FOREST PRODUCTS LABORATORY (Madison, Wis. 53705)
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
Approved Technical Article

# WOOD RESIDUE AS AN ENERGY SOURCE--
# POTENTIAL AND PROBLEMS

By

Andrew J. Baker
Chemical Engineer
Forest Products Laboratory
USDA - Forest Service
Madison, Wisconsin

and

Edward H. Clarke
Manager - Forest Residues Program
Pacific Northwest Forest and Range Experiment Station
Portland, Oregon

## ABSTRACT

The potential of wood for energy production in the United States in minor compared with our direct energy needs. The problems are that the forest residues are costly to collect and most manufacturing residues have higher value when used for wood products. Unused residues will be important as fuel to reduce wood industry requirements for fossil fuels. The type and amount of residue to be left in the forest are important in survival of the forest ecosystem.

## POTENTIAL

The need for additional energy supplies in the United States has created interest recently in the potential of wood for fuel and chemicals.

For fuel, the proposed uses of wood range from heating homes to firing large electric generating plants. For chemicals, the proposed uses of wood include production of alcohol as an automotive gasoline additive, sugar and single-cell protein for food, and organic chemicals for petrochemicals. All these proposed uses are technically feasible.

Sources of wood for such uses might include forest residue, primary and secondary manufacturing residues, municipal solid waste, and trees or other biomass specifically grown for fuel.

Being a renewable resource, wood sounds like the answer to the energy and raw material problem of the United States. The real potential of wood as a source of energy and chemicals can be assessed only when the U.S. consumption of these products is compared with the annual growth and consumption of logs, the amounts of wood and wood residue available annually, and the collection problems. Two particular points show up:

Reprinted from "Trees-The Renewable Resource,"
Proceedings, Rocky Mountain Forest Industries Conference
March 13-14, 1976, Tucson, Arizona, p. 7-13.

First, because demands for wood for construction materials and wood pulp are expected to increase more rapidly than timber supplies, wood cannot become a major new raw material resource for energy and chemical production. After all, logic dictates that wood generally be used for its highest value products, so wood will probably be burned for fuel only when it cannot be used for these products.

Second, exceptions are likely, where wood will be locally important as a fuel. As a natural result of the high cost of other fuels, the amount of wood residue burned for heat recovery at wood-processing plants will grow. Instead of being a costly nuisance, it will become a coveted source of fuel at many wood-processing plants.

## Energy Contribution From Wood

Grantham and Ellis compared the annual per capita consumption of fossil fuels with consumption of forest products. They concluded that, even if all the wood now processed for conventional products were used instead for energy, it would meet relatively little of our total energy requirements (1).

Another way to consider the impact wood might have on our energy budget in the United States is to compare the heat equivalent of the roundwood consumed by forest industries with the energy required for steam-electric generating plants. In 1971, we consumed forest products equivalent to about 13.3 billion cubic feet of roundwood; this is equivalent to about 300 million tons of green wood. This 300 million tons of wood, our total consumption for 1 year, could have supplied only about one-fifth the energy required to operate all steam-electric generating plants in the United States.

Forest residues have been proposed as fuel for steam-electric generating plants. In 1970, about 4.5 billion cubic feet of timber were killed by insects, disease, and fires. Logging residues and precommercial thinnings amounted to perhaps another 5 billion cubic feet. If these volumes and the unused wood and bark residues from primary manufacturing plants had been economically available, they might have supplied about 10 percent of the fuel for steam-electric generating plants. But these residues are widely scattered, and the costs of harvesting and transporting them to generating plants generally would be prohibitive.

## Energy Plantations

A possibility appealing to some is "energy plantations"; these are proposed for cultivation of fast-growing trees or other crops specifically as a fuel source. The principal problems are land and water requirements and costs. With an annual production of 4 cords per acre (quite a high growth rate), about 300 square miles would be required to supply a single steam-electric generating plant of average capacity. It seems highly unlikely that sufficient productive land will be available toeestablish such plantations. Besides, use of high-quality timber or fiber for fuel is undesirable.

Thus our energy demand is great, it is growing rapidly, and it is much greater than our forest growth capacity. But there is still a place for wood fuels.

## Residue Burning at Wood-Processing Plants

Most older wood-processing plants burned wood residue and coal for heat and power. Newer plants, especially those of small and medium capacity, installed gas or oil boilers because they are simple to operate and cost less to install. In addition, gas and oil were low cost fuels. The wood residue was either burned without heat recovery or buried in landfills.

Recently, however, gas and oil have become less attractive as fuels because of their cost and availability. At the same time, disposal of wood residues costs more because of air pollution regulations on waste burners and the restrictions on landfill sites. In one State, for instance, permits are often required for new disposal sites and they are subject to about the same requirements as for a sanitary landfill. Thus, just obtaining the permit is costly after suitable land has been found.

The burning of wood residue for energy recovery at wood-processing plants offers many advantages. For instance:

(A) Forest residue can be sorted and processed for higher value product uses, with only the unusable material burned.
(B) Raw material and transportation costs are usually borne by the major products from logs, not by the residue component.
(C) Mills are less dependent on purchased fuel supplies that are usually obtained on an interruptible basis and in the future may be available only on allocation.

For a sawmill, more than enough heat can be obtained from combustion of the bark and sawdust to kiln dry the lumber. It has been estimated that about 3.2 million Btu's are required to kiln dry 1,000 board feet of green softwood lumber. More than twice this amount of heat can be obtained from 1 ton of hogged fuel.

## Municipal Solid Waste and Wood Residue

Burning wood residue and sorted municipal solid waste with coal in steam-electric generating plants seem to be a practical and economical method of disposing of residue and obtaining useful energy. This is a common practice in Europe; West Germany has a very impressive solid waste handling system that includes combustion of the sorted solid waste for steam and electricity. Some units operate entirely on sorted solid waste, some co-fire with coal, and some with oil.

Sorted solid wast can be burned along with coal without incurring serious problems and expenses in operation of the boiler. The fuel is about 10-percent solid waste and 90-percent coal. Using wood residues along with sorted municipal solid waste and coal should also be possible, but looked on more as a way of disposing of residue where accumulations exist, rather than as a method of producing electricity from wood.

# PROBLEMS

With this background, we should look at some of the difficult problems of

collecting and transporting available wood residues to a point of use. Important is to distinguish between kinds of residues.

In growing and managing timber stands, forest residue accumulates as a result of natural mortality and harvesting processes. In the conversion of trees and logs into primary products, additional mill residue develops in the form of bark, slabs, edgingd, trim, sawdust, and planer shavings. Generally, less than one-half the volume of logs going into the mill ends up as lumber or plywood.

In most regions of the country today, mill residues do not represent a waste--they become the raw material for other wood-base products, such as pulp, hardboard, particleboard, and insulation board--and are easily transported to the next point of use as chip, flake, or particle.

In the Pacific Coast States, mill residues now account for more than 85 percent of the region's pulp industry raw material needs, nearly 20 percent of that industry's energy needs, and all the raw material needs for the region's composition board industry (2). These uses alone consume about 13 million tons annually; together with other domestic uses and some export, the bulk of mill residue is now used. At present levels of demand, mill residue is priced too high for commercial power generation. Significant price increases of other energy sources, of course, will make mill residues a more attractive energy source.

The situation with regard to the supply of forest residues is entirely different. Any crop produces residue. When the crop is large, the amount of residue is large, the amount of residue is large. When the crop is trees, the amount of residue is very large.

The amount is especially great in harvested old-growth stands west of the Cascades where high stand volume, large percentage defect, and steep and rocky terrain combine to produce large losses. For example, patch-cut harvesting in the National Forests of Oregon and Washington is applied to approximately 60,000 acres annually. The forest residues larger than 4 inches by 4 feet on these acres average about 60 tons per acre, dry weight--maximums approach 300 tons per acre. In addition, over one-half million acres per year are partially cut, where the residue volume varies from a few tons to as much as 150 tons per acre (3). Such material, in the form of limbs, broken chunks, cull sections, etc., is accumulating in the Pacific Northwest at the rate of about 14 million tons annually.

About three-fourths of this material in Oregon and Washington is in pieces 8 inches and larger in diameter and 8 feet or longer in length. Moreover, about two-thirds to three-fourths of it is sound and chippable. There is no technical reason preventing its removal and utilization, either as an energy source or as raw material for some fiber wood product. The reason is economic. Favorable markets certainly help to defray the relatively high cost of moving it off the land so good land management can be practiced.

Forest residues concern land managers and the public alike for (A) increasing fire hazard and providing fuel for potential conflagrations; (B) repre-

senting fiber which could help meet national wood goals; (C) being an obstacle to regeneration and other silvicultural activities; and (D) appearing to give an impression of waste and mismanagement. The Forest Service is condusting studies in both the Pacific Northwest and the North ern Rocky Mountain areas aimed at managing forest residues by reducing residue created in the logging operation, maximizing its utilization, or treating it in place.

In the Northwest, we are investigating two directional felling procedures as a way of reducing the amount of breakage occurring during harvesting. We estimate that up to 20 percent of the stand volume may be lost through breakage, depending on defect and terrain. One procedure uses cable-pull and the other hydraulic jacks. In both procedures, only those trees are treated that cannot be directionally felled through normal wedging and safety practices. Cable pulling appears to be the more expensive method; moreover, it requires a road at the top of the cutting unit for access of a mobile yarder. On the other hand, some trees have such severe Lean that the jacking procedure may be inadequate to accomplish uphill falling.

Another study involves modified bucking practices, also aimed at reducing the amount of residue created. Normally, material such as long butts, broken ends, and cull sections are bucked off and left in the woods. In this study, such material remains attached to the merchantable log until yarded to the landing where the cull section can be better disposed of. The Rationale behind minimum bucking is that these cull sections get a lower cost ride out of the woods when attached to a merchantable log and thus may cross the economic breadeven point and go to a mill. Conversely, once separated, cull sections must bear the full cost of collection and transportation.

Studies are in progress to determine the product recovery potential of standing dead and down pine in the Inland Empire and tussock moth-killed Douglas-fir in Washington and Oregon. Results of these studies will provide both the timber purchaser and the land manager with informat-ion useful in processing and in appraisal.

In a lodgepole pine study in Wyoming, near-complete harvesting was attained by chipping. The utilization limits were 3 inches for live and 6 inch es for dead standing and down material. Full-tree skidding to a chipper was used, increasing total fiber yield by about one-third. Another comprehensive study in northwestern Montana aims at achieving different Levels of tree utilization with skyline logging systems operating in three different silvicultural treatments. In addition, environmental effects of residue removal on such components as nutrient cycling, surface and ground water hydrology, wildlife habitat regeneration, and esthetics are being measured.

We realize that in parts of the Pacific Northwest Region, even with favorable economics which encourages the removal and utilization of as much of the forest residue material as possible, excessive volumes still require some in-place treatment to achieve sound land management objectives. An appreciable amount of research effort is directed at this facet of the residue problem, and guidelines have been prepared for management of

forest residues in different areas within the region (4). From the knowledge available on the effects of residues, or their treatments, on the other resources and components of the environment, a cadre of scientists prepared a compendium on the state of the knowledge which was recently published (5). Using this as a knowledge base, technical task groups, each dealing with a separate land management component, formulated residue management guidelines appropriate to their field or specialty (4). Both public and private forestry representatives participated in countless reviews of the 200+ guideline statements. These statements should be available later this year and these, together with the compendium, will form a basis for improved management of forest residues in Oregon and Washington.

These studies were directed primarily at solving serious forest residue-related land management problems. Obviously, some specified level of residue is a necessary component of every forest environment--that is, for soil stability on steep slopes, wildlife cover, micro-climate benefits on dry sites, etc. Our goal is to identify those levels and work with industry to find uses for the balance.

## CONCLUSION

We have a large and growing energy demand in the United States; but wood as fuel will not contribute much compared with coal, gas, and oil. Wood residue will be important as a fuel to the wood industry, however. At wood-processing plants, where the unused residue is accumulated, it should be burned to recover the heat value rather than disposed of in incinerators of landfills. If it cannot be burned at the mill because it is available only in small quantitities or because the mill has no need for the steam, it should be hauled to a place where it can be burned rather than to a landfill site.

Research is underway to identify the forest residue that is necessary for survival of the forest ecosystem and to reduce the amount of residue left after logging. Utilization research is also in progress on forest residue for structural products. The remaining residue should be considered for energy production.

## REFERENCES


1. Grantham, John B., and Thomas H. Ellis. 1974. Potentials of Wood for Producing Energy. Journal of Forestry. 72(9): 552-556.

2. Grantham, John B. 1974. Status of Timber Utilization on the Pacific Coast. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-29, 42p., Illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

3. Howard, James O. 1973. Logging Residues in Washington, Oregon, and California--Volume and Characteristics. U.S.D.A. For. Serv. Resour. Bull. PNW-44, 26p., Illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

4. Pierovich, John M., Edward H. Clarke, Stewart G. Pickford, and Franklin R. Ward. Forest Residues Management Guidelines for the Pacific Northwest. (In preparation for publication, Pacific Northwest For. & Range Exp. Stn., Portland, Oreg.)

5. Cramer, Owen P. (Compiler) 1974. Environmental Effects of Forest Residues Management in the Pacific Northwest, a State-of-Knowledge compendium. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-24, 532p., Illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.


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