Biomass plant relies on variety of local fuels

Straw, Bermuda grass, Muni Ag, orchard prunings, woodwaste—these are the regional byproducts that this 47-MW biomass plant in California is using to fuel its boilers. Recirculating fluidized-bed boilers are central to the operation

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The Mecca biomass powerplant is located in the Coachella Valley of Riverside County in southern California, an arid region with mean monthly temperatures of 31 to 107F and annual rainfalls of only 2.8 in. Colmac Energy Inc's 47-MW facility capitalizes on both wood chips and a variety of waste agricultural byproducts that are processed and blended to provide a stable fuel for the boilers (see box). Full commercial operation is expected this month.

Plant details

The plant has two recirculating fluidized-bed boilers, which have a combined output of 464,000 lb/hr of superheated steam at 1255 psig/925F (Fig 1). Fuel is discharged from a day bin atop the boilers via screw conveyors, which feed it to the bed injection pipes. Fines that exit the boilers are separated at the 10-15-micron level from the gas stream by cyclones and reinjected into the bed. The boilers are designed for limestone and ammonia injection to control SO_2 and NO_x emissions. Fuel is supplied to the boilers via a receiving, storage, and processing system (Fig 2).

The turbine/generator is a nominal 47-MW, axial-flow unit. It has a high-pressure, gear-driven turbine section on one end of the generator and a low-pressure section mounted on the opposite end. The condenser is mounted transversely at the low-pressure end.

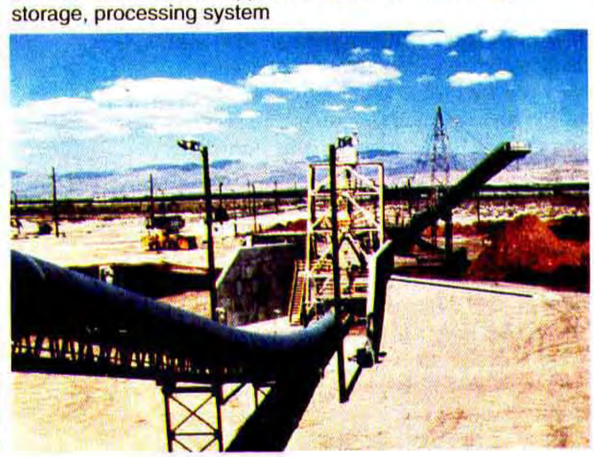
The balance of plant is fairly conventional, with the exception of the water treatment system (Fig 3), which includes a brine concentrator and leased demineralizer equipment that minimize the amount of effluent water. Cooling water is supplied through a closed system using a mechanical-draft cooling tower. Particulate emissions are controlled with a pulse-jet fabric filter. Each unit has an induced-draft fan that discharges to a common stack. Electric power is transmitted to the utility via a 92-kV line.

Fuel characteristics

The total anticipated fuel requirement is 277,000 tons/yr (dry) of biomass fuel, based on 85% plant availability. The

1. Biomass plant (left) has two recirculating fluidized-bed boilers, which have a combined steam output of 464,000 lb/hr at 1255 psig/925F

2. Processed fuel is supplied to boilers via receiving, storage, processing system



3. Water treatment system features brine concentrator and leased demineralizers

design fuel-mixture ranges are: woodwaste, 85-100%; agricultural waste, 0-15%; municipal agricultural, 0-10%.

The woodwaste is clean wood byproducts from commercial sources. Collected from local wood-processing industries, it contains less than 1% paint, preservatives, glue, varnish, and foreign matter. Woodwaste treated with creosote is not acceptable. The wood is chipped by the supplier so that 99% is minus 3 in. (all dimensions). The maximum allowable amount of foreign matter is 3%; the maximum allowable moisture level is 35%.

Agricultural waste includes several local farmland byproducts like straw and Bermuda grass (Table 1). It is delivered in bales that measure 15 × 22 × 42 in., bound using either wire or twine. Each bale weighs up to 120 lb and can contain no more than 3% mud, grit, and other noncombustible materials.

As Table 2 shows, most of the fuel has relatively low sulfur and ash content. However, heating values (6600-8800 Btu/lb) and moisture (5-40%) and ash (5-15%) contents vary widely, which is one reason why precise fuel blending is important.

Physical properties of the fuel were measured to determine the handling requirements for the fuel system. Tests for strength, friction, segregation, and bulk density were conducted, and seven material-strength tests were performed. Individual fuel components and mixtures were tested with and without elastic effects. It was found that both the straw and wood chips were sensitive to elastic over-compaction. The steepness of the strength vs consolidation-pressure curve, especially at low consolidation pressures, indicated strong arching and rathole potential—essential criteria to have at hand when designing the bins and feeders.

When segregation potential was measured, fuel mixtures were discharged from a chute to form a pile. Relative pile composition (fine/coarse) was determined as a function of pile radius. Minor segregation tendencies were indicated by these tests. The fines tended to deposit closest to the chute and near the center of the discharge point. The amount of segregation was not considered critical.

Bulk density is an important characteristic for sizing conveyors, bins, and other equipment. Because these materials compact under pressure, densities were measured at several consolidation pressures (Table 1). As shown, these are low bulk densities, lower than those given in industry classifications for bulk materials. It affected system design—illustrating the importance of tests for systems that handle materials that can vary widely from industrial norms.

Fuel handling system

At the plant site (Fig 4), trucks loaded with waste fuel proceed to the weighing station, which is operator-controlled. The truck-scale operator provides primary control for the plant's fuel deliveries, ensuring that specified quality levels are maintained. He visually inspects agricultural bales for decomposition, excessive moisture, and foreign matter; loads of wood chips are similarly inspected. However, because of the arid climate and readily identifiable fuel sources, few fuel-quality problems are anticipated.

Once admitted by the operator, the trucks are sequenced to the scale, to a dumper for wood chips or a bale unloader for agricultural waste, then back to the scale again to weigh the empty trucks. Here's how these distinctive fuels are processed:

The wood chips are unloaded at one of two dumpers—typical backup-style hydraulic machines with a 75-ton capacity, 70-ft-long deck, 60-deg lift angle, and rated 10 cycles/hr. They are pushbutton-controlled by the truck driver. Under normal operating conditions seven or eight trucks an hour can be unloaded by either dumper.

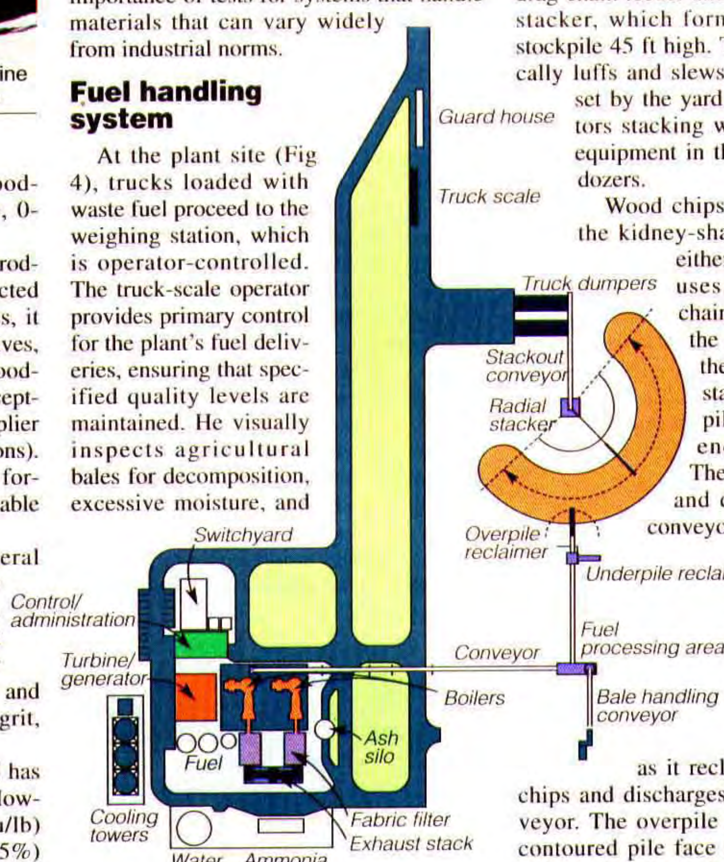
The wood chips are dumped onto a drag-chain feeder and conveyed to a radial stacker, which forms a kidney-shaped stockpile 45 ft high. The stacker automatically luffs and slews within an arc range set by the yard operator, who monitors stacking while operating other equipment in the area, such as chip dozers.

Wood chips are reclaimed from the kidney-shaped pile (Fig 5) by either of two systems. One uses an underpile drag-chain reclaimer similar to the drag-chain device on the dumpers. Chips are stacked or dozed into a pile that buries the tail end of the reclaimer. The chips are reclaimed and discharged to a belt conveyor.

The other system uses a boom-type overpile drag-chain reclaimer. The boom luffs and slews and is gradually lowered as it reclaims layers of wood chips and discharges them to a belt conveyor. The overpile reclaimer requires a contoured pile face for a steady reclaim rate; to do this, it first dresses the pile to provide a smooth surface. It can then operate unattended for eight or more hours.

From the belt conveyor, the wood chips are screened and hogged in a redundant system. Disc screens size the chips. These positive-displacement devices use rotating discs to move the oversize chips forward while the sized material falls between the screen openings. The sized material discharges directly to another belt conveyor.

The oversize material from the head end of the screen is discharged to a wood hog. Since most of the wood chips are within the required size range, only a portion of



4. Fuel handling begins at plant site, when trucks loaded with waste fuel proceed to weighing station, which is operator-controlled

Table 1: Bulk density, lb/ft^3

	Consol.	press,	lb/ft^2
Fuel	2	20	100
Wheat straw	1.4	2.3	3.8
Bermuda grass	2.3	3.9	6.3
Anaheim wood chips	9.4	9.7	10.4
Gardenia wood chips	6.9	7.2	7.8
Straw/Anaheim, 30/70	6.3	6.9	8.0

the reclaimed material must be hogged. The reclaim rate is 60 tons/hr, while the hog rate is only 20 tons/hr. The reclaim material that must be hogged is expected to be well below this amount.

Agricultural bales are unloaded by a squeeze-loader. Similar to a fork lift, it is fitted with an attachment for bale handling, unloading 8 × 8 × 10-ft cubes, each of which contains 64 bales. The squeeze-loader also stacks bales into a row-and-aisle arrangement, reclaiming bales from the stack to the bale feeder.

The bale processing line consists of a bale feeder, unbaling station, tub grinder, and connecting drag conveyor. They process the cubes into minus 2-in. material. Since the line is prone to jamming, an operator monitors bale processing.

The bale feeder receives the cubes from the squeeze-loader. An accumulating conveyor on the feeder queues three cubes and lifts the last cube. The top row of bales is pushed off the cube and aligned to feed individual bales onto a drag-chain conveyor, which moves the bales to an unbaling station.

At the unbaling station, one or two workers cut and remove the wire or twine that secures the bales. The drag-chain conveyor then moves the loosened bales to the tub grinder (a bowl-shaped vessel that rotates on rollers), which shreds the loose bales. The shredded bales contact a hammer mill that further shreds them into minus 2-in. particles. The material is discharged to a belt conveyor.

Combined fuel processing

The sized wood chips and shredded bale fuel are combined on a single belt conveyor. The agricultural fuel is loaded first and

All parties benefit with conversion of agricultural waste to fuel

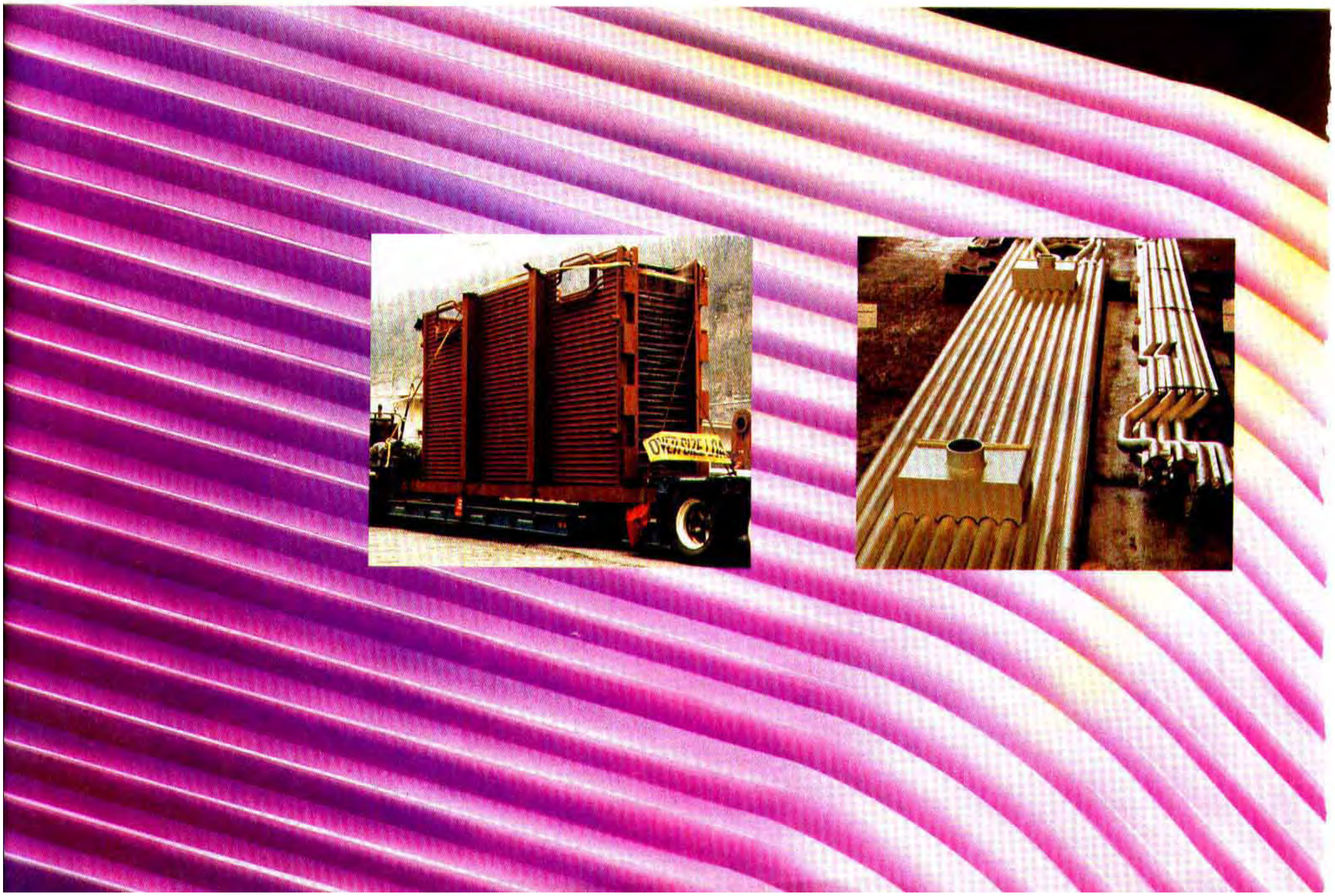
The use of agricultural waste for fuel provides several benefits. It is generated locally by the many large farms that populate California's Riverside County. Before the Mecca biomass plant, agricultural waste byproducts were disposed of via controlled field burning, which contributed to the region's air pollution. Converting the waste into a fuel solves this pollution problem. Thus, the biomass plant disposes of large quantities of waste in an acceptable manner, providing a service to the local farms and surrounding community.

The plant also benefits financially. The facility is funded, in part, by bonds issued by the California Pollution Control Finance Authority. The bonds will be repaid from the sale of electricity to Southern California Edison Co. Local truckers benefit by an added need for their services. The plant itself, of course, provides employment opportunities and locally generated electric power.

Table 2: Biomass fuel characteristics

Fuel	Heating value, Btu/lb (dry wt)	Moisture content, %	Key constituents, % (dry weight)			
			Ash	Nitrogen	Sulfur	Chlorine
Straw	6600-8000	5-18	15	1.3	0.35	2.50
Bermuda grass	7000-8000	7-10	10	1.2	0.80	1.00
Muni Ag*	7500-8500	8-35	12	1.2	0.20	0.50
Orchard prunings	7300-8800	10-40	5	1.0	0.15	0.25
Woodwaste	7900-8800	10-30	8	0.7	0.15	0.18

*Grass clippings, residential tree trimmings



normally represents 10 to 20% of the fuel input. The heavier wood chips are loaded on top, to help minimize dust-related problems.

Belt scales automatically control blending of the two fuels. They are located on the wood-chip conveyors and the conveyors on which the two fuels are combined. Belt scales are sensitive to the effects of belt forces when light materials are measured; therefore, the lighter agricultural material is not weighed by itself. Wood chips and the combined fuels are weighed to control blend percentages. The operator sets the blend ratios, and the belt scales automatically control the wood-chip reclaimers and bale feeders to meet these requirements.

The processed fuel is conveyed to the fuel-metering bins. A belt conveyor carries the fuel to the first bin. The fuel discharges via a splitter gate to Unit 2's surge bin, or remains on the belt conveyor for Unit 1. The splitter gate can also divide the fuel to feed both units simultaneously. Bin level is controlled automatically via level sensors.

Since the processed fuel has poor flow properties, the metering bins are designed with a relatively low height to minimize compaction. Bin sidewalls have a negative angle (the bin's base is larger than its top) to avoid nonflowing areas caused by converging hoppers. The bins also have a 100% live bottom, using screw conveyors for discharge.

5. Wood chips are reclaimed from kidney-shaped pile by underpile drag-chain reclaimer or boom-type overpile drag-chain reclaimer

The fuel system must operate 100% of the plant's on-line time. Fuel-system downtime is planned to coincide with scheduled and emergency maintenance on other plant systems. For this reason, the reclaim, processing, and plant feed systems are conservatively designed and feature redundant screens, hogs, and conveyor drives.

Plant startup

Startup of Mecca powerplant has progressed without major incident. Power was backed into the plant in May 1991, and the first unit was synchronized last October—well within the contract schedule. Punch list items were resolved before turnover for startup—important since incomplete systems can impact plant reliability and availability during the startup program.

As with any startup, a number of equipment malfunctions, wiring discrepancies, and control-philosophy changes were experienced—none major. Example: the rotary fuel-feed valves were boosted in size to accommodate the varying density of the fuel. Also, valve motor operators were increased in horsepower and provided with reversing capability so any jams could easily be cleared.

A modification was made to the boilers' wood-storage day bin during startup. To prevent potential motor overloads on the feed screws, the back portion of the bins was modified to stop biomass material from entering the last few feet of the screws.

Changeout of control-valve trim was required on three valves. The actual flows and pressures varied from design by an amount sufficient to warrant trin changes but not valve-body changes. The differences can be attributed to a combination of design evolution, design margin, and overall system characteristics.

The condensate pump head was higher than anticipated (caused by design and manufacturing margins), resulting in greater flow and pressure drop through the minimum-flow control valve. This condition was resolved by changing out the control-valve trim.

Desuperheater valve trim was changed to accommodate a higher-than-design pressure drop. This valve was originally sized based on downstream pressure of the feedwater control valve. To ensure a constant water supply to the desuperheating valve, the line was connected upstream of the feedwater valve, which is at a higher pressure. Also, the auxiliary steam control-valve trim was changed to accommodate actual steam flows, which were slightly higher than design values.

One problem still remaining: reduced auxiliary cooling-water flow. The flow rate is about 33% less than the design pump flow. Several tests have been performed to determine whether the difficulty is with the pumps or with the pump-suction piping arrangement. The problem must be resolved before summer, when ambient temperatures will necessitate added water flow.

Tom Elliott

Major equipment suppliers

Turbine/generators and auxiliaries	
Turbine/generator, 1	ABB Power Generation Inc
47-MW, axial-flow unit with a high-pressure, gear-driven turbine section on one end of generator and a low-pressure section mounted on opposite end	
Condenser	Joy Power Products Inc, Ecolaire Condenser **(See our ad, p 63)**
Condensate pumps	Johnston Pump Co
Cooling tower	Research-Cottrell Companies, Ecodyne Cooling Tower Services
Steam generators and auxiliaries	
Fluidized-bed boilers, 2	ABB Combustion Engineering Systems **(See our ads, pp 55, 57)**
Combined output of 464,000 lb/hr of superheated steam at 1255 psig/925F	
Limestone handling/preparation	ABB Combustion Engineering Systems **(See our ads, pp 55, 57)**
Air heater	ABB Air Preheater Inc **(See our ad, p 195)**
Primary and secondary air fans	Howden Sirocco Inc
Induced-draft fan	Buffalo Forge Co
Boiler-feed pump	Goulds Pumps Inc **(See our ad, pp 18-19)**
Boiler-feed-pump turbine	Elliott Co
Sootblowers	Copes-Vulcan Inc **(See our ad, p 161)**
Stack	Research-Cottrell Companies, Custodis
Environmental control systems	
Ash handling equipment	McNally Wellman Co
Fabric filter	Environmental Elements Corp
Control systems	
Boiler controls	ABB Combustion Engineering Systems **(See our ads, pp 55, 57)**
Burner management system	ABB Combustion Engineering Systems **(See our ads, pp 55, 57)**
Integrated plant controls	Bailey Controls Co **(See our ad, p 108)**
Balance-of-plant equipment	
Critical valves	Valtek Inc, Atwood & Morrill Co
Major pumps	Goulds Pumps Inc **(See our ad, pp 18-19)**
Compressors	Atlas Copco Industrial Compressors Inc **(See our ad, pp 40-41)**
Circulating-water pumps	Johnston Pump Co
Evaporator/crystallizer	Resources Conservation Co