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Wood Energy For Alabama

Case Studies in Cost Savings

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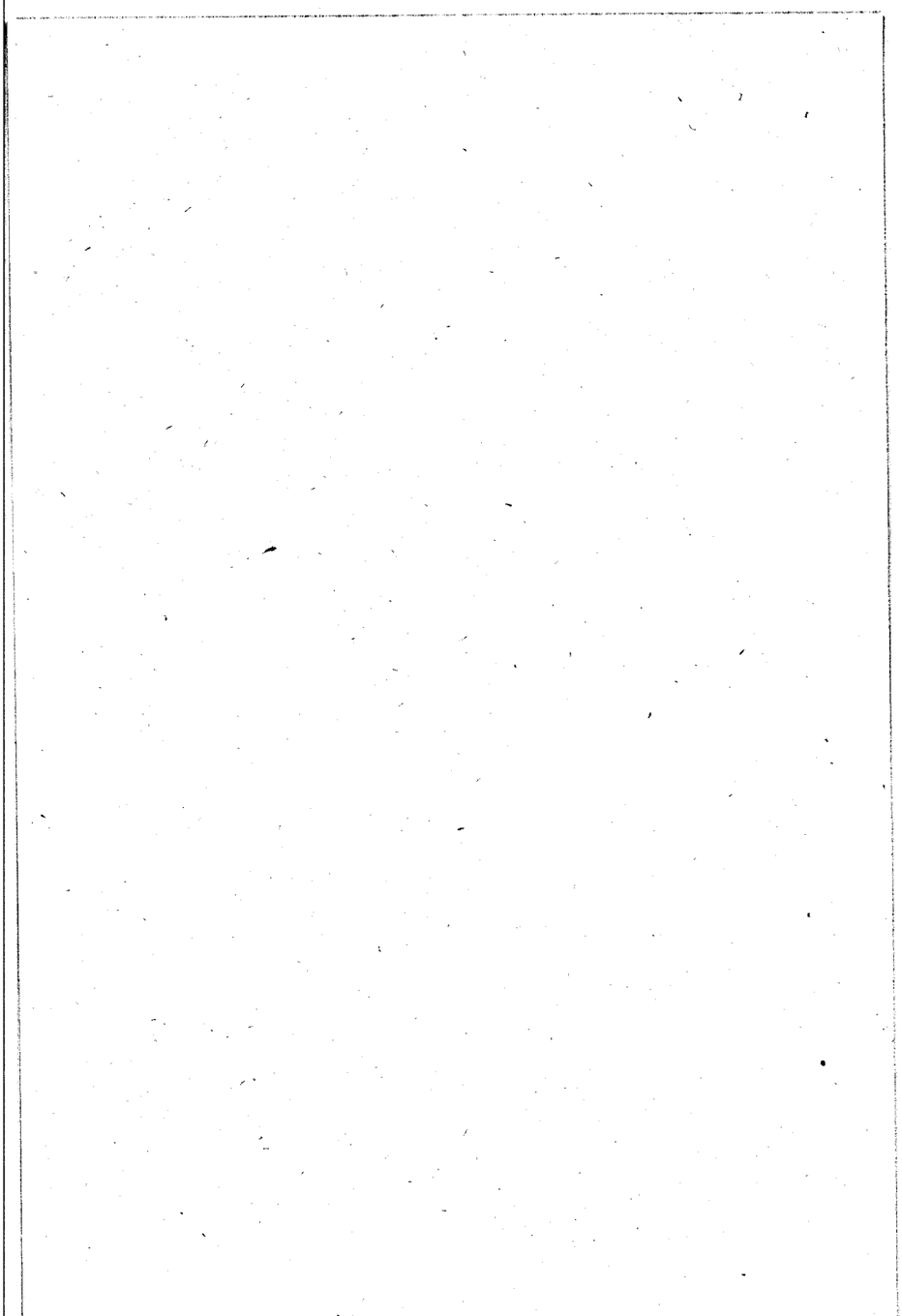

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Introduction

For over ten years the Alabama Department of Economic and Community Affairs (ADECA) has offered a program to increase the use of wood, wood waste, and other biomass residue for production of useful energy in commercial, industrial, and institutional facilities. The projects represented by this program save their owners almost $10M per year in energy costs alone. Since the state is a net importer of energy, increased use of a renewable form of energy also provides a number of public benefits including an increased tax base from the use of an Alabama resource, increased jobs in the forest products industry, and more productive use of land. More recently, the environmental issue has become as important as the energy issue. Most communities are facing increased costs to operate landfills due to the imposition of federal environmental regulations, such as Subtitle D and State mandates, to reduce the amount of material entering landfills. To contain landfill costs and increase the life of existing landfills, many communities are removing recyclables from the waste stream and refusing to accept waste not requiring a sanitary disposal. Since it is increasingly more difficult to find buyers for residue, biomass energy offers many facility owners an alternative for the profitable consumption of a waste on-site that would otherwise constitute an expensive disposal problem. Global warming is another important national and global environmental issue. The combustion of biomass residue for energy production adds no more CO_2 to the atmosphere than would its natural biological degradation. On the other hand, the combustion of fossil fuels releases "new" CO_2 to the atmosphere and any measure which reduces the consumption of these fuels, including the use of biomass energy, would reduce this disturbance to the equilibrium of the global carbon cycle.

The Science, Technology, and Energy Division of ADECA, which manages the program, has provided support in the form of a subsidy on the financing of biomass energy projects. In addition to the financial support, technical assistance has also been provided by staff engineers. The program has a major impact on the state's economy since the forest-related industry ranks as the number one manufacturing industry in Alabama with total business of four billion dollars. Experience acquired with the biomass energy projects makes it possible to provide the Alabama forest products industry and other producers and potential users of biomass fuel with firsthand information on new and possibly more profitable methods of operation.

This document provides a summary description of the twenty-five projects that have participated in this program. Technologies utilized in the program range from direct-fired kilns to large water tube boilers and multistage steam turbines for power generation. The program includes at least one project which utilizes hospital medical waste to generate steam. The purpose of this document is to illustrate the potential of biomass energy to a facility manager who may identify with a project that is similar to one meeting his own needs.

Background

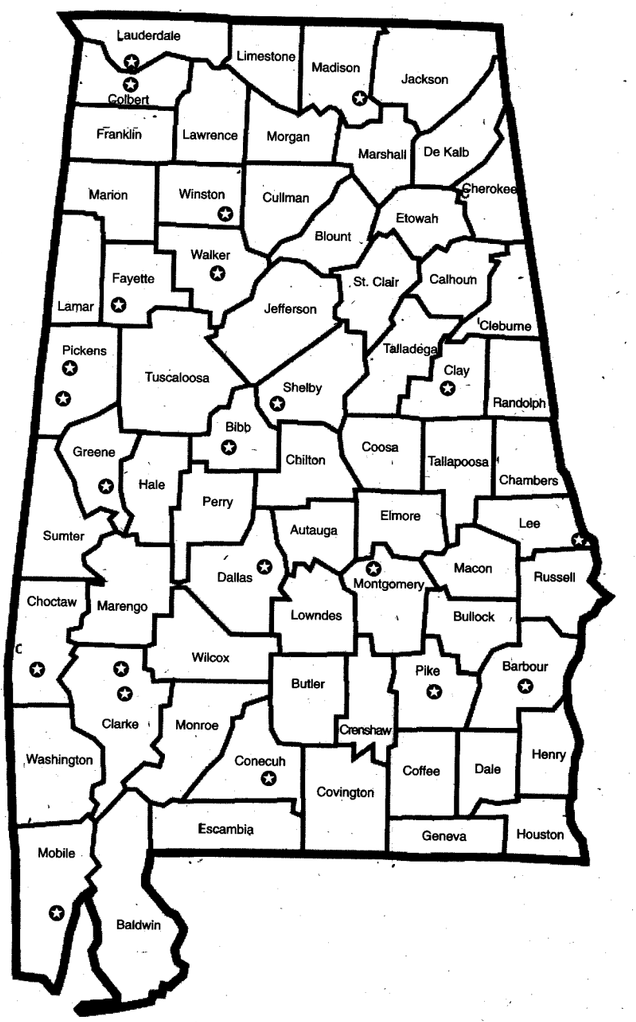
The goal of the Alabama Biomass Energy Program is to encourage and assist the state's forest products industry to achieve greater profitability by promoting the use of wood wastes as the primary fuel for generation of process heat, process steam, and electrical power. The assistance program, first announced in 1984, has subsidized all or part of the interest on loans used to finance qualifying biomass energy projects, with the maximum assistance limited to $75,000 for each project. (The term of the subsidy may not exceed three years and the interest subsidized beyond a rate of two percent above prime.) This program is not restricted to members of the forest products industry and does not require that program participants burn their own wood waste, although most of them do. Upon completion of the project and passing a final inspection, the lending institution submits statements of each loan payment indicating the portion which is interest. The borrower is then reimbursed directly for the interest paid.

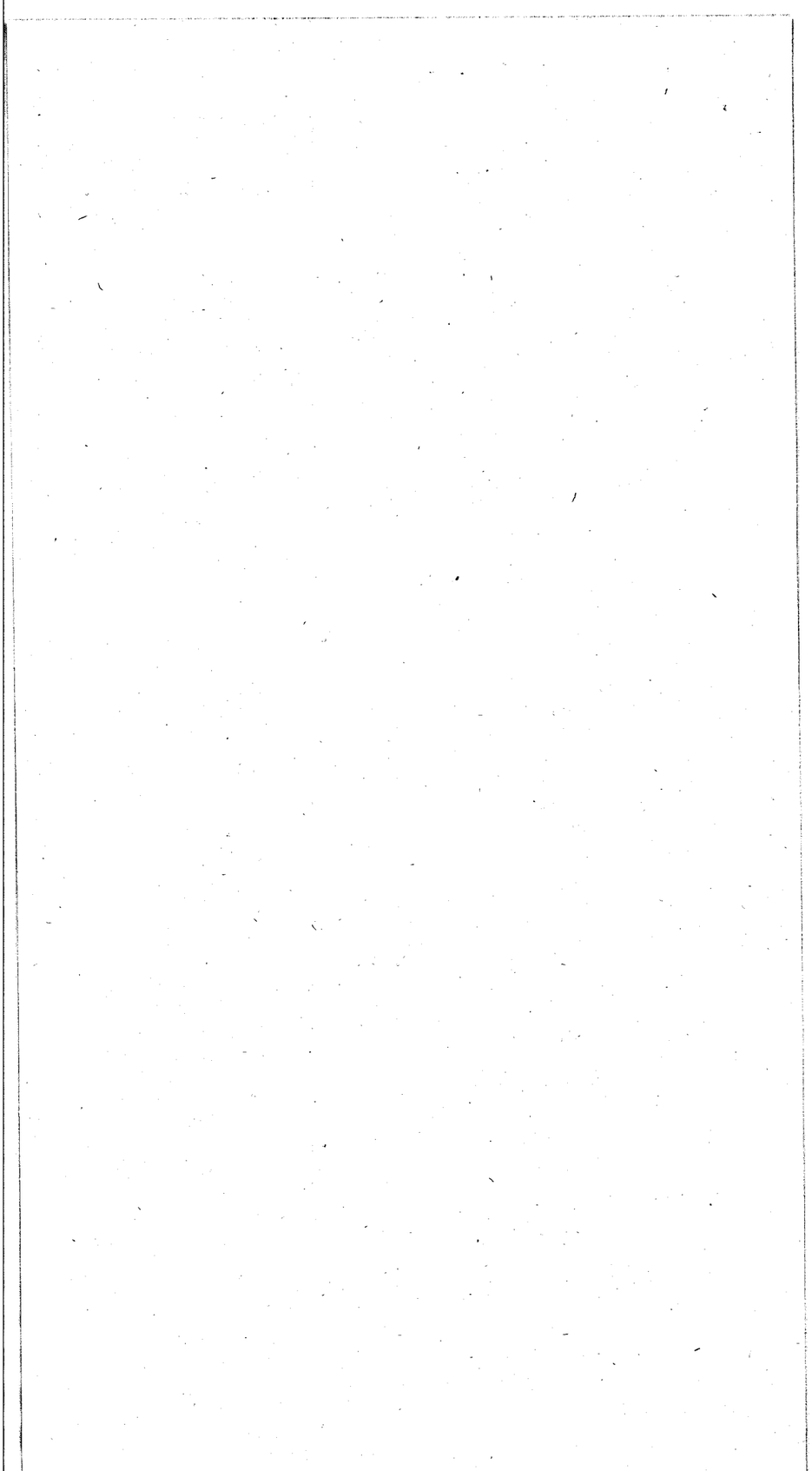
Project Descriptions

One of the requirements for participation in the biomass energy program is that the participants provide a detailed description of their projects. After becoming operational, periodic operational data for the length of the loan interest subsidy period is submitted.

The program has included twenty-five projects since its inception. Figure 1 is a map of Alabama indicating the counties in which they are located. Some summary statistics of the projects are as follows:

- biomass residue consumption .....256,234 ton/yr
- natural gas savings.....18,840,707 mcf/yr
- fuel cost savings.....$9,458,035 /yr
- thermal energy production.....1,470,268 MMBtu/yr





ALA-TENN Industries

Sheffield (Colbert County)

The costly and time-consuming method of drying lumber before soaking in chromate copper arsenate (CCA) had been considered necessary in order to get adequate penetration into the interior wood fibers. To eliminate this two to six-day kiln drying step, ALA-TENN elected to use a preservative application technique that was developed overseas. This technique employed a steam-heated autoclave which permitted the use and the treatment of wet or green timber. The steam used during the three to six-hour autoclave heating cycle is at least 30 percent less than is required for conventional kiln drying. Because of the decreased processing time, the autoclave has a throughput capacity 8 to 48 times as great as conventional kilns of equal volume; therefore, its higher cost could be easily justified.

To produce the 120 boiler horsepower, 50 psig steam required of the autoclave, ALA-TENN obtained a used 600 hp Cleaver-Brooks boiler in good condition. Since this boiler was intended to operate on oil or gas only, it was fitted with a vortex burner and fuel dryer to operate on the wood waste fuel available from ALA-TENN's sawmill. As a result, the boiler can produce 300 hp output on 100 percent wood fueling. A semi-experimental vortex type burner design was selected because it appeared to have several advantages over existing systems. Since wet fuel will not burn properly in a vortex type (air suspension) burner, a combination metering bin/fuel dryer was included to permit the use of waste wood fuel with a moisture content greater than 20 percent. After some initial break-in problems, the vortex burner worked as designed. The metering bin/fuel dryer had some developmental problems and was redesigned. Use of the wood waste (dry sawdust and shavings) as fuel instead of natural gas resulted in a simple payback of 1.3 years.

This project demonstrated that oil and gas-fired boilers can be economically converted to wood fuel using air suspension-type burners if sawdust and fine shavings having no more than 15-20 percent moisture content are available.

By using wood instead of gas to fire its boiler, **ALA-TENN achieved a net annual energy savings of 17,800 MMBtus at a value of $102,096. Because of changing market conditions, this project is no longer in service.**

Miller and Company

Selma (Dallas County)

The Miller and Company flooring mill and general sawmill makes both hardwood flooring strips and large dimension lumber. This plant had several steam kilns powered by five vintage, secondhand, watertube wood-fired boilers. More steam was needed to power the operational 500 kW General Electric and an out-of-service 750 kW Westinghouse turbine that was to be put back into operation. To increase capacity the Dutch oven brickwork was removed from the furnace and replaced with a steel furnace section fired by suspension burners.

In addition to increased capacity and efficiency, the conversion provided improved load-following ability for the turbine/generators, and stack emissions were greatly reduced.

The suspension burners are fueled with dry sawdust and chips from the flooring mill. A concrete silo, supplied by a pneumatic conveyor, was built to store this fuel. The suspension burners receive air from large central forced-draft blowers. Direct contact condensers, cooled by water from a spray pond, are used to increase steam turbine efficiency. With this system, a vacuum averaging about 25" Hg can be produced at the turbine exhaust.

The added steam capacity from this project has permitted simultaneous operation of the lumber kilns and the two turbo alternators. Although these units produce 75 percent of day-shift power, it has not been practical to operate them at night. The boiler fuel can be sold for $12 per ton, but excess electrical power produced at night can only be sold for about $0.01/kWh to Alabama Power Company. Therefore, it is cheaper to shut down the turbines and save the cost of a night turbine room operator. To reduce demand costs, especially when a boiler or turbine is inoperable, a 400 kW Diesel generator set was installed. Using this backup generator and the turbo alternators, the plant could operate on internal power if public power failed.

The net annual energy savings of this project are 6,500 MMBtus at a value of $37,282.

Phenix Lumber Company

Phenix City (Russell County)

The Phenix Lumber Company saws and dries yellow pine dimension lumber. Prior to this project all lumber had been air dried before sale. Consequently, during some wet months the plant was unable to produce lumber at the required moisture level of 19 percent or less. Furthermore, the sawmill has been modernized for greater production, but this was limited by the existing drying capability. On the other hand, a large amount of waste wood at about 45 percent moisture content was available on-site to potentially fuel a wood-fired kiln.

The company elected to install a direct system which introduces furnace gases directly in the kiln rather than the more conventional system that uses a boiler to produce low pressure steam, which transfers the heat to the kiln indirectly through radiators. The capital cost of the direct method was less because it eliminated the cost of a boiler, radiators, and feedwater treatment. The furnace is rated at 20 MMBtu/hr. Fuel is pneumatically conveyed to a metal silo next to the furnace, where it is burned on a sloping grate. The green lumber is loaded into the kiln entrance with rail cars. As a consequence of direct drying, the dried lumber has a very dark appearance which is caused by soot deposits. However, this soot is removed when the dry, rough-sawed lumber is processed in the planing mill. The fact that the lumber is surfaced as a final processing step is the key to acceptable use of the direct system in this facility.

Production was doubled over air drying and product can be delivered all year round. The net annual energy savings of this project are 77,500 MMBtus at a value of $444,521.

Capital Veneer Works

Montgomery (Montgomery County)

Capital Veneer Works of Montgomery is a major Alabama producer of veneer sheets. Faced with rising costs of steaming veneer logs and veneer drying with a gas-fired boiler, the company purchased a wood-fired, low pressure, industrial boiler capable of 20,700 pounds of steam per hour (1200 hp). The boiler is equipped with a pinhole grate and spreader stoker. Its maximum pressure is 240 psig. A concrete silo was erected next to the boiler house for fuel storage. The boiler burns up to 900 tons a month of hardwood bark and shavings with a 45 percent moisture content. The pollution control system contains a reinjector to reburn the collected soot particles.

The productivity per shift has increased 200 percent, and the plant is less labor intensive than with the two smaller dryers previously used. The boiler has excess capacity, even after one of the two gas-fired dryers was converted to steam. The boiler helps use waste wood fuel that is often difficult to market, and the plant is protected against increased natural gas costs.

The net annual energy savings from this project are 76,500 MMBtus at a savings of $438,785.

Sumter Veneer Works

Eutaw (Green County)

Sumter Veneer Company is a small, family-owned veneer mill that was searching for a means of increasing profitability through use of more efficient equipment. Sumter's old direct gas-fired veneer dryer consumed 1,706 mcf of natural gas monthly. A wood-fired, hot oil furnace was selected as the most effective sytem for use with a new veneer dryer. This unit employs an oil heat transport medium to transport heat to the kiln rather than steam, as with a conventional boiler. The wood-firing capability was especially attractive to Sumter Veneer because of a large quantity of wood butts and cores of about 45 percent moisture content that could not be easily disposed of. In order to sell this material, it would have to be chipped and transported a considerable distance.

The furnace is fed wood chips automatically from a feed hopper and requires little attention after start-up. Most of the hot oil (over 500 degrees F) is transported to radiators in the new dryers. About 20 percent of the hot oil is diverted to the small, compact boiler that feeds the log steaming pit. At night the unit operates at a low output to keep the steaming pit hot. Gum or poplar logs, steamed for 24 hours or more, are placed in the veneer lathe. Output from this lathe feeds the dryer and excess is taken up by the old, direct-fired gas dryer .

This project has been operating since April 1985. Current production is 1,500,000 board feet of veneer monthly, requiring about 100 tons of wood chip fuel. Most of this production is from the new dryer because the smaller, gas-fired dryer is only used about six hours per day.

The new dryer has twice the capacity of the old unit. Benefits of the project include 64 percent reduction in energy costs, increase in productivity of 200 percent, and the creation of eight to ten new jobs.

The annual net energy savings of this project are 25,000 MMBtus at a savings of $143,394.

Boutwell Lumber Company

Clayton (Barbour County)

Boutwell Lumber Company in Barbour County installed a dry kiln with a capacity of 46,000 board feet of 7/4 lumber. The kiln required approximately 5 MMBtu/hr to dry green southern yellow pine to 15 percent moisture content. As an alternative to a gas-fired burner, the company installed an indirect burner system capable of burning green sawdust on a sloping grate. Heat is conveyed to the kiln via an air recirculation system which contains a heat exchanger. Heat is transferred from the hot combustion gases to the recirculated air through the walls of the heat exchanger. Indirect heating of the kiln completely eliminates sooting and other contamination of the lumber by combustion products.

Other conventional components of the system include a dust storage bin and a conveyer to move the sawdust to the fuel feed hopper.

Energy savings of the project were estimated to be 20,531 MMBtus/year at a savings of $117,761. This project is no longer in service.

Re'Vod Corporation

Arley (Winstōn County)

The Re'Vod Corporation renovated a plant in Haleyville for the manufacture of furniture. This plant required a large amount of low pressure steam to dry furniture items after various spray coating operations. It also needed steam for space heating during cold weather. The steam had previously been provided by a natural gas-fired boiler.

Re'Vod installed a rebuilt firetube boiler which produces up to 450 bhp after being converted to burn dry woodwaste with a suspension burner. Most of the boiler fuel is in the form of sawdust and planer shavings which can be fed directly. Cut-off pieces are reduced to burning size in a hog. The project also includes a fuel collection system for the sawdust and shavings. A boiler house was built to house the boiler and a fuel bin constructed to store pneumatically transported waste and the output from the fuel hog.

The facility consumes about 571 tons/year of residue for an energy savings estimated at 3,276 MMBtus/year and a value of $18,793.

Patè Lumber Co., Inc.

Carrollton (Pickens County)

Pate Lumber Company installed a 400 Hp boiler to burn green sawdust and bark and a 350 kW steam turbine generator to produce electricity. The sawmill produced 350 tons of bark and sawdust per week and disposal of this residue was becoming a problem. The steam pressure at the turbine inlet is 140 psig and the exhaust pressure is minus 10 psig. Steam is condensed by a surface condenser which is cooled by a cooling tower. The horizontal return (HRT) boiler can produce up to 12,000 lb/hr of 150 psig steam. The installation also included a cyclone for fly ash removal and a 30' x 50' fabricated building which houses the system.

The project was estimated to save 79,041 MMBtus/year during 1990 at a value of $453,360.

Seaman Timber Co., Inc.

Montevallo (Shelby County)

This project involves the installation of a steam turbine/generator to produce up to 325 kW of power using excess steam from an existing biomass-fueled boiler. The installation was performed by a turnkey contractor and Seaman constructed the 15'x 35' steel, concrete-floored building using in-house labor and materials. It is estimated that as much as 140,000 kWh/month of electricity could be generated by the steam produced in excess of that required by the kiln.

The project is estimated to save 13,200 MMBtus/year at a value of $75,712.

Freeman Lumber Company, Inc.

Centerville (Bibb)

The Freeman Lumber Company project involves a direct-fired kiln utilizing a dual chamber cyclonic suspension combustor in which dry wood fuel is converted to heat energy with conversion efficiency equal to that of fossil fuel burners. Wood fuel for this burner must be dry - less than 15 percent moisture, clean - less than one percent ash, and finely divided to approximately 1/8" size and smaller.

Combustion is accomplished by injecting precise ratios of wood fuel and combustion air into the primary chamber where the fuel is ignited and forced into a cyclonic flow. The cyclonic flow provides the retention time necessary for complete combustion.

The secondary chamber is a multi-purpose chamber designed to complete combustion of oversized fuel particles and to reduce combustion gas temperatures to the lower levels required by the heat-process system.

The metering bin is a 50 cubic-foot bin with live bottom output screws driven with a DC motor. The output from the screws drop through

a rotary airlock into a high pressure delivery system delivering fuel to the burner. The output screws on the metering bin are controlled by the fuel/ air ratio control system. This system measures the combustion air being delivered to the burner and controls the speed to the screws through the use of a differential pressure transmitter integrated into a SCR controller. The SCR controller controls the speed of the DC motor driving the screws. Fuel/air ratio control are maintained on a volumetric basis through a 5-to-1 turndown ratio.

The level in the metering bin is controlled by high and low sensors which control the fuel delivery into the metering bin. There is also a sensor located in the drop-out chute above the airlock. In the event the airlock becomes plugged, the burner will shut down.

A high pressure blower system is used to transport the fuel from the metering bin directly into the burner. The high pressure system is protected with high pressure and low pressure switches that will shut off the fuel-fed metering system if excessively high back pressure or low pressure are detected.

The combustion air blower, cool and blend blower, and process air system are all protected with pressure switches to prove that the blowers are operational. These three systems must be proved prior to purging the burner, which is required before lighting. Any interruption on the pressure switches on any of these air systems will cause the burner to shut off.

A thermocouple is installed in the cool and blend air stream which is used to cool the exterior of the refractory combustion section. If this temperature exceeds a preset limit, which could indicate impending failure in the refractory lining, the burner will be shut down.

The burner is monitored by an infrared scanner designed for scanning a wood flame. One scanner is used on the gas pilot which must be proved prior to lighting the wood burner. Upon lighting the wood burner the scanner monitoring the gas flame is blocked off and only the wood flame scanner is active.

The burner will produce 18 million Btus/hr, enough to dry one load (90,000 board feet) of green lumber every 24 hours. In doing so, the system is estimated to save 66,000 MMBtus annually at a value of $378,560.

Tolleson Lumber Co., Inc.

Cullman (Cullman County)

This project primarily involves boiler repair and renovation of two old, existing boilers. Both boilers are of the water tube type. One is rated at 300 bhp and the other at 450 bhp. The work involved includes installing new grates, repairs, and extension to breeching/insulation, installation of two new wood, fuel-fed systems, and rework of both the induced draft, and forced draft combustion air systems.

These boilers burn bark and wet sawdust, and the steam produced is used to heat the low temperature lumber kiln and power the "shotgun" type steam saw carriage drive.

The project produces a savings of 21,345 MMBtus/year at a value of $122,432.

Alabama Timber Industries

Thomasville (Clarke County)

This project consists of a steam boiler to burn sawdust and produce steam for heating dry kilns. The horizontal return (HRT) boiler is rated at 20,000 pounds per hour of 150 psig saturated steam. The system incorporates an enclosed fuel storage facility consisting of a 24' x 45' x 24' high steel building. The building is sized with a capacity sufficient for three days of operation. The fuel is unloaded from the fuel house by a walking floor. The operation of the unloader is controlled by demand of the metering bin, which is a steel hopper outfitted with a live bottom unloader driven by a variable speed motor. The bin holds approximately one-to-five hours of fuel and is outfitted with a series of controls which maintains a proper level of fuel by cycling the fuel house unloader. The quantity of fuel discharged from the metering bin is controlled by the variable speed drive which receives its "increase" signals from the metering bin.

In 1996 this project consumed 3,683 tons of wood waste and produced 18,415 ktons of steam. The energy savings are approximately 21,133 MMBtus/year at a value of $121,214.

Lewis Brothers Lumber Co.

Aliceville (Pickens County)

Lewis Brothers Lumber Company needed a cost-effective method of disposing of 967 tons/month of green hardwood, sawdust, and bark generated by a sawmill. The existing facility contained a kiln which was operated by steam produced in a boiler fired with planer shavings. To dispose of the residue the company elected to install a used 400 hp boiler and a 625 kVA steam turbine and generator set. The turbine and generator have enough power to operate the sawmill, planer, lumber stacker, and kiln fans. In addition to the boiler and turbogenerator, the project also included a fuel storage and distribution system, steam condenser, and cooling tower.

The project was estimated to save 80,670 MMBtus of energy at a value of $463,703.

Mobile Infirmary

Mobile (Mobile County)

The hospital produced approximately 1,538 ton/year of pathological and hazardous waste, which was incinerated by a fixed-grate, gas-fired incinerator. After considering several alternatives to reducing its power and natural gas consumption by incineration heat recovery, the hospital elected to install a two-chamber incinerator/boiler for production

of steam. The primary chamber pyrolyzes the waste under "starved" air conditioning. The fuel-rich pyrolysis gas enters the secondary chamber where combustion is completed, and the steam is produced in a heat energy boiler. The chamber is continuously loaded with a hydraulic ram. The waste is forced through the chamber by a series of rams until all the volatiles have been driven off. Final combustion takes place at 1800° F or higher to assure complete destruction of pathological or hazardous materials.

This project is estimated to save 11,946 MMBtus/year at a value of $68,519.

Wellborn Cabinet Inc.

Ashland (Clay County)

Wellborn Cabinet, Inc. is a cabinet manufacturing facility that is located in Ashland, Alabama, employing over 500 employees. The company purchases rough hardwood, which is sawed, dried in steam kilns, and finished to specification. Large amounts of both wet and dry woodwaste are produced in these operations. The wet wood residue amounts to ten semi-trailer loads per week. Annually, dry waste of at least 35,000 MMBtus (about 2,500 tons or 160 truckloads) was available to burn to produce steam for dry kilns, paint ovens, and space heating. Wellborn elected to install a new wood-burning, 300 bhp, low-pressure boiler to provide this heat energy. The use of wood residue fuel in this boiler eliminated the annual need for natural gas which would have been used for the same purpose.

This project became operational during March 1989 and was estimated to save 42,448 MMBtus in 1990 at a value of $243,471.

Lassiter Lumber Company

Collomburg (Choctaw County)

The company had an existing wood-fired boiler capable of generating 12,000 lb/hr of steam for a dry kiln. After initial heat-up the kiln's demand for steam diminished over the 22-hour drying cycle. A condensing steam turbine was installed parallel with the kiln to utilize steam not required by the kiln. This arrangement provides better utilization of the boiler and consumes surplus bark and sawdust. The turbine and generator are capable of producing 200 kW with 140 psig inlet steam pressure and exhausting at a pressure of minus10 psig. A surface condenser condenses the exhaust steam, using a steam ejector to maintain the subatmospheric pressure.

The project is estimated to save 14,600 MMBtus/year at a value of $83,742.

McKinney Lumber

Sheffield (Colbert County)

A recent project to be admitted into the program is McKinney Lumber. This innovative project involves the installation of a gasifier that produces low Btu gas for sale to a third party. The project also includes a steam turbine which is operated by steam generated in a combustor and boiler owned by the third party. Other elements of the project include a fuel-fed system, controls, and instrumentation.

The gasifier is an underfeed, stoker-fired, air-blown, up-draft type designed to be close coupled to a furnace for recovery of sensible heat in the gases, as well as the chemical energy which is released upon secondary combustion. The gasifier is heated at 29.5 MM Btus/hr when burning bark and sawdust at 35 percent to 50 percent moisture content (wb). The gasifier has not achieved rated output to date. The steam turbine is designed to operate on 275 psig saturated steam with a rated output of 650 kW at 4500 rpm and an exhaust pressure of minus 5 psig. An air-cooled condenser is used to condense the exhaust steam and maintain the sub-atmospheric pressure. The actual output is 500 kW because of the inability to generate the pyrolysis gas required to produce the steam flow of 17,800 lb/hr.

The facility consumes 11,418 tons of wood waste per year for an estimated energy savings of 65,514 MMBtus/yr at a value of $375,770.

Southern Wood Chips

Jasper (Walker County)

Southern Wood Chips, Inc. manufactures wood chips for sale to paper mills to use in the manufacture of paper. They produce 5,000 tons per month of wood waste (green bark) which was becoming extremely difficult to find markets for and/or disposal means. As a result, the company installed two 600 hp single-stage steam turbines, driving two 575 kW induction generators. The boilers contain an extended waterwall radiant section to efficiently produce 37,000 pounds per hour of 270 psig steam with an input of seven tons per hour of waste wood. The generated electric power is used to reduce the plant energy requirements during normal operating hours and supply power for sale to the utility when the plant has low energy requirements. The single-stage turbine exhausts at 0 psig into an air-cooled condenser and requires 32 pounds of steam per kW at 4200 rpm.

Fuel storage consists of one 40' x 80' x 25' storage building with a walking floor recovery system. Conveyors collect and transport fuel to the boilers' metering bin. A conveying system was installed to receive fuel from the existing hog and deliver the material to a scalping screen. Over-sized material is returned to the hog, and sized fuel is discharged into the storage.

The energy savings of this project are 265,133 MMBtus/yr at a value of $1,520,738.

Scotch Lumber

Fulton (Clarke County)

This cogeneration project consists of a high-pressure steam boiler and noncondensing steam turbine to produce electricity for mill operations and heat for dry kilns. The boiler burns tree bark and sawdust to generate 60,000 lb/hr of superheated steam at 600 psig and 750° F. The steam is supplied to a 2500 kW turbine/generator which has an exhaust pressure high enough (90 psig) to operate three dry kilns. An air-cooled condenser is connected parallel with the kilns. Therefore, when steam demand from the kilns is reduced, power generating capacity can still be maintained by using the condenser to condense steam leaving the turbine. Condensation from the kilns and condenser is returned to the boiler to reduce the cost of raw-water heating energy and boiler feedwater chemicals.

This project consumed 48,112 tons of residue fuel and produced 228,458 ktons of steam.

The energy savings of this project are 500,365 MMBtus/yr and it produces 3,722,390 kWh of electricity per year at a value of $2,869,976.

Henderson Black and Greene

Troy (Pike County)

This Troy, Alabama, manufacturing company generates wood waste in excess of 225 tons per month, which it had been disposing of in the city landfill. To solve the waste disposal problem and reduce the cost of electricity, the company decided to install a residue boiler and steam turbine-driven generator system. Since the company produces insufficient waste to operate the 200 bhp boiler, it also receives about 161 tons per month of shredded wood waste from the City of Troy and 350 tons per month of mixed wood fuel from two nearby manufacturing plants. The boiler produces 6,900 pounds of steam per hour at 275 psig. A steam turbine, exhausting at atmospheric pressure, generates 185 kW of power. An air-cooled condenser condenses the steam and returns the condensate to the boiler.

This project consumed 1,985 tons of fuel in 1995, saved an estimated 15,856 MMBtus and produced 311,760 kWh of electricity at a value of $65,330.

Lumber ReManufacturing

Belk (Fayette County)

Lumber Manufacturing Services, Inc. buys wet or distressed lumber and cleans it up for the market by drying, sawing, and/or planing. The lumber must be dried to about 10 percent to 15 percent moisture content to receive full price. The company installed a wood-fired furnace

to supply heat to a dry kiln. The furnace burns dry planer shavings on a sloping grate to produce relatively clean stack gases. These stack gases pass through an air-to-air heat exchanger constructed of two foot diameter steel tubing and mounted on one side of the kiln. Overhead fans circulate air over the heat exchanger and equalizes the temperature inside of the kiln. Roof exhaust vents are opened automatically to control temperature and humidity.

This system can dry a 23,000 board foot load of lumber in 48 hours at a temperature low enough to minimize warping and checking. Because the heat exchanger isolates the combustion products from air in the kiln, wet fuel can be burned without producing soot deposits on the lumber. Only four tons of dry fuel are needed per load of lumber.

In 1990 this project saved 7,291 MMBtus at a value of $41,819.

Moss Lumber

Gurley (Madison County)

The wood-fired boiler system installed at Moss burns green sawdust of either oak or poplar and provides steam to operate two lumber dry kilns. The kilns had been supplied by a propane gas-fired package boiler which was left in place to serve as a backup. Green sawdust from the fuel shed adjacent to the boiler room is reclaimed by a reclaimer and placed into a fuel feed system which feeds the green sawdust to the boiler furnace. A fan and a distributor distribute the fuel across the furnace floor which is fitted with partial grates. Venturii feed fuel tangentially into the furnace needed for good combustion efficiency, thereby increasing furnace retention time and providing turbulence needed for good combustion efficiency. The tangential furnace is a modified Dutch oven so that the bottom of the boiler can receive radiant heat from the furnace. Hot gases leave the furnace, pass under the HRT boiler, and then pass through the tubes to an outlet damper. The exhaust then passes to a mechanical collector for flash removal and then to an induced draft fan and stack. The mechanical collector has an air lock rotary valve to serve as an air seal when dumping collected flyash into barrels.

The boiler control system operates off boiler pressure, cycling the variable speed, fuel-feed system to maintain desired steam pressure. The outlet of the stack is fitted with a temperature sensor which provides signals to a control system that limit the temperature of the flue gases by interrupting fuel feed when a limit temperature is reached. This safety feature is designed to warn operators if the tubes are dirty or if the system is being overfired. The system also has a smoke detector to sense stack-gas opacity. If the opacity exceeds the set point, the system will shut down the fuel feed for a predetermined amount of time.

In 1995 this system consumed 2,900 tons of residue fuel and produced 708 ktons of steam.

The energy savings are estimated to be 24,408 MMBtus/year at a value of $174,362.

Olen Belcher
Brent (Bibb County)

This project consisted of an upgrade of existing wood-burning steam and power generation system at a sawmill. The upgrade was to increase capacity, efficiency, and permit continuous operation at 1,300 kW electrical output for internal plant use. The project involved capital improvements to the boiler, waste wood fuel preparation, storage and transport systems, as well as modernization of the 1,300 kW turbine/ generator set.

Automation and efficiency improvements were made with the installation of two automated fuel flow bins, two cyclo-blast, fuel-firing cells with water-cooled grates, a combustion air heater using stack gases, and an automated control panel for operations and monitoring. Fuel storage and handling were upgraded to give better burning controls and increased automation. Additional fuel hogging capacity was added to permit 100 percent hogging instead of the 65 percent. These changes increased furnace response to changing steam demands while maintaining the Air/Fuel ratio required for clean, efficient combustion.

It is estimated that this project saves 2,720 MMBtus/year at a value of $15,601.

CRERET
Sheffield (Colbert County)

CRERET installed a 600 bhp boiler to generate 20,700 lb/hr of steam using pyrolysis gas produced from gasification of wood residue. The pyrolysis gas is purchased from a supplier and the steam sold to the supplier for operation of a steam turbine generator. The boiler is a three-pass, wetback boiler outfitted with a combination waterwall and refractory furnace. The pyrolysis gas burner contains an air nozzle and a separate fan to provide combustion air for complete mixing and burning of the fuel gas. Particulate emission control equipment includes a dry mechanical multi-tube collector with an ash hopper and support steel. A rotary air-lock valve is used to remove ash from the hopper during operation. An induced draft fan is mounted on-grade.

Cahaba Pressure Treated Forest Products
Montevallo (Shelby County)

This project consists of a 600 bhp, two-pass, wood-fired boiler to produce 20,700 lb./hr of 150 psig steam. The boiler burns pine sawdust for fuel and is capable of burning chunks of one-inch cube size. A high-efficiency cyclone is used to remove particulates from the stack gases. This is a new project that is not yet operational.

Linden Steam

Linden (Marengo County)

A Hurst boiler was installed on a site leased from Linden Lumber Company. The 600 hp boiler receives pyrolysis gas generated in a gasifier, and it produced 300 psig steam for sale to Linden Lumber Company. The steam is used in their dry kiln and for generation of electrical power in a steam turbine. The gasifier uses selected oak shavings and log fuel residue generated in the manufacture of hardwood flooring. This new project is not yet operational.

Appendix A

Some Important Characteristics of Biomass Fuel

Table 1

Bulk Density Of Several Types Of Wood Fuel

Wood Fuel Type	Moisture Content %	Bulk Density (lbs/ft^3)
Whole Tree Chips	50	24.0
Dry Planer Sawdust	13	6.0
Green Sawdust	50	20.0
Dry Sawdust	13	11.5
Wood Pellets	10	35.0

Table 2

Higher Heating Values (Btu/lb) For Wood And Bark

	Range	Average
Hardwoods		
Wood	7,590-8,920	8,530
Bark	6,920-10,310	8,040
Softwoods		
Wood	7,780-11,320	8,910
Bark	8,200-10,190	8,950

Table 3

Natural Gas Equivalent of Biomass Fuels

Natural gas (77.8% Eff.)		1,000 cft
		10 mcf
		1 ccf
Butane gas (79.0% Eff.)		10.20 gal
Propane gas (78.7% Eff.)		11.04 gal
#2 Fuel oil (82.5% Eff.)		6.73 gal
#4 Fuel oil (82.5% Eff.)		6.50 gal
#6 Fuel oil (82.5% Eff.)		6.29 gal
Electricity (90% Eff.)		253.26 kWh
Bituminous coal (85% Eff.)		0.034 tons
Lignite or sub-bituminous coal (80% Eff.)		0.057 tons
Oven dry wood (80% Eff.)		0.056 tons
Planer shavings	15% MC (78.08% Eff.)	0.067 tons
	30% MC (76.08% Eff.)	0.077 tons
	40% MC (74.74% Eff.)	0.085 tons
Chips, sawdust,	50% MC (73.40% Eff.)	0.092 tons
and bark	60% MC (72.07% Eff.)	0.100 tons
	70% MC (70.73% Eff.)	0.109 tons
	80% MC (69.39% Eff.)	0.117 tons
	90% MC (66.72% Eff.)	0.126 tons
	100% MC (66.72% Eff.)	0.136 tons

Table 4

Energy Production And Equipment Size For One Ton/hr of Residue Consumption

(HHV = 8610 Btu/lb @ MC = 0)

MCdb (%)	MCwb (%)	Energy (Btu/hr)	Steam (lb/hr)	Boiler Size (hp)
0	0	13,775,000	14,195	411
15	13.0	11,678,000	12,034	348
30	23.1	10,065,000	10,372	300
40	28.6	9,182,200	9,462	274
50	33.3	8,416,600	8,673	251
60	37.5	7,747,200	7,983	231
70	41.1	7,156,000	7,374	213
80	44.4	6,630,800	6,833	198
90	47.4	6,160,800	6,348	184
100	50.0	5,738,000	5,913	171

Table 5

Power Production (kW) For Single Stage Steam Turbines (Saturated Steam)

Steam Flow= 10,000 lb/hr

Pex = 0 psig

180 kW @ Pin = 100 psig
220 kW @ Pin = 150 psig
270 kW @ Pin = 250 psig

Pex = 25 psig

100 kW @ Pin = 100 psig
125 kW @ Pin = 150 psig
170 kW @ Pin = 250 psig

Steam Flow= 15,000 lb/hr

Pex = 0 psig

300 kW @ Pin = 100 psig
350 kW @ Pin = 150 psig
440 kW @ Pin = 250 psig

Pex = 25 psig

160 kW @ Pin = 100 psig
200 kW @ Pin = 150 psig
280 kW @ Pin = 250 psig

Steam Flow= 25,000 lb/lhr

Pex = 0 psig

550 kW @ Pin = 100 psig
650 kW @ Pin = 150 psig
850 kW @ Pin = 250 psig

Pex = 25 psig

275 kW @ Pin = 100 psig
350 kW @ Pin = 150 psig
500 kW @ Pin = 250 psig

Table 6

Wood Fuel Quantity Requirements

Boiler Hp	Steam Output (lb/hr)	Wood Consumption Tons/hr	Tons/24 hrs	ft^3/hr	Truckload/day @ 23 tons/load
100	3,450	0.67	16.08	55.83	3/4
200	6,900	1.35	32.16	111.67	1 1/2
300	10,350	2.01	48.24	167.49	2
400	13,800	2.70	64.32	223.33	3
500	17,250	3.35	80.40	279.17	3 1/2
600	22,500	4.02	96.48	334.98	4
700	24,150	4.69	112.56	390.81	5
800	27,600	5.40	128.64	446.67	6
900	31,050	6.03	144.72	502.47	7
1000	34,500	6.70	160.80	558.33	7

Notes: 1. Fuel is green wood chips
2. Boiler combustion efficiency assumed to be 65%
3. Source: "Wood Energy Systems" Georgia Institute of Technology

Table 7

Economics of Wood Conversion

(a) Current oil/gas/coal consumption	_____ gal/cu.ft./ton/yr
(b) Current price for oil/gas/coal	_____ $ gal/cu.ft./ton
(c) Current operating/maintenance costs (energy plant only)	_____ $/yr
(d) Annual energy costs [(axb) + c]	_____ $/yr
(e) Annual wood use (a x conversion factor)	_____ tons/yr
(f) Wood price	_____ $/ton
(g) Estimated operating/maintenance costs	_____ $/yr
(h) Wood fired energy costs [(exf) + g]	_____ $/yr
(i) Avoided cost of residue disposal	_____ $/yr
(j) Projected annual fuel cost savings [h-d]	_____ $/yr
(k) Desired payback period in years	_____ yrs
(l) Target cost for installed system	