ENERGY FROM FOREST BIOMASS—SOME POTENTIAL BENEFITS AND PROBLEMS

Raymond A. Currier
Forest Research Laboratory
Oregon State University
Corvallis, Oregon

Introduction

The topic "Energy from Forest Biomass" currently is of widespread interest, not only within the forest products industry, but also within some segments of the electric power industry. An information explosion on this subject has appeared in print during the past 2 years.

Biomass can briefly be defined as material derived from solar energy via the process of photosynthesis. Included are all portions of trees and shrubs (bole, limbs, leaves, or needles, and roots) and agricultural residues such as plant stalks, leaves and roots. Thus biomass is a renewable form of energy.

Without becoming mired in statistics, we can look at the extent that forest-derived biomass (mill residues and logging slash) currently contributes to our total energy and at the future capability of this energy form. The United States now uses annually about 75 quadrillion Btu's of energy. A quadrillion (commonly referred to as a "quad") is formidable both to think about and to read--1,000,000,000,000,000 Btu's. We devour 75 of these quads each year to keep our industries running, our homes heated and cooled, our transportation systems moving, and our crops planted and harvested.

About 50 percent of the 75 quads is derived from petroleum, of which about half is now imported (15). Wood now supplies less than 2 percent of the 75-quad total. One quad equals about 60,000,000 tons of oven-dry wood fuel. If we used all available mill and forest residues, they would generate about 2 to 3 percent of the total, or 1.5 to 2.3 quads. This is approximately the amount of energy needed by the forest products industry, so, in theory, we could become completely energy self-sufficient (11, 13, 16).

Economics and Availability

A report published in September 1978 by the Department of Natural Resources in the State of Washington (6) gives an idea of the price relation of various forms of energy. Wood costing \$32 per ton was equivalent to oil at 45¢ per gallon, coal at \$15 per ton, or natural gas at 45¢ per 1,000 cubic feet.

To those who predict we never will be able to economically utilize forest slash I say, "Look back about 25 years in the Pacific Northwest." At that time the teepee burner was a standard piece of sawmill equipment. Most of the bark, edgings, trim, sawdust, and other mill residues were consumed by burning in a rather inefficient manner. In fact, disposing of refuse cost a mill money. Since that time, we have found uses for clean, chippable residues (pulp and paper), planer shavings (particleboard) and bark (decorative bark and mulch). What residue is left, if any, now becomes hogged fuel to produce process steam or heat. Who can tell how we will be utilizing logging slash 25 years from today?

How much forest biomass material is available? From a recent study completed for the Department of Energy (8), I am convinced no one knows for certain. For instance, let's look at estimates for one species, lodgepole pine. Several recent publications estimate logging residue tonnage to range from 4 to 44 tons per acre. The State of Washington estimated in its reports (6) 13.8 and 11.0 tons per acre for logging residues in western and eastern Washington, respectively. Other publications estimate 100 or more tons of slash residue per acre after old-growth Douglas-fir is logged (10). A State of Oregon Interim Legislative Task Force on Forest Slash Utilization estimated annual production of forest slash in western Oregon at 7 to 10 million tons (14). The U.S. Forest Service estimates that 11 billion cubic feet of dead and dying, diseased, fire-killed, and insect-killed timber currently occupies commercial forest lands in the western United States (2). In theory, much of this could become available for energy production.

Until recently, much logging slash was deliberately burned, often causing air pollution in addition to being costly. In Oregon and Washington, the U.S. Forest Service spends an estimated $15,000,000 annually to broadcast burn, pile and burn, or otherwise treat logging slash (8).

How do we "log" forest biomass? Today, portable equipment can economically fell and bunch trees up to medium diameter. Portable whole-tree chippers are capable of chipping or hogging in the woods and the material can be hauled out by conventional possum-belly chip trucks. Reported costs for logging and delivering forest biomass range from $9 to $18 per green ton ($18 to $36 per dry ton) (6). In many stands, felling and hauling the whole tree to a concentration or sorting yard would make more sense economically. Delimbing would be followed by inspection of the bole and assignment to the highest prevailing economic use, such as sawlogs, poles, veneer blocks, fence posts, pulp chips, or firewood. The limbs, needles, leaves, and cull material could be made into hogged fuel. As time goes by, we will surely see improvements in all of the machinery needed to log, sort, and haul the various products obtainable from forest biomass.

Changes must be made in the federal and state bureaucratic structures. Forest biomass may be used more fully if incentives are developed for removal and utilization of this resource. By utilization, I refer not only to energy use, but also to production of forest products.

Mill trials have proved that whole tree chips, which include some bark, are usable for many grades of paper products. Both laboratory and full-scale mill runs using whole-tree residues have yielded particleboard which passes all requirements of U.S. Department of Commerce Commercial Standard CS236 for mat-formed wood particleboard, type 1-B-1. Both paper and particleboard plants today could offer higher prices for some grades of forest biomass than is offered for it for energy production. What the future holds for this relationship between residues for products and residues for energy remains to be seen; J. B. Grantham of the U.S. Forest Service has prepared a report discussing the subject (12).

Energy Projection

Of course, large amounts of mill residues in the form of hogged fuel have been used for decades to provide process steam and heat in pulp and paper manufacture, sawmills, veneer and plywood mills, dry-kilns and other segments of the forest industry. The continuously rising price for fossil fuels such as oil and natural gas has caused many a forest-products manufacturer to put in new hogged-fuel or suspension fired boilers, thus eliminating or drastically reducing consumption of oil and gas. The heating value of wood or bark residues is around 8,500 Btu's per pound, dry basis, and decreases as moisture content of the hogged fuel increases. With green or wet fuel, the Btu output is roughly one half that of dry fuel.

To compare the heating value of wood with oil, natural gas, electricity, or other forms of fuel, we must know such things as unit heating values, conversion efficiencies, and moisture content. Fortunately, at least one company has recognized this need and prepared a fact sheet showing comparative energy costs. Using this sheet, Table 1, we can make valid comparisons of energy costs per million Btu's.

So far, I have discussed only industrial or commercial applications of forest biomass for energy production. How about home heating with wood fuel? In forested areas of this country, especially, a "backward revolution" is taking place. Wood-fired space heaters are being produced and sold in increasing numbers, supplementing or replacing completely home heat provided by oil, natural gas, or electricity.

A study on firewood, completed last winter by the U.S. Forest Service for the 19 national forests in Oregon and Washington (9), shows that during fiscal year 1978, 104,758 free-use firewood permits were issued. The estimated amount of wood removed, largely forest biomass from logging slash, was 205-million board feet or 378,000 dry tons of fuel. Removal of this material reduces fire hazards and often eliminates the need for slash burning programs.

Estimates of the number of households using wood for home heating are difficult to obtain for Oregon and Washington, but a recent article states that 32,000 homes in Oregon burned wood during 1970, and 75,000 homes, 10 percent of all Oregon households (5), burned wood during 1978.

Data for New England, a forested area with high fuel oil and electricity prices, are even more impressive, and give an indication of what we can expect in the Pacific Northwest. In 1978, 46 percent of Maine households burned firewood (1) and in Vermont, an estimated 66 percent of all households burned at least some wood (3). If Pacific Northwest woodburning homeowners increase only modestly, say from 10 percent to 25 percent, the amount of wood required to service this market will leap tremendously.

Another aspect of the "backward revolution" is the renewed interest in densified fuel (7) taking place in home and industry. In 1944, the U.S. Forest Products Laboratory estimated that 40,000 sawdust-burning furnaces were being used in homes in the Pacific Northwest (4). In addition to sawdust, many homes and commercial buildings in eastern Washington and Oregon and in northern Idaho were heated during the 1940's and early 1950's by a densified wood-residue product called stoker fuel. This material could be burned alone or admixed with coal in automatic stoker-fired boilers. The introduction of cheap (at the time) fuel oil and natural gas into the region put these wood burning units out of business. Today, newer more automated production equipment is available, and this kind of wood burning for home heating should begin to make a comeback.

Besides saving money on energy costs for fuel, what other benefits can we attribute to using forest biomass? First, forest managers will have the possibility of making a profit on timber stand improvement cuttings, that is, on the removal of poorly-formed trees, inferior species, and dead or diseased material to create better growing conditions for the remaining upgraded stand. Second, removal of logging slash and dead or dying trees will reduce fire hazard and make slash burning less necessary, which will reduce air pollution.

In the Pacific Northwest, a net power deficit is predicted each year through the 1980's. It is already too late to build a large coal-fired plant or a nuclear plant (assuming this will be possible again) to fill the gap during the first part of the decade. But small power plants, up to 50 megawatts, can be fired by wood, especially forest biomass. Such a plant could be constructed and operating in a comparatively short time, alleviating the predicted power shortage in the region. The Washington Water Power Company announced earlier this year their decision to construct a 40 megawatt power plant fueled by forest biomass in Northern Stevens County, Washington. Fuel will be a mixture of mill and forest residues, and the plant is projected to commence power production in mid-1982.

Currently, the Bonneville Power Administration and the U.S. Forest Service are cooperating in studies to decide the feasibility of power plants fueled by forest biomass be located near Portland, Oregon and Morton-Randle-Packwood, Washington. In addition, the Bonneville Power Administration is actively investigating cogenerated power potentials within its region. Cogeneration refers to steam production for an electric generator, and use of the exhaust steam for other purposes, such as operating a lumber dry kiln.

If enough need for biomass arises, "energy plantations" of fast-growing species such as cottonwood or red alder could be established in the region. These would be farmed, not unlike corn, except the crop might be harvested every 5 years instead of annually. Several studies are underway in this area to determine growth rates as well as the economics of energy plantations.

If there are potential benefits from forest biomass, there also are potential problems. Land completely harvested for forest biomass could look "picked clean", and environmental objections could be raised on this point. Continued cropping of forest land with removal of leaves and needles would in time deplete soil nutrients, which would have to be replaced, thus raising the cost of the energy derived. Complete removal of forest biomass would cause problems for wildlife and might hinder tree reproduction. We do not know the possible health effects of burning large quantities of wood in industrial boilers, power generating plants, and perhaps 50 percent of all homes. Questions surely will be raised in this regard.

Finally, we must consider cold economic facts. Forest biomass will go to the buyer who can afford to pay the most. Pulp and paper, composition board, and energy will compete for its use. This competition will temper both the speed and extent to which forest biomass will be used in the coming years.

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TABLE 1. Comparative energy costs in dollars per million Btu's

Fuel	Price	Energy Cost
NATURAL GAS (1000 Btu/ cu.ft.) Conversion Eff. = 80%	Per Therm.	Per Mil. BTU
	$ .10	$ 1.25
	.15	1.88
	.20	2.50
	.25	3.13
	.30	3.75
	.40	5.00
	.50	6.25
	.60	7.50
#2 OIL (138,000 Btu/ gal.) Conversion Eff. = 80%	Per Gallon	Per Mil. BTU
	$ .35	$ 3.17
	.40	3.62
	.45	4.07
	.50	4.53
	.60	5.43
	.70	6.34
	.80	7.24
	.90	8.15
RESIDUAL OIL (150,000 Btu/ Gal.) Conversion Eff. = 80%	Per Gallon	Per Mil. BTU
	$ .30	$ 2.50
	.35	2.92
	.40	3.33
	.45	3.75
	.50	4.17
	.55	4.58
	.60	5.00
	.70	5.83
ELECTRICITY 3415 Btu/kwh Conversion Eff. = 95%	Per KWH	Per Mil. BTU
	$ .020	$ 6.16
	.025	7.71
	.030	9.25
	.035	10.79
	.040	12.33
	.045	13.87
	.050	15.42
	.060	18.50
	.070	21.59
RAW WOOD (35 Million Btu/Cord) 50% MC Conversion Eff. = 40%	Per Cord	Per Mil. BTU
	$15.00	$ 1.07
	20.00	1.43
	25.00	1.79
	30.00	2.14
	35.00	2.50
	40.00	2.86
	45.00	3.21
	50.00	3.57

Fuel	Price	Energy Cost
WOOD PELLETS (8500 Btu/ LB.) Conversion Eff. = 70%	Per Ton	Per Mil. BTU
	$20.00	$ 1.68
	25.00	2.10
	30.00	2.52
	35.00	2.94
	40.00	3.36
	45.00	3.78
	50.00	4.20
	55.00	4.62
COAL Bitum (13,000 Btu/ LB) Conversion Eff. = 75%	Per Ton	Per Mil. BTU
	$25.00	$ 1.28
	30.00	1.54
	35.00	1.79
	40.00	2.05
	45.00	2.30
	50.00	2.56
	60.00	3.07
	70.00	3.58
COAL Sub-Bitum (Wyoming & Montana) (8500 Btu/ LB.) Conversion Eff. = 70%	Per Ton	Per Mil. BTU
	$25.00	$ 2.10
	30.00	2.52
	35.00	2.94
	40.00	3.36
	45.00	3.78
	50.00	4.20
	60.00	5.04
	70.00	5.88
PROPANE (92,000 Btu/ Gal.) Conversion Eff. = 80%	Per Gallon	Per Mil. BTU
	$ .35	$ 4.76
	.40	5.43
	.45	6.11
	.50	6.79
	.55	7.47
	.60	8.15
	.70	9.50
	.80	10.86
	.90	12.22
WOOD CHIPS (20 Million Btu/unit) 50% MC Conversion Eff. = 55%	Per Unit	Per Mil. BTU
	$ 5.00	$ .45
	10.00	.91
	15.00	1.36
	20.00	1.82
	25.00	2.27
	30.00	2.72
	35.00	3.18
	40.00	3.64

Courtesy of Industrial Combustion Inc., 4465 North Oakland Ave., Milwaukee, Wisconsin 53211