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# Urban Waste Wood Utilization

## Proceedings of a Conference on Alternatives to Urban Waste Wood Disposal

March 26-28, 1979

Charleston, South Carolina

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Southeastern Forest Experiment Station
Asheville, North Carolina

# URBAN WASTE WOOD UTILIZATION

## Proceedings of a Conference on Alternatives to Urban Waste Wood Disposal

**March 26–28, 1979**
**Charleston, South Carolina**

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# Preface

Raw materials and energy resources for production of consumer goods and services are no longer abundant. Our American society must change its behavior and its values. We must learn to do more with less and to overcome our habitual wastefulness.

This Conference was an attempt to make a contribution to much-needed energy and materials conservation. Urban waste wood represents a resource that can have an impact on resource conservation. This Conference focused on defining the urban waste wood resource and on exploring available technologies for its utilization.

Waste wood from our cities now constitutes 10 to 20 percent of the volume of materials going into landfills. The reasons for this situation are numerous. Among these reasons, lack of information on the utilization potential and on available technology seems most prominent.

The Urban Waste Wood Utilization Conference brought together the most knowledgeable persons in the United States to address the resource situation, utilization options, and planning for the future. This Conference is the first to comprehensively address urban waste wood utilization.

The Conference audience represented a wide range of professions and interests. Included were representatives from city and county management, urban foresters and urban forestry consultants, extension agents and researchers, and producers and consumers of urban waste wood from both the private and public sectors.

Special acknowledgments are due several key persons responsible for this Conference. Mr. Tom Clements (formerly with the U.S. Forest Service) spent numerous hours assembling names and information and was instrumental in compiling the knowledge base for planning and conducting the Conference. Mr. Larry Biles (U.S. Forest Service) developed the program and organized the speakers and moderators. Ms. Linda Anderson (U.S. Forest Service) organized and managed Conference communications and assisted in organizing the Conference proceedings. Mr. Don Ham (Department of Forestry, Clemson University) managed local arrangements and Conference disbursements. Mr. Elwood Shafer (U.S. Forest Service) was central in identifying and securing financial resources for support of the Conference and for printing these Proceedings.

Others playing key roles included Mr. Jimmy Walters and Mr. Charles Rountree (both of South Carolina State Commission of Forestry), who assisted with local arrangements. Mr. Joseph Riley, Jr. (Mayor, City of Charleston) and Mr. Leonard Kilian (State Forester, South Carolina Commission of Forestry) hosted the Conference. Mr. Mike Keel (Florida Division of Forestry) and Mr. Dale Higdon (Georgia Forestry Commission) lined up Conference exhibitors. Mr. Ed Banks (Georgia Forestry Commission) and Mr. A. B. Curtis (U.S. Forest Service) assisted in planning the Conference. Ms. Nancy Haynie and Ms. Sandy Conger managed Conference registration and were assisted by Ms. Rosemary Jordan (each with U.S. Forest Service).

Very special appreciation is extended to Ms. Alice Clarke and Mr. Bob Biesterfeldt for review and editing of the Conference papers and to Mr. Rob Mallette (each with U.S. Forest Service) for proofreading.

It is our hope that this Conference and the printed Proceedings will provide a reliable information base for bringing about waste wood utilization through materials recycling and energy conversion.

H. Ken Cordell
Conference Chairman
U.S. Forest Service
Southeastern Forest
Experiment Station

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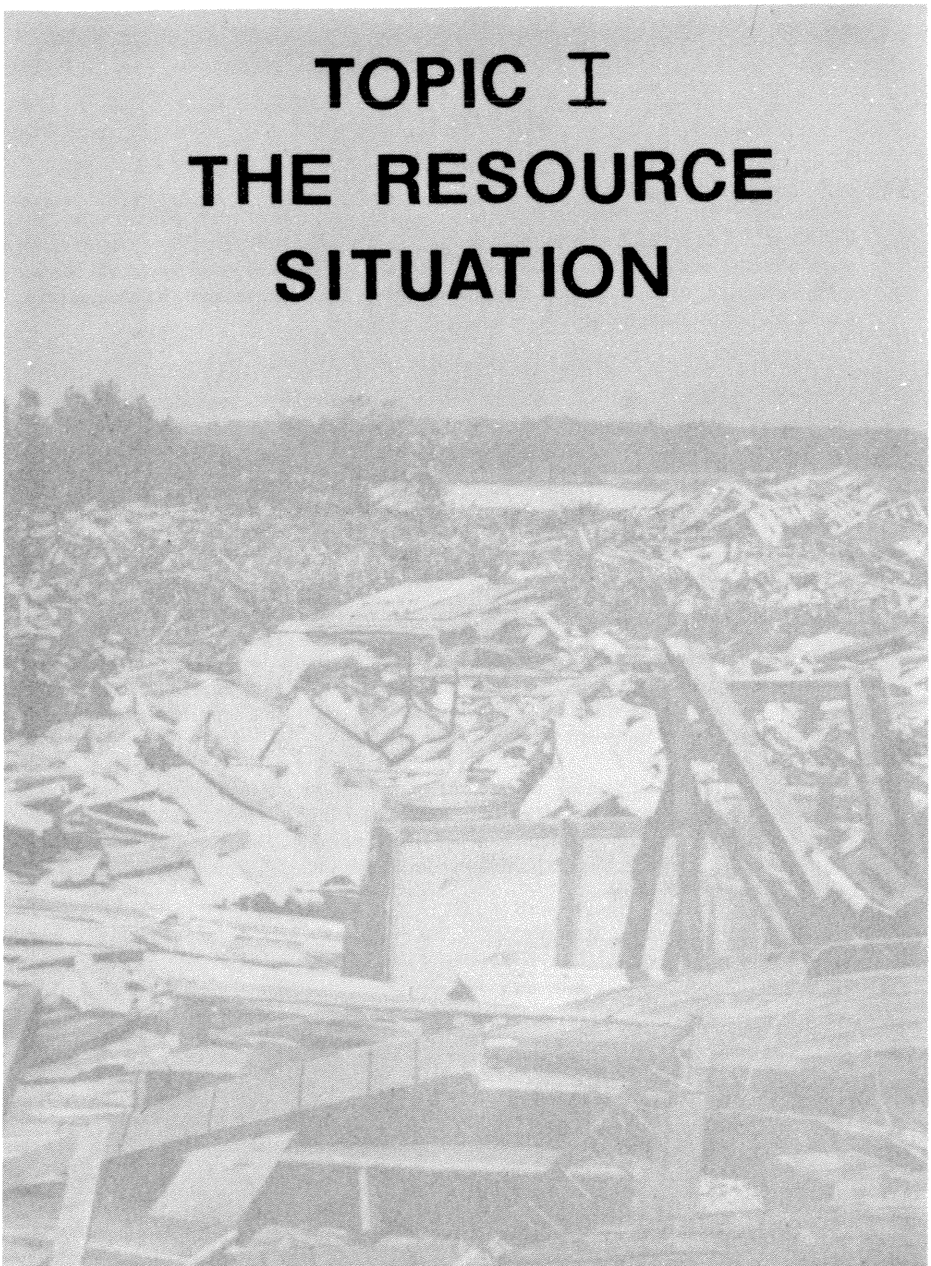

# TOPIC I
# THE RESOURCE SITUATION

## *ABSTRACTS*

CORDELL and CLEMENTS

*Urban Waste Wood: A National Perspective.*—Large amounts of metropolitan solid wastes (MSW) are produced each year in this country. Of this potentially important resource, wood waste is vastly underutilized. In the future, recovery and reuse of wood waste will become a more viable and attractive option. Comprehensive study of the resource and alternative programs of utilization are needed.

DENNISON

*FIBREST—A Tool for Quantifying and Qualifying Wood Residues.*—A computerized accounting system, FIBREST, has been developed to aid the assessment of wood fiber residues generated in urban areas. Computed from survey questionnaires, residue amounts can be reported by industry, county, and town/city sources in 10 form categories and 3 disposal classes.

LOGGINS

*Composition of Landfilled Urban Waste Residues.*—Purpose of the study was to determine various quantities of wood waste being landfilled in the Atlanta metropolitan area. A survey was completed during the summers of 1977 and 1978. Information collected emphasized a large volume of potentially useful urban wood residue that was being wasted.

DAVIS

*Source Separation—Procedures and Practices.*—Urban programs in source separation of waste wood in New Jersey center economically on two types of programs, those which expect remuneration and those which do not. Those with a future tied only to the public-service aspect appear to have the greatest potential for survival.

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*Determination of Wood Content in Demolition and Construction Wastes.*—Demolition and construction waste streams were evaluated on a national basis by a unique combination of empirical and predictive techniques. National figures developed indicate 55 million tons, the waste wood fraction of which is 22 million tons, representing 2 percent of the heating value of all U.S. coal production.

# URBAN WASTE WOOD: A NATIONAL PERSPECTIVE

H. Ken Cordell and Thomas W. Clements[1]

*Abstract.*–Large amounts of metropolitan solid wastes (MSW) are produced each year in this country. Of this potentially important resource, wood waste is vastly underutilized. In the future, recovery and reuse of wood waste will become a more viable and attractive option. Comprehensive study of the resource and alternative programs of utilization are needed.

A tour of any landfill in any metropolitan U.S. city in any year will reveal that Americans, either as individuals or through business or government, are discarding large amounts of possibly reusable material. Over 90 percent of this metropolitan solid waste (MSW) is landfilled, burned, or dumped into the ocean each year (Grinstead 1970).

Methods of raw material extraction and refinement and product manufacture and distribution have been in the center of technological and economic concern. But these systems, coupled with social concerns, have noticeably excluded the recovery of solid waste. Modern methods of managing solid waste as a resource are only slowly being incorporated. In light of a growing population, increasing prosperity and consumption, and a diminishing resource base, it is of vital importance that waste of all sorts be reduced through methods of solid waste recovery.

The U.S. Forest Service is charged under the National Forest Management Act of 1976 (U.S. Congress 1976a) to investigate the recovery of waste wood materials. Through this investigation, it is hoped, a more conscientious program of resource utilization will evolve. Urban waste wood is an integral part of such management.

## ESTIMATES OF QUANTITY

There are many different and somewhat conflicting estimates of the amount of solid wastes in the Nation. Among these, figures from the Environmental Protection Agency give an idea of the magnitude of the solid waste resource in the United States. For 1971, EPA estimated that nationally there were 4.45 billion tons of solid waste. These estimates include much mill and mining waste, most of which is rurally located. Wood and paper, however, make up significant proportions of the solid waste total; by weight, in 1975, about 4 percent was wood. The dramatic increase in product packaging since 1945 is largely responsible for these high percentages.

Wood reuse, particularly of manufacturing waste, is increasing. In 1974, the USDA report entitled "The Outlook for Timber in the United States" indicated that approximately 2.8 billion cubic feet of slabs, sawdust, veneer cores, and other such materials were being reused for particleboard, pulp, fuel, and other products (USDA

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[1]The authors are, respectively: H. Ken Cordell, Project Leader, Urban Forestry Research in the South, Southeastern Forest Experiment Station, Forestry Sciences Laboratory, Athens, Georgia; and Thomas W. Clements, Research Technician, Urban Forestry Research in the South, Southeastern Forest Experiment Station, Forestry Sciences Laboratory, Athens, Georgia.

FS 1974). This figure represents an 18-fold increase since 1952; however, in 1970, 1 billion cubic feet of manufacturing waste wood still was not being used.

It is important to note that urban waste wood in general is much more contaminated than manufacturing wood residues. EPA estimates that of the nearly 5 billion tons of solid waste, about 9 percent (450 million tons) is classified as MSW. Of this MSW, about 3.6 percent (16.4 million tons) is wood. This wood is mixed with and joined to all manner of debris. Reuse of urban waste wood is a complex undertaking.

Estimates of the amounts of urban waste wood, by source and use, have been provided by Carr (1978). Table 1 shows that urban waste wood totals about 16.4 million tons and urban waste paper about 44.5 million tons. Together these total 61 million tons of reusable resources.

Table 1.–Sources and uses of urban wood waste (approximate annual figures)

| Source | Quantity (air-dry tons) | |
|---|---|---|
| | *Million* | *Percent* |
| Wastepaper | 44.515 | 73 |
| Waste timber products | 13.662 | 22 |
| Trees | 2.800 | 5 |
| Total | 60.977 | 100 |

Current disposals of these wastes are for:

| | *Quantity* |
|---|---|
| *Fiber and Allied Products* | *Million* |
| Wastepaper | 12.330 |
| Waste timber products | 1.697 |
| Trees | 0.140 |
| Total | 14.167 |
| *Energy* | |
| Wastepaper | 1.000 |
| Waste timber products | 1.814 |
| Trees | 0.280 |
| Total | 3.094 |
| *Landfill, Dump, Incineration, etc.* | |
| Wastepaper | 31.185 |
| Waste timber products | 10.151 |
| Trees | 2.380 |
| Total | 43.716 |

Total resource recovery (fiber and allied products of energy) equals 17.261 million tons, or 28 percent of annual formation.

Of this total, only 28 percent (17 million tons) currently is being used (fig. 1). Uses include fiber and allied products (14 million tons, 82 percent) and energy (3 million tons, 18 percent), as shown in figure 2. Seventy-two percent (44 million tons) currently goes into landfills or is incinerated.

Large cities have massive amounts of waste wood. For example, Chicago has estimated its wood to exceed 400,000 tons; Atlanta has about 75,000 tons per year and 80,000 cubic yards of leaves; and Minneapolis-St. Paul has over 300,000 tons of elm waste wood alone per year.

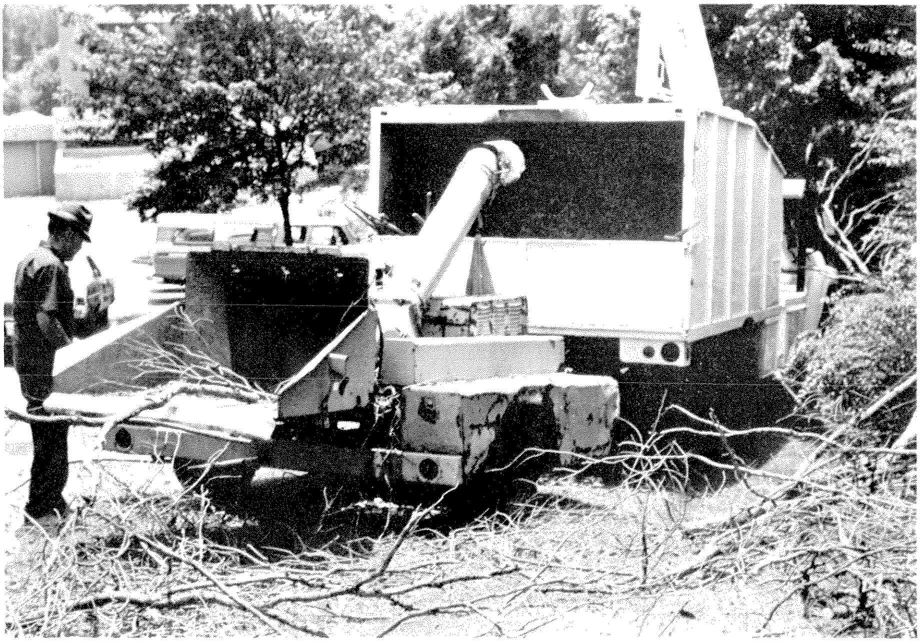

Figure 1.–Chipping of Dutch elm diseased trees on the University of Georgia campus.

## SOURCES OF URBAN WOOD

The major sources of urban waste wood are: municipal agencies, which remove wood from residential trimmings, construction sites, and street trees; commercial users, who discard such things as pallets and packaging; and industries that manufacture finished products such as furniture.

Waste timber products account for 13.662 million air-dry tons per year and tree disposal 2 million air-dry tons per year. Of the waste timber products, 47 percent is demolition debris, 31 percent is pallets and containers, 4 percent is dunnage, and 18 percent is from wood product manufacturing (Carr 1978).

According to "The Outlook for Timber in the United States" (USDA FS 1974), about 900,000 units of housing are demolished each year. Because about 75 percent of

Figure 2.—Wood chips falling from a tire shredder—Cobb County, Georgia, landfill—may be utilized by paper companies.

the U.S. population lives in urban areas, most of this housing demolition is urban.

Demolition wastes are, unfortunately, not homogeneous and thus pose problems in the removal of contaminating nonwood materials. But the sheer volume of this resource coming from easily identified points of origin strongly favors reusing these wastes.

Housing starts also contribute huge volumes. Estimates are that about 2.5 million new units of housing will be built each year during the 1970's (USDA FS 1974). Unused construction lumber and trimmings increase as the number of new units increases. A report for the EPA by the JACA Corporation (1977) estimates tonnage for construction and demolition waste at 21.9 million tons annually. Demolition waste wood accounts for 19.3 million tons, and construction wastes account for 2.6 million tons.

Certain forms of packaging, especially at the retail level, are used only once before disposal. Heavy-duty packaging such as crates, boxes, and dunnage may be reused industrially and commercially, even though lifespans are short. Pallets have a lifespan of about 3 years (USDA FS 1974) before they enter the waste stream. Approximately 205 million pallets were made in 1974 (USDA FS 1974), so there should be an even larger number entering the waste stream today. Better design and use of stronger materials may lengthen their lifespan, but in time all these materials will become waste.

The greatest single contributor of waste wood in many cities is municipal government itself. Since the government must prune and remove a large number of trees on municipal lands and streets and since the average lifespan for a city tree is only 10 years, it is not surprising that large volumes of tree removal and pruning materials are generated.

Dutch elm disease alone has had great impact on the vegetative cover of many cities (fig. 1), especially northern cities where more than half of the planted trees were elm. In cities such as Chicago and Minneapolis-St. Paul, there is a flood of elm wood. Leaves and limbs of elm trees have a high volume-to-weight ratio and create problems at landfills where fill space is very limited. Utilization of this elm wood would be very beneficial.

## LEGISLATION CONCERNING WASTE WOOD

Laws in the United States to encourage recycling or to discourage waste are few and weak. The problems and some opportunities with solid wastes have been recognized for many years, but the approach has been to dispose of solid waste rather than to reuse it.

The Solid Waste Disposal Act of 1965 (U.S. Congress 1965) was one of the first attempts by Congress to address the issue. Its main focus was on dump and landfill practices and on environmental protection through safer disposal procedures. The Act also called for conservation of natural resources by reducing solid waste disposal.

The Resource Conservation and Recovery Act of 1976 (U.S. Congress 1976b) is full of language encouraging–and even requiring–planning to recover materials from solid waste. Each state is required, under the guidelines of the Act, to have in its solid waste management plan some discussion of recovery and recycling; however, there are no requirements for implementation of those plans, so participation is voluntary.

The U.S. Forest Service is involved in the recovery of urban waste wood through the National Forest Management Act of 1976 (U.S. Congress 1976a). The Forest Service has a legislative mandate to determine the reuse potential of urban waste wood, but the reduction of waste, which is a key to the problem, is not addressed.

An innovative program was begun by the State of Oregon in 1967 to encourage recycling and environmental protection. A law was passed which provides tax relief "to encourage the construction, installation, and use of facilities to prevent, control, or reduce air, noise, or water pollution and to utilize solid waste by providing tax relief for persons who do so" (State of Oregon 1967, Sec. 1). The law was amended in 1973 and 1975 to allow for tax benefits to certified solid waste facilities. "Such a facility to be certified must produce as an end product a usable source of power or other item of real economic value . . ." (State of Oregon 1967, Sec. 2.B).

## REUSE PROGRAMS IN THE UNITED STATES

In the U.S. it is difficult to find successful urban waste wood recovery programs which are not tied to energy production. Either there is not enough information about nonenergy uses, or the economic returns from such uses have not been sufficient. Most likely, this lack of success has been due to the new interest in recycling resources, which has only recently prompted investigation of utilization methods.

Use of wood for energy is perhaps the easiest option, since energy is a universal use for all forms of wood. But this is a final use; the possibility for any further reuse is gone once the wood is converted to energy.

Other uses of wood include transformation into other products, such as particleboard or woodchip mulch. From many of these uses, production of energy from waste wood is still an option.

## USE FOR ENERGY

Numerous wood-processing companies have begun to use their own waste wood to supplement the energy needed for their operations. It has become standard procedure for companies such as Weyerhaeuser and Georgia-Pacific to burn waste wood for energy rather than to dispose of it. Most of these plants are located in rural areas, so little urban waste wood is involved, though use of urban waste wood by paper companies in Georgia has been investigated. Wood from the Cobb County landfill (in Metro-Atlanta) has interested Georgia Kraft, and wood from the Chatham County (Savannah) landfill is wanted by Union Camp. At both landfill sites, the incoming wood would be chipped and transported to the plant site (fig. 2).

In another example, wood from the DeKalb County landfill (near Atlanta) is already being chipped and sold. The results are not very promising at this time, however, because of small volumes of wood.

In Portland, Oregon, a company called Grenco, Inc., is purchasing dunnage, pallets, demolition debris, and other waste wood from manufacturers. By a chipping and contaminant separation process, they are creating material used as boiler fuel and in hardboard manufacturing. Reports from the plant indicate a steady delivery of chipped demolition debris from Portland to energy users.

Large-scale use of wood for fuel to produce electricity is underway in Burlington, Vermont. The city is now operating a 10-megawatt generation plant fired solely by wood. Burlington also is building a new 50-megawatt plant. Some urban garbage containing urban waste wood will be burned in this new plant. Two tons/hour/megawatt is needed for electricity generation; thus, a larger amount of wood is needed than could possibly be provided through use of the city's waste wood.

Pelletizing wood to be burned for energy is apparently gaining acceptance. A leader in the use of this process is Woodex, Inc., of Brownsville, Oregon. The plant is particularly efficient and has a daily capacity of 125 to 300 tons of wood and agricultural waste. Although this plant uses mostly logging wastes, the process demonstrates a technology applicable to urban waste wood.

Different methods to derive energy from wood are through pyrolysis and gasification. In both processes, wood is subjected to high temperatures in an oxygen-poor environment, converting the wood into either oil, gas, or combustible char.

The Georgia Forestry Commission has been involved in research on these methods, and two companies in Atlanta are currently using gasification to operate hardwood dry kilns. Although urban wood is not currently used very much, application of this technology seems to be viable. The State of California is investigating pyrolysis of agricultural wastes. A number of cities are either burning their garbage for energy or planning to do so. Since wood is only a small constituent of this garbage, these efforts are of only passing interest. Ames, Iowa, is perhaps the best-known example of solid waste disposal through burning of refuse for fuel. The U.S. Navy has also been a leader in this area.

Tacoma, Washington, and Columbus, Ohio, are soon to begin energy recovery from garbage. This is "high technology" since large amounts of machinery and energy are necessary to keep the process going. A low technology approach to the garbage problems would be source separation where different kinds of recoverables, such as glass, paper, metal, and wood are separated at the point of discard, such as a home or business.

A few cities have been involved in impressive attempts to solve their waste wood problems. In these attempts, energy production has been the major product in cities such as Chicago, Madison, and Minneapolis-St. Paul. The amount of wood in Chicago could be as high as 1,000 tons of ovendry material per day. Estimates are that Chicago and surrounding municipalities remove 450,000 tons of tree debris annually and that dunnage and demolition waste may exceed 200,000 tons annually. The city hoped to find someone to utilize this waste wood for conversion to energy when it began looking at the problem in 1976.

Commonwealth Edison, the major energy producer in Illinois, had no interest in this waste wood, however, because of perceived technical and economic drawbacks. Other potential sources were identified, including Grenco Company of Portland, Oregon, but no guaranteed outlet for disposal was located.

The Metropolitan Sanitary District of Chicago also expressed an interest in the use of chips with their sludge composing project. Hopes for large-scale uses of Chicago's wood debris through burning, particleboard manufacture, or other use, however, have not been realized. Costs of collection, separation of foreign matter, processing, storage, and transportation have thus far seemed too high.

Madison, Wisconsin, and St. Paul are other cities which have actively studied the possibilities of using waste wood. Only limited success has thus far been realized.

## NONENERGY FORMS OF REUSE

The number of programs, successful or otherwise, involving recovery of nonenergy waste wood is relatively small. But there are signs that technology is being generated and that some success is being achieved. Perhaps the simplest type of operation is represented by a project established in Birmingham by the Alabama Forestry Commission. At a recycling center, paper, glass, and aluminum are brought in, already separated, and exchanged for firewood or wood chips from trees on city lands. In this manner, the recycling center is paying for itself through receipts from materials sold.

Birmingham, which earlier was uninterested in the project, has recently expressed strong interest in becoming more active in such an operation. Huntsville, Alabama, is undertaking a similar project. These low technology operations may be a key to future waste disposal. The cost of separation is spread over large numbers of people, as perhaps it should be.

Other cities involved in nonconventional waste wood disposal include Toledo, Ohio; Lansing, Michigan; and Atlanta. Lansing, forced by law to eliminate landfilling and open burning of wood, adopted incineration and utilization through production of firewood, rough lumber, wood chips, bark chips, and sawdust. In 1970, that utilization program, run by a private company, went bankrupt and the city began chipping all of its own small wood to use on trails, as mulch in flower beds, and for various uses in parks. All other waste wood that the city generates is taken to a firewood yard which is open, 2 days a week, to residents.

Toledo, Ohio, also forced to eliminate open burning, devised a recycling program for brush and logs. End products anticipated from the operation were: wood chips for mulch in city parks, logwood chips for paper companies, firewood for public sale, fencing and pavers, and solid logs for use in playgrounds or for sale to sawmills. Down time caused by damage to machinery from metal contaminants in the wood caused problems in the operating costs, but officials felt that what is being learned about the use of waste wood and the environmental benefits assure that the effort will eventually pay off.

Atlanta has successfully implemented a program to divert city-generated waste wood from being landfilled. The city has over 5,000 miles of rights-of-way and 4,000 acres of municipal land to maintain. On these lands there are an estimated 1.5 million trees under the city's care. Normal maintenance produces large amounts of waste wood from pruning and removal. The Atlanta program involves: free firewood yards, wood chips, and composting. The programs to use self-generated waste run smoothly in Atlanta, but thousands of tons of private waste wood are still not reused and continue to be landfilled.

Use of wood chips with sludge composting has been subject to experimentation at the U.S. Department of Agriculture test facility in Beltsville, Maryland. Implementation of a sludge composting project has occurred also in Ft. Lauderdale, Florida. Wood from construction sites is purchased, chipped, and then mixed with sludge to allow aeration, which causes quicker breakdown of the sludge.

Kellbro Corporation in Sacramento, California, makes mulch and garden additives from mill wastes, demolition wastes, and street trees. The company was producing a fiberboard from waste until its sources were depleted, but success with its mulching product seems to be established.

The manufacture of fiberboard and chipboard is a growing industry because of better technology. The Medford Corporation in Medford, Oregon, makes a medium density fiberboard utilizing plywood trim, planer shavings, and sawdust. The material is refined and reduced to wood fiber, dried, and formed with resin into boards. Most of this waste material is not now urban, but much of it would be landfilled or burned if not used for fiberboard.

Williard's Sawmill in Trenton, New Jersey, is another example of urban waste wood reuse. Trees cut from city rights-of-way and from private lands are purchased by the sawmill and made into special products, including tabletops, plaques, clockfaces, and lumber.

One successful program is administered by the New Jersey Bureau of Forestry. Through this program, businesses generating wood residue are matched with those which have a use for the materials. This Statewide program began with a preliminary feasibility study in 1970 and was implemented in 1972. Currently, four people are working with the project.

Examples of reuse include sale of turned material to a toy manufacturer and sale of bay-window corners to a company which makes plaques and foot pedals for drums. In 1977 about 2 million cubic feet of waste wood were recycled, with a savings of over $900,000 to New Jersey businesses.

A thorough inventory of industry in a city or region would discover possibilities for more efficient reuse of waste wood.

## SUMMARY AND CONCLUSIONS

Our estimates of the amount of MSW are not very good at this time. Generally, we estimate that there are approximately 500 million air-dry tons of MSW annually. Between 16 and 17 million tons of this MSW are some form of wood. Of this, we currently use only 28 percent for products or energy.

As is the case with solid waste in general in the U.S., we seem to be vastly under-utilizing a potentially important resource. It is our strong conviction that, for a number of reasons, recovery and reuse of urban wood waste will become a more viable and attractive option in the near future. To realize the full potential of this option, we should now begin planning programs and conducting research (fig. 3). Our reasons for suggesting the growing feasibility of urban waste wood recovery include:

Figure 3.–Whole-tree chippers, as used here by Georgia Forestry Commission, may be useful in future urban wood utilization programs.

1. Rising costs and decreasing availability of forest-derived, primary wood for paper, fiberboard, and similar manufacturing are making alternative sources of wood fiber more attractive. Income derived from using urban waste wood, even though not enough to cover recovery costs, will help offset the costs of waste disposal. This potential income should continue to increase at least as fast as disposal costs and thus should be viewed as a buffer against rising costs.

2. Demand and costs for energy are rising at high rates. As the cost of energy increases relative to other costs, the option of using wood (and other organic wastes) for energy production becomes more attractive. The Energy Research and Development Administration has estimated that by 1985 the U.S. will have a quantity of solid waste available to produce the equivalent of 500,000 barrels of oil per day.

3. Costs for landfilling operations and sites are increasing. In addition, space for landfilling is becoming limited, to the extent that locations are often difficult to find. As these costs rise, resource recovery and waste wood utilization become more and more attractive as a means of reducing disposal costs for all solid wastes. Comprehensive recovery programs can reduce solid waste volumes by 75 to 95 percent.

4. Technology for waste wood recovery seems to be in its infancy. Systems designed to produce energy, separate usable wood and other resources, and involve the public have been tested in only a few locations for relatively short periods of time; thus, some of the negative conclusions are perhaps premature. There are too many success stories and too many changing conditions to conclude that wood recovery is not feasible. We should keep in mind that there are many objectives involved. Among these are: environmental protection through reduction of solid waste; resource conservation through reuse; and partial cost recovery.

If we look only at any one of these, waste wood recovery can be viewed as a failure. If we consider all simultaneously, acceptable and sufficient returns will be realized.

One of the bigger needs in this area is for comprehensive study of the resource, alternative programs of utilization, and the cost-return schedules associated with each alternative. Thus far we really haven't done this.

Ultimately we will have to reuse whatever resources we can. We should begin planning and testing alternatives now so that we are prepared for these future needs and so that we are creating a better urban environment.

# LITERATURE CITED


Carr, Wayne F., and John N. McGovern
1978. Report on urban wood waste in the United States of America. Unpublished report. Prepared for U.S. Dep. Agric. For. Serv., For. Prod. Lab., Madison, Wis.

Grinstead, Robert A.
1970. The new resource. Environment 12(10):2–17.

JACA Corporation
1977. Energy potential from construction and demolition wood wastes. p. 1. Off. Solid Waste, U.S. Environ. Prot. Agency, Washington, D.C.

State of Oregon
1967. Pollution control facility tax relief in Oregon. Chapter 52, Oregon Laws 1967.

U.S. Congress
1965. Solid waste disposal act of 1965. 79 Stat. 992. Public Law 89–272.

U.S. Congress
1976a. National forest management act of 1976. 90 Stat. 2949. Public Law 94–588.

U.S. Congress
1976b. Resource conservation and recovery act of 1976. 90 Stat. 2795. Public Law 94–580.

U.S. Department of Agriculture, Forest Service
1974. The outlook for timber in the United States. For. Resour. Rep. 20, p. 30, 150–159, 174–177.

# FIBREST–A TOOL FOR QUANTIFYING AND QUALIFYING WOOD RESIDUES

Steven E. Dennison[1]

*Abstract.*–A computerized accounting system, FIBREST, has been developed to aid the assessment of wood fiber residues generated in urban areas. Computed from survey questionnaires, residue amounts can be reported by industry, county, and town/city sources in 10 form categories and 3 disposal classes.

## INTRODUCTION

Wood fiber waste is produced in a wide array for forms, types, and conditions. Familiar examples are sawdust, bark, edgings, trim, and various types of paper materials. Other types include pallets, telephone poles, broken furniture, wooden containers, and limbs and brush from yard and tree maintenance.

Depending upon the source, one or more types of residue may be generated at the same locale. Sawmills generate bark, sawdust, edgings, trim, and chips as byproducts. Residential and commercial sources produce newsprint, cardboard, crates, and pallets as discards, while a printing and publishing firm may throw away paper cutoffs and trim.

Our failure to apply either modern management or modern technology to the ultimate disposal of this abundance has resulted in a monumental solid waste problem. Federal legislation, such as the Solid Waste Disposal Act of 1965 (Black 1970), the Resource Conservation and Recovery Act of 1976 (McGlennon 1977), and the National Forest Management Act of 1976 (Foley 1976), has focused attention on the need for recovery of these materials from the Nation's trash.

Approaching the problem from another aspect, many states and communities (Mass. DEH 1971; Massey and Dunlap 1975; US EPA 1975) are setting specific guidelines for sanitary landfills to cope with the volume of waste material. These guidelines may include strict regulations for burning, salvage operations, and the disposal of woody materials. In the last decade, municipal governments, wood-using industries, and other private firms have also been turning to these solid waste piles as a source of material to help defray the rising costs of energy, raw material, and disposal.

## WASTE MEASUREMENT

For the potential user of residue materials, information must be obtained on their availability and reliability as a resource, their location, and the forms in which they are generated; however, to date there have been no consistent, comprehensive methods for collecting and reporting this information. The heterogeneous nature of residue material makes detailed measurement difficult. As a result, most of the completed inventories were done for specific reasons and the results reported in an array of units, thus making comparisons difficult.

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Several efforts aimed at waste analysis (Combustion Engineering 1969; Ingram and Francia 1968; Muhich and others 1968) were undertaken using funds provided by the Solid Waste Management Act of 1965. These studies, for the most part, were national in scope and resulted in the reporting of waste-per-capita averages for the country as a whole.

A new approach in the prediction of solid waste amounts and components was introduced by the URS Research Company (Black and others 1972) in 1971, under contract with the U.S. Environmental Protection Agency. This method uses a material flow locus which assumes that waste generated in an area is derived primarily from the goods and services consumed in that area. A synthesis approach is used in which estimates and predictions of residuals are based on knowledge of materials and quantities before they become a part of the solid waste stream.

Despite the obvious advantages of this system, it is not without its drawbacks—the main one being the cost of implementing the system. An inventory of all waste-producing activities in an area must be conducted to compile standard information on the materials consumed per unit size and time for each activity type, as well as to define which of these materials become waste. Smith (1975) also points out that wastes not passing through a production sector (e.g., removal of street trees) will cause incorrect estimates in using this type of system.

Other studies, such as those conducted by Burry (1975), Frame (1974), and Quink and others (1974), used surveys designed to quantify the multiple forms of wood residues in order to encourage their utilization. These canvasses, although inexpensive to implement and designed for specific purposes, found that conversion figures varied widely.

Because of the marginal value of wood wastes and the economic constraints surrounding materials flow data, residue inventories usually resort to the canvassing format. Letter questionnaires and personal interviews, if properly designed and pretested, provide a relatively easy and inexpensive method of data procurement. The major problem with this type of system is that there is no general form to follow in analyzing the data. Each inventory is unique when it comes to conversion figures and measurement units.

The remainder of this paper will discuss another inventory system, *FIB*er *R*esidue *EST*imation (FIBREST), which deals with the problems associated with the common canvassing format (Dennison 1977).

## FIBREST SYSTEM

FIBREST is a wood residue computer-accounting system written in standard ANSI FORTRAN; it is designed to analyze industrial wood residues in urban areas. It examines survey returns, is flexible in its use, and attempts to present the output data in a rational, readable fashion.

It will accept a variety of measurement units, while providing an estimate of wood residue amounts in one reporting unit for a given region. FIBREST will report these amounts according to their location, their form, the degree to which they are contaminated, and how they are currently disposed.

## SYSTEM INPUTS

Obtaining a list of wood residue generators (the starting point for conducting the inventory) is often the most arduous task of the whole process. Sources that would help in compiling this list may include state industrial directories, state and local Chamber of Commerce indexes, Extension Service lists, and as a last resort (although often a good source), the yellow pages and classified advertisements in the area to be surveyed.

As this information is obtained, each waste generator should be coded numerically by location (town, county, state, etc.) and by its Standard Industrial Classification (SIC) number. SIC codes can be found in the U.S. Department of Commerce's "Standard Industrial Classification Manual" (USOMB 1972). If waste producers other than industry are surveyed (e.g., city/town tree maintenance departments), other codes can be added. A partial listing of the types of wood residue generators which might be included is shown below.

| SIC | Descriptor |
|---|---|
| 0783 | Ornamental shrub and tree services |
| 1522 | General contractors |
| 1795 | Wrecking and demolition crews |
| 2421 | Sawmills and planing mills |
| 2448 | Wood pallets and skids |
| 2499 | Miscellaneous wood products |
| 2642 | Envelopes |
| 2711 | Newspapers, publishing |
| 3732 | Boatbuilding and repairing |
| 3994 | Caskets |

From this listing the FIBREST system is capable of handling a 100 percent sample or a partial sampling scheme.

## SURVEY INFORMATION

Data requested on the questionnaire, in order to conform to FIBREST, should include:

1. The amount of residue produced (an estimate often has to suffice) in some unit and time period.
2. A percentage estimate of the amount produced in any or all of 10 different form classes (e.g., chips, pallets, paper).
3. A percentage estimate of the waste produced that is contaminated.
4. A percentage estimate of the waste material in each of the following categories: waste being used by the generator, waste that is sold or given away, and waste actually going to a disposal site.

Each survey response—the amount, the measurement unit, and the percentage in the above categories—is recorded in a consistent manner on computer processing cards according to SIC and locational codes.

## AREA PARAMETERS

In order for the survey information to be properly sorted, other data must also be compiled and coded. These data include the SIC codes and descriptors being inventoried as well as the total number of firms in each class. Place names and locational codes of the governmental units and associated subunits of the area in the survey (e.g., counties and towns) are also used. Optional information includes populations as well as the number (and size) of disposal facilities in each subunit.

## CONVERSION PARAMETERS

The uniqueness of FIBREST lies in its ability to accept the variety of measurement units associated with the residue amounts on the survey responses and to convert them to a specified reporting unit. It is this capacity that also allows for a comparison with other wood residue inventories.

The system constructs 12 tables, each containing a matrix of conversion figures. These figures are calculated from eight variables (supplied by the user) associated with wood fiber materials. For illustrative purposes, the variables used in a test of the program are listed below:

| | | |
|---|---|---|
| Moisture condition (green basis) | = | 0.50 (dry is 50% of wet) |
| 1 uncompacted cord | = | 75.0 cubic feet |
| 1 uncompacted cord | = | 500.0 board feet |
| 1 compacted cord | = | 128.0 cubic feet |
| 1 cord, softwood (uncompacted) | = | 2.5 tons (green) |
| 1 cord, hardwood (uncompacted) | = | 3.0 tons (green) |
| 1 cubic yard, paper (uncompacted) | = | 190.0 pounds |
| 1 cubic yard, paper (compacted) | = | 500.0 pounds |

The conversion tables are then used in FIBREST as each survey return is analyzed. Using the coded measurement unit on each response, the total amount of residue is converted to the predetermined reporting unit selected from the following list:

| | |
|---|---|
| dry tons | wet tons |
| dry pounds | wet pounds |
| dry cubic feet | wet cubic feet |
| dry cubic yards | wet cubic yards |
| dry board feet | wet board feet |
| dry cords | wet cords |

The system is currently being modified to include BTU as an additional reporting unit.

SYSTEM OUTPUTS

The residue amounts are calculated, expanded to totals, and sorted for each location unit (e.g., SIC, governmental units). The data are then generated by FIBREST in tabular form. This accounting format allows the residue user to examine more accurately the resource situation in the survey area.

In addition to choosing a reporting unit, the user of the system may choose any or all of the following forms of output:

1. Residue account, by the source of generation (SIC).
2. Residue account, by each major administrative unit (e.g., county).
3. Residue account, by each subunit (e.g., city/town).
4. Conversion tables.
5. Return statistics of the survey.
6. Multiple listings of the above choices.

If none of these options is chosen, the output consists of a single table summarizing the residue amounts in the surveyed area. This summary includes the physical components (forms) of the residues and how they are disposed—all by each SIC (source) code. Table 1 is a partial illustration of this summary table.

Table 1.—Sample summary table showing physical components and disposal methods

| Physical components | Type of wood residue generators | | | | |
|---|---|---|---|---|---|
| | Shrub and tree services (0783)[1] | General wood products (2499)[1] | Envelopes (2642)[1] | Caskets (3994)[1] | Grand total |
| | . . . . . . . . | . . . . . . . . | Percent . . . . | . . . . . . . . | . . . . . . . . |
| Wood fines | – | – | – | – | – |
| Sawdust | – | 28 | – | 3 | 18 |
| Edge trim | – | 32 | – | 3 | 21 |
| Limbs | 48 | – | – | – | 16 |
| Chips | 43 | 2 | – | – | 15 |
| Bark | 6 | 1 | – | – | 3 |
| Paper | – | – | 100 | – | 0 |
| Misc. board | – | 24 | – | – | 16 |
| Pallets | – | 12 | – | – | 8 |
| Other | 3 | 1 | – | 94 | 3 |
| Estimated total (Dry tons) | 6,948.7 | 13,711.9 | 26.7 | 218.2 | 20,905.5 |
| *Disposal Methods Used* | . . . . . . . . | . . . . . . . . | Percent . . . . | . . . . . . . . | . . . . . . . . |
| Internal usage | 24 | 28 | – | – | 26 |
| Sold or given away | 54 | 63 | – | 100 | 60 |
| Waste disposal facility | 22 | 10 | 100 | – | 14 |

[1] Standard industrial classification code.

Table 2 provides an example of the residue account for one industry type in a region that was surveyed. Each of the other residue accounts is generated in tables of similar construction.

Table 2.–Sample residue account for one industry[1]

| Residue | Survey amount | Population estimation |
|---|---|---|
| | *Estimated amounts of wood fiber residues (dry tons)* | |
| Wood fines | 10.46 | 18.31 |
| Edge/trim | 415.50 | 727.13 |
| Chips | 1.20 | 2.10 |
| Paper | 0.00 | 0.00 |
| Pallets | 0.00 | 0.00 |
| Sawdust | 1,666.99 | 2,917.23 |
| Limbs | 0.00 | 0.00 |
| Bark | 409.50 | 716.63 |
| Misc. board | 0.00 | 0.00 |
| Other | 1,638.00 | 2,866.50 |
| Contaminated | 0.00 | 0.00 |
| | *Estimated Disposal Amounts* | |
| Internal usage | 0.00 | 0.00 |
| Sold or given away | 3,638.25 | 6,366.94 |
| Waste disposal facility | 503.40 | 880.95 |
| Estimated total amount | 4,141.65 | 7,247.89 |

[1]*Survey statistics:*

| | | | |
|---|---|---|---|
| Net sent 7 | | Percent sample | 100.00 |
| Net return 4 | | Percent return | 57.14 |
| Population correction factor | | | 1.75 |

## UTILIZATION OF FIBREST

A mail survey of 600 wood-using industries in three central Massachusetts counties (which included 69 cities and towns) provided a practical test for the FIBREST system.

Results tabulated by FIBREST indicated an estimated amount of 679,000 dry tons of wood fiber residues calculated from a 27 percent return of the two-page questionnaire. Interestingly, 68 percent of that amount was contaminated, having been generated by wrecking and demolition firms in the region.

Soon after this test, a private concern in the area, seeking to burn clean residues in place of fossil fuels, conducted its own survey to determine the availability of uncontaminated waste wood. The findings closely paralleled those figures generated by FIBREST in the uncontaminated categories (Johnson 1977).

To the potential user of wood residues, FIBREST provides the opportunity to assess more accurately the availability of the resource. By tabulating, locating, and describing the amounts of waste wood in an area as well as noting its current disposition, the user will be better equipped to make decisions on what is, normally, a marginal resource. With these capabilities, the system can be used for individual assessments of the residue situation. Or, with its flexibility of reporting modes and conversion parameters, it could be used to compare different waste wood inventories.

In conclusion, a note of caution is in order. For any inventory, the degree of accuracy desired (in the measurement and reporting of data) is directly dependent upon considerations of cost and scope. If estimates of wood residue amounts are used in FIBREST, then only extensions of those estimates will be reported.

As the potential of residues becomes more widely recognized and their need as a resource more acute, waste wood measurements should become more than just estimates. Only then will FIBREST, and other systems like it, be precise tools for resource management.

## LITERATURE CITED


Black, R. J.
1970. Present practices and future trends in solid waste management. *In* New Directions in Solid Waste Processing. Proc. Inst. Tech. Guid. Cent. for Ind. Environ. Control, Amherst, Mass. p. 4–9.

Black, R. H., R. R. Fielder, M. B. Hawkins, and R. O. Strom
1972. A planning model for the prediction of residential and commercial solid wastes. URS Res. Co. for Off. Solid Waste Manage., U.S. Environ. Prot. Agency. 123 p.

Burry, H. W.
1975. Personal communication. Wood Util. Serv., SUNY, Syracuse, N.Y.

Combustion Engineering, Inc.
1969. Technical-economic study of solid waste disposal needs and practices. 4 vols. U.S. Public Health Serv., Publ. 1886, sw–7c.

Dennison, S. E.
1977. An inventory of industrial wood fiber residues in the Connecticut River Valley counties of Massachusetts. M.S. Thesis (Unpubl.), Univ. Mass., Amherst. 207 p.

Foley, R.
1976. Report on the National Forest Management Act of 1976. Congr. Rec. 122(150): H11837. (Sept. 30, 1976).

Frame, E. D.
1974. Virginia forest products residue study, 1974. Va. Div. For. & Lumber Manuf. Assoc. 11 p.

Ingram, W. T., and F. D. Francia
1968. Quad-city solid waste project–an interim report. Public Health Serv., U.S. Solid Waste Program. 153 p.

Johnston, T.
1977. Personal communication. Montgomery Rose Co., Inc. Hadley, Mass.

Massachusetts Department of Environmental Health
1971. Regulations for the disposal of solid wastes by sanitary landfill. Mass. Gen. Laws, Chapter 839. Acts of 1970.

Massey, D. T., and L. H. Dunlap
1975. Solid waste management law–focus on Indiana. Natl. Tech. Inc. Serv. PB252284/AS.

McGlennon, J.
1977. The future of solid waste management. Environ. News (U.S. Environ. Prot. Agency, New England Reg. Off.). Jan. 1977. p. 17–18.

Muhich, A. J., A. J. Klee, and P. W. Britton
1968. Preliminary data analysis–1968 survey of community solid waste practices. U.S. Public Health Serv., Publ. 1867.

Quink, T. F., P. K. Whitehouse, and M. A. Brouilette
1974. Wood residues–volumes and availability in the western Massachusetts area for industrial development. Mass. Coop. Ext. Serv., Amherst. 13 p.

Smith, F. L.
1975. A solid waste estimation procedure–materials flow approach. U.S. Environ. Prot. Agency, Publ. SW-147. 56 p.

U.S. Environmental Protection Agency
1975. Third report to Congress–resource recovery and source reduction. U.S. Environ. Prot. Agency Publ. SW-161. 96p.

U.S. Office of Management and Budget
1972. Standard industrial classification manual. Exec. Off. of the President–Off. Manage. Budget. Washington, D.C., USGPO. 649 p.

# COMPOSITION OF LANDFILLED URBAN WASTE RESIDUES

Tommy J. Loggins[1]

*Abstract*.–Purpose of the study was to determine various quantities of wood waste being landfilled in the Atlanta metropolitan area. A survey was completed during the summers of 1977 and 1978. Information collected emphasized a large volume of potentially useful urban wood residue that was being wasted.

Landfill surveys were conducted by the Georgia Forestry Commission in the summer of 1977 and again in the summer of 1978. The majority of the landfills was located in the Atlanta metropolitan area and a smaller number in the cities of Rome and Macon, Georgia.

The Atlanta area has increased rapidly in population and land use in the last decade. Correspondingly, there has been an increased volume of solid waste going to landfills and other disposal sites. An integral part of this waste stream is waste wood of all types.

New emphasis is being placed on reducing waste and recycling materials whenever possible. Since waste volumes have grown, resource potentials have increased.

Reuse can also lessen disposal and landfill problems. Disposal problems for wood residue are greatest in urban areas because a dense population and high industrial concentration generate great amounts of waste wood.

Disposal expense, environmental regulations, lack of disposal space, and a growing demand for wood products create an ever-increasing need to recycle or reuse those heretofore discarded materials.

With the growing interest in energy and recycling, the Forestry Commission became involved in determining the volumes of various wood products going into area landfills. A total of 22 landfills was surveyed by commission personnel to determine the relative amounts of various wood products.

This wood comes basically in two forms. Manufactured items, such as furniture, crates, pallets, and various manufacturing wastes, represent approximately one-half the wood residue being landfilled in the Atlanta area, according to our study results (fig. 1). Raw wood (stumps, tree trunks, limbs, and leaves) make up the other component (fig. 2). This amount does not include the vast quantities of paper packaging that is discarded in the area.

The survey was conducted by stationing an individual at each landfill for a 1-week period, typically from 8:00 a.m. until 6:00 p.m., Monday through Friday; however, hours varied and several landfills were surveyed on Saturdays also.

As might be expected, the quantity of wood residue and its overall composition varied by day of the week and individual landfills (table 1). Some landfills were

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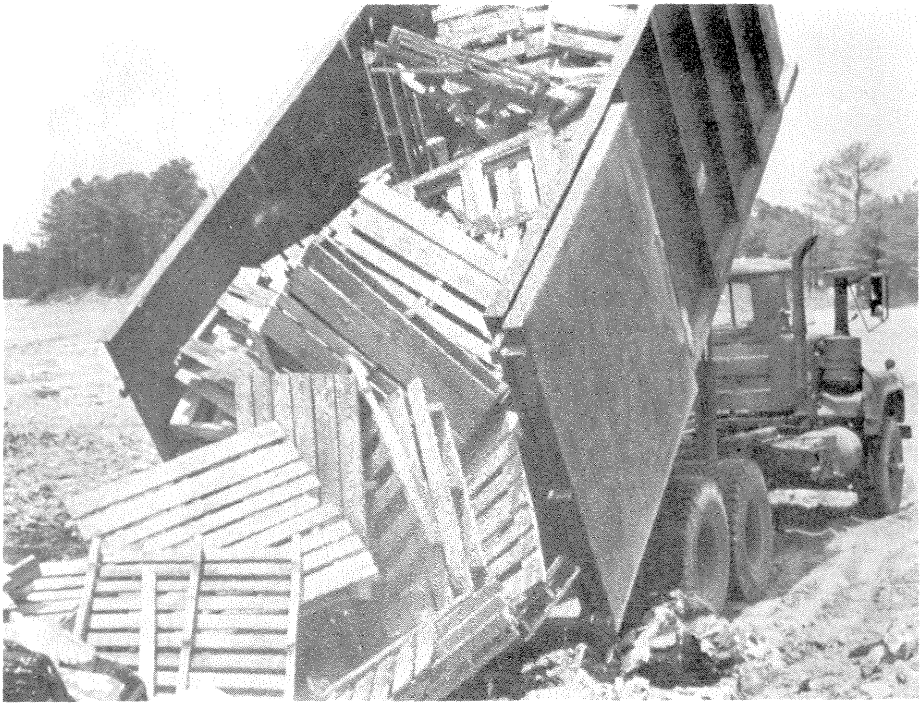

Figure 1.–Discarded pallets are unloaded into landfill.

Table 1.–Measured weekly totals[1]

| Type | Volume (cu. yd.) | % | Weight (tons) | % | Cords | % |
|---|---|---|---|---|---|---|
| Junkwood | 8,886.0 | 57.8 | 740.6 | 49.3 | 296.2 | 49.3 |
| Brush | 5,495.6 | 35.8 | 512.7 | 34.1 | 205.1 | 34.1 |
| Roundwood | 703.2 | 4.6 | 77.7 | 5.2 | 31.1 | 5.2 |
| Stumps | 179.9 | 1.2 | 135.0 | 9.0 | 54.0 | 9.0 |
| Wood chips | 102.8 | .6 | 36.5 | 2.4 | 14.6 | 2.4 |
| Total | 15,367.5 | 100.0 | 1,502.5 | 100.0 | 601.0 | 100.0 |

[1] All tables compiled by Dale Higdon from data collected during the summer of 1977. During this period a total of 22 landfills was surveyed. These measurements included both government and private landfills.

located near manufacturing plants that generated large volumes of waste wood, such as door trimmings, edgings, and sawdust. Others would receive packing crates, pallets, and other shipping containers. Still other landfills, which catered to residential customers, would receive a large amount of tree waste in the form of trimmings, stumps, etc.

At most landfills, the material was brought in by truck, weighed, and then taken to the dump site. At the remaining landfills, it was dumped without being weighed. In

Figure 2.–Typical wood residue generated in the residential areas of an Atlanta suburb.

these instances, dumping fees were based on truck volume, not weight. Truck sizes varied from pickup loads to tractor-trailer loads hauling 50 cubic yards or more. For commercial haulers, 25 to 40 cubic-yard loads were the most common.

The final dumping of the wood residue was of two general types. One mixed the wood indiscriminately with the other waste, such as household garbage, plastic, etc. This method was by far the most common since the primary purpose was to bury all the residue in as small a space as possible. Most commercial landfill operators did not have any facilities for recycling.

The second method was a separation type, where all wood residue went to a separate site from other waste and garbage. Only two landfills were operated by this method, both of which were county government operations. The advantage of this particular system was that it allowed the separation of usable wood materials, such as firewood, specialty packing crates, etc., without posing a hazard to equipment operation or violating regulations.

This second method required additional work for the hauler, for foreign materials, such as metal, wire, and garbage, had to be separated from the wood to be dumped. The other alternative is to haul only wood products on each load, a method that worked particularly well for government crews that hauled debris while another truck picked up garbage from households. Tree service companies also benefited since they haul loads composed mostly of wood.

To obtain weights of the various components of wood debris (brush, roundwood, stumps, chips, junkwood, etc.), each load of material was weighed and its volume determined by measurement. From this, an average weight per cubic yard was calculated for each type of wood waste. Based upon the data of this type collected from the two landfills with weight scales, conversions were possible for the remaining landfills where only volume measurements were obtained. A correlation between weight and volume was drawn for each category (brush, roundwood, junkwood, stumps) and species (tables 2 and 3).

Volumes were converted to cords, using weight as a factor. An average cord weighs 5,000 pounds, or 2.5 tons. In converting stumps to cords, 90 cubic feet were used. Cords from wood chips were figured, using 190 cubic feet per cord (table 4).

It should be noted that since the majority of field observations was taken during the summer months, leaves remained attached to the brush. This factor obviously accounts for some weight that would not be encountered in the winter months.

Further, it was assumed that due to adverse weather conditions in winter, the flow of wood residue will result in greater variability than that encountered during the summer. Ice storms, working conditions, etc., all have an immediate effect upon the amount of residue hauled.

Table 2.–Species composition

| Species | Volume (cu. yd.) | % | Cords | % |
|---|---|---|---|---|
| Pine | 5,905.3 | 38.4 | 230.8 | 38.4 |
| Hardwood | 9,462.2 | 61.6 | 370.2 | 61.6 |
| Total | 15,367.5 | 100.0 | 601.0 | 100.0 |

Table 3.—Category of classification

| Category | Volume (cu. yd.) | % | Weight (tons) | % | Cords | % |
|---|---|---|---|---|---|---|
| Tree parts[1] | 6,378.7 | 41.6 | 725.4 | 48.3 | 290.2 | 48.3 |
| Junkwood | 8,886.0 | 57.8 | 740.6 | 49.3 | 296.2 | 49.3 |
| Wood chips | 102.8 | .6 | 36.5 | 2.4 | 14.6 | 2.4 |
| Total | 15,367.5 | 100.0 | 1,502.5 | 100.0 | 601.0 | 100.0 |

[1]Brush + roundwood + stumps.

Table 4.—Assumptions

| | | | | |
|---|---|---|---|---|
| Brush | : | Average weight per cubic yard | = | 186.6 lbs. |
| Roundwood | : | Average weight per cubic yard | = | 221.1 lbs. |
| Junkwood | : | Average weight per cubic yard | = | 166.7 lbs. |

5,000 lbs. (2.5 tons) per cord

| | | |
|---|---|---|
| Wood chips | = | 190 cubic feet per cord |
| Stumps | = | 90 cubic feet per cord |

Weight of wood chips and stumps = No. cords × 2.5 tons

# SOURCE SEPARATION–PROCEDURES AND PRACTICES

Millard C. Davis[1]

*Abstract.*–Urban programs in source separation of waste wood in New Jersey center economically on two types of programs, those which expect remuneration and those which do not. Those with a future tied only to the public-service aspect appear to have the greatest potential for survival.

Source separation programs in New Jersey are on the increase, from about 30 programs reported in 1977 (U.S. Environ. Prot. Agency 1978) to over 130 municipally supported programs and an unknown number of private operations as of December 1978. Until now the major impetus for these recycling efforts has been the drive of private individuals and groups. A fluctuating balance has, in most of the privately run projects, been struck between the provider of recyclable or secondary materials and businesses in the secondary materials market, with homeostat feedback loops keeping the system in equilibrium most of the time. Choosing one point of entry into this circuit, to give an example, a group decides that it needs money, locates a market for recyclables it might sell, collects the materials, and sells it to the market. If the market, the secondary materials merchant, can prosper very much by receiving these materials, it will offer a high price. If the market is down, the price will drop. Naturally the group collecting the materials will tend to match its efforts to the strength of the market. In this way the market receives about what it needs and suppliers are repaid for their efforts.

In the case of municipally supported recycling programs, however, long-term contracts between the supplier (the municipality) and the market (one or more collectors or secondary materials merchants) are being encouraged by the State of New Jersey with floor prices and escalating clauses. Now the material will tend to have a steady flow rather than a fluctuating one.

This sort of program brings the significance of recyclables so much to the forefront of commerce that the use and continuing reuse of secondary materials is enhanced.

For New Jersey, the New Jersey Solid Waste Management Act (c.326, Laws of 1975) and the Federal Resource Conservation and Recovery Act (P.L. 94-580; called RCRA) operate to promulgate strong source-separation programs. The provisions of c.326, which divide the State into 22 Solid Waste Management Districts (the 21 counties and the Hackensack Meadowlands District), require that each district, alone or jointly with another, prepare a master plan for solid waste management. Each plan must include an evaluation of possible programs in source separation, with the first plans required to be submitted to the Commissioner of the Department of Environmental Protection by July 26, 1979, and the last ones by January 24, 1980. Source separation of urban waste wood will be given impetus by the support given to recyc-

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ling in New Jersey, which a number of sources have begun dubbing "the Recycling State."

How much waste wood is available from municipal solid waste? According to the "Fourth Report to Congress: Resource Recovery and Waste Reduction" (U.S. Environ. Prot. Agency 1977) in 1975, 1.8 million tons of wood packaging were discarded from post-consumer and commercial solid waste sources; not even 1,000 tons were reported as recycled. Of yard wastes, 26.01 million tons were discarded, and again not even 1,000 tons were recycled. Many tons of each probably were recycled, but the relatively minute figures were dropped during the production of massive accounting. What remains as significant is the general lack of commitment to recycling of waste wood, much less commitment to strong municipal source-separation programs, efforts which are economic and environmental answers to economic problems.

In New Jersey the hard economics are that, while we have over 300 landfills (serving 567 municipalities as well as the other generators of solid waste), many are rapidly nearing capacity and others will be phased out as not meeting the "sanitary landfill" definitions of RCRA. Into these landfills in 1977 went 465,348 cubic yards of vegetative wastes. Most of that probably arrived in the form of leaves, but strong municipal composting programs could have significantly reduced that figure where both leaves and wood were picked up for composting. In Camden County during 1977, about 19,012 tons of tree and landscaping refuse were collected from 30 (out of a possible 37) reporting municipalities. So tight has the situation become there that while in 1976 the county landfills served 81 percent of the population, by the beginning of 1978 only about 34 percent (or about 146,758 tons) of the county's total solid waste was being shipped to landfills elsewhere (Camden County (N.J.) Solid Waste Advis. Counc. 1978).

While tree and landscaping refuse does not play a great role in the total municipal refuse picture (about 4 percent), even a modest source-separation program could help in that county. Neighboring counties have shown increasing resistance to filling their landfills from Camden's overflow.

As the New Jersey district master plans are submitted, feasible source-separation programs will obviously be looked upon with great favor by the State reviewing agencies. Efforts in urban waste wood utilization can look forward to a strong positive response from the Solid Waste Administration.

What is being done currently by municipalities in the way of source-separation programs? Two types of programs seem popular.

A. In the first type the cost of the operation is borne by the agency, with no direct remuneration. A savings is reckoned from the potential cost of the only other considered alternative–landfilling. Four examples stand out:

1. Collection of trees, most notably Christmas trees, by the municipality and a free return of them to the public as chips. Usually the trees and/or other wood residues are picked up at curbside, transported to a municipal site, chipped, and then dumped as chips at a public site on a designated day for the citizens to come and collect.

In one municipality of nearly 70,000 people, an estimated 750 yards of compacted Christmas trees were last year returned to the public as 180 yards of chips. The only constraint placed upon people coming to collect, which was done in the parking lot of a local high school on two Saturday mornings, was that they take away no more than four containers worth; no one monitored this closely however. Fifty yards were left over, and these went for municipal mulching needs. The cost to the town was estimated at about $200. This amount was figured on the saving of dumping costs (about $1,200), minus labor and other direct costs, as well as those associated with owning two chippers, valued at about $5,700 each, which are able to cut sections of wood 6 feet by 3 inches in 1 second, large ones taking longer. Such a service has been operating for 4 to 5 years.

2. Another municipality of about 58,000 people includes free 2-foot lengths of firewood in its program. Both chips (cut up by two municipal chippers) and firewood are derived from trees and branches collected throughout the year and are stored at the end of a dead-end street where people can come for them any time. Some of the chips are used by the municipality itself, as mulch in parks, etc., and some of the firewood is used in one of the maintenance buildings, which is heated solely by a wood stove. Christmas trees play no role in either aspect of this program, for they are picked up by a private collector.

3. In the case of a County Park Commission, trees are collected if there is enough of a load; otherwise, people are welcome to drop them off themselves. About 2,100 Christmas trees were acquired under this program last year. All the trees or parts thereof are chipped by the park, stored until spring, and then used as mulch in ornamental beds and around the Commission buildings.

4. In still a fourth situation, a municipality of about 110,000 people collects trees and branches (as available or necessary) and chips them. Some of the chips are used by the municipality itself as mulch; the rest are unloaded onto State property, from which the State takes them for use in parks and elsewhere.

B. In the second type of source-separation program, there is some direct return on the investment by making direct sales of chips and/or firewood to individuals. Here three cases will suffice:

1. For 8 years a pair of municipalities, with populations of about 20,000 and 6,000, has cooperated in a broad-scale source-separation program, part of which has included Christmas trees. The program began as far back as 1970–71 with volunteers from the community and members of the civic environmental committees, which soon included members of the municipal Environmental Commission. From December 1971 onward, township sanitation crews were provided to handle curbside newspaper collection and to maintain the six recycling stations; in addition, there was some private curbside collection on the monthly basis under a contract which stipulated a return of 10 percent of the income from sale of the newspaper. Heavy use was made of reminders via local newspapers, community letters and notices, radio station broadcasts, posters, and displays. Guidebooks and programs for schools were available, and many community groups (ecology committees, school students, scouts, League of Women Voters, Welcome Wagon, etc.) pitched in. The intake was annually: 250 tons of waste

newspapers, 125 tons of glass, 60 tons of tin and aluminum, 500 to 1,200 old telephone books, 3 to 4 truckloads of "old but still usable" household items for the Rescue Mission, and 1,000 Christmas trees recycled into mulch and sold to residents. The average annual profit for the town of 20,000 people was considered to be about $3,000. Figures for 1975 show a slight loss in the Christmas tree program. One thousand Christmas trees were chipped and placed in 560 bags as mulch, then sold at 25¢ per bag, resulting in an income of $140. The township saved an estimated $46 in landfill and trucking costs. The chipper was paid $221. The loss of $35, however, was obviously absorbed in the overall gains from the program.

The curbside recycling program has recently been dropped, and with it went the wood source-separation project. At present, bins are available at two sites for people to bring in newspapers and glass, separated by color, which are picked up by a private collector. The Christmas trees are picked up by the municipality and dumped in a semi-wooded area.

2. In another municipality of about 45,000 people, located in the most industrial part of New Jersey, tree cuttings alone are sold. They are offered on Saturday mornings between 8 a.m. and 1 p.m., primarily from November to March, at 10¢ per piece, with only 30 pieces allowed to be taken away per car. This year more was sold than ever before. The program costs the town more than it makes, primarily for the labor of three or four men splitting wood. Though the going price of the wood sections is only one-half that of local commercial prices, not enough is sold here to draw complaints. Still, the temptation to steal is reduced by piling the wood in a fenced-in area behind a park.

Although this municipality has a strong curbside source-separation program for used newspaper and glass, the operation for wood is kept separate.

3. Another municipality of about 25,000 people in the same general area has a slightly more structured price system. Here cordwood is sold by the rick ($5), quarter-cord ($10), half-cord ($20), and full cord ($36). Unfortunately, since the wood is stored openly, most of it is stolen. As a result, splitting is delayed until the selling time in October. This program is viewed as perhaps more of a liability than an asset because of the number of serious injuries which occur to municipal employees during splitting, which is done by a machine.

What supports apparently successful municipal programs in source separation of waste wood?

1. Putting the program on a public service basis where there is no attempt to create a money-making operation. Most so-called recycling programs try to appear as economically self-supporting, even as profit-making. Rises and crashes are frequent and, as a result, entry into such programs is often considered as political death for elected officials.

2. Results which reach into another area, especially a nonessential but forward-looking one. In one municipality, wood chips are not only distributed to parks and around municipal buildings, as well as to the public, but at least one official considers them potentially useful in helping condition soil in an area which is being left "natural,"

essentially as a municipal wild preserve. This person also sees value in allowing the final cover on landfills to go wild, establishing wild parks.

What can bring down urban wood programs?

1. Being tied to another program which, while presently very promising in one place, has a history of fluctuating success elsewhere. While recycling industries in New Jersey appear to be in excellent health, municipal programs in source separation have had enough ups and downs to render them uncertain bases, unless perhaps the whole recycling effort is declared a public service, or even associated with a national necessity of broad scope.

2. Failure to accomplish the plain mechanics successfully, such as handling machinery, in a way which results in accidents that mar the program.

In conclusion, not only do the requirements of the new solid-waste laws offer a new lift to source-separation programs, but a new operation being considered by the Camden County Shade Tree Commission may prove to be a way of increasing markets:

> Trees, tree wastes, and wood products now contribute significantly to the problem. During the sixteen-year period between 1955 and 1971, over 120 million cubic feet of wood residues from land clearing were destroyed in New Jersey alone— enough lumber mass for the construction of some 37,000 average homes. These statistics were compiled at a time when open burning was the accepted means of disposal. With 1973 came the prohibition of this method, resulting in this inordinate amount of usable wood waste becoming a key component in the solid-waste disposal dilemma.
>
> The implementation of a Waste Wood Recycling Facility in Camden County shows great promise for helping to alleviate these conditions in the future. Waste wood heretofore earmarked for disposal can be rechanneled through the facility— either directly to the proposed Lakeland site, or indirectly through the establishment of four to six transfer stations strategically situated throughout the county.
>
> At the facility itself, the material would be sorted first into a tree's component parts; i.e., tops, large branches, leaves, boles, stumps, etc. Next, further separations as to quality and/or species would be performed (a lumber mill might be interested in purchasing certain species of oaks for use in veneer production). A metal detector would ensure against equipment damage due to hidden hardware within the tree. Lower-quality logs would be cut into uniform lengths, to be split as firewood.
>
> The Shade Tree Commission of Camden County, working in cooperation with the Camden County Municipal Utilities Authority, the N. J. Bureau of Forestry, and Cook College, Rutgers University, has found a great potential use for wood chips produced at the facility in the City of Camden's Sewage Sludge Composting Program. Under this program, wood chips are currently being purchased on a contractual basis from a major area land-clearing operation. The chips are combined with dewatered sludge at a ratio of two parts chips to one part sludge, then stacked in composting piles and aerated to hasten the decomposition process. The end product is suitable for use especially as a growth medium for nurseries, and in slope stabilization. The participants in the program have expressed a great interest in

obtaining wood chips for this operation from the proposed Camden County facility. This program in particular is definitely a progressive step toward wise utilization of two "waste" sources.

In addition, with procurement of a front-end loader equipped with power take-off (a necessity to all operational phases) and a single attachment, leaves from municipal collection rounds can be stacked, aerated, and decomposed into a fine organic material perfectly suited for farm and garden soil enrichment. This material could be made available to low- and moderate-income families who grow their own food.

## LITERATURE CITED

Camden County (N.J.) Solid Waste Advisory Council
1978. Preliminary study on solid waste planning.

U.S. Environmental Protection Agency
1977. Fourth report to Congress: Resource recovery and waste reduction.

U.S. Environmental Protection Agency
1978. Resource recovery technology: An implementation seminar workbook.

# DETERMINATION OF WOOD CONTENT IN DEMOLITION AND CONSTRUCTION WASTES

James A. Commins[1]

*Abstract.*—Demolition and construction waste streams were evaluated on a national basis by a unique combination of empirical and predictive techniques. National figures developed indicate 55 million total tons, the waste wood fraction of which is 22 million tons, representing 2 percent of the heating value of all U.S. coal production.

## INTRODUCTION

Forty years ago the practice in demolition and construction was to save and sell the used materials. In fact, many demolition and construction companies had a thriving business in used lumber. As labor costs increased and powerful wrecking equipment became available, hand-wrecking (which made possible the utilization of used lumber in new construction) became economically unfeasible. Today it is practically extinct. The wood fraction of demolition and construction waste is generally in shattered form, mixed with other debris, and disposed of at landfills.

Two factors have signaled the need to alter this process. Regulations on solid waste disposal were tightened, dramatically increasing the trucking distances to acceptable disposal sites and raising the dump fees because of increased site preparation and operating costs. During the same period, the United States got its first taste of energy shortages and much higher energy costs. These two factors—high disposal rates and high energy costs—are responsible for the interest in waste wood.

Prior to 1975, considerable work had been done in analyzing municipal household wastes and examining energy options. A fundamental knowledge for any production operation is the availability, quality (constituents in the case of waste streams), and cost of feedstocks on which to base production estimates. While such data were generally available in the case of municipal waste, no such comparable condition prevailed for demolition and construction waste.

In July 1976, EPA's Office of Solid Waste Management awarded to JACA Corporation a contract to determine the energy potential from construction and demolition waste. This work was completed in February 1977, and the final report issued in April of that year. I was the principal investigator for that work, which is the subject of this paper. The interest in this work might be not only with the findings, but also in the methodology applied, since it uses human estimates in an optimal balance between sampling and measurement error.

Before this study was conducted, there were only sketchy data on the wood fraction in demolition and construction wood wastes. What little data there were exhibited large variations, some 700 percent. The goal of the study, therefore, was to determine the flow and percentage of wood waste with a nominal predicted accuracy of ±30 percent.

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Predictive or empirical techniques might be used in determining the combustible fraction of demolition and construction waste. Predictive techniques involve determining the composition of buildings presently being demolished on the basis of knowledge of materials and quantities and construction techniques generally employed during the time of construction. Information concerning the age of structures demolished, as well as the number of razed units of each construction type, is employed in conjunction with information on number of buildings demolished, average number of cubic yards of waste generated per building, and the density of the waste per cubic yard to yield the total number of tons of combustibles available.

There are limitations on predictive and empirical techniques. Those affecting the predictive technique have been summarized in a report.[2] First, estimates of building composition at demolition will incorporate errors since alterations, additions, and replacements take place after the building is constructed. Second, the set of buildings being demolished is not a homogeneous combination of all types and sizes, and the use of the computed content of the average building may differ significantly from those being razed. Third, clean fill or waste not containing wood, metals, or plastics may be short-circuited and never reach the dump site. Fourth, on many jobs, the demolition contractor leaves any basement or foundation intact, and fills the basement with nonwood waste from the structure. Any waste so diverted is not truly available but is part of predictive estimates.

Empirical sampling involves actual analysis of representative waste streams and inferences made on the total, based on this sampling. It also has some drawbacks. First, sampling involves the random selection of sites and times of observations; it is often not possible to achieve this randomness because of time and budget constraints. To the extent that randomness is lacking, errors may enter into the estimation process. Second, measurement error is involved in making the empirical findings.

In this study we employed a combination of empirical and predictive techniques to develop estimates of the annual amount of construction and demolition waste and the fraction of that waste which is wood. Our study found that the United States annually produces 55 million tons of waste from demolition and construction activities; that waste wood accounts for 22 million tons (40 percent) of this total; that this waste wood has a heating value of $3.75 \times 10^{14}$ BTU, or about 2 percent of the energy derived from coal in this country annually. The amount of waste wood and its BTU potential discarded by various cities is shown in table 1.

An important finding for the design of any waste-process facility that uses wood waste from demolition and construction activities is the bimodal distribution of the wood content in the waste arriving at a landfill. A frequency distribution plot for 32 loads was developed during training of field observers (discussed later). The same general type of distribution occurred in field tests at 29 sites in 10 cities. This distribution has important implications for the design of a recovery facility since it affects staging area, storage, and separation.

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[2]Wilson, David Gordon. 1976. An investigation of the potential for resource recovery from demolition wastes. Mass. Inst. Technol.

Table 1.–Annual tons and BTU potential of wood waste from construction and demolition wastes of 10 cities in 1976

| City | Thousand tons | BTU potential |
|---|---|---|
| Philadelphia | 190 | $3.3 \times 10^{12}$ |
| Los Angeles | 670 | $11.0 \times 10^{12}$ |
| Chicago | 400 | $6.9 \times 10^{12}$ |
| Houston | 110 | $1.9 \times 10^{12}$ |
| Detroit | 490 | $8.5 \times 10^{12}$ |
| Miami | 67 | $1.1 \times 10^{12}$ |
| St. Louis | 230 | $4.0 \times 10^{12}$ |
| Atlanta | 42 | $.72 \times 10^{12}$ |
| Pittsburgh | 100 | $1.8 \times 10^{12}$ |
| Minneapolis | 67 | $1.2 \times 10^{12}$ |
| Average | 237 | $4.0 \times 10^{12}$ |
| Total | 2,366 | $39.9 \times 10^{12}$ |

## METHODOLOGY

At the outset of the study, it was intended that the following equation would be used separately for demolition and construction waste to arrive at the number of tons of combustible debris generated annually from demolition and construction activities:

$$\underset{(1)}{\frac{\text{Average yd}^3}{\text{building}}} \times \underset{(2)}{\frac{\text{tons}}{\text{yd}^3}} \times \underset{(3)}{\frac{\text{buildings demolished or constructed}}{\text{year}}}$$

$$\times \underset{(4)}{\%\ \text{combustible by weight}}$$

$$= \frac{\text{tons of combustible}}{\text{year}}$$

(1) was determined from primary data obtained from members of the demolition and construction industries;

(2) was calculated from the weights of 30 sample truckloads of demolition waste and 30 sample truckloads of construction waste of known volumes;

(3) was determined by extrapolation from the figure on total number of residential buildings demolished in the United States, found in U.S. Bureau of Census Report C45, to obtain an annual figure on all categories of residential, commercial, and industrial buildings demolished. Extrapolation was based on the ratio of residential buildings constructed or demolished to nonresidential buildings (commercial and industrial) constructed or demolished. Data were derived from the annual building construction and demolition permit records of the 10 cities visited. These calculations are based on

the number of buildings demolished or constructed after issuance of a permit; they do not cover unpermitted operations. Unpermitted operations, which occur most often in rural areas where levels of demolition activity are low, are expected to represent a negligible part of the total activity.

(4) was obtained from statistical analysis of the data collected at disposal sites in Philadelphia, Los Angeles, Minneapolis, Houston, St. Louis, Miami, Pittsburgh, Chicago, Atlanta, and Detroit. A total of 29 disposal sites was visited and 1,001 truck dumpings observed.

## TRAINING

The data-collection methodology for part (4) of the equation used visual estimation to measure percentage of combustibles by weight. Therefore, special training was instituted. The questions to be answered in the training phase were:

1. What were the best techniques for observing and estimating the volume of construction and demolition waste in a disposal operation?

2. What was the accuracy of the estimation?

3. Was the accuracy improved significantly by averaging the estimates of two or more observations?

A 6-week-training session was initiated during which these issues were addressed. It was conducted at a suburban Philadelphia disposal site licensed by the State of Pennsylvania for demolition and construction waste. After meeting with site personnel, several areas were designated and cleared so that the training loads could be kept separate for future analysis. Arrangements were made with a local demolition contractor to have his incoming 50-cubic-yard trucks stop at a nearby scale to obtain gross and tare weight for the vehicle. Trash bins of 12 to 18 cubic yards and a dump truck were used in the separation of the wood fraction.

When a weighed truck pulled into the landfill area, the observers positioned themselves around the rear of the truck at safe distances and at unobstructed observation points. The best location proved to be about 30° from the rear centerline of the truck. Observation of material was made while the load was dumped and after it was on the ground to make an estimate of the amount of wood and wood products in the load. Because this was a training exercise, estimates of the first loads were made on a volume basis until the observers developed a correlation between the volume and weight percentages.

Estimates of weight, along with date, time, source, truck weights, and general comments were recorded on a data sheet. All loads were photographed for subsequent analysis (fig. 1).

Four JACA employees went through the training program. Two had college degrees, and two were technicians with several years experience. It was not known how many loads would be required to develop an acceptable degree of accuracy (20 percent). Progress was monitored and terminated at 32 loads, when accuracy was satisfactory.

The loads were hand-separated into wood and nonwood piles. Portable trash dumpsters and a dump truck were used to transport the separated materials back to

Figure 1.—An unseparated load of demolition waste with a high percentage of wood.

the scale. Because of the size and weight of some of the beams and concrete blocks, a front-end loader was occasionally used as an aid in loading the receptacle. Since the debris was often very small at the bottom of the pile (these smaller pieces were often ground up when the front-end loader raked the pile), the weight percentages of the remaining 10 percent or less were often estimated and added to the weigh-ticket totals. The estimated remainder was less than 200 pounds. All of the debris came from the Philadelphia area; information about the type of structure from which it originated was obtained from the drivers or dispatcher.

The actual percentage of combustibles was obtained in the following manner:

Percent combustibles

$$= \left(\frac{\text{gross weight of separated materials}}{\text{gross weight of incoming truck}}\right) \left(\frac{\text{weight of container}}{\text{weight of truck}}\right) \times 100$$

Thirty-two loads of demolition waste were hand-separated and weighed during the training period. It was noted that demolition loads tend to occur most frequently with high-percentage combustibles or low-percentage combustibles rather than in the middle range. This same condition prevailed in 1,001 observations in later fieldwork.

The sampling process is subject to two types of errors. The measurement or nonsampling error occurs because of a difference between the actual value and the measured value; this kind of error arises from factors such as imperfect observation, faulty questionnaires, or inaccurate tallying. The sampling error results from the chance selection of sampling units; this error occurs when a partial observation of the universe takes place. If the entire universe were studied, the sampling error would be zero.

The total error in a statistical survey such as this one is the sum of the measurement error and the sampling error. The major concern is to minimize the total error. Reduction of the measurement error is achieved by defining precisely the population to be studied and its traits, by refining the measurement process to the highest degree, and by training the individuals doing the measurement as thoroughly as practicable. These precautionary measures are usually costly, leading to the necessity of using small samples. However, small samples tend to have larger sampling errors. Therefore, there are two options available: the sample size can be kept small and the measurement made in a sophisticated manner, or the sample size can be large and the measurement made in an unsophisticated manner. The following example should help illustrate the method of estimating the percentage of combustibles in construction and demolition waste. Assume that a sophisticated measurement process would limit the sample size to 50 observations; an unsophisticated technique would employ trained observers to estimate the combustible proportion and would allow for a sample size of 300 observations. Assume that the measurement error in the first case would be 5 percent and in the second case 10 percent. In estimating proportions, the formula for the maximum sampling error is given by:

$$(1) \quad \delta = z\sqrt{\frac{\pi\,(1-\pi)}{n}}$$

$\delta$ = sampling

z = normal curve deviate, which is determined by the level of confidence

$\pi$ = universe proportion being estimated

In the absence of information concerning the possible size of $\pi$, it is assigned a value of ½, which maximizes the expression $\pi(1-\pi)$, and, therefore, maximizes $\delta$ for a given level of confidence and sample size. In the cases cited above, if a level of confidence of 90 percent is employed:

$$(2) \quad \delta_{90} = 1.645\sqrt{\frac{(.5)\,(1-.5)}{50}} = .116$$

$$\delta_{90} = 1.645\sqrt{\frac{(.5)\,(1-.5)}{300}} = .047$$

Using a level of confidence of 95 percent:

$$(3) \quad \delta_{95} = 1.96\sqrt{\frac{(.5)\,(1-.5)}{50}} = .139$$

$$\delta_{95} = 1.96\sqrt{\frac{(.5)\,(1-.5)}{300}} = .056$$

Since:

Total error = Sampling + Measurement error, the following results are obtained with a 90 percent confidence:

Case 1 Total error = .166 + .05 = .165
Case 2 Total error = .047 + .10 = .147

with 95 percent confidence:

Case 1 Total error = .139 + .05 = .189
Case 2 Total error = .056 + .10 = .156

At both levels of confidence, the total error is smaller when the sample size is increased at the expense of a larger measurement error. In the case of this study, we chose the option of increasing the sample size as opposed to reducing the measurement error, and the cost of doing so was significantly less than reducing the measurement error.

## STRATIFYING THE SAMPLE

In stratified random sampling, the universe is classified into mutually exclusive subgroups or "strata" and samples are drawn from each of them. Sample statistics are calculated from each of these strata and are combined to yield an overall estimate of a population parameter. The basic purposes of stratified sampling, as compared to simple random sampling, are to obtain a sample that closely resembles the universe from which it was drawn and to reduce sampling errors. These objectives are accomplished by grouping together into strata those elements which are more alike with respect to the characteristic under investigation than are elements in the universe as a whole. Stratification is most effective when the elements within strata are as homogeneous as possible, as regards the property to be studied, and the differences among strata are as great as possible.

In this study, the demolition samples were to be stratified by type of structure. Initially, four strata were contemplated: residential, multi-unit residential, commercial, and industrial buildings. Experience in the field led to a reduction in the number of strata to two: residential and other. This reduction was made because many cities did not distinguish among the various types of structures, or because the required number of observations to define strata was not generated in each of the four areas. The same strata were initially proposed for the construction data. The number here was also reduced to two for the same reasons. The stratification by phase of construction was also considered but was abandoned after attempts to gather the data proved highly impractical within budget and time limitations.

In determining the geographical sites, the United States was divided into four areas and a percentage of the total population calculated for each area. This technique resulted in a selection of cities that would represent any regional peculiarities of building material and techniques. Ten cities were selected on this area breakdown on the basis of construction and demolition activity. Within each of these 10 cities, disposal sites were chosen on the basis of activity at the site and the willingness of the operator to cooperate by allowing field technicians to make observations.

Once the cities had been selected, the desired number of observations in each stratum (residential and other) for construction and demolition was determined by averaging the number of construction and demolition permits issued in each city during the period 1970-75. These permits were used to establish the ratio of residential to other units constructed or demolished. This ratio was then applied to the number 30, the desired number of observations for each city, to determine the desired number of observations in each of the two strata for that city.

Teams of two technicians each were sent to disposal sites in each of the 10 cities. Each technician independently observed loads as they were dumped, and the individual readings were averaged to obtain a better estimate of the percentage of combustibles. Varying lengths of time were spent in an effort to gather enough data to meet the desired stratification, which was universally met.

Since the observed samples exceeded the required number at each location, a weighting technique was devised to allow the use of all the data generated, even where the actual number observed exceeded the desired number. Weights were assigned in such a way as to keep the strata in the proper desired ratio. The weighted technique calculated the percentage combustible for each city as the weighted mean of the two strata, employing the desired number of observations in each stratum as weights.

To determine the overall percentage combustibles, the arithmetic mean and standard deviation of the 10 weighted percent combustibles were calculated. Employing this datum, a confidence interval for the overall percentage of combustibles was calculated as follows:

$$\bar{X}p - t_{.05}\ (s/n) \leqslant \frac{95\%}{Mp} \leqslant \bar{X}p + t_{.05}\ (s/n)$$

where:

| | | |
|---|---|---|
| $\bar{X}p$ | = | mean of the 10 weighted percent combustibles |
| s | = | standard deviation of the 10 weighted percent combustibles |
| $t_{.05}$ | = | coefficient, which is determined by the level of confidence |
| n | = | sample size (10) |
| Mp | = | mean percent combustible for the universe. |

For demolition $s = 12.12$

$$38.60 - 2.262\left(\frac{12.12}{3.16}\right) \leqslant Mp \leqslant 38.60 + 2.262\left(\frac{12.12}{3.16}\right)$$

$$29.92 \leqslant Mp \leqslant 47.28$$

For construction $s = 8.34$

$$47.59 - 2.262\left(\frac{8.34}{3.16}\right) \leqslant Mp \leqslant 47.59 + 2.262\left(\frac{8.34}{3.16}\right)$$

$$41.62 \leqslant Mp \leqslant 53.56$$

This interpretation of the confidence interval is as follows: there is 95 percent certainty that the mean percentage combustible of all demolition waste is between 29.92 and 47.28 percent. The calculation of the percentage combustible of construction waste and the interpretation of the resulting confidence interval is analogous to that for demolition. Once the mean percentage combustible was determined, the total number of tons of combustibles was calculated by employing this percentage in conjunction with data developed on the basis of predictive techniques. The calculation for demolition waste is:

$$TCD = A \cdot D \cdot B \cdot P$$

where:

| | | |
|---|---|---|
| TCD | = | total number of tons of combustibles per year from demolition waste |
| A | = | average number of cubic yards of waste per building |
| D | = | average density of demolition waste |
| B | = | number of buildings demolished per year |
| P | = | percent combustible of demolition waste |

The average number of cubic yards per building was determined from a National Association of Demolition Contractors (NADC) cooperative questionnaire. The average density was determined in field experiments with JACA technicians. The number of buildings demolished per year was determined from literature searches.

In the case of construction waste, it was impossible to develop data from haulers as to the average volume of loads from typical waste sites, as was done via the questionnaire for demolition waste. These data were not available because of the long duration of construction activity.

The calculation for construction waste differs significantly from that for demolition waste:

$$TCC = P \cdot W$$

where:

| | | |
|---|---|---|
| TCC | = | total number of tons of combustibles per year from construction waste |
| P | = | percent of wood that is wasted in construction |
| W | = | total amount of wood consumed in building and construction |

The percentage of wood that is wasted in construction was determined from information gathered through literature searches and discussions with building contractors based on their estimating procedures. The total amount of wood consumed is taken from existing government sources.

The primary segment of this study utilized field measurements of properly stratified samples. The plan was to use a total of at least 600 random samples from three sites at each of the 10 cities visited. In the final analysis, 1,001 samples were obtained. This sample size was large enough to account fully for geographical differences in building sites and to allow for different sizes and types of buildings. Trained observers were used to estimate the percentage of combustibles as the trucks dumped their loads. A satisfactory measurement accuracy by this means would be 20 percent for all sample totals. The training showed that even higher accuracy was obtained. The objective in each city studied was to collect enough samples (percentage combustible values) for demolition and construction waste to meet the previously determined requirements in each category of a 60-sample stratified set.

The first data collection was done in the Philadelphia area. The Annual Building Construction Reports for the years 1970–75 were obtained to determine the stratification, in preparation for actual fieldwork. Construction and demolition permits for the past 5 months were examined to determine the recent activity levels in each stratum. The contractors whose names appeared frequently on these permits were contacted to determine which Philadelphia area landfill sites they were using and arrangements were made with landfill operators to station field observers at five local sites.

The activity in demolition and construction was extremely low during the initial data-collection phase when compared to the activity levels during the earlier training session. This difference indicated that the generation of demolition and construction waste was sporadic. As a result, the fieldwork was rescheduled to coincide with periods of high demolition and construction activity in order to get the most samples during field visitations.

It was evident that a refinement in the scheduling of cities was extremely important. Following discussions of our objectives with the NADC, Mr. Ron Dokell, President, offered the Association's assistance and, together with the Energy and Recycling Committee, provided assistance on our visits to the 10 cities. The NADC committee supplied names of local members who aided in scheduling fieldwork to coincide with high demolition activity. These contacts were also helpful in directing us to the landfills where most of the waste was being hauled.

Arrangements were made to visit three landfills at each of the 10 cities. Because one of the determining factors as to where demolition and construction debris will be dumped is the cost of hauling based on distance, the observation of three local sites helped neutralize intra-city peculiarities in activity or in composition of waste.

The method of obtaining percentage combustible data followed the procedure described in the training section. At safe observation points, each load of construction and demolition debris was analyzed while being dumped and while on the ground to estimate the percentage combustible by weight. The driver of the vehicle was questioned briefly as to what building category provided the waste.

Depending on activity levels in each city, observers spent 1 or 2 weeks on site, and in some instances had to return to a city to satisfy the stratification requirements. The stratification for the city was referred to periodically during the week to determine whether sufficient residential, commercial, and industrial loads were being sampled. Photographs were taken at several dumping sites for future reference.

Construction activity evidenced at the 10 cities was mainly in the form of small truckloads and portable bins of wastes generated in renovation, roofing, and siding projects. Very little waste was observed from new building construction. One explanation for this phenomenon is that waste generated on construction projects is disposed of on the site to avoid paying dumping fees at a landfill. Therefore, it was necessary to schedule return visits to obtain fully stratified, 60-sample sets of construction samples.

Some of the city building reports did not distinguish between commercial and industrial demolitions. Therefore, these two categories were combined into "nonresidential" construction and demolition for all the cities surveyed. Decreasing the number of strata did alleviate some of the problems in obtaining a proper sample. After the data on the 10 cities were reviewed, it was necessary to return to Miami, St. Louis, and Chicago for sufficient data on construction. Sufficient demolition data were collected in all 10 cities on the first visit because the demolition volume to building volume ratio is so large that continual landfill dumping is necessary.

Individual observers' estimates were averaged at each of the 10 cities, and the difference between one observer's average for the entire sample and the average of two observers for the entire sample was negligible. Therefore, one observer was sent to each of the three cities where insufficient data had been collected on the first visit.

The field data results collected on percentage of combustibles in the 10 cities are tabulated in table 2.

The density of the loads was a second piece of primary data to be obtained in the field. During the initial training session, 32 loads of demolition waste were weighed and separated at a local landfill site. A value for the average density of demolition waste was needed. The concentration of the various components of demolition waste (such as wood, brick, concrete, and dirt) and the permitted road weight of a particular truckload help determine the density of the load and the volume to which the truck

Table 2.—Weighted percentage of wood in demolition and construction waste
—Field Data—

| City | Wood demolition | Wood construction |
|---|---|---|
| | *Percent* | |
| Philadelphia | 41 | 42 |
| Los Angeles | 63 | 48 |
| Chicago | 44 | 60 |
| Detroit | 42 | 43 |
| Houston | 27 | 63 |
| St. Louis | 51 | 50 |
| Miami | 37 | 43 |
| Pittsburgh | 27 | 36 |
| Atlanta | 20 | 40 |
| Minneapolis | 34 | 51 |
| Average weighted percent combustible | 39 | 48 |

can be filled. Often a 50-cubic-yard-capacity demolition truck with high density components may be filled to only 20 cubic yards; a truck with a high percentage of wood is generally filled to volume capacity. The average volume of 32 truckloads averaged 40 cubic yards.

When the average densities for the 32 truckloads were calculated, the value for the density of demolition waste was found to be 25 pounds per cubic foot. This figure was considered accurate for this study because the percentage combustible values for the 32 training loads had good distributive representation from both low-percentage and high-percentage combustible loads.

In order to use the equation presented in the National and Area Estimates section, a value for the average number of cubic yards of waste generated per type of building demolished or constructed was needed:

$$\frac{\text{Average yd}^3}{\text{(const./demo.)}} \times \frac{\text{tons}}{\text{yd}^3} \times \frac{\text{bldgs. (const./demo.)}}{\text{year}} \times \begin{array}{c}\%\text{ combustible}\\ \text{by weight}\end{array}$$

$$= \frac{\text{tons of combustible}}{\text{year}}$$

To determine the volume of waste generated in the demolition of buildings, the NADC cooperated with JACA Corporation in administering a response-card program, which supplied data collected by 17 volunteer members of NADC.

Respondents remained anonymous through a respondent numbering system, and the geographical distribution was statistically sound. One card was completed for each demolition job. The information entered on the card included duration of job, type of building, number of units if residential, number of loads, and the truck size.

The NADC response-card program ran for approximately 3 months, yielding 200 responses from the 17 respondents. Following completion, cards were separated according to building category, and the average volume of waste per demolished building was calculated for residential, commercial, and industrial buildings.

*Average volume of waste per building*

| | |
|---|---|
| Residential | 450 $yd^3$/bldg. |
| Commercial | 2,022 $yd^3$/bldg. |
| Industrial | 3,860 $yd^3$/bldg. |
| Overall | 1,370 $yd^3$/bldg. |

From other information included on the response cards, the average duration of a demolition job could also be determined.

| *Average duration of demolition job* | (days) |
|---|---|
| Residential | 3.87 |
| Commercial | 9.56 |
| Industrial | 14.7 |
| Overall | 6.92 |

Lengthy job duration, variation in methods of disposal of construction waste, and the inability of members of the hauling industry to provide average estimates of volume of waste generated by each construction job frustrated attempts to determine the volume of wood waste generated in the construction of a residential building, a commercial building, and an industrial building. Therefore, it became necessary to develop data on the basis of estimates made by construction contractors on the percentage of wood waste generated on their jobs. Contractors were requested to estimate the wood waste as a percentage of wood ordered for each construction job. The results of this survey of 20 contractors indicated that an average of 7.4 percent of wood delivered is wasted in the process of construction. The average was tested for significance by the following equation:

$$\bar{x}_W - t_{0.5}\left(\frac{s}{\sqrt{n}}\right) \leqslant \mu_W \leqslant \bar{x}_W + t_{.05}\left(\frac{s}{\sqrt{n}}\right)$$

At a 95 percent level of confidence, $5.28 \leqslant \mu_W \leqslant 9.52$.

## TOTAL ANNUAL ESTIMATES

Annually, the U.S. Department of Commerce, Bureau of the Census, issues a report entitled "Housing Units Authorized for Demolition in Permit-Issuing Place." The report gives the total number of permits issued for demolition annually.

Using the figures presented for the number of housing units demolished in cities over 50,000 population (0.34 of total U.S. population, 1970 Census) as well as the cities' populations, a statistical evaluation was conducted to determine whether a linear relation existed between population and number of units demolished, using methods of linear regression analysis. The equation $y = -3.05 + 0.0018x$ was derived where $y$ = number of units demolished and $x$ = size of population. This equation explained 61 percent of the variation for this relation. Therefore, there would be a certain degree of error in pursuing the calculation of a total for demolition of housing units by this method.

While the above equation might be useful in predicting the amount of demolition for an area, a more reliable estimate was needed. Therefore, it was decided that the figures for U.S. total number of housing units demolished based on reports from permit-issuing places authorizing the demolition of one or more housing units would be used. The Bureau of the Census states that these annual figures are based on reports from areas which represent about 80 to 85 percent of the population and would therefore imply that these figures probably represent 95 percent of the total U.S. housing-unit-demolition rate.

To convert from units demolished per year to residential buildings demolished per year, the average number of units per building demolished from the building reports of the 10 cities was calculated. This was found to be 1.4 units per building. To determine the total residential and nonresidential buildings demolished per year, the ratio of residential to nonresidential buildings demolished per year in the 10 cities surveyed was computed and averaged from their respective building construction and demolition reports. The following equation was used:

$$\frac{\text{No. of residential buildings demolished}}{\text{year}} \times \frac{1}{.803}$$

$$= \frac{\text{No. of residential and nonresidential buildings demolished}}{\text{year}}$$

$$87{,}123 \times \frac{1}{.803} = 108{,}497$$

To determine the total number of buildings constructed per year in the United States, a similar approach was used. Using data on residential construction obtained from the National Association of Homebuilders, the following procedure was used:

$$\frac{\text{Residential units constructed}}{\text{year}} \div \frac{\text{average units}}{\text{bldg. constructed}}$$

$$= \frac{\text{residential bldgs. constructed}}{\text{year}}$$

$$\frac{1{,}512{,}900}{1} \div 2.5 = 605{,}160$$

$$\frac{\text{Residential buildings constructed}}{\text{year}} \times \frac{1}{.724}$$

$$= \frac{\text{residential and nonresidential buildings constructed}}{\text{year}}$$

$$605{,}160 \times \frac{1}{.724} = 835{,}856$$

## ESTIMATING ENERGY POTENTIAL

The heating value of wood was taken as 8,613 BTU's per pound. By multiplying the tons of combustibles generated annually from these two sources, the energy potential of the waste wood can be calculated on a national level:

*Demolition:*

$$\frac{\text{avg. yd}^3}{\text{bldg.}} \times \frac{\text{tons}}{\text{yd}^3} \times \frac{\text{bldgs. demo.}}{\text{year}} \times \%\ \text{combustible} \times \frac{\text{BTU's}}{\text{ton}}$$

$$= \frac{\text{total BTU's}}{\text{year}}$$

$$1{,}369.8 \times .337 \times 108{,}500 \times .386 \times (1.72 \times 10^7)$$

$$= \frac{3.3 \times 10^{14}\ \text{BTU's}}{\text{year}}$$

*Construction:*

Tons of wood consumed annually by construction industry

$$\times\ \text{average}\ \%\ \text{wasted per job in construction} \times \frac{\text{BTU's}}{\text{ton}}$$

$$= \frac{\text{Total BTU's}}{\text{year}}$$

$$35{,}000{,}000 \times .074 \times (1.72 \times 10^7)$$

$$= \frac{4.5 \times 10^{13}\ \text{BTU's}}{\text{year}}$$

Total energy potential from demolition and construction nationwide

$$= \frac{3.75 \times 10^{14}\ \text{BTU's}}{\text{year}}$$

To determine the energy potential from demolition waste for a given local area, the above equation is used with a substitution of number of buildings demolished per year within the city for the number of buildings demolished on the national level. The local weighted percent combustible figure can be substituted for the national average of 39 percent. The volume per building must be recalculated in accordance with the average ratio of residential, commercial, and industrial buildings indicated in the building reports.

To calculate the energy potential available from construction waste on a local level, the amount of wood consumed must be estimated. The method used was to set up an equality which relates amount of wood consumed by the construction industry on a given level to the number of buildings constructed on that level.

$$\frac{\text{Wood consumption nationwide, by construction industry}}{\text{buildings constructed nationwide}}$$

$$= \frac{\text{Wood consumption, by city, by construction industry}}{\text{buildings constructed, by city}}$$

$$\text{e.g., Chicago} \quad \frac{35{,}000{,}000 \text{ tons}}{835{,}856 \text{ bldgs.}} = \frac{x}{2{,}482}$$

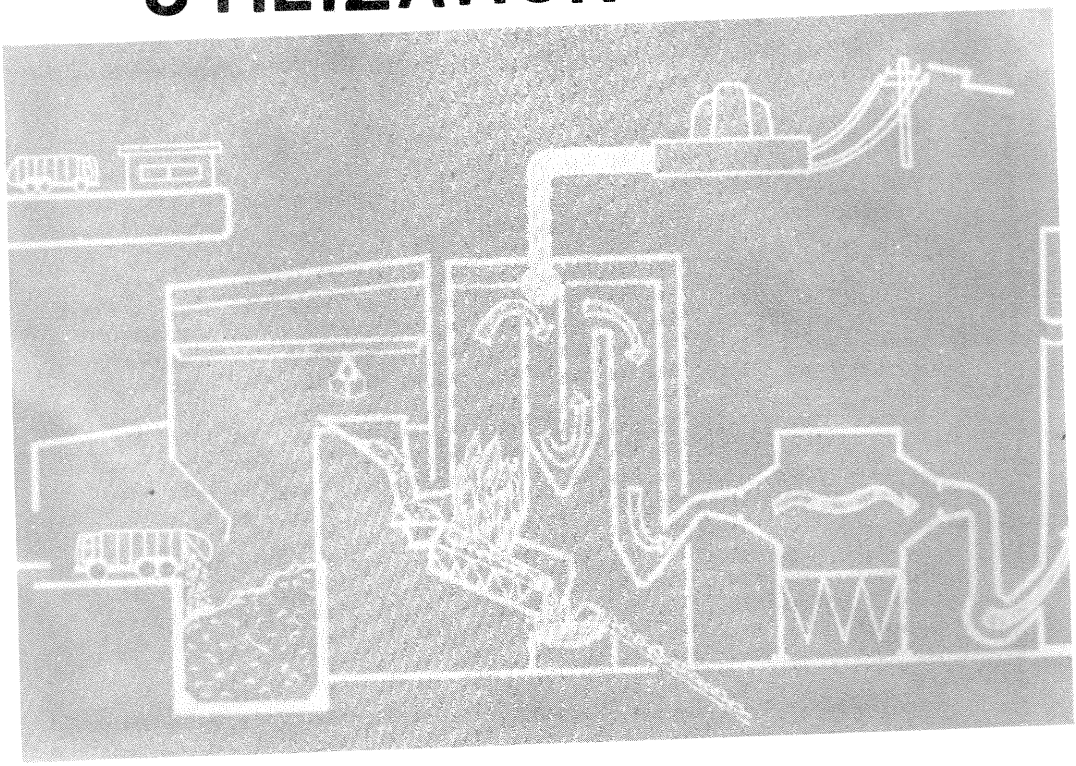
x = wood consumption = 104,000 tons per year, by Chicago construction industry

Using the construction waste energy potential equation:

$$104{,}400 \times .074 \times (1.72 \times 10^7) = \frac{1.3 \times 10^{11} \text{ BTU's}}{\text{year}}$$

These equations may be applied to any locality that has the appropriate data available.

# TOPIC II
# UTILIZATION OPTIONS



# TOPIC II
# UTILIZATION OPTIONS

## *ABSTRACTS*

DeVOTO

*Paper from Municipal Trees.*—Because they encountered increasing numbers of trees killed by Dutch elm disease, the cities of Minneapolis and St. Paul attempted to find a method for wood disposal other than burning and/or burying in landfills. A large-size chipper seemed to be the solution to the problem.

WALKER

*Mulch from Limb and Trunk Debris.*—Faced with the rising cost of pine straw, Georgia Institute of Technology experimented with using site-generated wood chips for mulch. It was learned that, compared with pine straw, wood chips were less expensive, longer lasting, less flammable, and better at retaining soil moisture.

LEMPICKI

*Products from Municipal Trees.*—Shade trees along city streets and state highways and those near suburban homes often reach a large size and have butt logs suitable for many specialty products. However, when these trees are felled, they are all too often used only for fuelwood and wood chips, or hauled to landfills. The following is an example of one company's experience in turning this underutilized material into an interesting and profitable commodity.

LOWERY

*Firewood from Municipal Trees.*—Firewood is becoming a necessary item in the life of Americans as we face increasing energy shortages. This paper summarizes an effort to supply the citizens of Atlanta with an energy source obtained from wood residues produced from the city's forestry operation.

COBB

*Fuel Preparation for Waste Wood Boilers.*—After proper preparation, wood residue may be used as fuel or as raw material for such products as horticultural mulch, animal bedding, poultry litter, particleboard, fireplace logs, and fuel pellets. The reuse of waste wood requires an understanding of waste wood boilers, wood-reduction machines (hogs), waste loads, economic considerations, and the services provided by consultants.

HOWARD

*Marketing Urban Wood Residues.*—This study defines the characteristics of wood residues that affect their marketability, discusses the processing required to upgrade residues to useful wood fiber, and lists potential markets and dollar values for various residues.

STUROS

*Segregation Processes for Urban Waste Wood.*—Three technologies—steaming-compression debarking, vacuum-airlift segregation, and photosorting—have been developed for improving the quality of whole-tree and wood-residue chips. Applications of these processes coupled with integrated utilization of the various output wood fractions should lower the barriers for increased urban waste wood utilization.

McMINN

*Importance of Wood as an Urban Energy Source.*—The paper reviews (1) theoretical limits to wood supplies, (2) characteristics of wood as a fuel source, (3) difficulties in predicting energy consumption and fuel prices, and (4) the outlook for wood-energy development. Woody biomass is likely to provide less than 10 percent of urban energy, and its use will be in small-scale, decentralized systems. Small towns will derive the greatest benefits from primary biomass, whereas use of urban waste wood will probably be unrelated to city size.

MILLS

*Recovery of Energy from Solid Waste–An Alternative to Landfill Disposal.*–There are many solid waste recovery techniques from which communities may choose. The technology described here is known generally as mass combustion in waterwall boilers. A facility using this technology takes all kinds of residential, commercial, and nonproblem industrial solid wastes and processes them into usable energy and marketable materials. This combustion process performs extremely well, with better than 96 percent burnout of combustible matter and a volume reduction of 95 percent.

## PAPER FROM MUNICIPAL TREES

David F. DeVoto[1]

*Abstract.*—Because they encountered increasing numbers of trees killed by Dutch elm disease, the cities of Minneapolis and St. Paul attempted to find a method for wood disposal other than burning and/or burying in landfills. A large-size chipper seemed to be the solution to the problem.

## THE NEED

A fungus (Ceratocystis ulmi) implanted in elm trees by bark beetles causes a condition called Dutch elm disease. This disease has become extremely serious in the cities of Minneapolis and St. Paul over the last few years. Beginning in 1961 in St. Paul and 1963 in Minneapolis, the disease plodded along without causing real problems until about 1975, when the number of infected trees began to soar, as is shown in figure 1.

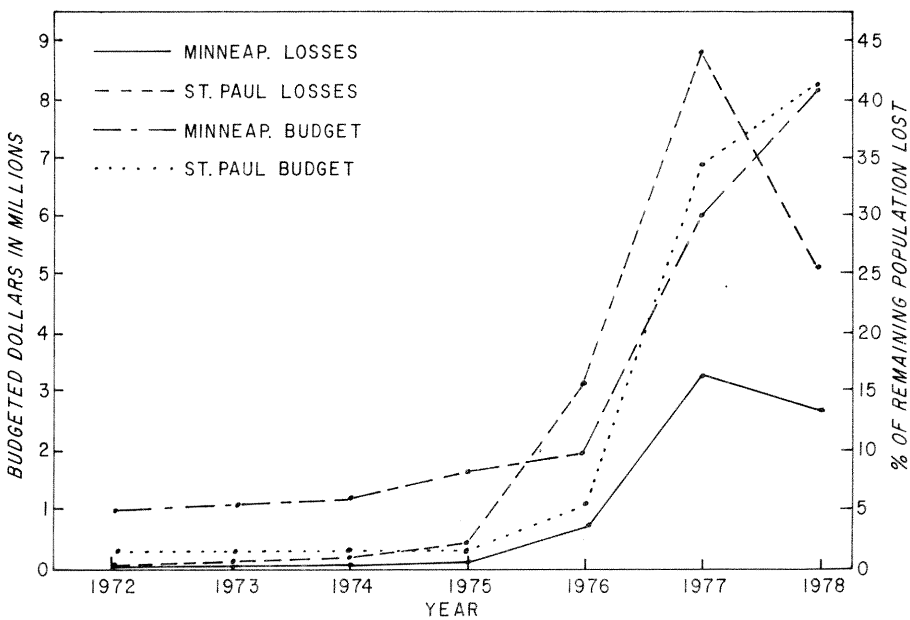



Figure 1.—Budgets and tree losses for Minneapolis and St. Paul.

[1]Director of Forestry, Minneapolis Park and Recreation Board, 250 South Fourth Street, Minneapolis, Minnesota 55415.

In the early seventies, realizing that losses were going to become high and that dollars for control were going to be limited, the cities (first independently, and then after realizing they were following parallel paths, jointly) began trying to find means of disposing of trees more efficiently. Until this point, trees were either burned or buried in commercial landfills. These methods were, even with low losses, not the best means for disposal. As losses increased, they became even less acceptable.

In any large metropolitan area, landfill space is scarce and should be reserved for household and industrial wastes rather than being quickly used up by tree brush and logs. When we discussed the possibility of bringing the large anticipated volumes to his site, one landfill operator said that he would only take our debris if we supplied a ton of covering sand for every ton of material we dumped; this obviously would become expensive.

The other means of disposal available was open burning. With air pollution standards becoming more stringent, with increasing amounts of pollutants being generated within cities, and with urban sprawl pushing suitable sites farther away, burning fell short of being a good alternative.

In both of the above methods, another problem became clear. Large increases in volumes meant more equipment would be necessary, causing more capital investment. Money for this had to be borrowed at increasing interest rates. More labor had to be hired at even higher salary rates. The dilemma became worse.

Table 1.–Comparative disposal costs/ton

| Year | 1976 | 1977 | 1978 |
|---|---|---|---|
| | | *Dollars* | |
| Landfill | 4.25 | 6.00 | 7.20 |
| Burning site | N/A | 2.00 | 3.00 |

## ALTERNATIVES

The most obvious alternative for a forester was to turn these costly-to-dispose-of logs into usable wood, which made sense because the wood was still sound. Its quality and structure were unchanged, and many of the logs were long and clear of limbs and knots. With the number of logs steadily increasing, it might even be feasible to move a sawmill into the area.

Not so, according to the sawmill operators. In our efficient methods for preservation of city trees we had created a major stumbling block. Whenever a tree began to develop decay, someone had been there to chip away the decay and plug the hole with concrete and reinforcement rod. Whenever a severe storm split and damaged a tree, we were "Johnny-on-the-spot" to screw in lag hooks, attach chains and cables, and fasten in large bolt-rods. We even went so far as to trace the bark around these fixtures so that the tree would neatly grow over them, making them almost invisible. An additional problem was that every housewife who planned a Saturday garage sale advertised it by nailing a sign (using a tenpenny nail) to our trees.

We had anticipated some problems with foreign objects in trees, but we did not realize just how serious these problems would be. It would have been nice to do away with the disposal problem and its inherent costs and perhaps even get a little return by selling our logs to sawmills. The sawmill operators quickly and firmly let us know that they were not interested in our trees, even if we gave them away.

Another possibility was to not saw up the material, but to grind it into wood chips. There seemed to be many uses for chips. We had, in the past, been chipping small branches (up to 6 inches in diameter) right on the street with small trailer-mounted limb chippers. Much of this material was used as mulch around our newly planted trees and shrubs. Any material not needed for our own use was easily given away to homeowners for their use. Hardwood chips of the proper quality and size were being used by local manufacturers of roofing felt. Although paper companies were at first somewhat reluctant to use hardwood chips for pulp, we felt a market could be developed and, if debarked and properly processed, many of our logs could be disposed of in that industry.

Further study indicated that chipper plants were relatively inexpensive, costing $½ million to $¾ million (compared to the cost of setting up a sawmill: more than $1.5 million). The amount of space necessary was also less, and the amount of waste would be extremely small if a wood "hog" were incorporated into the system to regrind bark and "overs-and-unders" into fuel material.

Since we did not want to go into the chipping business, our next task was to find someone in the private sector who would be willing to invest in building and operating such a system. Again we ran into problems. The private investors needed many guarantees to protect their investments. Could we guarantee a certain number of tons of chips delivered in relatively even amounts and for a specified number of years? If we could not fulfill the quota, who would be responsible for the difference in the expected profit? This was all taking place in 1973–74 and, of course, hindsight now shows us that certain of these guarantees could have been met. At the time, however, acting as a public agency dealing with the citizens' tax dollars, we could not make such commitments.

We were then at the spot that the "little red hen" (in the children's story) found herself. When she could not get any help she said, "Then I'll do it myself," and she did. Well, we did too but not quite so easily; we built a chipper plant ourselves. Since we were not in the chipping industry and therefore knew very little about it, we searched a lot of printed matter, talked to a great many individuals and finally (with considerable help from a consulting engineer) came up with what seemed to be a workable plan.

## SITE SELECTION

It was determined that we would need about 10 acres of land for erecting the plant and to use for storage and handling of the material. Although vacant 10-acre sites are not very common in a metropolitan area, there were five locations that were feasible. Best of all, they were owned by various government agencies and could be used without the need to buy land. As usual, things did not go quite the way we would have liked.

Site number one (fig. 2) was the most convenient for both cities and was our first choice. It turned out, however, that the agency owning it had it set up as an industrial development site. The owners needed a long-term lease and expected us to pay them for the revenue they would lose while it remained undeveloped. Since our whole venture needed to be done with a very tight budget, the costs incurred would have been entirely too high.

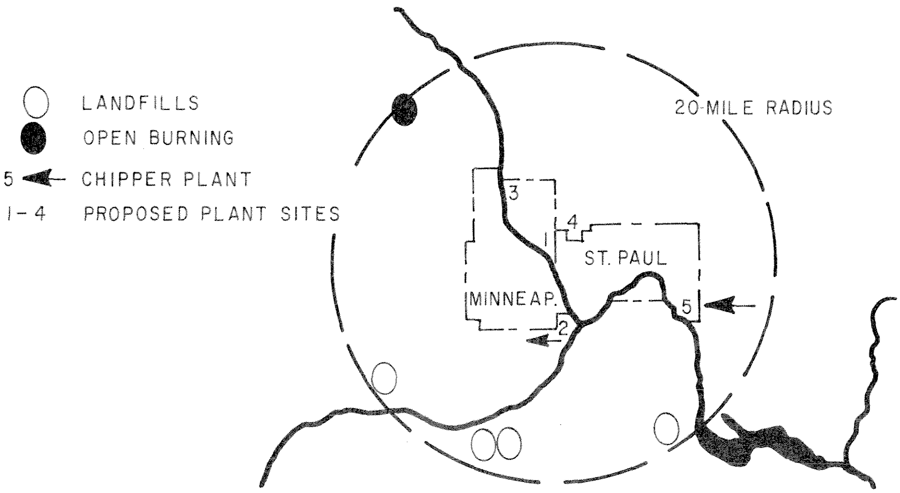



Figure 2.—Actual and proposed disposal sites in Minneapolis-St. Paul.

Site number two (fig. 2) was next best, but we found that it would be directly under the flight path of the airport. Dust from trucking and from the machinery would create a hazard for landing aircraft. The metropolitan airport commission felt strongly that this would be an unsuitable location unless we would be willing to shut the plant down during problem times. Since this would not be feasible, the next site was considered.

This location (number three in fig. 2) appeared to be a good choice, even though it meant a little farther hauling distance for St. Paul. It was located on property owned by the City Water Department. No other use was foreseen for it, and it also had railroad access, which meant that if rail transportation of chips turned out to be our best method, it would be inexpensive to put in a loading spur. Again, problems!

Use of the property required City Council approval. Just prior to our request, a special-use permit had been given to a barge company to install a loading terminal on the river just across from our proposed site. The Alderman for that ward had been receiving many complaints about loud noises due to barges being banged into each other night and day. He absolutely refused to allow anything to be done in that area that might possibly make any noise.

Location number four (fig. 2) was convenient to both cities. It had enough space and could receive Council approval. In closely examining the area, however, it was clear that interjecting many large trucks full of logs into an area of heavy traffic congestion would become frustrating to all concerned.

Another area (number five in fig. 2) was finally selected to be used for the plant. This area had certain drawbacks which caused it to be the last to be considered. Of primary concern was that it is within the "100 year" flood plain. Even though the odds of flood were very small, machinery that would be affected by water would have to be made so it could be easily removed to high ground. The site was originally a sanitary landfill, and soil borings from as deep as 60 feet were showing undecomposed garbage, which meant that pilings would be required under equipment pads. Access to the site was also somewhat constrained, and we realized that during spring thaw and heavy rains, we would be severely hampered by mud.

On the other hand, the site was on St. Paul Port Authority land, which we could use at no cost. It was remote from other land use except for a railroad-repair facility, a cement plant, and a sewage-treatment facility. For this reason, there would be no neighbor problems. If necessary, we could rather inexpensively put in a railroad spur for shipping and possibly even set up for loading river barges.

## PLANT COMPONENTS

While site selection was going on, we were also determining what components were necessary for operation. It was decided that the best power to use was electric motors. Components (fig. 3) were as follows:

1. Nicholson 55- by 58-inch roto-drum chipper (fig. 4).
2. Precision No. P848M debarker, complete with control panel and motor starter (fig. 5).

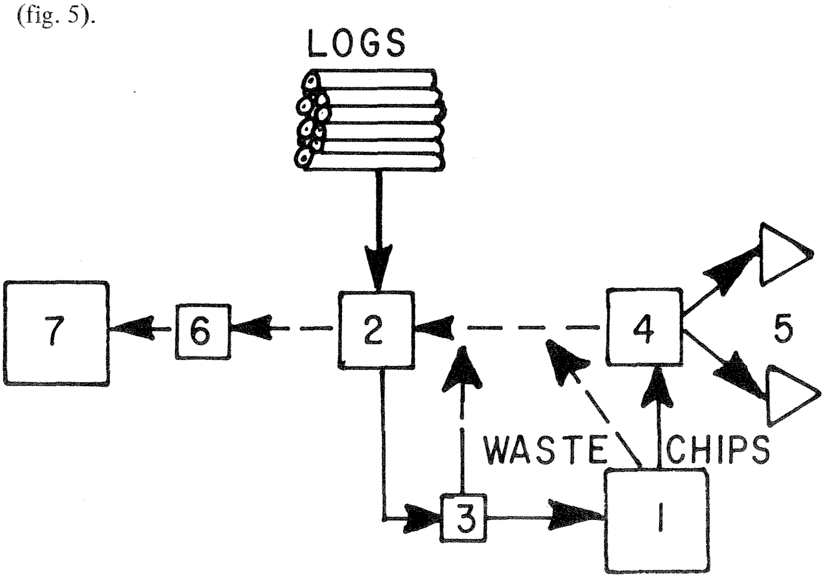



Figure 3.–Components of the chipping plant.

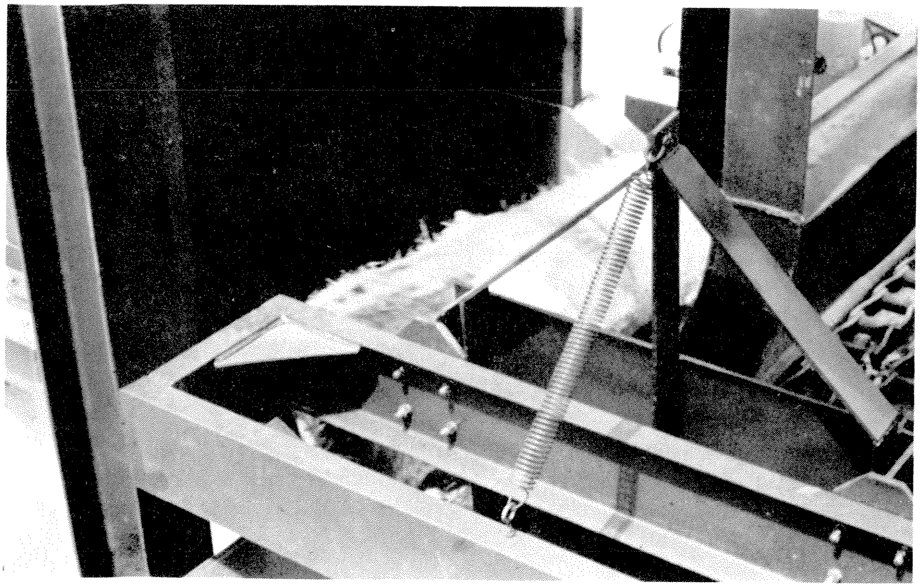


Figure 4.–Cutoff saw in operation.

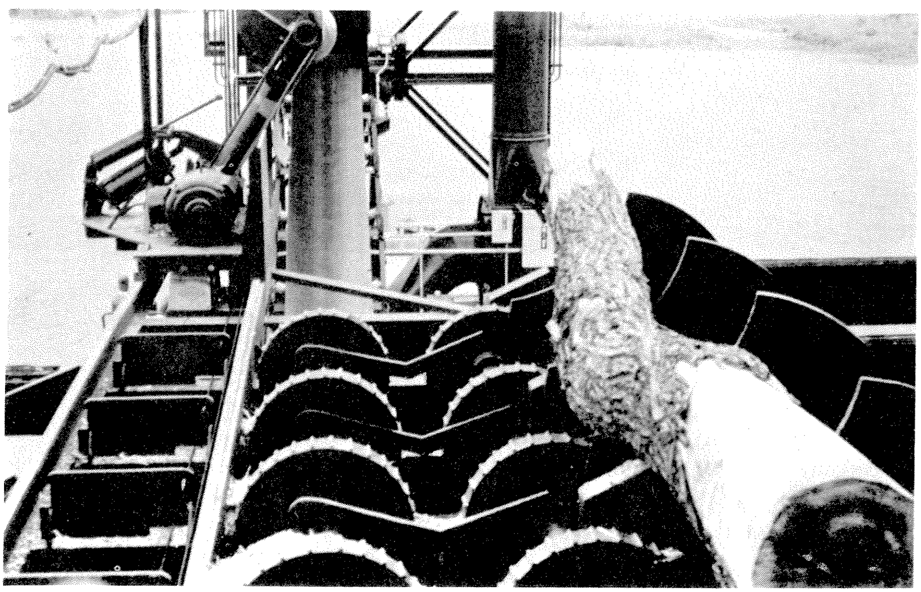


Figure 5.–Log being loaded onto debarker.

3. LM Model No. 200 HSA chain-saw cutoff, complete with control panel and motor starter (fig. 6).
4. 8- by 8-foot chip screen manufactured by Precision.
5. Two van truck loaders with feeder manufactured by Phelps.
6. Bark and waste hog manufactured by Bush Manufacturing Company.
7. Large-capacity storage bin manufactured by Carothers Brothers.
8. Miscellaneous log decks with stops, conveyors, log jack, log clam, etc., manufactured by Mellott.
9. Miscellaneous conveyors, transporters, supports, and walkways manufactured by Minneapolis Sheet Metal Works.

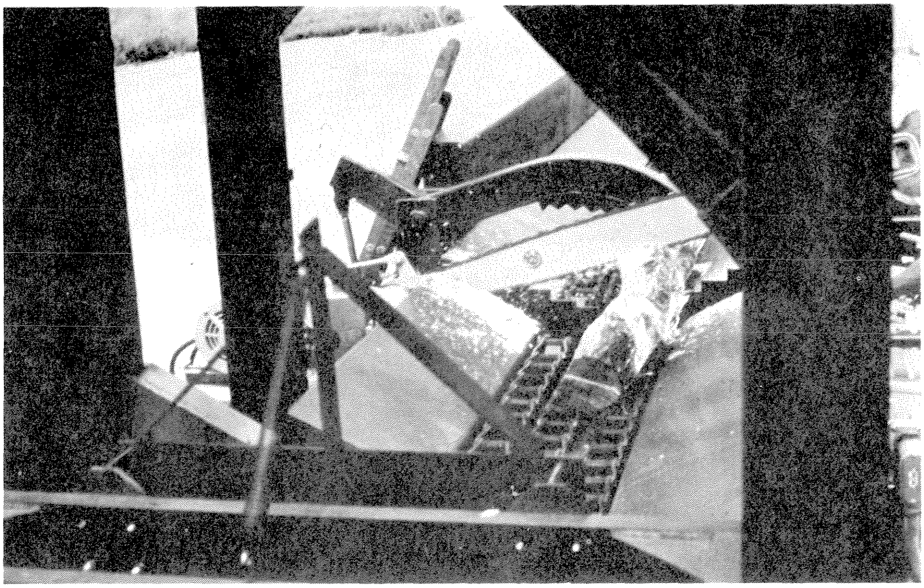


Figure 6.—Debarked log entering chipper.

The total cost for construction, $460,000, was shared by the Minneapolis Park and Recreation Board ($115,000 or 25 percent), the City of St. Paul ($115,000 or 25 percent) and the State of Minnesota, Department of Agriculture ($230,000 or a 50 percent matching grant). The program was set up under a joint-powers agreement between Minneapolis and St. Paul, with the latter being designated as the lead agency. Bids to furnish the equipment, prepare the land, and install all components were requested, and an award was made to the lowest bidder, Minneapolis Sheet Metal Co.

Construction was begun during January 1977, and the plant was ready for a trial run during August 1977. After the usual equipment shakedown problems, the plant was ready for operation.

A decision had previously been made that actual operation of the facility would be best handled by the hiring of a private operator chosen by the open-bid method.

The Northland Pulp Company was chosen as the operator. Production began, and things seemed to be going well. Chips and hog fuel were being produced and marketed.

## 1977–DISASTER!

The 1977 season opened with a bang. Suddenly trees were wilting in both cities in unbelievable numbers. In Minneapolis we had lined up 19 private contractors and felt very comfortable. It turned out that they were not sufficient; even bringing in an additional 13 through an emergency bid did not give us enough. Fortunately, when we had asked for bids we requested two price quotations, one for free dumping at the chipper plant and a second price if the contractor had to find his own disposal area and pay his own dumping fee.

To help alleviate overload problems at the plant, all contractors working in Minneapolis were required to find their own dumping areas. The Hennepin County Public Works Department set up a burning site open to these contractors, and the bulk of the trees removed from Minneapolis and surrounding areas literally "went up in smoke." Our own city crews were aided in disposing of all material up to 22 inches in diameter by our renting four 22-inch Morbark chippers, which chipped trees right at the removal location on the street. This left for the large chipper only logs over 22 inches in diameter, which were cut properly for running directly through the chipper plant.

Unfortunately, things did not go as well for St. Paul. The contractors in St. Paul, as well as the city crews, had to haul all of the logs, brush, and other debris to the chipper plant. The removal of some 40,000 trees over a 4-month period caused brush and log piles to rise like mountains. It was estimated that by the end of summer some 30,000 trees were piled on the site.

The plant, of course, could not handle these volumes. Trucks found themselves having to wait up to 3 hours just to get through the gates. Then, because of mud, most of them had to be pulled into and out of the dumping areas by tractors. St. Paul hired cranes to unload trucks, and debris was piled 20 to 25 feet high. Attempts to pull logs out of the piles were extremely difficult because of all the entangled brushy material.

The chipper itself was running at full capacity for 1½ shifts per day, and the other ½ shift was spent trying to keep it in repair. A lot of logs were being processed, but the volumes of brush (for which the plant had not been intended) were becoming huge. St. Paul then located and purchased two large log-chippers, one a Morbark and the other a Nicholson. They helped on the brush, but by the end of fall, tremendous volume still remained. The standard joke of the day was, "Anybody got a match?"

Actual burning was considered. The air-pollution problem that would occur, however, would not allow for it. Since the ground upon which the trees were lying was an old landfill with undecomposed material many feet deep, it was feared that if this material were to catch fire it might not be easily extinguished. There was also the fear that methane pockets might exist in sizes sufficient to cause serious explosions.

By midwinter some progress had been made in reducing the volume, but it was still a substantial problem. Speculation then began about how much of a threat this pile of beetle-infested wood would become to elms in the surrounding area. There were two schools of thought. One held that the beetles would go no farther than a nearby river bottom full of elms for them to feed upon. The second held that the winds associated with wide river valleys would blow them out into the neighboring areas and cause serious tree losses.

We never found out who was right. It seems a welder making repairs on a piece of machinery allowed sparks to ignite oil-soaked rags, which then ignited a gasoline storage can in an old shack. The shack, in turn, caught fire, culminating in the acres of wood catching fire. They burned out of control for 10 days. The fire department could do little more than keep the chipper plant from burning up. The firemen were hampered by low pressure in the scarcely available fire hydrants.

The fire was finally brought under control, and the remainder of the debris was allowed to continue to burn for an additional 20 days under controlled conditions.

## 1978–OPERATING!

The 1978 season was much better. The only brush allowed to be brought into the area was carefully kept separated from the logs, and only what could be disposed of in 1 day was allowed on site. Stockpiles of logs were held to reasonable sizes and separated by fire lanes. The season ran quite well, and by the end of the year most material had been processed.

During the summer of 1978 the plan produced for sale some $350,000 worth of chips. Prices received for the chips varied with their type, quality, and intended use. Total-tree chips (those not screened and with higher bark content) sold for $5 to $6 per ton. The price varied, with debarked and screened chips selling for $9 per ton.

There were many companies buying chips; e.g., Horner Waldorf Paper Company (located right in St. Paul), Certain-Teed Corporation (producers of building materials and also located in the suburban area), Celotex Corporation (in Iowa and Illinois), and both Owens-Illinois and Weyerhaueser Corporations in Wisconsin. A great many chips were sold for landscaping and agricultural purposes. Driving into the metropolitan area, one sees tons of chips used as mulch in shrub plantings along highways.

It appears that some marketing problems will always occur. Value of chips varies with the type and quality being produced. Most buyers need to have certain guarantees with regard to volume, steady and even production flow, and long-term commitments. Since our production depends on factors beyond our control (rate of disease incidence, weather effects on the disease vector, possibilities of improved disease-control methods or even cures), commitments of these types cannot be made. The primary problem is that we are not trying to produce a salable product. We are simply trying to find a way of disposing of a waste in a manner most efficient and economical for the taxpayer.

We are currently investigating two possible outlets for our chipped material. One is with the local electric power company, Northern States Power, who could, after certain plant conversions, use all of the material we can produce. Since they have large storage capacity, they can even handle our extreme fluctuations in material flow. The chips would be fed into their boilers along with coal in producing electricity.

The second possibility is to sell our chips to Guaranteed Fuels, which has recently (in cooperation with the Minnesota Department of Natural Resources) completed a plant for waste wood (in the form of chips) to be compressed into pellets to be used uel. Their findings are that the pellets have a BTU content comparable to western . A second finding, perhaps of more interest to Easterners, is that, although the J content of the pellets is not as high as eastern coal, they have the ability to nteract the sulfur problems inherent in eastern coal, to the extent that scrubbers not needed in many furnaces.

## CONCLUSION

In summary, then, there are certain concerns that must be addressed when trying find a means of disposing of municipal tree debris:

1. First, it must be completely understood that our tree debris is debris, not a roduct.

2. It is something that can be terribly expensive to dispose of; our concern should imply be to find the most economical method of disposal. If, along with this, a certain profit can be derived, all the better. But profit should not be the prime motive.

3. Even though we are trying to do the most economical thing, we must also be concerned with the side effects of our disposal. In most instances, open burning is probably the least expensive method; however, it can also cause serious pollution problems, especially in large metropolitan areas. Landfilling, especially where the landfill is owned and operated by the municipality itself, can look very attractive; however, we need to consider what the future potential of the land could be if it were not fouled by the burying of logs and brush, and how much the long-term capacity of this landfill is being shortened by wasting it with this debris.

4. Finally, it must be remembered that the wood from municipal trees is just as valuable a natural resource as is the wood from forest trees. As with any natural resource, we have a responsibility to use it wisely. That wise use can vary from putting it into our homes and structures in the form of lumber, roofing and insulation materials; to turning it into paper and boxboard; to burning it in furnaces, which saves other natural resources for future use.

# MULCH FROM LIMB AND TRUNK DEBRIS

Dave Walker[1]

*Abstract.*—Faced with the rising cost of pine straw, Georgia Institute of Technology experimented with using site-generated wood chips for mulch. It was learned that, compared with pine straw, wood chips were less expensive, longer lasting, less flammable, and better at retaining soil moisture.

From 1970 to 1978, I worked on a research project at Georgia Tech called Liabil ities to Assets. One of the major successes in this program was known as "organic mulching with wood chips." It was always interesting to see the expression on people's faces when they learned that during the years 1976 and 1977 we were given 10,000 and 9,000 cubic yards of chip material at no cost to the Institute. That we were given the material was hard enough to believe; however, that the material was processed and hauled to us for free was even harder to believe in a time when costs are constantly rising on materials, labor, and equipment.

First, we had to see our own need. That came in 1970, when funds were hard to come by for landscaping around our buildings. We thought pine straw was expensive then, but look at it now!

Second, we had to find an alternative to the straw. Many times we fail to recognize a good idea simply because we are unable to picture something for what it could become instead of what it is. In this case, an ice storm during the winter of 1970 caused us to generate about eight truckloads of chip material when we had to bring in a private tree contractor to clean up the downed limbs. Rather than throw this material away, we tried using it around one of our buildings as a temporary mulch and found in the long run that it was far superior to the pine straw we had been using (fig. 1).

Third, we had to find a source of supply large enough to meet our demand. We found that the tree companies were more than happy to give us the chips if they had a place to dispose of them at no charge. This is important as an incentive because most landfills charge a dump fee by the load, yard, or estimated tonnage, which in turn raises the tree contractors' overhead. Another way to look at it would be to say that a contractor's profit margins increase if his prices stay competitive with other firms and yet his trucks are able to dump their loads at no charge. Keep in mind, however, that the dumping site must be closer to the job site than the landfill, or the above principle may not apply. In any case, at Georgia Tech, we had crews hauling to us when they were within a 3- to 5-mile radius of our facility; most landfills were 7 to 30 miles away.

Fourth, we had a responsibility to the contractors. If they were going to process, haul, and give us the chip material, the arrangement had to be beneficial to them. Our chip-recycle station was located on an abandoned street. The paved area meant that the trucks could come and go in any type of weather without fear of getting stuck in

[1]Urban Forestry Consultant, Hayesville, North Carolina.

for fuel. Their findings are that the pellets have a BTU content comparable to western coal. A second finding, perhaps of more interest to Easterners, is that, although the BTU content of the pellets is not as high as eastern coal, they have the ability to counteract the sulfur problems inherent in eastern coal, to the extent that scrubbers are not needed in many furnaces.

## CONCLUSION

In summary, then, there are certain concerns that must be addressed when trying to find a means of disposing of municipal tree debris:

1. First, it must be completely understood that our tree debris is debris, not a product.

2. It is something that can be terribly expensive to dispose of; our concern should simply be to find the most economical method of disposal. If, along with this, a certain profit can be derived, all the better. But profit should not be the prime motive.

3. Even though we are trying to do the most economical thing, we must also be concerned with the side effects of our disposal. In most instances, open burning is probably the least expensive method; however, it can also cause serious pollution problems, especially in large metropolitan areas. Landfilling, especially where the landfill is owned and operated by the municipality itself, can look very attractive; however, we need to consider what the future potential of the land could be if it were not fouled by the burying of logs and brush, and how much the long-term capacity of this landfill is being shortened by wasting it with this debris.

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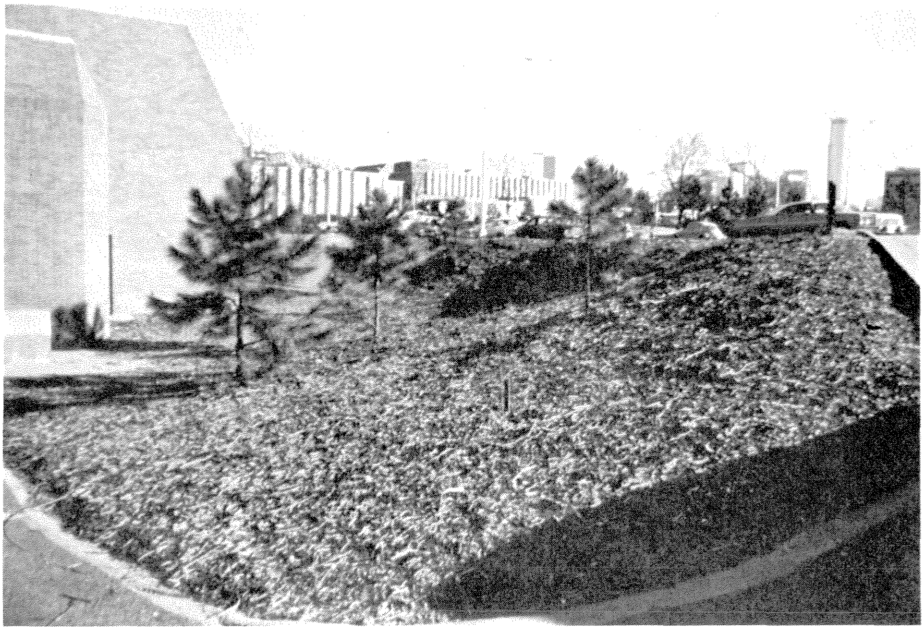

Figure 1.–Wood chips provide an attractive mulch around buildings.

the mud or having flat tires, which would certainly be hazards at a local landfill. Because we were given the chips free and did not charge for dumping, the contractors could dump at their convenience. Most of the time the trucks would arrive before or after our normal workday when traffic on the campus was light (fig. 2).

What about the type of material and volume storage? In our research we found that separating the hardwood and softwood chips was an extra problem for the contractor and required a lot of space. Most crews are chipping up whatever they come to and do not work on just one type of wood. The combined chip material worked very satisfactorily as an organic growing medium, as well as being attractive. The rougher, stringier chips were used to hold steeper slopes (up to 60 percent grades), and the finer chips were top-dressed over this or used in areas of lesser grade.

As for volume storage, our facility had a total capacity of 10,000 cubic yards. However, because we were constantly drawing on our stockpile, we never reached capacity. Unlike leaves, the wood chips are generated year round, which means that supply is more constant than seasonal, thus eliminating overloads and handling problems.

What were some of the advantages in using the chips?

1. *Long lasting*.–The chips would last up to 3 years when applied in layers 4 to 6 inches thick.

2. *Fire safety*.–Our research showed the chips to be far superior to pine straw or leaves because of the larger particle size and moisture-retaining value.

Figure 2.–Ample dumping site with ready access for contractors.

3. *Moisture control*.–We found that the wood chips would control water runoff on all grades up to 60 percent, slowing it down to allow for greater soil penetration. (This does not mean that the chips will not float or wash. Any material will move given enough force behind it; however, under normal slope conditions where a water-head is not involved [no drainage ditches, or concentrated parking lot, or street run-off], the chips can effectively control erosion.) Once the soil has absorbed the water, the chips will drain to soil capacity. After this has occurred, the chip layer will then act as a moisture blanket, increasing the amount of moisture available to plants even during droughts. This fact is important in controlling watering and its labor costs as well as being beneficial for plant growth. No summer slump!

4. *Soil amendment*.–The chips can be used in place of peat moss or other soil incorporants if fertilizer is added.

5. *Mulching*.–Chips make a fine mulch. The chips will weather to a uniform color within 6 months and do not require fertilizer if used strictly as a mulch. After 1 year, this material can be worked into the ground, again without the need for fertilizer.

6. *Fertility*.–We did not make any laboratory studies to determine the fertility value of the chips; however, the observation of plant growth response without any fertilizer being added on mulched plantings would indicate a moderate supply was released over a period of time. We observed five varieties of hardwoods during a study made in 1978, and the results showed a growth response of 3 to 4 feet during

the first year of planting. (I might add that this was a very dry year in Atlanta, and no additional water was added except for two good waterings within 2 weeks after planting in late March.) The trees were 18- to 24-inch year-old seedlings.

What about value? At first, we put a $1 per-cubic-yard figure on the chips just to give us a means of tabulating some type of value system. However, when the chips are compared with other materials, a much higher value can be realized.

| Material | Estimated cost (1978) |
|---|---|
| Peat moss | $30/yard |
| Perlite | $20/yard |
| Sawdust | $5/yard |
| Vermiculite | $20/yard |

Given the above figures, it would not be unreasonable to put the value of the wood chips at $10 per cubic yard. In the beginning, I said that we received 10,000 and 9,000 cubic yards of chips during 1976 and 1977. If the chips are valued at $10 per yard, we received approximately $100,000 per year free.

The chip idea is not a Utopia, and it takes a lot of hard work to get the program started. A successful program must have a good location convenient to both supply and demand, an all-weather site, equipment to work it, and personnel who can sell the idea to local tree contractors as well as local landscapers. But the system does work.

# PRODUCTS FROM MUNICIPAL TREES

Edward A. Lempicki[1]

*Abstract.*–Shade trees along city streets and state highways and those near suburban homes often reach a large size and have butt logs suitable for many specialty products. However, when these trees are felled, they are all too often used only for fuelwood or wood chips, or hauled to landfills. The following is an example of one company's experience in turning this underutilized material into an interesting and profitable commodity.

Sam Willard started Shearer Tree Service Company in 1949. Employing approximately 40 people, his company is involved in normal arboreal services such as pruning, planting, spraying, removal, and maintenance. In 1974, Sam was paying about $20,000 per year in landfill fees to dispose of tree removals. Because of the noncompactable, bulky nature of this material, the landfill rates were expected to increase steadily, thus making this form of disposal economically unattractive.

Sam decided to do something about the problem and began his effort with the purchase of a used Frick Sawmill, along with an edger, crosscut saw, planer, stake pointer, and metal detector (fig. 1). Instead of hauling his tree removal material to

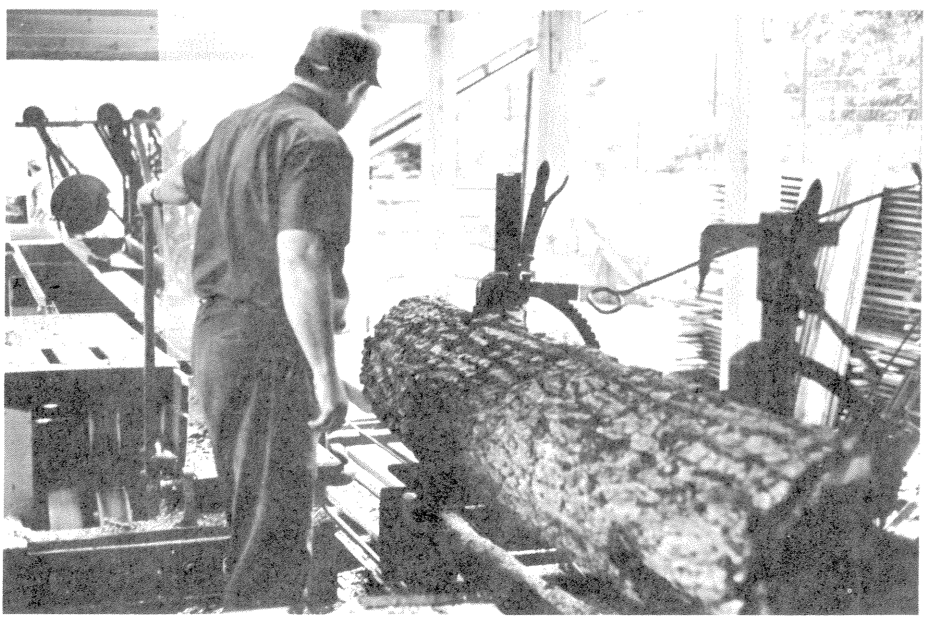

Figure 1.–Urban tree removal material is processed through a sawmill and Alaskan Mill sawing systems.

[1]Utilization and Marketing Forester, New Jersey Bureau of Forest Management, CN 028, Trenton, New Jersey 08625.

landfills, he began processing the saw logs through his mill and converting the tops to firewood. Lumber, timbers, nursery and survey stakes were the original products from the mill. The logs are first scanned with a metal detector before any processing is attempted. Metal in the form of nails, spikes, or barbed wire is a common component of logs acquired in tree service work. Once located by the metal detector, the metals must be removed. This removal can be a time-consuming process; however, this particular mill does not concern itself with high production, so the extra time taken to remove metal from some logs is well spent. Logs are processed on a lumber order basis and only high-grade lumber (FAS and SEL) is kept in inventory. His suburban location proved a good spot for marketing specialty products to homeowners in the area.

The mill has evolved since its first days of operation and provides a wider range of products, including free-form furniture, clocks, planters, and decorative plaques. This type of product is made possible with the use of an "Alaskan Mill" sawing system. This specialized machinery basically consists of a metal frame with guide rollers, two chain saw power drives, and a large ripping chain. Suitable logs are elevated at one end and diagonally cut with the rip chain, which results in thick, matched slabs. These slabs are used as raw material for the free-form furniture styles: tables of all kinds and sizes, bar and counter tops, plaques, clocks, and many other highly decorative items. Variations in species, grain pattern, color, and figure greatly enhance the free-form product's marketability. This type of sawing accentuates the wood grain in such a way that the pattern normally produced is quite unlike that shown in standard sawn lumber. Large stumps and abnormal tree butts are also sawn in this fashion, creating unique and decorative patterns.

The diagonally cut slabs are stickered and air-dried for 3 months before kiln drying. The operator uses a small West Air Kiln system for drying these thick slabs. Kiln schedules are a very important facet of the operation since the product must be free of checks or splits if it is to bring its maximum price. Normal kiln schedules had to be adapted to fit this particular type of material. After kiln drying, the slabs are sanded and sold as is, or are processed into a finished free-form furniture item.

Willard's sawmill is a classic example of how urban tree removal material can be processed and marketed. His products are a response to the specific type of raw material handled. The utilization of these municipal trees is almost complete; logs are processed either through the sawmill or Alaskan Mill, large topwood is marketed as firewood, branches are chipped at the point of origin and sold as mulch, and the sawdust from the mill is sold to local horse owners for use as bedding. This unique urban sawmill is one answer to the problem of municipal shade tree utilization.

# FIREWOOD FROM MUNICIPAL TREES

Jay W. Lowery[1]

*Abstract.*–Firewood is becoming a necessary item in the life of Americans as we face increasing energy shortages. This paper summarizes an effort to supply the citizens of Atlanta with an energy source obtained from wood residues produced from the city's forestry operation.

We all know that America is the land of plenty; as a consequence this great country has waste wood byproducts in many forms. It is estimated that in the city of Atlanta, 67 to 85 percent of materials going into the landfills is wood in the form of paper, cardboard, and wood scraps. Materials are being buried that could be used for heating or recycled for products.

The supply of firewood has reached critical levels in less fortunate countries. An average of one-fourth the annual income for an average family in Upper Volta is used for firewood. In China, the reforestation program is being severely hindered by the theft of newly planted trees, which are being used for firewood.[2]

Deforestation, in the name of firewood, has been occurring at alarming rates in Africa, Asia, and Latin America. As a result, severe land problems are developing. Erosion and floods are becoming rampant, and deserts are expanding because of the unstable soil surface created by the loss of trees. Some areas which have depleted their firewood sources have resorted to burning animal dung, thereby breaking the delicate balance of the nutrient cycle in crucial areas.

Will this country have to meet a critical period before the value of firewood can be fully realized? Let us look once more to the less fortunate countries: (1) they have expended, for the most part, all firewood materials; (2) they are not prosperous enough to switch to an oil product; (3) they have no way to stay warm or cook their food. Result? CRISIS. Solution: A sonic device has been developed that breaks down dung and other organic materials into methane gas and a byproduct that is good compost. Here a crisis was needed before a solution to a known problem could be found. The cost of the project presents a problem; however, it does have potential.

These are extreme cases; however, they are pertinent to the problem at hand. In our cities we are experiencing similar problems: (1) a high concentration of people; (2) oil, gas, and electricity are becoming scarce and expensive; (3) the growth of cities has stifled, if not totally eradicated, the supply of firewood.

Firewood consumption dropped sharply for the first 5 decades of this century with the onset of oil, gas, coal, and electricity used in cooking and heating. In recent years, however, firewood has become a sought-after item in today's markets. The

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[1]Parks Arboriculture Manager, City of Atlanta Bureau of Parks and Recreation, 260 Central Avenue, SW, Atlanta, Georgia.

[2]Eckholm, E. P. 1975. The other energy crisis: FIREWOOD. Am. For. 81(11):12–13.

major part of the market exists in communities in and around the Nation's cities. A majority of the homes being built in the East include wood-burning fireplaces and/or stoves.

Although this trend may be limited by increased air pollution standards, people continue to search for alternatives to their dependency on oil.

Ironically, there is now cash for both "culled" or "worthless" trees and residues left by timber or pulpwood operations. This market is either for firewood or chip material.

In Atlanta, Georgia, the wood residues taken from the 3,000 acres of parks and 5,000 miles of rights-of-way were being buried in the landfills. Within the last few years, two programs have developed: the increased use of wood chips and the free firewood program, which has brought tremendous public response and at the same time saved the city money. It also has reduced pressure on the landfill operations around the city.

Since 1975, two of Atlanta's three municipal landfills were closed, placing a hardship on all dumping activities. The one remaining site was located at an inconvenient area outside the perimeter. Average travel time to and from the area averaged 3½ hours per day. By having three crews to handle logs and chip materials, a total of approximately 10½ hours (depending on weather and traffic conditions) is spent transporting trees to the landfill area.

A proposal was made to establish three holding areas in Atlanta: one on the north side, one around midtown, and one on the south side of town. Small areas of parkland which were not being used and were not close to residents were designated as dumps for the tree residues.

Before this system could be implemented, the Mayor and City Council had to give their consent. The city cannot give to a nonprofit organization or dispose of "city property" without holding a public auction or obtaining the consent of the Mayor and Council. By identifying the residents of Atlanta as the "nonprofit organization" and proving that the program would save the city money, the proposal was approved.

Costs for using the landfills were as follows:

- –average 21 manhours (2 men/truck) at an average of \$4.50/hr. = \$94.25 per day.
- –average 10½ running hours at an average equipment cost of \$3/hr. = \$31.50 per day. Total: \$125.75 per day.
- –\$125.75 X 5 (days/week) = \$628.75 per week.
- –\$628.75 X 50 (work weeks/year) = \$31,437.50 per year.

With the implementation of the program, it was estimated that travel time would be reduced by 50 percent, a savings of \$15,718.75 per year. In actuality, there is only a savings of \$10,397.

Now that the political red tape has been cut, the Law Department blessed the program. Questions were raised about the liability of people cutting wood on city property. It was decided that warning signs would be erected. Although this action would not totally relieve the city of its liability, it did give fair warning to users (fig. 1).


Figure 1.–Signs were erected to provide warning and use information to the public.

Although there is no one assigned to oversee these woodyards, the implications of the signs keep the people honest. The reason for the limitations on trucks is to discourage commercial people from taking advantage of this wood source.

In lieu of having a person stationed at each site, all crews in the Bureau of Parks and Recreation have been asked to report any discrepancies they observe, either while working nearby or just passing the areas. To date, only a few incidents have occurred.

On the few occasions that residents or commercial people have tried to use these areas for dumping, there have been no problems in having them clean up the area or prosecuting them according to the dumping laws of the city.

The question of selling this wood was considered; however, this operation is a temporary measure, and the massive amount of paperwork, amending of ordinances, and setting up new systems make this impractical.

Firewood has become a backup heating and cooking source during times of ice storms, floods, and blackouts (fig. 2). The city is working in cooperation with Civil Defense to supply firewood to victims of any major catastrophe.

Because of Atlanta's climate and rainfall, wood cut and stored in the open will last only 3 to 4 months. Each year the city culls decomposing wood and chips for other uses.

Figure 2.–Ice storms produce problems of repair and removal for Atlanta residents, but also increase demand for firewood due to power outages.

Chips are the most versatile and economical use of wood accumulated in Atlanta's system. Chips are being used in place of asphalt, concrete, sand, rock, and dust. Using chips in place of these materials saves replacement cost, restores nutrients to the regular nutrient cycle, and disposes of a material which was once taking up landfill space.

The encouraging part about wood chips is that after only a few hours of educating the city administration about the benefits of this byproduct, demand for wood chips soon exceeded supply. Presently, requests average 80 truckloads (40,320 cubic feet) per week. With the existing resources, the program is able to supply only 10 truckloads (5,040 cubic feet) per week, with 20 loads (22,400 cubic feet) of wood going to the woodyards. With the purchase of a whole-log chipper, the program will not be able to meet the current need, but we will be using *all* wood waste products.

Future efforts are being directed toward using waste materials from tree businesses, utility companies, and, possibly, construction companies in an effort to increase the supply of chips in the system.

Chips, as mentioned before, are replacing traditional ground covers in the park system. However, all trees, shrubs, and flower boxes do not have a mowing edge of mulch around them, nor have all the banks of the park system been erosion stabilized.

The only problem in using chips was presented during an arts festival where they were being used as a ground cover in a tent. The Fire Marshall refused to approve "flammable material" being used in an "enclosed" area, even though the chips' water-retaining ability was higher than the first 3 inches of soil.

If you have a valuable resource such as firewood or chips, get excited about it; you are sitting on a gold mine. You may not be able to prove savings in actual budget dollars, but improving an operation, developing a complete environment, and solving maintenance problems are measures which cannot be budgeted for, but they do save dollars.

# FUEL PREPARATION FOR WASTE WOOD BOILERS

Alex D. Cobb, Jr.[1]

*Abstract.*–After proper preparation, wood residue may be used as fuel or as raw material for such products as horticultural mulch, animal bedding, poultry litter, particleboard, fireplace logs, and fuel pellets. The reuse of waste wood requires an understanding of waste wood boilers, wood-reduction machines (hogs), waste loads, economic considerations, and the services provided by consultants.

## INTRODUCTION

Annually the volume of solid waste in the United States amounts to over 4 billion tons and is increasing at a disturbing rate. Everyone–producers and consumers–creates solid waste. The larger and more affluent the population, the greater the volume of solid waste. The problem is compounded by archaic municipal and county collection and disposal practices.

Of the solid waste produced annually in the United States, animal waste accounts for some 2 billion tons; mineral waste for more than 1 billion tons; agricultural waste for nearly 650 million tons; household, commercial, and other municipal waste for about 300 million tons; and industrial waste for almost 130 million tons. Projections are that solid waste generated in the metropolitan areas will more than triple by the year 2000.

Sixty-five percent of our population now lives in urban areas. Generally, cities settle for the least expensive means of solid waste disposal–open dumping and open burning. These methods pollute the air and water, devour valuable land, pose fire hazards, breed germs and–worst of all–waste natural resources. Over the last 5 or 10 years, air and water pollution problems have caught the interest of the public. Only recently has attention been given to solid pollutants and the need to conserve valuable materials that would otherwise be lost in countless city and town trash heaps.

There is uncertainty about how much municipal waste goes where, but the Federal Government has estimated that 77 percent goes to open dumps, 10 percent to incinerators, and 13 percent to sanitary landfills. The remaining waste is converted into compost or salvaged for reuse. Studies have shown that waste wood constitutes 10 to 20 percent of landfill material and takes a disproportionate share of landfill space because it does not compact as well as other materials. Furthermore, as buried wood begins to decompose it forms methane, which is a colorless and odorless but highly inflammable hydrocarbon gas, sometimes known as marsh gas. Gasification of the rotting wood causes pockets which later collapse in the landfill.

What is the solution? The open dump is not the solution. Sanitary landfills are only a stopgap measure. Incineration is becoming increasingly costly and is subject to stringent EPA regulation. More importantly, none of these methods recovers resources;

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they merely dispose of them. The method of the future, therefore, is to reclaim much of our urban refuse and reuse it.

## WASTE AS FUEL

Many industrial plants are spending considerable amounts of money to get rid of waste materials that are a potentially valuable supplemental energy source. One study indicates that combustible waste equivalent to over 700,000 barrels of fuel oil is thrown away daily in this country.

Plenty of waste is available, the equipment to process and burn it is on the market, and the economics are favorable. In addition, burning waste as a supplemental energy source reduces fossil-fuel requirements. For example:

- Less than 1½ tons of general plant waste produces heat equivalent to that produced by 1 ton of coal.
- One ton of this waste produces heat equivalent to that produced by over 60 gallons of fuel oil.
- Less than 1 ton of this waste produces heat equivalent to that produced by 8,000 cubic feet of natural gas.

Any plant requiring 1,000 pounds of steam per hour and generating 1 ton of waste per day should consider using waste-fuel firing as a supplementary source of energy. Three factors should be considered when the potential of waste as a fuel source is being evaluated: the amount of onsite waste produced; the BTU content of this waste; and an economic comparison of the waste wood fuel and the fuel presently in use.

The following chart shows the heating values of some common waste wood materials:

### HEATING VALUE OF COMMON WASTE MATERIALS

| Waste material | Heating value/lb (as fired) (BTU)[1] |
|---|---|
| Used automobile tire casings | 13,000 |
| Type "O" trash (paper, cardboard, wood, boxes, sweepings | 8,500 |
| Wood sawdust (pine) | 9,600 |
| Wood sawdust | 7,800-8,500 |
| Wood bark (fir) | 9,500 |
| Wood bark | 8,000-9,000 |
| Oak scrap | 7,990 |
| Pine scrap | 8,420 |

[1]BTU = British Thermal Unit—the amount of heat required to raise the temperature of 1 lb. of water 1° F at or near 39.2° F.

Many industries with high energy requirements are switching from fossil fuels to wood. Wood-energy production could play a very important role, especially in such highly timbered areas as the South and West.

## RECOVERING THE COST OF CONVERSION

Industry experts have estimated that the cost of converting to a waste wood boiler can usually be recovered, from savings, within 3 to 5 years, depending on the location of the plant, the type and amount of onsite waste generated, and the cost of other fuels.

A major factor to be considered is the rather high initial capital cost to purchase and install the fuel-handling, processing, and firing equipment required with a waste wood burner. However, this is more than offset by wood fuel that will be used at a cost vastly lower than that of commercial-grade fuel oil or natural gas.

In one system, which is about 3 years old and uses the fluid-bed combustion chamber, the total first-year investment in boiler-house equipment and a 20,000 cubic-foot material-handling system came to $240,000. However, the first year's fuel savings (using wood residue instead of 1 million gallons of No. 6 fuel oil at $0.30/gal) amounted to $285,000. Subtracting $7,770 per year for increased maintenance costs, electricity, and insurance resulted in a net savings of $277,230. So, in the first year the owner saved enough to pay for the system, plus a small profit. In succeeding years, he will be putting at least $277,230 annually toward profits.

## TYPES OF WASTE WOOD BOILERS

Numerous conventional boiler systems are now being designed and installed to provide industry with heat, process steam, and onsite electricity from raw-wood material as a fuel. These systems are primarily of three basic types:

*Dutch oven.*—The oldest and most simple boiler system—though not necessarily the most efficient or the most pollution free—is the Dutch oven. This is a large refractory-lined compartment, with grates, which sits in front of and below a boiler. A large pile of fuel—in our example, shredded or hogged wood scrap—is maintained in the oven, where primary breakdown takes place. Combustion is completed in the chamber situated behind the radiant section of the boiler. The Dutch oven has been known to perform satisfactorily even with very wet fuel, but it does not respond well to widely fluctuating steam demands, as the large pile takes considerable time to burn down or build up, and the system must be attended constantly. Nevertheless, if fired conservatively with a reasonable fuel (not overfired), Dutch ovens can meet most anti-pollution requirements.

*Stoker feeder.*—A second, very popular way to fire wood in a boiler is through a stoker feeder or spreader-stoker. Here the incoming fuel is metered into a wide, flat, horizontal air stream and spread in a thin bed over grates for aeration and uniform exposure to combustion. Fuel feed is more easily controlled to follow fluctuations in steam demand. If the grates are at the bottom of a rather large refractory-lined combustion chamber, performance can be quite satisfactory. However, it should be pointed out that stoker-fed systems, in general, require cinder reinjection and high-efficiency collection equipment to meet today's rigid air pollution standards.

*Suspension burners.*—A third boiler system burns the fuel in suspension; these are of two types: (1) A cyclonic burner, which usually requires dry fuel with moisture content of 15 percent or less, as might be found in dry planer-mill shavings, sawdust, or kiln-dried wood scrap. The material must be finely pulverized for feeding the burner. (2) A fluidized bed unit which burns either dry or wet fuel having up to 55 or 60 percent moisture content. The dryer wastes, of course, have a higher BTU content. For example, kiln-dried scrap wood contains approximately 16 million BTU's per ton, which is the equivalent of 114 gallons of fuel oil or 16,000 cubic feet of natural gas.

Waste wood boilers must, in most cases, be prepared to operate overnight and on weekends. Thus, it will be necessary to have a storage system for the wood fuel, just as it is necessary to provide onsite storage for fuel oil or liquified gas. Storage bins used in connection with waste wood boilers are generally tall silos with either mechanical or pneumatic infeed and discharge conveying systems for loading and unloading. The wood fuel must be hogged (reduced in size) to facilitate storing and conveying. Hogging is necessary even though some of the units will burn large chunks of wood; obviously, large chunks cannot be stored or conveyed well, so it is necessary to hog the fuel down to a manageable size.

## FUEL PREPARATION HOGS

Fuel preparation for waste wood boilers is accomplished by a machine called a hog–sometimes referred to as a hammermill, shredder, or pulverizer. The derivation of the term "hog" is not accurately known, but it may have something to do with the voracious appetite these machines have for devouring waste materials–especially wood waste from sawmills, lumber mills, plywood and veneer plants, wood-manufacturing operations and, of course, urban wood waste. Hogs are used to grind bark–large quantities of it, in fact–which is removed from the raw logs in sawmills and pulpmills.

Some hogs employ a unique cutting action involving stationary anvils positioned on the side of the machine with rotating teeth (hammers) that pass through rectangular pockets formed by these anvils. This positive cutting action between the teeth and the anvils performs what amounts to the first particle-sizing function in a two-stage process.

The second sizing action occurs when the material cut by the action of the teeth against the anvils is directed downward and across a curved particle-sizing screen which fits underneath the rotating element. The screen contains either round or rectangular-shaped openings whose size is determined by the specific application for which the machine is sold. Obviously, small, round or square holes are used to produce fine, sawdust-like material; larger round or rectangular openings produce chunky pieces having a greater cross-section and length.

Hogs can be furnished with either gravity infeed or horizontal infeed of the material to be processed. However, horizontal infeed models, which are designed primarily for handling long, flat pieces of scrap over 8 feet long, have restrictions on the thickness of material which may be processed, depending on the diameter of the cutting circle. None of these horizontal-feed models would be suitable for certain types of waste, such as bark, small cutoff and blocks, loose sheets of paper, and similar materials.

Hogs made by Montgomery Industries, for example, are available in the following series: HD, PM, PM-KC, CS-KC, XL-KC, and NAS. The difference in each series is the diameter of the cutting circle of the teeth and/or whether the anvils are mounted on the side of the hog in a stationary position (as is the case with HD and PM models), or mounted on a pivot shaft to swing away from the cutting area on severe impact with tramp steel (as with the KC and NAS models).

## VARIETIES OF HOGS

The HD model has an 18¾-inch cutting circle, and the PM model has a 22-inch cutting circle. Both models employ 2-inch-wide cutting teeth and 2-inch-wide anvils mounted on the side of the housing. The anvils are adjustable to maintain the proper tooth-anvil clearance for efficient hogging. The wear surfaces of both teeth and anvils are hardfaced for extra long life, and when worn may be rebuilt at about half the cost of new parts. The hogs will handle light tramp steel ¼ inch and smaller, nails, small bolts, and steel strapping. An internal bronze shearpin arrangement protects against damage from heavy tramp steel.

The HD and PM models can be furnished with either gravity discharge or an integral fan for applications where it may be more convenient to pneumatically convey the material after grinding. The integral fan model uses less floor space than a gravity-type hog with a separate fan, as only a single motor and drive is required; two motors and two drives are required when the fan and hog are separate.

The HD and PM models are normally equipped with a steel flywheel which provides additional energy to carry the rotor through surge loads. Integral fan models normally require a V-belt drive because the shaft speed seldom coincides with the full-load motor speed. Bottom discharge models are normally connected directly to the motor with a flexible coupling because the first cost on the flexible coupling is lower than the cost of a V-belt drive.

The range of sizes on the HD and PM series, measured parallel to the shaft, starts with a small 10-inch model and increases in 8-inch increments to a 74-inch rotor length. Such hogs are generally used for most light and medium sawmill, lumbermill, and wood-furniture applications to process wood scrap, small quantities of bark, veneer roundup, broken pallets, and similar industrial waste.

Cutting circles on the KC and NAS hogs range from 22 to 54 inches. The teeth and anvils on these models are 3 inches wide and are hardfaced for extra long life. The anvil points are mounted on swinging anvil holders supported in a yoke and pivoted so they will swing away from the cutting circle if large tramp steel enters the hog. On such occasions, a trip latch releases and drops the screen, preventing serious damage; a pressure switch activates a signalling device which informs operating personnel that the protection mechanism requires resetting.

The KC models and the NAS hog are designed for gravity discharge only, with the exception of one model of the Montgomery Railroad Crosstie Destroyer, which accepts full-length ties horizontally. No flywheels are required with these models because of the large mass of the rotating element. Sizing on the KC models, measured parallel to the shaft, commences with 15 inches of rotor length and increases in 6-inch increments to 75 inches. The NAS model has been built as large as 87 inches of rotor length. Applications include grinding heavy bark (in sawmills and pulpmills), railroad crossties and boxcar dunnage, demolition waste, tree limbs, discarded tire casings, and soft metals.

## SELECTING THE PROPER HOG

There are three major factors to be considered in selecting a hog for any application: the size of the waste, including length, width, and thickness; the quantities of waste, including average flow rates and maximum surge rates; and the desired size and use of the final product.

First, the bulk dimensions of the scrap must be known to ensure that the waste material will fit into the opening of the hog. When dealing with urban wood waste, the maximum width of the scrap is used to determine the minimum hog infeed opening parallel to the shaft. The maximum thickness of the scrap and the type of material are used to determine the proper bearing size. The maximum length of the scrap is used to determine the height of the upper infeed hopper, if a gravity-infeed model is selected, or whether the length of the material requires a horizontal-feed model.

Second, the capacity of the hog selected for a given application must be adequate to handle not only the average flow of incoming material, but also occasional surge loads caused by a sudden buildup on the infeed conveyor.

Third, the required particle size governs the screen size, and this in turn has a substantial bearing on hog selection and capacity. The larger the screen openings, the larger the hog capacity for a given size. If the desired size of the end product and its use are known, it is possible to select a screen opening that will produce the appropriate product. The following chart shows the capacities of various hogs:

WOOD BLOCKS, EDGINGS, AND SLABS
Average capacity (lbs/hr)

| Hog size HD series (inches) | Screen size 3" | 1½"[1] | ¾"[1] | HP required Max. | Min.[2] |
|---|---|---|---|---|---|
| 18 | 10,800 | 5,400 | 2,700 | 97 | 50 |
| 34 | 20,400 | 10,200 | 5,100 | 182 | 50 |
| 58 | 34,800 | 17,400 | 8,700 | 310 | 60 |

[1] The screen area on slabs must be 2 inches or larger to keep the screen from filling up with chips and acting as a brake on the rotor.

[2] Minimum horsepowers shown are required to accelerate the hog up to speed (normally 1,200 RPM) within 30 seconds.

There are many other factors used in selecting the correct hog for a given application. Among these are: size of infeed opening, bearing size, maximum bearing speed, wood species, and drive selection.

## SCREEN SIZES FOR WASTE WOOD BURNERS

For hogs used in the preparation of fuel for waste wood burners, there are three size ranges, depending upon the type of boiler in use. For coarse boiler fuel, a 3-inch screen is recommended. For grinding waste wood to use as fuel in boilers with automatic stokers or fluid-bed burners, screens with 2-inch holes are recommended, as are baffles welded transversely along the outer surface of the screen to prevent sticks from passing into the discharge conveying system, thus causing a blockage somewhere down the line. Cyclonic-type burners need a two-stage grind to produce the finely pulverized material required to support combustion: the primary breakdown unit uses a 1-inch screen; the secondary unit is a high-speed hammermill that reduces material to less than ¼ inch.

## ESTIMATING WASTE LOADS

The prospective customer for a fuel-preparation hog would be expected to furnish the average and surge flow rates of material going to the hog. These rates should be incorporated into the quotation by the factory as part of the design conditions under which the performance of the hog is guaranteed. Consulting engineers or suppliers of waste wood boiler systems will generally verify these figures with the hog manufacturer.

In the case of wood-processing industries, such as pulpmills, sawmills, veneer mills, dimension mills, and other lumber manufacturers, certain waste factors are known from experience and can be used as rules of thumb in estimating the amount of wood scrap available for boiler fuel or other recyclable material. Following are some examples:

*Pulpmill.*—The bark from a standard cord of wood (128 cubic feet) will weigh 700 pounds at 50 percent moisture content. The quantity of oversize chips produced when chipping a cord of wood is approximately 5 percent.

*Sawmill.*—Determine plant production in log feet per hour. For estimating purposes, use 1,200 pounds of bark per 1,000 log feet. The amount of green sawdust produced when sawing logs to produce 1,000 board feet of lumber is approximately 2,000 pounds per 1,000 log feet.

*Veneer mill.*—Determine plant production in log feet per hour. The amount of veneer roundup and clippings is approximately 5,500 pounds per 1,000 log feet. The amount of cores produced, whether hogged or chipped, is approximately 2,450 pounds per 1,000 log feet.

*Planer mill.*—Multiply the plant production in board feet per hour by 5 percent to determine the waste load in board feet per hour. Then multiply this quantity by the weight per board foot to determine the waste load in pounds per hour. For estimating purposes, use 2½ pounds per board foot for pine; 3½ pounds per board foot for hardwood.

*Dimension plant.*—Multiply the plant production in board feet per hour by 45 percent to determine the waste load per hour in board feet per hour. Then multiply this quantity by the weight per board foot to arrive at the waste load in pounds per hour. For estimating, use the same weights for pine and hardwood listed above under Planer mill.

*Furniture plants, industrial and urban wood wastes.*—Where the customer does not have accurate information on the expected waste loads, but the material is being accumulated (perhaps from a belt conveyor, in buggies, carts, bins, or haul-off containers) determine the cubic content of the bin or container and reduce this quantity by 50 percent to allow for voids which are created when material is tumbled loosely into the container. Multiply this approximate volume of solid wood by the appropriate density factor in pounds per cubic foot to determine the quantity of actual waste in pounds for each load. Knowing the average number of loads for each container on an hourly or daily basis would provide a fairly accurate basis for selecting the proper hog size. An alternative method where material is being conveyed on a belt would be to scrape off and weigh the material that passed a certain point on the belt in 15 seconds, then multiply this weight by 240 to obtain the approximate pounds per hour to be processed by the hog.

## CONCLUSION

Because all plants, as well as their energy requirements and applications, are different, a plant considering conversion to waste wood fuel should commission an energy study by a qualified employee or outside consultants.

In addition to its use as fuel, waste wood has many other potential applications. Wood residues have the following uses: as animal bedding and litter to be sold to riding stables, kennels, stockyards, zoos, biological laboratories, and auction barns; as absorbent materials to be sold to service stations, machine shops, butcher shops, and meat packers; as mulch to be sold to nurseries, landscapers, gardeners, and government agencies; and as industrial supply for making particleboard, fiberboard, hardboard, and molded products.

# MARKETING URBAN WOOD RESIDUES

John W. Howard[1]

*Abstract.*—This study defines the characteristics of wood residues that affect their marketability, discusses the processing required to upgrade residues to useful wood fiber, and lists potential markets and dollar values for various residues.

In this presentation, I will discuss the characteristics of wood residues that affect their marketability, the types of processing required, the potential markets, the procedures for marketing, and the monetary value involved.

The characteristics of wood residues that affect marketability and value are: species, moisture content, physical form, and degree of cleanliness. Wood residues may be composed of hardwood species, softwood species, or a mixture of both. Green wood contains 40 to 50 percent moisture, air-dried wood 15 to 25 percent, and kiln-dried wood less than 10 percent. Wood residues may exist in the form of sawdust, shavings, chips, slabs, boards, blocks, trunks, limbs, leaves, or twigs. Wood residues may be clean, or they may be contaminated with dirt, metal, concrete, paper, plastics, or other debris.

The species and moisture content are fixed; they are determined by the source. The physical form and cleanliness will depend on the source but can be altered by processing. The processing has to be justified by the markets available and the dollar value that can be realized by upgrading the residues.

Essentially all types of wood residues are now marketable if the supply is within reasonable distance of the consuming point and the residues are clean and of the right physical form.

The greatest potential outlets, by far, are agricultural and fuel uses. All residues in sawdust or shavings are valuable to farmers for bedding and ground control for livestock. Fuel will be the greatest outlet in the near future since the price of oil is escalating rapidly. However, wood residues for fuels require processing to be marketable and to realize their optimum value. Each type of wood burner is designed to handle wood in a specific physical form.

I will define the types of residues by markets and by specifications required of the residues for processing or use as is (tables 1 and 2).

Wood residues for markets requiring exact processing (fillers for plastics, paper, fur cleaning, and foundries) have to be ground and sized in their applications. Chemical and physical properties are critical. These residues are usually from secondary wood manufacture and have exact specifications. These residues have the greatest value but are not typical of urban wood residues unless the governmental agencies involved

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Table 1.—Markets requiring exacting processing and specifications for wood residues

| End use | Species | Moisture | Physical form | Cleanliness |
|---|---|---|---|---|
| Woodflour manufacture | Softwood | Under 8% | Secondary residues | Very pure |
| Paper filler | Softwood | Under 10% | Secondary residues | Clean |
| Foundry filler | Hardwood | Under 10% | Secondary residues | Clean |
| Fur cleaning | Hardwood | Under 10% | Secondary residues | Clean |
| Firelogs | Softwood<br>Hardwood | Under 15% | Secondary residues | Clean |

Table 2.—Other markets for wood residues

| End use | Species | Moisture | Physical form | Cleanliness |
|---|---|---|---|---|
| Fuel | Hardwood<br>Softwood<br>Mixed | 10–20%<br>Green | Sawdust<br>Shavings<br>Hog fuel<br>Wood chips<br>Sander dust | Bark O.K.<br><br>Debris &<br>dirt free |
| Particleboard | Hardwood<br>Softwood | Dry<br>Green | Secondary<br>Residues | Clean |
| Sewage composting | Hardwood<br>Softwood | Green | Wood chips<br>Total-tree<br>Chips | Debris<br>Free |
| Agriculture | Hardwood<br>Softwood | Dry or<br>Green | Sawdust<br>Shavings | Clean |
| Paper | Hardwood<br>Softwood | Green | Wood chips<br>Hog wood | Clean |

require industrial wood residues to be considered as part of the urban residue program. I list these to show the breadth of the residue markets.

A second category includes the major applications of wood residues. Included are: general urban wood residues encountered in disposing of land clearings, packaging residues, dunnage, demolition lumber, tree tops, limbs, and stumps. Essentially all of these residues require processing in equipment. Their use requires large volumes and specific physical forms of residue.

I will define the procedures for marketing residues:

1. Characterize residues according to species, moisture, form, and cleanliness.
2. Determine potential marketing outlets.
3. Locate potential markets within economically feasible shipping range.
4. Determine end use and physical form required.
5. Evaluate against dollar value available.
6. Evaluate costs of upgrade and market.

7. Obtain sales commitments prior to investments.
8. Locate minimum-cost disposal if marketing is not feasible.

Freight costs are the most significant factor in marketing wood residues. Green materials contain 50 percent water by weight. Shipment beyond 150 miles will usually not be feasible; freight costs will offset the value of the residue.

Specialists in marketing wood residues are available to evaluate residues and provide advice about obtaining optimum dollar value. Specialists include: brokers, state and federal forestry specialists, industrial representatives from papermills, particleboard plants, professional forestry associations (such as FPRS).

Estimated dollar values listed for wood residues are based on the ultimate end use and processing required. Obviously, the more demanding the specifications, the higher the value and the less supply. In large-volume uses, supply is often abundant and the dollar value is lower.

## ESTIMATED DOLLAR VALUE FOR RESIDUES

1. High specifications (exacting processing required):
   (a) grinding and screening ($50–$80/ton delivered),
   (b) secondary residues ($20–$45/ton delivered; dry, clean, specific species)
2. Intermediate specifications (specific physical forms required):
   wood chips, hog wood, species limitations ($18–$35/ton delivered)
3. Low specifications (liberal requirements on physical form):
   sawdust, mixed materials ($10–$18/ton delivered; unlimited species).

I have three case histories of marketing urban wood residues that will illustrate processing and dollar value.

The first example is converting pallets, packaging, dunnage, and miscellaneous waste wood from a large industrial plant into hog wood for fuel. This installation is at Kodak Park, home of Eastman Kodak in Rochester, New York. A small tractor is used to crush oversize material such as pallets, and the material is then mechanically scooped up and through a hog mounted on the tractor. This procedure allows Eastman Kodak to convert waste wood, that is expensive to dispose of, into hog wood fuel worth $20 to $30 per ton on a BTU basis when incinerated in a burner producing low-pressure steam for plant consumption.

The second example is improving sewage treatment where green sawdust is used as a fuel and a filter aid in treating the sludge. This is done in Monroe County, Rochester, New York, with sawdust delivered at $15 per ton in dump trucks and self-unloading trailers.

The third example is preparing hog wood for pressure fiber processing for paper filler. Separated softwood dunnage and packaging residues collected in northern New Jersey are hogged to small size and delivered to GAF, Gloucester, New Jersey, for conversion to a filler for industrial paper. The value of the wood is approximately $25 per ton delivered.

## SUMMARY

Marketing wood residues is complex because essentially all end uses require specifications of some kind on physical form, moisture, and cleanliness. Use of marketing specialists is strongly recommended to obtain the best dollar value and least cost and investment.

# SEGREGATION PROCESSES FOR URBAN WASTE WOOD

John A. Sturos[1]

*Abstract.*—Three technologies—steaming-compression debarking, vacuum-airlift segregation, and photosorting—have been developed for improving the quality of whole-tree and wood-residue chips. Application of these processes coupled with integrated utilization of the various output wood fractions should lower the barriers for increased urban waste wood utilization.

A tremendous underutilized wood resource exists in urban areas in the form of tree removals and trimmings, industrial waste, demolition wood, and secondary manufacturing residue. In 1976 the total urban wood residue was estimated to be more than 16 million air-dry tons (table 1) (Carr 1978). Demolition lumber alone accounted for 6.4 million air-dry tons, or 39 percent of the total. One municipality has estimated that it will have to dispose of 10,000 tons of wood per year from diseased trees for the next 8 years, and tree trimmings could be more than 1,000 tons per year from an urban forest of 140 square miles (Ratcliffe 1976).

Table 1.—Estimates of urban wood residue generated in 1976[1]

| Source of wood residue | Thousands of tons (air-dry) |
|---|---|
| Tree removals and trimmings | 2,820 |
| Demolition lumber | 6,410 |
| Pallets, containers, dunnage | 4,790 |
| Secondary manufacturing residue | 2,400 |
| Total | 16,410 |

[1] Carr (1978).

Excluding secondary manufacturing residues, the degree of urban waste wood utilization in 1976 was very low (table 2) (Carr 1978). Only 2 percent, 15 percent, and 30 percent of the demolition lumber, urban trees, and industrial and commercial wood waste, respectively, were used. The remaining wood was either used for landfill or incinerated.

Cities and highly populated counties are currently being forced to process their wood waste because disposal by incineration and/or landfill is no longer acceptable. To increase urban waste wood utilization, new and improved roughwood processing equipment and methods must be developed to convert these materials to marketable products. Hopefully this will promote integrated utilization so that each of the various components of the urban wood waste can be used for its highest value end use.

[1]Principal Mechanical Engineer, North Central Forest Experiment Station, Forestry Sciences Laboratory, Houghton, Michigan.

Table 2.—Estimates of urban wood utilization in 1976[1]
(In thousands of air-dry tons)

| Use | Urban trees | Industrial, commercial | Demolition waste | Secondary manufacturing residues | Total |
|---|---|---|---|---|---|
| Fuel, industrial & residential | 280 | 960 | | 850 | 2,090 |
| Pulp, composition board | 60 | 240 | | 470 | 770 |
| Mulch and bedding | | | | 480 | 480 |
| Salvage for lumber | | | 110 | | 110 |
| Saw logs | 80 | | | | 80 |
| Miscellaneous | | 240 | | 150 | 390 |
| Landfill or incineration | 2,400 | 3,350 | 6,300 | 440 | 12,490 |
| Total | 2,820 | 4,790 | 6,410 | 2,390 | 16,410 |

[1] Carr (1978).

Research on improving the quality of whole-tree or wood-residue chips has resulted in several promising segregation processes. These processes should be considered for incorporation into an integrated urban waste wood recovery system. This paper discusses these segregation processes.

## SEGREGATION PROCESSES

Research on the beneficiation of whole-tree chips or contaminated residual chips at the Forestry Sciences Laboratory of the North Central Forest Experiment Station, USDA Forest Service, Houghton, Michigan, has resulted in three promising processes—steaming-compression debarking, vacuum-airlift segregation, and photosorting (Mattson 1975; Arola 1976; Sturos and Brumm 1978). In addition, combinations of the above processes are possible.

### STEAMING-COMPRESSION DEBARKING

The steaming-compression debarking process has been put into practice by Parsons & Whittemore, Inc., who designed and built a debarking plant at one of their pulpmills. The results of their first 16 months of operation are similar to those obtained in Forest Service research studies (Wawer and Misra 1977). The basic process consists of three steps: (1) presteaming the unbarked chip mass, (2) passing the chips through a compression debarker, and (3) screening the compression debarker output to remove bark fines (fig. 1). Additional (optional) steps include mechanical attrition of the smaller chip output fractions followed by screening to remove additional fines.

In cooperation with Urban Wood and Fiber Products, Inc., steaming-compression debarking of elm chips was evaluated (table 3). Results indicate that 66 percent of the bark was removed and 85 percent of the wood recovered with a final bark content in the accept fraction of 3.1 percent. By including only the +3/8-inch-size chips in the accepts, the bark content decreases to 1.6 percent but yet more than 60 percent of the wood fiber is recovered.

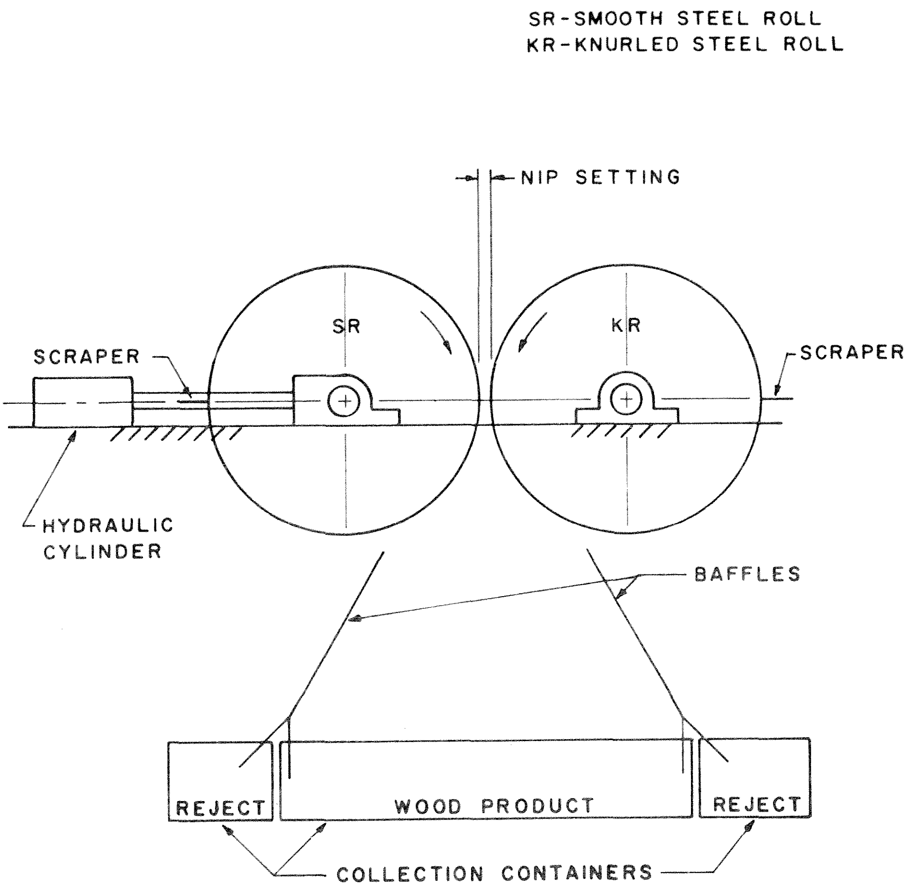

Figure 1.–Compression debarker.

Table 3.–Results of steaming-compression debarking of elm chips[1]

| Product | Input material | Bark content | Total wood | Total bark |
|---|---|---|---|---|
| | *Percent* | | | |
| Accepts | | | | |
| +3/8" fraction | 57.7 | 1.6 | 61.4 | 12.3 |
| -3/8 + 3/16" fraction | 23.6 | 6.9 | 23.7 | 21.6 |
| Combined accepts | 81.3 | 3.1 | 85.1 | 33.9 |
| Rejects | 18.7 | 26.4 | 14.9 | 66.1 |
| Input | 100.0 | 7.5 | 100.0 | 100.0 |

[1] Chips supplied by Urban Wood and Fiber Products, Inc.

## VACUUM-AIRLIFT SEGREGATION

The vacuum-airlift segregator has received laboratory scale testing both by the USDA Forest Service and by industry. It consists of a wire mesh conveyor belt with vacuum hoods placed above the belt at various stations (fig. 2). Whole-tree chips are spread over a continuously moving conveyor belt that passes through fields of air currents that subject the chips to vacuum forces from above the belt. The material is then segregated on the basis of differences in terminal settling velocities caused by density and geometric differences. Typically, in a multiple-stage system, foliage, clean wood chips, and "middlings" are removed at different locations along the belt. Bark, knots, and twigs remain on the belt to discharge to a "reject" product area, and fines—bark, some foliage, dirt, and grit—fall through the mesh belting.

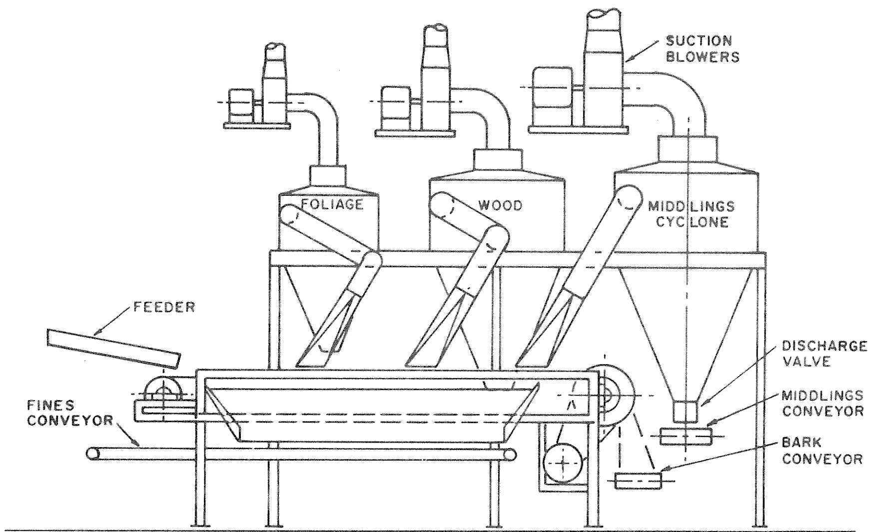


Figure 2.—Multiple-stage vacuum-airlift segregator. Fines fall through the wire mesh conveyor.

The "middlings" fraction contains from 30 to 50 percent of the total input material, depending on species, and has a bark content equal to or higher than the as-received whole-tree chips. This fraction can be used for pulp, particleboard, fuel, or chemicals. If the middlings are to be used for pulp, further beneficiation by the compression debarking process is recommended.

For maximum recovery of "clean" fiber, a combined system is recommended (fig. 3) (Sturos 1978; Sturos and Marvin 1978). It consists of vacuum-airlift segregation followed by steam-compression debarking of the middlings fraction (table 4, fig. 4). By means of the vacuum-airlift stage, 4 percent of the input is removed as commercial foliage, 4 percent falls through the wire mesh conveyor as fines, 42 percent is recovered as clean wood chips acceptable for pulping, 36 percent is recovered as middlings, and 14 percent is left on the conveyor as bark (fuel). Passing the middlings through the compression debarker results in an additional 29 percent clean wood chips and 7 percent bark. The combined product recovery results are 71 percent fiber, 25 percent fuel, and 4 percent foliage.

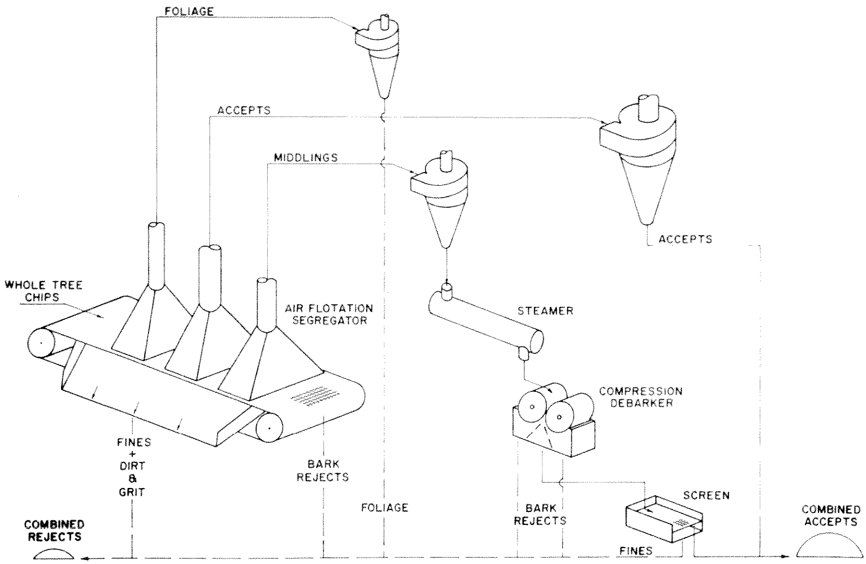


Figure 3.—Combined vacuum-airlift and compression debarking system for beneficiating whole-tree chips.

Table 4.—Typical foliage and bark removal results obtained by combining the vacuum-airlift and compression debarking processes[1]

| Process and components | Aspen | Sugar maple | White birch |
|---|---|---|---|
| | | *Percent* | |
| Vacuum-airlift segregation: | | | |
| Input bark content | 20.2 | 13.2 | 16.4 |
| Bark content | 4.8 | 5.7 | 7.6 |
| Wood recovery | 52 | 37 | 40 |
| Bark removal | 51 | 41 | 45 |
| Foliage removal | 84 | 85 | 94 |
| Vacuum-airlift & compression debarking: | | | |
| Input bark content | 20.2 | 13.2 | 16.4 |
| Bark content of accepts | 5.3 | 5.3 | 5.9 |
| Wood recovery | 88 | 87 | 87 |
| Bark removal | 80 | 69 | 73 |
| Foliage removal | 86 | 86 | 94 |

[1] All calculations are based on dry weight.

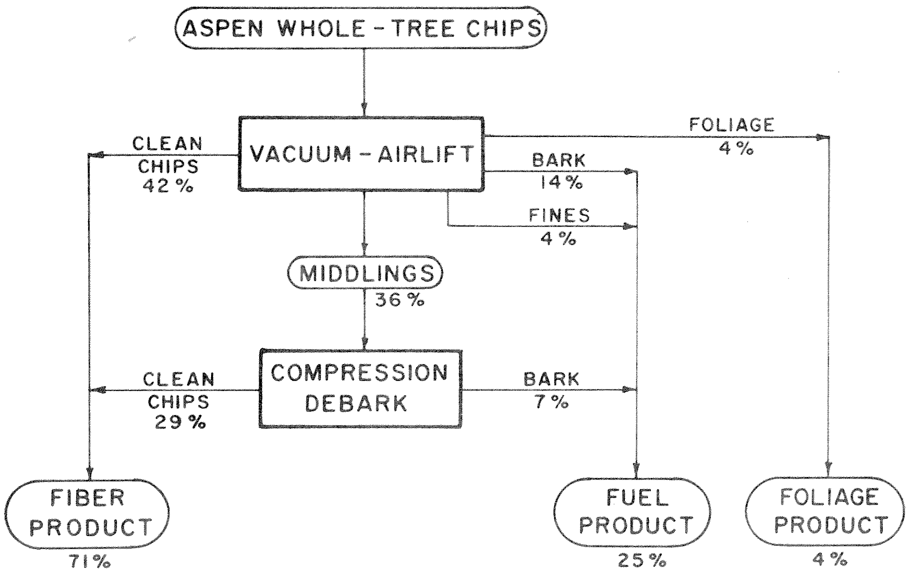


Figure 4.–End products and intermediate steps in segregating aspen whole-tree chips.

## PHOTOSORTING

Wood and bark chips differ sufficiently in their optical transmittance to be sortable. When photosorting, the chips are fed by a conveyor over a linear array of optical detectors (fig. 5). Light from an incandescent source is incident on the chips from above. The light intensity is adjusted such that most wood chips transmit sufficient light to be sensed by the detector array. When a bark chip passes over the detectors, the transmitted light falls below a preset detection threshold and the detector photocurrent decreases. The resulting signal is amplified to energize an air valve, which deflects the bark chips with a blast of air (fig. 6). Preliminary results for 5/8-inch aspen chips are promising (table 5). Depending on light level, bark content of 1.4 and 5.1 percent with corresponding wood recoveries of 70 and 96 percent are possible.

## ECONOMICS

The Forestry Sciences Laboratory has conducted several cost analyses of the steaming-compression debarking system, the vacuum-airlift system, and combinations of these two systems. They have revealed that the combined system is the most cost efficient. One of the primary advantages of coupling the vacuum-airlift segregator and the compression debarker is to reduce capital equipment cost and consequently, beneficiation cost. This decreases the amount of material the compression debarker has to process, which in turn reduces steam requirements, the size of the press, and therefore cost. The beneficiation costs (1978 basis) range from about $6.70 per output dry ton of "clean" chips for a steaming-compression debarking system to $4.70 for a combined system in which only 34 percent of the material is compression debarked. Total capital investment for a 60 ton per hour debarking plant ranges from about $3 million for a steaming-compression debarking plant to $1.7 million for a combined vacuum-airlift and steaming-compression system.

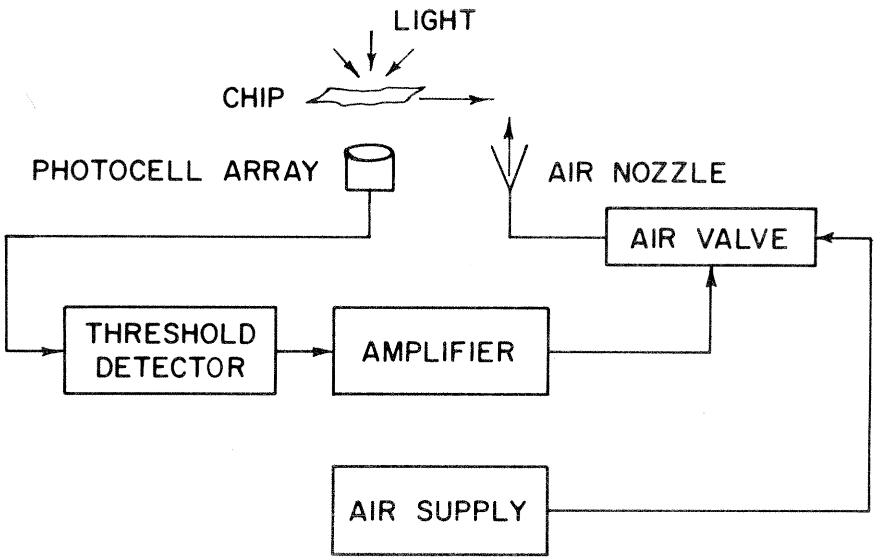


Figure 5.—Photosorting system diagram.

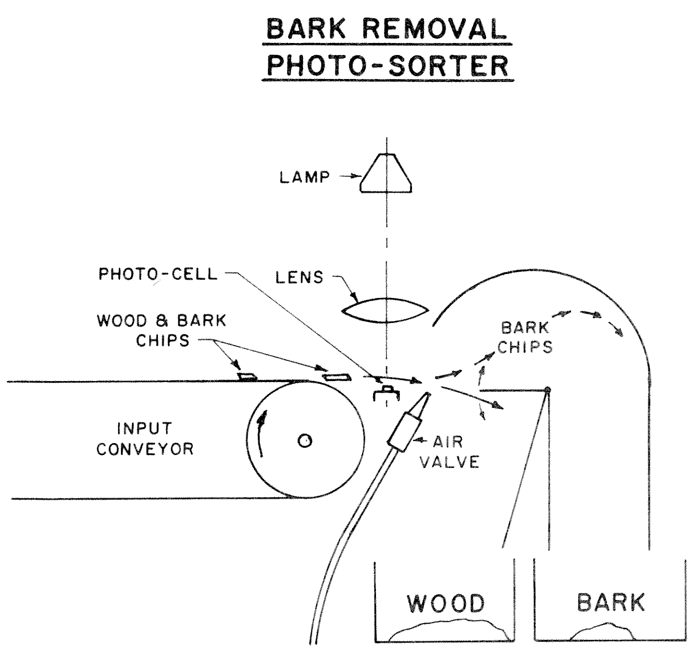


Figure 6.—Mechanical configuration of the photosorting system.

Table 5.—Effect of light level on photosorting 5/8-inch aspen wood and bark chips
(In percent)

| Product | Bark content | Portion of total chips | Portion of total wood | Portion of total bark |
|---|---|---|---|---|
| LIGHT LEVEL - 2.5 mW/cm | | | | |
| Input | 10.6 | 100 | 100 | 100 |
| Accepts | 1.4 | 63 | 70 | 8 |
| Rejects | 26.2 | 37 | 30 | 92 |
| LIGHT LEVEL - 3.5 mW/cm | | | | |
| Input | 9.3 | 100 | 100 | 100 |
| Accepts | 2.3 | 79 | 86 | 19 |
| Rejects | 36.7 | 21 | 14 | 81 |
| LIGHT LEVEL - 4.5 mW/cm | | | | |
| Input | 8.9 | 100 | 100 | 100 |
| Accepts | 3.3 | 88 | 93 | 32 |
| Rejects | 48.5 | 12 | 7 | 68 |
| LIGHT LEVEL - 5.5 mW/cm | | | | |
| Input | 9.7 | 100 | 100 | 100 |
| Accepts | 5.1 | 91 | 96 | 48 |
| Rejects | 56.4 | 9 | 4 | 52 |

A typical urban wood waste recovery plant includes a number of processing steps such as crushing, washing, hogging, screening, and magnetic separation (fig. 7). How and where would a vacuum-airlift segregator be incorporated into such a recovery plant? A three-stage segregator is one possibility (fig. 8). It would be one of the last stages in the total material flow through the plant (fig. 9) resulting in at least two fractions of wood chips—high-quality chips and fuelwood chips. Cost to install a 20-ton-per-hour vacuum-airlift segregation system (fig. 8) into an already existing plant has been estimated to be $175,000. The processing costs would be less than $1 per input ton. Total connected horsepower is 205.

## SUMMARY

Three new systems have been developed for upgrading the quality of whole-tree and wood residue chips—steaming-compression debarking, vacuum-airlift segregation, and photosorting. A combined system using steaming-compression debarking and vacuum-airlift segregation has proved to be the most economical for maximum clean fiber recovery and the vacuum-airlift segregation system can easily be incorporated into present waste wood recovery, systems. Installation of a 20-ton-per-hour system is estimated to cost $175,000. With the large number of energy products, chemicals, and fiber products that are potentially available from waste wood, we are at the doorstep of converting it from a disposal problem to a valuable resource.

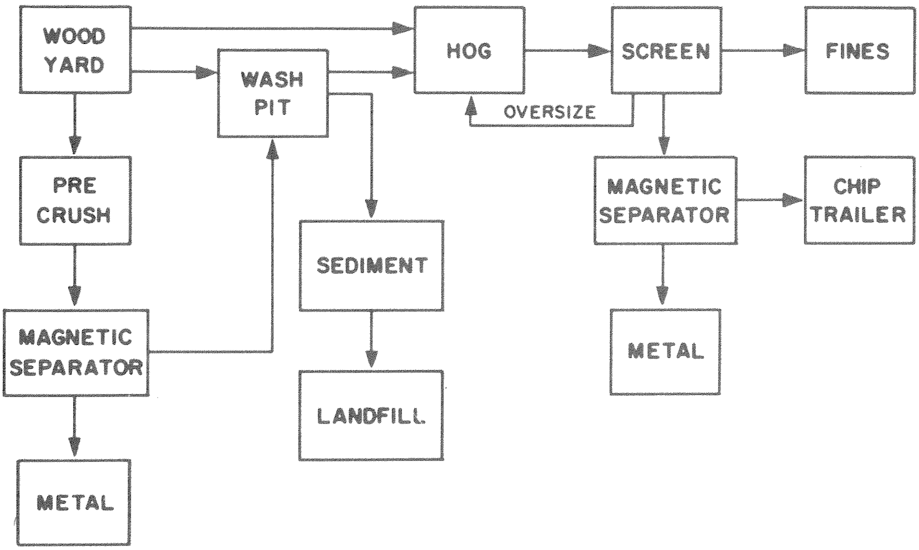


Figure 7.–Typical urban waste wood recycling plant.

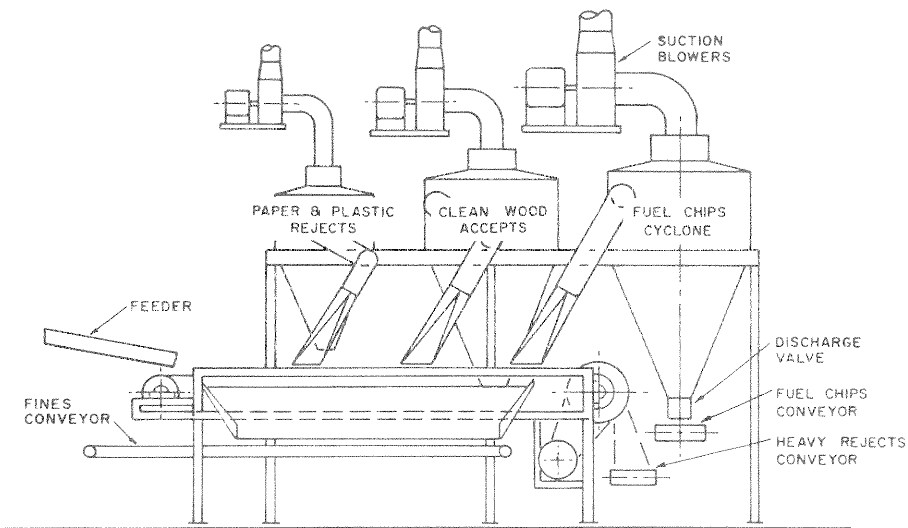


Figure 8.–A three-stage vacuum-airlift segregator for urban waste wood recovery.

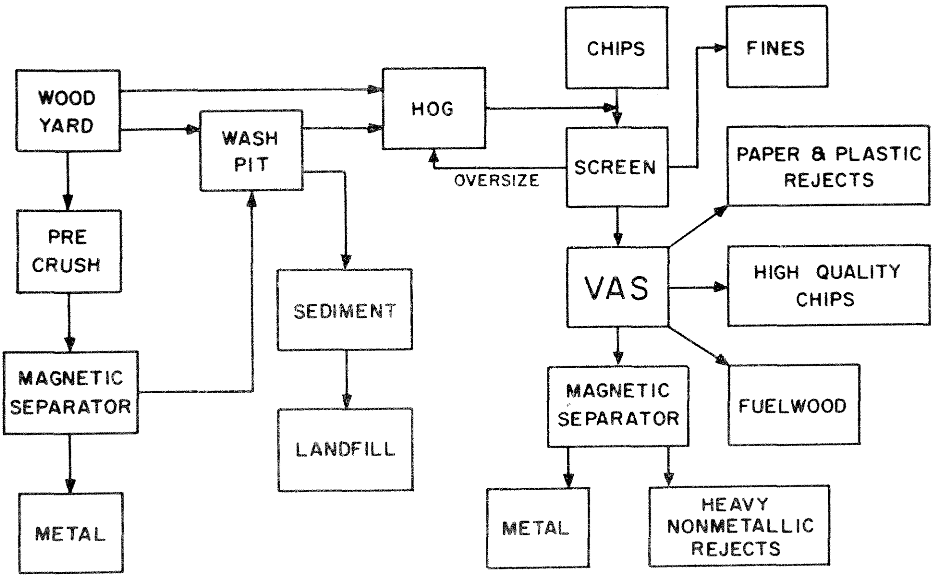


Figure 9.–Proposed urban waste wood recycling plant including vacuum-airlift segregation (VAS).

## LITERATURE CITED


Arola, Rodger A., J. A. Sturos, and J. A. Mattson
1976. Research in quality improvement of whole-tree chips. TAPPI 59(7):66–70.

Carr, Wayne F.
1978. Urban wood waste in the United States. Unpubl. rep. to the For. Prod. Lab., U.S. Dep. Agric. For. Serv., Madison, Wis.

Mattson, James A.
1975. Debarking chips from whole trees in the Lake States. U.S. Dep. Agric. For. Serv., Res. Pap. NC-115, 9 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Ratcliffe, Pete
1976. Full forest residual and unwanted trees as fuel to replace or supplement existing fuel. *In* Energy and the wood products industry. Meeting sponsored by the FPRS. Proc. P-76-14:53–55.

Sturos, John A.
1978. Bark, foliage, and grit removal from whole-tree chips–results and economics. TAPPI Pulping Conf. Proc. p. 121–134. [Atlanta, Ga.]

Sturos, John A., and D. B. Brumm
1978. Segregating wood and bark chips by photosorting. U.S. Dep. Agric. For. Serv., Res. Pap. NC-164, 6 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Sturos, John A., and John L. Marvin
1978. A process for removing bark, foliage and grit from southern pine whole-tree chips. *In* Complete-tree utilization of southern pine. Symp. Proc., p. 277–294. [New Orleans, La., April 17–19.] USFS/FPRS/IUFRO.

Wawer, Adolf, and M'N. Misra
1977. Whole-tree chips compression debarking–St. Anne Pilot Plant Study. Paper presented at the 63rd Annu. meet. of the Tech. Sec., CPPA [Montreal, P.Q., Canada, Feb. 1–4.]

# IMPORTANCE OF WOOD AS AN URBAN ENERGY SOURCE

James W. McMinn[1]

*Abstract.*–The paper reviews (1) theoretical limits to wood supplies, (2) characteristics of wood as a fuel source, (3) difficulties in predicting energy consumption and fuel prices, and (4) the outlook for wood-energy development. Woody biomass is likely to provide less than 10 percent of urban energy, and its use will be in small-scale, decentralized systems. Small towns will derive the greatest benefits from primary biomass, whereas use of urban waste wood will probably be unrelated to city size.

Energy consumption in the United States has increased almost twentyfold in the last century. During the same period, the amount of energy the Nation derives from wood has decreased to a little more than a third of its former contribution. At one time, 75 percent of our energy was supplied by wood, whereas it presently supplies well below 5 percent (Curtis 1978). A large proportion of the national energy supply will probably never again be derived from wood, but use of wood for energy could be substantial in certain areas. This presentation covers (1) theoretical limits to wood supplies, (2) some advantages and disadvantages of wood as an energy source, (3) some complexities inherent in projecting fuel use and prices, and (4) future possibilities for wood-energy development.

## WOODY BIOMASS SUPPLY

In determining quantities available for conversion into energy, annual growth rather than the total wood volume in the forest must be considered. Professional foresters routinely base estimates of possible use on growth, but individuals not involved in renewable-resource management often fail to recognize the distinction between mining an inventory and harvesting growth. Estimates of total growth over a large geographic area are not sufficiently precise for an individual or firm that is seriously considering wood as an alternate fuel. However, such estimates are valuable to planners and policymakers for placing upper limits on wood harvests for all purposes. Some of the more reliable estimates follow.

Worldwide, plants store about six times as much energy in biomass as humans use each year (Dubos 1976). More than half of this biomass is produced in forests that receive no more than custodial management. Less than one-tenth of the annual biomass accumulation occurs on cultivated areas, so their current energy potential is quite low when energy inputs are accounted for.

In contrast to the world situation, annual biomass increment in the continental United States is equivalent to only about half the energy consumed (Burwell 1978). Furthermore, this biomass includes food, fiber, and feed grains as well as forest and crop residues and surplus increment. Woody biomass growth on our commercial

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forestland is equivalent to somewhere between 10 and 15 percent of our annual energy consumption. The United States ratio of biomass accumulation to energy use represents a prodigious rate of consumption, rather than a low level of productivity.

The foregoing figures do not mean that wood fuels are impractical or insignificant. They do mean that on a national or regional scale there are definite limits to the role wood can play in supplying energy for urban areas.

In many places, wood can be a very practical source of energy. One plant in France has generated electricity from wood-fired boilers for over 50 years (Jagles 1978). In Maine, Vermont, and New Hampshire, 18 percent of all households use wood as their primary heating source, and citizens of Burlington, Vermont, have approved a $40-million bond issue for a 50-megawatt wood-fired power plant (Anon. 1979). Burlington currently has a 30-megawatt plant supplied by three 10-megawatt boilers; one of those boilers has operated successfully for several months on wood. A recent study indicates that a 25-megawatt wood-fired plant would probably be feasible in north-central Minnesota (Rose and Olson 1979). The wood-products industry currently derives over 30 percent of its energy from waste wood.

The pertinent question, then, is not whether wood energy is feasible, but where and on what scale. Approximately half of the biomass growth on our commercial forestland occurs in the southeastern quarter of the country (Burwell 1978), so it is probable that substantial development opportunities exist here. The Southeastern Forest Experiment Station's wood-energy research unit at Athens, Georgia, is developing procedures to identify communities with high development potential and to determine the degree to which development in one community will constrain development in others. We are focusing on physical supply and will be dealing with several supply variables, beginning with sawmill residues presently generated and working ultimately with the long-term productive capacity of the land. We do not include urban wood waste, primarily because reliable inventory data are not available. Urban areas may produce waste wood at a rate equivalent to 23 percent of the growth on commercial forestland (Burwell 1978). If so, this source of energy would be significant in many communities.

## WOOD AS A FUEL SOURCE

Since 1974 wood-energy development has been surprisingly slow in light of the interest and available technology. Some of the disadvantages of wood as a fuel source explain the limited development.

Woody biomass is quite variable, and its energy is less concentrated than that in other common fuels (Jagles 1978). It is therefore difficult to handle and costly to transport, and it requires a relatively large amount of storage space for a given burner output. The most difficult problem, however, is water content. The energy equivalent of green wood is less than half the 8,500 BTU per pound of dry wood.

Biomass is one of several potential energy sources derived from the sun. Solar energy in any form has broad appeal because, in theory, it is freely available and the worst forms of pollution are not associated with its use. However, practical application of solar energy requires capture and storage. Plants perform both functions. They capture less than 5 percent of total insolation, but they do so at low cost. Woody plants are particularly attractive as energy sources because, unlike annual plants, they can accumulate energy for many years before harvest. Large quantities of fuel, therefore, can be harvested per unit area. Burwell (1978) has shown that ratios of energy output/input can be relatively high (35–40/1) for unmanaged forestland because the only input required is for harvesting.

Some investigators have concluded that the net effect of the above advantages and disadvantages will lead to small-scale, decentralized conversion of woody biomass to energy (Dubos 1976; Burwell 1978). This conclusion seems to imply that opportunities for wood-energy development will be more numerous for small towns than for large urban areas. However, urban waste wood differs from other woody biomass in two important respects: (1) some of it is at least partially dry, and (2) it is already centralized to a degree. Some of the costs associated with wood-fuel transportation and processing are, therefore, borne by other products.

## ENERGY COST COMPARISONS

There are many uncertainties associated with predicting the relative costs of wood and alternate energy sources. In the absence of operational experience, costs of harvesting, concentrating, and/or separating types of material can be only roughly estimated. Furthermore, changes in energy supplies and costs can be predicted only with great uncertainty.

On the basis of Carter's (1974) discussion, the uncertainties may be grouped under the following categories:

*Waste trimming.*—Decades of inexpensive energy have led to waste that conservation efforts can reduce at little or no cost. More leeway probably exists in space heating and lighting than in industrial processes.

*New technology.*—Notable examples of energy-saving technology are new processes for manufacturing steel and aluminum, but advances are taking place in many fields and at all scales of use.

*Implementation of existing technology.*—No new technology is needed for carpooling, widespread use of mass transit, or for efficient recycling of many energy-expensive materials. As energy costs rise, greater economic incentives should force implementation of known technologies.

*Labor-energy substitution.*—From World War II until the 1973–74 oil embargo, energy costs decreased and labor costs increased. The benefit of energy substitution became axiomatic. With energy costs increasing faster than labor costs, that axiom no longer holds. We can now expect a gradual substitution of labor for energy.

Schipper and Lichtenberg (1976) have demonstrated how some of the above factors influence Sweden's rate of energy consumption compared to that in the United States. They found the main contributing factors to be ". . . smaller automobiles, more use of mass transit, more insulation and tighter construction, more efficient industrial processes, and the use of cogeneration and district heating." Of these factors, only district heating varies substantially from near-term United States capabilities; in Sweden, waste heat from power stations is distributed throughout rather large districts for space heating. A high standard of living is commonly thought to depend on high energy consumption. Swedish energy consumption per unit of Gross National Product is only 68 percent of that in the United States, and the two countries have generally comparable standards of living. A policy-study group here in the United States has concluded that it will be "... technically feasible in 2010 to use roughly a total amount of energy as low as that used today and still provide a higher level of amenities, even with total population increasing 35 percent" (Demand and Conservation Panel of CONAES 1978).

## FUTURE OUTLOOK

Most authors dealing with energy agree that use of oil and natural gas will decline and that in the short term no single large energy source will replace them. The variety and character of alternate energy sources will probably force a trend toward more individually tailored systems, rather than uniform, energy-wasteful systems (Jagles 1978). This environment will be conducive to wood-energy development. It could also lead to depletion of wood supplies and increased fuel transportation costs for local areas.

For the longer term, Hayes (1979) builds a logical case for the likely development of coal as the single large energy source in the United States. He points out that public opposition, increasing capital costs, and decreasing growth in electrical energy use are recognized as obstacles to nuclear development, but the availability of uranium is a more significant restriction than is generally realized. If coal use increases rapidly, the combustion of wood with coal is potentially significant for maintaining sulfur emissions at acceptable levels (Inman 1977).

Energy plantations can have a favorable energy output/input ratio and could fulfill some of our long-term energy needs (Inman 1977). However, they have definite limitations and are no panacea for energy problems. One of the greatest fallacies associated with energy plantations is the emphasis on so-called fast-growing species. Plant growth is a result of genetic capacity and environmental conditions. The only difference between fast-growing species and slow-growing species is that the former have the capacity to respond to a rich environment and the latter do not. Therefore, fast-growing species do not grow fast on marginal land. Phenomenal production is possible through fertilization and irrigation of marginal lands, but these operations are energy-expensive. Current research efforts are comparing outputs with inputs for such situations. Cities close to marginal lands have a unique opportunity to coordinate waste management and energy production by using ash and sewage as soil amendments to increase production on biomass plantations.

## CONCLUSIONS

Wood can be expected to supply less than 10 percent of the energy for urban areas, but its contribution could be substantially greater in selected communities.

Generalizations about the relative costs of wood and other fuels are extremely difficult to make.

Most systems for conversion of wood to energy will probably be small, decentralized, and tailored to local conditions.

Because of high transportation costs, small towns are most likely to use forest-grown wood for energy.

Since urban waste wood must be concentrated for disposal even if it is not used, transportation need not be considered in estimating cost of converting this wood to energy.

Biomass plantations will probably play a limited role in energy supply, but some urban areas have unique opportunities to develop innovative energy plantation systems.

## LITERATURE CITED


Anonymous
1979. Glowing future for forest power: New England gets fired up over an ancient fuel. Time 113(4):59.

Burwell, C. C.
1978. Solar biomass energy: An overview of U.S. potential. Science 199:1041–1048.

Carter, A. P.
1974. Applications of input-output analysis to energy production. Science 184:325–329.

Curtis, A. B., Jr.
1978. Wood for energy: an overview. For. Prod. Util. Bull., 4 p. U.S. Dep. Agric. For. Serv., Southeast. Area, State and Priv. For., Atlanta, Ga.

Demand and Conservation Panel of the Committee on Nuclear and Alternative Energy Systems
1978. U.S. energy demand: Some low energy futures. Science 200:142–152.

Dubos, R.
1976. Symbiosis between the earth and humankind. Science 193:459–462.

Hayes, E. T.
1979. Energy resources available to the United States, 1985 to 2000. Science 203:233–239.

Inman, R. E.
1977. Silvicultural biomass farms. Vol. I: Summary. METREK Div., McLean, Va. Mitre Corp. Mitre Tech. Rep. 7347, 62 p.

Jagles, R.
1978. Forest biomass for the competitive consumer. *In* Energy and the southern forest, p. 108–120. Proc. 27th Annu. For. Symp., La. State Univ., Baton Rouge.

Rose, D. W., and K. P. Olson
1979. Wood–an economical and reliable fuel for generating electricity in northern Minnesota. J. For. 77:88–90.

Schipper, L., and A. L. Lichtenberg
1976. Efficient energy use and well-being: the Swedish example. Science 194:1001–1013.

# RECOVERY OF ENERGY FROM SOLID WASTE–AN ALTERNATIVE TO LANDFILL DISPOSAL

Gloria A. Mills[1]

*Abstract.*–There are many solid waste recovery techniques from which communities may choose. The technology described here is known generally as mass combustion in waterwall boilers. A facility using this technology takes all kinds of residential, commercial, and nonproblem industrial solid wastes and processes them into usable energy and marketable materials. This combustion process performs extremely well, with better than 96 percent burnout of combustible matter and a volume reduction of 95 percent.

Pinellas County, Florida, located on the west coast between the Gulf of Mexico and Tampa Bay, is primarily an urban area, having as its two largest municipalities the cities of St. Petersburg and Clearwater; in fact, it is the most densely populated county in the State. Pinellas County faces a problem encountered by many other urban areas: how to dispose of its solid waste in an environmentally acceptable manner at a time when disposal costs are rising and landfill space is diminishing.

The county took a number of steps to reduce its waste collection costs and to improve productivity. It switched to hydraulically operated packer trucks and one-man collection vehicles. A variety of factors, including the limited future life of its largest landfill, led to a search for an alternative to that method of disposal.

An act of the Florida legislature gave the Board of County Commissioners the responsibility for the disposal of all solid waste throughout Pinellas County. The same legislative act established the Solid Waste Technical Management Committee (TMC). Members are technically qualified representatives from designated municipalities. The TMC has been instrumental in providing guidance to the Board of County Commissioners in the development of a solid waste program for the county.

The program began with the selection of Henningson, Durham, and Richardson (HDR) as the county's engineering consultant and William R. Hough & Co. as the county's financial consultant. Both firms are nationally recognized experts in developing programs for solid waste disposal.

HDR conducted a feasibility study to determine how much and what kinds of wastes existed in the county, what technological alternatives existed for the disposal of those wastes, what markets existed for the energy and materials recoverable from the waste stream, and what sites were available for the location of a resource recovery facility. The results of the study indicated that resource recovery was feasible, and a plan for the implementation of a resource recovery system was developed.

The plan had three major objectives. The county wanted a system that was (1) technically sound, (2) environmentally acceptable, and (3) economically accept-

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able. Private firms were invited to indicate their interest in contracting for the disposal of 12,000 tons per week of the county's waste. Following an initial prequalification process, seven of the largest and most experienced companies in the solid waste business were invited to submit proposals for a total resource recovery system. The six proposals actually received were subjected to a detailed evaluation that included the use of computers to process cost data and provide sensitivity analyses. An extensive description of this Request for Proposal (RFP) process can be found in an article by Mr. D. F. Acenbrack, Director of Solid Waste Management for Pinellas County.[2] The result of the evaluation was the selection by the County Commission of the proposal received from UOP, Inc.

UOP, formerly Universal Oil Products Company, is an international high-technology firm with more than 60 years of experience in commercializing new technology, with emphasis on energy and the environment. In addition to resource recovery, UOP is involved in petroleum refining, chemicals and petrochemicals production, water purification, air pollution control, minerals processing, process engineering, and construction and manufacture of high-technology products.

The technology to be utilized in the Pinellas County resource recovery facility, which will be designed, constructed, and operated by UOP, is in the category known generally as mass combustion in waterwall boilers. UOP has a long-term agreement with the Josef Martin Company of Munich, West Germany, to market their extensive combustion technology in the U.S. and elsewhere.

The facility proposed for Pinellas County, and shown in the artist's rendering (fig. 1), will contain two combustion trains and will accept all kinds of residential, commercial, and nonproblem industrial wastes and process them into usable energy and marketable materials. As there are presently no suitable energy customers in the immediate vicinity of the facility site, the sole energy product will be electricity, which will be purchased by a public utility, the Orlando Utilities Commission.

Figure 2, a simplified schematic drawing, shows how the facility works. Collection vehicles, after being weighed at the entrance, drive into the processing building where they unload directly into a large receiving pit. Once unloaded, the trucks exit from the processing building and are quickly on their way.

Except for bulky wastes, the unsorted refuse is picked up by overhead cranes and transferred to the furnace-feed hoppers. Bulky refuse, including tree trunks and furniture, is first reduced in size, then processed with normal waste materials. The size reduction is accomplished with a shear-type device to get these larger items down to about a 1-foot dimension.

Part of the air needed for the combustion process is drawn from the area above the refuse receiving pit, which accomplishes two things. First, it creates a slight negative pressure, which prevents dust and odor from escaping to the outside; second, it draws airborne bacteria and dust from the pit area into the furnace where any bacteria are destroyed. Personnel working in the pit area are thus supplied continually with fresh, clean air.

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[2]Acenbrack, D. F. 1978. Tools and team expedite resource recovery project. Public Works Mag. (Oct.)

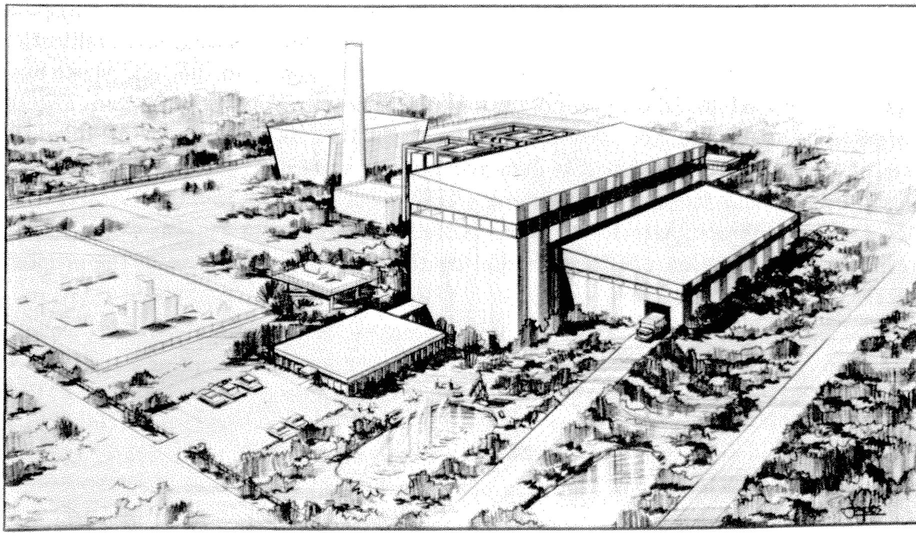


Figure 1.—Pinellas County resource recovery facility.

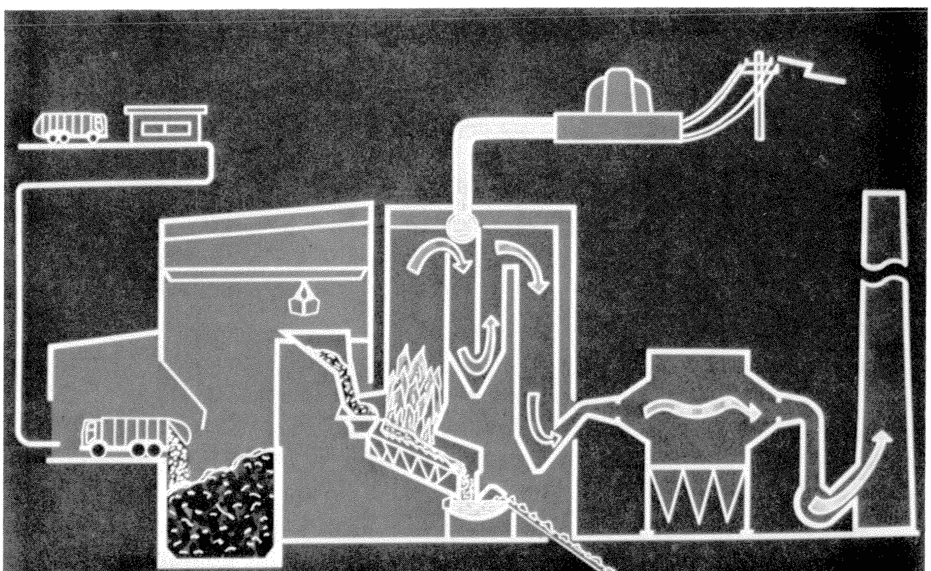


Figure 2.—UOP resource recovery system.

Once loaded into the feed hopper, the refuse passes down through a water-jacketed feed chute from which it is metered onto the stoker grate by means of hydraulically operated feeder rams. The Martin reverse-reciprocating stoker is one of the features that make this resource recovery system unique (fig. 3).

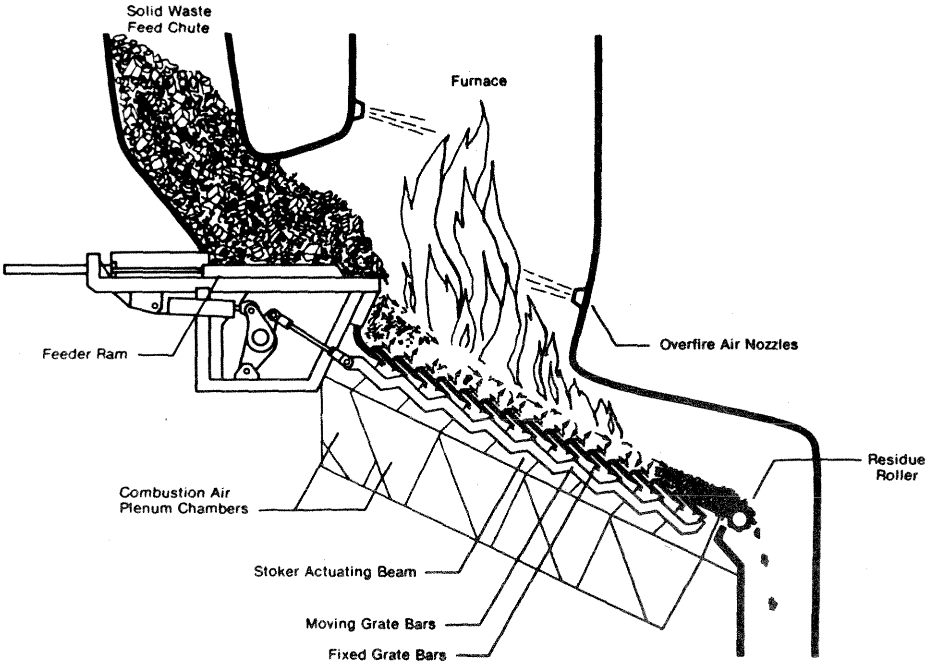



Figure 3.–Martin reverse reciprocating stoker.

As can be seen in the schematic drawing, the Martin reverse-reciprocating stoker is unlike conventional stoker designs. It is inclined downward toward the discharge end and is divided alternately into fixed and moving rows of grate bars. The moving grates push upward against the natural downward gravitational movement of the refuse. This movement agitates the burning refuse to form an even depth over the fuel bed. Burning refuse is pushed back underneath the incoming raw refuse to achieve continuous drying, volatilization, ignition, and burning. The result of this unique agitation is a uniform burnout of better than 96 percent of the combustible matter.

A series of plenum chambers underneath the stoker grate admits combustion air in volumes controlled to suit the combustion conditions of each burning zone. With the use of preheated combustion air, thorough burnout is achieved even when processing wastes high in moisture content. No manual cleaning of the undergrate plenums is required because an automatic siftings-removal system periodically sweeps the plenums.

A series of overfire air nozzles, located in the front and back of the furnace-throat area, provides maximum flame turbulence and prevents the stratification of gasses.

The speed of the residue roller is independently controllable to regulate the depth of the fuel and ash layer on the grate. The ability to control the feed rate of refuse into the furnace, to control the agitation and depth of the refuse bed on the stoker, and to control the volume and distribution of the combustion air is a key to the unmatched performance of this combustion system.

The grate bars themselves are also unique. A close-up view of the grate bars shows the 2-mm airgaps at the heads of the bars (fig. 4). These airgaps represent only 2 percent of the total-grate surface area. High-pressure combustion air passing through these gaps causes intense burning, even of dense materials like carpeting, and minimizes sifting of ash through the airgaps. The precision-ground grate bars are cast of durable chrome-alloy steel for long operational life.

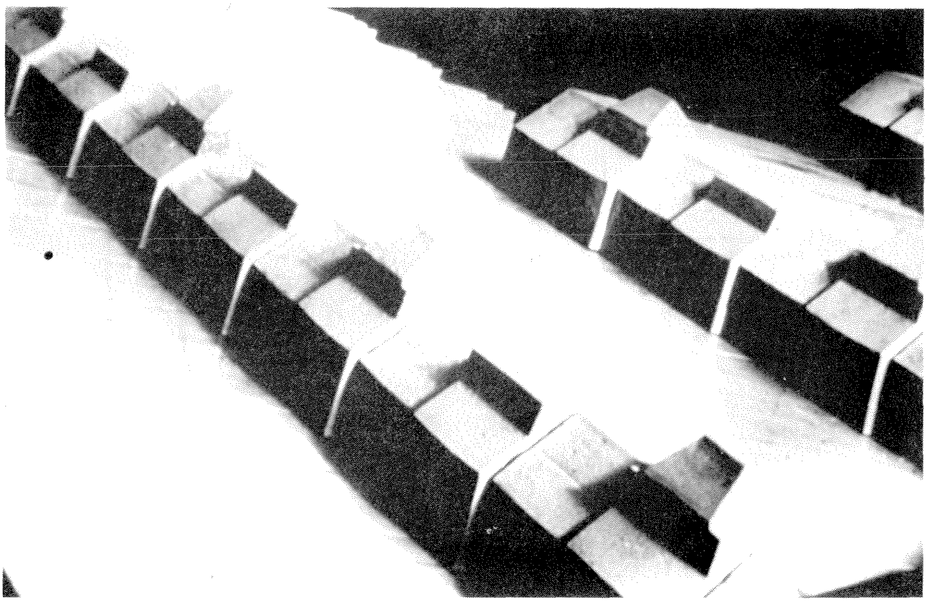


Figure 4.—Martin grate bars.

A furnace interior shows the modular approach to unit design. The stoker consists of multiple longitudinal grate sections across the width of the furnace. Larger units contain several grate sections, while smaller units contain fewer. The boiler furnace is constructed of gas-tight, continuously welded waterwalls down to the grate surface. These waterwalls are coated with refractory material above the grate surface to a height of about 20 feet. The refractory has good heat-transfer characteristics and prevents corrosion in the lower section of the furnace where high temperatures are encountered. The large volume of the furnace above the throat area is designed for low gas velocities to avoid high fly-ash carryover to the gas-cleaning equipment and excessive slagging in the boiler.

The boiler, which is integrated with the furnace, is also specifically designed for refuse combustion. Boiler tubes are arranged in widely spaced rows, not staggered, to permit effective cleaning by sootblowers and to prevent plugging of tube rows. The multipass design of the boilers reduces the particulate load into the gas-cleaning equipment as the reversal of the gas flow at the bottom of each pass causes particulates to drop out of the gas stream. The superheater is strategically located away from the radiant furnace zone in an open pass. This location requires a larger superheater surface area but has resulted in a recorded operating life of more than 40,000 hours without tube replacement. The steaming conditions at the Pinellas facility will be 615 psig., 750°F.

Combustion gases from the boiler pass through an electrostatic precipitator for removal of particulates before the gases are released to the atmosphere through the stack. This equipment is also designed to accommodate fly ash. The precipitators proposed for this facility contain three electrical fields, which will keep emissions below current standards. Provision has been made in the design, however, for the installation of a fourth field in the event that emission requirements become more stringent in the future.

The steam produced in the boiler is used to drive a turbine-generator to produce electricity for sale. A portion of the steam is also used in-house to drive some of the equipment. The whole operation is monitored from an air-conditioned central control room.

Conceptually, the UOP materials recovery system begins on the Martin stoker grate where combustible material that might hamper recovery efforts is completely burned out. The precise distribution of underfire combustion air prevents combustion "hot spots" that could damage or destroy recoverable materials.

The combustion residue is discharged from the furnace into residue dischargers. Here, the residue is quenched in water which also serves as an air seal to prevent leakage of uncontrolled combustion air into the furnace. The residue is cooled below 212°F by the quench water and is pushed, by a discharge ram, up into a draining and drying chamber. The discharged residue contains just enough moisture to control dust, which permits the use of ordinary conveyors to transport the residue to the materials recovery system.

Materials recovery, as seen in the simplified schematic (fig. 5), is essentially a series of sizing and separation processes to separate the metallic from the nonmetallic residue and to separate the ferrous from the nonferrous metals.

Bulky ferrous and nonferrous scrap is the first item separated for sale. A rotating trommel screen divides the remaining stream into two fractions, one larger than 2 inches and the other smaller than 2 inches. The plus-2-inch fraction, which is primarily "tin" cans, will pass a magnet for ferrous removal. This ferrous material is then shredded to remove surface contamination and to increase the density of the metal prior to sale.

Material less than 2 inches will also pass a magnet where small bits of ferrous metal will be removed. The remainder will be primarily aluminum, heavy nonferrous metals, glass, ash, and other inorganic materials.

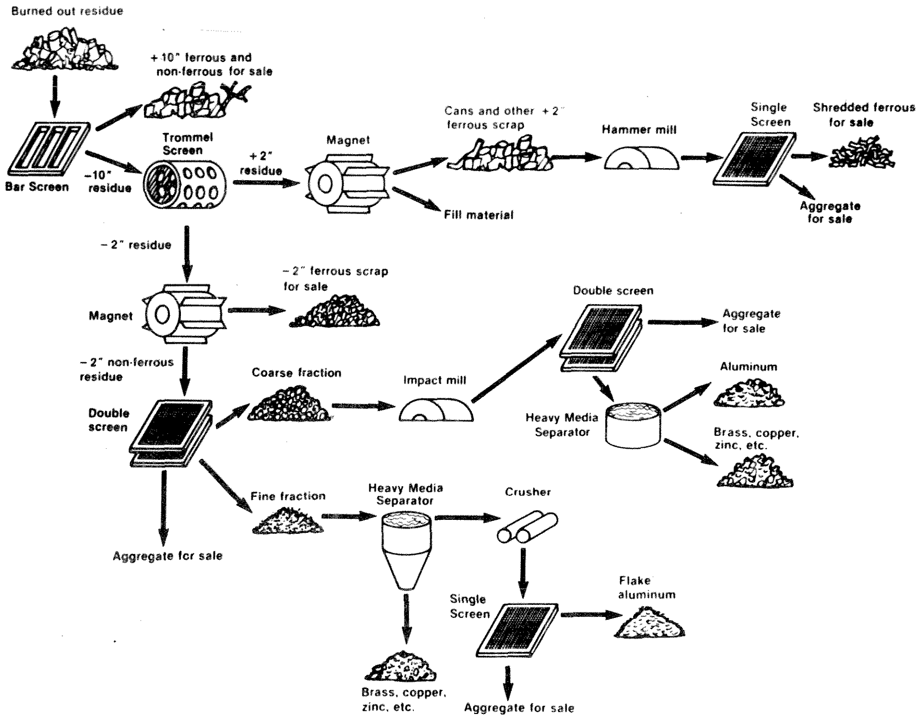



Figure 5.—UOP materials recovery system.

Additional screening will subdivide the stream into coarse and fine fractions, removing most of the glass, ceramics, dirt, and other nonmetallic particles. Aluminum and other nonferrous metals will be recovered from each fraction by heavy-media density separation. Because of the difference in specific gravity, aluminum will float, while zinc and copper alloys sink. Small aluminum particles will be crushed into recoverable flakes.

The crushed glass, ceramics, dirt, and other nonmetallic particles removed during this sizing process may be admixed with the precipitator fly ash, which is collected separately. This aggregate material may be sold and used as supplemental aggregate in asphalt paving mix, in roadbed construction, as landfill cover, and as fill for land reclamation.

After recovery of metals and aggregate material, the remaining stream will consist primarily of larger stones, bricks, and similar noncombustible and nonmetallic objects. This stream will generally be the only residue. Although it may have value as clean fill, it will usually be disposed of in a landfill. This process residue will represent about 1.5 percent, by weight of the incoming raw solid waste.

The Pinellas County facility will operate 24 hours a day, 7 days a week. Each of the two combustion units is scheduled for shutdown for inspection and maintenance twice a year. The plant's 50 MW turbine-generator is scheduled for shutdown and inspection every 3 years.

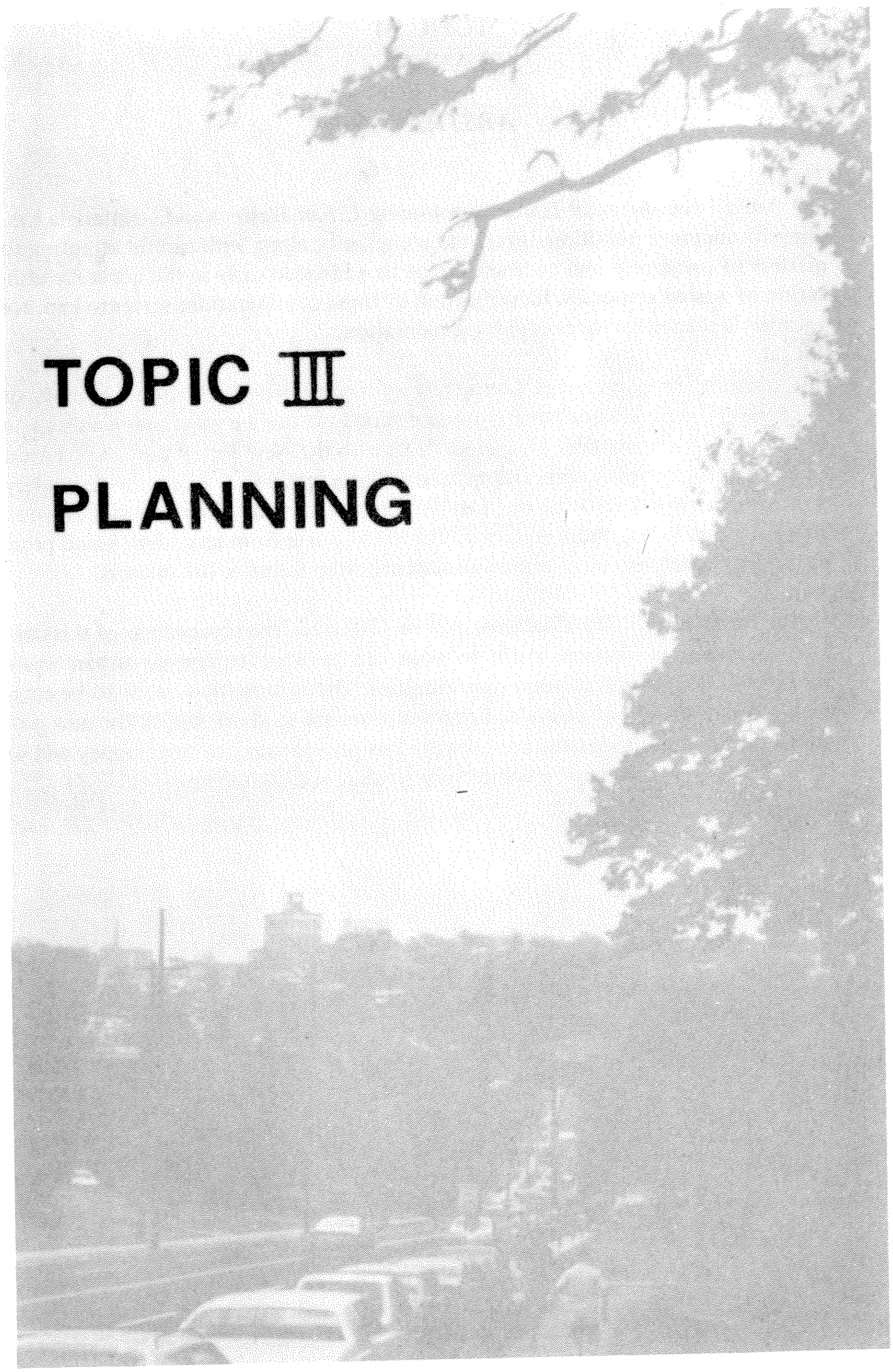
To minimize use of potable water, a precious commodity in Florida, effluent from a tertiary water treatment plant will be used in the cooling towers of the resource recovery facility.

The resource recovery plant will be centrally located within the county for service to all county communities. UOP has allocated funds for landscaping and site beautification so that the facility will be attractive.

Applications for required Federal and State permits covering air emissions and powerplant siting have already been filed. To bring the project to fruition, a number of contracts must be negotiated, including contracts for the construction and operation of the facility and for the transmission and sale of energy, all of which must be completed before the bonds for the plant can be sold. After reviewing both public and private ownership options, the county has decided that it prefers to be the owner of the facility.

Once the bonds are sold, the county will notify UOP to proceed with construction. Thirty-two months later, the Pinellas County resource recovery facility should be ready for startup. Raw solid waste will then be converted into clean energy and materials.

Pinellas County is far ahead of most other urban communities with its solid waste program. By working together, its citizens and officials are turning their solid waste problem into a solid solution.


TOPIC Ⅲ
PLANNING

## TOPIC III
## PLANNING

### *ABSTRACTS*

WHITMER

*Legal and Environmental Issues Surrounding Urban Waste Wood.*—Materials handling to minimize pollution, litter, and complaints, along with careful attention to matters of ownership and contracts, must be addressed early in the quest for utilization of wasted resources. Identification of these considerations serves to improve a project's chance for successful implementation.

LEMPICKI

*Coordinating Producers and Consumers of Urban Wood Residues.*—Sources of urban wood waste are both numerous and varied, so finding ways to use this waste can be a complex problem. This paper deals with the New Jersey Bureau of Forest Management's program concerning wood waste generated from the secondary processing of wood, locating the manufacturers, estimating their volumes of wood waste, and marketing these materials. The wood waste from secondary wood processors is a collectively large source of material often found in urban areas.

PARDO

*Urban Waste Wood: The Challenge and the Future.*—The proceedings of this conference present a valuable guide to what can be done to convert urban waste wood problems into utilization opportunities. The information needs to be communicated as widely as possible. Federal dollars are in short supply for new programs, but if these programs are presented as proven ways to save money and to lower costs, Congress may be willing to buy what you are selling.

# LEGAL AND ENVIRONMENTAL ISSUES SURROUNDING URBAN WASTE WOOD

George L. Whitmer[1]

*Abstract.*–Materials handling to minimize pollution, litter, and complaints, along with careful attention to matters of ownership and contracts, must be addressed early in the quest for utilization of wasted resources. Identification of these considerations serves to improve a project's chance for successful implementation.

## INTRODUCTION

Many aspects of waste wood management are identical to reuse or disposal of municipal solid waste. In fact, one might envision that processed garbage or baled wastepaper might compete with wood waste in the marketplace. The purpose of this presentation is to call attention to several technical and nontechnical considerations which are shared by waste utilization programs.

Legal and environmental issues cannot easily be separated, for failure to recognize one aspect would tend to have a great impact on the other. One consideration in particular, ownership, has the potential to influence a program's financial risk.

Waste wood occurring naturally in a forested area becomes a part of the ecosystem. It not only presents no environmental problems other than fire hazard but is utilized by insects and forest animals and recycled through the forest itself. Waste wood occurring in an urban area presents an entirely different set of circumstances. In most cases, waste cannot be allowed to remain where it occurs. It requires transportation to another site to be disposed of or to receive further processing. Stumps, limbs, or demolition debris present an operational problem at disposal sites. Most waste wood in urban areas is not the result of natural occurrences but results from land clearing, construction and demolition, and other activities.

Nature provides a solution for waste wood in the natural environment. It is not an instant solution, but we cannot argue with the results; however, once we alter natural processes, it is then up to us to provide solutions for the problems we create.

Waste wood presents a handling problem at any land disposal site. In Georgia, the Environmental Protection Division (EPD) recognizes two types of approved disposal sites: the sanitary landfill for putrescible (rapidly decomposable) waste, which requires daily cover, and the landfill for nonputrescible (demolition debris, wood waste, etc.) waste, which requires monthly cover. Waste wood normally goes to landfills since it does not decompose rapidly. It presents a handling problem in either type of site though. Much of it will not compact (tree stumps, logs) and presents a hazard to the equipment operator when mixed with other refuse. A large stump or log is capable of upsetting a piece of landfill equipment. This type of material also takes up valuable

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space in the landfill because it does not compact well. More cover material is required to cover logs, stumps, and limbs because the air spaces around them must be filled. With the rising cost of land and suitable cover material, these important factors will become even more critical.

Site supervisors have the authority under State law to refuse any waste at a site where acceptance of the material might cause a problem. This stipulation is for the purpose of protecting site operators from hazardous materials. It may also be applicable to waste wood, especially logs, if the supervisor feels that his site is filling up too rapidly or that the wood might constitute an operational problem or be hazardous to his personnel or equipment.

It becomes clear that, while protecting the site operator from hazards and preventing overutilization of site space, waste wood that is refused admittance to a site continues to be a disposal problem.

Control over the burning of waste wood is the responsibility of the Air Protection Branch of the EPD, along with local fire and forestry officials. Permits may be issued, under certain circumstances, for existing conical (teepee) burners, land-clearing debris, and tree and limb debris resulting from ice or wind storms. In many cases, permits for the burning of land-clearing and storm debris are a local option. However, in counties with a population greater than 65,000, burning of land-clearing and storm debris is prohibited unless adequate disposal facilities are not reasonably available. Burning is permitted in this case, except that no open burning of more than 100 cubic yards per day of land-clearing debris is permitted unless the person performing the burning has first given 2 days' notice of the time and place of the burning to the Director, EPD.

Air curtain destructors may be permitted for burning of brush and small limbs. This practice has in some cases led to air pollution problems due to burning of unauthorized waste.

## ENVIRONMENTAL CONSIDERATIONS

The air in urban areas already contains high quantities of air pollution from vehicle emissions, industry, and coal-fired boilers. Burning of waste wood adds unnecessarily to the already overburdened air in major urban areas and has led to the tightening of restrictions placed on obtaining a permit for open burning of land-clearing and storm debris. Accidental burning of waste wood through acts of nature or carelessness also contributes heavily to the urban air pollution problem. Accidental burning or deliberately set illegal waste wood fires may become a problem following a wind or ice storm. Variances of open burning restrictions may be issued by regulatory agencies.

Waste wood also has the potential for causing water pollution. This water pollution may take the form of floating or partially submerged debris in rivers, streams, and lakes. In this form, it poses a hazard to persons skiing, swimming, or fishing in recreational areas. Water pollution may also take the form of tannic acid leaching into bodies of water from certain types of waste wood. Tannic acid may not be an environmental problem as it is a natural phenomenon in forested areas; however, tannic acid would be a problem if leaching from a tremendous amount of wood waste were to occur in a small body of water. Also, as tannic acid can cause darkening of water, it may have a negative impact, esthetically, on bodies of water used for recreational purposes.

With the increased cost of natural gas and fossil fuels, wood is becoming an attractive alternative. Wood chips are being used by many industries as boiler fuel to generate process steam. Any industry switching from natural gas or fossil fuels to wood chips or a combination of fossil fuels and wood chips must advise the State Air Protection Branch of the change. Very strict emission controls are required; it is possible that the emission control equipment may have to be altered, or the permit for operation of the boiler may have to be amended. A significant increase in the amounts of fly ash, sulfur dioxide, other particulates, or smoke opacity would require a change in the emission control equipment.

The pulp and paper industry is utilizing much wood waste as fuel. One particleboard company in south Georgia utilizes sander dust as fuel, creating an ash which must be disposed of. Sander dust used in the boilers creates an ash slag; the boilers are blown out four times a day, and there is one day a week for boiler cleaning. During this day, a chemical is added to the boiler walls, hardening the slag so that it may be chipped off. In these sander-dust burners, soft slag puddles at the bottom; all of the slag and ash is presently landfilled.

Another company using a hogged fuel boiler had its ash analyzed for nutrient content. The result was that it did not contain high enough percentages of minerals to offset the hauling expense to a fertilizer company. Recovery of the ash material from this plant would probably be economically feasible if a fertilizer plant were located close by. This plant landfills its ash at the present time.

An Atlanta company that buys fly ash for use in fertilizer and cement purchases the ash from coal but none from wood; the reason for this is that coal fly ash is generally consistent, while that from wood burning is extremely variable. Wood ash varies from source to source, depending on equipment, mixture of fuels, type of supplemental fuels, geographic location, mixture of softwoods and hardwoods, handling procedure, and types of environmental controls used. The company, however, is very interested in the utilization of wood ash and is presently doing research on it.

If large quantities of wood chips, bark, or sawdust are stored outside, certain problems could arise. As mentioned earlier, the leaching of water through this material could cause tannic acid to enter the groundwater and, ultimately, nearby ponds or streams. The storage area could be considered an eyesore by nearby residents who might complain to local officials. Zoning regulations and local nuisance ordinances should be researched beforehand in order that problems of this nature can be avoided.

The major environmental consideration in the transportation of waste wood is litter. The Georgia solid waste law does not specifically require that trucks be covered, but it does require that vehicles be loaded and moved in such a manner that contents will not fall or spill, and it states that vehicles be covered "when necessary" to prevent blowing of material from the vehicle.

## LEGAL CONSIDERATIONS

RCRA and the Georgia Solid Waste Management Act do not specifically address the ownership of waste. Waste handling is a local governmental trust in most cases, and ordinances establishing ownership of waste are generally passed by the city or county. Normally, this will not affect waste wood if it is a material of no fuel value and is merely a disposal problem; however, when this waste material becomes a commodity—has a monetary value—then the legal problem of ownership comes into focus. Communities that have instituted curbside newspaper, glass, and aluminum can recycling programs have had to deal with this problem. Residents would place their garbage at curbside for pickup and disposal; at the same time, they would place bundled newspapers, bagged aluminum cans, and glass at the curbside for pickup and placement in separate compartments of the garbage truck or in separate trucks for recycling. Problems developed when scavengers would precede the garbage truck and pick up the recyclables for sale themselves. Local ordinances had to be passed providing that anything placed at the curbside by the resident was the property of the city.

If a city were selling its waste wood to a mill for use as fuel in its boilers, this wood would then be a commodity. An ordinance would be needed to prevent local entrepreneurs from collecting and selling the waste wood fuel themselves and thus preventing the city from collecting the revenues generated by it.

Military installations sell their waste wood through their Defense Property Disposal Offices. The military considers all waste as government property and has complete ownership of it. Waste wood—wooden crates and boxes, pallets, land-clearing debris, demolition and construction debris—is sold by the lot on a competitive bid or by the truckload by retail sale. All waste wood has to be paid for before it leaves the military installation.

In selecting a market for and obtaining a contract to buy or sell waste wood, a number of elements must be taken into consideration. Most city and county governments in Georgia do not allow for contracting beyond a 1-year limit or beyond a current administration. This, of course, has made it almost impossible for cities and counties to contract with recycling companies to take scrap material. Many scrap companies would have to make an investment in the form of collection, transportation, or processing equipment to enter into such an agreement and would not be interested in less than a 5-year contract. Exceptions are companies that already recycle such materials as scrap metal, newspaper, corrugated board, and glass. They would require no additional investment to enter short-term contracts. Contracting for any type of waste to be used as a fuel generally requires extensive alteration or construction of boilers and conveying equipment and would require a long-term contract.

Subtitle D of RCRA, under requirements for approval of state solid waste plans, requires all state plans to provide that local governments can no longer be prohibited from entering into long-term contracts for the supply of solid waste to resource recovery facilities. This provision would pertain to wood waste which is to be used as a fuel.

In any contract, provisions should be made for the amounts of allowable contaminants in waste materials. There are strict requirements on contaminants and different grades of scrap metal and waste paper; waste wood types also have this problem, as anyone buying bark for use as fuel can attest. Sand is a major and unavoidable contaminant in shipments of bark; there should be an allowable level which, if exceeded, would cause a shipment to be rejected. It is amazing how much scrap metal and other unwanted material tends to turn up in bark shipments.

Contracts should state insurance limits and which party is liable if damage to equipment occurs from contaminated shipments. Metal in a shipment of bark could cause damage to shredding equipment, or bark containing too much moisture might cause boiler corrosion. Liability insurance for personal injuries should be stated in a contract.

Method of payment should also be clearly stated. Military installations require payment for any scrap before it leaves the installation. Other industries are allowed to transport material to their plant, where it is weighed, and payment is then issued. Some contractors buying ferrous metals or aluminum are allowed to transport mixed loads of scrap to their plant, run it through a magnetic separator, and pay according to the amounts of ferrous and nonferrous materials delivered. Payment should be specified as to load, ton, or cubic yard.

A contract should specify minimum and maximum volumes, particularly if the waste material is to be used as a fuel. The industry buying the fuel has a minimum volume that can be utilized in order to maintain operations. The contractor's failure to deliver the minimum volume could jeopardize plant operation. There may also be a problem of receiving too much fuel at the industry if adequate storage area does not exist.

Provisions should be made in the contract for downtime on the part of the fuel user. Boilers and burners will have scheduled downtime for maintenance. During this time, the contractor will still be generating waste wood fuel, and the contract should stipulate where the fuel will go during these downtimes. The same is true for unscheduled maintenance or repair. Many plants have built-in redundancy so that they can remain operating during unscheduled shutdown of the main boiler.

If the ash cannot be utilized, contractual arrangements must be made to dispose of it. If the ash can be used in fertilizer or cement, then additional contracts will be needed between the generator and the buyer; these contracts should specify minimum and maximum volume, type of payment, number and type of contaminants allowed, liability and insurance. The U.S. EPA is currently writing guidelines on the use and disposal of ash; these guidelines also will have to be considered.

## SOCIAL AND POLITICAL ASPECTS

Finally, there are certain social and political aspects that must be taken into consideration with respect to waste wood or any other waste.

Local governments have the authority to issue business licenses and to control zoning laws. Any industry changing from one type of fuel to a mixture of that fuel and waste wood (or any other type of waste material) may encounter some opposition from the local zoning board. Also, an industry wanting to locate in an industrial park and burn a waste for fuel may find it more difficult to get zoning approval or a business license.

Whenever waste material is hauled, whether for fuel, recycling, or disposal, there are going to be complaints. Care should be taken to provide that trucks are properly covered to prevent littering. If possible, trucks should be routed to avoid use of residential streets, which will help prevent complaints about noise, dust, damage to streets, and danger to children. If citizens feel that a facility is emitting too heavy a smoke plume, it, as well as governmental regulatory agencies, will get complaints. Citizens may also complain if they think water leaching through the waste material is getting into nearby water.

A tremendous amount of waste wood occurs from ice storms, hurricanes, and tornadoes. We have already discussed what this extra volume does to the capacity and operation of disposal sites. Some contingency methods should be available to handle this extra waste wood. Limb and tree shredders and chippers are good methods of dealing with this situation. The resulting shredded material may then be used as compost or decorative mulch.

The subject of public relations has been left for last but not because it is least important. It is imperative that any new procedure be preceded by an extensive public relations campaign. If a facility is planning a switch from a conventional fuel to burning waste wood or any other waste, the citizens should know why. They should be told that it will conserve natural resources, that emissions will continue to meet environmental standards, that it will contribute to the longevity of their disposal sites, and that the operation will be clean. A properly informed public will be more apt to welcome the facility as a good neighbor. In fact, good public relations—backed up with a good operation—may be a facility's most valuable asset.

# COORDINATING PRODUCERS AND CONSUMERS OF URBAN WOOD RESIDUES

Edward A. Lempicki[1]

*Abstract.*–Sources of urban wood waste are both numerous and varied, so finding ways to use this waste can be a complex problem. This paper deals with the New Jersey Bureau of Forest Management's program concerning wood waste generated from the secondary processing of wood, locating the manufacturers, estimating their volumes of wood waste, and marketing these materials. The wood waste from secondary wood processors is a collectively large source of material often found in urban areas.

## LOCATING MANUFACTURERS

Companies that use lumber to manufacture wood products often locate in or near urban areas because they are near a large labor supply, are accessible for receiving and shipping materials, and are near markets for their products. Consequently, the secondary processors of wood are concentrated, as are their wood wastes.

To locate and identify these wastes, one must first locate the manufacturers. If no directories of these processors are available, one must be compiled. In most states, the sources of information for such a directory include the Lumbermans National Redbook Service, Dun and Bradstreet listings, and state industrial directories.

A questionnaire can be used to update listings and gather more detailed information. It might include requests for information on the type of raw material used (such as lumber, bolts, plywood), species of wood and amount of wood used annually, products manufactured, estimated amount of wood residue and the percentage used at the plant, and the difficulty of disposing of wood residues.

The New Jersey Bureau of Forest Management constructed such a questionnaire and mailed them to woodworking firms throughout the State (fig. 1). According to the Bureau's survey, there are approximately 1,500 wood-product-manufacturing firms in New Jersey. The responses were organized into product categories, and the location of each company was pinpointed on a State map to give an overall view of area workload. It showed a great industry concentration in the highly populated northeastern section of the State and other clusters around smaller urbanized areas of the State. A direct relationship between population density and location of secondary wood-processing companies was evident. With this information gathered, companies were contacted concerning materials generated as waste from product manufacturers.

## ESTIMATING RESIDUE VOLUMES

Residues from the secondary manufacture of wood products fell into two broad categories: dimensional waste such as rippings, cutoffs and rejects; and fine material such as sawdust, shavings, and chips.

[1]Utilization and Marketing Forester, New Jersey Bureau of Forest Management, CN 028, Trenton, New Jersey 08625.

Company Name: ____________________ Address: ____________________
Person to Contact: ____________________ Phone: ____________________

1. Please note the product(s) made (from wood):
____________________ ____________________
____________________ ____________________

2. What form of wood raw materials do you use? Please check.

| | | |
|---|---|---|
| ____ Blanks | ____ Precut or Dimension Stock | ____ Post |
| ____ Blocks, Cants or Flitches | ____ Lumber | ____ Roundwood |
| ____ Composition Board | ____ Moulding | ____ Veneer |
| ____ Fiberboard | ____ Piling | ____ Other |
| ____ Hardboard | ____ Plywood | (Please specify) |
| ____ Particleboard | ____ Poles | ____________ |

3. Approximately what quantity of the following species do you use? Please indicate by percentage.

| | | |
|---|---|---|
| ____ Ash | ____ Soft Maple | ____ Balsam Fir |
| ____ Basswood | ____ Sycamore | ____ Western Fir |
| ____ Beechwood | ____ Red Oak | ____ Eastern Hemlock |
| ____ Birch | ____ White Oak | ____ Southern Pine |
| ____ Cedar | ____ Walnut | ____ Western Pine |
| ____ Cherry | ____ Yellow-Poplar | ____ White Pine |
| ____ Hickory | ____ Mixed Hardwoods | ____ Eastern Spruce |
| ____ Hard Maple | ____ Tropical Woods | ____ Mixed Softwoods |

Other (please specify) ____________________

4. Please indicate your annual requirement of wood, according to your method of measurement.
Board Feet ____________ Cords ____________
Square Feet ____________ Tons ____________
Linear Feet ____________ Other ____________

5. What residues are produced in your operation(s) that are currently going unused? Please check.

| | | | |
|---|---|---|---|
| ____ Bark | ____ Cores | ____ Sawdust | ____ Rippings, Cutoffs |
| ____ Chips | ____ Excelsior | ____ Shavings | ____ Wood Flour |

____ Other (Please specify) ____________________

6. Annual Wood Residue Volume and Method of Disposal.
Wood Fines (sawdust, shavings, etc.) ______cubic yards or tons
Dimensional Waste (ripping, cutoffs, etc.) ______cubic yards or tons
Method of Disposal ____________________

7. How many personnel are in your firm? ____________________

8. Please check, if you desire a copy of this directory ____________

9. Comments:

Figure 1.—Secondary wood-using industry survey.

The amount of waste produced depends on the product being manufactured, the volume and quality of raw material used, and the efficiency of production. The range in amount of waste can be wide—from less than 5 percent to more than 50 percent of the raw material. In the manufacture of floor trusses, the waste might be about 5 percent of the volume of raw material but 50 percent for wood shoe heels.

Collectively, the industry was having great difficulty with these waste materials. Most of it was being contracted for landfill disposal at substantial cost to the producer.

An estimated 20 million cubic feet of this material were disposed of in this manner annually. This is not only a costly burden but also a tremendous waste of a resource.

Specific information must be obtained on residue type, production, and availability. The only accurate way to obtain volume information is by measurement, but most companies know the volume of residues produced over a period of time in general terms—by a hopper, container, or truckload. Normally, wood fines and dimensional waste from a particular producer must be categorized separately.

In the case of wood fines, the important factors concerning marketability are species, grade, particle size, moisture content, quantity, and storage capacity. Samples of the material should be collected and specifically identified in these terms for future reference. Dimensional waste, rippings, cutoffs and product rejects are more difficult to define accurately. Quite often a range of dimensional material is normally generated. Basically, this material may be grouped into broad categories with average sizes noted. Often only a portion can be marketed, so separate information must be obtained for each category. Samples are required since this material is often difficult to describe accurately.

## MARKETS FOR RESIDUES

A particular residue must not only fit a specific use but must also be produced in sufficient quantity to allow marketing on an economically sound basis. Hence, available markets must be investigated as thoroughly as the producers; information is needed on material specifications, volume requirements, and the buyer's shipping, receiving, and storing facilities.

While markets for residues are as numerous and varied as the producers, the major markets for dimensional waste include the shipping industry (for storing and bracing), other secondary processors, landscapers and nurserymen (for stakes), and the residue dealers and companies that use the wood fines in a variety of products.

There are wood-residue companies located in New Jersey that collect, store, refine, package, and deliver sawdust, shavings, chips, and other forms of wood residues to a multitude of markets. Sawdust, for instance, has a variety of applications; sweeping, absorbent and cleaning compounds, animal bedding, metal polishing, and wood fines for plastic and rubber processing are just a few uses. The average residue dealer in New Jersey handles about 8,000 tons of wood fines per year. On a cubic-foot basis, this equals roughly 1.5 million cubic feet of material, or enough fines to fill 700 large tractor-trailers. The Bureau has been working with these residue dealers and other demand sources and has had substantial success in diverting material from landfills to more productive uses.

Utilization possibilities exist not only for wood fines but also for rippings, cutoffs, and product rejects. This kind of material is the common result of sizing and shaping lumber for product manufacture. Through our visits, we found that one company's dimensional residues may well be acceptable as another manufacturer's raw material. Companies producing the same products generate residue types that are essentially the same; however, those manufacturing entirely different products tend to create utilization possibilities. Experience has shown that most often a particular company's entire dimensional residue production cannot be recycled to another manufacturer for reuse.

Usually, a portion of this material has potential—a particular cutoff-size range or all rippings larger than a specified minimum width. The important point is, however, that data must be obtained for the entire range of dimensional residues generated.

## SUMMARY

The wood-using industry has accepted the Wood Residue Utilization Program and is cooperating well. The residues generated from product production come in many different forms and can really be thought of as a resource, every bit as renewable as trees themselves.

The problems and pitfalls of recycling wood residues are many. Raw material sources must first be located; locating must be followed by an on-site survey, something which requires a great deal of time and effort. Actual samples of material from specific sources are needed since use is usually rather specific, and wood residues, especially those generated by wood-product manufacturers, are quite variable and difficult to describe accurately. Also, the material seems more attractive to a potential buyer if it can be seen and possibly tried for use.

Experience has shown that waste wood must really sell itself. One must first have something that a potential buyer can use. Not only must it be acceptable for a specific use or product, but it must also be available at the right price. Further, waste wood involves a certain cost for storage, handling, and transport. Economics is ultimately the deciding factor and most often the real incentive to both residue producer and user. There is a wide range of uses for wood residues both inside and outside of the wood-products industry, and most of this material need not be a burden.

# URBAN WASTE WOOD: THE CHALLENGE AND THE FUTURE

Richard Pardo[1]

*Abstract.*–The Proceedings of this Conference present a valuable guide to what can be done to convert urban waste wood problems into utilization opportunities. The information needs to be communicated as widely as possible. Federal dollars are in short supply for new programs, but if these programs are presented as proven ways to save money and to lower costs, Congress may be willing to buy what you are selling.

This Conference has been a real learning experience for me, and I want to commend the people who put the meeting together and each of the speakers for a job well done. The Proceedings of the meeting will be a gold mine of valuable information and ideas in an area that so far has gone almost unnoticed.

Let me begin with a few words about the American Forestry Association for those of you who may not be familiar with AFA. We are neither a trade association nor a professional society but are a citizen conservation organization. Membership is open to anyone. We are perhaps best known for our monthly magazine "American Forests." Our primary role is conservation education: informing the public about the broad spectrum of forest-land management opportunities and issues. We are communicators at AFA, which is one reason why I am excited by what I have heard here at this conference. The information presented here is specific, practical, and tremendously useful. Now it needs to be communicated.

Are we really talking about problems, or are we also talking about opportunities? One man's problem can be another's opportunity. Perhaps what we really have is a problem of communication–communication between the person with the waste wood and the one for whom that wood may be an opportunity.

With that thought in mind I want to begin by taking a quick look back at the last 2 days to see whether our speakers were talking about problems, or opportunities, or about turning problems into opportunities.

Ken Cordell began by setting the stage with an overview of the urban waste wood situation.

Steve Dennison followed with a discussion of one solution to the communications problem: Fibrest, a computerized inventory program. Certainly this is a key element in bridging the gap from problem to opportunity. He noted that so far we have failed to apply either modern management or modern technology to the disposal of urban wood waste.

Tommy Loggins was next with a description of another part of the inventory process: the landfill survey made by the Georgia Forestry Commission in Atlanta,

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which clearly showed that a large volume of usable wood was being discarded. Here, again, was an effort to identify a problem which could be turned into opportunity.

George Whitmer was next, with a discussion of the legal problems involved in waste wood disposal and utilization. I was particularly glad that he mentioned the value of public relations in these kinds of programs. It is important to let the public know what you are doing. This aspect is often overlooked unless the public is somehow directly involved in the program.

Millard Davis discussed the difficult problem of source separation. He warned not to tie your waste wood program to other recycling efforts such as waste paper or aluminum. If those fail, for any reason, your waste wood goes down with them.

Dave DeVoto spoke next. He described the ups and downs, the successes and failures, in trying to deal with a massive problem of urban waste wood from Dutch elm disease in the Minneapolis-St. Paul area. There was no question which this was; it was a problem that needed a solution, and this is a case-history worth documenting.

Dave Walker then talked about the other side of this same coin: how at Georgia Tech they were able to set up a program to use wood resulting from a natural disaster and save the school some $10,000 by turning the problem of wasted trees into usable mulch.

Ed Lempicki followed with a description of still another opportunity from waste wood, describing how tree contractor Sam Willard saved disposal costs and turned expense into income by operating his own specialty sawmill to convert waste urban trees into specialty wood products. As the saying goes: if you get a lemon, make lemonade.

The next speaker, Jim Commins, described the urban demolition and construction wood survey conducted by his company and the way in which they were using these woods for landfill and productive use. He said that there is a market out there because the supply is almost everywhere, costs of competitive materials are rising, solid waste laws are getting tougher, and attitudes of municipal officials are changing for the better.

Jay Lowery focused on the fuelwood situation, with an example of how the disposal problem was converted into a utilization opportunity in Atlanta with the institution of public fuelwood dumps. And he predicted that more of this material will be converted into salable chips in the future.

Alex Cobb described one method of fuel preparation, the use of a hog. He obviously feels that urban waste wood is an opportunity since he concluded that he is in the right business at the right time. He also provided us with some examples of the various products and uses for hogged waste wood.

Jack Howard spoke next, describing the functions of a broker in the process of turning one man's waste product into another's raw material. Here was the voice of experience. He described several ongoing activities in which he is engaged, and he set out a step-by-step procedure for marketing wood residues.

John Sturos described some of the research projects being carried out at Michigan Tech to improve utilization technology, including a detailed slide and film description of an innovative vacuum system to separate usable materials from whole-tree chips.

Jim McMinn took a close look at the wood energy picture and suggested that the problem may be not how we dispose of urban waste wood but rather how we can get more of it. He pointed out that not every situation is right for converting waste wood to wood energy but that in some areas the potential is great and growing.

Gloria Mills presented a fascinating description of how Pinellas County, Florida, will be creating energy from municipal waste, with a highly sophisticated and technologically advanced waste conversion plant.

Ed Lempicki took the podium for a second time to describe how he and his New Jersey colleagues are serving the brokerage function in their State by bringing waste products together with waste users to turn problems into opportunities.

Which brings me back to my starting point: do we have a problem, or are these really opportunities that need better communications to be realized?

Frankly, I would not look to Washington at this time to finance the kinds of things that we are talking about here. The federal budget is tight, new programs are not being considered because of inflation and, as the previous speaker said, few people in Washington know there is a problem of urban waste wood.

My advice to you is not to go to Washington and say that you have a waste wood problem. Instead, go to Washington and tell your Congressmen how *you* can help *them*. You have the examples of what has been done and what can be done. You have a solution, not another problem.

I have a feeling that if we can get the word out on the potential savings or profits that you have shown are possible, the people in Washington may begin to pay attention.

I would encourage you to be evangelists in the cause of turning urban waste wood problems into opportunities. In other words, keep on doing what you have been doing. There must be hundreds of municipal foresters, solid waste managers, politicians, tree companies, wood users, and homeowners who would be delighted to know that things can be done, that the technology exists, and that although you may not make a profit, you certainly may save a dollar.

We will do our best at AFA to help you spread the word.

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Included in the Conference Proceedings are five papers on the resource situation, nine papers on possibilities for utilization, and three papers on planning.

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