

USED PALLETS AS A SOURCE OF PELLET FUEL: CURRENT INDUSTRY STATUS

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ABSTRACT

U.S. companies discard approximately 4 billion board feet per year of wood pallets and containers. Manufacturing fuel pellets from this wasted wood may be an alternative to disposal. This study traces the development of biomass energy and the wood pellet industry in the United States and considers the production aspects of making pellets from used pallets. In addition, an attempt is made to analyze the current market for wood pellets and pellet stoves and ascertain the industry's views on exports. The study concludes that the rising cost of raw material to manufacture pellets encourages the use of used pallets. If this resource is tapped, it could be a useful fuel source for the residential, commercial, and industrial market. At present, wood pellets and pellet stoves are mainly sold in the domestic market, with some exports, which might change in the future considering the growing interest in exports.

Roughly 4 billion board feet per year of wood pallets and containers are discarded by U.S. companies (1). Also, city managers and residents cope with a large quantity of urban waste, which includes trees, garden waste, furniture, old dwellings, and excess recycled paper. In addition to charging fees, waste dumps have limits on shape and material (6). Unfortunately, most of this material is not being used for any product, including fuel, and to a large degree this abundant source of potential energy is being wasted. Densified wood fuel in the form of pellets, briquettes, and logs may be an alternative to disposal (2).

Briquettes and pellets have been used commercially and industrially in central heating systems and gasifiers, in addition to residential heating. A typical pellet is 1/4 inch in diameter, 3/4 inch in length, and has a bulk density of 42 pcf. As a dry, dense, and uniform fuel, pellets work

well in automated stoves and burners (9). In the past, fuel logs have been primarily used for residential heating. In this paper, preliminary information pertaining to the feasibility of using used pallets to manufacture pellets is discussed. An attempt is made to trace the development of biomass energy and the wood pellet industry in the United States. In addition, the future of wood pellet use, marketability, and export is explored.

Wood pellet fuel is a product that can

be profitably produced from wood residues according to recent production and cost studies (9, 16). Possibilities of raw material shortages have led to the discussion of using increasingly marginal raw materials, such as used pallets, to manufacture pellets. Currently, large numbers of used wood pallets end up in construction and demolition waste facilities and in landfills. There is a tipping fee for disposal of the waste at these sites. Presently, there are only three manufacturers who are using pallets to make pellets on the East Coast of the United States. There may also be some manufacturers on the West Coast, but these could not be verified. About 40 average-size pallets of 40 by 48 inches create about 2,000 pounds of woodwaste. This subsidized or free raw material shows potential for pellet manufacture.

A number of combustion facilities that generate power using waste wood have been built on the East Coast and in the Midwest. These facilities were, for the most part, developed by independent power producers. In an effort to cut costs, utilities with coal-fired power plants are

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exploring the economic benefits of supplementing their primary fuel with waste wood. Waste wood from pallets, spools, shipping crates, etc., offers an ideal combination of low moisture, high heat content, and low metal emissions. Several utilities are testing the co-burning of waste fuels as a means of reducing SO₂ and NO emissions.

Ridge Station, a power-generating company in Florida, burns a unique mix of urban woodwaste (tree trimmings from municipalities and utility crews, pallets and reels from industrial sites, utility poles, railroad ties, demolition debris, construction remnants, and the wood portion of residential trash) and scrap tires to provide 45 megawatt (MW) of electricity while keeping large quantities of solid waste out of landfills (19). Fiber Fuel International, a pellet manufacturing company in Georgia, has co-fired coal with pellets (manufactured from pallets) to generate power. The pellets produced at this facility are being consumed locally for power generation and also being exported for use in gasifiers and central heat distribution systems (18).

The objectives of this paper are to 1) trace the development of biomass energy and the wood pellet industry in the United States; 2) study the production aspects of making pellets from used pallets; 3) analyze the current market for wood pellets and pellet stoves; and 4) determine how pellet fuel and pellet stove manufacturers view exports.

METHODS

A review of various studies, magazine publications, newsletters, and other literature was done to gather information pertaining to the different aspects of this study. Informal personal interviews and telephone contacts were made with representatives of pellet producers and pellet stove manufacturers (found on a list published by the Pellet Fuels Institute). Views on the production aspects of manufacturing pellets from used pallets were gathered. In addition, pellet manufacturers and stove manufacturers provided views on exporting pellets and stoves.

DEVELOPMENT OF BIOMASS ENERGY IN THE UNITED STATES

There are no reliable government statistics on the value of production and trade of biomass energy products and equipment. Information on industry

growth and development is based exclusively on estimates from, and data collected by, industry sources.

The biomass industry is composed of three groups of companies. First are those that produce equipment to harvest, transport, shred, and pelletize biomass feedstock. A second group of firms specializes in the manufacture and sale of combustion, gasification, and decomposition equipment that utilizes biomass feedstock. In the third group are project engineering and development companies that design, develop, finance, and operate biomass power projects. These projects can be 1) waste-to-energy plants (also called municipal solid waste plants); 2) wood and agricultural waste-fired plants; and 3) landfill plants.

Installed biomass power in the United States grew from less than 100 MW in 1979 to 5,100 MW in 1988. The total capacity of biomass power reached 7,090 MW by the end of 1992 (21).

The same factors that slowed other types of renewable energy development between 1986 and 1992 also affected the biomass power industry. These factors included: lower prices for fossil fuels; growth in the consumption of natural gas; termination or modification of many federal and state tax benefits for renewable energy; and the introduction of a federal policy to encourage utilities to buy energy from the lowest-cost producer. These factors have also made it difficult for planners to justify development of biomass power projects. While the average utility could purchase power from combined natural gas or co-generation sources for 4 to 5 cents per kilowatt hour, most biomass projects produce electricity at 6 to 9 cents per kilowatt hour (21).

In addition, these factors explain the decline in biomass power projects in recent years. In the United States, new biomass power capacity was 220 MW in 1991, 150 MW in 1992, and an estimated 85 MW in 1993. By comparison, total new energy production capacity averaged 510 MW each year between 1979 and 1988 (21). Municipal solid waste plants held a 37 percent share of the nation's biomass power capacity in 1993, up from a 25 percent share in 1988. Wood and agricultural waste-fired plants held a 60 percent share in 1993, down from 75 percent in 1988. Landfill projects held

the remaining 3 percent share, incrementally up from 1 percent in 1988 (21).

The outlook for biomass energy in the future is closely tied to government policies. The U.S. Department of Energy is seeking to establish a renewable energy base, and has established tax credits for using biomass fuel. Many public utility commissions have recommended that the utilities put in place renewable energy sources within the state.

Many observers expect the export market to undergo significant growth. According to the International Trade Administration, exports of biomass power equipment and services are expected to increase 20 to 40 percent per year during the remainder of the 1990s. The U.S. installed an estimated 30 MW of biomass power in developing countries during 1993-1994. At an average cost between \$1,000 and \$1,200 per kilowatt installed, the total value of biomass power projects built during 1993 and 1994 was estimated to be in the range of \$200 million to \$240 million per year. New biomass power capacity is forecast to increase by 15 to 25 percent annually between 1995 and 1999 (21).

DEVELOPMENT OF THE WOOD PELLET INDUSTRY

The wood pellet industry in the United States is a relatively young and growing industry. It began around 1978 to 1980 as a result of the "energy crisis." Pellets were promoted as a cheap, locally produced alternative to oil and natural gas. A number of large plants were built to process sawmill residues into pellets for industrial/commercial fuel users. The number of wood pellet manufacturers has grown since the 1980s. Four mills produced pellets for the residential market in 1985. According to the Pellet Fuels Institute, this has risen to 53 companies making bagged fuel pellets during 1996. There are 16 producers in the West, 10 in the East, 9 in the Midwest, 2 in the South, and 16 in Canada (15).

Significant market interest in pelletization developed during the 1980s. This was largely a response to the 1986 EPA regulations aimed at curbing emissions from traditional (cordwood burning) wood stoves. Driven by air-quality regulations and lower prices for pellets in the 1980s, wood pellet stoves have emerged as one of the most energy-efficient and clean wood-burning appliances available for residential heating purposes. Pellet

TABLE 1. — Regional breakdown of North American pellet production, 1991-1992 heating season.^a

Region	Production (tons)
Canada	6,000
Western U.S.	264,000
Eastern U.S. (east of Rockies)	26,000
Total	296,000

^aSource: Fiber Fuel Institute. Production figures are not available after 1992 and sales figures are used instead in subsequent tables.

stoves are superior to the traditional cordwood-burning wood stoves because they have a better overall combustion efficiency. This reduces the amount of ash generated, as well as the emissions of carbon monoxide, particulate matter, and carcinogenic gases (11).

As of July 1992, the Clean Air Act Phase II regulations covering residential wood-heating appliances stated that if a wood-burning device has an air-to-fuel ratio of less than 35:1, it must have total emissions of all gases that contain particulate matter (PM-10s) of less than 4.1 g per hour if the stove has a catalytic converter. The figure is 7.5 g per hour if it is non-catalytic. All pellet stoves have emissions well below the EPA limits (most emit less than 1 g per hr.). Some stoves have air-to-fuel ratios greater than 35:1, while others have ratios below this cutoff. As a result, some pellet stoves must be certified by the EPA, while others are considered exempt from certification (11).

The majority of the pellet manufacturers are undertaking pellet production as an "add-on" to an existing forest products business (primary or secondary processing), agri-business, or municipal solid waste disposal company (10). Consequently, they do not have to purchase land and office space, since labor and equipment are already in place from the primary business of the company. Usually one employee operates the pellet manufacturing side of the company. Production comprises different tasks: residue handling, pre-processing, processing, pelleting, maintenance, and final packaging. Producers utilize the residue that is generated by the primary company

for pellet production, and also purchase some residue from other companies if the situation demands. Sales personnel are responsible for pellet marketing.

Table 1 shows the regional breakdown of pellet production in North America based on the survey that was undertaken by the Fiber Fuels Institute¹ during the 1991-1992 heating season. It is estimated that the total production of bagged pellets during this season was 296,000 tons. Most of it was in the premium grade (lower-ash fuel), with less than 1 percent of the total production being a higher-ash fuel. The survey also indicates that roughly 12,000 tons of pellets move from west to east within North America. Production figures after 1992 are not available. However, figures for total sales of both pellets and pellet stoves are presented in subsequent tables.

PELLETS FROM PALLETS: PRODUCTION ASPECTS

CONTRASTING VIEWPOINTS ON FEASIBILITY

There were two sharply contrasting views about making pellets from pallets. Some manufacturers consider it non-economical. For them, the costs estimated were too high to make any profit. They felt that good raw material of the preferred types was available, avoiding the problems encountered in making pellets from pallets.

Other manufacturers see future competition for sawdust and other waste to be keen. In the event of a shortage, an alternative source needs to be sought, e.g., used pallets. In addition, pellet manufacturers may be able to recover a tipping fee if they take pallets from the landfills and municipal dumps or directly from disposers.

As reported by Schutte (17), there is a big market for colored mulch manufactured from ground-up pallets. A few industries are manufacturing composite board products from ground-up pallets, but the key to using pallets in manufacturing any product is removing all the metal.

TECHNICAL ISSUES

Davis (7) indicated that pallets are made from different species and grades of wood, leading to product inconsistencies. Some species like red oak are more acidic than others. Acidity causes corrosion of pelletizing equipment. Too much variation in feedstock causes pellets to be of irregular form, and scoured or broken

into bits. Hence feedstock control is very critical.

Natural adhesives in the wood (e.g., lignin) are lost when pallets are broken down to manufacture pellets. Hence, binding additives have to be replaced, which could be an additional cost that could affect pellet prices.

If the pallets are in a landfill and are exposed to weathering, then the variation in moisture content can pose problems. Moisture content is critical in manufacturing pellets. According to Staab (18), the grinding of used pallets for pellets has to be done indoors to maintain a controlled moisture content. Therefore, it would be advisable to place pallets to be used for pellet production in covered storage.

Extreme care is needed to separate out all metals and other extraneous matter from the ground-up pallets. Normal grinders have excellent separation capabilities. Presence of sand (silica) and other dirt results in a fuel with high ash residue.

RESOURCE BASE

Long-term supply of raw materials for a pellet manufacturer is affected by timber sales, timber harvests, primary processing production levels, and economic and regulatory trends. At present, the availability of waste wood does not appear to be a limiting factor on the East Coast, where prices have been stable. Pellet producers experienced raw materials shortage in the Northwest during 1995, as evidenced by rising prices for sawdust and other woodwaste during that period. Some composite board mills were using ground-up pallet materials due to the drop in primary processing. In the Northwest and Mountain regions, paper mills and board plants were aggressively buying all the sawdust and shavings they could. The result was higher prices and limited supplies for manufacturers. Since then, many new pellet manufacturing firms have opened on the East Coast. Similar situations could arise in the future, which could create competition for raw material.

Possibilities of raw material shortages lead to discussion of using increasingly marginal raw materials, such as those that produce higher ash fuels. Using ground-up pallets to make pellets, for example, would create higher ash. Several firms make small quantities of higher-ash wood pellets, but at this time, these fuels are only a tiny share of the

¹This organization was first known as the Fiber Fuels Institute, then the name was changed to Pellet Fuels Institute.

market. According to the Pellet Fuels Institute, an estimated 99 percent of the bagged pellets sold in 1994 and 1995 were premium grade (under 1% ash).

As reported by Bitler (3), very few stoves in the marketplace at present can burn a higher ash fuel. Ash residue causes "caking" in the stoves. The amount of ash residue is a function of dirt (silicates), contaminants, and the nature of the biomass material. Unless the stove technology advances enough to be able to burn higher-ash fuels, these fuels will be hard to sell for residential heating. In the absence of stoves capable of handling higher-ash fuels, these fuels will be limited to commercial and industrial heating.

MARKETING ISSUES

MARKET SETTING

The western part of the United States produces a large part of the total pellet production, mostly from sawdust. Of this, a significant amount is sold to the local market, and some is shipped to the East Coast.

There is a close relationship between pellet sales and pellet stove sales in the context of residential heating. A certain level of communication should be established between pellet manufacturers and stove manufacturers for efficient marketing of both. But this has not materialized to date, neither for domestic nor for export marketing.

For the household market, pellets and stoves are currently being sold through "Mom and Pop stores" and some mass merchandisers. Advertising for both the products has been mainly through trade shows, in-store advertising, and through the Pellet Fuels Institute's brochures and newsletters. Sales are seasonal, mainly during late fall and winter.

As reported by Monk (12), "Mom and Pop stores" have done a better job in terms of customer satisfaction than the mass merchandisers. These stores know their customers personally, and have tried to gain customer confidence by providing quality service. In contrast, the sales

personnel in mass merchandisers are not familiar with the product, since many sales personnel move in and out of jobs. Pellets and pellet stoves are only one of the items they market. Since the pellet industry is relatively young, the manufacturers do not have enough financing to undertake advertising on a large scale. Therefore, the sales personnel have a very important role to play in marketing, but they are not currently fulfilling this obligation.

SALES OF PELLETS AND STOVES: RECENT TRENDS

According to a survey of the Pellet Fuels Institute, sales of bagged fuel pellets in the 1995-1996 heating season was approximately 586,000 tons. **Table 2** shows the regional distribution of pellet sales for the last 4 years. Sales of bagged pellets rose 7.2 percent in 1996 and 14 percent in 1995 compared to the preceding year. The main reason attributed for this slow growth was warm winter temperatures all across the country.

A closer look at the regional sales numbers shows some interesting trends. Reported statistics over 4 years (1992-1996) indicate that the western United States (Pacific and Mountain) continues to be the largest market, accounting for almost 65 percent of the total bagged fuel sales in 1995-1996. The Northeast, however, continues to grow rapidly. Sales for the Great Lakes region increased by 50 percent from 1994-1995 to 1995-1996. This area has a large population, a strong economy, and cold winters. It should be fertile ground for pellets. A major drop in sales occurred in the Pacific region in 1995-1996, where shipments were down about 41,000 tons (11%), which can be attributed to the warm winter in the region. Most of the pellet sales in the Southeast region are in Maryland, Virginia, Washington D.C., and Delaware.

Table 3 shows pellet sales in Canada. Canada's market is still small, but shows strong growth. The total 1995-1996 sales rose 74 percent in 1996 over the preceding year. A few firms on both Canadian coasts continue to export to the United States, but several producers report they are busy with local customers.

Canadian producers are forecasting a major market expansion. Total shipments among 16 plants are projected to be 135,000 tons, a 60 percent increase over the 1995-1996 season. They foresee strong local demand and significant ex-

TABLE 2. — Pellet sales in the United States. ^a

Region	1992-1993 pellet sales	1993-1994 pellet sales	1994-1995 pellet sales	1995-1996 pellet sales
----- (t o n s) -----				
Pacific	198,000	239,000	293,000	262,000
Mountain	145,000	130,000	120,000	123,000
Central	21,000	18,000	16,000	19,000
Great Lakes	11,000	26,000	24,000	36,000
Northeast	35,000	62,000	84,000	107,000
Southeast	16,000	21,000	34,000	39,000
Totals	426,000	496,000	571,000	586,000

^aSource: Pellet Fuels Institute. Pellet sales figures are based on heating season (April 1 - March 30)

TABLE 3. — Pellet sales in Canada. ^a

Region	1993-1994 pellet sales	1994-1995 pellet sales	1995-1996 pellet sales
----- (t o n s) -----			
Quebec and Maritime	10,000	16,000	33,000
Ontario, Manitoba, and Saskatchewan	10,000	15,000	19,000
Alberta and B.C.	7,000	8,000	16,000
Totals	27,000	39,000	68,000

^aSource: Pellet Fuels Institute. Sales figures are based on heating season (April 1 - March 30).

TABLE 4. — Total pellet stove sales in the United States and Canada. ^a

	1992	1993	1994	1995
Appliance sales (units)	53,000	70,000	76,150	47,500

^aSource: Pellet Fuels Institute. Annual sales figures are based on calendar year.

ports to the Northeast and to the Pacific Northwest. Exports accounted for about 25 percent of Canadian output last year and that share is expected to increase (15).

Table 4 shows pellet stove sales in the United States and Canada. Pellet stove sales declined (37%) in 1995 over the preceding year. However, this trend is not expected to continue, as U.S. producers have reported a significant increase in sales since then (7).

PELLET PRICES AND ENERGY COSTS

A factor influencing customer demand is the price of compressed wood fuel compared to competing fuels (4). According to the Pellet Fuels Institute, the May 1996 Free on Board (f.o.b.) plant prices (per ton) for premium-grade bagged fuel are as follows: In the eastern United States, the price range is \$98 to \$110, with most available at \$90 to \$95. In the Midwest, the range is \$85 to \$95 for early-season shipments. There is ample plant capacity in this region, and producers are looking for new or expanded markets. In the Southeast, the range is \$80 to \$100 per ton. In the Southwest, it is \$90 to \$110. In the Northwest and Mountain regions there is a wide price range, \$85 to \$128.

Fuels are compared on the basis of delivered energy cost, i.e., \$/Btu (8). The price of an energy source for a given use is determined by its demand and supply. Consumers face different prices depending on whether they are an industry or residential consumer. The price must account for the greater inconvenience of using pellets compared to electricity, gas, and other fossil fuels, which have fewer or no handling requirements. This makes comparing the cost of energy sources quite complicated.

According to a study in Colorado (1), the consumer cost for wood pellets is \$10.93/MBtu. This is cheaper than \$30.52/MBtu for electricity and \$13.75/MBtu for propane. Natural gas was the cheapest at \$5.38/MBtu. In this study, consumer cost for pellets was based on a delivered price of \$163/ton, however, the 1995 price for a ton of wood pellets was only \$70 to \$106 (14), which is considerably lower than that used in the Colorado study.

HOW THE INDUSTRY VIEWS EXPORTS: AN INFORMAL ASSESSMENT

PELLET MANUFACTURERS

The profit margin from pellet production is not high (around 15% on an average) and the majority of pellet manufacturers undertake pellet production as an "add-on" to an existing forest products business. Pellet manufacturers undertake pellet production mainly to reduce their costs because they get a better price for pellets than for sawdust. Most pellet manufacturers perceive that it is expensive to ship pellets. Some U.S. manufacturers indicated that they were contacted by business interests from Sweden, China, and Czechoslovakia. A few larger manufacturers indicated that in the past they have exported mainly to Canada and some to Japan. U.S. export to Canada is minimal now, mainly because of a Canadian regulation that does not allow the disposal of sawdust and other wood-waste in landfills and other dumps, which has encouraged many forest products industries in Canada to establish their own pelletizing plants.

STOVE MANUFACTURERS

There are many stoves in the market that burn only specific kinds of pellets. Each stove can handle only a certain grade of pellet fuel by ash content. Stove manufacturers indicate that pellet stoves represent the highest gross profit to retailers, and remain the most expensive hearth appliance they sell. Compared to other heating units, profit on pellet heaters remains at the top of the list (around \$600 per unit). In addition, pellet stoves represent major income to retailers. About 80 percent of them are installed by dealers who get additional income from pipe sales, hearth pads, and accessories. However, some stove manufacturers indicate that dealers sometimes steer customers toward propane over pellet stoves, citing reduced service calls, near equal operating costs, and maintenance-free operation. According to Coles (5), when retail prices of wood pellets exceed \$180 per ton, pellet stove sales tend to decrease. Manufacturers are interested in selling stoves wherever people are interested in buying them. Stoves have been sold to Canada, Sweden, and Japan in the past, but the number is not significant. Manufacturers cannot export stoves unless someone else exports pellets, or unless the importing country manufactures

pellets that burn in the stoves they manufacture.

CONCLUSIONS

There are two sharply contrasting views on producing pellets from used pallets. Some manufacturers consider it non-economical, while others see promise due to future competition for raw materials. According to some manufacturers, technical issues like variation in wood species, natural weathering, and presence of extraneous matter limit the use of ground-up pallets as a raw material source. Pellets made from used pallets have a high ash content, which limits their use in some residential stoves. With sufficient research, in the future we can expect better stoves and a better fuel. However, ash content is not a major factor if pellets are used industrially and commercially in either central heating systems or gasifiers.

With rising costs for raw materials as already evidenced on the West Coast in 1995, discarded pallets that producers could be paid to take (tipping fees) show potential for use. Nails and other metallic objects that cause problems in the manufacturing process can be removed using tub grinders. Pellets from pallets provide an ideal combination of low moisture, high heat, and low metal emissions. Even if these pellets pose a few limitations for residential pellet stoves, they are an extremely useful fuel source in combustion units generating power, gasifiers, and other central heating systems.

The price of a pellet in relation to the price of alternative energy sources like gas, electricity, and other fossil fuels will be a keen factor influencing the decision of a consumer. Studies comparing different fuels on the basis of delivered energy cost need to be done to understand the fuel efficiency of various energy sources. Further research should focus on the costs and benefits of using a renewable resource like waste wood.

LITERATURE CITED

1. Araman, P. 1995. Personal communication. Project Leader, Forest Products Recycling, Center for Forest Products Marketing, Virginia Tech, Blacksburg, Va.
2. Atkins, R.S. 1995. Generating power with waste wood. *Power Engineering* 99(2).
3. Bitler, H.C. 1995. Personal communication. Glo King Stoves, Florence, Ore.
4. Callas, B. and J. Haygreen. 1987. An analysis of the densified wood fuel industry in the Lake States. Misc. pub. 42. Minnesota Agri. Expt. Sta., Univ. of Minnesota, St. Paul, Minn.

5. Coles, R. 1995. Personal communication. Pellet Master Marketing, Lewiston, Idaho.
6. Coulter, E. 1995. Financial analysis of a briquette plant. North Carolina State Univ., Raleigh, N.C.
7. Davis, R. 1996. Personal communication. Pellet Fuels Institute, Edina, Minn.
8. Fiber Fuels Institute. 1992. Newsletter. Fiber Fuels Institute, Edina, Minn.
9. Fisher, J.E. 1990. Pellet fuel - a market for wood residues. Tri-State Lumber Co., Duluth, Minn.
10. Folk, R. L., R.L. Govett, L.R. Johnson, and H.W. Lee. 1988. Manufacturing and marketing of wood pellets. Tech. Rept. 20. Univ. of Idaho, Forest Wildlife and Range Expt. Sta., Moscow, Idaho.
11. Haase, S., D. Rue, and J. Whittier. 1993. Wood pellet manufacturing in Colorado. Office of Energy Conservation and U.S. Dept. of Energy, Western Regional Biomass Energy Program. U.S. Dept. of Energy, Washington, D.C.
12. Monk, M. 1995. Personal communication. Energy Innovations, Monroe, Wash.
13. Pellet Fuels Institute. 1994. Biannual newsletter. Pellet Fuels Institute, Edina, Minn.
14. _____ 1995. May-June newsletter. Pellet Fuels Institute, Edina, Minn.
15. _____ 1996. Biannual newsletter. Pellet Fuels Institute, Arlington, Va.
16. Resch, H. 1990. Case studies: how mills produce fuel from residues. *World Wood* 31:14-21.
17. Schutte, R.D. 1995. Personal communication. Vice President - Operations, New York Pellet Products, Arcade, N.Y.
18. Staab, L.E. 1995. Personal communication. Executive Vice President, Fiber Fuel International, Savannah, Ga.
19. Swanekamp, R. 1994. Ridge station eases Florida's waste disposal problems. *Power* 138(11).
20. _____. 1995. Biomass co-firing technology debuts in recent test burn. *Power* 139(2).
21. U.S. Dept. of Commerce. 1995. U.S. Industrial Outlook. Electrical and renewable energy equipment. Chapter 18. USDOC, Inter. Trade Admin., National Trade Data Bank CD. March 30, 1995. USDOC, Washington, D. C..