

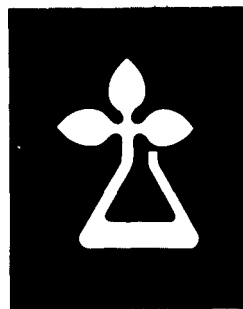
U. S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE • FOREST PRODUCTS LABORATORY • MADISON, WIS.

In cooperation with the University of Wisconsin

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RESEARCH NOTE

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WOOD FUEL PREPARATION

Summary

This report gives information on the preparation of wood fuel from wood residues and other wood raw materials. Types of wood fuel discussed are cordwood, stovewood, slabwood, kindling, chips, hogged fuel, sawdust and shavings, bark, charcoal, alcohol, and briquets. Related information is given on types of machinery for preparing wood fuel and on possible markets for its sale.

WOOD FUEL PREPARATION¹

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High values for lumber, veneer, and various other wood products, coupled with a very heavy demand for wood products of all kinds, have led to widespread interest in possible uses for residues that occur in nearly all operations in the wood-using industries. Residues from harvesting and manufacturing are basically a result of the extreme variation in size, form, quality, species, and accessibility of the raw material. Much residue or offal is, of course, inevitable in processing wood to finished products, even with the most efficient machinery.

Converting residue into useful products is seldom simple; for instance, wood cannot be melted down and reshaped, as metals are reshaped, but must be sawed, planed, turned, and otherwise worked to form. Residues from these necessary operations may range from sander dust in factories to slabs, sawdust, and like material in sawmills, as well as parts of or entire trees in the woods.

This report is intended primarily for forest managers, commercial wood-fuel producers, and other technicians interested in the use of wood residue for fuel. Principles of combustion of wood fuels and a discussion of improved wood-burning equipment are given in another Forest Products Laboratory report.³

¹This Research Note is a slight revision of Forest Products Laboratory Report 1666-19 of the same title, originally issued in 1947 and revised in 1960.

²Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

³Reineke. L. H. Wood fuel combustion practice. Forest Products Lab. Rpt. 1666-18. 1947.

The volume of wood cut for fuel (2,002 million cubic feet per year) is second only to that cut for lumber (2,145 million cubic feet per year) and therefore merits serious consideration, not only as a drain from the Nation's forests, but also as a means of improving timber stands and salvaging residue. It is estimated that an additional 2,478 million cubic feet of wood, annually discarded while making various wood products, is used as fuel.

As a fuel, wood has several inherent advantages. Wood is a renewable fuel resource. Furthermore, it is widely distributed and accessible. It can be harvested with simple tools by unskilled labor and requires no elaborate equipment to locate, unearth, and process. Wood is relatively inexpensive when harvested on a spare-time basis or in conjunction with a regular logging operation. It will burn cleanly in many types of equipment under widely varying operating conditions, producing a minimum amount of ash (of some value as fertilizer). In open fires the flames of wood have an esthetic appeal.

Wood is readily kindled, and its burning rate can be regulated reasonably well if it is properly prepared and burned in suitable equipment. On the other hand, its moisture content is usually high and it normally requires piece-by-piece preparation, handling, and stoking, when used in the form of chunk wood and unhogged green scrap. In any form, it is bulkier than other common solid or liquid fuels.

Large recapture of wood-fuel markets lost to other fuels in the metropolitan and highly-industrialized zones is hardly feasible, nor desirable. To meet all fuel needs with wood in such zones would involve excessive haulage, an unreliable supply because numerous independent owners control it, and excessive cutting of the forests for fuel wood instead of restricting fuel production to thinnings and logging residues (culls, tops, and little-used species). Markets for wood fuel for domestic use in metropolitan areas are, nevertheless, still large enough to absorb most of the low-grade round and slab material available nearby for fireplace wood, while edgings and trim can be sold as kindling.

A different situation exists in many rural areas and in urban localities adjacent to large forest areas. With other fuels costly and wood residue in great oversupply, special types of domestic burners for sawdust are justified.

Continued use of wood for fuel is dependent on the changing economic and technological picture. Overall costs of various fuels on the basis of actual heat production will figure largely in industrial choice of fuel; for farm use, home production will be a decisive factor; for city homes, convenience in storing, availability, handling, and use will be deciding factors. Wood fuel will continue

to come into these markets as long as they remain profitable, or possibly even at some small immediate loss if such cuttings will result in forest improvement. The prospect that other uses of wood residue will curtail the supply available for fuel is remote, except where pulp mills can use properly-prepared chips produced from slabs, edgings, and trim.

Continued use of wood for fuel, if restricted to otherwise unusable material, can be of widespread benefit to wood-using industries and to the forest. Use of manufacturing residues to heat boilers, or for similar purposes, cuts fuel costs while disposing of the residue. Removal of diseased or insect-infested trees, overmature, fallen, or broken trees, and snags and logging slash will aid forest sanitation and reduce the forest-fire hazard. Cutting trees of low-grade species will improve the composition and quality of the stand. Trees removed from thinnings to improve growth rates can be used for fuel when no other outlet is available.

Wood Fuel Uses

Uses of wood fuel are numerous and diverse. Wood is familiarly utilized as fuel for home heating and cooking, for recreational activities such as picnics and other outdoor activities, and on the farm to heat brooder houses, cure tobacco, and burn out stumps.

Various commercial processes consume large quantities of wood fuel of different types. Meats are often prepared over charcoal grills in restaurants. Charcoal and wood briquets are used almost exclusively in railroad dining cars. In cities with large foreign-born populations, some breadstuffs are baked for them over wood fires. Wood is essential in smoking meats and fish. Sap for maple syrup is usually evaporated over wood fires.

During rail transportation, potatoes and other vegetables are safeguarded from freezing by heaters that use charcoal, preferably in briquetted form. Wood fuels have a place in the metallurgical industry, where charcoal iron is a premium metal, and wood chips are used in making "electric" steel in induction and arc furnaces. Special brasses are annealed in sulfur-free wood or charcoal fire atmospheres, although this use is becoming obsolete because of the use of gas purifiers with other fuels.

Formerly an important fuel for locomotives and boats, wood has given way in the United States to other sources of power except in a few logging operations. In frontier sections of other countries, including parts of Canada, wood still fuels boats and locomotives. During World War II, in parts of Europe and Asia, large numbers of wood- or charcoal-burning gasogens were used to drive automobiles, trucks, boats, and tractors. Gasogen-powered tractors and portable donkey engines, fueled with wood, develop mechanical power for logging operations and are still used in a few primitive areas,

Steam is generated by wood fires in stationary boiler plants for direct application to turbines, engines, and veneer lathes, and to generate electricity. Wood-generated steam is used in large quantities to dry lumber, veneer, paper, and other wood products. It enters into various processes, such as veneer-log heating, pressing, distillation, evaporation of paper-mill liquors, and pulp cooking.

Stationary wood-gas generators are reportedly used in Australia to produce electricity on some farms, and one European town used wood gas for many years for street lighting and household purposes. Several large wood-burning gas producers are reported in operation in Africa and Sumatra for production of electricity and, at one operation, for the production of gas to reduce silver ores. A few wood-gas producers have operated in this country for process-gas production. Gas generators in sizes from 15 horsepower to 1000 horsepower are currently available. Gases generated in the destructive distillation of wood are collected and used for process heating.

Wood-Fuel Raw Materials

All parts of a tree are combustible, but because of variations in heating value, ease of handling, or special properties, some parts are used for fuel more often than others.

Foliage, green or dry, is never taken specifically for fuel use.⁴ Small twigs and branches are likewise ignored. Pine cones are used to a small extent as a luxury kindling material, but irregularity of prolific seed years results in sporadic cone production. In the South there has long been widespread use of "lightwood," the highly resinous heartwood of longleaf pine stumps and roots,

⁴A French process of making tar-bound charcoal briquets of 8,660 British thermal units per pound from carbonized leaves has been reported, in which an average tree yields 1 hundredweight of fuel. Commercial manufacture does not appear to have been established.

for kindling. It often sells locally in small bundles at a price that would be high by the cord. Bark from pulpwood is often burned alone at pulp mills, where the wood is completely utilized. At veneer mills and elsewhere, where logs are debarked, the bark is mixed with wood scrap in the furnace. Ordinarily, however, the greater portion is left on the wood and burned with it.

The greatest portion--more than 70 percent--of wood fuel is used as round wood. It is cut specifically for fuel, or salvaged during clearing operations for right-of-ways, construction, farming, replacement of defective stands, thinning operations, stand-improvement cuttings, and logging. Mill and factory residue constitutes one-fourth of the wood used for fuel.

Scrap veneer is sometimes burned in its original sheet form, but often it is hogged for reduction to small chips. Other types of residue may also be chipped, and additional fine sizes of fuel, such as sawdust, shavings, and sander dust, may be used in various combinations. Sander dust requires admixture with sawdust or shavings; or, with suitable precaution against explosive combustion, it may be introduced directly into the combustion zone of the furnace.

Fuel Types

The greatest portion of wood and bark for fuel is used with no modification except cutting it into cordwood, stovewood, slabwood, kindling, hogged mill waste, or sawdust. Other forms of fuel are derived from wood by chemical processing. Charcoal is a common form of derived fuel. Methane, the wood gas produced while making charcoal, is ordinarily used in the carbonizing process when retorts are employed.

Producer gas is derived from wood or charcoal in mobile or stationary gas producers. Wood-derived alcohols, both methyl and ethyl alcohol, are usable as fuels, and ethyl alcohol is suitable for motor fuel. Lignin, produced as a residue from the production of sugar or alcohol from wood, and as a residue in pulping liquor, is also a derived fuel.

Preparation of Wood Fuels

Cordwood

Preparation of cordwood for fuel requires no special skill--it consists merely of felling, bucking, splitting, piling for seasoning or measurement, and hauling. Local custom should be followed for length of stick, minimum diameter, splitting, species, and allowable rot and crook.

Fuel wood grades have been established by some States and are available through their forestry departments. Standards for these grades specify permissible species, sizes, form, and condition of the wood, sizes to be split, and the like. (Better salability will result if the operator retains the lowest grades for his own use.)

Excessive handling is required when cordwood is cut into 4-foot lengths at the stump and piled nearby. Cordwood production can be simplified materially with better methods and tools.

Chain and buzz saws are now priced at levels acceptable for small, intermittent operations, such as on farm woodlots. On large operations, such as acid-wood cuttings, stand improvement in commercial or public forests, or salvage after logging in the Pacific Northwest, power saws can be advantageous when matched to the material. Two-man saws are well adapted to the large snags and broken material of the West Coast, or to the overmature hardwoods of the South. When the terrain is firm and level and the trees small, the wheeled circular saw may be used effectively. In hilly or rocky areas, the one-man chain saw is more effective. Where the tops contain recoverable fuel wood, the one-man power saw may be more efficient than the two-man power saw.

For thinnings and stand-improvement work where the trees are small and the cut relatively light, the power saw is inferior to a good faller equipped with the light, fast-cutting Scandinavian bow saw, which is suitable for both falling and bucking trees 11 inches or less in diameter.

Another effective hand tool is the Oregon splitting maul, which has a splitting blade on one side of the head and sledgehammer face on the other. Swedish twist wedges are lighter than regular splitting wedges and equal to them in splitting power. An 8-inch length of old automobile or truck spring, flattened, sharpened, and then twisted about 45°, provides a good substitute for the Swedish wedge.

In producing cordwood, much labor is expended in splitting the larger sticks into two or more pieces of convenient size. Power splitting can save a half or more of the time required to prepare cordwood. Accordingly, a number of splitting devices have been devised. One is the explosive wedge which is driven into the end of the stick, charged with black powder, and fired by a fuse.

A second device is the flying wedge, which consists of a wedge fastened to the rim of a large heavy wheel, such as an old tractor wheel. The wheel is turned at a suitable speed by a gas or electric motor operating through a belt that runs over the wheel rim. A ledge is provided to support the end of the stick as the wedge passes through it.

A third device is the screw splitter, developed and extensively used in Norway since about 1950. Such splitters are sometimes combined with a cut-off saw to permit splitting as long bolts are cut up. This avoids piling the short bolts before splitting them. The screw splitter is highly efficient, easy to operate, and much safer than other methods. Splitters that drive a wedge lengthwise through the stick by a hydraulic piston are also available.

Efficient procedures in the woods can markedly reduce the labor of working up the felled tree or slash into fuel wood. Where branches are too small to yield fuel wood, it is best to skid the tree-length logs to landings alongside a road. There, a power splitter and a portable cut-off saw⁶ or combined loader, cut-off saw, and splitter can be used to cut the logs to desired fuel-wood sizes and to load or pile the wood for seasoning. The cut-off operation might include cutting posts, props, bean poles, or similar round products from suitable trees.

A 4-foot length for fuel is the most common, but 5-foot wood is preferred by dealers who recut it for retail trade, since it can be subdivided into a greater variety of short lengths than 4-foot wood. In the South, where rapid drying is essential to avoid decay, fuel wood to be seasoned in the woods is cut into 8-foot lengths to expedite piling in "pens" (log-cabin style).

If piling in the woods or at landings for seasoning is necessary, either in pen style or solid stack, it should be done in open, airy locations to insure good circulation. Piles should be raised 4 inches or more above the ground on skids. A top cover of tarpaper or slabs will retard decay and facilitate seasoning the wood by keeping rain, snow, or ice off the sticks.

For domestic use, it is desirable for wood to be seasoned 3 months in the South and up to 9 months in the North. Seasoning is not a rigid requirement for wood to be burned in specially designed industrial furnaces or slow-combustion stoves. This is because the gain in heat value, when wood is dried from 60 to 20 percent moisture content, is only 6.7 percent, too low to repay piling and other seasoning costs.

Obviously, all unnecessary piling should be avoided, since each rehandling of the wood is an expense. Rough bunching in the woods is sufficient when the cord-wood is to be hauled to a roadside or yard for seasoning. A judicious price adjustment may permit delivery of green wood to the consumer some months before its period of use. Thus, a single piling on the customer's premises will be all that is necessary. Costs can be reduced by handling the wood in racks or bundles to eliminate repeated handling of individual sticks.

⁶Unless a special setup is used for the wheel-type circular saw, cutting will not be accurate or square, which is important when the wood is graded or when stovewood is produced, especially for the magazine type of heater,

Stovewood

Much wood is burned in short lengths (12 to 18 inches) in stoves, ranges, and room heaters. For cooking purposes, dry wood is needed. For room heating, green wood can be used in a magazine-type, slow-combustion heater if sufficient dry kindling is used at the start and if the magazine is recharged before the fuel bed gets too low.

Stovewood may be prepared from round wood, slabs, veneer cores, or sawmill scrap. Sizes vary a great deal because of variation in firebox dimensions. However, lengths of 12 and 16 inches are common. Sticks are usually 2 to 4 inches in diameter or split to a maximum face of 4 inches. Square ends and accurate lengths are necessary in wood prepared for stoves with fuel magazines so that the charge will settle down evenly as it burns.

Accurate bucking is relatively easy with power buzz saws. A simple stop will prevent troublesome excess length. Pieces that are moderately underlength cause little trouble in stacking or burning. Gang slashers used at mills cut slabwood and other scrap to uniform length provided the material is placed squarely on the cross chains feeding the saw; if placed otherwise, diagonally cut ends and excessive length will result.

Slabwood and Kindling

Slabwood is sometimes roughly slashed to convenient lengths for fuel at the sawmill. Frequently, however, a greater return can be obtained by cutting the slabs to 4-foot or stovewood lengths for local sale. One mill cuts all slabs and other sizable scrap to 4-foot lengths before placing it on the conveyor to the residue burner. At a fuel-wood station, the larger pieces are taken from the conveyor and placed on cross chains that lead to a gang of slashing saws spaced to stovewood lengths. Edgings and other narrow rejects can be processed in like manner for use as kindling. Most kindling, however, originates at planing mills, cut-up plants, furniture factories, and the like, where dry wood is in use. Accumulations of small, narrow waste are often jackstrawed in the yard and sold at a fixed charge for whatever amount the customer can load onto his conveyance.

Such dumping tactics may seem to be the simplest way of disposing of low-value material, but higher returns sometimes can be obtained by cutting such kindling into uniform lengths and tying it into bundles. The convenience of bundled wood promotes sales at a worthwhile premium,

Chips or Hogged Fuel

Scraps produced at sawmills and wood-processing plants usually vary so much in size and shape that it is impossible to use them directly for fuel and obtain even passable furnace efficiency. To establish uniform fire-bed conditions and accurate control of combustion, it is necessary to reduce the scrap to uniform size, usually to chips about 1 inch long and about 1/4 to 1/2 inch thick. The thickness of chipped or hogged veneer waste naturally depends on the veneer thickness.

For reducing residue to chips, three types of machines are in common use. Veneer and comparable fine scrap can best be reduced to chips in a hammer-mill, in which rotating bars of various designs break up the material by impact. The disk chipper with knives set in radial slots is suitable for solid scrap and round wood of various sizes. The knife hog is similar in action to the chipper, but the knives are set in the sloping surfaces of a V-shaped drum; it is suitable for solid wood and for scraps that maybe somewhat smaller than the disk chipper can handle.

Hogs of portable size, with which chips could be produced in the woods, are available. There is a possibility that tree lengths can be chipped in the woods or at roadside landings and handled thereafter by pneumatic or gravity-flow methods. Preparation of chips in the woods has been done successfully in the U.S. and abroad in some instances, and could provide fuel chips for medium-sized structures.

Hogged fuel is ordinarily burned without predrying. This is because a furnace properly designed for burning hogged fuel does the necessary drying as a part of the combustion cycle, a procedure that is more satisfactory than separate drying.

Sawdust and Shavings

Sawdust and shavings are often burned in mixture with hogged fuel in industrial furnaces and require no special treatment. Shavings are unsuitable for burning alone because of their lightness and lack of body; hence, they are mixed with sawdust or chips to create a fuel bed with sufficient air resistance to permit good draft control. Sawdust and shavings of plants working with reasonably dry wood can be burned in suspension. The type of furnace required does not have grates and is unsuitable for very wet fuels.

Sawdust from sawmills, usually mixed with chipped wood, is used extensively in parts of the Northwest as fuel for special sawdust burners. No shavings are used in these burners, because they do not feed well from the hopper and do not form an adequate air seal. No preliminary drying is given, and the material is handled in bulk.

Bark

Bark is burned in domestic fires only as it comes attached to wood. In industry, bark is separated from wood at veneer plants and at pulp mills, and a rapidly increasing number of sawmills are debarking their logs before sawing. Bark is also removed from posts and poles. Tannin extraction leaves much hemlock bark residue.

Bark removed by dry methods requires only hogging to prepare it for burning. Drum and hydraulic debarking methods leave the bark very wet, due to surface water. To be suitable for fuel, bark removed by those methods must be dried or pressed to a water content of not more than 55 percent of its total weight, and preferably less.

Water can be removed from bark with presses that operate on the roller or clothes-wringer principle. It is necessary to keep a uniform-depth, full-width ribbon of bark passing between the rollers, since thin spots and gaps in the layer of bark reduce the effective roller pressure so that the water is not thoroughly squeezed out. Screw presses, using tapered screws, are also in use for the dewatering of bark.

Charcoal

Charcoal is commonly prepared from solid wood (round and split), slabs, and larger edgings, but briquetted charcoal has been made at two wood-distillation plants operating with hogged wood and sawdust. The methods and equipment used for making charcoal are described in another Forest Products Laboratory report.⁶ For fuel use, charcoal is used in lumps of irregular size and shape or as briquets.

⁶Forest Products Laboratory. Charcoal production, marketing, and use. Forest Products Lab. Rpt. 2213. 137 pp., illus. 1961.

Solid wood for "coaling" is cut to lengths of 8 feet, or to 50 or 48 inches, depending on the method of carbonizing and the equipment in use. The material is dried (usually air seasoned for a year) prior to coaling or dry distillation. Bark is not removed. Chipped mill waste, immediately before it is put in the distillation apparatus, is dried by flue gases or steam. A continuous-flow carbonizer designed by Svend Thomsen⁷ passes sawdust, chips, or other ground-up wood residues through horizontal retort tubes, and the resulting charcoal powder is briquetted as it leaves the retort.

Any species may be used to make charcoal. However, for lump charcoal the denser hardwood species, such as birch, beech, maple, oak, and hickory, and the heavier softwoods, such as longleaf pine, are preferred because of the denser, more slowly burning charcoal produced and the greater weight of charcoal yielded per cord of wood. When the charcoal is pulverized and briquetted, increased densities are obtained and the species used is immaterial, except as the charcoal yield by weight varies for a given volume of wood.

Alcohol

Methyl and ethyl alcohol, both derivable from wood, are used as fuel for spirit lamps, blow torches, some types of cigarette lighters, and in other heating equipment of small size where an exceptionally clean flame is desired. Such uses consume only a very small portion of the total alcohol production.

A very good alcohol motor fuel, made of ethyl alcohol and blended with about 10 to 15 percent of petroleum derivatives, was marketed in the early 1920's but it could not compete with straight gasolines. If petroleum resources become short, gasoline supplies could be extended by blending with ethyl alcohol in quantities up to 10 percent. Such a potential market would be large, and alcohol from wood residue could share in it.

Methyl alcohol is a coproduct of the carbonization of wood, but the low yield eliminates it as a major factor in future motor-fuel markets. Wood for the production of ethyl alcohol must be in the form of chips or fine particles, but need not be dry. Ethyl alcohol is a fermentation product of wood sugars resulting from an acid treatment of wood. Therefore the coniferous species are better for this purpose than hardwoods because of their higher percentage of alcohol-forming sugars from the cellulose. One ethyl alcohol plant in Oregon operated on Douglas-fir residue during World War II, when alcohol prices were high. The plant could not compete later with alcohol produced from molasses, and was converted to other uses.

⁷A new market for sawmill residues? *Pulpwood Production and Sawmill Logging* 8(8):14. 1960.

Briquets from Wood

The art of briquetting is relatively old and has been applied to a great variety of substances. Briquetting methods have been used in some European countries for many years on sawdust, shavings, extracted bark, and chips. In the United States, because of the cheapness of other fuel and the plentiful supply of solid firewood, many similar ventures during the last half century have been financially unsuccessful. As a conservation and stop-loss measure, there remains a strong inducement to convert otherwise residue wood of low value to dense, clean, easily burned briquets. A radically different method of briquetting has, in recent years, made manufacture of wood residue into briquets a financially successful operation under favorable conditions. Briquetting of wood is discussed in another Forest Products Laboratory report.⁸ Bark is often present in the residue being briquetted, and bark alone can be briquetted with the same equipment. All-bark briquets are not common at present, possibly because the large volumes of bark required for economic briquetting are found principally where wet debarking systems are used and excessive drying costs would be involved. One New England processor, however, produces bark briquets with flame-coloring chemicals added.

Measurement of Wood Fuels

Solid fuel wood is ordinarily sold on the basis of stacked volume, although some sales are made on a weight basis. Neither basis provides a fully satisfactory measure of the fuel value of the wood. Weight is unreliable because moisture content is variable and difficult to check. Stacked volume, although easy to determine, is not an accurate measure of the amount of solid wood. The standard cord embraces 128 cubic feet of 'space (equivalent to a pile 4 by 4 by 8 feet), but its solid content will vary with the length of the sticks and their diameter, roughness, and crookedness.

Shortening the sticks will increase the amount of solid wood per cord. In one test (based on more than 50 cords) there were 78.8 cubic feet of solid wood per cord in 4-foot lengths. However, when cut to 12- and 16-inch lengths, this same wood measured 97.5 cubic feet per standard cord. Similarly, 8- or 5-foot wood will show less solid wood per cord than 4-foot wood. Solid content may vary from 65 to 90 cubic feet per cord of 4-foot wood, depending upon the diameter, roughness, and crookedness of the sticks. These variations of solid content with stick length and form should be considered in setting fuel wood prices.

⁸Reineke, L. H. Briquets from wood residue. U.S. Forest Service Research Note FPL-076. 1964. Forest Products Lab., Madison, Wis.

One way to eliminate the effect of bucking is to sell all short lengths on the basis of the volume of the 4- or 5-foot sticks from which they were produced. Sometimes short lengths are sold by the "loose load," which may or may not be equivalent of a cord of 4-foot wood. A cord of 4-foot wood bucked into 12-inch lengths and thrown (not piled) into a box will occupy 140 to 153 cubic feet of space, an increase over stacked space of 9.5 to 19.5 percent.

Stovewood is often sold by the "face cord." This unit of measurement is the amount of wood of specified length contained in a stack 4 feet high and 8 feet long, or its equivalent, and may be applied to bucked cordwood and to slabwood. Kindling is sometimes bundled but seldom stacked for sale. Usually it is sold by the bushel bag or by the "load," the amount the buyer can place in his vehicle.

Chips, sawdust, and shavings are extensively sold for fuel use only in the Northwest, where the "unit" of 200 cubic feet is the standard measure. A cord of round wood will produce, roughly, one unit of chips and sawdust. Bark, if used for fuel, is consumed at the mill where produced and is not a regular trade item.

Of the processed fuels, lump charcoal is sold by weight in bushel sacks (20 pounds) or smaller bags. Briquetted charcoal for picnic use is sometimes packaged in cartons. Briquetted wood waste, in large-quantity sales, is sold by the ton, while some luxury-trade sales for fireplace use are made by the carton.

Stoker-size briquets are becoming popular in some western localities for mechanically-stoked home furnaces. These small briquets are also being packaged for camp use and outdoor cooking. The liquid fuels, methyl alcohol and ethyl alcohol from wood, are sold by liquid measure in lots varying upward from a few ounces.

Byproducts of Wood-Fuel Combustion

Byproducts of the burning of wood fuel for heat or energy are (1) waste energy, (2) gases, (3) volatiles, and (4) solids.

Standard waste-heat recovery methods are usable with the flue gases of wood. These gases are sulfur-free, but may contain some tars or acetic acid that may influence choice of materials or layout of the system used. Combustion gases from charcoal or alcohol are largely free of constituents that might interfere with waste-heat recovery. Waste heat in gases is recovered chiefly by using them for drying. For example, the gases may be circulated directly through sawdust. Other standard heat-recovery methods are applicable. They may be industrially economical where the wood-fuel supply does not exceed requirements and other fuels are expensive.

Apart from their heat content, flue gases are chemical byproducts that are occasionally of value. Composed chiefly of nitrogen from the air supplied for combustion, flue gas normally contains, however, from 12 to 17 percent of carbon dioxide. A few papermills use this carbon dioxide component in their process. One mill burns wood primarily for such use. Otherwise, no use of carbon dioxide as a chemical is made in the wood-using industries. One coal-burning electric generating station has installed scrubbers and other equipment to produce a pure carbon dioxide for the trade. A similar operation may be feasible for wood-burning plants to provide a local supply of dry ice or liquified carbon dioxide in cylinders for fire extinguishers, spray painting, inert atmospheres, or other industrial processes, and for carbonation of water.

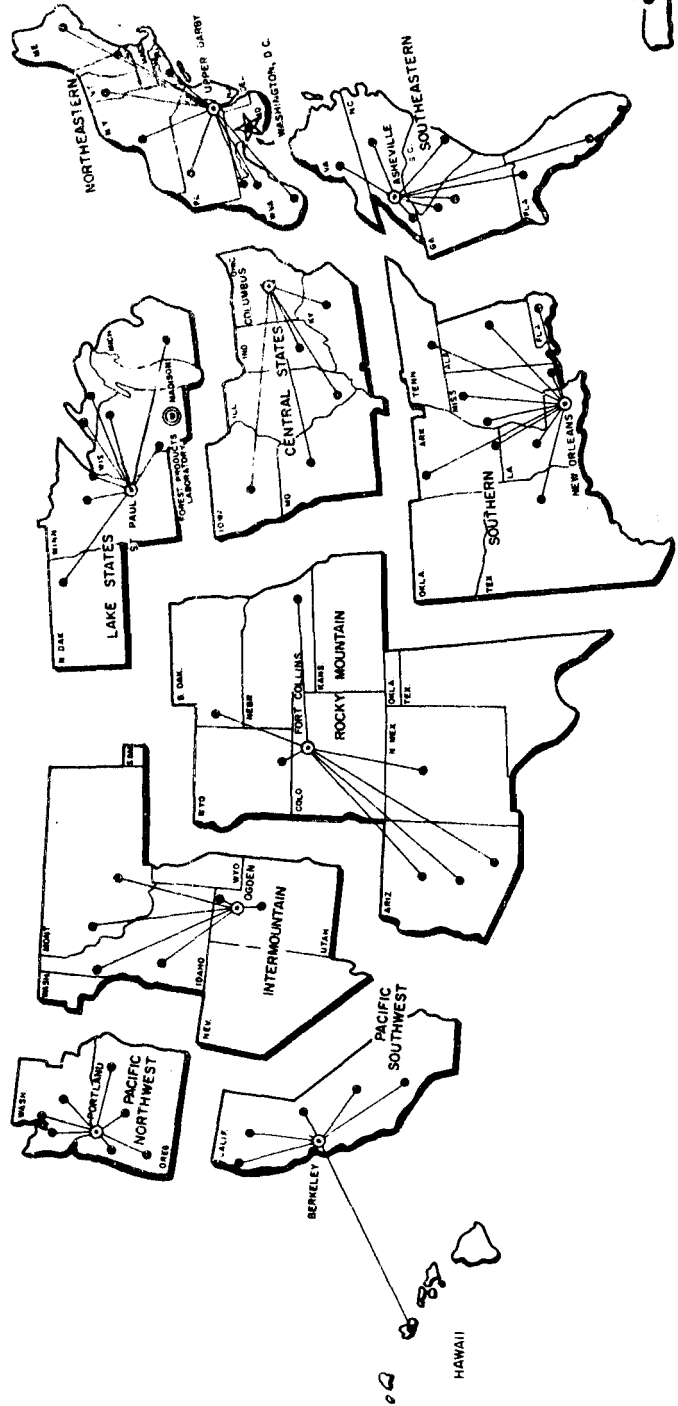
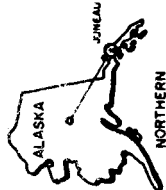
Flue gases normally contain water vapor and small quantities of other volatiles. Under improper operating conditions, the percentage of oils, tars, acetic acid, and other distillation products may rise to troublesome levels. They may cause corrosion, stains, excessive smoke, or hazardous combustible accumulations of tars. Because of the low market value of these volatile byproducts and their low concentrations under proper firing conditions, it would not be feasible to attempt their recovery, except, perhaps, as an incidental product of carbon dioxide recovery.

The nonvolatile product of combustion is, of course, ash, which contains the mineral residue of the wood and some unburned carbon. The mineral ash from wood amounts to 0.5 to 1 percent of the dry weight of the wood. However, total ash may be increased by unburned carbon or decreased by loss as fly ash when excessive draft is used.

Potash is an important constituent of wood ash and formerly was used for soap. Present potash prices do not warrant its recovery by separation from the ash. Wood ash, however, is used for fertilizer because of its potash, phosphorus, and calcium content, and its sale for this purpose by large wood users may noticeably reduce fuel costs.

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