use of asphalt rubber was demonstrated in Florida where the Florida Department of Transportation (FDOT) had been looking at a number of asphalt additives and modifiers as a means of improving properties of its surface course mixes. During 1989, FDOT implemented two initial demonstration projects to evaluate the short-term field performance of various percentages of finely ground tire rubber in asphalt mixes. As a result of its finding the FDOT permitted the use of ground tire rubber in joint sealers and asphalt rubber surface treatment and interlayer construction. One of the first demonstration projects using asphalt rubber in the surface treatment and interlayer application was conducted in 1978 in Florida.

The initial cost of applying asphalt rubber will continue to be higher than conventional asphalt, however, the asphalt Rubber Producers Group (ARPG) estimates the life expectancy of rubberized asphalt to be about three times that of regular asphalt. States can receive an additional 5% in federal gas tax revenues when they use recycled materials such as scrap tires in road construction.[9]

The possible environmental pitfalls appear minimal at this time. The one exception is the possible leaching mentioned in regard to roadbed fill. The State of Florida is examining this issue as part of a study on the effects and environmental consequences of using

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9 California Waste Management Report, Published by the California Waste Management Board, Dec. 1983- Jan. 1984.

rubberized asphalt on its highways.[10]

Although the cost of asphalt rubber exceeds that of conventional asphalt, the benefits include:

1. Durability
2. Less oil rising to the surface in hot weather
3. Reduced fatigue
5. Noise reduction
6. Better resistance to tire damage
7. Reduced surface glare
8. Thinner overlays[11]

Asphalt rubber can be prepared several ways. Crumb rubber can be pre-blended with asphalt (asphalt-rubber); crumb rubber can be added dry to asphalt (rubber-filled); and the asphalt-rubber can be mixed with varying grades of aggregate (asphalt-concrete). Rubber-filled asphalt is the cheapest.[12] Rubber-filled asphalt is often marketed under the patented Plusride label. This patent has been skirted by some projects by adding a different grade or size crumb rubber to the asphalt base than is called for in the Plusride system.

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10 Current data on all aspects of asphalt rubber can be obtained by contacting the ARPG, 3336, N. 32nd St. Suite 106, Phoenix, AZ, 8501. Chamberlin, William, P., Gupta, Racanta, K., Use of Scrap Automobile Tire Rubber in Highway Construction, Special Report May 1986, for the Engineering Research and Development Bureau, New York State Dept. Of Transportation.

11 Report to the Minnesota Pollution Control Agency on "Scrap Tires in Minnesota", p. 212, October 1985, by Waste Recovery Inc., Portland.

12 Id.

There are two primary uses of asphalt rubber besides simple crack sealing. A stress absorbing membrane (SAM) utilizes asphalt rubber as a surface covering. A stress absorbing membrane interlayer (SAMI) is a surface seal with asphalt rubber that is overlaid with aggregate and rolled into the hot asphalt rubber.

All the data is not yet in on asphalt-rubber, but the advantages appear to outweigh the disadvantages when the cost of disposing of the waste tires is factored into the additional cost of asphalt rubber over conventional asphalt. ARPG insists that the negative results in some projects resulted from altering the asphalt rubber specifications. With the expiration of patents, asphalt rubber will soon be getting more attention and warrants further study in the New Orleans area. Louisiana may soon be building a laboratory for accelerated testing of road construction materials and processes.

Incineration and Tire Derived Fuel

Tires have a greater energy value than coal. However, if tires are first chipped and then burned this significantly reduces their overall energy value because of the considerable amount of energy required to shred the tire.

The emissions associated with incineration of tires are usually quite high in sulfur and require scrubbing. Further, when tires are incinerated along with other wastes, toxic emissions including dioxins may be produced. Particulate and zinc emissions were found to be higher when tires were used as a fuel supplement in the pulp and paper mill industry.[13] Incineration of tires or using tires as fuel supplement often meets with strong community opposition and is heavily regulated through air pollution control legislation. The incineration of tires

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13 Pillsbury, Hope and Beachey, Jacob E., Markets for Scrap Tires, Presented at the First U.S. Conference on Municipal Solid Waste Management, p. 18, June 13-16, 1990.

has been associated with adverse human health effects ranging in severity from minor eye irritation to cancer from the release of volatile organic compounds.[14]

Pyrolysis which is defined as thermal cracking does have few environmental concerns that will be discussed later, but to a lesser extent than when tires are incinerated because when tires are cracked thermally at very high temperatures the emissions are less, and meet the environmental air quality regulations for air quality more readily. In particular, cement kilns operate at extremely high temperatures, approximately 2,600 degrees F. An added benefit in using tires as fuel for the cement industry is that the steel in the tires reduces the amount of iron which would otherwise be added in the cement production process.

Overall, tire incineration would not be a high priority option for disposing of New Orleans' waste tires. The vector problem associated with whole waste tire storage in this area would only be compounded by storing large quantities of tires before the plant began operating.

This would necessitate treatment with pesticides and, thus, could create the same groundwater contamination problems associated with storage for a pyrolysis plant.

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[14] Oregon Department of Environmental Quality Memo from Rammel L. Rivera to Deanna Mueller-Crispin, Feb. 22, 1989.

Microwave Processing

One company, Tollbridge Reduction Systems[15], operates a demonstration microwave facility in Ontario, Canada, which produces end products similar to pyrolysis.[16] The energy requirement is 1/3 KWH per pound of tire material. The structure is enclosed in a metal housing and equipped with leak detection devices. If a microwave leak is detected the system automatically shuts down. Tollbridge is setting up several operations in Canada. The company has not had any environmental opposition to the microwave process. Communities were more willing to accept this, having become familiar with home microwave use. Tollbridge optionally guarantees a market for its end products through the contract with purchasers of their system. Tollbridge also has a mobile system.

Goodyear appears to be the only other company to have used microwave technology with tires. Goodyear used this process with tires in the late 1970's, but discontinued its use because the process was too expensive and they had problems handling steel belted tires.

Grand Isle Breakwater Project

Jefferson Parish gave the town of Grand Isle $50,000 to shred two barge loads of tires to be used for a shore erosion project. The tire pieces will be used to build a levee and breakwater to stop erosion on the northern side of the island. The intent is to restore the shoreline and the proposed levee will allow the wetlands to be drained and filled to become developable property. The Army Corps of Engineers and State

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15 A.J. Heiner
Tollbridge Reduction Systems
P.O. Box 2156 Cambridge, Ontario, Canada N3C 2V8
(519) 658-8580 FAX (519) 740-3642

16 The Tollbridge system reduces an average twenty pound scrap tire to:
- 9 lbs carbon
- 2 lbs steel
- 0.2 lbs sulphur
- 1 gallon oil

Health Department of Natural Resources criticized the plans for potentially destroying about 20 acres of salt march on the island.

Pyrolysis

Tire pyrolysis involves the thermal depolymerization of whole or chipped tires, at 900 to 1,400 degrees F, to extract their elements (carbonaceous material including ash, oil, gas, and steel). The amount of each component varies depending on the feedstock, temperature and detention time of the process. [17]

Tire composition varies slightly from manufacturer to manufacturer, with the exact composition of each company's tires being a trade secret. In addition to vulcanized and synthetic rubber, tires may contain styrene-butadiene copolymers, butyl, EPDM, cisopoly-butadiene, aramid, steel, glass fibers, nylon, rayon, polyester, antioxidants, antiozonants, vulcanization accelerators, extending oils, zinc oxide, tackifiers, stearic acid, sulfur and carbon black. As a consequence, a tire may reasonably be expected to contain antimony, arsenic compounds, barium, beryllium, boron compounds, cadmium, calcium and magnesium carbonates, clay fillers, cobalt, copper, lead, mercury, potassium, sodium, and various pigments.[18] When complete combustion occurs, the results would be carbon oxide, water vapor, oxides of nitrogen and sulfur, steel and particulates.[19]

The aforementioned recycling alternatives can be a potential solution for the local waste tire problem in New Orleans because of the new existing state legislation. However, the purpose of this study is to

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17 Waste Tire Market Development Study, presented to the Michigan Department of Natural Resources by Resource Conservation Consultants, p. 5-4, Feb. 1987.

18 Waste Tire Market Development Study, presented to the Michigan Department of Natural Resources by Resource Conservation Consultants, p. 1-3, Feb. 1987.

19 Memo to the Honorable Robert C. Smith from James E. Mielke, 12/31/85.

focus on pyrolysis technology which is a large scale tire reclamation process that can consume the entire long-term supply of waste tires in New Orleans.

C. ENVIRONMENTAL HAZARDS OF PYROLYSIS

Although there are several pyrolysis technologies, the possible environmental hazards discussed below are generic; some may apply to one process and not to another.[20]

Storage of whole tires presents a health problem unless properly managed. If an average plant utilizes between one and two thousand tires daily, and a ten to thirty day feedstock is needed, then the number of tires which must be stored is immense.

If the tires are stored whole outdoors they would have to be treated with pesticides for vector control. Heavy rains in the New Orleans area would cause dirt, road oil, and pesticides to be washed off the tires. This runoff of contaminated water would threaten the soil and groundwater. Contamination could be an expensive problem depending upon its extent and the time of discovery. It might be governed by the Resource Conservation and Recovery Act (RCRA) or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Control of water runoff through containment and capture of materials from the cleaning and handling of the tires or tire chips and use of various solvents might produce a solid waste sludge that would require special handling and/or treatment; it may even require monitoring for contaminants. Any solid materials which are not directly marketable or convertible into marketable products may have to be monitored as well. Existing technology for the petrochemical and synthetic fuel industries should be adequate for pollution control of

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[20] Some of these environmental hazards are discussed in J. Dodds, Scrap Tires: A Resource and Technology Evaluation of Tire Pyrolysis and Other Selected Technologies, U.S. Department of Energy, p.24-25, 1983. EGG-2241.

pyrolysis mass recovery facilities.[21] In addition, the tire chips, if stored on certain soil types, may leach substances into the soil as discussed above.

Pyrolysis mass recovery (PMR) produces a gas which has certain chemical components which exceed maximum levels allowed for natural gas pipeline transportation. Storage of the gas under pressure also produces undesirable circumstances such as explosions. If the gas cannot be consumed on site or by a neighboring industrial site the excess can be flared,[22] with the emissions produced by flaring regulated under the state's air pollution control regulations. All of the gases generated during pyrolysis are able to be processed, which makes pollution control quite feasible. Scrubbers are not required.

A steady flow of raw materials is critical to the success of PMR. Therefore, a collection network must be in place in the region before a PMR begins operation. Some pyrolysis designs call for a mixed waste stream such as combustible solid waste material (x-ray films, pine sawdust and nitropropane, etc.) to help guarantee the supply of raw materials and to influence the quality of end products. These facilities, depending on what waste products (feedstocks) are used, may produce hazardous emissions and more pollutants than the single waste PMR facility. One PMR plant in the group studied for this report is switching from waste tires to a mixed waste fuel stream. The results from the survey of national and international pyrolysis operations is provided in Appendix A.

D. EXISTING LEGISLATION

Louisiana Act 185 of 1989 prohibits the disposal of whole waste tires at a landfill after January 1, 1991, a practice some local landfills had instituted ahead of Act 185's mandate. This does not mean that waste

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21 Id.

22 Id. at p.28.

tires will no longer find their way into the landfills. Tires may be disposed of legally in landfills if they have been processed. Act 185 does not define "processing" and it could be interpreted to consist of little more than halving the tires.[23] Compared to Act 185 the term "processed" is defined differently in the waste tire regulations currently being considered by the DEQ Solid Waste Division. The draft regulations refer to "processed" tires as being pieces of no more than five or six inches.[24] Thus, some waste tires which are incidental to dump loads are still being landfilled after January 1, 1991.

The tire scrappers contacted reported frustration and anger at no longer being able to dispose of the scrap tires economically within the law. For this reason many scrappers have been forced to curtail their operations or to give up a significant portion of their livelihood. Most scrappers reported that they soon will stop handling used tires entirely, while several admitted to using illegal disposal practices. Thus, the number of illegal scrap tire piles should rise significantly within the next year, as will the number of scrap tire bred mosquitoes harbored within them.

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23 House Bill 1199 section 2418(C) enacted as Louisiana Act 185, 1989, states: "tires that are not subjected to processing or recycling may not be deposited knowingly and intentionally in a landfill as a method of ultimate disposal after January 1, 1991."

24 In the definition section of the draft regulations "processing facility" is defined to include a facility which reduces waste tires to squares of five inches or less, where as, Chapter V Section IV (C) states that "processed tires" stored for recycling must be six inches square or less. Furthermore, the definition of "tire material" addresses waste tires <u>after processing</u>. Examples of "after processing" are given and include shredded material with no mention of what size the tire material must be reduced to constitute shredding.

SECTION II: LOCAL SITUATION

A. LOCAL WASTE TIRE SITUATION

This section addresses the waste tire supply for the New Orleans Metro area and the volume of illegal waste tire dumping. The City of New Orleans' Data Analysis Office considers the metropolitan area to include the Parishes of Orleans, Jefferson, St. Bernard, Plaquemines and St. Tammany, which have a combined population of 1,285,270. New tire dealers and waste tire transporters, commonly called scrappers, from Orleans and Jefferson Parishes, (the two most populous parishes which account for 70% of the metro area population) were contacted by phone and asked questions from standardized survey forms (See Appendix B). The data collected is summarized in this section.

Although this study has been conducted by the City of New Orleans, the problems surrounding waste tire disposal are regional and national. New Orleans' waste tire problem does not respect city limits. Some of the largest new tire dealers in the metro area are located in the neighboring population centers of Metairie and Kenner, in Jefferson Parish. There is little doubt that many of the waste tires illegally disposed of within the city limits of New Orleans were purchased outside of Orleans Parish and vice versa. Some scrap tires from the metro area are shipped out of state for disposal, but the vast majority are disposed of illegally in and about the City of New Orleans. Not all tire piles are outdoors. It is believed that several abandoned buildings within the city are filled with waste tires.

The existence of waste tires in a given geographical area is no assurance of a feedstock stream for a successful operating plant. For sustained operation of a pyrolysis plant, for example, scrap tire feedstock must be conservatively quantified. Long term contractual relationships must be established to assure a source of scrap tires and/or other hydrocarbon-based materials. For purposes of this study, it is assumed that legislative action will mandate that a flow of scrap tires be made available for use as a raw material for a PMR facility. The following tables illustrate the quantity of tires which are produced and discarded annually in the United States. Table 2 reflects the trends in U.S. tire shipments; Table 3 estimates the number of scrap tires generated annually in the New Orleans metro area; and Table 4 lists the number of new tires produced in the United States.

TABLE 2: TRENDS IN U.S. TIRE SHIPMENTS (IN MILLIONS)

	1989	1990	1991	1992
Passenger				
(Replacement)	153.3	154.2	154.5	157.5
(OE)	51.2	48.5	46.5	51.5
(Retread)	11.5	9.8	9.0	9.0
Truck, Light Truck				
(Replacement)	34.0	34.0	33.8	34.2
(OE)	8.2	7.0	6.7	7.3
(Retread)	22.0	22.8	23.1	23.1
Farm				
(Replacement)	2.742	2.600	2.610	2.650
(OE)	.890	.945	.945	.960
Large OTR				
(Replacement)	.130	.130	.130	.130
(OE)	.069	.062	.056	.055
Industrial Pneumatic & Utility				
(Replacement)	4.900	4.900	5.100	5.300
(OE)	9.600	10.000	10.000	10.000
TOTAL	298.531	294.937	292.441	301.995

Note: Some of these numbers are estimates.
Source: Rubber Manufacturers Association, Tire Retreading/Repair Journal, General Tire, Goodyear, and others.

Table 3: QUANTIFICATION OF SCRAP TIRES IN REGIONAL AREA

Population-1,285,270

Scrap Tires Generated Annually

Number of passenger tires (0.8343 tire per person, national average)		1,072,300 tires
Weight (20 pounds per tire)		21,446,000 pounds
Number of truck tires (0.1657 tires per person, national average)		212,970 tires
weight (90 pounds per tire)		19,167,300 pounds
Total Number/Pounds	**1,285,270 tires**	**40,613,300 pounds**

Average weight per tire is 31.60 pounds

Table 4: 1991 All New Tires Produced (million)

Passenger tires	209	77.44%
Truck tires	41.5	15.37%
Farm equipment tires	3.61	1.34%
Large OTR Tires	0.185	0.07%
Industrial tires	15.6	5.78%
TOTALS	**269.895**	**100%**

1992 Passenger and Truck Tires only (million)*

Passenger Tires	209	83.43%
Truck tires	41.5	16.57%
Total	250	100%

*Passenger tires represent usage for 83.43% of total U.S. population of 250 million people. Truck tires represent 16.57% usage for of total U.S. population

B. NEW TIRE DEALER PRACTICES AND NUMBER OF SCRAP TIRES GENERATED

The Yellow Pages lists approximately 200 new tire dealers and 11 used tire dealers in the greater New Orleans area. Fourteen of the better known and larger new tire dealers were contacted. An attempt was made to contact the same dealers who participated in a 1983 study performed by the Mosquito Control Division of the New Orleans' Health Department. Some of these dealers were no longer in business or were otherwise unreachable. The 1983 study showed that each of the fourteen new tire dealers contacted handled approximately 315 tires per week. With an estimated 90 tire dealers in the New Orleans metropolitan area, that meant a total of 1,360,800 tires were disposed of each year.

As mentioned above, looking at Orleans Parish does not provide an accurate picture of the potential waste tire disposal problem. Therefore, the geographic area considered here differs from the 1983 study and includes the 200 new tire dealerships listed in the Yellow Pages. Despite this, the actual number of waste tires disposed of was found to be surprisingly similar in the two studies. It appears each dealer is handling a significantly smaller share of the market. It is conceivable that some dealers intentionally underestimated the number of waste tires going through their establishment because they are no longer able to legally dispose of them. The survey phone calls were made by an announced representative of the City of New Orleans. Thus, some dealers might have feared that fines or other reprisals would occur if it was discovered that they were connected with illegal disposal practices.

Most of the dealers surveyed stated that the used tires they handle are generated almost exclusively when consumers replace car tires and leave the old tires at the dealership. Dealers reported that one percent or less of their customers ask to keep their old tires. While some dealers serviced trucks, the number was not large enough to allow a valid estimation of the number or sizes of used truck tires generated in the metro area. In addition, those dealers servicing trucks reported that 80% of truck tires are usually recapped several times.

The fourteen new tire dealers surveyed collectively took in 1,842 used tires per week for an average of 131 tires per week per store, or 6,812 tires per year per store. The total number of waste tires generated by these dealers is about 1,362,400 tires per year. The 1983 study found 1,360,800 tires in the metropolitan area but the size of the new tire dealer population was only 90 stores.

Of the 1,842 tires collected each week, an average of 71.5 (3.9%) tires were sold as used, 85.5 (4.6%) were taken for recapping and 1,687 (91.5%) were scrapped. The recapping percentage is most likely inflated because one of the larger stores surveyed dealt exclusively in truck tires and recapped over 80% of the used tires it received. The other dealers recapped form 0% to 20% of their used tires. The truck dealership was therefore treated as a passenger tire dealership and the numbers herein represent only a 20% recapping figure for that store.

Each tire dealer in the metro area is thus responsible for disposing of an average of one-fourteenth of 1,687 used tires per week, or 120.5 tires a week, 6,266 tires per year. For the 200 tire retailers in the metro area this means that a total of 1,253,200 tires must be disposed of each year. This figure is just under the one tire per person per year figure which is generally cited as the rule of thumb. A 1983 United States Department of Energy Study[25] determined that 33 pounds of waste tire material is discarded for each person in the New Orleans metro area per year and 34 pounds per person per year in Louisiana (these figures assumed weights of 22 pounds for automobile tires and 72 pounds for heavy truck tires). The current population of Louisiana is 4,381,682 and the population of Orleans and Jefferson Parishes combined is estimated at 945,244 according to the 1990 U.S.

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25 J. Dodds, Scrap Tires: A Resource and Technology Evaluation of Tire Pyrolysis and Other Selected Technologies, U.S. Department of Energy, 1983. EGG-2241. See Appendix A.

census.

C. TRANSPORTATION COST

Transportation and labor costs for scrap tires are a significant factor in determining the cost effectiveness of recovery and reuse technologies. The first two costs to consider in looking at tire recycling technologies are the costs of tire collection and transportation. These costs will determine the geographic area for effective collection efforts. Transportation costs are significantly lower if the tires are shredded. Shredding reduces the original volume of the tire by 50 to 60%. In addition, trucking companies and railroad operators have minimum weight charges which are an incentive to ship full container loads.

A 1990 telephone survey of tire dealers conducted throughout New Orleans and Jefferson Parish asked tire dealers' for the price they are charged by jockeys or haulers for picking up the dealers' scrap tires. Seven out of 17 tire dealers who were called were paying $0.80-1.00/tire for the jockey to come and pick up whole scrap tires. The dealers indicated that these tires are transported for disposal to areas within approximately a 100 mile radius. 100 miles is considered the maximum economical distance involved in any active collection system. Names of jockeys were not given by any of these tire dealers, although the question was asked.

As mentioned above, shredding reduces tire volume by 50 to 60%. The shipment of whole tires and shredded tires is limited by the volume of the container. Only in cases of shipping shredded tires by truck does a legal weight limitation prevent the shipment of a full load. According to the tire dealers, if the City installed a shredding machine, transportation cost could be reduced by 50%, or $0.40-0.50 per tire.

During 1989, a cost analysis study for tire disposal in New Orleans was performed to fulfill a doctoral dissertation requirement of one of the authors. Part of this study analyzed transportation costs of whole and shredded tires. Distances to be covered were divided into less than 100 miles and above 100 miles. Results of this study are summarized in Table 5.

TABLE 5

TRANSPORTATION COST

	CENT/TON-MILE	CENT/TIRE-MILE
Up to 100 miles (whole)	98	1.08
Up to 100 miles (shredded)	61	.67
Above 100 miles (whole)	32	.35
Above 100 miles (shredded)	25	.27
RAIL		
Whole	15-17	CENT/TON-MILE
Shredded	9.8-15	CENT/TON-MILE

Source:" 1989 Doctoral Dissertation-Lina Balluz, Tulane University School of Public Health & Tropical Medicine, New Orleans, Louisiana".

Tire dealers were asked about a government imposed mandatory surcharge to be used for disposal. Most dealers responded favorably, as long as the surcharge would cover their administrative costs. The concern local dealers raised was that whatever surcharges are imposed should apply to the entire New Orleans Metro area and not just the City of New Orleans. They feared that a surcharge limited to the City of New Orleans would give Jefferson Parish dealers an advantage and most therefore, favored a state imposed surcharge. Few dealers cared to estimate what a fair surcharge would be, but those who did felt that 50 cents to one dollar would be the limit a customer would pay. This small amount would not adequately cover their administrative costs and a disposal fee. One dealer even commented that if this measure were put to a vote it would fail miserably.

Smaller dealers were concerned that the larger dealers would simply pay any surcharge themselves. This would allow larger dealers could to underprice the smaller establishments to a greater extent than they already do. This assumes that the larger dealers would be able to absorb the administrative burden of a surcharge more easily.

The City of New Orleans has recommended to the State that any mandatory surcharge apply to tire passenger car tire dealers, new truck tire dealers, and to any new car dealerships, service stations, trucks, trailers, boat trailers, recreational vehicles, mo-peds, and all other goods which have tires. Spare tires sold with a vehicle must also be included.

An additional problem arises when considering junk yards and salvage companies. These businesses collect waste tires but do not sell new tires. Thus, they would not be able to collect the surcharge to help defray their disposal and administrative costs. To be fair, their administrative costs would have to be supplemented, or covered, by the city, parish or state. The government would be economically able to cover these costs because the sellers of products such as mopeds and boat trailers would be collecting the surcharge at the time their tire goods are sold, but do not replace worn tires on the shop premises. Businesses that operate in this fashion do not have any waste tires.

Some of the problems that surfaced during discussions with the dealers and scrappers in February of 1990 will soon be resolved by the State Department of Environmental Quality (DEQ) regulations. The proposed regulations set up a tire monitoring system using a five part manifest. The system will apply to all tire dealers selling vehicle or trailer tires. The proposed fee will be used to help clean up waste tire stockpiles and for administrative and enforcement activities across the state. After initially proposing a fee of $1.00 per tire, DEQ officials revised the fee to $2.00 in October, 1990 proposed regulations. The higher fee was needed to help tire dealers collect a fee that would realistically cover disposal costs.

Most dealers had no opinion when asked what percentage of scrap tires were presently being disposed of illegally. The persons who did respond felt that well over 50% of all waste tires are being disposed of illegally. Several dealers commented that a common way to dispose of small numbers of tires would be to hide them in a regular dump truck load that is then taken to a landfill. When tires are incidental to a regular trash load there is no sure way to detect the tires before they are landfilled. Although, it is now illegal to knowingly and intentionally landfill whole waste tires, it may be difficult to prove that tires were knowingly and intentionally placed in a garbage load. Every dealer contacted was aware of the problem and concerned about proper disposal of their tires. Some dealers, however, mentioned that they simply took their scrapper's word that the scrapper was disposing of the tires legally, and did not wish to complicate their business by finding out differently. One dealer did ask that he be notified if it were discovered that his scrapper was not using proper disposal methods.

D. TIRE SCRAPPERS

When the 1983 survey was taken, the City dump did not accept waste tires. Other regional landfills, however, were still accepting waste tires without charging higher tipping fees. During our 1990 survey we found that either high tipping fees were charged or landfilling whole waste tires was completely forbidden at area landfills. Act 185 now statutorily forbids landfilling of whole tires anywhere in the state.

Many scrappers were able to dispose of their waste tires more easily in 1983 than they can presently. Few waste tires collection businesses still exist in the New Orleans area. Many times the dealers surveyed did not know, or would not disclose, the names of the person with whom they contracted for waste tire disposal. Some dealers reported that someone with a truck comes by every so often to collect the accumulated tires.

The scrapper usually charges the dealer a minimal fee or charges the dealer no fee, but then resells the better tires. Examples of fee arrangements provided by the scrappers in their responses to the survey included: $75.00/ truck load; no charge for recappable or resalable tires, but 25 - 50 cents for waste tires; and 50 -75 cents/ tire. Most scrappers contacted did not charge a fee. A similar study by Jefferson Parish found that dealers were paying a fee of $.35 to $1.00 to get rid of their tires.[26] The average scrapper collects the waste tires and divides them into recappable, resalable as "used", and scrap categories. The tires which are recapped or sold as "used" pay for the scrappers' time and expenses in transporting the other scrap tires to a disposal site. Since few legitimate disposal sites are located near New Orleans and transporting small loads of tires is expensive for scrappers operating on what they make on resalable and recappable tires, it is easy to understand why waste tire stock piles are increasing so quickly in the New Orleans area.

Very few scrappers disclosed what was actually being done with the waste tires. One man has built his own cutting machine. He halves the tires which makes them acceptable for landfilling. Another scrapper admitted to taking the waste tires to the country and illegally burning them. This individual takes the tires to the country because he is concerned with the way the city is beginning to look as the used tires collect in makeshift dump sites.

Another unique person has been collecting waste tires for twenty years as hobby and "therapy". He stores his collected tires on properties he owns in Louisiana and Mississippi, using above ground piles and temporary storage underground (make-shift monofill). Both Louisiana and Mississippi have begun taking legal action to curtail his efforts. He claims to be saving the tires for future recycling or reclaiming and estimates that he has approximately 200,000 tires in

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26 Disposal and, or Utilization of Scrap Tires, Engineering Study, p. 5, Nov. 1989, by Cartier and Assoc., Inc. Consulting Engineers, Job No. 8901.

storage.

Other final waste tire resting places which were mentioned in the survey included: landfills as part of a trash load, state erosion control, a mystery landfill in Baton Rouge, a shredder in Mississippi, and the Westbank landfill which charges per truck load. One scrapper did not feel disposal was a problem, but he also did not disclose exactly why it was not a problem. Some of the larger tire dealerships ship their waste tires to a parent corporation in Mississippi where they are then landfilled.

When asked what percentage of tires were disposed of illegally the tire scrappers answers included "100%" and "everyone but me" with most declining to answer.

E. STOCKPILES OF WASTE TIRES WITHIN THE CITY

The New Orleans Mosquito Control Board is currently surveying the number and location of waste tire stock piles throughout the city. A 1983 Mosquito control survey gives the best estimate of how many waste tires are located in the City, but not technically stockpiled. The survey estimated that there were from three to five tires per city block. New Orleans has approximately 75,000 city blocks. This means that a total of between 225,000 and 375,000 waste tires are scattered throughout New Orleans, or 0.45 to 0.75 tires per person.

DEQ's new waste tire regulations will require a report to the DEQ of all waste tire stockpiles throughout the state. No definite date for reporting has been set.

F. NEIGHBORING COMMUNITY ACTIONS

Once DEQ institutes the waste tire manifest tracking system and licenses scrappers to transport waste tires, the tires will make their way to the least expensive disposal alternative. It is important, therefore, that Orleans and Jefferson Parishes consider what action each will take to solve its own disposal needs. A regional solution would help ensure that a constant economic incentive is maintained and that one jurisdiction will not defeat the other's purpose by creating lower tipping fees for a less sound use.

This situation is illustrated by the United States Environmental Protection Agency (EPA) as follows[27]. If one City built a tire to energy plant it would be counterproductive for a neighboring City to subsidize a tire shredder that will accept tires at a lower tipping fee, because most of the region's waste tires would go to the shredder and be landfilled rather than going to the energy plant for use as a fuel. This could mean that New Orleans could find itself without an adequate number of tires for its PMR unit if Jefferson Parish puts in a shredder with a lower tipping fee.

In 1989, Jefferson Parish conducted an engineering study concerning waste tire disposal[28], and has an ongoing waste tire committee that meets on an irregular basis. Jefferson Parish is considering imposing a tax of $2.00 to be collected at the time of sale that will be used to set up collection and disposal facilities for the Parish. It has expressed interest in trying to work with Orleans Parish so that one parish does not set up taxes or incentives that will harm the other's

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27 Pillsbury, Hope and Beachey, Jacob E., Markets for Scrap Tires, Presented at the First U.S. Conference on Municipal Solid Waste Management, June 13-16, 1990.

28 Disposal and, or Utilization of Scrap Tires, Engineering Study, p. 6, Nov. 1989, by Cartier and Assoc., Inc. Consulting Engineers, Job No. 8901.

efforts in eliminating the waste tire problem.

Jefferson Parish estimates that their parish generates approximately 800,000 automobile and light truck tires per year. If this figure is correct, the 448,306 Jefferson Parish residents are generating waste tires at almost twice the national rate of one tire per year per person.

G. FUNDING AND PUBLIC EDUCATION

The 1990 recycling program proposed for the City of New Orleans was adopted to respond to a state requirement that 25% of the city's waste be recycled by the end of 1992. This program dealt primarily with commonly recycled materials, and did not give much attention to source reduction. The program does mention upgrading the City's Elysian Fields site to act as a collection site for tires and other recyclable products. In order to do this the City will soon be required to have permits and licenses issued by the DEQ.

SECTION III: LEGISLATION AND PERMIT REQUIREMENTS

A. STATE AND NATIONAL WASTE TIRE LEGISLATION

Proposed Federal Legislation

House Bill 4147 (HB 4147) is known as the Tire Recycling Incentives Act and was assigned to the Energy and Commerce Committee, and then to the Transportation and Hazardous Materials Subcommittee. HB 4147 would amend the Resource Conservation and Recovery Act (RCRA) to mandate that the EPA set up a credit and reporting system within two years of the Bill's passage. Tire manufacturers and importers would be required to recycle 5% of their products the first year and an additional 5% each year until a 50% recycling rate was reached. The proponents of HB 4147 hope to offer incentives to the tire recycling industry.

The Clean Air Act amendments do not impact waste tire recycling. Tires, when burned as fuel, produce fewer problem emissions than the burning of high sulfur coal and other fuels.[29]

Existing Federal Legislation

The Public Utility Regulatory Policy Act (PURPA) of 1980 requires utilities to buy power generated by qualifying non-utility sources. This is important when using waste tires as fuel for generating electricity; PURPA requires the utility to buy the energy generated. The result is an immediate and guaranteed market for the electricity that results from a waste tire to energy plant. The price paid by the utility is called the avoided cost and is determined by figuring what the utility would pay for the power if they were to purchase the same amount of power from another utility company, or if they were to build a unit to generate the power. Appendix C provides New Orleans Public

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29 Response by Alan Caldwell, a contract employee for the EPA Region 7, at the 33rd Annual Louisville Retreaders' Conference and Trade Show, Louisville, KY, April 20-22, 1990.

Service Inc.'s figures for projected avoided costs.

RCRA and its implementing regulations require that any Federal Agency purchasing $10,000 or more of tires to procure items with the highest percentage of post-consumer recycled materials. For agency tire purchases, this translates into purchasing retread instead of new tires. This Act applies to all Federal agencies, State and local agencies using appropriated Federal funds, and to persons and organizations contracting with such agencies. The $10,000 threshold purchase amount applies to the procuring agency as a whole and not to each arm of the agency individually. This regulation would impact the City of New Orleans if it was to purchase tires under a federal grant or contract.

Proposed Louisiana Legislation

During the 1990 State of Louisiana legislative session several bills dealing with waste tires were proposed in both the House and the Senate. None of the bills were enacted into law. The bill which received the greatest support would have imposed a $2.00 tax on the sale of new tires. Part of the money collected would have gone to municipalities to help initiate waste tire recycling programs.

As a Home Rule Charter city, New Orleans may impose a waste tire fee by ordinance without first seeking legislative approval.

DEQ's Proposed Waste Tire Regulations: Summary and Comments

The DEQ's Used Tire Recycling Regulations are divided into 29 sections. Sections 10501 to 10504 are devoted to the purpose, scope and definitions of the regulations. The purpose and scope are to dispose of promiscuous tire piles and encourage recycling of waste tires. The number of tires which would constitute a "promiscuous tire pile" is defined as 50 or more waste tires. "Tire" includes all tires for motorized vehicles as well as tires for trailers and other vehicles pushed or pulled by a motor vehicle. A "collection center" would be allowed to collect waste tires until it becomes economical to transport the tires to a processor or disposal facility. The DEQ may impose a ceiling of 30, 60, or 90 days on the storage time permitted before shipment occurs to a final disposal site.

Section 10505 details a five part manifest to keep track of the transfer of waste tires. The five parts are as follows:

1. DEQ Original Copy (sent to DEQ by receiving facility)
2. Receiving (Recycling, Collecting, Processing or Disposal) Facility Copy
3. Transporter Copy
4. Tire Dealer (or site owner) Copy
5. DEQ (sent to DEQ by tire dealer)

Section 10507 details the reporting and manifest requirements for all tire dealers and owners or operators of promiscuous tire sites. A "tire dealer" is defined in section 10503 to include all persons, businesses, and fleet services which generate 100 used tires per calendar year by replacing the used tire with another tire. Section 10507 requires owners or operators of promiscuous waste tire sites to notify the DEQ of the size, location, and quantity of stored tires within 90 days after the effective date of the relocations. Waste tire collection sites must be licensed or they will be considered a promiscuous tire site. The owner or operator of promiscuous tire sites must abate those sites. If the owner or operator can demonstrate to the DEQ a financial hardship then they may apply for grants, to finance the cleanup from the Used, Scrap, or Waste Tire Cleanup Fund of the state. Section 10509 requires the dealers to accept one used tire for every new tire sold. It also requires that individuals deliver any used tires they retain to an appropriate collection center.

Scrappers who resell used tires from the loads they transport would be required to get a transporters license and possibly a license to resell the used tires. The type of license required to resell used tires is unclear; section 10509(B)(3)(a) states that transporters shall only deliver used tires "to a licensed or permitted facility", however, the "regs" fail to specify the type of license needed to resell used tires. Vehicles used for transportation will need to be adequately maintained and have to show a decal. Section 10511 requires a recycling or processing facility to have a vector control plan, closure plans, security, and emergency contingency plans. The owner must also demonstrate financial responsibility and obtain a license pursuant to section 10519. Disposal facilities must also obtain a license.

Section 10521 specifies licensing fees and the Used, Scrap, or Waste Tire Cleanup and recycling Fee. The Used, Scrap, or Waste Tire Cleanup Fee is proposed at $2.00 for each new tire sold in Louisiana, to be apportioned as follows: 90¢ going into the Fund, 10¢ to DEQ for administration costs and $1.00 for the receiving tire recycle or processor.

Regional collection centers are the most important link in the state recycling system. If collection centers are not readily accessible the scrappers will have nowhere to take the waste tires and they will continue to be placed in promiscuous tire piles. The manifest tracking system breaks down when no place exists for disposal of waste tires, and with DEQ's allocation of only 5% for administrative costs the enforcement budget will be minimal. If DEQ receives 500 copies of Part 1 of the tire manifest from the receiver facility and then receives only 250 copies of part 5 of the tire manifest, very few of the violators will actually be identified and prosecuted.[30]

Furthermore, the major PMR and other tire processing operations contacted in the course of this study expressed a need for a long term supply of waste tires, before they would locate in the New Orleans area. This same principle would apply statewide. In order to attract large scale and reliable tire processing operations there must be a plan for

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30 This same situation took place in Portland, Oregon. Portland found the enforcement cost to be so high that they abandoned the manifest system and instituted a disposal fee. From: Deese, Patricia L., et. al., Options for Resource Recovery and Disposal of Scrap Tires, p. 34. Sept. 1981, EPA-600/2-81-193. by Municipal Research Laboratory Office of Research and Development, U.S. EPA, Contract NO 68-03-2725

regional collection centers so that the collection companies can solicit bids from, and contract with, tire processing facilities which are able to guarantee the lowest tipping fees. Tipping fees can be assessed when the processor also functions as the regional collection center. Processors will locate where tire supply can be guaranteed. Expecting a processing facility to solicit individual dealers and scrappers in order to guarantee a supply of waste tires is unrealistic.

Even if prospective processors are able to solicit individual contracts, the time between promulgation of the regulations and the time the processing facility would result in a period where disposal of waste tires was not possible. The orderly flow of waste tires from dealer to processor would be halted while numerous individual contracts were solicited, collection centers set up, and processing facilities built. There would be a period after promulgation, during solicitation, where scrappers would have no place to take the waste tires. During that time, tires would continue to collect at area dealerships. If planning for regional collection centers was begun before promulgation of the regulations and the second dollar of the fee was used to offset the cost local governments would incur in establishing the collection centers, then the whole program and manifest tracking system would run more smoothly. Additionally, local communities would be able to attract new tire processing facilities.

Section 10523 establishes operational standards for facilities proposing to store whole or shredded used, scrap or waste tires. It sets out operational standards with separate requirements for indoor and outdoor storage. Recycling and processing facilities must process at least 75% of the tires received annually; each facility would have a storage limit of 365 times the daily capacity of the processing facility.

New Orleans City Ordinances

The present ordinances of the City of New Orleans would not directly interfere with waste tire recycling. Tire storage facilities would have to comply with all applicable city ordinances and show that rats and other vectors would not be a problem. A thirty day supply may be stored as long as the tires are continuously moving through the storage area. Individuals might be cited for violating city ordinances if they improperly store waste tires and could be prosecuted if the situation is not corrected.

Long-Term Contracts

An operator of a tire recycling facility, in order to ensure an adequate supply of material, will need to enter into long- term contracts. These long- term contracts have dual benefits. The facility operator is assured of receiving waste tires at a fixed rate and those disposing of waste tires are assured the tipping fees will remain within a fixed limit. Most states require that the state legislature pass legislation enabling regional or local governments to control the flow of solid waste and to assure the long- term supply of materials. Minnesota passed the Waste Management Act of 1980, which allows local governments to establish by ordinance the legal authority to direct waste flow within their geographic boundary.[31]

The New Orleans' City Attorney was asked: "what prohibition or limitation is there on the City, a group of Parishes, or the State to enter into a long-term, ten year plus, contract for services to dispose of waste tires?" In essence there are no direct limitations except that the City offer the project up for public bid and that it has adequate finances appropriated for the term of the contract. The City may also be able to dispose of waste tire through a franchise or grant.

While New Orleans has the authority as a Home Rule Charter city to enact certain ordinances, it will want to work with Regional Parishes. Thus, if it turns out that there are restrictions on long term contracts the City may want to, in conjunction with Regional Parishes, lobby for waste flow control legislation in the State Legislature.

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31 Report to the Minnesota Pollution Control Agency on "Scrap Tires in Minnesota", October 1985, by Waste Recovery Inc., Portland, Oregon.

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The proposed DEQ waste Tire Regulations in Chapter IV would provide that: "[a] Parish or Municipality may set up a used, scrap, or waste tire collection (USWTC) Center (usually a permanent facility) and contract with transporters, dealers, groups of dealers, parishes or municipalities to secure a steady guaranteed supply for their operation. Even with this provision the City may still have to consider the effect of the City Charter and assess whether uniform State legislation would be appropriate.

B. PERMITS REQUIRED FOR PMR AND OTHER WASTE TIRE OPERATION

Federal programs which can require permits, such as air, water, and solid waste, are administered by the State. Thus, no federal permits would be required for a PMR facility. When considering what permits may be needed for a PMR facility all materials discharged and/or stored at the facility should be considered. Therefore, the possible permits would concern air emissions, water discharge, oil storage, and solid waste disposal.

City Permits

One end product of tire pyrolysis that may require storage is waste oil. The typical size of a PMR facility based pyrolytic oil storage tank is 10,000 gallons. After numerous calls and conversations with the DEQ it was determined that an oil storage permit is not needed from the DEQ,[32] unless the oil could be characterized as a hazardous waste. The Louisiana Department of Natural Resources, Office of Conservation would not require that an oil storage permit be issued.

A hazardous waste, as defined by Louisiana, has four distinguishing characteristics,[33] any one of which will make a substance hazardous. These regulations only apply to used oil and not newly produced oil such as pyrolytic oil. A DEQ official indicated that if the pyrolytic oil were sold as fuel some Louisianians may refuse to buy it unless the PMR facility has a federal i.d. number.

The New Orleans Fire Department would have to issue a Certificate of Compliance for oil storage. To obtain this certificate the facility would need to show that the oil storage tank was enclosed by a dike capable of holding one and one quarter the storage tanks capacity. For example, a 10,000 gallon tank would require a 12,500 gallon dike system: 7.5 gallons of liquid needs one cubic foot of spill capacity. Of course, building permits are also necessary.

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32 Conversation with Tom Patterson, DEQ's Hazardous Waste Enforcement Division, July, 30, 1990.

33 The hazardous waste regulations can be found in, Title 33 of the Louisiana Administrative Code, volume 13. The four characteristics of a hazardous waste are:

1. 140 degree F flash point
2. reactivity (explosivity)
3. corrosivity (ph below 2.0 or above 12.5)
4. toxicity

Water Discharge Permits

Water discharge permits will not be needed, because none of the companies surveyed discharged water during the pyrolysis process. Two companies recycled their water for plant use. A plant in Wisconsin recycled all water used for cooling, but stated that some discharge would occur when the tank is cleaned.

The Wisconsin plant discharges waste water into the sewer system with the approval of the Wisconsin Department of Natural Resources. A discharge permit was not needed because the water is not contaminated during the PMR process.[34]

Solid Waste Permits

At the present time, the DEQ is assessing the need for solid waste permits on a case by case basis. They are usually requiring that tires be covered in some manner and that separation between piles be maintained for emergency access. If the tires are chipped before storage and prior to processing, no permit is required. If the tire chips are to be used for fuel, a permit may be necessary in the future.[35]

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34 One differing report did surface. Chemical Engineering, July 19, 1976, reported that Occidentals Flash Pyrolysis created water (13%) as a pyrolysis by-product. The water could present an environmental problem because some of the pyrolysis oil is water soluble and could contain organic compounds. The specific system cited, however, was a refuse pyrolysis system of very early design.

35 Conversation with Jim Brett of the DEQ's Solid Waste Enforcement Division, July 30, 1990. DEQ'S Solid Waste Regulations are located in Title 33, Volume 14, Part 7 of the Louisiana Administrative Code.

Air Emission Permits

This particular area is very complex.[36] The following effluent are regulated by Louisiana as criteria pollutants: sulfur dioxide, oxides of nitrogen, carbon monoxide, unburned hydrocarbons, particulate, lead, and ozone, which is regulated as a volatile organic compounds. EPA regulates a longer list of non-criteria pollutants.[37]

New Orleans is a non-attainment area for ozone. This means that if a facility is going to release more than 40,000 tons of hydrocarbons per year the excess amount must be offset against another neighboring facility's release. For example, if company X releases 42,000 ton/ year and company Y releases only 37,000 tons/ year an agreement between X and Y could be reached where by X's additional releases are offset by Y's releases under 40,000 tons.

The first step in permitting a new facility is to see if it has been designated as a regulated source under the Louisiana Air Pollution Control Regulations.[38] If more than 250,000 tons of any of the other non-ozone materials are released per year then the facility would fall under the Prevention of Significant Deterioration Program (PSD). The exact composition and quantity of emissions will determine the permits and restrictions that the new facility must satisfy.

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36 The Louisiana Application for Approval of Air Emissions of Air Pollutants, and the Louisiana New Source Review Manual provide the details on Louisiana's air permitting system.

37 A list of regulated pollutants can be found on pp. 2-4 of the Louisiana New Source Review Manual.

38 Ibid.

SECTION IV: SCRAP TIRE PROCESSING: A PROFORMA

A. COLLECTION

For purposes of this study and to provide flexibility in implementing a scrap tire disposal program, it will be assumed that scrap tires will be collected and shredded at a site remote from the pyrolysis plant.

Based upon the quantifying analysis in Section II, whole scrap tires must be shredded to a 2 inch by 2 inch nominal size for disposal by means of pyrolysis. To conform with proposed State Legislation, scrap tires would be collected by new tire dealers, who would decide if the tire is to be scrapped, reused or retreaded. For tires designated as scrap, the bead would be cut and the scrap tire would be stored on the dealers premises until 100 tires, more or less, were accumulated. A licensed whole tire hauler, would then pick up and haul the scrap tires to the collection site for processing. As proposed in the pending legislation, a manifest would be established for mandatory delivery and accounting purposes. The charge for shredding and pyrolysis processing is suggested at $0.50 for a passenger tire and $1.50 for a truck tire, which covers the total cost of operations, including hauling of the shredded rubber to a landfill in the event a pyrolysis plant were not provided for recycling the shredded rubber. For each scrap tire generated and hauled to the collection/shredding site, the dealer would prepare the manifest and then give the manifest to the hauler for delivery to the collection/shredding site. The collection/shredding entity would pay the hauler on a per tire delivered basis as per manifest.

B. STORAGE AND SHREDDING

Whole tires will need to be stored at the collection site to maintain an adequate supply of feedstock for the pyrolysis plant. It is estimated that a minimum of 50,000 tires would have to be inventoried at the collection/shredding site to adequately accommodate the need for feedstock, and to provide for seasonal variations in the industry, weather, equipment maintenance, etc. Shredded rubber would be hauled from the site to either the landfill or to the site of the pyrolysis plant as generated by contract haulers.

Several qualified sources manufacture tire shredding machinery capable of shredding 20,000 pounds of tires per hour (1,000 passenger tires). This level of performance would accommodate the anticipated requirement of some 42,000,000 pounds per year on an eight hour day, five day per week basis. In the event of system breakdown, some overtime may be required. It is anticipated that system maintenance would take place on weekends.

The number of tires to be processed, as well as the poundage will help determine the design of the collection and processing systems. This study assumed that the demand will be:

Number of Tires Processed	1,311,061
Pounds of Rubber Processed	42,175,500

The number of scrap tires stockpiled in the New Orleans regional area is estimated as follows:

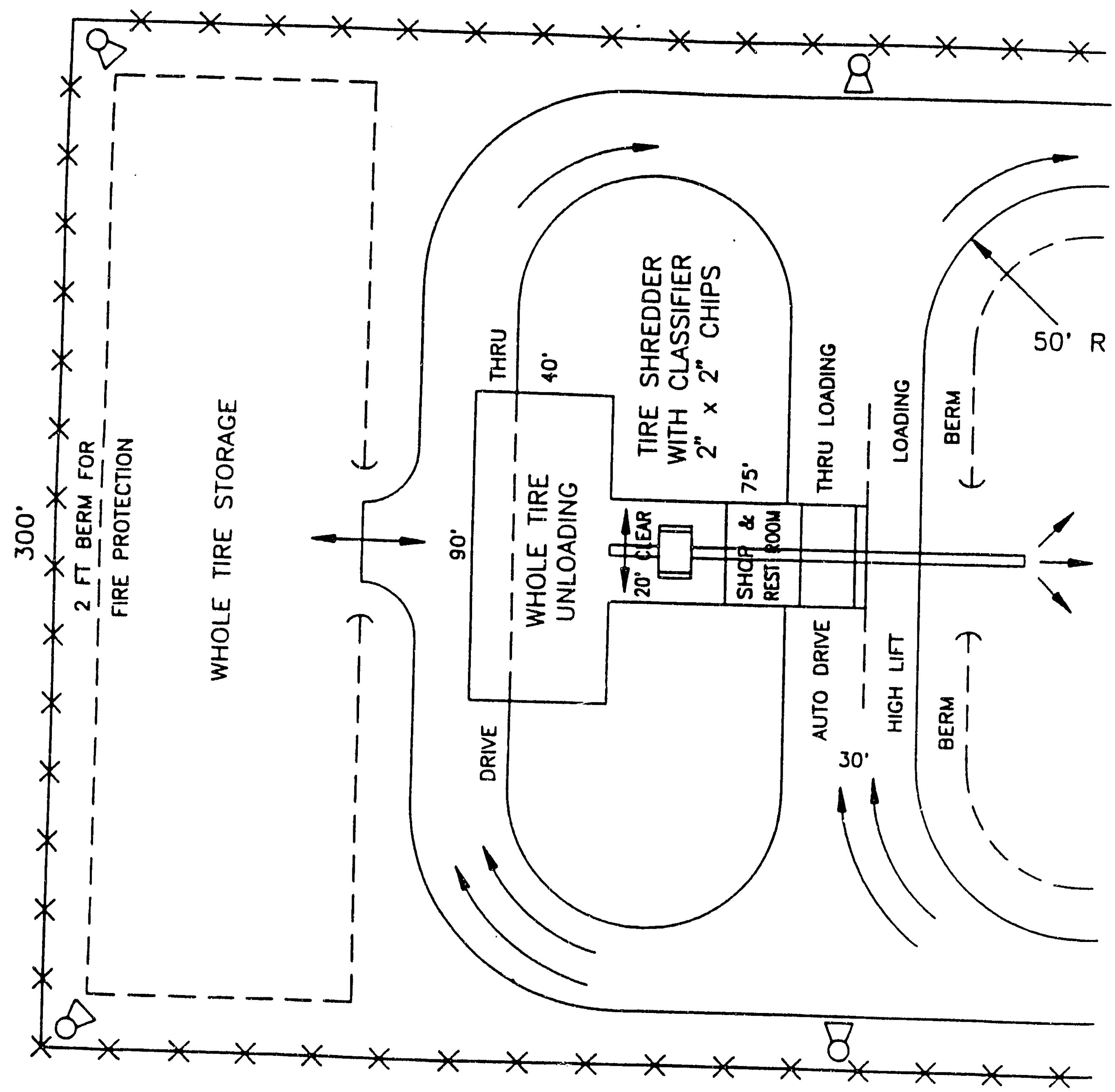
Table 6: Scrap Tires Stockpiled in Regional Area

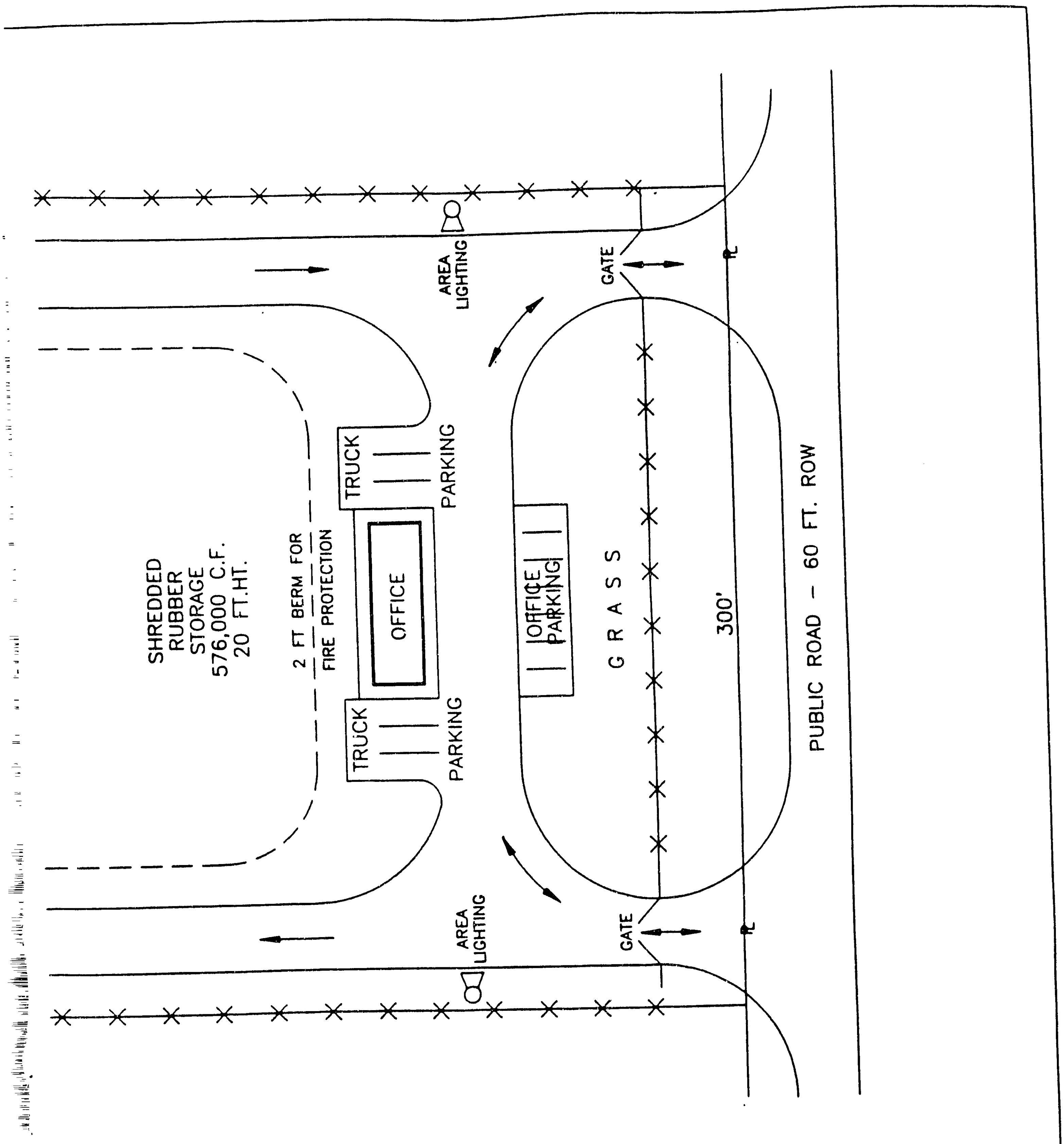
EPA National Estimate - Total No.	2,500,000,000
Per Person - 250 Million People	10
New Orleans Regional Area - Assumed	2
Number of Tires - Population x 2	2,570,540
Weight at 31.60 pound/tire - Pounds	81,229,064
Term for Clean-up - Years	10
Annual Pounds Processed in Pyrolysis Plant	8,261,710
Total Pounds For Process Design (6000LB/HR)	49,573,540
Less: Discount For Other Uses For Scrap Tires	15
Actual Scrap Tires Processed - Pounds	42,137,507
Number of Tires Processed Per Year	1,311,061
Passenger	1,093,800
Truck	217,261

C. TYPICAL COLLECTION/SHREDDING SITE

Shredding equipment would be permanently installed on a 4.2 acre site, possibly now owned and utilized by the City of New Orleans. Improvements would include adequate access roads, paved parking areas, fencing and utility services including area lighting. A small office would be provided with semi-public restrooms for management functions and clerical services. The shredding operation would reduce whole tires to 2 inch by 2 inch nominal size pieces for transport to the pyrolysis plant. Transport of chipped rubber would be by contract hauler using open top (properly covered) dump trucks capable of hauling a minimum of 30,000 pounds of chipped rubber per load, or approximately 1,300 cubic feet. Two such tractor/trailer trucks would be required to haul 5/6 loads per day. It is assumed that the distance between the collection/shredding site and the pyrolysis plant would approximate ten miles. (A Conceptual Collection Shredding Site Plan, Figure 2 is included showing the details needed at the site). Given the facility, supplies and operation as outlined above, a PMR plant costing some $2.2 million is projected to yield a pre-tax return on investment in excess of 25% A capital cost budget and projected income (Table 7) and expense statement (Table 8) have also been developed and are included.

FIGURE 2


300'
2 FT BERM FOR
FIRE PROTECTION
WHOLE TIRE STORAGE
THRU
DRIVE
40'
90'
WHOLE TIRE
UNLOADING
TIRE SHREDDER
WITH CLASSIFIER
2" x 2" CHIPS
75'
20' CLEAR
SHOP &
REST ROOM
THRU LOADING
AUTO DRIVE
LOADING
HIGH LIFT
30'
BERM
BERM
50' R



PYCO REGENERATION SYSTEMS INC
CLARK MARITIME CENTER
JEFFERSONVILLE, INDIANA

TYPICAL SITE DEVELOPMENT PLAN
TIRE COLLECTION/SHREDDING CENTER.

DATE	DRAWN BY	SCALE	DWG. NO.

TABLE 7: SCRAP TIRE COLLECTION & SHREDDING SITE
CAPITAL COST ESTIMATE

Land - 4.3 Acres	$ 150,000.
Site Improvements, including:	
Land Survey, Grade & Drain, Berm Fill & Construction, Stone Surfacing & Compacting, Service Roads & Parking Areas, Curbs & Gutters with Drains, Utilities to Site	
Total Site Improvements	290,000.
Major Equipment, including:	
Area Lighting, Fencing & Gates, Prefabricated Steel Buildings - Erected, Shredding Equipment with Spare Parts, Automated Material Handling Conveyors, Machine & Other Tools, Office Equipment & Communications, Vehicles, including Pick Up Truck and High Lift	
Total Major Equipment	860,000.
Installation & Construction, including:	
Concrete Work & Piling, Electric Service & Wiring, Sanitary Plumbing & Drainage, Process Building Finishing, Office Building Finishing, Major Equipment Installation, Construction Contractor Fee	
Total Installation & Construction	460,000.
Indirect Costs, including:	
Permits, Fees & Legal Costs, Construction & Performance Bonds, Engineering Design and Project Contingencies	
Total Indirect Costs	460,000
Total Project Cost Estimate	**$ 2,220,000.**

TABLE 8: TIRE & COLLECTION & SHREDDING OPERATIONS
PROJECTED INCOME & EXPENSE STATEMENT

(Presumes operation in parallel with and sale of chipped rubber to pyrolysis plant)

Operating Income:			
Tipping Fees:			
Passenger Tires - 1,093,820 @ $0.50		$546,900	
Truck Tires - 217,240 @ $1.50		325,860	
Total			**872,760**
Sale of Chipped Rubber to Pyrolysis Plant			
21,000 Tons @ $20./Ton Delivered			**420,000**
Total Operating Income			$1,292,760
Operating Expense:			
Plant Personnel:			
Dispatcher	$ 24,000		
Shredding Crew			
Foreman	17,680		
Crew (2)	29,120		
Highlift Operator	16,640		
Mechanic	24,000		
Total	**$111,440**		
Benefit Package - 40%	44,560		
Total Shredder Operation		**$156,000**	
Shredder Operation:			
Electric Power	$172,000		
Equipment Maintenance	40,000		
Total Shredder Operation		**212,000**	
Vehicle Operation:			
Pick up Truck	1,800		
Highlift	7,200		
Equipment Maintenance	3,600		
Total Vehicle Operation		**12,600**	
Chipped Rubber Transport - Contract			
20 Mi.Trip @ $1.50 per T/M		**42,000**	
General & Administrative Expense:			
General Manager	$ 42,000		
Clerical/Accounting	18,000		
Benefit Package - 40%	24,000		
Utilities	6,000		
Insurance	25,000		
Accounting & Auditing	12,000		
Office Supplies & Services	6,000		

Misc. & Unallocated	20,000		
Total General & Administrative		**156,000**	
Depreciation-15 Yr/St.Line-$2,200,000		146,600	
Total Operating Expense			725,200
Operating Income Before Taxes			$ 567,560
ROI on $2,200,000 Investment - Before Taxes			25.8%

SECTION V: PYROLYSIS

A. PYROLYSIS

Pyrolysis is the process of breaking organic chemical bonds by heating. It is also known as thermal cracking, carbonization, coking and thermal depolymerization. Pyrolysis technology is rather simple and requires a very high temperature (1500 F) that provides a means for organics to decompose and vaporize. As the temperature increases, the vapors are released. When condensed, the vapors result in fluids and gases which are not solvents but more complex molecules of organic compounds. They appear in gas and oil form and have potential use for energy purposes.

Just like gasoline, tires are a valuable fuel when thermally decomposed in the absence of oxygen. An average passenger tire weighs 20 pounds and has a heating value of about 15,000 BTU/lb. This equates to 300,000 BTU's per tire. Gasoline has a heating value of 20,750 BTU/lb, and a weight of 6.152 lb/gal. A tire has over 13.4 times the energy value of a gallon of gas. If the energy derived from discarded tires were used to fuel our cars, we could save 432 million gallons of gasoline annually.

In the pyrolysis process, a ton of tires will produce approximately 90 gallons of oil at 18,500 BTU/lb, 7,000 SCF of gas at 1,000 BTU/SCF and 750 pounds of carbonaceous material. At low temperature, pyrolysis will produce enough gas to make the process self-sustaining since the gas can be used to provide the thermal energy required. At high temperature, the excess gas produced can be sold as industrial fuel. An advantage of pyrolysis over other tire disposal methods is the high degree of material and energy balance that is obtained.

B. TYPES OF PYROLYSIS PROCESSES

There are many criteria used to classify the pyrolysis process are many according to Dodd et al., 1983. The criterion used in this report is the atmosphere within the reactor. The pyrolysis process is either oxidative or reductive. The oxidative process includes the injection of a reactant that can be air, oxygen or steam. As a result, a portion of tire material is burned to produce carbon monoxide, carbon dioxide and hydrogen. The reductive process, however, represents the major type of pyrolysis. It produces a reductive atmosphere by excluding air. The gas produced has a high heating value and is used to heat the reactor. The consultant for this project examined the reductive process. Examples of the oxidative and the reductive pyrolysis process follow:

Example of Oxidative Pyrolysis Process for Scrap Tires

When scrap tires are shredded, some steel is magnetically removed. However, some pyrolysis operations use whole tires. In a typical process, shredded tires are moved to feed storage which feeds the reactor. The chipped rubber undergoes pre-treatment before entering the reactor to depolymerize the rubber. There are several types of reactors; the two commercial types, fluidized bed and rotary kiln, will be discussed below. In the oxidative process, air, oxygen or steam is injected into the reactor. The solids leaving the reactor are cooled in a solid recovery system. Steel and fiberglass are removed and the remaining material (charcoal) undergoes several treatments before it is marketed.

Pyrolytic oil is collected in a quench tower in which vapor released by the pyrolysis process is cooled. The gas remaining after oil recovery is rich in paraffins and olefin. In the oxidative process, the gas contains carbon monoxide, carbon dioxide and hydrogen. Any gas that is not consumed during pyrolysis can be purified and sold as an energy source.

Example of Reductive Pyrolysis Process for Scrap Tires

In the reductive process, tires are first shredded and then fed into the reactor. The feed rate is regulated by air seal valves to eliminate oxygen from the reactor. The reactor consists of one or more large retort tubes mounted inside an isolated combustion chamber. The tire feed drops by gravity into the retort and is continually propelled to the discharge end by a paddle augur conveyor. Multiple burners in the combustion chamber with individual burner settings are intended to assure uniform heating and to minimize hot spots. Waste heat is recovered from the combustion flue gases to preheat and dry the feedstock. The off gas and vapors are removed from the top of the reactor and the inorganic particulate drop to the bottom. The oil is separated from the gas in a quench tower designed to produce many boiling fractions. The oil is then cooled, filtered, and sent to storage. Typically 20% to 25% of the non-condensable gas is recycled for process fuel. The solid residue is discharged by gravity from the reactor, cooled, then reduced to fine particles, separated from the metal magnetically, separated from the fiberglass by screening, and then processed as char black. With further processing 98% of the ash can be removed to produce specification carbon black.

C. TYPES OF REACTORS

Fluidized bed reactor and rotary kiln are two pyrolysis reactors that provide extended solids residence time and short vapor residence time.

Fluidized Bed Reactor

Energy Products of Idaho (EPI) uses a fluidized bed that has high temperature sand chamber occupying the bottom section. The sand is fluidized by the incoming combustion air as it enters through nozzles located a couple of feet below the surface of the sand. The air moving up through the sand produces a violent boiling action.

Fuel is suspended by this fluidized bed much the same as it would be in a pot of boiling water. As the fluidizing air strikes the fuel, combustion is enhanced. Dense materials, like rocks and metal, sink to the bottom of the active bed, and are continually removed by the automatic trap removal system. The temperature of the sand is maintained at about 1500 degrees F. At this temperature, shredded tires in the combustor ignite spontaneously. As the tires burn, the sand scrubs the outside layer of ash and exposes a fresh combustible surface for the incoming air to consume.

This action produces an extremely efficient and complete combustion and results in very little charcoal loss. The tire derived fuel is shredded prior to being fed into the combustor to alleviate hot spots that could be caused by a whole tire burning in one small area. When shredded, tire chips are spread across the bed, providing an even heat release and ultimately a greater control of the temperature throughout the combustion process. With this control of the combustion process and the temperature profile maintained within the combustor, the formation of certain undesirable emissions, such as NOX, dioxins and furans are minimized.

Rotary Kiln

In the rotary kiln, pyrolysis reactor solids travel through the kiln in a plug flow with little mixing along the length of the reactor (Dodd, et.al. 1983). According to Dodd, "the usual practice with a rotary kiln is to place paddles on the inside wall of the kiln to continuously lift solid material away from the bottom, then drop it so it falls through the gases in the kiln. This solid-gas contacting pattern gives good temperature uniformity at any position along the length of the reactor." This type of reactor has problems when a large area needs to be sealed. Hence, excluding air is quite difficult in a rotary kiln reactor.

D. DESCRIPTION OF THE SELECTED PYROLYSIS PROCESS

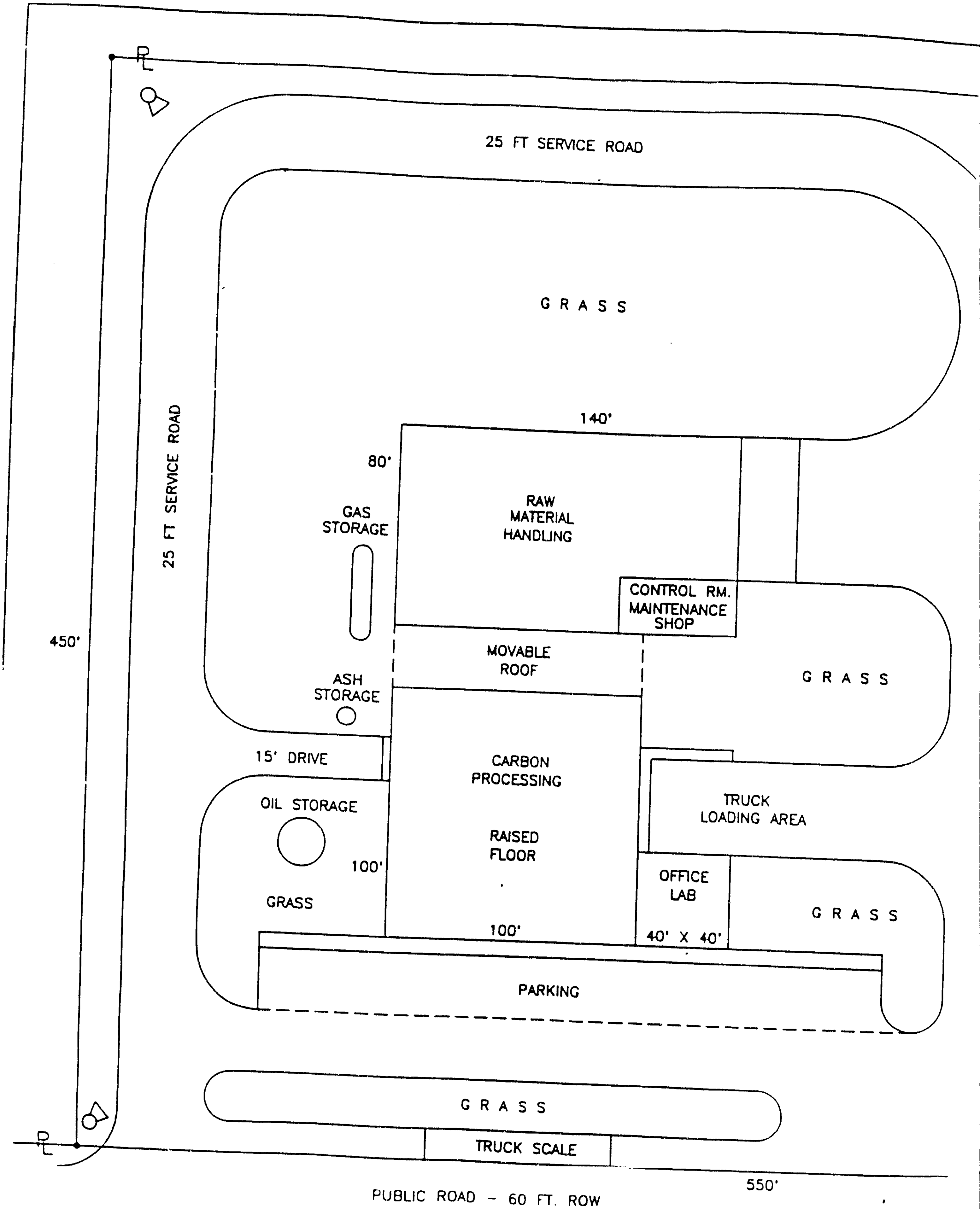
Design Parameters

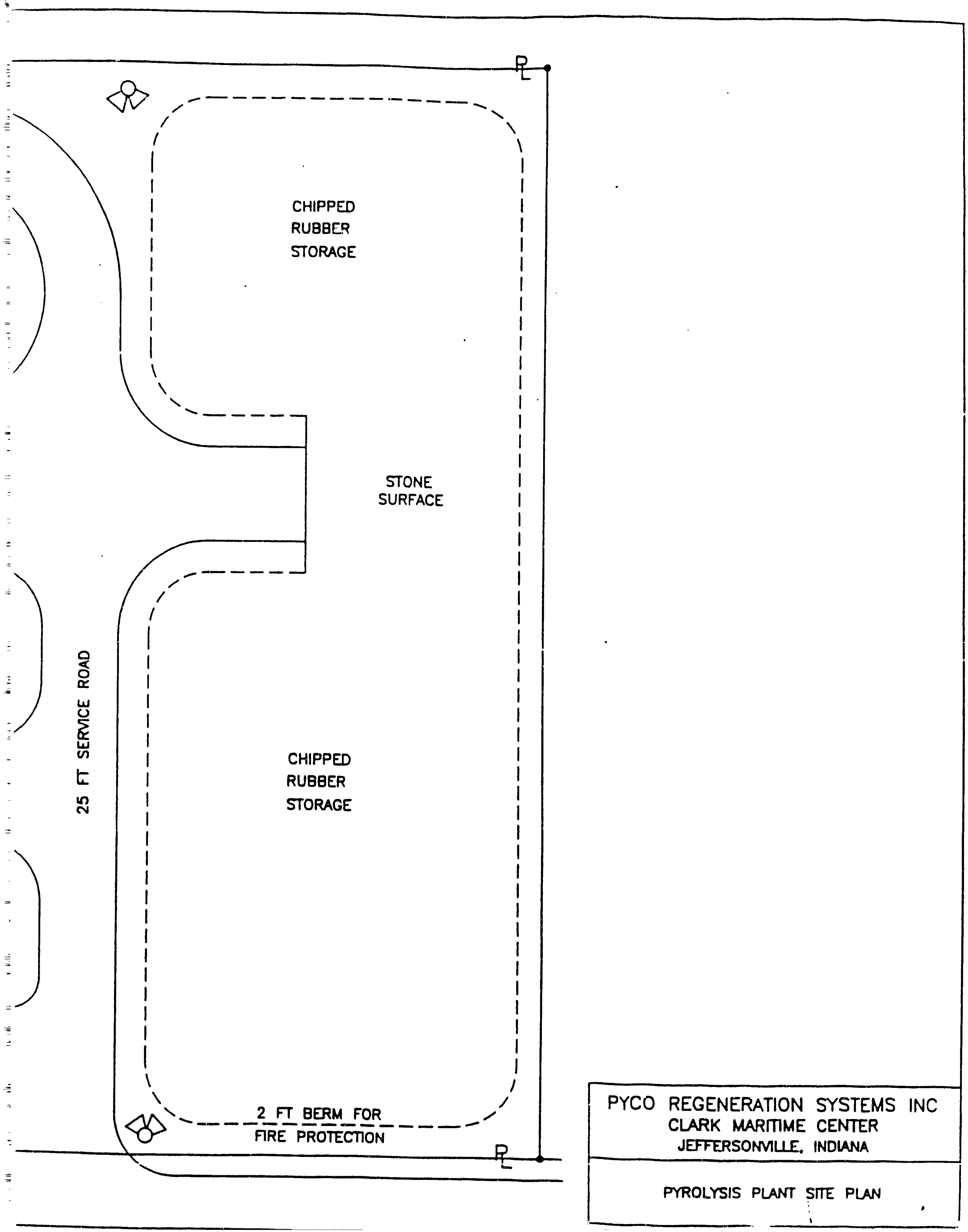
The proforma presented in the previous chapter is a realistic scenario for a city such as New Orleans. For equipment and plant design purposes, a 6000LB/HR feed rate will be used to provide excess capacity for future expansion. Economies of scale do not increase capital costs appreciably. All moving equipment, such as conveyors, will include variable speed drives that are computer controlled to optimize operation. Structural integrity of high temperature equipment components (pyrolyzation temperature for rubber feedstock will approximate 1000 degrees F.) will be provided for, together with quenching, cooling and refrigeration components. Constant monitoring by a computer system that controls the pyrolysis process would include plant shut down in the event of serious malfunction using a series of air lock valves and seals. If a malfunction occurs, shut down prevents oxygen from entering the system and reduces the possibility of fire. Storage of the 2 inch x 2 inch scrap rubber feedstock is minimized because of the close integration with the tire collection/shredding operation. A 30 day supply should be sufficient. Figure 3 illustrates a pyrolysis site plan.

Raw Material Handling

Feedstock (2 x 2 rubber chips) is received from the collection/shredding plant via self-unloading dump trucks. After weighing, the chips are unloaded onto the dump floor, then moved by loader into a feed hopper adequately sized to provide a continuous feed by conveyor into a secondary shredder that reduces the size of the chipped rubber to 1 inch x 1 inch pieces. A conveyor delivers the feedstock onto an automated adjustable conveyor to fill a movable bed hopper capable of supplying feedstock to the process for a minimum of 16 hours. This arrangement allows one loader operator to be employed for an eight hour day five days per week. A swing shift employee operates the equipment on weekends.

FIGURE 3


25 FT SERVICE ROAD
GRASS
25 FT SERVICE ROAD
140'
80'
GAS STORAGE
RAW MATERIAL HANDLING
CONTROL RM. MAINTENANCE SHOP
450'
MOVABLE ROOF
ASH STORAGE
GRASS
15' DRIVE
CARBON PROCESSING
OIL STORAGE
TRUCK LOADING AREA
RAISED FLOOR
100'
OFFICE LAB
GRASS
GRASS
100'
40' X 40'
PARKING
GRASS
TRUCK SCALE
550'
PUBLIC ROAD - 60 FT. ROW


PL
CHIPPED
RUBBER
STORAGE
STONE
SURFACE
25 FT SERVICE ROAD
CHIPPED
RUBBER
STORAGE
2 FT BERM FOR
FIRE PROTECTION
PL
PYCO REGENERATION SYSTEMS INC
CLARK MARITIME CENTER
JEFFERSONVILLE, INDIANA
PYROLYSIS PLANT SITE PLAN

Raw Material Processing

The 1 inch x 1 inch rubber chips (Figure 4) are delivered by conveyor to a rotary dryer, where the material is preheated and dried using waste exhaust gases from the pyrolyzer. This step also removes some of the air that is entrained in the feedstock. Prior to entering the pyrolyzer the feedstock is quantified and the remaining air (oxygen) is removed using a nitrogen purge, to eliminate the possibility of oxygen entering the pyrolyzer reactor. The raw material feedstock is quantified and computer controlled based on temperature of the vapor and char being produced.

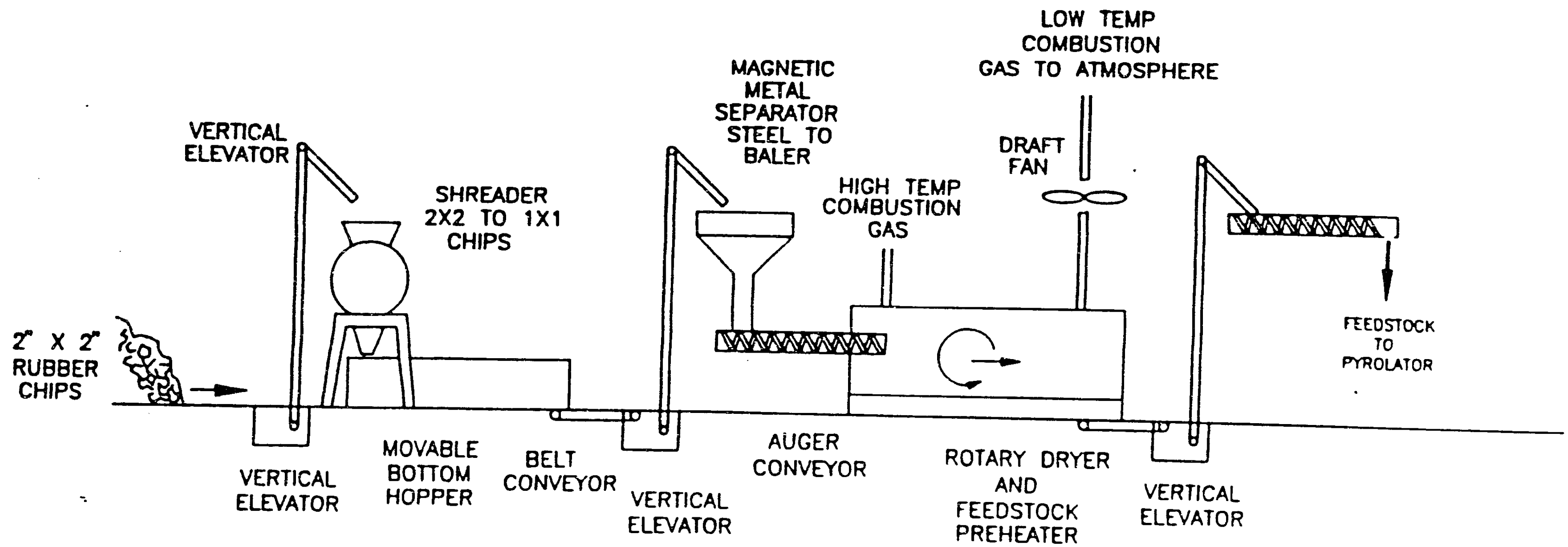
Pyrolyzation

The pyrolyzation process is essentially a thermally induced chemical process that decomposes the feedstock into its original components in the total absence of oxygen. Organic materials revert to vapor (Figure 5), which is condensed into gases and oil, and inorganic materials are reduced to carbon and ash, commonly referred to as char. Time of detention within the reactor and temperature are the determining factors that qualify the end products produced from pyrolyzation. To prevent infiltration of air into the reactor during the process some of the gas produced is used to pressurize the reactor. If a malfunction occurs and air is allowed to get into the reactor, gaseous liquid nitrogen is used to purge the system. Computer controlled sensors continuously monitor the system for operating control and safety.

Char and Carbon Production

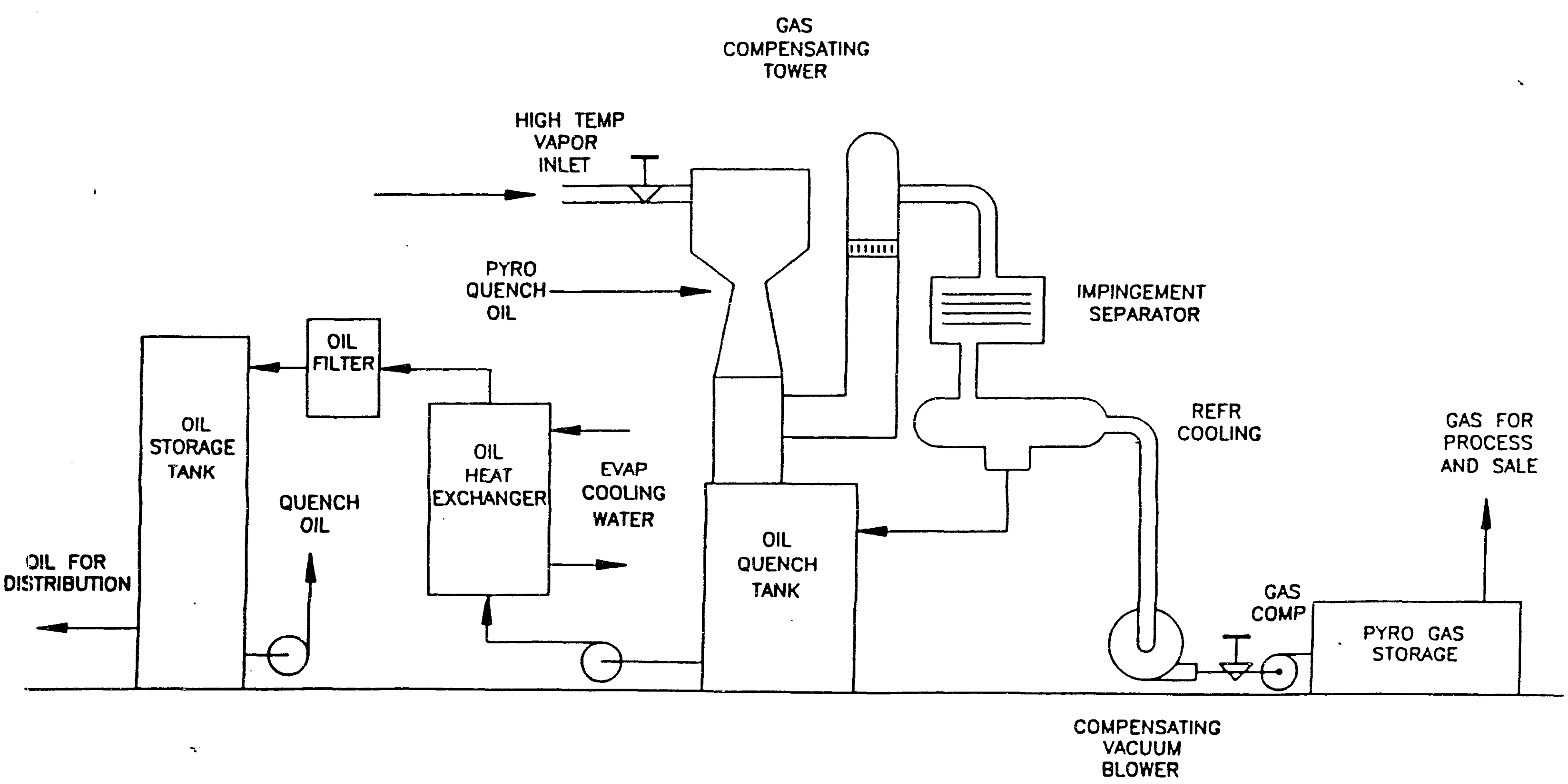
Char leaving the pyrolysis reactor is cooled using water that is recirculated and reused. After cooling, the char is deagglomerated, screened to remove fiberglass and passed through a magnetic separator to remove steel as demonstrated in Figure 6. The fiberglass and steel are baled for shipment, and the char is conveyed to storage for further processing. Char storage would be provided for a minimum of four days of production, as inventory.

FIGURE 4



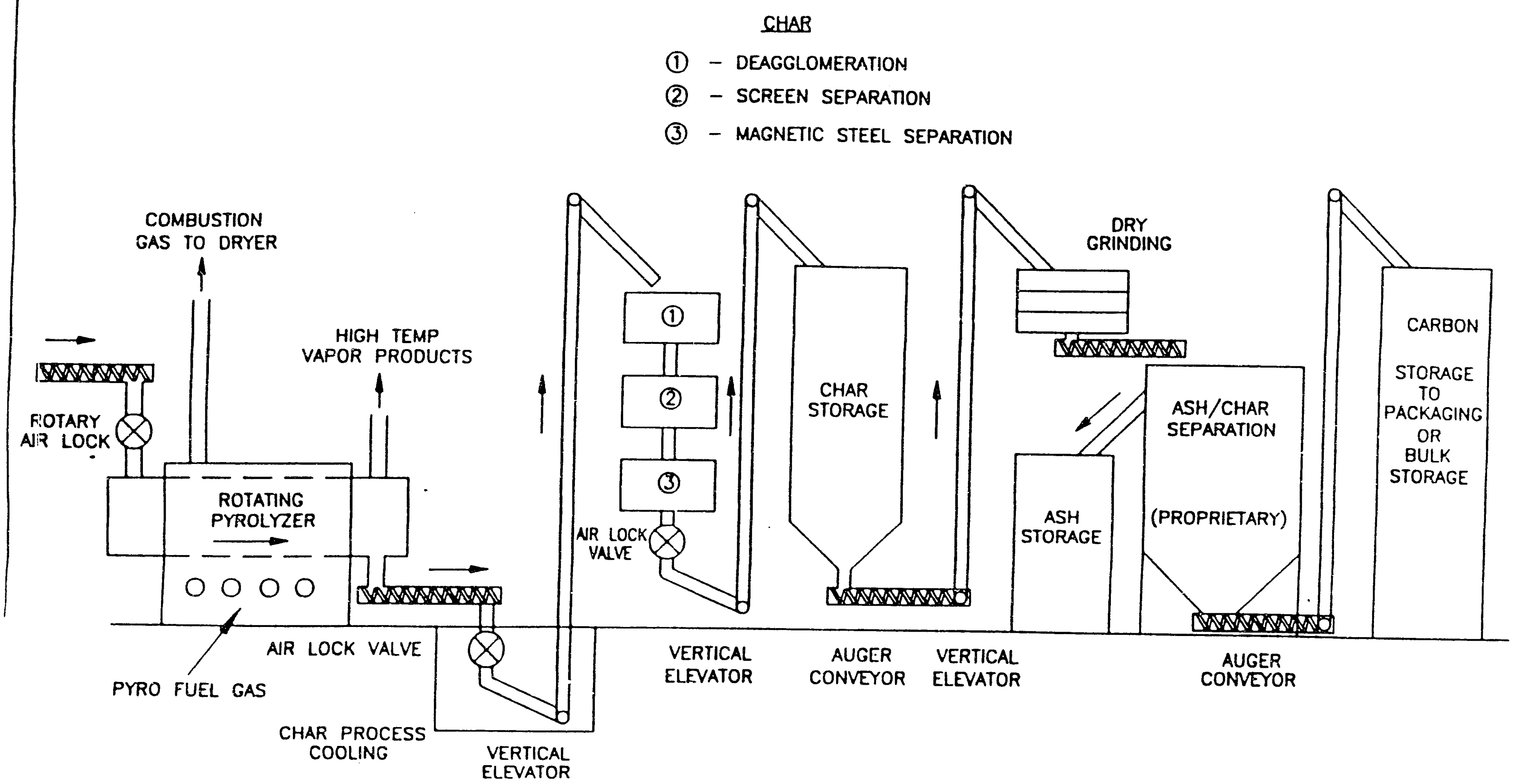
PYCO REGENERATION SYSTEMS INC CLARK MARITIME CENTER JEFFERSONVILLE, INDIANA			
PYROLYSIS PLANT FLOW SCHEMATIC RAW MATERIAL HANDLING			
DATE 2/26/91	DRAWN BY JTD	SCALE NONE	DWG NO 4

FIGURE 5



PYCO REGENERATION SYSTEMS INC CLARK MARITIME CENTER JEFFERSONVILLE, INDIANA			
PYROLYSIS FLOW SCHEMATIC PYROLYZATION – VAPOR PROCESSING			
DATE 2/26/91	DRAWN BY JTD	SCALE NONE	DWG NO 5

FIGURE 6



PYCO REGENERATION SYSTEMS INC CLARK MARITIME CENTER JEFFERSONVILLE, INDIANA			
PYROLYSIS FLOW SCHEMATIC PYROLYZATION – CHAR PROCESSING			
DATE 2/26/91	DRAWN BY JTD	SCALE NONE	DWG NO. 6

Char Processing

The method used to separate ash from the char is proprietary and involves grinding, washing, rinsing and drying operations, that produce carbon black at less cost than the virgin materials now being supplied. Bulk storage for refined carbon black is provided with pneumatic conveyors to deliver in bulk, or to packaging machinery for bagging and shipping. The ash, containing mostly silicates and carbonate material, together with minute quantities of metal salts, becomes a raw material for the cement industry.

Vapor Processing

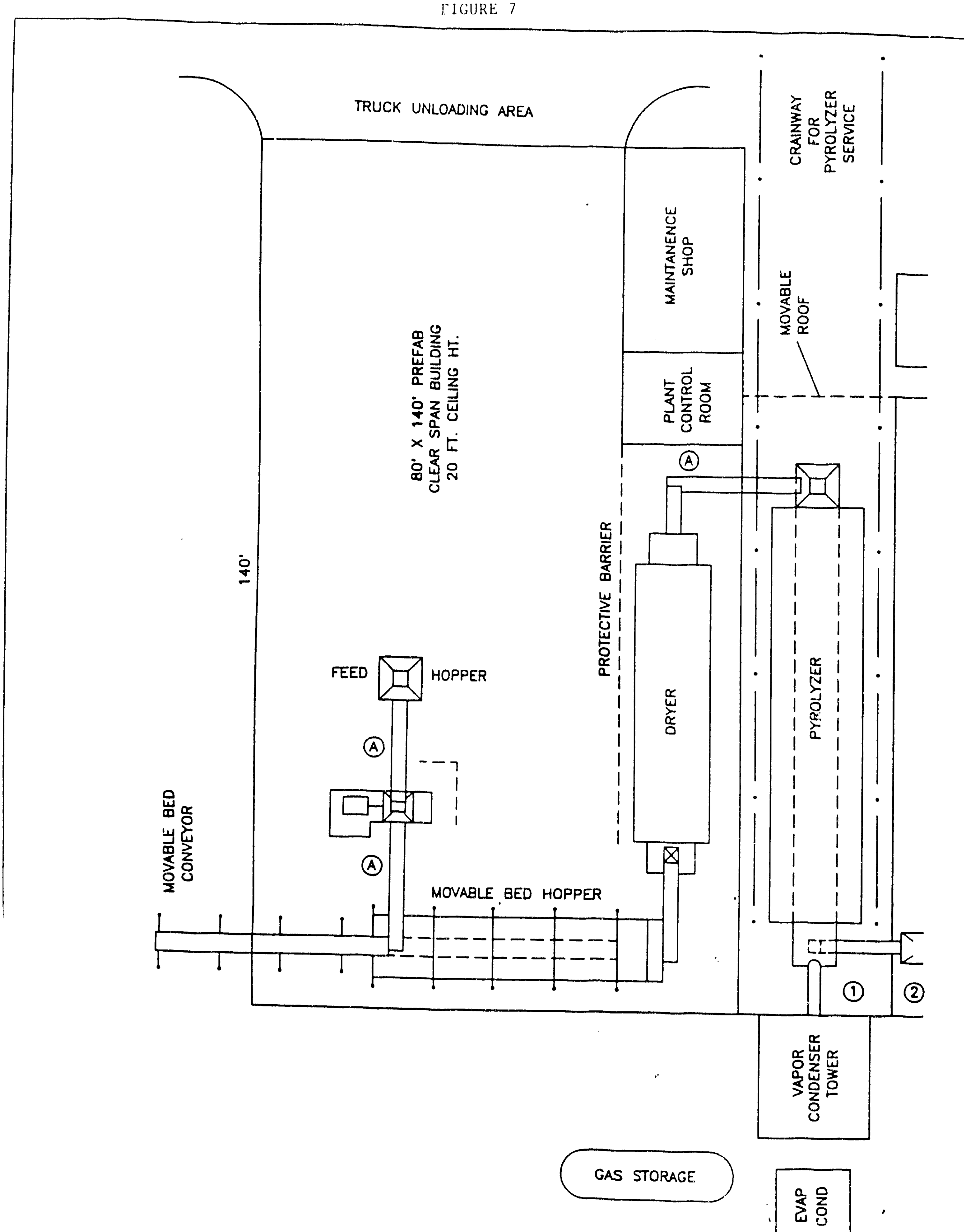
The high temperature vapor leaving the reactor is quenched using cooled pyrolysis oil, and subsequently reduced in temperature to 30 degree F. using mechanical refrigeration to remove all liquids. The pyrolysis oil is filtered and stored for distribution as boiler fuel. The pyrolysis gas is compressed and used to maintain operating pressure on the system, with some being consumed to provide the thermal energy required for pyrolysis. The pyrolysis system produces surplus energy products that are marketable. The oil can be transported, but the gas cannot without great expense. Therefore, siting a pyrolysis plant should consider the potential for selling the gas to a nearby or contiguous industry that can consume the gas on a continuous basis.

Product Storage

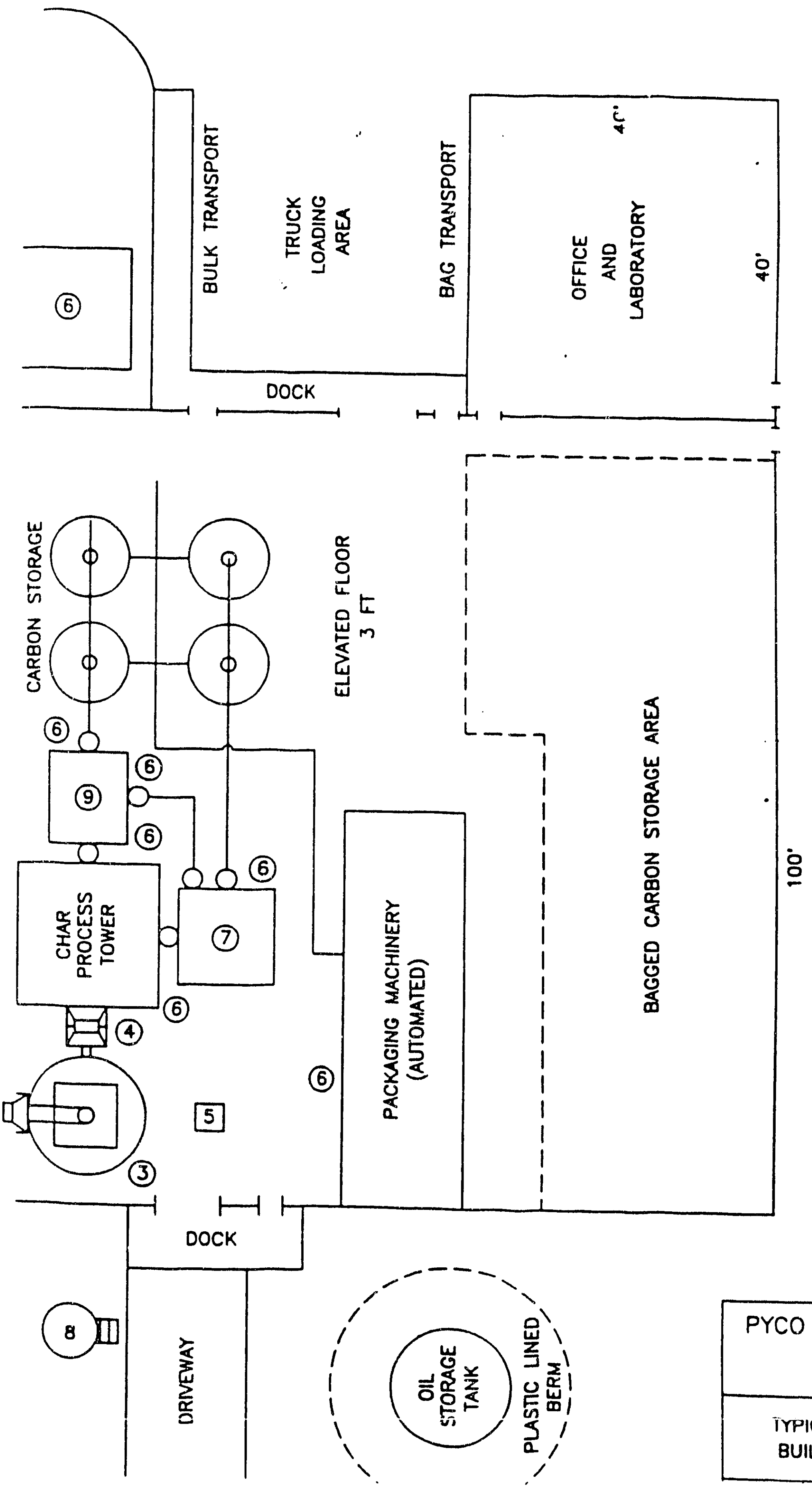
Storage for 25,000 gallons, or a minimum of four days production, of pyrolysis oil is to be provided on site. The pyrolysis gas would be stored in such quantity and pressure as would be required to satisfy the need of the industrial client-consumer, and transported by pipeline. Ash would be stored on the premises and hauled to a cement plant on a regular basis. Four or more storage tanks would be provided to accommodate two or more specification carbon products in pelletized or powdered form to satisfy the requirements of the industrial consumer. A flexible pneumatic conveyor system is provided to deliver char and other carbon products in bulk, or to packaging machinery for bagging.

Figure 7 represents a typical pyrolysis plant schematic.

FIGURE 7



TRUCK UNLOADING AREA
CRAINWAY FOR PYROLYZER SERVICE
MAINTANENCE SHOP
MOVABLE ROOF
PLANT CONTROL ROOM
80' X 140' PREFAB CLEAR SPAN BUILDING 20 FT. CEILING HT.
140'
PROTECTIVE BARRIER
A
DRYER
PYROLYZER
FEED HOPPER
A
A
MOVABLE BED CONVEYOR
MOVABLE BED HOPPER
1
2
VAPOR CONDENSER TOWER
GAS STORAGE
EVAP COND



LEGEND

1. PROCESS COOLING
2. BUCKET ELEVATOR
3. DEAGGLOMERATION
   SCREENING
   METAL SEPARATION
   CHAR STORAGE
4. BUCKET ELEVATOR
5. METAL BALER
6. PNEUMATIC CONVEYOR AND BAG HOUSE
7. PELLITIZING
8. ASH STORAGE
9. CARBON PROCESSING

(A) BELT CONVEYOR

PYCO REGENERATION SYSTEMS INC
CLARK MARITIME CENTER
JEFFERSONVILLE, INDIANA

TYPICAL PYROLYSIS PLANT SCHEMATIC
BUILDING & EQUIPMENT SCHEMATIC

E. PMR SITE LOCATION

Two PMR companies responded to the survey question regarding estimates of space needed for a facility. One estimated five acres were needed, the other estimated ten, giving us a very rough bracket within which to plan siting needs, costs and logistics.

F. PMR ZONING RESTRICTIONS

Three companies addressed zoning in their replies to the PMR survey. Representative of Conrad Industries of Centralia, Washington stated that they felt that there would be no problem locating a PMR plant in an area already zoned for commercial or industrial use. Garb Oil and Power Corporation felt that a heavy industrial or manufacturing zone designation would best suit a pyrolysis plant. Kutrieb Corporation of Chetek, Wisconsin has a system in which the infeed and discharge systems can be detached and the reactor unit can be hauled on the highway. A portable unit such as Kutrieb's could significantly reduce zoning restrictions.

The City's Zoning Administrator within the Department of Safety and Permits was consulted and commented that a PMR plant would be considered a hazardous use. A hazardous use is allowed only after approval by the Board of Zoning Adjustments. In applying for such a special use, the Federal Coastal Zone Management Act, as implemented by Louisiana's State Coastal Zone Plan, would be one of the considerations.

The aspect of PMR which made a plant a possible hazardous use was the reclamation component. The reclamation process is a manufacturing process which the City has not studied and thus, has not been categorized as a designated use. Other waste tire technologies that concentrate on recycling and reuse of waste tires would most likely be categorized as a use which would not require a new designation and special application to the Board of Zoning Adjustments.

REFERENCE ON PYROLYSIS SECTION

1. Sladek A. Thomas, proceeding of workshop on "Disposal Techniques With Energy Recovery for Scrapped Vehicle Tires.

2. Dodd et al., Scrap Tires : A Resource and Technology Evaluation of Tire Pyrolysis and Other Selected Alternative Technologies.

3. Pope Kent, Energy Product of Idaho, : " Tires and Municipal Wastes to Energy in a Fluidized Bed Combustion System." Presented at fluid bed combustion symposium.

4. Asphalt Rubber Producers Group. Proceeding National Seminar on Asphalt Rubber, Kansas City, Missouri, October 30-31, 1989.

5. Conrad Industries, Kleenair Pyrolysis System "A Technology that Recovers Both Energy and Material from Waste.

SECTION VI: ECONOMIC FEASIBILITY

B. TYPES AND QUALITY OF PYROLYSIS PRODUCTS

Qualification of Pyrolysis Products

For optimum quality and quantity of end products, pyrolysis temperatures recommended will approximate 1000 degree F. Due to variations in the composition, condition and age of the tires in the feedstock, the end products from pyrolysis will be variable, but stable. As a consequence, the description of pyrolysis products presented herein are typical and not exact. Predictability and repeatability of quality of end products from pyrolysis can be assured by adjusting the pyrolization process.

Pyrolysis Fuel Oil

Pyrolysis fuel oil is comparable to the ASTM standards for No. 2/3 boiler fuel. It will have a higher flashpoint (110 degrees F vs. 100 degrees F), lower pour point (-70 degrees F vs 28 degrees F), higher specific gravity (.925 vs .8765), lower BTU content per pound (18,455 vs 19,404), higher BTU per gallon (142,720 vs 14,650) on a gross heat basis and higher sulfur content (.75 vs .5). Products of combustion will be comparable using similar fuel to air ratios.

On a million BTU basis pyrolysis fuel oil would have a slightly higher value than No. 3 fuel oil, but for purposes of this report, the proforma will use a 25% discount from the value of No. 4 boiler fuel due to customer unfamiliarity with the product and to assure sales on a long term contractual basis. For comparison, No. 4 oil, FOB Baton Rouge in January, 1991, was quoted at $31.40 per barrel ($5.15 per million BTU). A price of $3.867 per million BTU FOB plant site is used in the proforma for the pyrolysis fuel oil.

Pyrolysis Fuel Gas

This product is directly substitutable for natural gas with the same BTU content per C.F. Pyrolysis gas will have a lower methane content, but has higher C2-C4 and hydrogen content, which balances out to comparable

BTU content per CF. All of the gas produced from pyrolysis will be used to sustain the thermal needs of the process. If the gas were sold to a contiguous industrial consumer, its value would approximate the cost of spot gas at the wellhead, or $1.83 per million BTU.

Steel Products Recovered

Steel used in the manufacture of steel belted tires is a high quality, high carbon product. In the pyrolysis process the temperatures used do not alter the steel in any manner. The steel and fiberglass are separated from the char produced and baled for shipment to a steel mill. Both products will have a coating of carbon, which enhances their value. Contacts with steel plants in Texas and local scrap steel brokers indicate a potential market value of $45.00 per ton.

Carbon Products

Char, as produced from pyrolysis of scrap rubber, has little value above its comparable fuel value, approximately that of pulverized coal. However, following refining (a proprietary process) the product qualifies as a recyclable product for reinforcement, pigment and activated applications with commensurate value enhancement above its value as a fuel product. Therefore, cleaned carbon of high purity (98.5% fixed carbon), which is the residue from pyrolysis of scrap rubber, has many applications as a recycled product in the marketplace. Ground to a 30/40 nm particle size, it can be used as a filler in gravure printing inks and for pigments. The product will also compare favorably to the ASTM specification N 700 for the carbon blacks used for reinforcement. It also can be activated for use in industrial water and air purification applications, as a powder as well as in pelletized form.

Pyrolysis plant design and operation must be dedicated for raw material supply, as well as end product. The higher value and demand for activated carbon products dictate that such products be given priority. Therefore, powdered and pelletized activated carbon is selected as the end product from pyrolysis, and the equipment selected for this purpose. Packaging equipment is included in the capital cost estimate and bulk delivery clients would be solicited for long term contracts. Off-specification products will also be produced that would not qualify for activation, and these would be sold as low grade pigment products.

Activated carbon products were selected as the end products of emphasis to meet a marketplace need resulting from more stringent environmental regulations. Although overall production growth for activated carbon is pegged at around 5% annually, growth in demand in one segment of the industry, ground water treatment, is expected to be in the double digits. Renewed interest in environmental problems caused the federal Safe Water Drinking Act to be amended in 1986, which redefined contaminant levels and expanded its synthetic volatile compound list. This list now includes 83 different compounds, with 25 new compounds expected to be added every three years. With surface water sources becoming less reliable, 40% of drinking water now comes from wells. Studies show that volatile synthetic compounds, chiefly in the form of solvents, are leaking into the water supply from industrial sources and through leaching from landfills. Many of these compounds are considered to be carcinogenic and are mandated for removal by the Environmental Protection Agency. Using activated carbon is one of two ways to effectively remove these compounds. For this reason activated carbon usage is projected to grow almost 15% per year.

Ash Residue

The ash residue separated from the char is non-hazardous and can be used as a filler in the cement industry due to its silicate and carbonate constituents.

Emissions

In pyrolysis, every pound of raw material entering the system is accounted for in end products. The only emissions to the atmosphere are the result of combustion of pyrolysis gas. Table 13, analyzes a gas sample produced by pyrolysis using GC/TCD; GC/FID (GC, gas chromatography) .

The pyrolysis plant proforma is presented in Table 9 through Table 15.

TABLE 9

CAPITAL COST ESTIMATE

Land - 5.7 Acres	$ 200,000
Site Improvements, including:	
Survey, Grade & Drain, Berm Fill & Construction, Stone Surfacing, Service Roads & Parking Areas, Curbs & Gutters with Drainage, Utilities to Site	
Total Site Improvements	**340,000**
Major Equipment & Buildings, including:	
Truck Scale, installed, Raw Material Handling, Feedstock Dryer & Preheater, Feedstock Conveyor, Measurement and Air Lock System, Pyrolyzer, Char Process cooler, Vapor Condenser Tower with Evaporative Condenser and Refrigeration, Char Deagglomeration, Screening and Metal Separation, Char Storage, Elevators, Char Process Tower with Pre-installed Piping for Washing, Cleaning, Rinsing, Heating and Drying, Ash Separation, Ash Storage, Oil and Gas Storage with Pumps & Compressors, Metal Baler, Pneumatic Conveyor System, Carbon Pelletizer, Carbon Storage, Packaging Machinery, Plant Computerized Control, Office Equipment, Pre-Fabricated Steel Buildings with Removable Roof for Pyrolyzer Maintenance, Craneway, Area Lighting, Vehicles, including Pick Up Truck, High Lift and Forklift	
Total Major Equipment	**5,240,000**
Installation & Construction, including:	
Concrete Work, Piling and Foundations, Raised Floor in Carbon Processing Building, Craneway Installation, Sod Seed of Open Areas, Electric Service and Wiring, Control Wiring, Sanitary Plumbing & Drains, Piping & Duct Work, Pneumatice Conveyor System Installation, HVAC and Refrigeration, Rigging, Control Room & Shop Area Finishing, Contractors Fee	
Total Installation & Construction	**1,950,000**
Indirect Costs, including:	
Permits, Fees & Legal, Engineering Design, Contractors Bonds, Construction Management, Project Contingencies	
Total Indirect Costs	**2,290,000**
Total Project Cost Estimate:	$10,020,000

TABLE 9 cont.
OPERATING EXPENSE DETAIL

Production Labor

Chemist (1) salaried	$48,000
Laboratory technician (1) salaried	37,500
Process Operators (4) $12/hr	99,840
Swing Shift Operator (1) $13/hr	27,040
Mechanic (1) $14/hr	29,120
high Lift Loader (1) $8.50/hr	17,680
Shipping and Packaging (2) $10-$9/hr	39,520
Total Wages	**$315,340**
Benefit Package	126,660
Total Production Labor	**$442,000**

Equipment Maintenance

Pyrolysis & Drying Equipment	$90,000
Carbon Black Processing Equipment	40,000
Tire Shredder	40,000
Pneumatic Conveyor System	15,000
Conveyors & feed Hopper	15,000
Computer Control System	10,000
Pelletizing & packaging Equipment	20,000
Refrigeration & Cooling Equipment	30,000
deagglomeration, Screen & Metal Separation Equipment	15,000
Misc. & Unallocated Maintenance & parts	42,000
Total Equipment Maintenance	**$317,000**

Process Operating Expense

Process Chemicals & Activation	$454,000
Electric Power	232,000
Property & Building Maintenance	12,000
Uniform Rental	10,000
vehicle Fuel	9,000
Water and Sewer Service	6,000
Nitrogen	5,000
Outside Services	20,000
Misc. Operating Supplies	10,000
Misc. & Unallocated Expense	51,000
Total Operating Expenses	**$809,000**

General & Administrative Expense:

Plant Manager- Salary	$54,000
Clerical	18,000
Benefit Package	28,800

Employee Training	5,000
Travel	5,000
Outside Services	6,000
Dues & Memberships	1,000
Telephone & Communications	6,000
Office Supplies & Postage	4,500
Office Maintenance & Cleaning	2,600
Property Tax Estimate	300,000
General Insurance	24,000
Legal & Accounting	27,500
Misc. & Unallocated	22,600
Total General and Administrative expense	**$505,000**

TABLE 9 cont.

Projected Income:

Pyrolysis fuel oil- 403,708 MMBTU @ $3.867	$1,561,130
Pyrolysis fuel gas	0
Activated carbon products- 13,109,730 lb. @@ $0.31/lb	4,064,000
Off-Spec. carbon products- 1,456,644 lb. @ $0.19/lb.	276,760
Steel- 628 tons @ $45/ton	28,260
total projected income	**$ 5,930,150**

Estimated Direct Operating Expense:

Feedstock purchases- 21,093 tons @ $20/T	$421,860
Production labor	442,000
Equipment maintenance	317,000
Processing operating expense	809,000
Total direct operating expense	**$1,989,840**

Estimated Indirect Expense:

General and administrative expense	$505,000
Depreciation- 20 yr. St. Ln. Investment- $10,020,000	501,000
Total estimated indirect expense	**$1,006,000**

Total Direct and Indirect Expense:	**$2,995,860**
Projected Net Income Before Taxes	**$2,934,310**
ROI- $10,020,000 Investment	29.34%

TABLE 10
PRODUCTS PRODUCED FROM PYROLYSIS OF SCRAP RUBBER TIRES PER TON OF RAW MATERIAL

Pyrolysis Fuel Oil - 18,500 BTU/Lb.			
Sp. Gv. 9765 - 8.138 Lb/Gallon	90	Gallons	13,550 MBTU
Pyrolysis Fuel Gas - 1,000 BTU/SCF	7094		7,094 MBTU
Scrap Steel	180	Pounds	
Char - Carbonaceous Material	750	Pounds	
Refined Carbon Black Products	653	Pounds	
Separated Ash	97	Pounds	

ANNUAL PRODUCTION FROM 42,175,500 POUNDS SCRAP RUBBER TIRES

Pyrolysis Fuel Oil	1,897,898	Gallons	285.6 MMBTU
@ 8300 Hour Operating Year	229	GPH	
BTU/Hr. @ 150,553 BTU/Gallon			34.4 MMBTU
Pyrolysis Fuel Gas	149,595	MCF	
@ 8300 Hour Operating Year	18.024	MCFH	
BTU/Hr.	18,024,000	BTU	
BTU Consumed As Fuel In Process	-3,572,000	BTU	
Net Marketable BTU/Hr.	14,452,000	BTU	
Net Marketable MCFH	14.452	MCFH	
Net Marketable MCFYr.	119,951	MCF	119.9 MMBTU
Scrap Steel	1,898	T/Yr.	
Refined Carbon Black	13,770,300	Lb/Yr.	
Ash	2,045,510	Lb/Yr.	
Total Marketable BTU Per Year			**405.5 MMBTU**

VALUE OF PYROLYSIS FUEL PRODUCTS

Pyrolysis Fuel Oil:		
Published Value #2 Oil, FOB Baton Rouge-Jan.'91		$0.73 gal.
BTU/Gallon #2 Oil - Gross	138,500	
BTU/Gallon Pyrolysis Oil - Gross	150,553	
Value of Pyrolysis Oil = $\frac{150,553}{138,500}$ x 0.73=		$0.79 gal.
Pyrolysis Fuel Gas:		
Published Value Natural Gas (1000 BTU/CF)		
Spot Market Quote - Jan.'91		$1.83 MCF
Value of Pyrolysis Gas (1000 BTU/CF)		$1.83 MCF

TABLE 11
PRODUCT YIELD FROM PYROLYSIS OF SCRAP TIRES

Raw Material Feedstock	**Pass. tires**	**Truck Tires**	**Total**
Number	1,093,800	217,261	1,311,061
Pounds Processed	22,584,017	19,553,490	42,187,507
Product Yield from Feedstock (%)			
Pyrolysis fuel oil	50.1%	54.0%	
Pyrolysis fuel gas	8.1%	9.5%	
Char (including ash and steel)	41.8%	36.5%	
Ash in char (98.5% removal)	3.8%	2.8%	
Cleaned carbon	36.1%	32.8%	
Steel	1.9%	0.9%	
Product Yield from Feedstock (quantities)			
Pyrolysis Fuel Oil			
Specific gravity	0.933	0.923	
Wt/gallon	7.775	7.692	
BTU/lb	18,501	18,409	
Pounds produced	11,314,592	10,558,884	
Gallons produced	1,455,253	1,372,710	2,827,963
MMBTU produced	209,330	194,378	403,708
Pyrolysis Fuel Gas			
Specific gravity	0.794	0.867	
Wt/CF	0.0606	0.0662	
BTU/SCF	835	1,145	
Pounds produced	1,829,305	1,857,581	
MCF produced	30,186	28,060	58,246
MMBTU Produced	25,205	32,128	57,333
Gas consumed in the process			59,701
Char			
Char produced (pound)	9,440,119	7,137,023	16,577,142
Ash and steel removed	5.7%	3.7%	
weight- pounds	1,287,289	723,479	2,070,768
Cleaned carbon- pounds	8,152,830	6,413,544	14,566,374
Steel			
Percent- processed weight	1.9%	0.9%*	
Weight -Pounds	429,096	723,479	
Tons	214	414	628

*Three pounds per tire is added to percentage because truck tires pyrolyzed did not include beads, which were removed

Reference: Destructive distillation of scrap tires- report 7302 U.S. Department of Interior, Bureau of Mines.

TABLE 12
INSTITUTE OF GAS TECHNOLOGY
PETROLEUM- ANALYTICAL REPORT

Specific Gravity:
API Hydrometer.....ASTM D-1298

API	3	60F	21.5
Sp. Gv.	60	/60F	0.925

Water and sediment
Toluene solvent....ASTM DPc D 1795 0.05%

Pour point.....ASTM D 97	temperature	-70.0F
Flash point....ASTM D 93	temperature	110.0F

Conradson carbon residue... ASTM D 189 Wt% 2.8%

Distillation..... ASTM D 86

IPB	175F
5%	239
10%	272
20%	322
30%	370
40%	438
50%	521
60%	597
70%	659
80%	736
90%	728F

decomposition PT
Vol % recovery **93%**
Wt % residue **5%**

Ultimate analysis

Wt% as received	Analyzed	
Carbon		
Hydrogen		
Sulphur	0.75%	**ASTM D24622**
Nitrogen		
Ash	0.003%	**ASTM D482**
total	0.7503	

Heating values... BTU/lb ASTM D240
Gross heating value 18,335
Net heating value 17,502 (estimate)

Calculated Cetane index	ASTM D 976	29.1
Kinematic viscosity	ASTM D 445	2.77 cST @ 100F

By Allen G. Jones 2/13/86

TABLE 13
INSTITUTE OF GAS TECHNOLOGY
CHROMATOGRAPHY LABORATORY ANALYTICAL REPORT

Gas Analysis by GC/TCD; GC/FID

Component	Concentration, volume %
Helium	ND
Hydrogen	30.2
Oxygen/Argon	(Air free)
Nitrogen	7.78
Carbon dioxide	3.94
Carbon monoxide	2.66
Methane	24.9
Ethane	6.61
Ethene	6.58
Propane	2.71
propene	4.56
I-butane	0.27
n-butane	0.55
Butenes	3.23
Butadienes	1.72
Neo-pentane	BDL
I-pentane	0.068
N-pentane	0.068
Pentenes & pentadienes	4.01
Total C(6)'s	0.080
Total C(7)'s	0.041
Total C (8)'s	0.006
Benzene	0.013
Toluene	0.006

BDL: Component concentration below detection limit (0.001%)
ND: Component not determined by the analysis.

Calculated Gross Heating Value; 1082 BTU/SCF (60F; 14.75 psia, sat.)
Calculated Specific Gravity: 0.778 (air=1.0)

TABLE 14
SECTION VI: ECONOMIC FEASIBILITY (Cont.)
INSTITUTE OF GAS TECHNOLOGY

ANALYTICAL REPORT - COAL AND OIL SHALE
CHEMICAL AND PHYSICAL TESTING LABORATORY

Proximate Analysis	Wt% (as received)		
Moisture	3.90		(D-3172)
Volative matter	7.07	7.36 dry	(D-3173)
Ash	8.66		(D-3175)
Fixed carbon	80.37		(D-3174)
	100.00		

Ultimate Analysis	Wt% (dry basis)	
		(D-3176)
Ash	9.01	(D-3174)
Carbon (total)	89.11	(D-3178)
Organic carbon		(D-3178)
Hydrogen	1.10	(D-3178)
Sulfur	2.40	(D-3177)
Nitrogen	0.23	(D-3179)
Carbon dioxide		
Oxygen (by diff.)	0.00	
Total	101.35	
Gross Calorific Value- BTU/lb =	13,674	(D-2015)

Date: 3/4/86

TABLE 15
VALUATION BASIS FOR RECYCLED ACTIVATED CARBON

Reliable sources have been contacted relative to value of activated carbon products. The following is indicative as per AWWA specification B-600-78

	Powdered		granular		Pyrocarbon
Iodine number (mg/g)	750	850	900	1000	950/1250
Modified phenol (g/l)	2.5/2.8	1/3	1/3	1/3	1/3
Moisture (%)	1/3	1/3	2	2	2
density (lb/CF)	35/45	40	45	45	31
Ash (%)	5/7	4/6	4/6	4/6	1.5
Sieve analysis					
Trough 100 mesh	99 min	90 min			90 min
200 mesh	95 min	90 min			90 min
300 mesh	90 min	95 min			95 min
Larger than No. 8			15%		
Smaller than No. 12			4%		
Larger than no. 12				5%	
Smaller than No. 40				4%	
List price:					
Bulk- 30,000 lb	$0.52	$0.66	$1.16	$1.27	$0.31*
Bagged 2/10,000 lb	$0.60	$0.72	$1.24	$1.37	$0.36*

* Sale price of pyro carbon would be discounted by 40 % to attract bulk sales customers on a long term contractual basis for the recycled product.

SECTION VII: SUMMARY

Waste tire piles in New Orleans pose health problems (e.g. vector control) in addition to the aesthetic, fire hazard and solid waste collection issues common nationwide.

This report examined recycling and disposal alternatives having application and transfer implications around the country, and in particular addressed pyrolysis as a technology that might be implemented in this region. While relatively benign environmentally, the pyrolysis process requires significant capital investment, which is most likely to come from the private sector, with a possible subsidy from the public sector.

During the development of the present project, staff recognized the critical role local government plays in evolving state regulations. The report discusses local participation in Louisiana Department of Environmental Quality (DEQ's) regulatory process in 1990. Subsequently, we were gratified to find the vast majority of our recommendations incorporated into later drafts of applicable regulations. From a political and a logistic sense, regional cooperation is essential to the resolution of waste tire problems.

As this report goes to press, national tire legislation is proposed to be re-introduced in the 1991 session by Congressman Esteban E. Torres. At the state level, the City of New Orleans is recommending that a $2.00 surcharge on new tires be mandated by state law to support the costs of waste tire disposal. Armed with the analyses in this report, regional decisionmakers will be better prepared to respond to proposals for special waste management, and more cognizant of the economics of a pyrolysis plant and related issues.

SECTION VIII
RECOMMENDATIONS

The City's study of waste tire recycling lasted more than a year and utilized the services of two professionals, a consultant and a number of city, state and national officials and experts. Funded under a contract with the U.S. Department of Energy, the object of our research was to evaluate pyrolysis technology as a solution to scrap tire disposal on both a local and national scale. The supporting library to this work includes appendix and reference material stored in offices of the Environmental Health Services Division, New Orleans Health Department. A number of issues of overriding significance have emerged from our work, resulting in the following recommendations:

1. Pyrolysis technology would be appropriate in a city where the economic climate can support the capital costs and industry is ready to receive the output products. In addition to tires, a plant can be designed to accept other dedicated waste streams, such as used carpeting, plastics and other rubber materials. At present, the City's own budget cannot sustain the costs of such an operation, so the City will turn to the private sector for investment, as part of an economic development strategy.

2. Based on our survey of pyrolysis plants (Appendix A) any city considering using this technology should not expect immediate economic success. Although tire pyrolysis is sound, economic success is based on unstable forces such as oil prices.

3. Proliferation of discarded tire piles is evidence of a need for leadership at the state level through executive and legislative action. In this report, analysis of proposed regulations outlines the critical concerns for local government which should be addressed. At a minimum, if laws prohibit disposal of tires in landfills, then there must be provisions for temporary storage facilities and an overall state program having enough flexibility

to allow the natural ability of the free enterprise system to provide cost- effective solutions in the context of a changing economic climate.

4. Funding is key to solving the local and state waste tire problem. The proposed $2.00 per tire charge at time of sale provides support to the retailer and to the state for administration of the program and creates a clean-up subsidy, all of which are essential to effective waste tire management.

5. Recognizing the hazards to health and the environment, the City 6 New Orleans should move aggressively to reduce waste tire piles by encouraging the private sector to propose storage and recycling projects, preferably aimed at a regional market. Among the preliminary steps to be taken by the City are the location of appropriate land for facility siting, examination of zoning and land use requirements and an active solicitation of cooperation from our counterparts in the region. Key players in the City include the Department of Sanitation and the Mayor's Office of Economic Development. A coordination function would be best performed by an Office of Environmental Affairs, which might also seek grant money separate and apart from solicitation of private sector participation by the Office of Economic Development.

6. During the interim period, while a comprehensive solution is being implemented, the immediate public health menace posed by tire piles can be abated by simply shredding them, a solution that has already been proposed to the City by private sector interests. The shredded material can be stored under cover, stored in a monofill, or, ideally, shipped to market. While reducing the potential health threat, chipping waste tires also minimizes fire hazard potential as well.

7. Community education, pointing out the negative impacts of improper tire disposal, will be an early part of the local program, but it

must also provide solutions for the average citizen. Enforcement, which could be included in existing adjudication functions also depends upon feasible solutions.

APPENDIX A

TIRE PYROLYSIS SURVEY

Purpose

The purpose of the following tire pyrolysis survey was to develop and present to the City a prioritized analysis of options for the disposal of scrap tires, with an emphasis on determining and comparing the costs and benefits of alternative pyrolysis technologies. Where responses were received, information was often limited. Follow-up telephone communication typically failed to yield any more detail than is presented below.

Action and Progress

National and international surveys were conducted of pyrolysis companies and operations. The survey form follows this summary. Surveys of pyrolysis operations for both national and international projects indicated that most of those that shut down did so because of difficulties in marketing residue materials rather than any failure to meet environmental standards.

An overview of the national survey is presented below, followed by the international survey:

NATIONAL SURVEY

I. Plants that did operate pyrolysis technology.

1. **Garb Oil Corporation**: (Salt Lake City, UT, 1982) No Garb Oil pyrolysis plants are operating commercially at present, however they operated three demonstration plants over a period of 15 years. Garb Oil has an agreement with a corporation in West Virginia to begin construction of a plant in the next three years. The plant is designed to handle 9,000 tires per day, recovering 16,000 gallons of oil, 63,000 pounds of carbon and 25,000 pounds of scrap steel wire per day. Tire acquisition costs are valued at 20 cents per tire. Projected revenues are $6.1 million annually. Revenues for oil were calculated at 95 cents per gallon. Charcoal sales are valued at 10 cents per pound and there

is a ready market for the carbon black.

Actual construction of the aforementioned plant is not yet certain since "political problems" have hindered the development.

Benefit of Garb Oil's Pyrolysis Design

Pyrolysis produces less emissions than incineration. The emissions are non-toxic, and there are no heavy metal emissions.

Problems of Garb Oil's Pyrolysis Design

The largest problem is getting firm markets for the products. At present no guaranteed revenue stream will pay for the operation.

2. **Kutrieb Corporation (Chetek, Wisconsin):** Kutrieb corporation designs and manufactures incineration, gasification and pyrolytic systems for processing scrap tires. During the past ten years Kutrieb has built several batch charge pyrolysis systems, one of which was purchased by Bergy, Inc., a tire sales and retreading company in Perkasie, PA at a price of $105,000.00. The system produced gas, carbon char, oil and process heat, which was recaptured by means of a waste heat recovery boiler. Kutrieb reports that the older batch charge technology has been superseded by new continuous feed technology which permits the system to process tires on a continuous basis, thereby increasing production in a 24 hour period by a factor of 8. Where a reactor of the type sold to Bergy could process 50 tires per charge in an 8 hour period, the new system will process 50 tires (1000 lbs) per hour. A pilot plant utilizing this new technology has been in operation in Wisconsin for over 4 months. The concept has been proven and a second generation system is currently under construction. Cost of a basic continuous feed gasification system is presently $340,000 f.o.b. factory. Larger systems capable of processing several thousand tires per day are planned. Kutrieb has begun marketing this technology on a national basis.

Benefits Reported by Kutrieb; Economical and ecologically preferable alternative to land filling scrap tires. Energy produced and available for other process applications such as heating, drying, production of steam, etc. far exceed energy input. System process whole tires, thereby eliminating the $35.00-50.00 per ton cost of shredding.

Problems reported by Kutrieb; Processing capacity of batch charge systems was not great enough to be operated profitably. The much higher thruput of the new continuous feed system has eliminated this problem. Until now, markets for by products were limited. The advent of new technology is changing this situation. Installation with asphalt plants could lead to utilization of all by-products except steel. The steel can be sold as scrap.

3. **International Tire Collection Corporation**: (Albuquerque, NM) They operate a pyrolysis plant that uses a proprietary technology to extract sulfur from oil and carbon. The market value of the carbon black is very high.

4. **J.H. Beers, Inc.**: (Wind Gap, Pennsylvania) This firm has a pyrolysis very successful tire pyrolysis operation. Beers operates a tire storage site in Wind Gap, Pennsylvania. It purchased a second Pyro-Matic System module and expects to process one million tires a year at this location. According to a Beers spokesman, a tire tipping fee is essential to plant economics. A tire tipping fee is the fee paid to dealers to dispose of tires. Beers sells the fuel oil and further refines the carbon black to produce a more marketable product. The spokesman mentioned that the carbon black is almost ash-free, but some effort was needed to develop a handling system that could clean the carbon of steel and fiber glass. Beers was not willing to provide any cost or revenue data.

5. **Conrad Industries Inc.**: (Centralia,WA) Conrad Industries Inc. of Centralia, Washington and Kleenair Products Company of Portland, Oregon have jointly developed a pyrolysis system for commercial use that converts carbonaceous material to recover combustible gases, oil and other products.

This project is the culmination of several years of research and development by testing numerous feed stocks including tires. A production plant has been operating since March 1986 and converts 1 ton of tire chips per hour into 600 pounds of carbon black, 90 gallons of oil and 30 therm of vapor gas.

Conrad Industries' pyrolysis plant was designed to produce a daily yield of 2,184 gallons of oil, 17,000 pounds of carbon black and 100 million Btus of gas from 24 tons of shredded waste tires. A portion of the gas produced in the system is scrubbed and burned to supply heat for the conversion process. The shredded tires are heated to approximately 1500F in an oxygen-free environment. Gas and oil from the process are fed to scrubbing and demisting chambers where heavy oil and carbon are removed.

Conrad sells oil to a fuel blender. Charcoal is sold to rubber and plastic manufacturers. Initially, there was some difficulty in moving charcoal, primarily because there are few markets in the northwest. Throughput for the system is 94-100 tires per hour, 24 hours a day. The plant currently operates five days each week but can operate continuously. Eventual throughput, according to a plant spokesman, will be 800,000 tires a year. Tire materials must be 2 inch chips.

The Conrad industries system costs approximately $3.5 million, about $2.4 million of it in equipment costs. No operational or revenue figures were given because, according to the plant spokesman, "they'll be different in each case."

Benefits of the Conrad Plant

The largest benefit of this pyrolysis plant is that it constitutes high technology recycling and meets EPA mandates for waste minimization and recycling. This is a market driven technology because of the by-products produced. It meets emission standards, produces no waste water and runs smoothly.

Problems Reported by Conrad

People are skeptical about pyrolysis because it has a history of failure. Moreover, buyers appear to think virgin materials are of higher quality in spite of evidence to the contrary.

6. **Tecson Corporation:** (Jamesville, WI) Tecson has a pyrolysis plant starting by the end of February 1990. Tecson was formed in 1984, as a research and development firm for scrap tire disposal and recovery products. According to Don Gaines, Tecson Technical Manager, they are a Pyro Mass Recovery System that heats the scrap tires in a closed loop system. This system will be sold in 4 sizes.

The PMR 250 uses 11 tires per hour, produces 11 gallons of oil and 175 cubic feet per hour gas. The capital cost for this system is $97,000. The PMR 500 consumes 23 tires per hour, produces 22.5 gallons per hour of oil and 150 cubic feet per hour of gas. It sells for $135,000. The PMR 1000 handles 45 tires per hour and costs $975,000. The largest, PMR 2000, takes 90 tire per hour and produces 90 gallons of oil and 5400 cubic feet gas.

According to Mr. Gaines, each passenger tire yields approximately one gallon of oil, 60 cubic feet of gas, eight pounds of carbon and one to two pounds of steel.

Benefit of Tecsons' Technology

The scrap tire problem will be solved at a range of cost and scale.

Problems Reported by Tecson

Getting an operation to work and being able to show people that it is economically successful.

Plants that rejected Pyrolysis

1. **Tire Recycling System**: (Detroit, MI) Tire recycling system tested a pyrolysis operation, but determined that the project unworkable because of economic problems.

2. **Oxford Energy**: (New York, NY) Evaluated the utility of tire pyrolysis, but rejected it because it was the least productive of several other options, such as reclamation, tire derived fuel, and the conversion of tires into asphalt rubber. The company found the products to be low market value and felt that the process involved an unacceptable risk of explosions.

3. **Enerco Inc.**: (Yardley, PA) Enreco ran a pyrolysis operation for three years, but stopped in 1986 because of economic problems due to the very low market value. The plant was converting 600 split or shredded tires daily into 500 gallons of oil, two tons of carbon black and 600 pounds of steel. The president of the plant said that a six month demonstration run under the Pennsylvania Department of Environmental Resources showed the plant could run safely, and develop high quality by-products. However, Enerco has sold all but a small portion of oil and carbon black. The process can break even if there is a tipping fee of $1.50/tire which will pay for the operating costs.

4. **Energy Conversion Corporation**: (ChaddsFord, PA) ECC had been marketed widely, but the plant has not been operating recently due to reported management and financial difficulties. The firm filed for bankruptcy in late 1986.

5. **Ergon Fluidized Bed, Inc.in Jackson, MS.**: The plant closed in 1981.

III. Other Closed Plants

6. **International Recycling LTD.** in New Windsor, NY.
7. **Maryland Resource Recovery Center, Inc.** in Hughesville, MD

8. **Recycled Energy** in Blair, NE8
9. **Tire Life** in Egg Harbor City, NJ
10. **Kennedy Enterprise** in Hillsboro, Mo
11. **Kamine Engineering** in Union, NJ
12. **Maine Energy Recovery Corporation** in Biddeford, ME
13. **Shirco Infra Red System** in Dallas, Tx

INTERNATIONAL SURVEY

Through FAX communication, our staff contacted several pyrolysis plants in West Germany and Japan. Out of 20 plants, only 6 replied. The answers were all negative. Following is a list of these different plants with a brief summary of comments received:

1. **Nippon Zeon Co. LTD (Japan, 1974)**: This firm constructed a continuous fluidized bed tire pyrolysis plant in 1974. In 1978, the project was abandoned because of the prohibitive tire collection cost.

2. **Sumitomo Rubber Industries (Japan, 1973)**: They developed a batch type laboratory scale pyrolysis project which was abandoned because of difficulty in collecting waste tires and in obtaining a suitable surplus steam source.

3. **Nippon Oil and Fats Co., LTD (Japan, 1983)**: This firm conducted limited experiments on tire pyrolysis using a low temperature cracking process. According to the plant manager the company can meet our design requirement for a tire pyrolysis plant and expressed an interest in supplying their knowledge of plant design to our project.

4. **Yokohama Rubber Company LTD (Japan, 1973)**: Yakohama constructed a prototype pyrolysis plant in 1973, but the project was abandoned because of unfavorable market conditions. Currently it is a small facility for waste tire disposal at one of their plant sites, which burns tires to supply steam to their plant as supplementary use for the main boiler to the plant. This does not pay economically, nor generate any end

products for re-selling.

5. <u>**Osaka Industrial Laboratory (Japan, 1972)**</u>**:** This laboratory conducted bench tests of a microwave tire pyrolysis process in 1972. The project was abandoned because of the uncertain marketability of the gas product and the high cost of magnetron, which is a diode vacuum tube in which the flow of electrons is controlled by an externally applied magnetic field to generate power at microwave frequencies.

6. <u>**Uniroyal Chemical Inc. (England, 1976)**</u>**:** Uniroyal studied tire pyrolysis in 1976. It decided to abandon the project in 1979 because it was determined that the end products needed to be upgraded before they become economically favorable. The cost of obtaining tires was also prohibitive.

7. <u>**Kiener Pyrolysis (West Germany**</u>**, 1978):** Kiener tested pyrolysis of tires, but they soon changed to using household garbage as a fuel source. No further information was given.

8. <u>**Berbauforschung (West Germany, 1973-1976)**</u>**:** This firm performed experimental work on a batch chamber furnace pyrolysis process, that used whole tires together with coal. The project was abandoned because the coke product was too low in quality compared with the coke produced from coal alone.

9. <u>**Bergbau-Forschung GumH (West Germany, 1973-1976)**</u>**:** Since January 1990, the company changed its name and organizations to DMT. They are involved in all aspects of conversion of solid feed stock, especially by coking and pyrolysis, but has no operational tire pyrolysis plant. However, they made in informal offer to do laboratory tests for this project, and to design a pilot plant to assess the characteristic data of the feed stock and the qualities of the products and byproducts. It would also help in consulting during the engineering, construction and start-up phase of a plant in New Orleans. New Orleans has not asked for a formal proposal as of this time.

II. **Others:**

The following plants in West Germany received our request but did not respond.

a. **Krauss Maffei Aktiengesellschaft.**
b. **AMA, Inhaber Sabine Eggert.**
c. **Abfallverwertung Lurch Pyrolse.**
d. **Deutsche Babcock Aktiengesellschaft.**
e. **Deutsche Babcock Analgen AG.**
f. **Kiener Pyrolyse Geselschaft.**
g. **Ruetgerswerke AG.**
h. **Deutsche-Reifen-und-Kunstoff-Pyrolyse (DRP)**

APPENDIX B

TIRE DEALERS SURVEY

1. NAME OF COMPANY: ______________________________

   PHONE: ______________________________

   ADDRESS :_____ ______________________________

2. Can you estimate or do you know exactly how many used tires you take in each week?

   Breakdown:

   A. # retreaded

   B. # resale as used

   C. # scrap /percentage

   TOTAL:

3. What are the sources of the used tires you take in ?

4. Where are the scrap tires disposed ?

5. Who does the collection/ scrapping of the tires ?

   NAME: ______________________________

   PHONE: ______________________________

   ADDRESS: ______________________________

6. What does disposal cost you ?

7. How do you feel about a surcharge on each new tire sold to be used towards disposal costs ?

8. Who are the other large tire dealers in the New Orleans metro area who handle used tires ?

9. Names of other scrap companies.

10. What percentage of tire dealers/small shops do you estimate illegally dispose of their scrap tire ?

11. What percentage of customers keep their old tires ?

TIRE SCRAPPER SURVEY

NAME: ________________________________

ADDRESS: ______________________________

PHONE: _______________________________

1. Person contacted:
2. How many tires do you handle each week ?

    Car ______________________________

    Truck ____________________________

3. What percentage do you

    Recap ____________________

    Sell as used ______________

4. Where do the tires you handle come from ?
5. What do you do with the tires you can not resell or recap ?
6. How much do you charge per tire to haul it off ?

    car ________________________________

    Truck ______________________________

7. do you know of any other scrappers in the New Orleans area ?

    Name ____________________ Name ________________

    Address _________________ Address _______________

    Phone ___________________ Phone _________________

8. What percentage of other scrappers do you think dispose of their scrap tires illegally ?

APPENDIX C

<u>Avoided Energy Cost For 100 MW Capacity ($/MWH)</u>

	1990		1991		1992		1993	
	Winter/	Summer	Winter/	Summer	Winter/	Summer	Winter/	Summer
Peak	15.50	22.01	17.93	22.30	21.40	24.35	23.35	28.12
Off-peak	17.26	17.66	20.33	19.81	20.43	22.09	25.53	23.52

Winter Months: January-March
October-December

Hours: Peak 7 a.m.- 11 p.m. Monday-Sunday
Off- peak all other hours

Summer Months: April-September

Hours: Peak 9 a.m.- 10 p.m. Monday-Sunday
Off-peak all other hours

CITY OF NEW ORLEANS

SIDNEY J. BARTHELEMY, MAYOR

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REPORT AND INFORMATION SOURCES

Additional copies of this report, "Waste Tire Recycling by Pyrolysis", are available from:

Publication and Distribution
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC, 20004

For additional information on the methods, results and uses of the information contained in this report, or for information on other energy management activities in the city of New Orleans, please contact:

New Orleans Health Department
1300 Perdido Street, Room 8W
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81-310	Simplified Methodology for Community Energy Management	20.00
81-309	Energy Management: The Public Sector	15.00
81-307	Municipal Technical Assistance-Energy Monitoring	6.00
81-306	New Technology Demonstration	10.00
81-305	Technology Transfer: Unit Report from the Energy Task Force	15.00
81-304	Development of Local Energy Management Preparedness	10.00
81-303	Municipal Energy Management	10.00
80-314	Methodology for Energy Impact Analysis of Urban Development Projects	15.00
80-313	Evaluation of Landfill Gas as an Energy Source	15.00
80-309	Decision Process for the Retrofit of Municipal Buildings	20.00
80-308	Primary Urban Energy Management Planning Methodology	7.50
80-306	Local Government Use of Thermography for Energy	15.00
79-300	Planning for and Purchasing Computer Technology	6.50

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