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MANUFACTURING AND MARKETING OF WOOD FUEL PELLETS

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This project was undertaken in response to requests made by a number of firms, for information concerning the manufacturing and marketing of wood fuel pellets. The purpose of this project was to develop a relatively extensive document of background information to serve as an initial reference source for forest industry managers contemplating the manufacture and marketing of wood fuel pellets. The authors have endeavored to make any listings of suppliers of products and equipment as complete and correct as possible, however, it must be recognized that some errors of omission or clerical errors in transcription of information are inevitable. The authors wish to offer their sincere apology to any firms whose products are not listed as appropriate within this document due to oversight or other errors.

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This publication should in no way be construed as any kind of endorsement by either the authors or the College of Forestry, Wildlife and Range Sciences of the University of Idaho, either for or against, the manufacture and/or marketing of wood fuel pellets as a business venture, or the use of wood pellets as an alternative fuel.

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MANUFACTURING AND MARKETING OF WOOD FUEL PELLETS

A NATIONAL PERSPECTIVE ON WOOD ENERGY IN THE UNITED STATES

In 1981, the U.S. consumed a total of about 78 quads of energy. Of this total, approximately three quads or four percent of the total were from wood (Slinn, 1984). Industrial consumption, mainly by the forest products industry, used nearly two quads of this wood energy supply which it generated by direct combustion of mill residue as a manufacturing by-product. The remainder, about one quad, was used for residential heating and was produced from burning firewood (Slinn, 1984).

[A quad is defined as one quadrillion or 1×10^{15} BTUs of heat. Since a barrel of crude oil contains about six million BTUs, a quad is equivalent to approximately 167 million barrels of crude oil. A supertanker carries about 1.5 million barrels of oil, so 111 supertankers would be needed to transport one quad of energy in the form of oil.]

Table 1. WOOD ENERGY POTENTIAL IN CONJUNCTION WITH FOREST INVENTORY, GROWTH, HARVEST, AND UTILIZATION (Steinhagen, 1986)

Inventory	
Commercial Forest Land	352 quads
Non-commercial Forest Land	80 quads
Total Inventory	432 quads
Net Growth (less mortality)	
Commercial Forest Land	7 - 14 quads/year
Non-commercial Forest Land	1 quad/year
Total Growth	8 - 15 quads/year
Harvest and Utilization	
Harvest Converted to Finished Products	1.7 quads/year
Harvest Converted to Wood Fuel	1.5 quads/year
Harvest Not Utilized	2.2 quads/year
Total Harvest and Utilization	5.4 quads/year

A conclusion that may be drawn is that 1980 inventory data indicate a surplus and potential energy supply, just from the growth alone, of approximately five to twelve quads per year.

The national pattern of wood energy use in 1982 within the forest products industry was as follows (Slinn, 1984):

* hog fuel	8.0%
* bark	5.4%
* spent liquor (from pulping)	37.4%
* fossil fuels, electricity, other	49.2%
totals	100.0%

Estimates of potential sources of annual available forest biomass (in million dry tons) for energy conversion by the year 2000 are summarized in the following table.

Table 2. Estimated Forest Biomass For Energy By the Year 2000 (DOE, 1981)

Biomass Source	Million Tons Dry Biomass	Million Tons Dry Biomass For Energy	Quads of Potential Gross Energy	Quads of Potential Net Energy
mill residue	200	100	1.70	1.08
logging residue	205	50	0.85	0.50
thinnings (TSI)	70	35	0.60	0.35
unharvested mortality/growth	310	30	0.51	0.30
non-commercial wood residue	55	55	0.94	0.55
wood energy plantations	10	8	0.17	0.10
totals	850	278	4.47	2.88

Total U.S. energy demand within various demand sectors in quads per year by the year 2000 is projected by the two scenarios, A and B, for a variety of fuel sources.

Scenario A (DOE, 1979)

	DEMAND				SUPPLY	
Fuel	Residential Commercial	Industrial	Trans-portation	Elec-tricity	Domestic	Imported
oil & NGL	3.0	5.0	21.0	2.0	22.0	10.0
natural gas	9.0	12.0	--	--	19.0	2.0
coal	--	9.0	--	30.0	39.0	--
nuclear	--	--	--	17.0	17.0	--
hydro-electric	--	--	--	4.0	4.0	
biomass	0.5	2.5	--	--	3.0	--
solar	1.0	1.0	--	--	2.0	--
totals	13.5	29.5	21.0	53.0	106.0	12.0

Scenario B (OTA, 1979)

oil & NGL	1.0	2.0	16.0	--	15.0	4.0
natural gas	4.5	11.5	0.5	0.5	16.0	1.0
coal	--	9.0	--	21.0	30.0	--
nuclear	--	--	--	7.0	7.0	--
hydro-electric	--	--	--	4.0	4.0	--
solar	1.5	1.0	--	1.5	4.0	--
syn fuel	--	1.5	3.5	1.0	6.0	--
biomass	0.5	2.5	--	--	3.0	--
totals	7.5	27.5	20.0	35.0	85.0	5.0

In spite of the liklihood of a surplus of wood energy supply in the U.S. by the year 2000, demand will probably increase only slightly or remain relatively constant throughout the period.

POTENTIAL SUPPLY OF WOOD FIBER FOR ENERGY IN IDAHO

Introduction

In addition to directly harvesting the standing forest resource, a large share of Idaho's forest products industry is based on the utilization of wood "residue" as a by-product of lumber and plywood production. This segment of Idaho's forest products industry is presently dominated by a kraft paper mill in Lewiston and a particle board plant at Post Falls. The following paragraphs are an examination of the type of residue that is available, its use, and the amount considered to be surplus and available for other alternatives such as wood pellet manufacturing.

Types of Residue

Sawmills and plywood plants generate three types of wood residue: 1) coarse or chipper residue composed primarily of slabs, edgings, and trim from lumber manufacturing, log ends from sawmills and plywood mills, and peeler cores and veneer waste from plywood plants; 2) fine residue in the form of planer shavings and sawdust from sawmills and sander dust from plywood plants; and 3) bark from sawmills and plywood mills.

Trends in Residue Production and Consumption

By 1980, sawmills and plywood mills were producing approximately 2.4 million bone dry units (BDUs) of mill residue, a decline from 1969 and 1970 levels when 2.7 million units were generated (Keegan et al, 1980). [A BDU is defined as 200 cubic feet in volume of wood chips at oven-dry conditions and weighing approximately one ton.] Utilization of this residue, however, increased significantly from 63 percent of the total available in 1969 to over 90 percent in 1980. Table 3 is a reflection of the trend for utilization of wood residue by Idaho forest industry in 1969 and 1979.

Table 3. Estimated Volume of Wood Residue Generated by Idaho Sawmills and Plywood Mills - 1969 & 1979 (Keegan et al., 1980)

	Estimated Volume (million BDUs)			Percent of Total	
Residue	Utilized	Unutilized	Total	Utilized	Unutilized
chipped					
1969	0.830	0.268	1.098	76	24
1979	0.987	0.021	1.008	98	2
fines					
1969	0.621	0.353	0.974	64	36
1979	0.739	0.078	0.817	90	10
bark					
1969	0.254	0.393	0.647	39	61
1979	0.473	0.174	0.647	73	27
totals					
1969	1.705	1.014	2.719	63	37
1979	2.199	0.273	2.472	89	11

Use of Residue in Idaho

Coarse residue has the greatest demand within the forest industry. Most of this residue type is currently being used in pulp and paper manufacturing. In 1980, approximately 1.008 million BDUs were available of which 98% was utilized. Of the total 1.008 million BDUs available, the pulp and paper industry consumed about 957,000 or 95%, hog fuel for steam boilers in sawmills took approximately 10,000 or 1%, and other industry requirements were about 20,000 or 2%. Approximately 20,000 BDUs of coarse residue remained unutilized.

Over 90% of the fine residue was used in 1980 compared to about 64% in 1969-1970. Sawdust made up the greatest proportion of this residue type, about 457,000 BDUs, and planer shavings accounted for approximately 360,000. Although sawdust comprises the greatest volume of fine residue, it is utilized less heavily than planer shavings (95% in 1980). Board plants used the greatest amount of planer shavings, about 215,000 BDUs, while 112,000 went into hog fuel and 13,000 ended up as bedding for livestock. In 1980, about 20,000 BDUs remained unutilized.

Of the total sawdust generated by the wood industry, 197,000 BDUs or 43% was consumed by pulp mills and board plants, 164,000 or 36% went into hog fuel, and 38,000 or 8% found other uses. In 1980, 13% of the total sawdust residue that was still available for use.

The utilization of bark has steadily increased from 1969 levels. In 1980, 73% of the bark was used compared to less than 39% in 1969. The total generated was approximately 647,000 BDUs. Of this volume, 429,000 or 66% was used as hog fuel and 44,000 or 7% went for animal bedding or mulch. The remaining 174,000 BDUs or 27% was either burned or piled for later disposal.

Table 4 shows a comparison of the utilized and unutilized volumes of residue in north and south Idaho in 1980 (Keegan et al, 1980). Although coarse and fine residues were heavily utilized in both areas, a difference did occur with bark consumption. In north Idaho, 386,000 BDUs or 77% of the total bark in that region (504,000 BDUs) was utilized, compared to 87,000 or 61% of the total (143,000 BDUs) for southern Idaho. Studies presently underway will soon provide a more accurate picture of present day residue utilization where several wood cogeneration plants now consume significant quantities of residue.

Table 4. Amount of Residue Generated in Idaho By Region - 1979 (Keegan et al., 1980)

	Estimated Volume (million BDUs)		
chipped			
north Idaho	0.779	0.018	0.797
south Idaho	0.208	0.003	0.211
planer shavings			
north Idaho	0.263	0.017	0.208
south Idaho	0.077	0.003	0.080
sawdust			
north Idaho	0.317	0.033	0.350
south Idaho	0.082	0.025	0.107
bark			
north Idaho	0.386	0.118	0.504
south Idaho	0.087	0.056	0.143
totals			
north Idaho	1.745	0.186	1.859
south Idaho	0.454	0.087	0.541
grand totals	2.199	0.273	2.400

Other Sources of Manufacturing Wood Residue in Idaho

Although large primary manufacturers of wood products generate the largest volume of wood residue, there are several small and medium primary processors that are likely to be significant contributors. These firms, numbering approximately 125 (Govett and Lange, 1985),include utility pole, house log, cedar products, post and pole manufacturers and small sawmills. There are currently no volume estimates of the total residue these firms generate however, only a small amount of this total is sold. Known markets include livestock bedding, organic material for nurseries, garden mulch, and firewood.

Logging Slash As A Souce of Wood Energy

Logging operations generate large voulmes of slash such as tree limbs and tops, cull logs, and unmerchantable, residual trees. The recovery of such residue from steep slopes, however, may be too costly even when performed simultaneously with harvesting activities. The amount of logging slash from Idaho forests often ranges from 45-50 tons per acre. Research with residue recovery suggests a cost that may run as high as $30 per ton, excluding the cost of transporting the residue to the location where it will be utilized (Lee, 1986). Even if the operator could economically recover the slash concurrently with sawlogs, he would also face processing, handling and storage problems that would very possibly make the operation cost prohibitive.

Forest Land and Timber Inventories in Idaho

Idaho supports a large commercial forest land base from which wood for energy could be obtained. Tables 5 and 6 present an overview of forest land acreage by region and ownership classification and a projection of volume growth for this ownership.

Table 5. Commercial Forest Land Within the State of Idaho - 1975 (Hatch et al., 1976)

Region	Ownership Classification		Acreage (thousands)
North Idaho	National forest		4,208.7
	other public		778.7
	forest industry		777.6
	other private		1,808.6
		total:	7,573.6
South Idaho	national forest		6,125.0
	other public		568.2
	forest industry		169.1
	other private		265.5
		total:	7,127.8
North and South Idaho (all classifications)			14,701.4

Table 6. Projected Annual Growth of Idaho Forests - 1975 (Hatch et al., 1976)

Year	National Forest	Other Public	Forest Industry	Other Private
	Million cubic feet/year (net)			
		North Idaho		
1980 - 1990	119.00	27.97	45.35	41.15
1990 - 2000	127.32	29.62	50.60	41.73
2000 - 2010	132.68	30.71	57.90	41.33
2010 - 2020	135.85	31.50	55.75	40.66
2020 - 2030	137.42	32.07	56.47	40.04
2030 - 2040	137.77	32.45	56.54	39.58
2040 - 2050	137.89	32.68	56.36	39.31
		South Idaho		
1980 - 1990	74.62	5.80	7.89	3.82
1990 - 2000	81.00	5.88	8.25	3.84
2000 - 2010	85.65	5.88	8.44	3.83
2010 - 2020	88.86	5.85	8.54	3.80
2020 - 2030	90.85	5.79	8.57	3.71
2030 - 2040	92.00	5.72	8.57	3.71
2040 - 2050	92.50	5.66	8.55	3.67

In summary, the forest products industry in Idaho is consuming more than 98% of the coarse and fine residue that is available. It is a result of the competition for utilization of this residue. Given this economic constraint, there is little excess for other uses such as wood pellet manufacturing. Wood pellet manufacturing must be expected to generate a higher economic return than other uses of these wood residues if supplies of residues are to be made available for such use. Other producers of wood residue, however, may be potential sources but these firms have not been inventoried and are scattered throughout the state. Under present technology, bark is not desirable from a quality stand point in the production of wood pellets. The recovery of logging slash could supply material for new residue utilization. However, the recovery, processing and handling costs of the material are expensive. The commercial forest land base throughout the state is substantial, particularly in north Idaho where total growth per year for the region is in excess of 230 million cubic feet. Net cubic foot volume growth for the state as a whole (average of both regions) is projected to increase approximately 16 percent over the next 70 years. This would suggest an increasing wood resource that could meet raw material requirements for new forest products industry.

RAW MATERIAL RECOVERY FOR ENERGY WOOD - FIXED SITE AND MOBILE CHIPPING

Much of the supply of raw material for existing pellet mills now comes from mill residue in the form of saw dust, chips and shavings. But if wood pellets are to become a growing source of energy, alternative raw material sources must be located and utilized. Alternative sources presently being drawn upon or considered for energy production are recovery of logging residue, the processing of unmerchantable material from thinning and timber stand improvement, and the utilization of cull trees and logs in conjunction with harvesting operations. Recovery of logging residue implies entering an area after logging is completed and recovering the residue from landing slash piles and other scattered accumulations throughout the logged area. Utilization of unmerchantable material usually means whole tree processing, sometimes from pulp grade trees, and the processing of green slash as it is produced during a logging operation.

Wood pellet manufacturing requires the roundwood or residue to be broken down into chips, shavings, and eventually to particles prior to pelletizing. There are many ways of acheiving this either through stationary (on-site) or mobile (in-the-woods) chippers, shredders, chunkers, or hammermills. One method to produce energy wood would be to use in-the-woods chippers and then transport the chips to the pellet mill. Another method would be the use of a stationary chipper at or near the pellet mill and transport the raw material to the chipper site. There are many different chippers on the market that cover a wide range of prices depending on the desired chip quality, the machine capacity and mobility, and material handling options.

One reason that current research focuses on logging residue recovery is that the residue is already delivered to landings during harvesting. Utilization of logging residue can also increase revenues from logging and benefit other forest management activities. Some studies indicates that the use of logging residue for energy is not feasible in most operations because of the inefficiency of using large capacity chippers, long hauling distances and low hog fuel prices. Researchers, nontheless, do feel that residue recovery with an ongoing harvesting operation, using a small chipper and 129 mile hauling distances, would be profitable at hog fuel prices of $30 per dry ton (Dean, 1983).

There is a great need with chipper operations to match skidder production, volume, and size of residue, to the chipper capacity (Keller, 1983). The main problem with in-the-woods chipping is the over capacity of the equipment. This in effect raises the per ton cost of the chips. One study with a large capacity chipper showed that efficiency was raised from 48.5% to 76.2% by using two skidders, instead of one, to supply material (Dean, 1983). This increased production from 4.63 tons to 8.5 tons per scheduled machine hour and lowered the cost of skidding and chipping the material from $24.71 to $21.60 per green ton. [A scheduled machine hour is defined as the planned operating time period for a piece of equipment disregarding downtime.]

Efficiency of operation using chippers is a continuing problem that has many ramifications. A study comparing three models of chippers on three different logging operations revealed a chipper efficiency that ranged from 28% to 52%. Cited as major delays were chippers waiting on skidders for residue delivery, chippers waiting for vans to load, and chipper downtime. The latter was due to knife changing, especially with sliding boom, infeed equipment. In the same study, when chipping costs alone were considered, whole tree processing with large chippers was found to be less expensive than residue recovery with small capacity equipment (Dean, 1983). This was a direct result of larger chippers being utilized more economically from larger piece volumes and from less mechanical downtime due to cleaner raw material. This information suggests a point where logging residue would be cost prohibitive for producing chips if it were below a certain quality. Total system costs for harvesting, skidding, and processing whole trees in the previously mentioned study, ranged from $8.16 per green ton of energy wood with a large capacity chipper to $25.14 per green ton for a small capacity machine in residue recovery. Overall, larger chippers with an 18 inch or greater capacity were found to be better suited for whole tree processing, and small chippers, 14 inces or less, better for salvage operations and residue recovery.

The Forest Engineering Institute of Canada in Prince George, British Columbia, examined hauling logging residue to a central site for processing (Powell, 1982). A front-end loader with a high capacity, self-feeding chipper were utilized. The loader emptied trucks and placed material within reach of the chipper. Production of the chipper averaged 277.75 green tons per day or 36.33 green tons per productive machine hour. Costs of the loader and chipper were estimated at $8.54 (U.S.) per green ton. [U.S. dollars have been determined from the Canadian dollar at an exchange rate of 78%.] Cost delivered to the mill, including logging and hauling, and the chipping costs were estimated at $39.04 (U.S.) per green ton. Records show that birch and aspen, while green, were the easiest to process, and dry softwood species were the most difficult. The chipper was also found to be sensitive to dirt, and incurred excessive downtime for knife replcement with material from landing slash piles. It was concluded that shredders or hoggers that are less sensitive to dirt would be a better alternative for processing this type of raw material.

Even though it is probably more economical in most cases to consume mill waste to produce wood pellets, an expanding pellet market will make the utilization of alternative raw material sources a necessity. The two likely sources identified are logging residue or slash left after harvesting and unmerchantable trees from thinnings and on-going logging operations. Whereas chippers may be economical for whole tree processing, more research is needed in the field of utilizing the residue from slash piles. Chipper downtime in dry, dirty residue due to mechanical problems appears to be an economical constraint. The availability of large amounts of this type of residue, however, make it a problem worthy of a solution. Efficiency in any chipping operation is of primary importance. Typical problems include scheduling vans for loading, matching equipment to volumes and sizes of the raw material, and mechanical downtime costs. If future raw material supplies are expected to lean heavily on logging residue, consideration of another type of processor, such as a shredder, hogger or hammermill, would appear prudent.

WOOD PELLETS - PATENTS, MANUFACTURING PROCESSES AND EQUIPMENT

Patents

The first recorded patent for using biomass material as a source of energy dates back to 1864. It was manufactured by combining sawdust, tar, wood cuttings or chips, water, and coal tar to form an artificial fuel. About one hundred years later, other techniques were used to shape wood waste material into briquettes.

An important process to produce pellets was invented by Rudolf W. Gunnerman in 1977 (U.S. Patent #4,015,951). In this process, a raw material of random particle size, such as sawdust or other wood product waste with a non-uniform water content, is carried by a conventional pneumatic conveyor to a hammermill. Here the particle size is adjusted to a uniform maximum dimension which is approximately 85% or less of the minimum thickness of the pellet to be produced. In a pneumatic conveyor, rocks, metal, and other foreign material are separated from the wood before it reaches the hammermill. Other types of conveyors that will separate foreign material from the wood may be used but best results have been obtained from a pneumatic conveyor. The product from the hammermill is transported to a rotary drum type dryer where the moisture content of the uniformly dimensioned wood particles is reduced to a range of 16 to 28% (ovendry basis). The particles are then moved by conveyor to a pelletizing machine. Once in the machine, the material is fed into a hopper and pressed through dies having the desired configuration and shape. The pellet mill must be capable of producing compression within the die which will cause the the temperature of the woody material to increase to approximately 350 degrees F. With some mills, load pressures may be as low as 8,000 or as high as 40,000 psi. Pressures within this range will produce the desired temperature during pelletizing. As a result, substances in the ligno-cellulose material exude from within and form a surface skin on the pellet that protects it from shattering and from any rapid change in moisture content before the fuel is used.

The wood pellets emerging from the mill are spread over a moving, endless belt conveyor where fans blow air over them to adjust the temperature and moisture content to approximately the ambient level. The product, now having a more uniform moisture content, may then be stored safely or used immediately. The equilibrium moisture content of the pellets will usually be within the range of seven to eight percent depending on the humidity at storage conditions.

The product is a combustible, organic, fibrous pellet having a symmetrical configuration with a maximum cross-sectional dimension of not more than one-half inch and a density greater than 65 pounds per cubic foot. Pellets burn uniformly and release approximately 8,500 to 9,000 BTUs per pound.

With this process, it is not necessary to add a binder material to the particles, provided the pressure during pelletizing is sufficient to produce the necessary 325-350 degrees F temperature. But if desired, organic materials such as waxes or the like may be added to the fibrous material to supplement the natural substances within the wood particles.

During the 1980's, other processes were developed that used different types of binders. By doing so, a heating value approaching that of coal was obtained. These binders not only improved the ignition and burning characteristics of the pellet but also lubricated the pelletizing dies and extended their lives.

In 1980, Ian F. Johnston invented a fuel pellet having a minimum dimension of at least 3/16 of an inch, for ease of handling, and was comprised of approximately 50 to 99% by weight of natural cellulosic material and from one to 50% by weight of a synthetic, polymeric, thermoplastic material (U.S. Patent #4,236,897). The thermoplastic material was chosen because it solidifies at at a temperture no greater than 200 degrees F. The thermoplastic serves to bind the pellet together, increases the heating value of the pellet, lubricates the pelletizing die, and improves the ignition and burning characteristics of the pellet. The pellets are easily ignited, burn evenly, resist changes in humidity, and generally produce a gross heating value in excess of 9,000 BTUs per pound.

The natural cellulosic material used to manufacture the pellet can be woody material such as sawdust, wood shavings, sander dust, hog fuel, peat, and bark. Agricultural waste such as banana and papaya stalks, straw, bamboo, jute, bagasse, corn cobs and husks, cotton "gin trash", sisal, seed hulls, and peanut hulls can also be processed. The synthetic thermoplastic material can be polystyrene, polyethylene, polypropylene, acrylonitrile-butadienestyrene, acetal copolymer, acetal homopolymer, acrylic, polybutylene, and many combinations of these.

A process developed by Charles J. Reilly in 1983 (U.S. Patent #4,398,917) modifies the cellulose and renders it more pliable and soft. The cellulose will then flow easily into the pelletizing press and can be processed without the use of excessive mechanical power. Moreover, the cellulose particles are less abrasive than the unmodified material and the life of the die is further extended.

The Reilly Process is directed at the preparation of fuel pellets that are derived in whole or in part from at least one cellulose based material. The only requirement for the material is that it can be softened by the enzyme, cellulase. The form of the cellulose can be paper, sawdust, roundwood, wood chips, wood waste, peat, bark, and urban or municiple waste principally in the form of paper or paper derivitives. The preferred moisture content of the processed material should not exceed 15 to 25% by weight.

The cellulose material is hogged by rotary knives, grinders and shredders, and hammermills to communate the material to the desired particle size. The preferred particle size for wood is approximately three quarters of an inch. After communating the cellulosic material, it is sieved to produce uniform size particles. At this stage, depending again upon the material being pelletized, it may be desirable to precondition it before the material is brought in contact with enzymes. Preconditioning can be effected by a variety of methods including acid, alkali, and steam treatment.

The next step is the modification of the cellulose structure by means of the enzyme, cellulase. The enzyme is applied over the material at the rate of about one to two pounds per ton of cellulose. The reaction requires from one-half to eight hours. The modified material is then ready for pelletizing, using any of the types of equipment presently on the market.

Pellets prepared by the Reilly Process have a density of 35 pounds per cubic foot as opposed to approximately five pounds per cubic feet prior to pelletizing. The calorific value is rated at about 7,500 BTUs per pound. The pellets produced are acceptable for home heating or for use in commercial and industrial boilers.

Manufacturing Information on Pelletizing Equipment

Pellet machines take finely processed, difficult-to-handle material, and compress it into small cylinders called pellets. Among the benefits of pellets are:

- an upgrade of the particle size
- bulk handling, storage and shipment are facilitated
- dust and associated control problems are reduced
- uniform appearance is acheived
- increased bulk density is obtained
- no product separation is necessary
- subsequent processes and uses are improved

Pelletizing by means of "die and roller" units is among several methods of particle size upgrading and densification of wood partilces. Others include densification with disk pelletizers or "flying saucers", drum and rotary cylinder pelletizers, tablet presses, compacting and briquetting rolls, and screw extruders. Each pelleting method is suited to particular materials and end products. Method selection is influenced by factors such as capacity required, abrasiveness, plasticity, finished particle appearance, size and shape, need and tolerance for lubricants and binders, and the material's adaptability to the process.

PRODUCT QUALITY, TRADEMARKS, AND END USES

Grades and Types

Wood pellets are used as an alternative energy source for commercial/industrial and residential applications. In general, pellets are three-sixteenths to one-half inch in diameter and one-half inch long (Zerbe, 1978). Presently, there are no standards for this type of densified wood fuel. There are, however, plans in the making to standardize this product to meet the following general requirements: (1) for commercial/industrial use, the ash content may be more than one percent, and for residential consumption, ash content must be less than one percent, (2) pellet diameter may range from one-fourth to five-sixteenths inch, (3) pellet length may range from one-half to two inches, (4) moisture content should not exceed ten percent and, (5) no species designation (Tucker, 1986).

Examples of some available pellet products outlined below offer a general description of product quality.

1) Woodex
Woodex is refined from almost any organic, fibrous material including wood waste, bagasse, agricultural waste, and peat. The manufacturer of Woodex pellets reports that the product has a moisture content of 10%, a low ash content, virtually non-existent sulfur content, and carbon dioxide emissions equal to the carbon dioxide released into the atmoshere if the raw material were left to naturally decompose. Natural resins serve as binders for these pellets. Woodex pellet density is approximately 35 pounds per cubic foot and delivers about 9,000 BTUs per pound (Blackman, 1978; Carpenter, 1981; Pearson, 1981).

2) Lignetics
Lignetics is a densified wood fuel manufactured by a proprietary process from wood waste including sawdust, wood shavings, bark, hog fuel, and trash wood. A small amount of a polystyrene additive, estimated at approximately one percent by volume, facilitates the formation of dust-free pellets, lubricates the dies in the pelletizer, increases the BTU content, and accelerates the burning rate. Lignetics pellets are reported to to produce about one percent ash when burned, contain a moisture content of 10 percent, and produce 8,500 to 9,000 BTUs of energy per pound of wood pellets (Lignetics, 1986). The product is sold by the ton in bulk or in 40 pound bags.

3) Roemmc
Roemmc fuel pellets may be used as a heating fuel for commercial/industrial and residential applications. Reported specifications by the manufacturer are that (1) pellets may be made from any biomass including wood, straw, nut hulls, bagasse, corn cobs, and peat, (2) moisture content may not exceed 12 percent, (3) ash content may not exceed five percent, (4) average density is about 40 pounds per cubic foot, and (5) the average BTU content is 8,500 per pound (Guaranty, 1986).

4) Pelletized Sludge

At the Abitibi-Price hardboard palnt in Alpena, Michigan, sludge collected by a dissolved air flotation process is dried and pelletized. The pellets are burned as a supplemental fuel in combination with coal and reduce the amount of coal used by about 15 percent. The BTU content of the pelletized sludge is approximately two-thirds that of coal or about 8,600 BTUs per pound. The moisture content of the sludge pellets ranges from seven to eight percent and varies from one-sixteenth to three-sixteenths of an inch in diameter (American Logger & Lumberman, 1981).

Industrial/Commercial Use

For an industry considering the use of densified wood pellets for fuel, there is some question as to whether the added expense of processing is justified by the increased ease of handling and the improved combustion efficiency of the end product. Where high sulfur emissions from coal are a problem, burning sulfur-free wood pellets in combination with coal may be a solution (Johnson, 1982). Having to choose between installing expensive scrubbers or burning sulfur-free fuel, a hospital in Oregon changed to wood pellets without expensive boiler modifications. In the case of a lumber mill, wood pellets may provide greater efficiency and fewer stack emissions than conventional mixtures of dry wood and manufacturing waste, and hog fuel (Zerbe, 1978). Where hog fuel is available to a mill within a 25 mile radius, the economic advantages of pellets may be nullified (Pearson, 1981).

Wood pellets can be used to fuel large industrial boilers, such as factory assembled package boilers up to 1,200 horse power (Guaranty, 1986). Pellet fuel can be burned in a standard, stoker-spreader furnace or it can be used in a suspension burner by reducing the pellets to powder with a hammermill and burning the particles in suspension.

Wood pellets can be easily handled by conveyor equipment. Short duration, outdoor storage using covers, silos, or bins reportedly will not adversely affect the moisture content. One study, however, involving delivery and storage of wood pellets for a small scale consumer showed that degradation during handling produced an unacceptable problem with fuel dust (Brandon and Wright, 1982).

Residential Use

An exploratory study of residential wood pellet use was conducted using a judgement sample of selected stove dealers. Information on pellet stoves and wood pellets was obtained through telephone and face-to-face interviews that concentrated on the residential use of the wood pellet technology. Three geographical areas in Idaho and Washington were canvassed by the telephone survey; Boise, Coeur d'Alene, and Spokane. A face-to-face interview of wood pellet and pellet stove dealers was conducted in Spokane.

Telephone Survey Description

The telephone survey asked retail dealers a series of questions to determine if they sold pellet stoves and wood pellets, and to gather opinions regarding overall wood pellet technology. If dealers sold pellet stoves, brand names and prices were requested. If wood pellets were sold, the supplier or manufacturer and retail prices were recorded. After the initial series of sales-related questions, dealers were asked to comment on customer satisfaction and to give their personal opinion regarding wood pellet technology. A summary of the results of the telephone survey is presented in Table 7.

Table 7. Summary of Telephone Survey Results

Area	Number Surveyed	Number of Responses	Sell Pellet Stoves	Sell Wood Pellets
Spokane	15	10	6	2
Coeur d'Alene	9	6	3	1
Boise	3	3	2	1
other	3	3	2	1
totals	30	22	12	5

Dealers were selected from the yellow pages of telephone directories. The difference between the number surveyed and the number of responses is the result of disconnected telephone service, and dealers who have changed location or gone out of business.

The survey showed that out of 22 dealers that were contacted, 12 sold wood pellet stoves as part of their line of wood burning appliances. Of the 12 dealers, seven displayed pellet stoves in their show rooms. The remainder stated that they would have them on display by the end of July, 1986.

The survey further indicated that only five of the 12 dealers who handled pellet stoves also sold wood pellets. Quantity sold by the five wood pellet suppliers ranged from 40 pound bags to bulk delivery. Those seven dealers not carrying wood pellets stated that they would act as an intermediary for pellet sales with the manufacturer or other suppliers but had no intentions at this time of keeping pellets on inventory.

wood pellet stoves

Table 8 is a summary of the manufacturers brand names and prices for wood pellet stoves in the telephone survey areas.

Table 8. Brand Names and Retail Prices of Pellet Stoves

brand	average cost	price range
Whitfield	$1,289	$1,200 - 1,500
Traeger	$1,336	$1,200 - 1,800
Collins	$1,330	$1,300 - 1,390
Sweet Home	$1,500	$1,200 - 1,800
Everlasting	$ 475	-
other	$1,300	-

The majority of the dealers selling pellet stoves carry more than one brand name in their show rooms. Three dealers dispalyed as many as three different brand names at one time. Whitfield, Traeger, and Collins Pellifier were the three most frequently carried brand names. Dealers had varying opinions as to their popularity. Some felt that these pellet stoves were the most efficient, had lower maintenence requirements, and were easier to install. The Sweet Home is a newer stove and only two of the dealers contacted carried it. The Everlasting stove is less expensive because it is an "add-on" pellet burning device. As the name implies, an add-on appliance is located next to an existing furnace or boiler and uses the duct-work or piping to deliver the heat generated by the add-on (Pursley, 1980). Thus, the add-on allows the homeowner to switch back and forth from the pellet fuel device to the primary heating system. Add-ons fit into most primary heating systems usually by modification of the furnace door and fire pot.

The pellet stove listed as "other" is currently being manufactured by the Brondt Company, Spokane, Washington. The brand name was not released at the time of the survey.

wood pellets

Pellet stove dealers who carried wood pellets did so because they felt that customer satisfaction with their appliance was important and that selling pellets was one way to insure this. Table 9 indicates price differences between bag and bulk supplies.

Table 9. Pellet Distribution and Price

quantity	price	units
40 pound bag	$2.50 - 2.85	bag
40 pound bag	$110 - 132	ton
bulk	$ 65 - 110	ton

The amount charged by dealers for 40 pound bags was fairly consistent. If the consumer bought the bags in orders of 1 ton or more, the price would be reduced to approximately $2.20 per bag. Bulk purchase would require the consumer to store the bags and may not be desirable in some residential applications.

The wide in price for bulk sales is due to differences in markup with the $65 per ton quotation being direct from the manufacturer. The bulk retail price of $110 per ton reflects the additional cost of shipping, handling, and storage by the retail dealer. One retail dealer offers a free ton of wood pellets with the purchase of a pellet burning stove.

Retail dealers report a major problem with consumer acceptance of pellet burning appliances; a concern about price and availability of pellets. Since the pellet price is largely determined by the costs and profit margins of the pellet manufacturer, dealer prices of pellet burning appliances, supplies and services are felt to be too closely tied to pellet prices. Although wood pellet prices currently allow the dealer to sell pellets and pellet stoves, he feels that if prices were to increase, wood pellet stove sales would slow or might stop completely. At present, obtaining a pellet supply has not been a problem for the dealers contacted. Two, however, have expressed concern with availability and cost in the future as demand increases. No widespread concern was expressed concerning pellet quality, although one retail wood stove dealer not handling pellet stoves did state that some pellets would not burn well.

Within the region, wood pellet manufacturing plants are located at Bozeman and Darby, Montana, and at Sandpoint, Idaho. A fourth facility is to begin operation by the fall of 1986 in Spokane, Washington and fifth small palnt is being built in Julietta, Idaho.

One retail dealer at Post Falls, Idaho, stated that 50% of his last year's stove sales were wood pellet burning equipment. Since being in business, he has sold a total of 131 units and feels that sales will increase. Another dealer at Hayden Lake, Idaho, reported that 98% of the people inquiring about new or add-on energy systems ask about wood pellet burning stoves. His sales of pellet stoves have almost doubled since last year.

One dealer contacted felt that a customer should base his decision to buy a wood stove or a pellet stove on only one criteria; does he have access to wood. If the customer lives relatively close to a forested area containing an available supply of firewood, he should use firewood. Otherwise, wood pellets would probably be less expensive and troublesome.

Two of the dealers contacted stated that they would never consider carrying wood pellet stoves. Both felt that pellet stove engineering has some definite problems and that the stoves do not burn very well. One retailer felt that the wood pellet stove was not traditional and that its dependence upon electricity was a drawback.

The majority of dealer opinion indicated that in the future, the wood pellet stove was the only way to meet our energy needs. One dealer went so far as to say, "The wood pellet burning stove has reached the theoretical limits of efficiency."

Face-to-Face Interview

wood pellet stoves

Of the dealers questioned, half currently sold pellet stoves. Several of the dealers intended to sell or manufacture pellet stoves in the future. At the present time, the major reasons given by the stove dealers for not selling wood pellet stoves were:

1. Current stove technology is unacceptable to the stove dealers.
2. Pellet quality and availability is questionable.
3. In the opinion of the dealers, pellet stoves currently on the market are unattractive.

Since 1981, pellet stove sales have consistently increased. Dealers are anticipating sales of the pellet stoves to increase in the future.

All pellet stove dealers kept pellet stoves in stock for inspection by potential customers. Sales were generally to first time customers. It appears that nearly all customers are installing pellet stoves as a primary source of residential heat (mortgage regulations often require a backup source of heat other than a wood based system).

Sales of wood pellet stoves were geared to smaller homes (900 to 1000 square feet range). Dealer markup was higher for pellet stoves than conventional wood stoves. However, dealers stated that there was often more profit potential on conventional wood stove sales due to installation costs and the sale of accessory items.

Pellet stove customers reportedly felt that stoves were clean and inexpensive to operate. The major concerns with wood pellet stoves, as voiced to the dealers, were:

1. problems with stove technology which include auger maintenance, plugging of blower tubes, blower maintenance, and miscellaneous minor mechanical problems,
2. pellet quality, and
3. stove safety (burn-back into fuel hopper).

<u>wood pellets</u>

All pellet stove dealers contacted stock and sell wood pellets primarily to their stove customers. The package size sold in greatest quantity was the 40 pound bag and the greatest quantity purchased was one ton. One ton of pellets represents a 30 - 50 day supply of fuel.

The major complaints concerning pellet quality were:

1. Dirty fuel containing bark and contaminates which resulted in variable pellet quality and "klinker" buildup in the stove, and
2. widely varying pellet length resulting in numerous augering problems.

The following comments summarize the views and opinions of the dealers contacted by a face-to-face interview :

1. The technology of wood pellet stoves is not well developed.
2. There is a lack of knowledge and codes regarding the installation and use of chimneys for pellet burning equipment.
3. The future of wood pellet sales appears optimistic as there is a growing proportion of the wood heat stove sales in pellet stoves.

4. Sales of wood pellets will be geared to geographic areas where pellets are manufactured and readily available.
5. There is greater profit in conventional wood stove sales compared to pellet stoves.

WOOD PELLETS - MARKETS AND MARKETING

Introduction

The industrial sector is a large consumer of energy and as a consequence, became the first market for targeting wood pellet production. Wood pellets have many advantages over some other conventional fuels in that they are relatively cleaner to handle and burn. Wood pellets may be burned in a conventional stoker-spreader furnace without modification, or in a gas or oil furnace with minimum modification. With a substantially higher usable heat compared to round wood, and less pollutants and lower cost as compared to fuels such as coal, the savings acheivable from using wood pellets is fairly attractive to most industrial establishments (Spangler, 1977; Pursley, 1980; Pearson, 1981; Johnson, 1982).

On the other hand, wood pellets face stiff competition from other sources of inexpensive and readily available fuels. An example is sawdust which can be used to fire furnaces without being compressed into pellets.

Hydro-elctric power and natural gas are strong competitors with wood pellets in some areas of the country. While this might seem to eliminate much of the Pacific and Inland Northwest from being a potential wood pellet market, the actual picture is perhaps not quite that bleak. Many believe that low energy costs for hydro-electric and natural gas are only temporary and that the imposition of more strict air and water quality regulations are imminent. This will further discourage the utilization of fuels such as coal (Pearson, 1981).

Despite competition, the industrial sector has remained attractive to wood pellet manufacturers for several reasons. Only a relatively few industrial contracts, each with a large volume, will keep a pellet plant at desired production capacity. Serving just a few customers further reduces the sales force requirement and other logistics problems such as distribution and delivery. There are however, some disadvantages related to industrial sales. Dependence on just a few customers can be equated to "putting all the eggs in one basket". Large volume bulk sales are generally associated with low profit margin.

Sales efforts are increasingly being directed toward residential heating in recent years as a market segment offering higher margin potential (Spangler, 1977; Pursley, 1980). An objective of this section is to examine these potential market segments and the relative marketing approaches.

Identification of Market Segments

There are number of stages to market a product that could be categorized with the following headings:

- identification of the market segments
- selection of the most promising segement(s)
- formulation of marketing approaches and allocation of resources

When identifying market segments, potential consumers of pellets can be grouped under three major segments - industrial, residential, and municipal/institutional. Industrial consumers of wood pellets can be further sub-divided into two classes; those that consume energy principally for generating process heat (steam or hot water) and those that use the energy for interior (space) heating (Pursley, 1980; Pearson, 1981).

Generally speaking, residential (including small businesses and offices) consumption of heat energy is almost exclusively for space heating. There are, however, certain differences that warrant further sub-division of this segment. One method of differentiating the sub-groups of residential consumption is according to their readiness to convert to using pellets. By applying this classification, four sub-divisions are identified (Pursley, 1980):

- residences with existing coal, wood, or other types of furnaces or boilers that could be easily converted, with little or no modification, to burn pellets

- residences that are contemplating an "add-on" or an additional furnace to connect into existing duct work

- residences having existing or seeking additional supplemental devices, including all non-central systems

- new residences installing central or non-central heating systems, including homeowners considering replacements for existing old furnaces or boilers

The municipal/institutional category of consumers uses energy primarily for interior heating although some institutions such as hospitals also require fuel to generate steam or hot water. Individual consumption by these customers is normally much larger than those of a residential consumer.

Since ranking the importance of these segments might differ among geographical regions, extensive market research will be required to verify the segmentation and locate them within the geographical region of interest. Detailed market segment research will probably be too costly for most wood pellet manufacturers however, a some basic marketing investigation will certainly help in avoiding serious mistakes in the subsequent formulation of marketing approaches.

Selecting Market Segments

There are several factors that need consideration before a market segment(s) is selected for use in determining the approach to selling wood pellets. Geographical constraints, production capacity, and the availability and cost of techniques and equipment for conversion of existing devices for burning pellets are very important.

While many of the current pellet manufacturers feel that a hauling distance with a 100 mile radius is generally feasible (Pearson, 1981), some market studies suggest that a distribution area with a 50 mile radius or less, especially for distribution to residential consumers, is more acceptable. There are others, however, that indicate ability to supply customers within a 200 mile radius with a reasonably good return. The rationale behind these arguments seem to tie in closely with the volume in consumption of each customer over a period, as well as the concentration of these customers, competition, and price of alternate fuels.

There are a number of ways that the production capacity or proposed capacity might affect the selection of the market segments. First of all, while it is critical to ascertain the availability of potential consumers for the product to be manufactured, the quantity that these consumers can absorb will largely determine the viable capacity. This viable capacity will also depend on the ability of this new product to penetrate the market of an establihed product. Any immediate penetration of the market would be very unlikely for any new venture. Thus, aside from other production logistics, a legitamate design capacity will need to be tied to market penetration, all within a specific geographical region.

The effect of availability and cost of techniques and equipment needed for the conversion of existing facilities to burn wood pellets varies among the market segments identified above. For large volume consumers such as industry and municipality/institution, the savings that could be realized would probably be sufficient and attractive enough to commit investment in such conversions. For residential consumers, such return on investment may be quite different.

There are many other factors that contribute to the final selection of viable market segment(s). Different segments require different distribution and delivery methods. The large volume consumer of the industrial and municipality/institutional segments will typically require bulk delivery, while the residential market may prefer supplies in packages. Furthermore, delivery requirements will not only vary in terms of quantity but also with consistency of delivery. While process heat generators will need fuel all year round, space heating requirements will be restricted to a specified period each year. This seasonal supply requirement is certain to increase the complexity of wood pellet distribution. Other factors that will likely affect decision making are budgetary constraints and required profit margins. Large volume sales will usually require less marketing effort with lower profit margin than individual, small volume sales to residential consumers. Some form of additional regulation by environmental agencies may also be expected with respect to particulate emissions, especially for large volume consumers. Regulatory approval may take up to a year to obtain (Spangler, 1977).

Market research, besides being required for market segmentation and segmentation identification, should also be designed to collect information for the decision making process of selecting the most promising segement(s). Prior to the actual formulating of market approaches, information such as potential wood pellet consumption, the types of existing furnaces, the availability of local suppliers of the needed equipment and auxilliary hardware, and the availability of contractors with knowledge of furnace modifications are important in selecting these segments.

Formulating Marketing Approaches and Allocating Resources

The prior stages of market segment identification and selection are actually initial marketing tasks that are covered in marketing research that involves market survey and analysis. After the needed data are obtained and analyzed, the next step is to formulate marketing approaches and allocate the necessary marketing efforts for selling the product. This will include the areas of promotion, consumer education, the sales approach, establishing distribution networks and delivery systems, and many other related activities. As stated earlier, the market segments have widely varying characteristics and will therefore call for different approaches to marketing wood pellets. Similarly, resource requirements will also vary according to the complexity of each segement, residential being the most complex followed by municipal/institutional and finally, the industrial segment.

Marketing Programs for Different Market Segments

Recognizing the variability among the three main groups of potential consumers, marketing programs with different approaches should be designed for each market segment. Marketing programs should generally follow a somewhat standard format, composed of such components as appointing a marketing agent, planning out promotion and consumer education programs, and establishing a distribution network and delivery system. Varying emphasis is applied according to the target group. Approaches that have been proven to be effective are outlined below, according to segment.

Industrial Segment

Either appointing a marketing agent or recruiting and training a marketing team have their advantages and disadvantages. While a marketing agent will more than likely do a better marketing job than a plant employee, it is frequently not feasible to have an independent agent that can be devoted solely to one product. An agent, more often than not, will handle more than one marketing program at the same time.If the programs are for the same product but from different manufacturers, there may be consumer confusion and a necessity to share promotional benefits among manufacturers. Since industrial wood pellet sales, as a rule, are small in terms of numbers of accounts, most of the continuing marketing functions with promotion and sales would typically be handled by in-plant employees.

Promotional approaches to selling wood pellets may include the following:

* advertising in trade journals, technical periodicals and the like that are targeted towards industrial plant owners, industrial engineers, physical plant supervisors, and boiler and furnace operators,

* mailing out technical pamphlets to plant owners, industrial engineers, and other industrial consumers of fuel,

* calling on plant owners or their technical staffs, or participating in promotional seminars to advertise the advantages of using wood pellets over other conventional fuels,

* contacting plants to test-fire wood pellets. (This would promote the product and, at the same time, educate potential users. Observations and data from the testing could then be included in promotional material or the test could be filmed for use as a promotional or educational tool.)

* participating in trade fairs, exhibitions, and other promotional shows, particularly in conjunction with appliance and heating equipment manufacturers.

Developing a distribution network for the industrial marketing of wood pellets may not be necessary as sales are usually direct transactions between the manufacturer and the industrial customer. Establishment of a delivery system will probably be in the form of bulk shipping, direct to the storage facilities of the customer, and be a year round activity.

Although the aforementioned approaches are logically important for industrial marketing of wood pellets, the necessity of carrying them out has been questioned. It has been argued that pellets are a bulk energy product and cannot be separated from the family of bulk energy commodities in a marketing scheme (Bossel, 1985). Pellets therefore do not become more attractive by creative packaging or advertising. In all liklihood, persuading a plant to operate with pellets on a trial basis may be all that is needed to "push" the product (Spangler, 1977; Pursley, 1980).

Residential Segment

With appointing a marketing agent or recruiting and training a marketing team, the same problems of control apply. A professional agent, however, might be better able to handle the complexities of residential marketing. Wood pellet promotion might be approached by:

* advertising in the media (television, newspaper, and magazine) as well as other household campaigns. This is probably expensive for the small manufacturer.

* participating in consumer trade fairs, home shows, and exhibitions.

* mailing promotional pamphlets of the product to retailers of combustion equipment and accessories (stove and boiler stores, home heating contractors, and hardware stores) that might provide display space or could become potential outlets for wood pellets.

* using sales personnel to contact potential retailers for accounts by offering attractive discounts and guaranteeing assistance with advertising and pricing.

* conducting and evaluating the use of pellets in residences and recording the results in an audio-visual program.

The distribution network for serving the residential segment will be typically longer and more complicated than the industrial network, involving at least one but usually more than one intermediary such as the warehousing wholesaler and the retailer. Since wood pellet demand is likely to be seasonal, detailed planning for inventory control and establishing a delivery system is paramount. Pellets will often be marketed to customers in a package size that is convenient to handle. This might require additional investment by the manufacturer for the installation of a packaging facility, or the packaging could be handled at the wholesaler level. Bulk delivery to residential customers will obviously be in different quantities and require different scheduling than to industrial accounts.

Institutional / Municipality Segment

This segment can be treated with approaches that are similar to those listed for the industrial segment. Consumption by customers here is usually in large volumes except for that part of the segment demand used mainly for space heating that is seasonal.

Proposed Marketing Strategy

The characteristics of the three market segments just described have been summarized in the following table to indicate a marketing startegy for wood pellet sales and distribution.

Table 10. Market Segment Charcateristics of Wood Pellets

market segment	demand mode	delivery mode	marketing	profit margin
industrial	year round	bulk	simple. direct sales	low
residential	seasonal	packaged	complicated	high
institutional/ municipality	mixed	bulk	simple, direct sales	low

A rational approach to be followed for a manufacturer entering the wood pellet market and serving these market segments will therefore be to: (1) begin by tackling large volume industrial customers, and (2) subsequently expand into the institutional / municipality segement, using (3) the excess or slack production capacity to serve the residential segment. This approach can be later modified when initial market penetration has been established.

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WOOD PELLET MANUFACTURERS

American Bio-Energy, Inc.
P.O. Box 635
Gilbert, Minnesota 55741
(218) 749-1818
mill capacity: 200 tons/day

Aspen Fiber Corporation
P.O. Box 27
Marcell, Minnesota 56657
(218) 832-3600
mill capacity: 180 tons/day

Biomass Fuel Supply, Inc.
112 West Spring Street
Marquette, Michigan 49855
(906) 228-9150
mill capacity: 160 tons/day

Bioshell, Inc.
6070 Sherbrooke Street East
Ste. 204
Montreal, Quebec, Canada H1N1C1
(514) 252-8300
mill capacity: 358 tons/day (3 plants)

Bitterroot Timber Products
Box 57
Darby, Montana 59829
(409) 821-4428
mill capacity: 30 tons/day

East Perry Lumber Company
P.O. Box 105
Frohna, Missouri 63748
(314) 824-5272
mill capacity: 20 tons/day

Forest Fuel Corporation
RR #2, Box 205B-1
Mason, Wisconsin 54856
(715) 746-2452
mill capacity: 250 tons/day

Grand Rapids Wholesalers
P.O. Box 101
Grand Rapids, Minnesota 55744
(218) 326-9477

Lignetics of Idaho
P.O. Box 1706
Sandpoint, Idaho 83864
(208) 263-0564
mill capacity: 200 tons/day

Modoc Energy Products
P.O. Box 257
Klamath Falls, Oregon 97601
(503) 884-3177
mill capacity: 80 tons/day

Mountain Energy
P.O. Box 3686
Bozeman, Montana 59772
(406) 587-0175
mill capacity: 90 tons/day

Nordheim Roofing & Sheet Metal
P.O. Box 188
Bemidiji, Minnesota 55601
(218) 751-3923

North Carolina Wood Fuels, Ltd.
P.O. Box 289
Cleveland, North Carolina 27013
(704) 278-2213
mill capacity: 300 tons/day

Northern Bio-Fuel
P.O. Box 28
Pequot Lakes, Minnesota 56472
(218) 568-8616
mill capacity: 192 tons/day

Rapid River Co.
P.O. Box 458
Baudette, Minnesota 56623
(218) 634-2041
mill capacity: 120 tons/day

Southern Energy, Ltd.
P.O. Box 14-H
Bristol, Florida 32321
(904) 643-2292
mill capacity: 300 tons/day

Spokane Pres-To-Logs
North 3124 Fiora Road
Spokane, Washington 99216
(509) 924-2807
mill capacity: 40 tons/day

U.P. Bio-Energy, Inc.
Highway #41 & Brigdecreek Road
Menominee, Michigan 49858
(906) 863-7853

MOBILE WHOLE TREE PROCESSORS

Morbark Industries, Inc.
P.O. Box 1000
Winn, Michigan 48896
(517) 866-2381
TELEX 386488

Precision American Corporation
Route #3
P.O. Box 360
Leeds, Alabama 35094
(205) 640-5181
TELEX 888382

Strong Manufacturing Company
498 Eight Mile Road
Remus, Michigan 49340
(517) 561-2280

CHIP VANS AND TILT DUMPS

Air-O-Flex Equipment Company
3030 East Hennepin Avenue
Minneapolis, Minnesota 55413
(612) 331-4925
equipment: tilt dumps

Lear Siegler, Inc.
Peerless Division
610 Mill Street
P.O. Box 760
Paragould, Arkansas 72450
(501) 236-7753
TELEX 537449
equipment: tilt dumps, chip vans

Walco National Corporation
Husky Hydraulics
P.O. Box K
Two Harbors, Minnesota 55616
(218) 834-2274
TELEX 294451
equipment: tilt dumps

Wesco Trailer Manufacturing
1960 East Main Street
Woodland, California 95695
(916) 662-9606
equipment: chip vans

ON-SITE CHIPPERS, HOGS, AND HAMMERMILLS

Acrowood Corporation
P.O. Box 1028
Everett, Washington 98206
(206) 258-3555
TELEX 328879
equipment: chippers,,debarkers

Hobbs-Adams Engineering
1100 Holland Road
P.O. Box 1833
Suffolk, Virginia 23434
(803) 539-0231
TELEX 4946083
equipment: hammermills

Jay Bee Manufacturing, Inc.
522 North Beverly Street
P.O. Box 986
Tyler, Texas 75701
(214) 597-9343
TELEX 735415
equipment: hammermills, grinders

Koppers Company, Inc.
Sprout-Waldron Division
Muncy, Pennsylvania 17756
(717) 546-8211
equipment: hammermills

Montgomery Industries International, Inc.
2017 Thelma Street
P.O. Box 3687
Jacksonville, Florida 32206
(904) 355-5671
equipment: hammermills, shredders, hogs, chippers

Precision American Corporation
Route #3
P.O. Box 360
Leeds, Alabama 35094
(205) 640-5181
TELEX 888382
equipment: chippers, debarkers, grinders

Triple/S Dynamics
1031 South Haskell Avenue
Dallas, Texas 75223
(214) 828-8600
TELEX 730023
equipment: shredders

West Salem Machinery Company
665 Murlark Avenue, Northwest
Salem, Oregon 97304
(503) 364-2213
equipment: hogs, chippers

STORAGE EQUIPMENT

Atlas Systems Corporation
East 6416 Main Avenue
P.O. Box 496 Parkwater Station
Spokane, Washington 99211
(509) 535-7775
equipment: bins

Baker/Rullman Manufacturing, Inc.
104 West Main Street
P.O. Box 67
Watertown, Wisconsin 53094
(414) 261-0708
TWX 9102603717
equipment: bins

Clarke's International, Inc.
660 Canyon Street
P.O. Box 2428
Eugene, Oregon 97402
(503) 343-3395
TELEX 364440
equipment: bins, spark detectors

Koppers Company, Inc.
Sprout-Waldron Division
Muncy, Pennsylvania 17756
(717) 546-8211
equipmenty: bins

McConnell Industries
3539 Mary Taylor Road
P.O. Box 5
Trussville, Alabama 35173
(205) 655-3261
TELEX 888381
equipment: bins

Lear Sieglar, Inc.
Peerless Division
P.O. Box 760
Paragould, Arkansas 72450
(501) 236-7753
TELEX 537449
equipment: bins

RESIDUE SCREENING AND CLASSIFYING EQUIPMENT

Acrowood Corporation
P.O. Box 1028
Everett, Washington 98206
(206) 258-3555
equipment: screens

Carter Day Company
500 73rd Avenue, N.E.
Minneapolis, Minnesota 55432
(612) 571-1000
TELEX 201669
equipment: cyclones

Clarke's International, Inc.
660 Conger Street
P.O. Box 2428
Eugene, Oregon 97402
(503) 343-3395
TELEX 364440
equipment: classifiers

Eriez Magnetics
Ashbury Road
Erie, Pennsylvania 16514
(814) 883-9881
TELEX 914470
equipment: magnets

Hobbs-Adams Engineering
1100 Holland Road
P.O. Box 1833
Suffolk, Virginia 23434
(804) 539-0231
TELEX 4946083
equipment: separators, bulk feeders

Koppers Company, Inc.
Sprout-Waldron Dibvision
Muncy, Pennsylvania 17756
(717) 546-8211
equipment: screens, cyclones, rotary air locks, classifiers

Precision American Corporation
Route #3
P.O. Box 360
Leeds, Alabama 35094
(205) 640-5181
TELEX 782541
equipment: screens

Rens Manufacturing Company
P.O. Box 37
Creswell, Oregon 97426
(503) 895-2172
equipment: metal detectors

Triple/S Dynamics
1031 South Haskell Avenue
Dallas, Texas 75223
(214) 828-8600
TELEX 730023
equipment: screens, cyclones, rotary air locks, classifiers

West Salem Machinery Company
665 Murlark Avenue, N.W.
Salem, Oregon 97304
(503) 364-2213
equipment: screens

ROTARY DRUM AND FLASH TUBE DRYERS

Aeroglide Corporation
7100 Hillsborough Road
P.O. Box Aeroglide
Raleigh, North Carolina 27602
(919) 851-2000
TELEX 579421

Baker/Rullman Manufacturing, Inc.
104 West Main Street
P.O. Box 67
Watertown, Wisconsin 53094
(414) 261-8107
TWX 9102603719

McConnell Industries, Inc.
3539 Mary Taylor Road
P.O. Box 5
Trussville, Alabama 35173
(205) 655-3261
TELEX 888381

WOOD PELLET MILLS

California Pellet Mill Company
1114 East Wabash Avenue
Crawfordsville, Indiana 47933
(317) 362-2600

Ferro-Tech
467 Eureka Road
Wyandotte, Michigan 48192
(313) 282-7300

Guaranty Performance Company, Inc.
1120 East Main Street
P.O. Box 748
Independence, Kansas 67301
(316) 331-0020
TELEX 437014

Koppers Company, Inc.
Sprout Waldron Division
Muncy, Pennsylvania 17756
(717) 546-8211

Landers Machine Company
207 East Broadway
Fort Worth, Texas 76104
(817) 336-5653

INDUSTRIAL/COMMERCIAL WOOD PELLET BURNING EQUIPMENT

Eshland Enterprises
P.O. Box 8A
Greencastle, Pennsylvania 17225
(717) 597-3196

PMC Corporation
Drawer S
Sheridan, Wyoming 82801
(307) 672-5801

Fire-View Products, Inc.
9003 A West Evans Street
P.O. Box 370
Rogue River, Oregon 97537
(503) 582-3351

BAGGING AND PALLETIZING EQUIPMENT

Hobbs-Adams Engineering
1100 Holland Road
P.O. Box 1833
Suffolk, Virginia 23434
(804) 539-0231
TELEX 4946083

RESIDENTIAL WOOD PELLET BURNING APPLIANCES AND MODIFICATIONS

Boston Boiler Works
Boston Post Road
Enosburg Falls, Vermont 05450
manufacturer: pellet stoves

Collins Enterprises, Inc.
P.O. Box 3686
Bozeman, Montana 59772
(406) 586-8987
manufacturer: add-on pellet burning device

Essex Thermodynamics Corporation
P.O. Box 817
Essex, Connecticut 06426
(203) 767-2651
manufacturer: wood furnaces modified for pellets

Fire-View Products, Inc.
9003 A West Evans Street
P.O. Box 370
Rogue River, Oregon 97537
(503) 582-3351
manufacturer: pellet stoves

Hunter Enterprises Orillia, Ltd.
P.O. Box 400
Orillia, Ontario, Canada L3V6K1
(705) 325-6111
manufacturer: pellet stoves

Layrite Products Co.
1225 East Trent Avenue
Spokane, Washington 99205
(509) 535-1737
retail dealer: Whitfield

Longwood Manufacturing Corporation
Box 223
Gallatin, Missouri 64640
(816) 663-2185
manufacturer: wood furnaces modified for pellets

Messersmith Manufacturing, Inc.
120 Highway #2 & #21
Box 68
Bark River, Michigan 49807
(906) 466-9947
manufacturer: add-on pellet burning device

PMC Corporation
Drawer S
Sheridan, Wyomong 82801
(307) 672-5801
manufacturer: pellet stoves and furnaces

Slant/Fin Corporation
100 Forest Drive
Greenvale, New York 11548
(516) 484-2600
manufacturer: wood furnaces modified for pellets

Spokane Fireplace Center
2415 North Division Street
Spokane, Washington 99205
(509) 483-1017
retail dealer: Traeger, Whitfield, Pellifier

Valley Fireplace
16610 East Sprague Avenue
Veradale, Washington 99037
(509) 922-2780
retail dealer: Sweet Home, Traeger

Volcanic Glow Stoves, Ltd.
R.R. #2
Elmira, Ontario, Canada N3B2Z2
manufacturer: pellet stoves & furnaces

Wood Heat Headquarters
3375 East Seltice Way
Post Falls, Idaho 83854
(208) 773-4289
retail dealer: Traeger