Chapter 5

# BIOMASS PROCESSING WASTES

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TABLES



FIGURES

# Chapter 5
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## Introduction

There are a number of byproducts associated with growing biomass and processing it into finished products. The byproducts that are not generally collected in one place, such as logging or crop residues, are termed residues and are dealt with in chapters 2 and 3. The byproducts that are collected in one place are termed processing wastes for the purposes of this report and are considered in this chapter. The three main types of wastes considered are the primary and secondary manufacturing wastes of the forest products industries, and the wastes associated with the processing of agricultural products and animal manures. Wastepaper, cardboard, and urban wood wastes are not considered in this report, since they fall into the category of municipal solid wastes, which is the subject of a previous OTA report.

[1]*Materials and Energy From Municipal Waste* **[Washington, D C.: Office of Technology Assessment, July 1979), OTA-M-93**

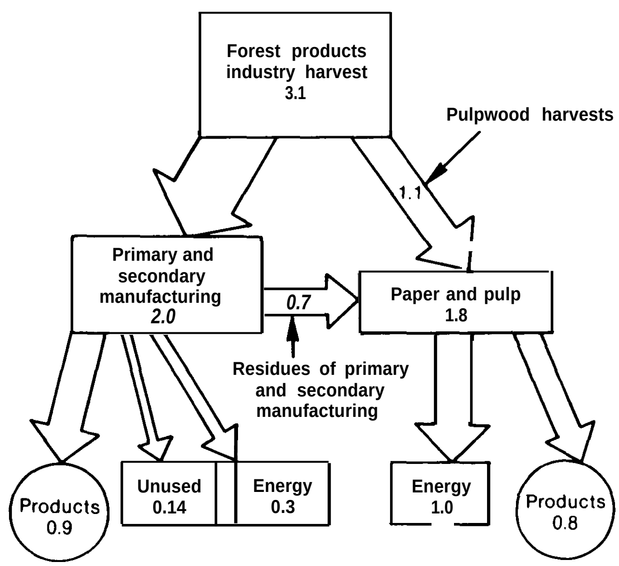
## Wood-Processing and Paper= Pulping Wastes

Based on published surveys and discussions with people familiar with the forest products industries, the fraction of wood feedstock that appears as residue was estimated for the various types of processes and regions of the country. These fractions and the U.S. Department of Agriculture's Forest Statistics* were used to estimate the quantities of residues generated by wood-processing and paper-pulping industries. There is, however, some uncertainty in these figures, since published data usually are reported in board feet or cubic feet (rather than dry tons) and often the bark is not counted. Furthermore, moisture loss during drying must be accounted for, Every effort was made to avoid these potential problems and adjust for the shrinkage.

Current data on the use of the manufacturing residues are not complete. In some cases data are available for only a few States or for some of the industries. In other published data, regional surveys are extrapolated to the entire country. The estimates presented here are based on several surveys,[3] but are nevertheless based on incomplete data.

Figure 14 shows an approximate materials flow diagram for the harvested wood processed by the forest products industry. This is a national average diagram. There are, however,

**Figure 14.—Material Flow Diagram for Forest Products Industry (in energy units, Quads/yr)**




| | |
|---|---|
| **Total wastes used as energy: 1.2 to 1.3 Quads/yr** | |
| **Unused waste** | **0.1 to 0.2 Quad/yr** |
| **Energy and unused** | **1.4 Quads/yr** |

SOURCE: Office of Technology Assessment.

*Forest Statistics for the United States, 1977* **(Washington, D C : Forest Service, U.S. Department of Agriculture, 1978)**

[3]**J S. Bethel, et al., "Energy From Wood," contractor report to OTA, April 1979.**

significant variations between the regions, with the unused fraction being about twice as large in the East as in the West.

The largest user of biomass energy in the United States is the pulp and paper industry. This industry is currently **45-** to 55-percent energy self-sufficient, up from **37** percent in 1967.[4] A major reason for the use of wood energy in the forest products industry is that the process used to recover the paper-pulping chemicals in most of the pulping processes involves burning the spent pulping liquor. This accounts for about 0.8 Quad/yr. The remaining 0.2 Quad/yr of bioenergy used in the pulp and paper industry comes from the bark of the harvested wood and reject woodchips.

The primary manufacturing industry produces lumber, plywood, poles, etc. The secondary industry produces furniture, prefabricated housing, etc. These industries are 20- to 40-percent energy self-sufficient.[5] About 50 percent (40 million dry ton/yr) of the primary manufacturing wastes and 40 percent (4 million dry ton/yr) of the secondary manufacturing wastes go to paper pulping. Another 20 percent of each of these industries' residues goes to particle board and various other uses. About 20 million dry ton/yr (0.3 Quad/yr) of wood are used for energy; 9 million dry ton/yr (about 0.14 Quad/yr) are unused.

The main reasons that the unused portion is not used appear to be the very low quality of these wastes and a geographical mismatch between the source and potential users of the waste. However, either a strong wood energy market or cooperative agreements with electric utilities for cogeneration could bring these wastes into energy use.

There are alternative uses for some of the wastes other than for energy. If the demand for forest products increases and other **fuels are available, then** more of the primary and secondary manufacturing byproduct may be diverted from energy use to particle board and paper and pulp production. In addition, **a** small fraction of the spent pulping liquor could be used to produce ethanol and lignin products (as one Georgia Pacific Corp. plant does) instead of simply burning the spent liquor to recover the pulping chemicals.

[4] E. P Gyftopoulos, L J Lazarides, and T. F Widmer, *Potential Fuel Effectiveness in Industry* (Cambridge, Mass : Ballinger Publications).

[5] S. H Spurr, *Renewable Resources for* Energy and Industrial Materials (Austin, Tex LBJ School of Public Affairs, University of Texas, 1978)

# Agricultural Wastes

With the exception of orchard prunings, agricultural waste byproducts are generally not collected at the place where the crops are grown. Rather, the wastes usually occur as byproducts to the agricultural product-processing industries. About 50 to 70 percent of these byproducts are sold as animal feed or for chemical production at prices that prohibit their use for energy.[6] The waste byproducts not being used for other purposes are considered in this section.

The various agricultural product-processing industries were surveyed[7] to determine the quantities and types of waste byproducts that are produced. Table 39 shows the 10 major types of agricultural wastes and the energy potential of each. These 10 wastes represent over 95 percent of all agricultural wastes available for energy. Of these 10, about 90 percent are materials relatively low in moisture, and suitable for thermal conversion (combustion or gasification). The remaining 10 percent appear to be acceptable for anaerobic digestion or possible fermentation to ethanol in the case of fruit and vegetable wastes and cheese whey.

In addition, there is an unknown quantity of spoiled and substandard grain. One source[8] es-

[6] R. Hodam, "Agricultural Wastes," Hodam Associates, Sacremento, Calif., contractor report to OTA.

[7] Ibid.

[8] M. T Danziger, M. P. Steinberg, and A. I Nelson, "Storage of High Moisture Field Corn," Illinois Research, fall 1971

**Table 39.–The Ten Major Agricultural Wastes With Potential to Produce Energy**

| Wastes | Btu/yr x $10^{12}$ |
|---|---|
| Orchard prunings[a] | 30-61 |
| Cotton gin trash[a] | 20-31 |
| Sugarcane bagasse[a] | 4-8 |
| Cheese whey[b] | 4-B[c] |
| Tobacco (burley)[a] | 2.3 |
| Rice hulls[a] | 2.2 |
| Tomato pumice[b] | 1.3-1.8 |
| Potato peel and pulp[b] | 1.0-1.1 |
| Walnut shell[a] | 0.9 |
| Citrus rag and peel[b] | 0.3-1.0 |
| Total | 66-117 |

[a]Suitable for combustion or gasification
[b]Suitable for anaerobic digestion or fermentation
[c]Based on starch content of milk and the volume of cheese production from *Agricultural Statistics* (Washington, D C U S Department of Agriculture, 1978)

SOURCE Off Ice of Technology Assessment, and R Hodam "Agricultural Wastes, " Hodam Associates, contractor report to OTA, 1979

timated corn spoilage from mold at 250 million bu/yr, but this number should be viewed as speculative. Furthermore, much of the spoiled grain may be accessible only as a supplement to existing distillery feedstocks because its occurrence is dispersed and unpredictable.

The four major sources of agricultural wastes are orchard prunings, cotton gin trash, sugarcane bagasse, and cheese whey. Most States have fruit or nut orchards, with the largest crops occurring in Arizona, California, Florida, Texas, New York, and Washington. Cotton gin trash is generally localized to the southern third of the United States and California. Sugarcane is processed primarily along the Gulf Coast, in Hawaii, and in New England. The majority of cheese whey is produced in Wisconsin, Minnesota, New York, Iowa, and California, but 30 States have some cheese production.

Orchard prunings are generally collected and burned onsite. A few growers disk whole prunings into the soil, although this is not a preferred practice for growers. With a strong energy market, much of this could be used for energy. The major expense is transporting the prunings to the place they are used.

Cotton gin trash is another potential source of energy. Texas cotton gins produce about five times as much energy in gin trash as they consume (mostly electricity). The major problems with using the trash for energy seem to be the difficulty of handling the trash, the seasonal nature of the ginning operations, and the difficulty in establishing cooperative ventures with the electric utilities. In addition, in the areas where the cotton plants are killed with arsenic acid prior to harvest, such as in much of Texas, special precautions will be necessary to burn the trash in an environmentally acceptable way.

Sugarcane bagasse is widely used in Hawaii as a source of energy. The sugar refineries have long-standing cooperative agreements with the electric utilities. Cogeneration is used to generate and export electricity to the utilities and to produce the process steam used by the sugar refineries. The electric generating facilities range in size from 1.5- to 33-MW electric. Most of the Hawaiian sugar refineries are 99- to 100-percent energy self-sufficient.

The New England and Southern sugar refineries should be analyzed in detail for the potential to duplicate the Hawaii experience, including the potential to purchase orchard prunings or wood wastes which are found in the same area in some cases.

OTA's analysis indicates that cheese whey is the largest source of food-processing waste suitable for conversion to ethanol, although other studies have indicated that citrus wastes are a larger source.[9] Based on total cheese production,[10] OTA estimates that 50 million to 100 million gal/yr of ethanol could be produced from cheese whey. Current production from this source is about 5 million gal/yr.

'The Report *of the Alcohol Fuels Policy Review* (Washington, D C : Department of Energy, June 1979), GPO stock No 061-(XX3-OO31 3-4,

[10]*The Outlook for Timber in the U.S.* (Washington, D C : Forest Service, U S Department of Agriculture, 1974), report No. 24; and *Agricultural Statistics* (Washington, D C U S Department of Agriculture, 1978)

# Animal Manure

The major sources of animal manures suitable for energy are from dairy cows, cattle on feed, swine, chickens (broilers and layers), and turkeys. Only animals in confined animal operations are considered. However, it has been estimated that 48 percent of all manure voided from livestock (primarily sheep and cattle), is **on open range.**[11] This open range manure would require collection and, therefore, will not be economic in the foreseeable future.

The inventory of onfarm confined animals was derived from inventory numbers for animals that remain onfarm for more than a year and from sales numbers and the average time the animal spends on the farm for animals on farm for less than a year.[12] These inventory numbers were converted to the common basis of the number of animal units, or the equivalent of a 1,000-lb animal (defined in figure 15). The quantities of manure were calculated and, assuming that the manure is anaerobically digested to produce biogas (60 percent methane, 40 percent carbon dioxide), the energy equivalent was derived.

Table 40 shows the energy potential from each type of animal operation, and figure 15 shows the percent of this energy potential that is present on confined animal operations of various sizes (expressed in animal units). Currently most of this manure is used as nitrogen fertilizer and soil conditioner or is unused.

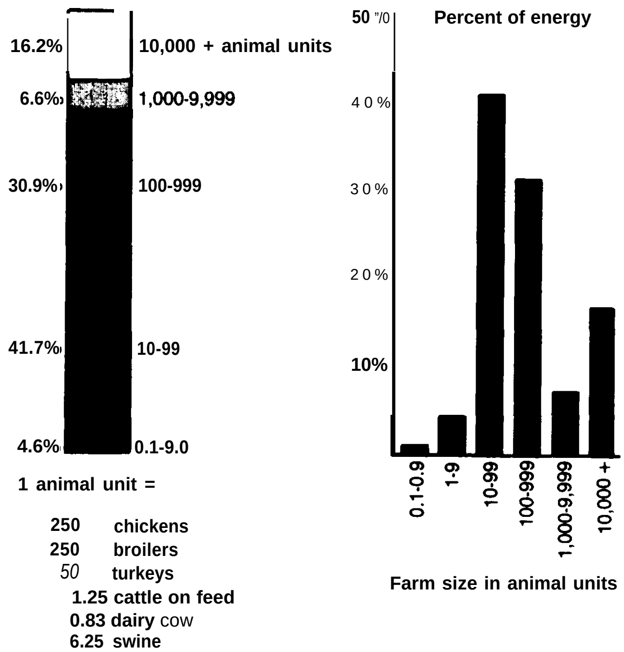
The total energy potential from manure produced in confined animal operations is about 0.3 Quad/yr. From one-third to one-half of this manure is currently allowed to wash away with rain or is allowed to dry which makes it unsuitable for anaerobic digestion. However, if it becomes economically attractive to digest the manure, then most of these operations can change their manure-handling techniques to accommodate anaerobic digestion.

Figure 15 shows that over 75 percent of the energy potential occurs on farms with less than 1,000 animal units and that about 45 percent of the potential is on farms with less than 100 animal units. Large feedlots (greater than 10,000 animal units) only account for about 15 percent of the total. Consequently, any technology development that is aimed at fully utilizing the potential for energy from animal manure will have to concentrate on relatively small-scale conversion units.

[11] D. Van Dyne and C. Gilbertson, **Estimating *U.S. Livestock and Poultry* Manure and *Nutrient Production* (Washington, D.C.: U.S. Department of Agriculture, 1978), ESCS-12.**

[12] *1974 Census of Agriculture* **(Washington, D C : Bureau of the Census, U S. Department of Commerce), vol. 1-50**

**Figure 15.—Total Energy Available From Manure by Farm Size (confined animal operations)**




SOURCE: K D. Smith, J. Philbin, L. Kulik, and D. Inman, "Energy From Agriculture: Animal Wastes," contractor report to OTA, March 1979.

**Table 40.–Enorgy Potential From Animal Manure on Confined Animal Operations**

| Type animal | Total energy potential Btu x $10^{12}$/yr | Percent or total |
|---|---|---|
| Dairy cattle | 90 | 33 |
| Cattle on feed | 80 | 30 |
| Swine | 32 | 12 |
| Chicken (broilers) | 30 | 11 |
| Chicken (layers) | 25 | 9 |
| Turkeys | 18 | 6 |
| Total energy potential from all manures | 274 | 100 |

SOURCE K D. Smith, J Philbin, L Kulik, and D. Inman, "Energy From Agriculture. Animal Wastes, contractor report to OTA, March 1979.