23 Forest Resources for Producing Energy

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The prospects for using more forest wastes for energy production are becoming noticeably better in the United States. More and more wood-burning boiler installations are being placed in forest products' manufcturing plants, and other industries and institutions are planning to burn wood fuel. For example, a school district in Grand Marias, Maine, has converted from burning fuel oil to wood waste; and a utility in Burlington, Vermont, has recently passed a bond issue to finance a 50 MW generating plant using wood fuel. Many rural homeowners are avoiding high fossil fuel costs for domestic heating by burning wood.

Residues are the most promising near-term source of wood fuels, although other sources, particularly fuel plantations and forests managed for multiple products including fuel, could be more important in the long-term.

WOOD RESIDUES

Wood residues that are or could be used as fuel include mill residues, logging residues, noncommercial timber, dead trees, cull trees, and precommercial thinnings from timber stand improvement.

Roughly 80 percent of wood residues, and 60 percent of bark residues from primary manufacturing (excluding pulp and paper manufacturing) were used in 1973. These mill residues are used for paper, fiberboard, and particleboard manufacture, as well as fuel. However, there are still about 20 million ovendry tons of wood and bark that are generated, which are unused each year. The South probably has the largest volume of unused mill residues.

Residues in logging operations include wood, bark, and foliage from growing stock, nongrowing stock, and uncut, small or undesirable trees. Removable logging residues from harvesting operations, together with

dead and cull trees, is estimated to amount to 145 million dry tons per year.

Another tempting source of wood is noncommercial timber. Total inventory of noncommercial timber is around 1,000 million tons. The annual increment from small noncommercial timber, and excess growth over cut, is estimated to be 230 million dry tons. In addition, about 20 million tons of soft woods and hardwoods are removed annually in the United States for such operations as timber stand improvement, land clearing, and changes in land use.

A further source of wood fuel is the urban forest. Municipal discards include significant quantities of dead shade trees, demolition waste, and used pallets. It is conservatively estimated that wood wastes and tree removals in urban areas amount to 70 million dry tons of material annually.

An estimate of unused wood from these sources is summarized in table 23.1. The total potential of 485 million dry tons annually would be equivalent to 8.3 x 10^{13} Btus. of energy (8.3 Quads) or 1.5 billion barrels of oil. If we assume that one-half of the 8.3 Quads could be made economically available, this is about 4.1 Quads, or 700 million barrels of oil. This compares to the current usage of wood for fuel to provide 1.1 Quads annually. (Table 23.2). The total of 5.2 Quads with the increase of 4.1 Quads would provide about 7 percent of our total National needs, if markets for the fuel were developed.

Forests might also provide wood fuel through intensive culture of biomass plantations. Forest Service research has shown that intensive culture can increase biomass yield five- to tenfold over conventional plantations and highly productive natural stands. The concept is dependent on development of hybrids with fast growing characteristics. For instance, stands of trees which normally produce about $1^1/_2$-2 dry tons per acre per year in the colder parts of the country, could be converted to high growth stands and produce 8-12 tons per acre per year. In the South, higher growth is possible. The highest production rates are dependent upon optimized conditions of nutrients, water, and spacing. Possibilities for using waste such as pulpmill effluent as an irrigating medium are also being invested.

However, there are economic, space and ecological considerations which will always limit the practicability of fuel plantations. In economic terms, wood for fuel is always likely to take second place to its other uses; and to keep an average steam-electric plant going would require 300 square miles of growing space to supply the necessary wood fuel. Ecological considerations, such as the effect of harvesting large areas of land on watershed, wildlife, and esthetics, have yet to receive widespread comments from the public. Therefore, collecting residues from land harvested for other products seems more feasible than fuel plantations.

Table 23.1. An Annual Estimate of Unused Wood

	Million Dry Tons
Forest	
1. Excess Growth and Small Noncommercial Timber	230
2. Logging Residues, Mortality, and Cull Trees	145
Urban	
1. Tree Removals and Wood Wastes	70
Other	
1. Forest Products Industrial Waste	20
2. Waste Wood from Land Clearing	20
Total	485 (equivalent to 8.3 Quads)

Source: Based on resource data from The Outlook for Timber in the United States, Forest Service, USDA, FRR no. 20, July 1974.

Table 23.2. The Estimated Significance of Wood to the National Energy Budget

Item	Energy Equivalents Quads	Energy Equivalents Million Bbls. Oil
1. Contribution of Wood for Energy if we Assume that One-Half of the 8.3 Quads Could Be Made Economically Available. (See Table 23.1)	4.1	695
2. Current Use of Wood and Wood Byproducts for Energy		
-- Use by Forest Industries	0.9	150
-- Wood for Home Heating and Miscellaneous Industries	0.2	35
Total*	5.2	880

*This represents nearly 7 percent of the National Energy Budget in 1978.

UTILIZATION PROBLEMS

The greatest problem in utilizing more wood for energy is its economic availability. Although tremendous amounts of forest residues are generated each year, harvesting, transportation, and processing involves cost of at least $20–$30 per ovendry ton. The challenge is to reduce these costs to make wood more competitive with fossil fuels. To this end, the Forest Service is encouraging work at several research stations. In the South at Alexandria, Louisiana, the Southern Forest Experiment Station is developing a mobile harvesting machine. It is being designed to clean up after logging operations, to chip accumulated slash, and to provide for efficient transfer of chips to vans for removal from the forest. The research is being sponsored cooperatively with the Forest Service by the Department of Energy and five forest products industries. The machine may be adaptable to areas outside the South, where slope of terrain and soil conditions are moderate.

Technology for combustion of wood is fairly advanced, although there is still room for improvement. An advanced burner for wet fuel, the Jasper–Koch suspension burner, is under development by Mississipi State and the Southern Forest Experiment Station. Dutch ovens, spreader stokers, fluidized beds, and oscillating grates in various sizes, factory fabricated or field–erected, are generally available. Combustion efficiencies may range from 60–80 percent. In some cases, wet fuel may be burned, or separate drying equipment may be installed before the combustor. It appears that burning wet fuel is generally more economical than drying. However, drying does impart a number of advantages, including easier pollution control, higher combustion efficiency ability to use smaller combustion equipment, and increased heating value per unit weight of fuel.

As a rough estimate, woodburning boilers and satellite equipment are estimated to cost $30-$35 per pound of steam per hour of output capacity.

An interesting approach to reduce costs of conversion of fossil fuel burning facilities to woodburning facilities is refinement of the wood fuel to make it compatible with existing equipment, thus, avoiding the costs of installing complete new boiler systems.

In some cases wood can be pelletized and burned in boilers designed for coal. One location where this is seen is at a hospital in Fort Steilacoom, Washington. Preparations are also being made for a similar operation at a prision in Stillwater, Minnesota.

Wood gasification might be used to generate a fuel gas for boilers designed to burn oil or natural gas. The Solar Energy Research Institute, in Golden, Colorado, estimates that a wood gasification unit might be installed in conjunction with an existing oil and gasburning facility at a cost of $8.00 per pound of steam per hour. However, wood gasification technology is not highly advanced, particularly in the United States.

In Europe during World War II, considerable use was made of gas from portable generators which operated mainly on wood. In Japan and

other countries, so-call gasogens were also used. As soon as gasoline became available after the war, however, the wood gasogens were quickly retired.

So-called producer gas and water gas have had wide application in the United States, as well as abroad. however, the most common fuel for this type of gas was coal or coke. If the proper equipment for making a producer gas from wood were available, this might work well for use in conjunction with a gas or an oil burning boiler.

Several wood gasifiers are now being developed in the United States by small inventors, such as Forest Fuels, in Keene, New Hampshire, and Combustion Equipment Co., in Monroe, Wisconsin, as well as large conglomerates, such as Union Carbide, in Tonawanda, New York. More effort should be taken to put these promising units on stream.

Another problem in wood utilization for energy is the conversion of wood to liquid fuels. As may be seen from table 23.3, the most efficient way to use wood for fuel is to burn it directly. Generally, more petroleum could be saved if wood were burned in boilers in place of petroleum-based fuels, than if wood were converted to a liquid and used as a substitute for motor fuels. Nonetheless, it is necessary to improve the technology for liquifaction of wood so that emergencies may be met in the future. There is an even greater need for the technology in other countries, such as New Zealand and Brazil, which are lacking both coal and petroleum, but have a relative abundance of wood.

Three technologies for liquifying wood are commonly proposed: conversion to oil, ethanol, or methanol. The most progress in converting wood to oil has been made by the Georgia Institute of Technology, and the Department of Energy. At Georgia Tech, a low temperature pyrolysis process to produce a combination of oil, char, and gas has been developed. It is being demonstrated with a 50 ton per day pilot facility at a sawmill in Cordele, Georgia. At Albany, Oregon, the Department of Energy has a complex wood to oil pilot facility. It produces two barrels of oil per ton of dry wood. The plant is still being modified to optimize the process. It operates with wood flour and pressures of about 4,200 pounds per square inch.

The Forest Products Laboratory has a long history of work in wood saccharification and fermentation research for production of ethanol, glycerol, and other chemicals. The Madison wood dilute sulfuric acid hydrolysis process for producing ethanol from wood was used in a plant for production of ethanol at Springfield, Oregon during World War II, but the plant was never fully operational. It was dismantled when the war ended. Forty plants using this process essentially are operating in the Soviet Union. Other new technologies for producing ethanol from wood are being proposed. These include enzyme hydrolysis, which is being researched at various locations in the United States, and a new version of acid hydrolysis, at Purdue.

A difficulty in producing ethanol from wood is the fact that it can be synthesized readily only from the cellulose fraction. Even so, starch from grain is much easier to convert to glucose and ethanol than

Table 23.3. Comparative Energy Recovery from Wood

Compound	Yield/T OD[1]	Product Heat Value Btu	Total Potential Heat Value MM Btu/T OD
Wood Direct Burning	2,000 lb	8,500/lb	17.0
Charcoal	670 lb	12,500/lb	8.38
Oil	370 lb[2]	14,380/lb	5.32
Methanol	647 lb	9,788/lb	6.33

(1) T OD = tons, ovendry.

(2) 1.25 bbl or 52.5 gal based on 7 lb/gal and 42 gal/bbl

cellulose from wood. If the wood cellulose is used for ethanol, uses must also be found for hemicellulose and lignin to permit economic operation of a plant. Hemicellulose could be converted to furfural, xylitol, and other products, for which there are currently no large markets. Lignin utilization poses more obstinate problems. Various solutions have been proposed, including hydrogenation to phenol, gasification to producer gas, with upgrading to synthesis gas, catalytic conversion to methanol, and burning for fuel.

A more promising approach to the liquifaction problem appears to be gasification of the whole wood fraction to producer gas, optimization of the gas through a shift reaction to provide hydrogen and carbon monoxide in the ratio of two to one, to yield synthesis gas, and the conversion of the synthesis gas into methanol.

With existing technology, this process might result in an overall energy recovery in the output methanol, compared to the wood input of 38 percent. However, the weak link in the process, as with boiler fuel, is the gasification step. If methanol were produced, it could be used as a motor fuel directly, or it might be converted to gasoline with a catalytic high-yield process under development by Mobil.

Another alternative would be direct conversion of wood to gasoline from a synthesis gas. Such a process for coal is in effect in South Africa. In this case, the most pressing problem with wood would also be the gasification process.

Given the various alternatives for using forest resources for producing energy, mill residues are being converted to in increasing amounts, and Grantham (I) predicts that essentially all this readily available material will be used by the year 2000. Other residues, including slash from wood harvesting operations, mortality, noncommercial timber, thinnings from timber stand improvement and land clearing, and urban wood waste will also be used in increasing amounts. Contributions from fuel plantations will probably be minimal in the near future.

The greatest use of wood for fuel will continue to be in boilers for production of process steam and electricity, mostly in forest products manufacturing plants. Use of wood fuel for domestic heating will continue to grow, but its share of the total wood use for energy will probably remain at 15-20 percent. Use of wood fuel by utilities for power generation will make some gains in the short-term. Conversion of wood to liquid fuel, especially methanol, may turn out to be viable in developing countries, but an optimal process to gasify wood must first be developed. Such a process is also necessary to permit expedient conversion of oil and gas burning boilers to wood producer gas fuel.

REFERENCE

(1) Grantham, John B. 1977. Anticipated competition for available wood fuels in the United States. In Fuels and Energy from Renewable Resources, ed. by David A. Tillman, Kyosti Sarkanen, and Larry L. Anderson. Academic Press.

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