4. Biomass Preparation

Biomass feedstocks have to be prepared, stored, and transported to the energy conversion process before they can be used to generate power or produce steam. This chapter describes the requirements and costs of preparing solid biomass fuel and biogas fuel for power generation.

4.1 Solid Biomass Fuel Preparation

The steps of preparation, storage, and transportation of a biomass feedstock comprise the ***preparation yard*** (prep-yard). The major requirements of a standard prep-yard can be divided into four categories:[46]

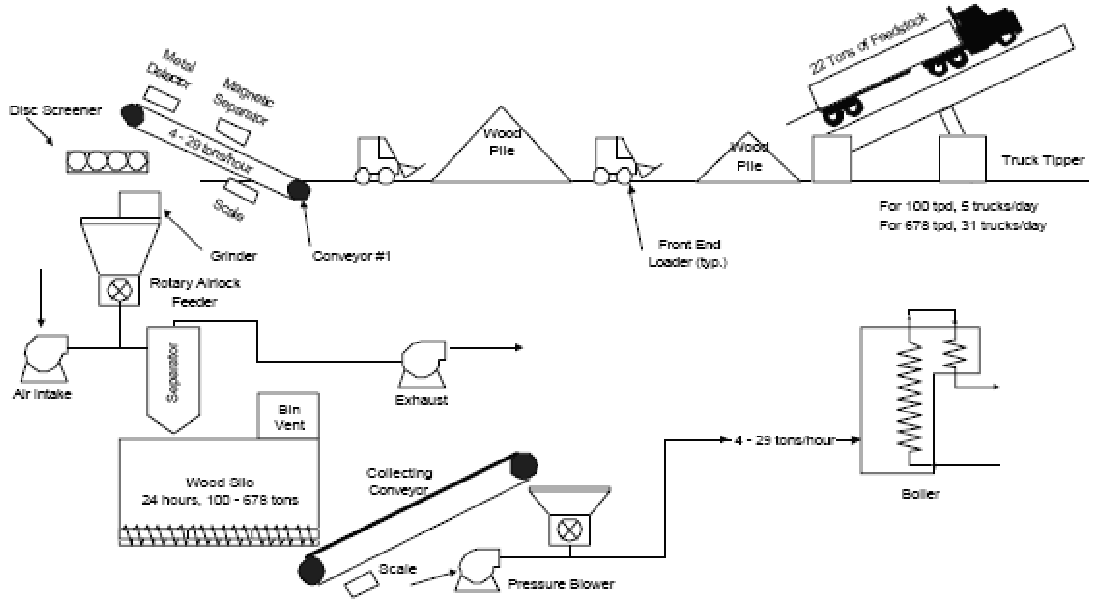
1. Receiving: truck tipper, conveyor, and radial stacker
2. Processing: reclaim feeder, conveyor, metal separator, dryer, screener, and grinder
3. Buffer storage: storage bin (24 hours)
4. Fuel metering conveyors, meters, and pneumatic transport

Two typical prep-yard configurations are shown in **Figures 4-1** and **4-2**. Figure 4-1 includes manual feedstock handling steps that reduce capital costs but increase labor requirements. The manual approach to feedstock handling would be primarily used for smaller facilities. Figure 4-2 shows a fully automated prep-yard, which is more capital intensive but requires less labor. An automated system is only cost-effective for large biomass conversion systems. Both of these configurations are based on woody biomass feedstock. The discussions throughout this chapter are based on three systems:

- 100 tons/day system based on manual biomass handling
- 450 tons/day system based on automatic handling
- 680 tons/day system based on automatic handling

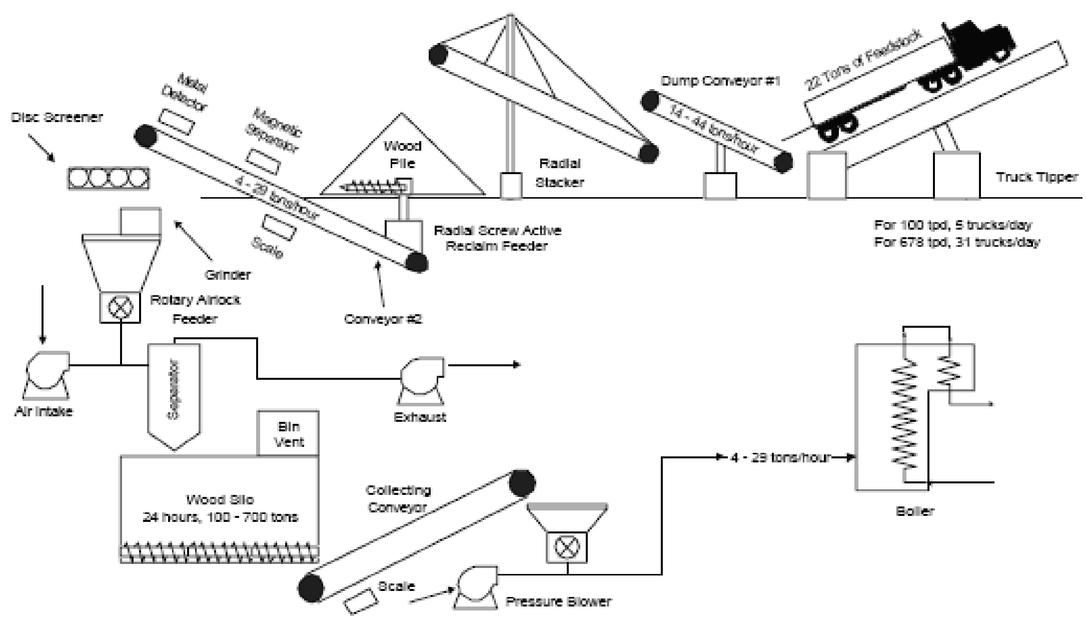
[46] The costs and schematics for this section are based on Antares Group, Inc., 2003.

Figure 4-1. Manual Biomass Receiving and Preparation System



Source: Antares Group, Inc., 2003.

Figure 4-2. Automatic Biomass Receiving and Preparation System



Source: Antares Group, Inc., 2003.

4.1.1 Receiving System

With the exception of residues generated in-house, virtually all woody biomass is delivered by truck to industrial users. Three types of trucks are commonly used for delivery of wood fuels: 1) dump trucks, 2) live-bottom (self-unloading) semi-trailer vans, and 3) standard semi-trailer vans. The choice of truck is dependent on the quantity of the biomass purchased and the equipment available for unloading. Dump trucks and live-bottom trucks have the advantage of being able to unload themselves directly onto storage piles. Standard semi-trailer vans require truck dumpers to unload. Smaller and less expensive dump systems only raise the trailer van for dumping, a process that requires decoupling the tractor and semi-trailer and is therefore more time intensive. Larger dump units can tilt the whole truck and unload in a manner of minutes, or approximately one-half the time of a trailer-only dumper. Minimizing unloading times is important because haulers can impose financial penalties for excessive unloading times.

A set of drive-on scales is used to determine how much biomass is on the truck. Although mechanical or electronic scales can be used, maintenance costs are generally lower for mechanical scales so those are more commonly used. Sometimes conveyor belt scales are used for determining weights, but these systems are less accurate, more time consuming, and more expensive to operate.

Biomass delivery and receiving methods depend on the size of the installation:

- **Very small installations** of a few tons per day use small dump trucks or standard semi-trailer vans for biomass delivery. Dump trucks drop the load at the site where it is then moved to storage by small front-end loaders. Where standard semi-trailer vans are used, a ramp or loading dock is required so that front-end loaders can remove the load—a process that takes about an hour per load.
- **Small-scale users,** 10 to 50 tons/day, typically use self-unloading semi-trailer vans. These trailers have a live-floor system that walks the load from the van, allowing a single person to unload a van in 10 minutes. The trailers are 30 to 45 feet in length and can carry 20 to 30 tons of biomass.
- **Intermediate-scale installations** 50 to 100 tons/day might add a light-duty frame-tilt hydraulic dumper for unloading fuel. For these systems, the trailer must first be disconnected from the tractor. Front-end loaders or bulldozers move the fuel from the concrete pad and stack the biomass on the storage pile. A system sized for 100 tons/day would handle about four to five trucks per day.
- **Large-scale installations** of greater than 100 tons/day typically use standard semi-trailers and hydraulic dumpers that can lift and tilt the whole truck up to an angle of 75°, emptying the entire load in a matter of minutes. The system includes a live-bottom receiving hopper. From the concrete pad, the fuel is conveyed to a woodpile. An automated storage radial stacker is used to stack the fuel on the pile for future processing needs. A system sized for 400 tons/day capacity would handle about 20 trucks per day.

The storage area for the options considered in this section is sized for a 30-day supply of biomass. This quantity of biomass can carry the plant through possible supply shortages in the spring or winter seasons. This amount of biomass storage requires an area between 12,500 and 93,750 square feet (for the 100 tons/day and 680 tons/day systems, respectively), assuming the wood has an average density of 40 lb/cubic foot and an average storage height of 12 feet. The larger area is greater than two football fields, so a significant area would be needed on site for a large biomass processing facility.

4.1.2 Processing System

The processing system treats the biomass prior to charging the energy conversion process. Common steps in processing include separation, sizing, removal of metals and other noncombustible materials, and grinding or other size reduction methods. An automated system conveys the correct amount of biomass required by the energy conversion process. In a manual system, a front-end loader will perform this function.

The sizing equipment separates oversized pieces and sizes them to meet boiler specifications. The disc screener separates the oversized particles and bypasses the undersized feedstock. The oversized particles are sent to a tub grinder to be properly sized. The tub grinder is adequate for wood chips and bark, but urban wood waste needs a hammer hog (hogger) because metal objects in this waste stream would damage a tub grinder. From the grinder or hogger, the material is conveyed into a wood silo to be stored until the boiler needs the fuel. Stoker and fluidized bed boilers can charge material up to about two to three inches in size.

Biomass might also have to undergo drying. If needed, this step occurs immediately after sizing. Of the technologies studied in this report, only gasification requires biomass drying. For all biomass conversion technologies, the lower the as-fired moisture content of the biomass feedstock, the higher the energy efficiency of the conversion process. If part of the fuel, moisture must be heated and vaporized and this energy is lost in the stack. In direct-fired conversion processes described in Chapter 5, each additional 10 percent of moisture in the fuel lowers the conversion (or boiler) efficiency by about 2 percentage points. Therefore, as-received biomass with moisture contents of 30 to 50 percent result in process efficiencies of 6 to 10 percentage points lower than bone dry feedstock. Efficiency reductions due to moisture contained in the biomass also occur in cofiring, but the effect is considerably reduced because the biomass is only a small part of the total fuel used. Typical practice in direct-fired and cofired applications, however, is not to dry the feedstock before charging in the boiler. In a well designed boiler, most of the available stack heat is already being extracted in steam production and other energy recovery options. Therefore, diverting stack heat from the process for drying would reduce what is available for steam generation. Gasification processes, on the other hand, typically require biomass feedstock drying for proper process function and control. Feedstock drying is an integral part of most gasification designs. Therefore, costs of drying are only considered in the section on biomass gasification.

4.1.3 Buffer Storage

A biomass silo serves as storage buffer in the 100 to 680 tons/day cases outlined here. The silo has a live bottom that moves the fuel to collector conveyors. The silo's capacity varies by fuel consumption rate. Prep-yard costs can be reduced by lowering the buffer size.

4.1.4 Fuel Metering

Fuel metering consists of the controlled delivery of the required amount of biomass to the energy conversion process. In the systems considered here, the biomass is metered as it is discharged from the silo to the collecting conveyor. An auger at the base of the silo feeds a conveyor, which then feeds a surge bin. From the surge bin, the fuel is metered into the boiler or other energy conversion device, passing through a rotary airlock. The metering rate is controlled by the boiler control room. The fuel is pneumatically transferred to the boiler after passing the airlock.

4.1.5 Prep-Yard Capital Costs

This section summarizes installed capital costs for biomass prep-yards of 100, 450, and 680 tons/day. The 100-tons/day plant utilizes a manual feedstock handling system. The two larger plants use an automatic system.

Table 4-1 shows installed capital costs, including the major equipment components described in the preceding sections. Installation costs, controls, civil/structural work, electrical work, engineering fees, and contingency costs are also shown. Prep-yard capital costs decline sharply on a per ton basis as the plant gets larger.

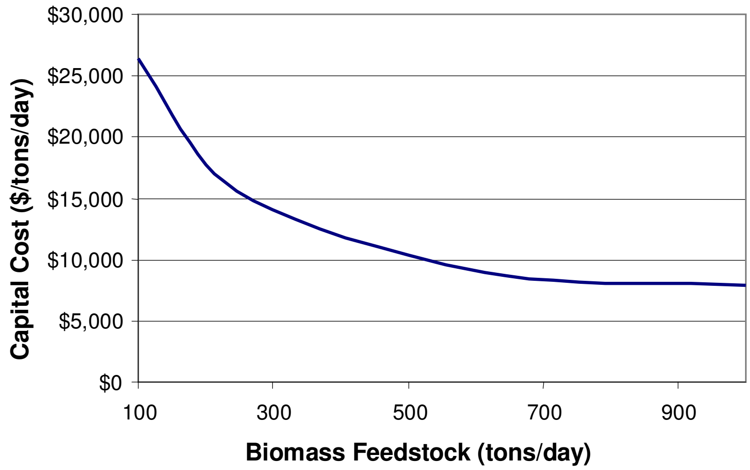
Table 4-1. Installed Capital Costs for Solid Biomass Receiving and Preparation

	Tons/Day Fuel (as received)		
Component	**100**	**450**	**680**
Receiving System			
Truck tipper	$230,000	$230,000	$230,000
Conveyor to wood pile		$40,000	$45,000
Radial stacker, adder		$190,000	$205,000
Front end loaders, adder	$100,000		
Receiving Equipment Subtotal	**$330,000**	**$460,000**	**$480,000**
Processing System			
Reclaim feeder		$230,000	$230,000
Conveyor		$149,000	$160,000
Metal separator	$40,000	$40,000	$40,000
Screener	$150,000	$220,000	$250,000
Grinder	$250,000	$400,000	$600,000
Processing Equipment Subtotal	**$440,000**	**$1,039,000**	**$1,280,000**
Buffer storage	$60,000	$98,000	$135,000
Fuel metering	$252,000	$313,000	$364,000
Controls	$115,000	$166,000	$196,000
Equipment Subtotal	**$1,197,000**	**$2,076,000**	**$2,455,000**
Equipment installation	$500,000	$1,093,000	$1,220,000
Civil/structural work	$370,000	$787,000	$877,000
Electrical work	$170,000	$275,000	$305,000
Direct Cost Subtotal	**$2,237,000**	**$4,231,000**	**$4,857,000**
Engineering (10% of direct cost)	$223,700	$423,100	$485,700
Contingency (8% of direct cost)	$178,960	$338,480	$388,560
Indirect Costs Subtotal	**$402,660**	**$761,580**	**$874,260**
Total Prep-Yard Cost	**$2,639,660**	**$4,992,580**	**$5,731,260**
Prep-Yard Unit Cost ($/tons/day)	**$26,397**	**$11,046**	**$8,453**

Source: Based on Antares Group, 2003.

These three plant sizes were used to develop a capital cost curve as a function of plant biomass throughput, as shown in **Figure 4-3**. Above 680 tons/day, the biomass prep-yard costs were assumed to increase as a function of a 0.85 power factor of the ratio of prep yard throughput.

Figure 4-3. Estimated Unit Prep-Yard Capital Cost As a Function of Throughput



4.1.6 Labor for Operating the Prep-Yard

There are also labor costs associated with operating the receiving and processing portions of the prep-yard. The amount of labor needed for the three options is based on baseline firing rates of 100, 452, and 678 tons/day. The labor requirements are shown in **Table 4-2.** Each employee is assumed to have a loaded compensation rate of $80,000/year. Each plant requires a delivery coordinator; larger plants need an additional person for this function. The manual handling system of the 100-tons/day plant requires three people to operate the front-end loaders, including a supervisor. The automatic operation of the larger plants eliminates this requirement. For the larger plants, two operators can manage the handling and processing equipment; for the 100-tons/day plant, only one is required. Overall, the 100-tons/day plant requires five people, and the two larger automatic prep-yards require four people.

Table 4-2. Labor Requirements

	Tons/Day Fuel (as received)		
Employee Position	**100**	**450**	**680**
Delivery Coordinator	1	1	1
Assistant Coordinator		1	1
Employee Supervisor	1		
Front End Loader Operator	2		
Operators	1	2	2
Total Employees	**5**	**4**	**4**

These labor estimates contribute to the O&M cost estimates presented in Chapter 6.

4.2 Biogas Fuel Preparation

Biogas fuel is generated from the anaerobic decomposition of organic material and is typically composed of about half methane, half CO_2, and small amounts of non-methane organic compounds and