Tribal Renewable Energy - Final Report

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This report and its findings are based on the best available data existing during the covering period and the analysis reflects good faith estimates and assumptions of factors for a biomass-based renewable energy project for the Mississippi Band of Choctaw Indians and any conclusions or findings herein should not be extrapolated to other areas of the country.

Executive Summary

In 2002 the Mississippi Band of Choctaw Indians received a grant from the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. The purpose of this grant was to explore how renewable energy sources could be used on tribal lands.

The Mississippi Band of Choctaw Indians partnered with the Mississippi Technology Alliance and researchers at Mississippi State University to review the renewable energy technologies which might be used on the Choctaw Reservation.

When the term “renewable energy” is used, one usually thinks of solar power, wind power, and geothermal power. Energy created from biomass is also “renewable energy”. Electricity can be generated from animal manure, wood waste, agricultural crop residues, and cotton gin waste. Biomass can be used to produce ethanol (made from corn); bio-diesel (made from any of the oilseeds such as soy or rapeseed); and bio-oils made from wood waste, agricultural waste, and manures.

Planners from the Choctaw tribe met with experts from the Mississippi Technology Alliance, the Mississippi State University Department of Electrical Engineering, the Diagnostic Instrumentation & Analysis Laboratory, and the Food and Fiber Center to determine what renewable energy technologies merited further study for use at Choctaw.

The Choctaw Reservation is located in an area with convenient access to interstate highways, rail, and pipelines. Most of its electricity is provided by the Tennessee Valley Authority at very favorable rates. Any renewable energy source would have to compete in an already low cost environment.

Several technologies were immediately dismissed because of the climate and location of the Choctaw Reservation. Wind power was excluded since there are no strong prevailing winds in the southern U.S. solar power was dismissed because there are too many cloudy days in central Mississippi, especially in the winter months.

After assessing the other possibilities for using renewable energy on the reservation, it was concluded that biomass was the most likely candidate. The reservation is located in a heavily forested region of Mississippi. Logging residue, mill residue, bark and sawdust are generated and are available in the reservation area. The reservation is also located in a region where commercial chicken production is concentrated. Broiler litter (a mixture of the wood shavings used as bedding in the large broiler houses and chicken manure) is readily available near the reservation. Thus, the decision was made to investigate the feasibility of using wood waste and chicken litter as sources of renewable energy.

The factors which were to be considered were:

- Whether there were opportunities on the reservation to use renewable energy to replace current energy sources.
- The availability of biomass that could be used in renewable energy projects.
- The cost producing energy using renewable energy sources.
- Whether there were cultural issues on the reservation which needed to be addressed if renewable energy was used.
- Whether use of renewable energy technology would create jobs for tribal members.

The tasks were divided in the following way:

- The Diagnostic & Instrumentation Laboratory (DIAL) at Mississippi State was primarily responsible to identify and evaluate new technologies (extruder-feeder liquefaction, biomass gasification, and bio-oil) which might have application on the Choctaw Reservation.

- The Department of Electrical Engineering at Mississippi State was selected to conduct an assessment of energy use on the Choctaw Reservation and offered suggestions of how biomass generated electricity could be used on the reservation.

- The Food and Fiber Center, a unit of the Extension Service at Mississippi State, would determine sources and availability of biomass in the reservation area.

- The Economic Development Department of the Mississippi Band of Choctaw Indians would address cultural and manpower issues which might be associated with use of biomass.

- The Mississippi Technology Alliance served as project managers to coordinate everyone’s efforts toward the development of the feasibility study to determine whether biomass applications might be cost effective on the reservation.

In conclusion, both poultry litter and wood waste are abundant in the reservation area. However, biomass-based renewable energy technology is not an economical alternative for the Mississippi Band of Choctaw Indians, at this time. This may change some day.

This report and its findings are based on the best available data existing during the covering period and the analysis reflects good faith estimates and assumptions of factors for a biomass-based renewable energy project for the Mississippi Band of Choctaw Indians and any conclusions or findings herein should not be extrapolated to other areas of the country.

Project Objective: The Mississippi Band of Choctaw Indians (MBCI) proposed a study of the feasibility of siting a biomass-based renewable energy installation on tribal lands. The purpose of the study was to determine whether such an installation can be economically sustainable, as well as consistent with the cultural, social, and economic goals of the Tribe.

Background: The MBCI is one of the most progressive tribes in the U.S. In the 1970's Chief Phillip Martin and tribal leaders realized that if the tribe's economic conditions were going to improve, the tribe itself would have to make it happen. No outside company was going to take a chance and build a plant on the reservation to provide jobs for the Choctaw people. Chief Martin and the tribal leaders first started to improve educational opportunities on the reservation. A high school was built. Adult education programs were started. In the early 1970's an industrial park was built on the reservation using EDA funds. The tribe organized a construction company and began building HUD houses and other reservation facilities. In 1977 the tribe started a company to manufacture automotive wiring harnesses for General Motors. Other tribally owned factories doing contract manufacturing soon followed. By the mid-1980s Choctaws were recognized throughout Indian country as an example of how hard work and good planning could improve economic and social conditions on a reservation. In the 1990's it became more difficult to compete with the cheap manufacturing labor available outside the U.S. and employment in manufacturing began to decline. Fortunately, Indian gaming began to develop and the Choctaws opened their first casino, the Silver Star, in 1994. Other resort properties followed. The jobs lost in manufacturing were replaced by new jobs in the tribal resort.

Choctaw leaders realize that the gaming boom will not continue forever. They need to be alert for new opportunities to diversify their economy and create new career opportunities for tribal members. The conduct of this feasibility study to discover whether there might be opportunity to utilize resources related to the area's poultry and forestry industries is just a part of the ongoing process to identify opportunities.

This feasibility study provided for the investigation of biomass-based renewable energy alternatives for the MBCI. The technologies to be utilized in the renewable energy installation would be those that can readily handle poultry litter, either alone or in combination with wood residues.

Major Tasks and Activities

Seven tasks were identified in the proposal to the Department of Energy. The findings related to each task are presented below. Three formal reports were prepared and are included as attachments.

Task #1. Resource availability assessment- The objective of this task was to determine the availability of both poultry litter and wood residues for use in the proposed facility on the Choctaw Reservation. The quantity and the cost of the resources had to be identified. Dr. Steve Murray, Mississippi State University Food and Fiber Center agricultural economist, conducted a detailed assessment of the locations and approximate amounts of poultry litter available in the Mississippi. A sample of poultry litter was submitted to the Mississippi State University Chemical Lab for analysis for a determination of energy and nutrient content. The sample analyses included bomb calorimetry, N-P-K content, total inorganic carbon & total organic carbon. The sample also was analyzed using ICP for metals content. In addition, locations of wood and wood residues, which may be used as an admixture to the poultry litter, were determined. The location of poultry litter and wood residues were also identified and mapped. (See maps in the appendices—Attachment 1).

Poultry Litter

The major findings of Dr. Murray's resource assessment for poultry litter were:

• The poultry litter is composed of chicken manure and pine shavings. The energy content is 5000 to 7000 Btu per pound. This is roughly equivalent to lignite coal found in counties immediately north of the Choctaw Reservation.

• About 900,000 tons of broiler litter is generated in Mississippi each year. Since the Choctaw Reservation is situated near the center of the region in Mississippi where chickens are raised, much of the litter is available if the price offered is enough. A maximum of 600,000 tons of broiler litter is available for use as biomass fuel in Mississippi (the remaining 300,000 tons will be spread on pastures adjacent to the chicken farms) at an average delivered price of $12.23 per ton. A maximum of 280,000 tons is available in Mississippi if the average delivered price is $10 per ton.

• Litter is used to fertilize pastures in the Choctaw Reservation area because of the nitrogen content. The litter is valued because of its nitrogen content. Litter is applied to pastures in the reservation area to meet the nitrogen needs of the forage. Its value as a nitrogen fertilizer is about $10 to $18 per ton.

• Disposal of poultry litter is a potential environmental issue because of its phosphorus content. When litter is applied to meet the nitrogen needs of the forage, the amount of phosphorus in the litter exceeds the uptake of the forage.
The excess phosphorus may be carried away in run-off or seep into groundwater.

• The cost of transporting litter is between 11 cents and 15 cents per ton-mile.

• Practices pertaining to the cleanout of broiler houses have changed because of new environmental regulations. Houses may now be cleaned out completely only every three or four years. This apparently has no detrimental effect on bird performance.

• Increasing the time between cleanout reduces litter quality because nitrogen levels in the litter decline over time.

• Consistent with findings in Alabama and Georgia, litter makes an excellent fertilizer for cotton because of its nitrogen and potash content. It is also desirable

for use on rice because, in addition to nitrogen, it adds organic matter often needed in rice fields. It should also be considered for corn because of the large corn acreage in counties near areas of concentrated broiler production.
• The new 2002 Farm Bill provides funds through the EQIP program which can be used to subsidize alternative methods of litter disposal, including those investigated in this project.

Additional Discussion of Litter Use

In December 2002, the U.S. Environmental Protection Agency published final rules relating to Confined Animal Feeding Operations (commonly referred to as CAFO). These regulations apply to larger animal farms and will regulate how manure is disposed. For broiler chickens, farms with 125,000 or more birds will be subject to these regulations. Basically, these farms must have a litter disposal plan that is approved by EPA and must maintain detailed records of how the disposal is accomplished. However, the new EPA Confined Animal Feeding Operation (CAFO) rules that came into effect in December 2002 have had little effect on litter use in Mississippi since most farmers were already using litter on pastures and since excess litter could be sold simply for its nitrogen content.

There are several other environmental issues that have been addressed when using chicken litter as a fertilizer. Most of the research on this topic has come from land grant universities in states with a significant poultry industry. Some of these issues overlap issues affecting use of litter as a feed supplement for beef cattle.

Some of the other issues related to litter use as fertilizer are:
1. The presence of arsenic in the litter and effect on forage and run-off.
2. The presence of heavy metals and iron in the litter and effect on forage and run-off.
3. Antibiotic residue in the litter.
4. Fecal coliform in litter and its effect on surface water in the area.
5. The presence of prions associated with BSE.

Arsenic

Arsenic in broiler litter occurs because of arsenic in the broiler diet. Anderson and Chamblee (Department of Poultry Science at Mississippi State University) investigated this issue and reported findings (2001 Journal of Applied Poultry Research 10:323-328).

Broiler chickens are routinely fed diets containing the growth promotant 3-nitro-4-hydroxyphenylarsonic acid (roxarsone; ROX). Anderson and Chamblee conducted experiments feeding ROX to broilers and reported these findings:

1. Including roxarsone in the diet of broiler chickens increased fecal arsenic levels. Fecal arsenic levels decreased when roxarsone was removed from the diet of broiler chickens.
2. Fresh pine shavings contained arsenic.
3. Litter arsenic levels did not continually increase in built-up litter produced by broiler chickens fed roxarsone during multiple growouts. Therefore, land application of broiler litter does not potentially provide any added risks to environmental processes that already exist.

Heavy Metals and Fecal Coliform

M.M. Eichhorn, an agronomist at the Hill Farm Research Station, LSU Agricultural Center at Homer, Louisiana published findings of research on this topic ("Heavy Metals, and Pathogens Such as Coli from Bacteria in Runoff", Proceedings: 2002 National Poultry Waste Management Symposium, pp. 239-247). His research involved spreading litter at three rates on Coastal Bermuda grass meadow and measuring the level of Cu, Fe, Mn and Zn uptake in the hay and in water runoff. Eichorn concluded that:

1. Heavy metal rates of Cu, Fe, Mn, and Zn applied as broiler litter were not efficiently removed from the meadow by harvested hay.
2. Broiler litter use rates had no adverse effects on runoff water quality relative to content levels of fecal coli form bacteria or heavy metals (Cu, Fe, Mn, and Zn).
3. Broiler litter use rates had no impact on runoff loads of fecal coli from bacteria.
4. The change in soil levels of Cu, Fe, Mn, Zn, Ni, and Pb following the application of broiler litter rates and Bermuda grass hay cropping hay was not sufficiently high enough to negatively impact water quality.

Land application of poultry manure, swine manure, cattle manure and municipal sludge is common throughout the U.S. and the world. Of these wastes, poultry litter is probably the easiest to use in agricultural applications. Municipal sludge is the most difficult because of the chemicals which get into the waste stream from industrial processes and household cleaning products.

Antibiotic Residue

Antibiotics are routinely fed to chickens by addition to feed and water. Residue is excreted in the feces and builds up in the litter. While this is an important issue when using litter as a feed supplement for beef cattle and dairy cattle, its effect on water runoff when litter is applied to pastures is negligible.

BSE

BSE, or mad cow disease, is an important public health issue which the U.S. beef industry must address. Chickens may still be fed (i.e., this is still allowed) meat and bone meal from cattle. It is not known whether the BSE prions could be passed through the broiler to the litter of the broiler house. Then, if the litter were spread on pasture or fed to cattle, whether the cattle might be infected with BSE. In January 2004 the FDA banned the feeding of broiler litter to beef cattle. No action has been taken as of this time on application of litter to pasture which will be grazed by cattle.

Number of Farms Affected by the New CAFO Regulations

The CAFO (confined animal feeding operation) regulations are now being put into effect. The Mississippi Department of Environmental Quality is responsible for implementing the new regulations in Mississippi. Farms which have more than 125,000 broilers at one time will be subject to these regulations. In most instances, this means that farmers with six or more houses will be affected since a house will hold about 22,000 birds. Five or six flocks of chickens are typically raised during one year. In general, more recordkeeping is required than in the past but there will be little immediate change in litter utilization, except that feeding to cattle is now banned.

Data are available from the 1997 Census of Agriculture on Poultry Inventory. This data is presented in Table 1. About 20% of the poultry farms in these reservation-area counties fall under the new CAFO regulations. However, the other farms must meet state regulations for poultry farms.

Table 1. Poultry Farms in the Choctaw Reservation Area Counties

COUNTY	Farms selling >500,000 broilers annually	Total poultry farms in county
Jones	17	168
Leake	24	141
Neshoba	27	118
Newton	28	102
Winston	0	17

All new broiler farms must have a litter disposal plan before the Mississippi Department of Environmental Quality (DEQ) will issue a permit for construction for new houses. The DEQ monitors water quality in the streams and rivers of the state.

Currently there is sufficient pasture in the counties surrounding the reservation to utilize all litter produced in the area. Research on using litter to fertilize pine plantations is currently active at Land Grant Experiment Stations (including the

Mississippi Agricultural and Forestry Experiment Station) throughout the south. The findings so far are that litter can be used in an environmentally sound manner to fertilize pines. The return from litter use to fertilize pines is less than to fertilize pasture. We would expect to see more litter diverted to forestry uses if its use in pasture is restricted.

The 2002 Farm Bill makes funds available through the EQIP program which can be used to subsidize disposal of litter. The exact allowable uses for these funds are determined at the state and county level by state and/or country committees, not the national level. Conversations with state FSA officials have indicated that EQIP funds could be used to subsidize transport of litter to areas where row crops are produced such as the Mississippi Delta. Currently there is some transport of litter to row crop areas going on without the subsidy simply because the litter is a least cost fertilizer and amendment. If pasture application rules become more stringent, then we certainly could see litter move to the Mississippi Delta for use on row crops such as cotton and corn.

The bottom line is that at this time in the counties surrounding the Choctaw Reservation there are no significant problems with litter disposal. The only practice that must be changed is that litter can no longer be fed to beef cattle. While it is not known what proportion of the available litter was being fed, the amount was quite small in comparison with the amount being used as fertilizer.

It is important to understand that no Choctaw tribal members own broiler houses and there is only very limited grazing of cattle on reservation land. A few families keep one or two cows, but no one has any significant commercial cattle operation. Thus, when looking at poultry litter, the questions that the Choctaw tribe raises are 1) Does poultry litter cause any pollution problems which negatively impact the reservation? and 2) Is there any business enterprise related to poultry litter that the tribe can participate in and make a profit and create significant job opportunities? The answer to both of these questions is "No." Poultry litter is not an environmental problem on the reservation or in the surrounding area. The current use of litter as a fertilizer for pastures is likely the most efficient use of the litter. The Choctaw tribe should be alert to the possibility that it may one day be profitable to use litter as a fertilizer for pine plantations. Since there are many thousands of acres of pine on the reservation, this use for litter is certainly a possibility.

Conclusions about Poultry Litter

- It is too expensive as a fuel.
- Existing methods of disposing by spreading on pasture as fertilizer will continue.
- The next best use of poultry litter is as fertilizer for pine trees and as a row crop fertilizer.

Wood Waste

There is one large lumber mill in the reservation area—the Philadelphia, Weyerhaeuser mill. This mill produces dimension lumber. There is no chip mill in the reservation area. The wood chips which result from the production at Weyerhaeuser are hauled 70 miles by truck to their paper mill at Columbus.

Most of the wood residue generated by manufacturers in the region is already being used. The Weyerhaeuser paper mill in Lowndes County (near the Choctaw Reservation) uses wood waste to fire its boilers and currently is seeking additional sources of wood waste. The limiting factor is the price they can pay since they have the alternative to shift to natural gas when it is more cost effective. The internal accounting value assigned by Weyerhaeuser to these chips is about $25 per ton. These would be considered "green" chips since no drying takes place during the harvest or manufacture of lumber.

The largest unused biomass in the region is primarily logging residue and noncommercial pine from thinning. The U.S. Forest Service has estimated how much logging residue is created in the woods during harvest (for data see Forest Inventory and Analysis database http://www.fia.fs.fed.us/). Researchers at Mississippi State University estimate that the cost of collecting this residue in the woods, chipping, and hauling to a user within 25 miles is $40 per ton. Sisson Trucking is the Philadelphia firm which hauls most of the Weyerhaeuser wood chips from Philadelphia to Columbus. Jim Sisson, owner, told us that putting trailers and a chipper in the woods to salvage logging residue had been tried but it was not cost effective. It costs more to produce chips this way than they received for the chips.

With respect to wood waste, the primary wood waste generated on the reservation is logging residue. This is the limbs, tree tops, deadwood, etc. which remains after the trees are harvested. The cost to chip and haul this material from tribal forest lands to a buyer exceeds $40 per ton. The value of first quality, dry wood chips at the end user's plant is $25 per ton. There are no environmental problems created by leaving the residue in the woods. Thus, it simply is uneconomical to use the logging residue.

There are also some used pallets which are disposed of by tribal businesses. When these pallets are disposed, tribal members usually take them home and burn them in their fireplaces.

Conclusions about Wood Waste

- Disposal of wood waste in the MBCI reservation area is not a problem.
- Wood waste is a valuable commodity which responds to local market conditions.
- At current market conditions, using wood waste for power generation is not economical.

Task #2. Power utilization assessment- The objective of this assessment was to determine the potential market size for power, the existing infrastructure for delivering power to that market, and the costs and economic returns for doing so. Of specific interest was whether distributed generation techniques (DG) using small biomass fueled generators could find application on the reservation.

The current use of power by the MBCI was determined and sent to Dr. Noel Schulz, Mississippi State University, Department of Electrical & Computer Engineering. Dr. Schulz then visited the MBCI reservation to obtain additional data on the use of power at several major facilities in the Pearl River community in Neshoba County. Schulz studied and defined the various parameters related to the costs and savings for using localized distributed generation. This information was incorporated into a template showing the economic analysis. (See attachment 2).

The MSU Electrical Engineering Department conducted a power utilization assessment on the reservation which included looking in detail at the Golden Moon Casino, Geyser Falls Water Park, and the Choctaw Laundry. The data from these assessments is presented in Attachment 2. The casinos, with over 1000 hotel rooms, 175,000 square feet of gaming areas, restaurants, and shops consume many times the power of the DG generators available today. Geyser Falls operates only in the summer months. The most likely use of DG capacity was deemed to be at the Choctaw Laundry, a commercial laundry which serves the resort hotels on the reservation as well as several other institutional accounts. Below is the load profile for the laundry:

Typical load profiles:

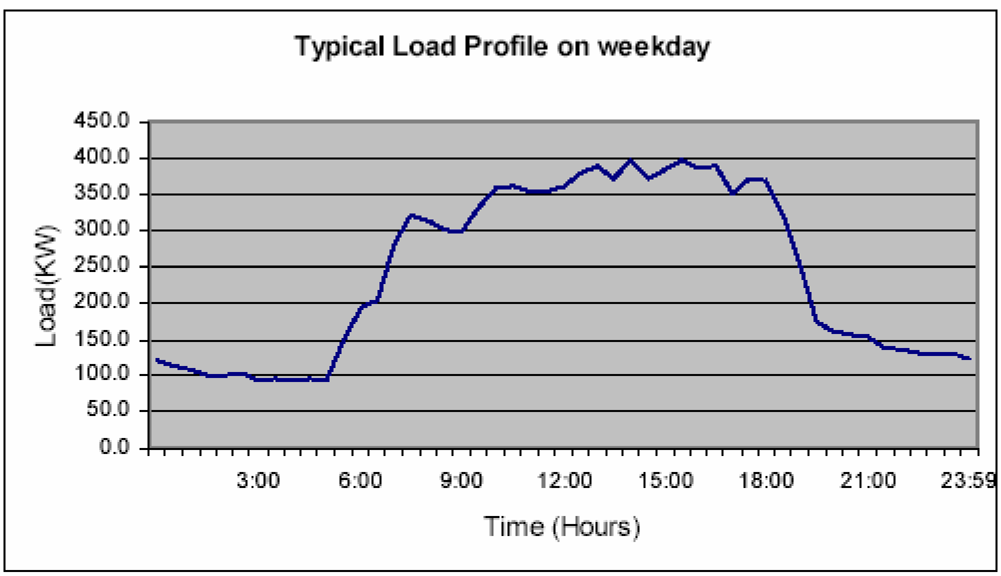


Fig 2.4. The typical load profile on weekday of commercial laundry facility

The report from the Mississippi State University Electrical Engineering Department was derived from a master's thesis by Vishwanatha Raju Brahmandhabheri. He developed a spreadsheet model for a life cycle cost approach to this project. The model uses the capital cost of the equipment, fuel cost (poultry litter), labor costs, and operation and maintenance costs. Revenues are sale of electricity and sale of the ash. Values were used for the Choctaw model which reflects market conditions in the reservation area.

Dr. Schulz provided a report with the following results:

• The load profile shown in the report documented both the kWh demand as well as the time of use features of three MBCI facilities.

• Besides the KWh power requirements, the load profiling data shows that several of the facilities have an additional surcharge with their power because of a low power factor (less than 0.85). It was recommended that the MBCI look into options to get some local capacitors to use during heavy loading to decrease this additional cost.

• The economic analysis provided a tool for looking at different distributed generation options depending on costs and savings by the DG. Due to varied options for costs of fuel, value of ash, capital costs and personnel staffing, the scenarios in our assessment concluded that over the life of the project (20 years) the costs are in excess of the revenues ranging from $3.15M to $600k for electricity production and use only.

• The electric load needs of the studied facilities are much greater than the capabilities of current biomass DGs. Because of this, there was no need to add the extra cost and engineering by connecting the DG to the grid. Instead the DG could be connected to the loads directly and would be treated as a negative load instead of generation.

• While these three facilities are too large for the current biomass technology available, it was recommended that the MBCI look into loading related to residential and small commercial facilities to see if the systems are cost effective for smaller loads. (This study was limited in its ability to obtain load information for residential and small commercial facilities.)

Task #3. Technology review- The objective of this review was to identify one, or more, technical options for detailed economic and technical assessment. The report prepared by DIAL is included as Attachment 3. The study considered a range of feedstock and product mixtures of poultry litter; wood residues as feedstock; and electrical power and other ancillary products as outputs. Distributed power sources were also examined. Technologies ranging from gasification to systems that produce both power and value-added chemicals were considered. Technologies selected for detailed review were those that can be sized to process the amount of available feedstock (poultry litter, or poultry litter and wood residues), and that also appear to make economic sense in terms of the value of their inputs.

The technology review leaned heavily on the experience from prior DOE projects, particularly those conducted by the National Renewable Energy Laboratory (NREL). NREL was involved in a consultative role, so that the project team could leverage their experience. John Scahill, NREL, provided insight into possible technologies. Dr. John Plodinec, Mississippi State University, Diagnostic Instrumentation and Analysis Laboratory (DIAL) reviewed three technologies including extruder-feeder liquefaction, biomass gasification, and bio-oil. In addition a review of a feasibility study of a large-scale waste-to-energy technology was conducted.

Dr. Plodinec's technical assessment of biomass gasification was that it was portable, easy to operate and maintain, and fuel flexible. However, at this time only a 15KWh unit is available. DIAL reviewed technical materials provided for the extruder-feeder liquefaction unit. They concluded that from a technical view, the extruder-feeder liquefaction planned unit was attractive. It is fuel flexible, can produce a variety of products with high value, and a potentially high rate of internal return. However, the technology is only at the pilot plant scale. DIAL reviewed information on a bio-oil technology. However, it was determined that their technology is not yet near commercialization.

Table 2. Comparisons of Renewable Energy Technologies Reviewed by DIAL

Technology	**Capital Investment**	**Required Manpower**	**Products**	**Status of Development**
Extruder Feeder Liquefaction Unit	$7,000,000 (50 tons/day capacity)	121	Chemicals – 3300 tons/year Clean liquid fuels – 1,200,00 gal/year Wood/plastic composites – 20,000 tons/year	Pilot scale, but not demonstrated on poultry litter
Biomass Gasification	$25,000 - $30,000 5 hr pilot scale test (22.5 kg/hr)	1 per unit per shift	Gas – 45 m^3/hr Electricity – 4.25 kW Ash –1.74 kg/hr (based on 5 hr pilot scale test results)	Full scale, but undergoing some redesign, based on initial testing with poultry litter
Bio-Oil	$1,200,000 (equipment only) 125 tons/day capacity	4 per 24 hour day	Bio-oil – 75 tons/day Ash – 20 tons/day (based on 125 tons/day capacity)	Pilot scale, but only lab scale testing on poultry litter

Prior to this feasibility study, a group from Mississippi had toured waste-to-energy facilities in England. Those in attendance all indicated that the technology was proven and capable of producing 40 to 50 megawatts. DIAL reviewed other financial information provided. The large-scale poultry litter fired power generation facility uses 300,000 tons of litter and 150,000 tons of wood waste. The 40 megawatt facility costs about $100 million. Cost of generating electricity is about 8 cents per KWh. However, retail prices of electricity in the MBCI reservation area is about 5.5 cents per KWh. Based on the fact the large-scale waste-to-energy technology cost so much and would require subsidies, this technology was determined to not be economically feasible at this time.

While it is certainly technically feasible to produce power using chicken litter, at this time the cost of doing so on a small scale in the Choctaw Reservation area is more than simply purchasing power from the local rural electric cooperative. There are new technologies being developed which attempt to use litter to heat broiler houses. Such technologies are directed at allowing a farmer to use the litter to heat his own houses. The major cost savings in this approach over hauling the litter to an off-farm site to be burned is that transportation costs are eliminated. Future analyses of litter utilization for heat or power in the south will likely show that this on-farm approach will be adopted before the off-site generator approach.

Task #4. Systems Design - Based on the technology review, a pre-conceptual design for an installation of an extruder-feeder liquefaction system was commissioned. This included identification of unit operations and equipment, maintenance, manpower, feedstock requirements, and output (power and any other ancillary products). Energy and mass flows were identified. A report regarding biomass availability and transportation costs is included as Attachment 4. A small batch commercial plant utilizing wood feedstock and poultry litter was proposed. The plant would have a floor space requirement of 32,000 sq. feet. Approximately 25 tons per day of shredded wood and poultry litter are fed to the extruder feeder liquefaction unit to produce clean liquid fuels, asphalt additives, plastic forming chemicals and binders. The remaining 25 tons per day of wood fines are utilized in the wood plastic composites. Financial information was also included in the summary. The amount of material which can be loaded on a trailer (in Mississippi this is about 25 tons) was used as a design constraint for the size of the plant.

The process flow diagram is presented as Figure 1.

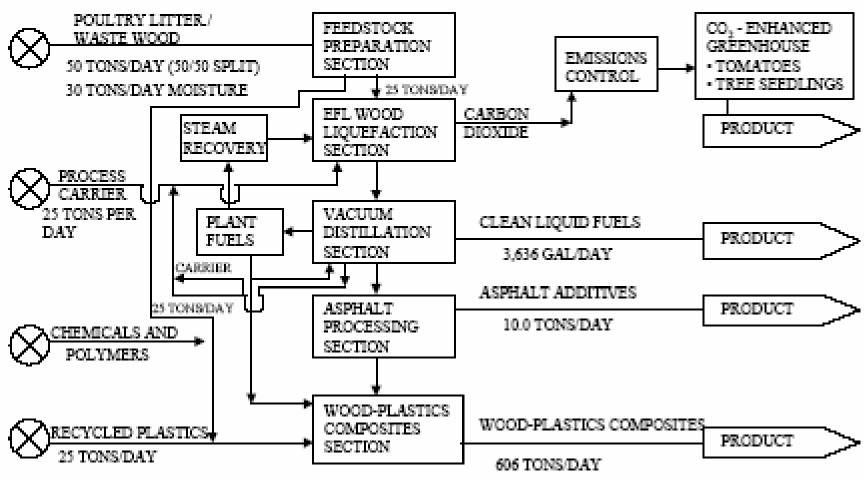


Fig. 1. Schematic Block Diagram for a 50 Ton per Day EFL Liquefaction Plant.

Task #5. Manpower development assessment- The objectives of this assessment were to identify training needs for the selected option(s), and determine how they could best be met. The selected technology option was the extruder-feeder liquefaction plant discussed in Task # 4. Using the manpower estimates from the pre-conceptual system design, skills and training needs were to be identified. A plan for providing the needed manpower was to be developed and any associated costs determined. This plan called for 121 employees. MBCI inventoried the training programs that they have available.

Table 3. PERSONNEL FOR A 50 TON/DAY LIQUEFACTION PLANT

Type of Job	Number
Direct Personnel	
Plant Operations	
Plant Operator	32
Shift Supervisor and Computer Control Operator	8
Machine Operator	5
Lab Technician	5
Labor - Experienced	10
Labor - Common	10
Maintenance	
Labor - Mechanic (Repairs)	5
Labor - Electronic (Repairs)	5
	80
Indirect Personnel	
Central Office	10
Marketing	
Sales Persons	10
Architectural	5
Technical Service	10
Warehouse	6
	41
TOTAL PERSONNEL	121

Mississippi has a strong community college system which has traditionally provided post-secondary vocational training for skills that are needed in local job markets. The community college serving the Choctaw Reservation area is East Central Community College (ECCC) in Decatur, Mississippi. ECCC's main campus is located less than ten miles from the Choctaw community of Conehatta. Over the years a good relationship has been built between the Choctaw community and ECCC. Many Choctaws have completed academic and vocational programs at ECCC.

The technologies investigated in this project require persons with special engineering and scientific training. However, the operation of these systems does not require high level specialization. Indeed, these systems are designed to work in rural, sometimes primitive, areas where highly skilled operators are not available. Once installed, operation can be accomplished by persons with technical skills and/or training in basic electrical and mechanical concepts.

ECCC offers two programs in electrical technology. The first is a two-year program leading to an associate degree. The second is a two semester (one year) leading to a certificate in electrical technology. Students completing these options would likely be qualified to maintain the power generation equipment investigated in this study.

ECCC also offers Associate programs in Machine Shop Technology and in Heating and Air Conditioning Technology. Graduates of these programs also would likely possess skills necessary for the options investigated in this report.

For specific training the Mississippi Development Authority will work with community colleges to tailor specific training needed for a new plant. Should the Choctaw biomass plant ever be built, the resources available through the state as well as through tribal job training programs could be used.

Currently there is a need on the reservation for college trained electrical engineers. Mississippi State University offers programs in electrical engineering at its campus in Starkville, about 60 miles north of the Choctaw Reservation. Many Choctaws have attended and graduated from Mississippi State over the past 30 years. There is a good working relationship between counselors at Choctaw and MSU. Chief Martin has lectured at Mississippi State and has been supportive of the university. Today there are opportunities for electrical engineers on the reservation in construction and in the operations at the tribal resort and tribal industries.

In this region of Mississippi many manufacturing plants and mills have been closed during the past five years. These plants employed several thousand workers who were used to working with heavy machinery, heavy and bulky raw materials, and process chemicals. If the proposed extruder-feeder liquefaction plant were to be built, many former factory and mill workers with the experience needed would be employed.

Task #6. Economic assessment- The objective of this assessment was to determine the economic viability and sustainability of the selected technology option. The costs of bringing the feedstock to the proposed facility was combined with nominal operation costs and potential production distribution costs to identify total costs. Revenue from power distribution (and, possibly, from sale of ancillary products) was combined with any possible government credits or payments to identify gross revenue. Economic viability was determined by net revenue and return on investment. A business plan for the selected option was to be produced that would consider long-term sustainability of the project. Project team members reviewed the business plan and financial information provided for the extruder-feeder liquefaction plant. The products that could be produced from an extruder-feeder liquefaction unit include 1) clean hot high-btu liquid fuels; 2) wood fiber plastic composites; and 3) asphalt additives for streets and roofing materials. It was estimated that the MBCI would invest $7,000,000 in a facility. The plant was proposed to be a 50 ton per day batch plant that would employ 121 people and have a 43.9 percent return on investment. The business plan and financial projections showed that the wood fiber plastic composites had the most promising market.

Additional research by team members showed that many companies were making this type material including one large publicly traded company. The major hurdle that the Choctaw would have to overcome would be establishing a marketing network for the product. While the Choctaw tribe has been very successful in manufacturing, their experience has not been with manufacturing finished products for sale in a retail environment. Rather, Choctaw plants have been component suppliers. Companies manufacturing wood plastic composites such as Weyerhaeuser have company owned distribution centers in large cities and also distribute their products through building supply chains such as Home Depot. Trex sells much of its product through smaller independent building supply stores and also markets its products through contractors.

Task #7. MBCI compatibility assessment- The objective of this assessment was to determine whether the renewable energy installation would be compatible with the MBCI's cultural, social and economic values. As part of this assessment, the environmental impacts and benefits were to be determined (Environmental stewardship is an important part of the Choctaw culture). The effects of a project on employment were projected. The compatibility of the biomass-based renewable energy project with MBCI cultural and social values was also determined. Most importantly, the compatibility of the extruder feeder liquefaction plant installation with the MBCI's economic development goals and directions was determined. Economic development representatives for the MBCI felt that the proposed facility was not compatible with their economic values. However, the MBCI have continued to work with Dr. Noel Schultz with the Mississippi State University Department of Electrical and Computer Engineering to look into energy efficiency programs within tribal facilities and the evaluation of solar energy.

Manures have been used for thousands of years to fertilizer pastures and crops. While there are some disadvantages to manure use, the alternative is to use chemical fertilizers. Chemical fertilizers are also frowned upon by some consumer groups. That is, crops grown with manures can be classed as "organic" while crops grown using chemical fertilizers cannot. Many think using manures is environmentally sound because petroleum and natural gas are not used and mining is avoided.

Of the manures that are available for fertilize, poultry manure seems to have the fewest disadvantages. A chicken converts feed to body weight at a rate of two pounds of feed to one pound of body mass. It takes six pounds of feed for a pig to produce one pound of gain and ten pounds of feed for one pound of gain for a cow. Broiler litter is a dry material; it is easy to handle. There is not much odor associated with broiler litter spread on pasture. Use of broiler litter in the counties surrounding the reservation is simply not viewed as a problem by residents or government environmental regulators (swine manure and odor is considered a problem, though). With regard to conflict with Choctaw cultural values, use of litter for fertilizer in the area has never been discussed as a problem.

Job Creation

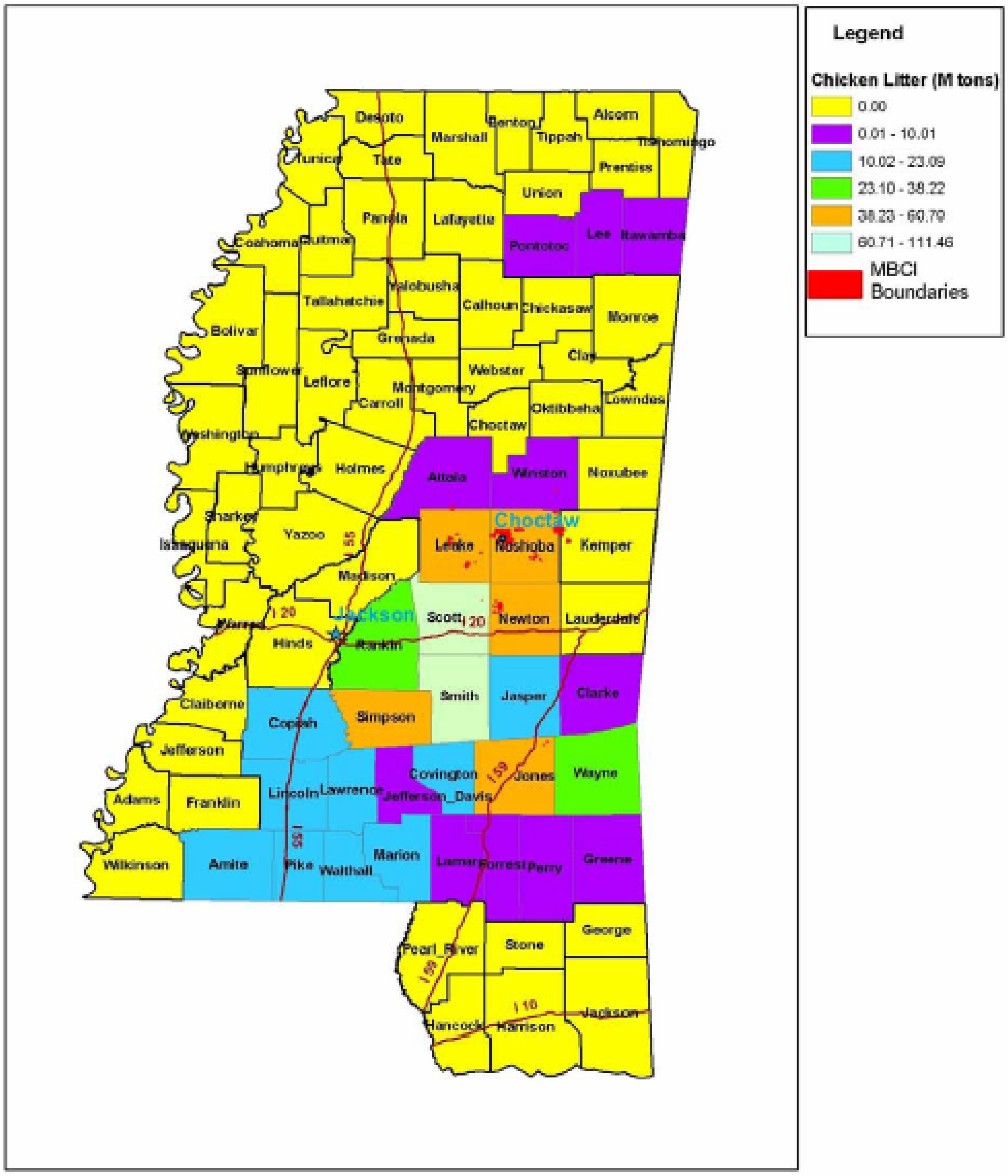
While the Mississippi Band of Choctaw Indians' reservation is located in rural Mississippi, the job market in counties surrounding the reservation continues to be quite strong. The issue on the reservation and in the surrounding job market is not the lack of jobs. Rather, the issue is educating and training the existing workforce so individuals can be more productive, get better jobs, and earn more. Choctaw Chief Phillip Martin and the Choctaw Tribal Council embraced the idea in the late 1960's that if the Choctaw people were educated and trained, jobs would follow. The tribe has gone through the cycle from emphasis on local government jobs (tribal, BIA and HIS), to an emphasis on manufacturing (late 70's to mid 90's) and today an emphasis on service/tourism jobs. During each stage of development, tribal members have upgraded themselves for better jobs. But, the job market will inevitably change again. More tribal members are attending college than ever before and investments in public infrastructure on the reservation are being made so that the next Choctaw generation will have even more opportunity.

The progress and development made by the Choctaw tribe has benefited many non-Indians living in the surrounding area. As many low-wage factories closed and transferred production out of the U.S., many non-Indians found work on the reservation in construction and at the Choctaw resort. Chief Martin is recognized and appreciated not only by tribal members, but his work and leadership is acknowledged throughout the non-Indian community in Mississippi. The local economies off the reservation have benefited greatly from the Choctaw tribe's progress.

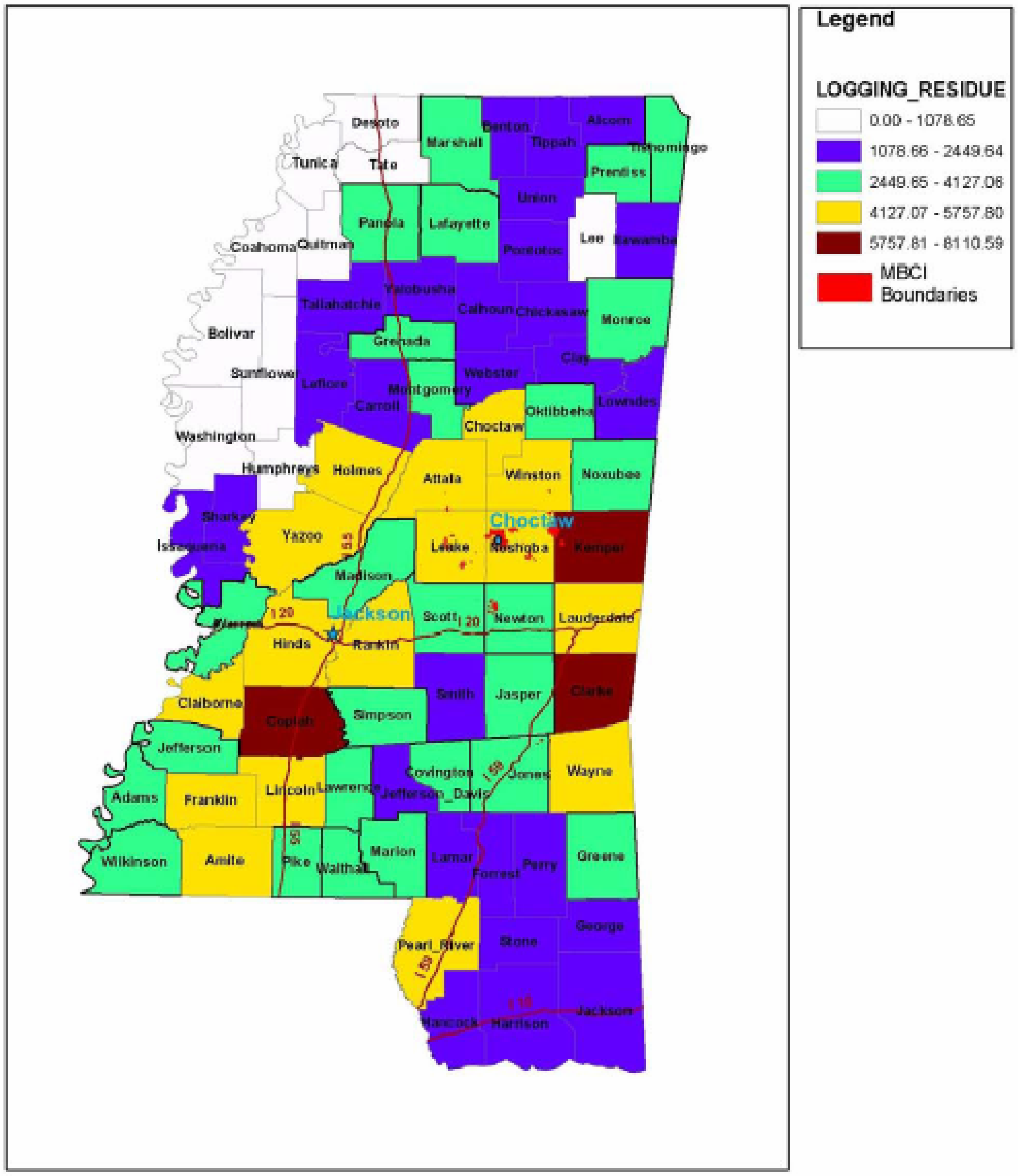
All tasks outlined in this DOE supported feasibility study are completed. Thanks to the project team members from the MBCI, MTA, MSU, and to Lizana Pierce, Project Officer with the U.S. Department of Energy, Golden Field office.

This report and its findings are based on the best available data existing during the covering period and the analysis reflects good faith estimates and assumptions of factors for a biomass-based renewable energy project for the Mississippi Band of Choctaw Indians and any conclusions or findings herein should not be extrapolated to other areas of the country.

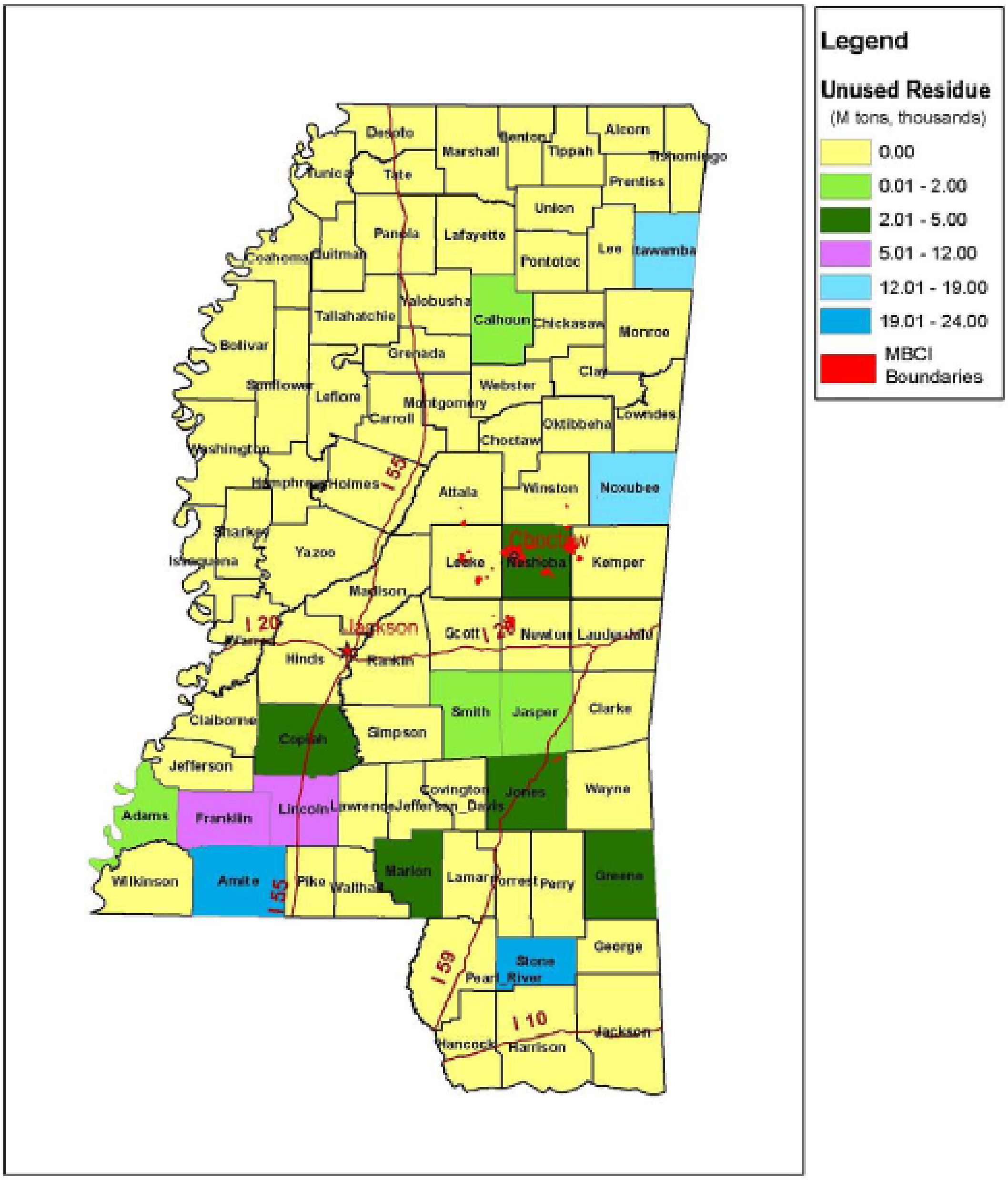
CHICKEN LITTER



LOGGING RESIDUE



TOTAL WOOD WASTE (Wood and Bark)



Attachment 2

Tribal Renewable Energy – Final Project Report

Project Title: Feasibility Study for Alternative Energy Development on Tribal Lands

Covering Period: June 1, 2003 to September 1, 2003
Date of Report: September 30, 2003

Research Group: Dr. Noel Schulz and her graduate students (Raju Brahmandhabheri and Vijaysimha Duvvuru Narasimhulu), Department of Electrical & Computer Engineering Mississippi State University,

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This report and its findings are based on the best available data existing during the covering period and the analysis reflects good faith estimates and assumptions of factors for a biomass-based renewable energy project for the Mississippi Band of Choctaw Indians and any conclusions or findings herein should not be extrapolated to other areas of the country.

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I. INTRODUCTION

1.1. **Project Objective:** The Mississippi Band of Choctaw Indians (MBCI) proposes a study of the feasibility of siting a renewable energy biomass-based installation on tribal lands. The purpose of the study is to determine whether such an installation can be economically sustainable, as well as consistent with the cultural, social, and economic goals of the Tribe.

1.2. **Background:** The MBCI is seeking new opportunities to diversify its economy and create new career opportunities for Tribal members, which is the purpose of this feasibility study. The feasibility study will provide for the development of a thorough business plan that will allow the MBCI to make an informed decision regarding this project. The technologies to be utilized in the renewable energy installation will be those that can readily handle poultry litter, either alone or in combination with wood residues.

1.3. **Patents:** There are no patents applied for or anticipated to be resulting from this award.

II. POWER UTILIZATION ASSESSMENT

2.1. Objective: The objective of this assessment was to develop an understanding of the electric power consumption needs of the MBCI facilities and to determine the economic and engineering issues related to using biomass distributed generation for these loads. Additionally we investigated the possibility of selling any excess power back to the local utility.

2.2. Background: The MBCI is seeking new opportunities to diversify its economy and create new career opportunities for tribal members, which is the purpose of this feasibility study. The MBCI will study the feasibility of locating a renewable energy installation on tribal lands. The technologies to be utilized in the renewable energy installation will be those that can readily handle poultry litter, either alone or in combination with wood residues. When planning a renewable energy (RE) system it is important understand the electric power needs of facilities.

Once needs are defined, we can then begin to design an RE system to meet them. Out of those needs, the important one is to determine and analyze how much energy it takes to meet the load demand of each facility. This can be procured by step-by-step analysis of a load profile. The term load profile describes the pattern of electricity usage for a customer or a group of customer over a given period. Similarly, the term load profiling is defined as estimated load shapes that are developed from historical or current data and balanced to actual meter reading on a daily or monthly basis[1].

2.3 Importance of Load utilization assessment: Renewable Energy (RE) systems are expensive. Costs to produce one’s own electricity from renewable sources average between $0.25 and $1.15 per kilowatt hour (kWh). This is many times the price of buying power from the electric utility. So the design and capacity of the system should be finalized based on energy needs and local demand.

Information on the customers' consumption pattern at MBCI is critical for the feasibility study. Such information has been used for system planning or better tariff design with new system's local generation. This information has considerable impact on the settlement price between customers and their suppliers. If done correctly, load profile's average daily kWh figure can be quite accurate. Careful load analysis can assure the size of RE system appropriately.

By knowing customer's load profile, one can decide the capacity of the proposed plant such that customer's demand can be met by local generation, thus avoiding paying higher bills for electricity to local utility. Thus they can provide better marketing strategies and improve efficiency.

2.4. Load profiles of Different Facilities in MBCI: The project activity started with a tour of the tribal facilities including the commercial laundry, remote sensing company, hospitality institute, water park and casinos. The MBCI Economic Development Staff also provided driving tours of other local facilities. We discussed getting time of use data for several major loads on tribal facilities to determine electrical energy needs. The facilities chosen for assessing the power utilization were Choctaw commercial laundry, Choctaw Geyser Falls (water park) and two casinos, Golden Moon and Silver Star. Before focusing more on the power utilization assessment of these facilities, we will discuss some definitions and acronyms involved in this activity [2].

2.4.1 Definitions and Acronyms related to Load profile:

i. *Demand and demand periods : "Demand,"* as normally used in electric load analysis and engineering, is the average value of electric load over a period of time known as the *demand interval.* Very often, demand is measured on an hourly basis but it can be on any interval basis-seconds, minutes, 30 minutes, daily, and monthly. The average value of power during the demand interval is given by dividing the kilowatt-hours accumulated during the demand interval by the length of the interval. Demand intervals vary among power companies, but those commonly used in collecting data and billing consumers for "peak demand" is 15,30,and 60 minutes. The regular time interval used for some of the load curves is 30 minutes.

ii. *Load curve*: Load curves may be recorded, measured, or applied over some specific time, for example, a load curve might cover one day. If recorded on an hourly demand basis, the curve consists of 24 values, each the average demand during one of the 24 hours in the day, and the peak demand is the maximum hourly demand seen in that day. Load data can be and are gathered and used on a monthly basis and on an annual basis.

iii. *Load factor*: Load factor is the ratio of the average to the peak demand. The average load is the energy used during the entire period (e.g., a day, a year) divided by the number of demand intervals in the period (e.g., 24 hours or 8,760) hours). The average is then divided by the maximum demand to obtain the load factor, as:

$$Load\ Factor = \frac{kWhr}{(kWDemand)*(Hr)} \text{x}100$$

Load factor gives the extent to which the peak load is maintained during the period under study. Load factor can be computed for daily or for monthly load. The maximum load factor possible is 100 percent.

2.4.2. Load profile of Choctaw Geyser Falls: Geyser Falls, a water theme park is a development of the MBCI located in Philadelphia under the management of Pearl Resort, Choctaw, Mississippi. The various loads of the Choctaw Geyser Falls include the water pumps for various water rides, Hard Rock Beach Club and lightings all around the park [3]. Figures 2.1 through 2.3 are load curves that show the load patterns of Geyser Falls. Local utility personnel and Tennessee Valley Authority (TVA) provided the loading information at water park during the week of July 4th, 2003. The padmount transformer for Geyser Falls has a 277/480 volt 4 wire wye secondary. The power monitor was set inside the padmount on the secondary side of the transformer and recorded the voltage magnitudes at the end of each 30-minute interval for load profile.

Typical load profiles:

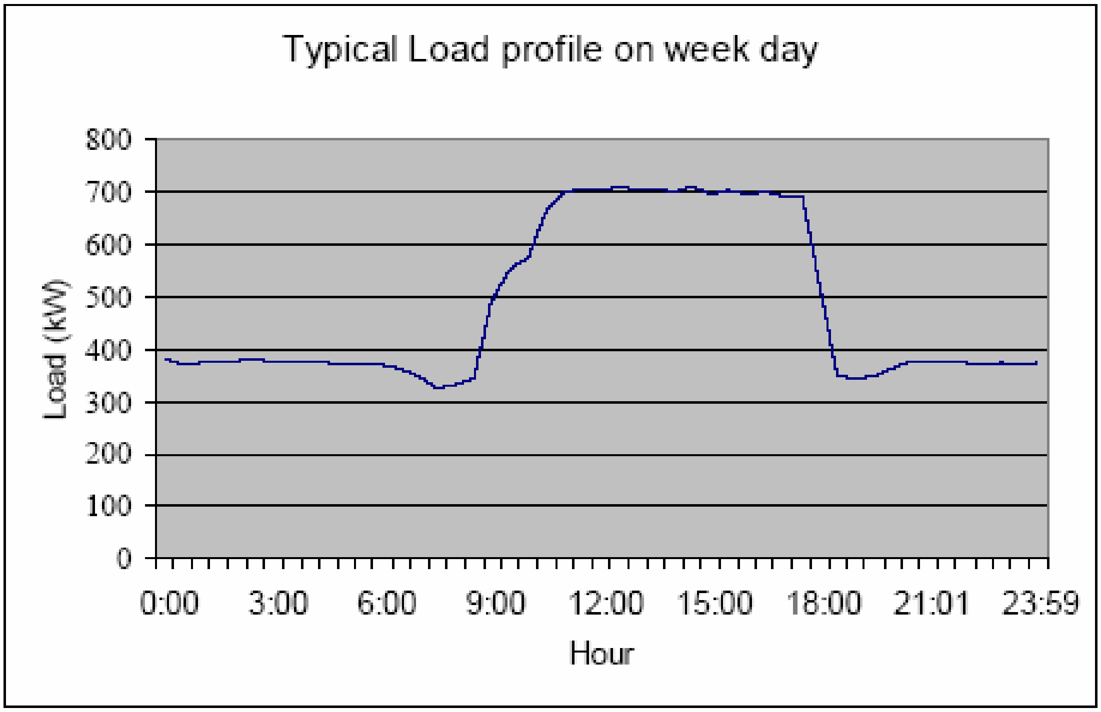


Fig 2.1. The typical load profile of Geyser Falls on weekday

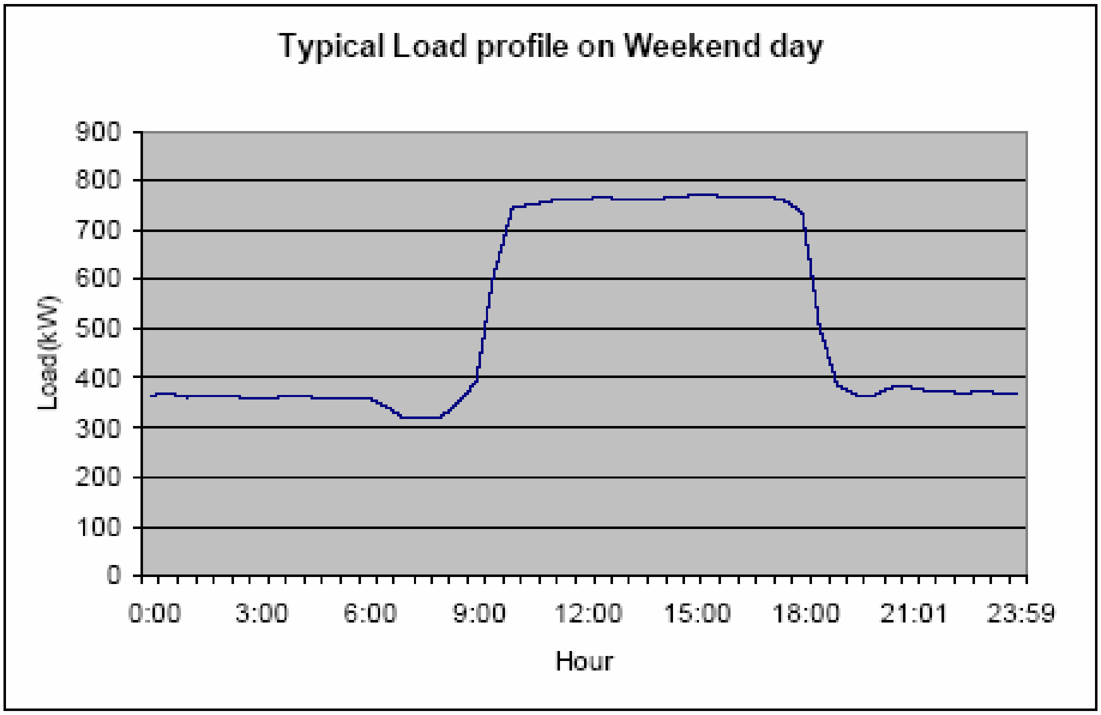


Fig 2.2. The typical load profile of Geyser Falls on weekend day

The load profiles during the days from 06/27/03 to 07/07/03 are included in appendix. An outage occurred at Geyser Falls on 07/02/03 and had a severe effect on the normal load pattern and the behavior of the load profile changed considerably as shown in Fig. 2.3.

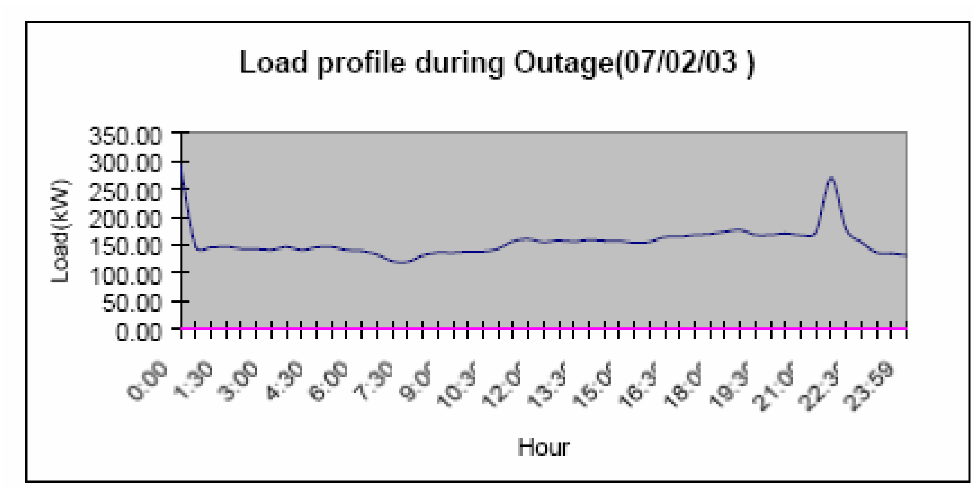


Fig 2.3. Load pattern profile during outage at Geyser Falls on 07/02/03

2.4.3. Load profile of Choctaw Commercial Laundry: Choctaw commercial laundry facility is a development of the MBCI located in Choctaw, Philadelphia, Mississippi. The various loads of the Choctaw commercial laundry facility include various washers, drying machines and some other types of machines used for pressing and folding laundry. Figures 2.4 and 2.5 show the typical load patterns of commercial laundry facility.

The loading information was provided by local utility personnel and Tennessee Valley Authority (TVA) during the days starting from 07/07/03 to 07/21/03. The laundry has a 500 kVA padmount transformer with a 277/480 volt secondary. The power monitor was set inside the padmount on the secondary side of the transformer and recorded the voltage magnitudes at the end of each 30-minute interval for load profile.

Typical load profiles:

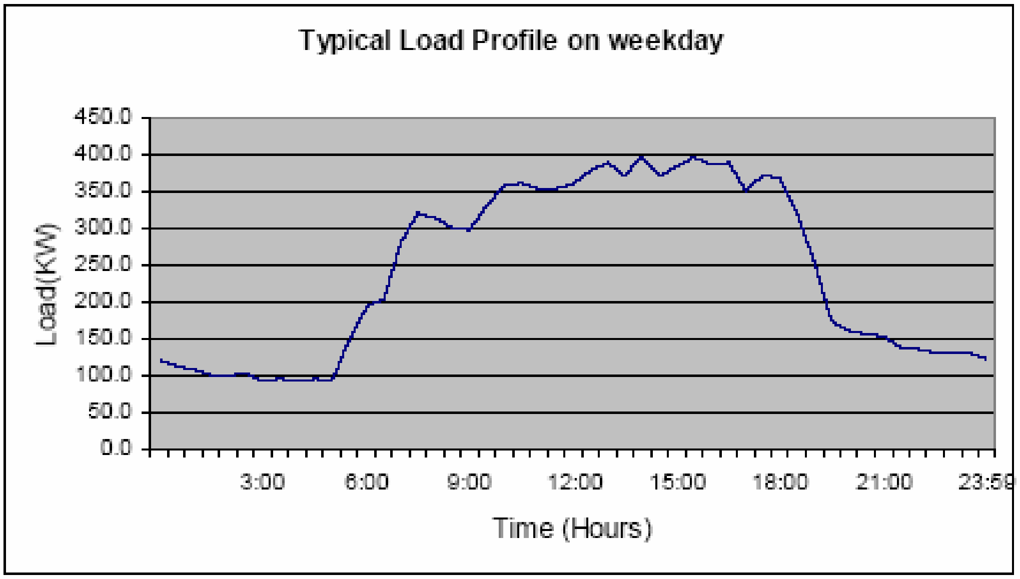


Fig 2.4. The typical load profile on weekday of commercial laundry facility

The observed load pattern on weekend day is shown in Fig 2.5

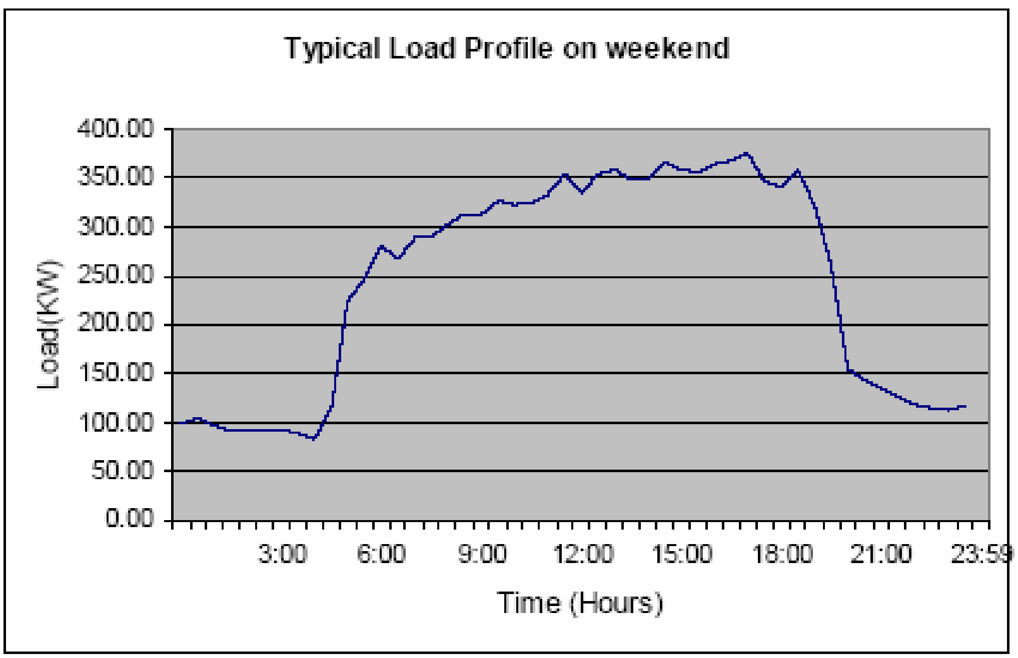


Fig 2.5. The typical load profile on weekend day of commercial laundry facility

The load profiles during the days from 06/27/03 to 07/07/03 are included in appendices.

2.4.4. Load profile of Golden Moon Casino: The Golden Moon Hotel and Casino is Pearl River Resort's newest addition. Golden Moon Hotel and Casino has 80,000 square feet of gaming space, 1,754 slot machines, 62 table games, five restaurants and five lounges, five retail shops, indoor and outdoor pools and a modern fitness facility [4]. These are the major loads considered in load profiles shown below.

The loading information was provided by local utility personnel and Tennessee Valley Authority (TVA) during the days starting from 07/21/03 to 08/01/03. For the Golden Moon casino the power monitor was set at the primary meter, on the secondary side of the potential and current transformers. The primary phase-to-phase voltage at that location is 25 kV. The meter records the voltage magnitudes at the end of each 30-minute interval for load profile.

Typical load profiles:

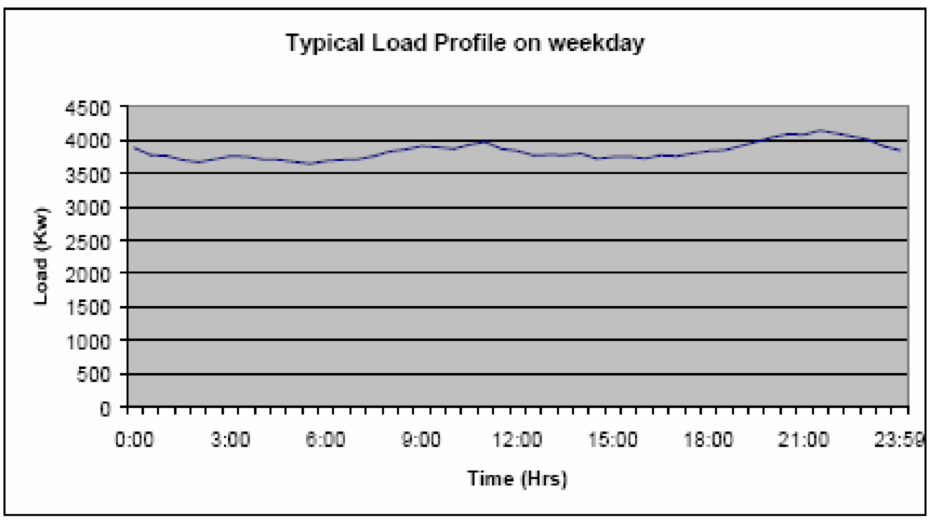


Fig 2.6. The typical load profile on weekday for Golden Moon

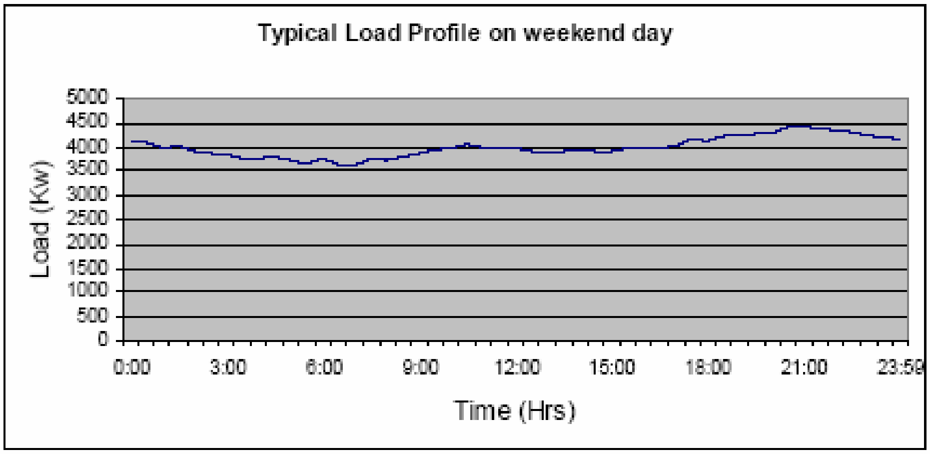


Fig 2.7. The typical load profile on weekend day for Golden Moon

The load profiles during the days from 07/21/03 to 08/01/03 are included in appendices.

2.5. Discussion on Load Profiles:

The appendices provide some additional information related to loading. Besides the recent load profiling of the three facilities, the appendices include local readings taken at the Golden Moon daily on energy consumption, load profiles done on the Silver Star in 2001 and information about the backup generation available to both casinos. In discussions with the facilities personnel this summer, we learned that the casinos have plenty of back-up generation to hold them through outages. However other facilities do not have this back up (such as Geyser Falls) as demonstrated by the outage during our load profiling time.

Some general information relating to the load profiling data follows. The Golden Moon Casino has an extremely flat load curve. The difference between the minimum and peak values during the day is approximately 10% of the peak value. The load profiles of the laundry facility and Geyser Falls have a much different shape. The water park has an extremely sharp increase and decrease based on its operating times. Additionally the load during the day is greater than twice the power required when the part is not open. The laundry also has a large difference between off-shift and daily power requirements. The difference for the laundry is three to four times higher during peak times than overnight requirements.

The casino load curve lends itself better to a constant distributed generation supply. The load doesn't have huge percentage fluctuations that might impact local distributed generation operation, reliability and stability. Besides the magnitude of the power requirements, another important issue is the how fast the power demand changes. The steep slope of the water park load profile means a rapid change in a short time. The power system needs to be able to follow this closely. The distributed generation would need to be part of the base load as following the changes in either the laundry or the water park would require tighter controls, increase maintenance and decrease operational stability.

III ECONOMIC ANALYSIS AND RESULTS

3.1 **. Introduction:** This section represents the economic analysis of 20-year (2003 through 2023) life-cycle costs associated with the proposed establishment of renewable energy plant at MBCI. It also presents the economic and operational assumptions relied upon to develop the 20- year life-cycle costs. The discussion also provides details of each of the key economic and operational assumptions relied upon in the analysis, including fuel costs, MBCI electric loads, capital costs, recurring operations and maintenance costs, and other relevant factors. The final section of this chapter presents the results of the life cycle cost analysis. This process was modeled after similar analysis done in reference [5].

3.2. **Analysis assumptions and parameters:** To estimate the life-cycle costs associated with the electric power generation at MBCI, numerous engineering, operational, and economic assumptions are required. The life cycle cost results are dependent upon these assumptions.

3.2.1**. MBCI Electrical Loads**: The power utilization assessment at MBCI in section II shows that the load requirement of facilities in MBCI is very high when compared to the capacity of the renewable energy plant. The peak demands of facilities tested for load utilization are given in below.

Facility at MBCI	Peak demand (kW)
Geyser Falls	700-750
Choctaw Commercial laundry facility	350-400
Golden Moon Casino	3500-4000

Table 3.1. Peak demand of facilities at MBCI

3.2.2. **Fuel costs, power costs, and financial/economic assumptions:** This subsection addresses the current and future costs of fuels used by for power generation, the cost of electric power purchased from Central Electric Power Association, and the financial and economic assumptions used in life-cycle cost analysis [5].

FUEL PRICES – Table 3-2 shows current prices for poultry litter and are based on the current contact between MBCI and poultry farms across various counties in Mississippi [6].

County	Poultry Litter Availability (M Tons)	Distance to PR (Miles)	$5+0.11 ton-mile Poultry Litter Cost
Covington	2,569	138	$20.18
Jasper	8,592	64	12.04
Jones	51,566	109	16.99
Lawrence	5,462	177	24.47
Leake	52,364	20	7.2
Marion	1,782	171	23.81
Neshoba	43,252	7	5.77
Newton	45,431	29	8.19
Perry	611	164	23.04
Pike	3,033	183	25.13
Rankin	17,951	87	14.57
Scott	138,701	38	9.18
Simpson	67,331	98	15.78
Smith	115,602	79	13.69
Walthalle	6,663	199	26.89
Wayne	38,832	113	17.43

Table 3-2. Cost of poultry litter per Mton-mile in counties of Mississippi [6]

The price of poultry was assumed to be $ 20.0 per ton, which includes the cost of removal and transportation from the farm to the proposed location of renewable energy plant at MBCI. The transportation costs associated with the total cost of poultry litter is $0.11 per ton per mile. It is noted, however, that there is substantial uncertainty regarding the removal cost of poultry litter at farms. The assumption of $20 per ton can be broken down to $12 commodity costs and transportation cost at $0.11 per mile per ton.

ELECTRIC POWER PRICES— Prices for power commercially purchased from Central Electric Power were computed from the applicable Central Electric Power tariff assuming an 85 percent load factor and converted to average annual per-kWh prices. The current electricity price per kWhr is 5.5 cents. For the analysis purpose it is assumed that there is no inflation in electricity prices during the life cycle period (2004-2023). Some of the facilities such as Geyser Falls and commercial laundry are surcharged for low power factor less than 85%. The details of this additional charge are given in section IV.

OTHER FINANCIAL/ECONOMIC ASSUMPTIONS -- In addition to the fuel and electric power prices, other economic and financial assumptions were required to complete the life cycle cost analysis. Each is discussed below.

Inflation Rate: An inflation rate of 2.5 percent per year was assumed throughout this analysis. The inflation rate is used to convert between real prices (and costs) and nominal prices (and costs). The life cycle cost analysis is presented in terms of net present value (NPV). The 2.5 percent inflation rate is consistent with general short-term and long-term expectations.
To the extent that any error exists in the assumed inflation rate, the life cycle cost results would not be affected since projections of prices and costs have been made in real terms (i.e., net of inflation).
Discount Rate : A nominal discount rate of 7.0 percent is used to compute life-cycle costs. This value is assumed in the analysis.

3.3. Scenario analysis

3.3.1 **Introduction :** This section presents the life-cycle cost (LCC) analysis associated with each of the costs involved in the proposed establishment of renewable energy plant at MBCI. Tables showing the annual net present value costs used to develop the life-cycle costs in detail are contained in the appendices to this report. Section 3.3.2, which includes detailed discussion of factors affecting the LCC estimates and the development of the estimates. Results are summarized in Section 3.3.3.

3.3.2 **Life cycle cost estimates** : This section provides the factors or various cost that contributed towards the total life cycle costs are discussed. It also presents the results of the life cycle cost analysis developed for the scenario addressed. Because of the limited remaining life of the existing power generation facility, the existing facility is to be replaced with a similar, power system unit in 2013. Life-cycle costs were calculated as the sum of:

- The cost of poultry litter for fueling the electric generating facility;
- The capital cost of the new electric generating facility, including ancillary construction requirements;
- Annual maintenance cost for the new generating facility;
- Demand charges from Central Electric Power Association for power demand;
- The capital cost of replacing the gen-set part of the power plant in 2014;
- Additional labor costs to operate the new generating facility;
- Revenue to MBCI from the generation of electrical energy from poultry litter;
- Revenue to MBCI from the sale of poultry litter ash, a negative cost element.

3.4. Results of Economic Analysis:

3.4.1. Introduction : The economic feasibility of renewable energy plant is clearly shown by developing a user interface spreadsheet in Microsoft Excel. This spreadsheet gives the user a better understanding of the economics involved in the establishment of renewable energy plant to be located at MBCI. The spreadsheet calculates project-screening information in the form of 20-year life cycle cost analysis that enables users to define projects that are most energy efficient and that offer the greatest financial benefit. The emphasis was on the user interface features of the application to make the application as user friendly as possible. The application has both numerical and graphical data representation using some of the features of Microsoft Visual Basic (VB).The following screenshot shows the DG-ECON, a Distributed generation economic analysis tool prepared for the economic analysis of current renewable energy system at MBCI.

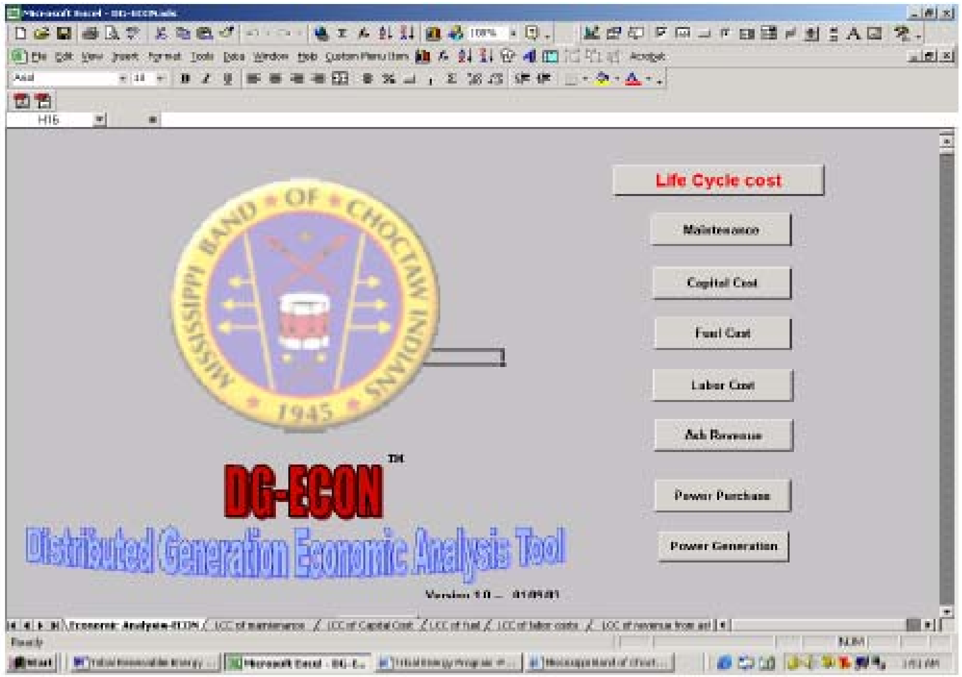


Fig 3.1 Screenshot of DG-ECON, Economic analysis tool

The MSU research team developed the DG-ECON spreadsheet to provide a tool for analysis of the various scenarios that would be possible related to a chicken litter based power plant. The numbers used in this report were collected in the summer of 2003 and then modified with additional information in the summer of 2004. As each site and possible project will have different parameters, future users are encouraged to modify numbers as requirements and technology specifications change.

For this project we have outlined four scenarios. It should be noted that these scenarios represent the best data available at the time. As in many technologies, chicken litter-related technology is making strides toward efficiencies and decreased costs per kWh. These scenarios should be viewed as examples and it is suggested that interested parties use numbers appropriate to their project to get a feel for the financial situation for each individual project. It should also be noted that waste heat costs and/or benefits were not considered in the spreadsheet. Depending on the load serviced by the plant, this could be a significant factor in the economics. Because the 100 kW biomass gasification system was not in production at the time of this work, the numbers were estimated given the resources available.

A brief summary of the general justification of the numbers used is provided below. More details are available upon request. For our analysis a cost of fuel was estimated at $20/ton. This was based on an $8/ton cost for the fuel and transportation and a $12 commodity price. On the capital costs the original price is based on the estimated purchase price of the gen-set, conversion equipment and physical plant necessary to house the power plant equipment as well as the fuel supply. After 10 years it is estimated that the gen-set will have to be replaced and these costs are approximately 50% of the original capital costs. For our original workforce numbers we assumed that three people would rotate between eight-hour shifts on the power plant. While computer control will provide some protection of the equipment and automated operation of the facility, this power plant would be operated near a manufacturing facility and for safety and reliability issues should have regular attention from personnel. Additionally with the large volume of chicken litter there will need to be personnel to handle the purchasing, shipping and stocking of chicken litter near the power plant. Some of these expenses may be able to be shared between staff already on the site of the manufacturing facilities but for completeness we have shown scenarios with one, two and three person helping manage the plant.

For our analysis, these are the things that are common between the scenarios displayed. All numbers are listed as 2003 dollars and adjusted via the discount rate and inflation. A discount rate of 7% and an inflation rate of 2.5% are used for all costs and income. Maintenance costs of $50,000 are year are used. A price of $55/MWh is used for electricity costs and approximately 720 MWh would be produced annually by the 100 kW chicken litter power plant.

The differences between scenarios A, B, C and D are given as shown below in Table 3.4.

Table 3.4: Scenarios analyzed in DG-Econ Spreadsheet Tool

	Scenario A	**Scenario B**	**Scenario C**	**Scenario D**
Capital Costs (per kWh)				Best Case Scenario
Start-Up	$3,500	$3,500	$2,400	$2,400
Replace Gen-Set	$1,750 after 10 years	$1,750 after 10 years	$1,200 after 10 years	$1,200 after 10 years
Fuel Needed	4500 tons per 100 kW/year	2190 tons per kW/year	2190 tons per kW/year	2190 tons per kW/year
Cost of Fuel	$20/ton	$20/ton	$20/ton	$10/ton
Labor	3 people	2 people	1 person	1 person
Ash Value	$5/ litter ton	$10/litter ton	$20/litter ton	$20/litter ton
Power	$55/kWhr	$55/kWhr	$55/kWh with	$55/kWh with
			1.5% increase per year	1.5% increase per year

Scenario A represents values determined in the original research during the summer of 2003.

Scenario B includes updated data on the efficiency of fuel needed provided in the summer of 2004. Additionally staffing was reduced to two people. The value of the ash was increased to $10/litter ton.

Scenario C includes recommended capital costs and ash value costs as supplied by a vendor but these have not been independently verified. Additionally this case employed only one person for operation of the power plant. Since this plant was planned to be operated close to a manufacturing facility as well as an entertainment complex (casinos and hotels), we do not recommend staffing at this level due to safety and reliability issues.

Scenario D includes all the items of Scenario C as well as a $10/ton cost for fuel.

Table 3.4.1 shows the costs and incomes related to the various parts of the chicken-litter power plant.

Table 3.4.1: Scenario Summaries for 20-Year Life Cycle Costs

	Scenario A	Scenario B	Scenario C	Scenario D
Maintenance	$679,665	$679,665	$679,665	$679,665
Capital Costs	$462,687	$462,687	$317,271	$317,271
Fuel	$1,223,396	$595386	$595,386	$297,693
Labor	$1,631,196	$1,087,464	$543,732	$543,732
Ash	-$305,849	-$297,693	-$595,386	-$595,386
Power Produced	-$538,294	-$538,294	-$609,055	-$609,055
20 Year Total	$3,152,801	$1,989,215	$931,613	$633,912
Life Cycle Cost				

IV TECHNICAL FEASIBILITY

4.1. Interconnection of DG to local utility: The capacity of the renewable energy plant is only 100 kW that supply part of load demand of Choctaw commercial laundry facility. So the available option is to run the DG unit parallel to the grid so that both DG and utility can share the load demand of commercial laundry facility. So as per the requirements, there is no need of interconnection of DG to local utility.

4.2. Power Factor Improvement: The power factor at the commercial laundry facility is below the mandatory 85% for most of the time. In such a case, the utility will charge for 85% of KVA rather than the actually KW demand. The power factor fluctuation is plotted in the graphs below.

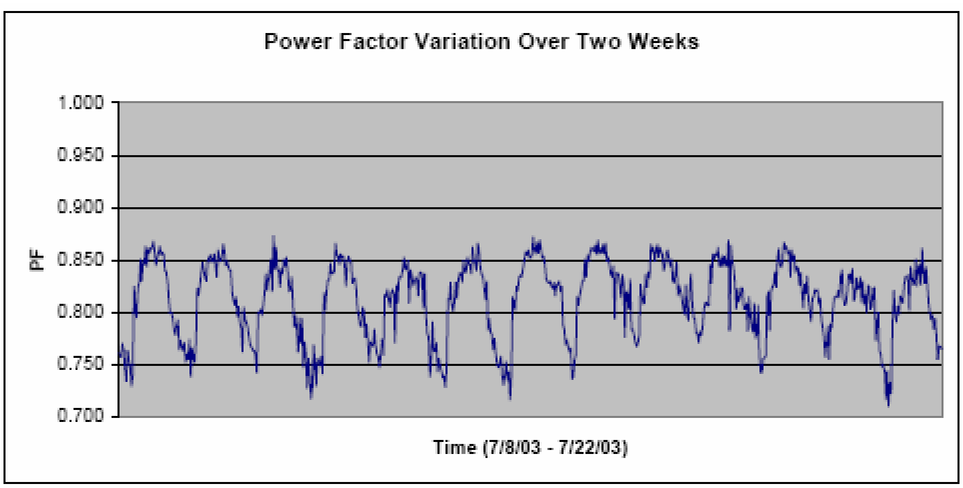


Fig 4.1 The variation of power factor at commercial laundry facility for certain period of time

As a result, power factor penalty charges are being paid to the utility. To avoid the penalty charges, power factor correction capacitors could be installed. Improving the power factor of the load will reduce the utility charges, power losses, and increase in efficiency.

To estimate the proper rating of the capacitor bank, a desired load power factor of 90% was assumed and the kVAr compensation requirements were calculated. The plot given below shows the KVAr required by the load for the power factor to be 90%.

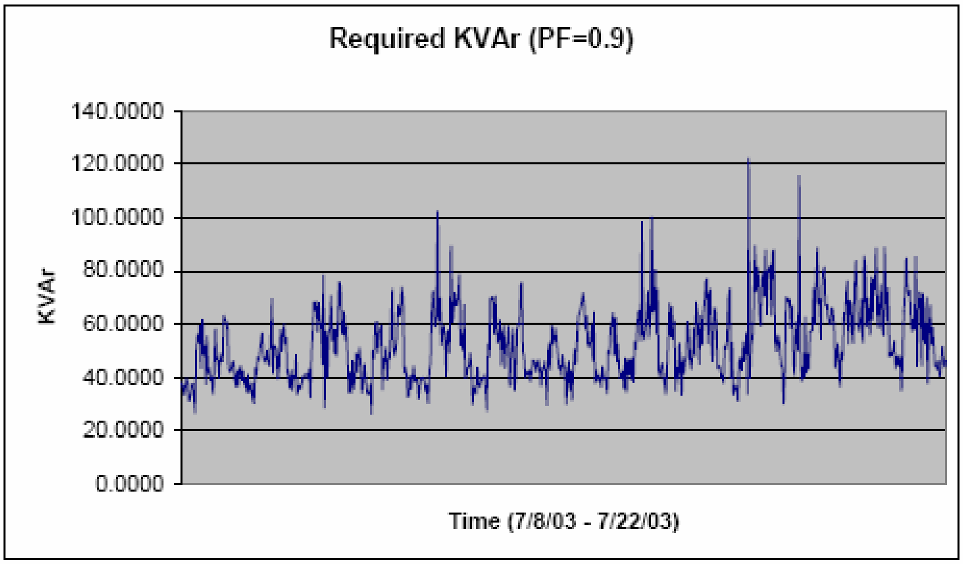


Fig 4.2 The actual KVAr required by load at power factor 0.90

The average required kVAr for the commercial laundry facility was found to be 53 kVAr. The improved power factor of the load was estimated with a capacitor bank of 50 kVAr/480 V.

The improvement in the power factor is shown below.

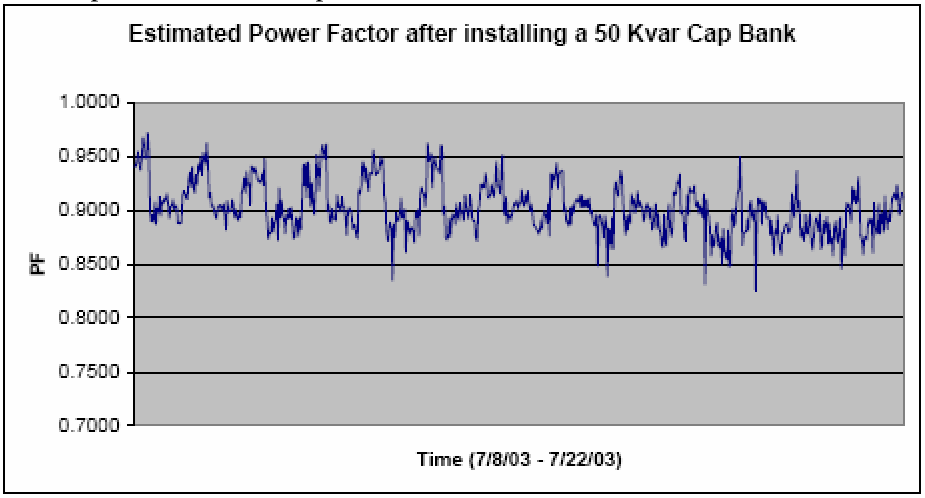


Fig 4.3 The estimated power factor after the installation of Capacitor bank

As seen in the above plot the power factor remains more than 85% most of the time. The best node to connect the capacitor would be the main bus, for it can supply the reactive power requirements for all of the equipment.

Cost of capacitor bank: The cost of the capacitor bank of capacity 50Kvar is $600[7].

V. SUMMARY OF PROJECT

Here is a summary of the key results of this research.

• The load profiles shown in this report document both the kWhr demand as well as the time of use features of the three facilities.
• Besides the kWhr power requirements, the load profiling data shows that several of the facilities have an additional surcharge with their power because of a low power factor (less than 0.85). It is recommended that the MBCI look into options to get some local capacitors to use during heavy loading to decrease this additional cost.
• The economic analysis spreadsheet provides a tool for looking at different biomass DG options depending on costs and savings for the DG.
• The electric load needs of the studied facilities are much greater than the capabilities of current biomass DGs. Because of this, there is no need to add the extra cost and engineering by connecting the DG to the grid. Instead the DG could be connected to the loads directly and would be treated as a negative load instead of generation.

While these facilities are too large for the 100 kW biomass facilities available, we recommend that the MBCI look into loading related to residential and small commercial facilities to see if the systems are cost effective for smaller loads.

REFERENCES

1. D. Gerbec, S. Gasperic, I. Smon and F. Gubina, "An approach to customers daily load profile determination", *Proceeding of IEEE Power Engineering Society 2002 Summer Meeting*, Vol. 1, pp. 587 -591, 2002.
2. Haina Hj Zakaria et al., "Load profiling in the new electricity market", *Proceedings of SCOReD, Research and Development*, 2002, pp. 278 –281
3. http://www.pearlriverresort.com/PropNav_GF/gf.html (Geyser Falls)
4. http://www.pearlriverresort.com/PropNav_GM/gm.html (Golden Moon Casino)
5. The final report on "The Engineering and Economic Feasibility of Using Poultry Litter as a Fuel to Generate Electric Power at Maryland's Eastern Correctional Institute" by The Maryland Environmental Service, February 16,1998, http://www.esm.versar.com/pprp/eci/eci.htm
6. Biomass and Poultry litter availability in MS data provided by MBCI (attached in appendix)
7. www.steelman.com (response from sales representative)

Attachment 3

Technologies for Chicken Litter Projects

Diagnostic Instrumentation and Analysis Laboratory (DIAL)
Mississippi State University
March 25, 2004

There are three companies with developed technologies, which may be feasible for use on the "Renewable Energy on Tribal Lands" project. They are Community Power Corporation (CPC), Waste Transfer Technology (WTT), and Renewable Oil International (ROI).

A good system will consist of a process that is capable of converting a wide range of biomass feedstock to a useable product. The system must be reliable and produce a good quality product. A good quality product can be described as being a high fuel value gas for heating or generating electricity. The capital cost associated with the process must allow for a reasonable return on investment.

Community Power Corporation (CPC) has done extensive Phase I work using chicken litter as a feedstock for its gasifier. CPC's technology can be directed toward either electric power or fuel gas for heating poultry houses. CPC has tested updraft gasifier configuration and downdraft gasifier configuration with both high-density litter pellets and lower density litter. They have determined that the downdraft gasifier configuration using lower density litter works best to achieve better gasification and minimal char inside the gasifier. The downdraft configuration improves the quality of the produced gas. Drying the litter prior to entering the gasifier helps improve gasification by increasing the flame front propagation in the gasifier. Excess moisture causes a decrease in the flame front propagation because the feedstock must dry inside the gasifier. The downdraft gasifier and dried litter produced 45m^3/hr gas with an energy content of 4.79MJ/m^3 and good quality ash.

CPC's Phase II plans include demonstrating a downdraft gasifier with secondary air injection to reduce tar content in the gas using low-density litter pellets and a fluidized bed gasifier with a tar reformer to manage litter fines. The fluidized bed gasifier requires little preprocessing of the litter other than drying. The fluidized bed has the greatest potential for multiple farm scale-up. The fluidized bed offers much better controllability than the downdraft gasifier. The phase II technology work will address the following concerns:

- Reduction of chemical NO_x and amine precursors in producer gas
- Fines in litter feedstock
- Product ash recovery
- Management of excess litter above energy needs of poultry house

Two technologies capable of catalytically reducing nitrogen compounds in the poultry litter producer gas have been identified by CPC. These technologies include a tar reformer and upstream catalytic reduction technology consisting of lower temperature catalytic NO_x reduction. CPC has identified several potentially feasible litter-to-energy solutions which could yield combined heat and power applications life cycle costs reductions as great as 50%. Heat only systems have 30% lower capital cost and are more easily installed and operated than combined heat and power systems.

CPC has determined the equivalent fuel value of poultry litter to be 93 gallons LPG per dry ton poultry litter in a 75% efficient gasifier. One poultry house is capable of producing 125 tons (20% moisture) per year litter with an equivalent fuel value of 9300 gallons LPG using a 75% efficient gasifier or $6000 equivalent value.

Approximately 25 tons of ash is produced by gasification of litter from one poultry house. The value of this ash product is approximately $50/ton wholesale or $1250 per poultry house. In contrast, selling the poultry litter at $5/ton yields only $125 per poultry house. This ash product is high in phosphorous (P_2O_5) and potassium (K_2O) compounds. The value of this ash product could be increased greatly if a commercial product was developed using it, particularly if combined with NH_3.

Life cycle cost comparisons show that a farmer could see a 50% reduction in life cycle costs with a small modular system costing between $13,000 and $20,000. This cost reduction equates to an annual savings between $3,000 and $6,000 per year. Typically, a farmer uses approximately 6000 gallons LPG per year ($0.65 per gallon) and 24,000 kWh per year. Meeting all the energy demands of the farmer will consume only 82 dry tons poultry litter. The heating only demands of the farmer will consume only 54 dry tons poultry litter. Excess litter would create an opportunity for an “Integrated Litter Management Company (LIMCO)” to service poultry farmers with the small modular bio-power equipment and also acquire the excess litter as a low cost feedstock for larger operations.

Waste Transfer Technology (WTT) has developed an Extruder Feeder Liquefaction (EFL) unit, which transforms solid organic materials (biomass) into a petroleum-like crude material (value-added chemicals). Biomass sources for the EFL unit include wheat straw, poultry litter, and corn. The Extruder Feeder Liquefaction technology is similar to the natural process of transforming organic materials below the earth’s surface using high pressure and temperature. The EFL technology is a real-time process. WTT has worked on the pilot plant scale and validated the results in laboratory testing. These petroleum-like products can be fractionated to produce products such as clean liquid fuels, asphalt additives for paving and roofing, coal fines binders, and activated carbon products.

The EFL unit operates near the critical point of water. The operating temperature is approximately 350^{o}C. The EFL unit can operate from 500 to 2,000 psi (lb/in^{2}). This project would require a biomass feed rate of approximately 1,000 pounds per hour. The unit will provide a residence time of 5-20 minutes residence time depending on the feed rate.

WTT can produce a clean liquid fuel by vacuum distillation of its EFL liquefaction crude products. This clean liquid fuel produced from biomass has a heating value of 15,000 BTU/lb and can be blended with fuel oil or diesel fuel for use in internal combustion engines or co-fired with natural gas in distributed power systems. Asphalt additives have been developed which will be sold as value-added products in the petroleum asphalt industry to improve both high temperature and low temperature physical properties of pavement and roofing. A product line of biomass fuels will be produced by pelletizing or briquetting mixtures of biomass waste into densified solid products using a formulated EFL liquefaction binder. This technology will be used to densify any waste biomass to give it a higher heating value and improve material handling. WTT will produce both powdered and pelletized activated carbons. These products have low sulfur, low metals, and low ash content.

A 160 tons per day plant would require a capital investment of approximately $10 million.

WTT technology demonstrates a degree of flexibility in that it is a continuous process with good plant operability, a once through process, and can be operated as a batch process for small plants. The technology can be set up as a central plant with mobile satellite units capable of producing the crude material.

Renewable Oil International (ROI) has developed a technology to make high quality biooils from all types of biomass, including woody materials, animal manure and poultry litter, grasses, and tires and waste plastics. Economic analysis has shown ROI can produce bio-oils that are BTU competitive for use in No. 2 fuel markets without subsidies by using biomass materials costing less than $10 per dry ton. The energy content of the bio-oil product is approximately 80,000 BTU per gallon. This technology does not require boilers or process water. The bio-oil product can be used in most applications where No. 2 fuel oil is consumed, such as, fueling boilers, certain combustion turbines and internal combustion engines, and reciprocating engines. The bio-oil is also a source of a number of chemicals.

Bio-oil plants based on the ROI technology can be made modular and portable. This mobility will allow the bio-oil plant to be taken to the biomass source for use. This is an advantage because it will eliminate the cost of transporting the waste for disposal. The ROI technology development has been ongoing since 1988. Encon Enterprises has been developing pyrolysis technology for the conversion of wood, tires, and agricultural waste into alternative fuels and chemicals. The biomass is first reduced to a coarse sawdust or shavings size and then fed to the process. The products from the process are a low BTU gas, solid charcoal residue, and a liquid fuel referred to as the bio-oil. The bio-oil has been successfully used in gas turbines to generate electricity and has fueled modified diesel engines for stationary power. Typically, the char and gas have been used onsite to dry the incoming biomass and provide the heat required for the reactions. The only residue is an ash product, which can be used as a fertilizer.

At present ROI has a bench-scale unit in operation. ROI is currently seeking funding and a host site for a 5 tons per day demonstration plant. A bio-oils plant consuming 125-tons per day wood feed stocks could produce 15,000 gallons of bio-oil per day, however; the yield using poultry litter would be less due to higher ash content. Preliminary economic analysis has shown that a 125-tons per day bio-oil plant is required to be cost effective. The cost for a 125-tons per day plant would be around $1.2 million for equipment only. This size bio-oils plant would support a 3-MW power plant. A $0.015 per kWh federal tax credit is available for plants using poultry litter as a feedstock.

Based on the research presented it is recommended that Community Power Corporation (CPC) and Waste Transfer Technology (WTT) be investigated further. Both CPC and WTT have done extensive research on the technologies and associated economics.

Waste Transfer Technology has done an in depth study of its technology and the associated economics for the Mississippi Band of Choctaw Indians. WTT proposes a process that converts biomass material into a mixture of thermoplastic polymer intermediates that can be further processed into value added products. This process is biomass Extruder Feeder Liquefaction (EFL) technology. WTT's technology processes shredded biomass material in a high-pressure (200 to 2400 psi) chamber at temperatures in the range of 350$_o$C to 450$_o$C in the absence of air to produce the thermoplastic polymer intermediates. These polymer intermediatescan be further processed to yield value added products such as clean hot high-Btu liquid fuels, wood-fiber plastics composites, and asphalt additives for street and roofing materials.

Additionally, this study includes information on potential major markets for these products and a possible niche market in Mississippi. WTT lists the major competitor for its products and a marketing strategy to surpass it. WTT provides a description of its first commercial plant, which includes a layout of the process components and an economic analysis. This study is included in Attachment 4.

The study on the feasibility of biomass distributed generation equipment for the Mississippi Band of Choctaw Indians compiled by the Department of Electrical Engineering at Mississippi State University is included as Attachment 2. The purpose of this study is to develop an understanding of the energy demands of the MBCI facilities and determine the economic and engineering issues related to utilizing biomass distributed generation for these demands. In particular, it looks at the energy demands of the Geyser Falls water park, Choctaw commercial laundry facility, and the Golden Moon casino. The study shows that the electrical demands of the facilities in the study are much greater than the current capabilities of biomass distributed generation equipment. Based on the findings in this study it is determined that the cost of connecting the distributed generation equipment to the power grid is not economically feasible. It would be more economically advantageous to look at connecting the distributed generation equipment directly to the loads.

This report and its findings are based on the best available data existing during the covering period and the analysis reflects good faith estimates and assumptions of factors for a biomass-based renewable energy project for the Mississippi Band of Choctaw Indians and any conclusions or findings herein should not be extrapolated to other areas of the country.

Attachment 4

Feasibility Study for
Renewable Energy Development on Tribal Lands

Grant & Project Administration by:
Mississippi Band of Choctaw Indians
Office of Economic Development

Subcontract Work for:
Diagnostic Instrumentation and Analysis Laboratory (DIAL)
Mississippi State University

Draft of Final Report on Subcontract by:
Waste Technology Transfer, Inc.
Tucson, Arizona
October 8, 2003

This report and its findings are based on the best available data existing during the covering period and the analysis reflects good faith estimates and assumptions of factors for a biomass-based renewable energy project for the Mississippi Band of Choctaw Indians and any conclusions or findings herein should not be extrapolated to other areas of the country.

Attachment 4

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Diagnostic Instrumentation and Analysis Laboratory, Mississippi State University (DIAL) has identified an emerging technology that can convert mixtures of waste poultry litter and waste wood into clean high-Btu liquid fuels and value-added products. This report summarizes the technology, markets and economics of that technology for Mississippi plant locations. A strategic marketing plan is suggested for the first five plants. It also suggests that this be followed by numerous plants in the “poultry and forestry land” of Southeaster U.S., stretching from Arkansas to Georgia. This is part of the feasibility study upon alternative energy from waste biomass, sponsored by the Mississippi Band of Choctaw Indians.

The emerging technology is called biomass EFL liquefaction, developed by Waste Technology Transfer, Inc., Tucson, Arizona. It converts any biomass, especially those rich in lignocellulosics, into a mixture of thermoplastic polymers that are still reactive to tailor them into specific value-added products. This is accomplished by treating shredded biomass under pressures of 200 to 2400 psi and temperatures of 350 to 450°C in the absence of air. Typically the heating values of the polymer intermediates are double those of the biomass feedstocks (16,000 vs. 8,000 Btu/lb). The U.S. DOE has sponsored research over the past 30 years at numerous labs and three pilot plants, (1) Bechtel-Rust Engineering, Albany, Oregon, (2) Lawrence Labs-U. California, Berkley and (3) University of Arizona, Tucson.

Three major markets are recommended for the State of Mississippi, taking advantage of its natural resources related to its important poultry and forestry industries:

1. Clean hot high-Btu liquid fuels.
2. Woodfiber plastics composites.
3. Asphalt additives for streets and roofing materials.

The economics of a first commercial plant for a Philadelphia, MS plant location are very attractive. Preliminary process designs have been prepared for a 50-ton per day batch plant. Based on an estimated $7,000,000 capital investment, 15-year amortization and 39 percent income taxes, a 43.2 percent return on investment is shown.

Each of the first two plants will require about 120 employees. The next three larger plants may require up to 200 to 300 employees each. Equally important, all of these plants call for a significant number of professional and engineering persons in positions where both men and women are successful in related-type industries.

INTRODUCTION

The poultry sector is the first agricultural sector in Mississippi to exceed $1.5 billion in sales at the farm gate. Total sales of poultry products by Mississippi processors in 1999 exceeded $2.2 billion. Mississippi produces 726 million broilers per year, or 1,347 broilers per minute. Mississippi is the 4th rank state, exceeded only by Georgia, Arkansas and Alabama. On any given day in Mississippi, there are 100 million broilers in broiler houses. If all the corn consumed by broilers in Mississippi were brought in by rail, it would take more than 22,400 jumbo hopper cars per year, or a train with 62 cars of corn each day.

The rapid growth of the poultry industry in Mississippi is creating large quantities of waste poultry litter. The application of waste litter to growing crops is a common practice. Broiler litter application needs to be based on the nutrient content of the litter and the nutrient requirements of the crop. When litter is applied by this standard, it is very effective as a fertilizer and safe for the environment. However, broiler litter applied in excess to crop needs creates a potential for leaching or surface runoff of nitrogen and phosphorus into ground water. The main focus of government environmental regulation is in preventing contamination of ground water with nitrates. Waste poultry litter has other disadvantages: It has an odor for a short time after being applied to soil, especially the first time it gets wet. Broiler litter is also very bulky and contains varying amounts of moisture. The excess moisture increases transportation costs. The nutrient content of broiler litter also is highly variable.

With current interest in energy conservation and less dependence upon petroleum crude imports, the conversion of poultry litter into high Btu liquid fuels and value-added products becomes attractive. An estimated 600,000 to 900,000 tons per year of broiler litter is generated in Mississippi, which is a significant waste resource.

The Mississippi Band of Choctaw Indians (MBCI) proposed a study of the feasibility of siting a renewable energy installation on Tribal Lands. The technologies to be utilized in the renewable energy installation will be those that can readily handle poultry litter, either alone or in combination with wooed residues. The purpose of the study is to determine whether such an installation can be both economically sustainable and consistent with the cultural, social, and economic goals for the Tribe. DOE funding for the feasibility study provides for the development of a thorough business plan that will allow the MBCI to make an informed decision regarding this project.

DIAL, Mississippi State University, has the responsibility for making a technology review to identify one, or more, technical options for detailed economic and technical assessment. The study considered a range of feedstock and product mixes, based on the resource availability assessment. These included poultry litter and mixtures of poultry litter; wood residues as feedstocks; and, electrical power and other ancillary products as outputs. Distributed power sources were also being examined. Technologies ranging from gasification to systems that produce both power and value-added chemicals were considered. Technologies selected for detailed review were those that can be sized to process the amount of available feed (poultry litter, or poultry litter and wood residues), and that also appear to make economic sense in terms of the value of their outputs. This technology review resulted in selecting the emerging technology of biomass EFL liquefaction, being developed by Waste Technology Transfer, Inc. (WTT), Tucson, Arizona. DIAL proposed a subcontract to WTT, effective May 15, 2003, to provide technical, marketing and economic details.

THE TECHNOLOGY

A. Biomass EFL Liquefaction Technology

The EFL liquefaction technology converts any biomass, especially those rich in lignocellulosics, into a mixture of thermoplastic polymers that are still reactive to tailor them into specific value-added products. This is accomplished by treating shredded biomass under pressures of 200 to 2400 psi and temperatures of 350 to 450°C in the absence of air. Typically the heating values of the polymer intermediates are double those of the biomass feedstocks (16,000 vs. 8,000 Btu/lb). The term EFL refers to “Extruder-Feeder Liquefaction”, one of several unique features of WTT’s technology.

WTT has many years of experience in developing the direct liquefaction of biomass into thermoplastic mixtures of polymers and fuels. Extruder Feeder Liquefaction is similar to the process of changing organic materials which nature transforms using pressure and temperature beneath the earth’s surface. Instead of the thousands of years required by nature for this transformation, the EFL technology is a real-time process taking 15 minutes.

The extruder feeder liquefaction process for converting biomass to oil and “valueadded” products was developed in an orderly manner over the past 30 years. It started with the basic laboratory work in the early 1970’s at the U.S. Bureau of Mines. It was part of the R&D thrust for obtaining liquid fuels by alternative energy processes when the price of petroleum crude oils was rapidly increased from about three dollars per barrel to nearly thirty dollars per barrel by OPEC actions. The first pilot plant was constructed at Albany, Oregon, followed by a more advanced pilot plant at the University of Arizona. Both pilot plants were specifically oriented toward oils for liquid fuels only, with no funding for developing value-added products.

The development of the extruder-feeder at the University of Arizona solved a major problem existing at the Albany pilot plant. The problem was two-fold. First, wood flour feedstock was forced into the pressure system intermittently through air locks. Second, a slurry of fresh wood flour feedstock with recycle oil could not exceed 12 wt. % without plugging the check valves on the piston pumps; any higher concentrations plugged the system and stopped operations. The major advantage of the extruder-feeder is its excellent operability on a continuous basis for generating sufficient pressure for pumping a viscous slurry of solids into a pressure system.

WTT has developed a new generation of EFL liquefaction processes, which demonstrate a reasonable degree of flexibility for its technology; e.g. (a) a continuous process with good plant operability, (b) a once through process, (c) a batch process for small plants and (d) a central plant with mobile satellite units. The mobile satellite units are mobile EFL liquefaction units producing only the polymer intermediates.

Biomass liquefaction research was heavily funded by the U.S. DOE in the 1970's and 1980's, and then by private industry in the 1990's. Therefore, we believe it is appropriate (and necessary) to provide a status report upon previous biomass liquefaction research that is relevant to this proposed feasibility study. It illustrates that it is a viable technology, and is ahead of many related energy projects in that it has already developed four value-added products and shows good economics based on pilot plant data.

The initial research work was conducted by the U.S. Bureau of Mines in Pittsburgh, later named the Pittsburgh Energy Research Center (Appell 1971). Extensive exploratory laboratory work was conducted for producing oils from wood, cellulose and urban refuse.

The laboratory work by the Bureau of Mines created interest in constructing a pilot plant. In 1973, Dravo Corporation performed a technical and economic feasibility study for the conversion of manure and/or waste wood to oil, based on the earlier Bureau of Mines experimental results. The study also included the conceptual design of a 3-ton per day pilot plant for waste wood liquefaction using three processing alternatives.

Rust Engineering Company provided the detailed engineering design for the pilot plant in 1974. The pilot plant was subsequently constructed by Bechtel Corporation at the Metallurgical Research Center of the Bureau of Mines in Albany, Oregon. In 1975, Bechtel prepared a series of detailed recommendations for the pilot plant under construction, including a consideration of alternative feedstocks (e.g., municipal solid waste, and agricultural wastes) in addition to wood wastes for processing at the facility. In late 1976, ERDA (now DOE) awarded a contract to Bechtel National, Inc., to monitor completion of construction and initially operate the facility. Rust Engineering took over pilot plant operations to produce about 50 barrels of crude wood oils.

The extruder-feeder not only provided a continuous feeding system into the pressure system, but also could pump a 60 wt. % of wood flour in recycle oil. This development of the extruder-feeder in the 1978-1980 period led to a second generation of the biomass liquefaction process. The advance process was designed and constructed at the University of Arizona during the period 1981-1984, and operated through 1998. Final analysis of data and reporting was completed in October 1991.

The pilot plant at the University of Arizona was located on the University's local Agricultural Farm, North Campbell, Tucson. A total of over 60 experimental runs were made. These were conducted on a continuous basis, controlled by a real-time computer system. Typically, electrical heaters were turned on at 6:00 a.m., the run started at about 9:00 a.m. and "lined-out" data taken from 10:00 a.m. to about 6:00p.m. One long run of 52 hours on a continuous basis was made to show operability - terminated by lack of prepared wood feedstock.

Other Fundamental Research

In addition, a total of 17 fundamental research projects were completed on this DOEsponsored liquefaction research by M.S. graduate students and one Ph.D. student in chemical engineering. Dr. Don H. White was Principal Investigator for all of this work.

1. A special laboratory single-screw extruder was designed, constructed and operated to supplement the two 1.75-inch diameter, 24 L/D single screw extruders in the pilot plant (Quevedo 1981).
2. A software program for on-line data acquisition was prepared and hardware installed on a 1.75-inch extruder for acquiring and correlating extruder energy balances (Iregbulem, I.A.).
3. Extensive rheology data upon liquefaction products and related model compound systems has been collected (Chehab 1982).
4. Concentrated mixtures of pentose and hexose sugars were prepared experimentally from Douglas Fir wood (Joshi 1983).
5. A fundamental rheology study was conducted upon concentrated slurries of liquefied products (Lezzar 1983).
6. Various solvents were investigated for biomass liquefaction at temperature up to 670ºF (Moghaddam 1984).
7. Gas were dispersed into viscous liquefaction products using a rotating spray nozzle attached to the end of the screw of a single screw extruder (Khan 1984).
8. A special tapered annular valve was designed, constructed and tested in a single screw extruder (Wong 1986).
9. A real-time computer control system was designed, installed and operated in the Tucson liquefaction pilot plant (Andrews 1984).
10. Control valves, level controllers, thermocouples, pressure transducers, electrical heater, rheostats and other sensors were assembled, installed and operated in the Tucson liquefaction pilot plant (Joshi 1985).
11. A High-Pressure, High-Temperature superheated steam system was designed, constructed and installed in the Tucson liquefaction pilot plant (Reyes 1985).
12. The "University of Arizona-Designed-Control-System" was replaced by "The-Fix Software" of Interlution Inc. (Davenport 1989).
13. The crude wood oils from the experimental pilot plant in Tucson were characterized by both chemical and physical properties (Zhao 1987).
14. Extensive vacuum distillation work was conducted upon the biomass liquefaction oils from the Tucson pilot plant (Cranford 1989).
15. Autoclave liquefaction batch runs with short residence times were conducted (Mathews 1990).

16. Various activated carbon products were prepared from the crude liquefaction oils from the Tucson pilot plant (Chen 1995).
17. Polymeric compatabilizers were evaluated in engineering resin systems (Park 1994).

B. Woodfiber Plastics Composites Technology

Wood plastic composites usually have 20 to 60 wt.% of woodfibers (fine sawdust) well mixed into a melted thermoplastic resin, along with additives. Most wood plastic composites are manufactured by extrusion systems, which have been developed continuously over the past 60 to 70 years for the multi-billion dollar plastics industries. Plastics extruders are now modular in construction and very reliable in performance. With proper maintenance, they last 50 years and are often upgraded by new technology. The wood plastics composites industry is only 20 to 30 years old but reliable complete extrusion systems are now available for the composite industry. The largest half dozen extruder manufacturers are global in scope and can purchase machine parts and dies from many places throughout the world. The most advanced extrusion technologies are in the United States and Germany.

Fortunately, WTT has extensive experience in plastics extrusion, as well as in biomass liquefaction technology. Dr. Don White was elected as the 50th Fellow in the Society of Plastic Engineers (out of 40,000 members). Barry Cooper, Vice President for Technology, WTT, is nationally known for his invention of stretch plastic film - -now a multi-billion dollar industry. Dr. Nick Schott, former Ph.D. student of Dr. White, has put engineering into the Plastics Engineering Department, U. Mass at Lowell, over the past 30 years to where it is now the only plastics engineering department in the USA to earn engineering accreditation by ABET. Dr. David Wolf, Israel, ahs been Dr. White’s associate in plastics and liquefaction research during 27 of the last 29 summers, working Tucson.

The single screw extruder is the “work horse” of the industry and is the most economical wherever it can be utilized. It is excellent for melting the recycled plastic to be used in composites. The twin screw is better for (a) mixing the melted plastic with the wood fibers and other additives and (b) for not breaking up the fiber nature of the wood particles. Therefore, a preferred method is to melt a plastic resin in a single screw extruder, followed by a gear pump to help smooth pressure fluctuations, and to force the melted plastic into the feed end of a twin screw extruder. The single screw extruder can develop whatever pressure is necessary to feed the viscous plastic melt into the twin screw extruder.

Almost all twin screw extruders use segmented screws that are assembled on high torque splined and hammered shafts. Barrels are also modular and can be configured from the following type sections: feed, plain, vent, side stuff, and liquid addition. Each barrel section is electrically heated, uses its own PID temperature controller, and is usually internally cored for high intensity cooling via liquid near the process melt. The modular nature of twin screw extruders offers process flexibility with regard to rearrangement of barrels, making the L/D longer or shorter, and for screw modifications.

Twin-screw compounding extruders perform these basic functions: feeding, melting, mixing, venting, developing die/localized pressure, and conveying. The segmented nature of the twin screw extruder in combination with controlled pumping and wiping allows specific screw and barrel geometrics to be matched to the required process tasks. This allows the same machine to perform both dispersive and distributive mixing, which is a major benefit for certain products.

The heart of any twin screw compounding extruder is its screws. There are seemginly an infinite number of screw design variations possible. There are, however, only three basic types of screw elements. Flighted elements to move material past barrel ports, elements for thorough mixing and elements to move materials out of the extruder to the die. Zoning elements isolate two operations within the extruder. Screws can be made shear intensive or passive, based upon the elements used in the design.

C. Asphalt Additive Technology

Highways, county roads, city streets and parking lots are 95 percent asphaltic formulations. Recycled tire rubber can now be processed into hot asphalt mixes, so that roads provide smoother riding and less road noise. Trucking traffic, increased speeds and tire pressures are forcing the industry to construct more durable roads. This is now being accomplished by adding expensive petroleum-derived polymers to the asphalt to (a) reduce brittleness at freezing temperatures and (b) to prevent rutting at high road temperatures.

WTT has developed proprietary asphalt additives, which will be sold as value-added products in the petroleum asphalt industry to improve both low temperature and high temperature physical properties of pavements and roofing. The asphalt market is approximately 30,000,000 tons annually with revenues of nearly four billion dollars. The potential market for asphalt additives is an estimated 1.2 billion dollars.

The current companies competing in the asphalt additive field are the producers of ethylene/propylene copolymer elastomers, such as DuPont, Shell and Phillips Petroleum. However, the major markets for these polymers are directed mainly to the plastics industry, and these products are derived from expensive petroleum-based ethylene and propylene, requiring a sales price greater than 60 cents per pound ($1200 per ton) in order to show a profit.

THE MARKET

WTT is an engineering and R&D company, established in 1992. It plans to widely license its various technologies, with emphasis upon recycling materials and its biomass EFL liquefaction technology. It plans to partner with a few of its future licensees. Its technologies have wide applications, but it has focused upon a narrow niche for this particular feasibility study for the State of Mississippi.

A. Major Markets
Major projects and markets will come from alleviating an environmental problem by converting wastes into economic products. These major markets are summarized below.
Environmental Solutions
(1) Help prevent and control forest fires endangering valuable properties.
(2) Make national forests and state parks better nature and recreational areas.
(3) Convert MSW landfills into "dry landfills" with no toxic leachates and no generation of methane gas.
(4) Provide MSW transfer stations with waste reduction and decreased costs.
(5) Assist in rubber tire and waste plastics disposal.
(6) Provide the broiler, turkey, and laying hens industries with healthier litter material and a more profitable method of disposal.
(7) Co-process municipal sewage sludges with lignocellulosics to eliminate spreading toxic metals upon agricultural soils.
(8) Help Indian Nations restore their forests.
(9) Help rural communities by economic utilization of their agricultural residues.
(10) Help depressed communities improve their welfare by using the new concept of Eco-industrial Parks that combine ecology with good economics, and by reducing transportation costs of raw materials and finished products.
(11) International-Provide distributive electrical power, potable water and sewage systems for third world villages.

B. Special Market Niche for Mississippi
The improper thinning of overcrowded Ponderosa Pine in the White Mountains of Arizona has revealed an astounding fact. The cross-section of three trees exactly the same age were 16, 7 and 2-inches in diameter. The 16-inch tree in the open grew 5-fold more wood then the partially shaded 7-inch tree and 60-fold more wood than the totally shaded 2-inch Ponderosa Pine. Does Mississippi have this same problem of not growing as much good timber lumber trees as it should due to insufficient thinning?

According to Short and Hooper, "Production and Utilization of Industrial Wood and Bark Residues in Mississippi," dated April 1996, two other facts appear important.
(1) The wood products manufacturing industry is Mississippi's largest manufacturing sector employing over 65,000 people. Its raw material value exceeded $1.1 billion in 1995 and the estimated total economic impact to the State was over $3.1 billion.

(2) With a 1995 harvest value of over $1.1 billion, timber is Mississippi's leading agricultural commodity.

Some of the other facts about forestry in Mississippi are that it is largely a forested state, namely, 62 percent based on 18,595,400 acres of total forestland out of a total state acreage of 30,024,800 acres. Equally important, 16,636,400 acres of forestland is privately owned (89.5%).

As stated earlier in the introduction, the "poultry sector is the first agricultural sector in Mississippi to exceed $1.5 billion in sales at the farm gate." Therefore, it becomes obvious that the current feasibility study should focus upon these two industries.

Wood-Plastic Composites:

The wood-plastic composites (WPC) industry provides an optimal market to pursue for commercialization in the State of Mississippi. The wood-plastic composites industry is relatively young, being initiated about 20-30 years ago as a result of the interest in recycling plastics. Wood-plastic composites are formulated by mixing 10 to 70 percent of wood fibers into melted waste plastic as a matrix. The formulation of composite resulting from WTT's EFL process provides properties that cannot be obtained by wood and plastics alone. These products are not to be confused with the so-called plastic lumber, which are composed of 100% recycled plastics.

The majority of current applications are in the United States where significant advances are being made and finished products such as outdoor decking, marina docks, door and window cladding, auto and recreational vehicle components, and furniture components are on the market. The WPC market has grown at a rate of 25 percent per year for the past five years and shows no sign of slowing as new processes and applications are developed. The current growth rate is 18 percent annually. While the current use of the products has been in the outdoor replacement of wood products, engineering applications are being developed to use the improved physical properties of WPC in new applications.

A brief summary of the markets for woodfiber plastics composites, based just upon three studies but which are believed to be reliable, is given below.

Brief Market Summary

The USA natural fiber and wood-plastic composite (WPC) market was 750,000,000 pounds in 2001 and is estimated to grow to 1,400,000,000 pounds by 2006 (Markariam, 2002). The WPC industry is growing at an annual rate of 18% but still is only a fraction of one percent of the total wood products industry (Smith, 2001).

The major markets for wood-plastic composites are (1):

(1) Building Products Decking, Fencing, Siding, Decoration Trim, Windows & Doors	66 %
(2) Infrastructure Boardwalks, Marinas, Guard Rails	18 %
(3) Transportation Interior Auto Panels, Truck Floors, Headliners	10 %
(4) Industrial/Consumer Pallets, Panels, Playground Equipment, Benches, Chains	6 %
	100 %

The USA natural fiber and wood-plastic composites market is estimated (Markariam, 2002):

Year	Annual Sales, Pounds
2001	750,000,000
2002	850,000,000
2003	1,000,000,000
2004	1,400,000,000

The largest current market for wood-plastic composites is for outdoor deck boards and railings (Smith, 2001). The USA market was $3.2 billion in 2000 and projected to be $3.9 billion in 2005, with a distribution as follows:

	Year 2001, %
Pressure treated lumber (75 % pine)	80
Redwood	6
Cedar	3
Plastic lumber	2
Wood-Plastic Composites	8
Imported	1
	100

It is predicted that residential decking will continue to grow, based upon strong home building, remodeling and the desire to extend the home to more patio living. Growth will continue in other building products, based upon the superior properties of WPC, e.g. nonwarping, water resistance, less maintenance and resistance to molds, insects and microorganisms.

Residential construction in the USA now exceeds $300 billion per year and spending on residential improvements and repairs is about $120 billion per year (Cannon, 1999). Wood-plastic composites cannot compete with dimensional lumber in residential construction in either price or structural properties. However, these composites are penetrating these building industries in niche applications in a steady manner. For example, cellular (foamed) polyvinyl chloride (PVC) has an established position in residential windows. Window sales by material category in 1998 was as follows (Cannon, 1999):

		Millions of Windows
Material	New Construction	Remodeling
Wood	12,500,000	10,500,000
Aluminum	3,500,000	3,500,000
Vinyl	8,900,000	4,100,000
Other	600,000	300,000
TOTAL	25,500,000	28,400,000

REFERENCES

1. Markarian, J. 2002. Additive Developments Aid Growth in Wood-Plastic Composites. Plastics Additives & Compounding, November, pp. 18 – 32.
2. Smith, P.M. 2001. U.S. Woodfiber-Plastic Composite Decking Market. In: Proc. Sixth International Conference Woodfiber-Plastic Composites. Forest Prod. Soc., Madison, WI, pp. 13 – 17.
3. Cannon, C. 1999. The Changing Nature of Windows Materials in North America. In: Fifth International Conference Woodfiber-Plastic Composites. Forest Prod. Soc., Madison, WI, pp. 23 – 25.

C. The Growing Asphalt Additive Market

Primary Industry – Asphalt

The tailored grades of asphalt additives developed by WTT can be sold into both paving grades and roofing grades of petroleum asphalts. The asphalt industry is a large commodity market that functions largely on supply and demand. The polymer additives currently used in asphalt are high-priced, but effective in (a) preventing asphalt brittleness in cold climates and (b) helping prevent road rutting in hot climates. WTT has developed products suitable for both hot and cold climates, and can be produced more economically than petroleum-derived asphalt additives. They will enter the market place through street maintenance, parking lot and country roads, saving in maintenance costs.

Asphalt Production by States

There are 161 active petroleum refineries in the USA. Petroleum asphalt is produced in 61 refineries in 25 different states. The installed capacity for asphalt is 623,360 barrels per calendar day in 1998, a decrease of 60,600 barrels per calendar day (8.9%) over the year 1997. All 61 producers of asphalt are potential customers for the additives developed by WTT.

Large Producers of Asphalt

Ten petroleum refineries have a total asphalt production capacity of 327,800 barrels per calendar day, which is 52,6% of total capacity in the USA. These plants are located in New Jersey, Illinois, Indiana, Michigan, Louisiana, Georgia, Minnesota and Kentucky (8 states). They are owned by Amoco, Shell, Marathon Ashland, Citgo, Chevron, Koch, an Tosco.

Medium-Size Asphalt Refineries
There are 25 medium-size refineries producing asphalt in 15 states, namely Alabama, Arkansas, California, Colorado, Illinois, Minnesota, Montana, New Jersey, Ohio, Oklahoma, Oregon, Pennsylvania, Texas, Washington and Wisconsin. Their total capacity for asphalt is 223,780 barrels per calendar day, or 35.9% of the total USA capacity. These are owned by about 22 different companies.

Small Asphalt Refineries
There are 26 small refineries producing asphalt in 13 states, namely, Arkansas, California, Georgia, Hawaii, Illinois, Louisiana, Mississippi, New Mexico, Oklahoma, Texas, Utah, Washington and Wyoming. Their combined capacity for asphalt is 71,780 barrels per calendar day, which is only 11.5% of the total USA capacity.

Refineries Producing FCC Heavy Oils
WTT has a unique use of FCC high-boiling gas oils in its bio-additives for petroleum asphalt. The crude liquefaction base for these additives is actually an “asphalt concentrate” which needs up to 20 weight percent of a high-boiling oil to make it more like conventional petroleum asphalts. This can be done by FCC oils or certain other heavy oils. FCC oils are also a beneficial carrier in the liquefaction process itself. FCC oils cost about half that asphalt, such that economics are also benefited.

FCC oils are the high boiling gas oils from fluidized catalytic cracking units, which are utilized in all modem refineries making gasoline and jet fuels. A total of 105 petroleum refineries in the USA (out of the total of 161 refineries) produce large quantities of catalytic cracked heavy oils, and thus have large quantities of FCC heavy gas oils. These oils are disposed of in whatever way possible for their fuel value. These catalytic cracking facilities are available in refineries in 26 different states in the USA.

The utilization of FCC heavy oils in the bio-additives for petroleum asphalts is optional, as many alternative formulation approaches are technically feasible.

D. Clean High-Btu Biomass-Derived Fuels
The Biomass EFL Liquefaction process produces an intermediate product that is a liquid mixture of thermoplastic polymers for further processing into value-added products. This intermediate product is often called “petroleum-like crude oil” because it has a heat of combustion value double that of its biomass feedstock (15,000 Btu/lb vs. 8500 Btu/lb for a clean pine wood, dry basis). This clean fuel (no sulfur, low ash) has many obvious markets.

(1) Co-Fire with natural gas in gas turbine generator units for electrical power.

(2) Co-Fire with powdered coal in existing coal-fire electrical power plants.
(3) Direct combustion for schools, hospitals and buildings not having natural gas connections.
(4) Blend stock for Fuel Oil No. 2.

THE COMPETITION

There are an estimated 30 to 40 companies now manufacturing woodfiber plastics composites. They are mostly small in size and sales. The largest manufacturer (TREX) is detailed below.
However, it is believed that the major competition is not the composite manufacturers, but rather the outdoor residential decking group still using treated wood, especially pine. As shown above, treated wood was specified for 80 percent of new decks in 2001. The voluntary phasing out of chromated copper arsenate (CCA) around residential homes may help composite decking as a replacement for CCA-treated wood because there does not appear to be a reliable replacement for CCA.

Trex Company Inc, Winchester, Virginia (From Standard & Poors Stock reports Aug. 7, 2003)
This company is the largest U.S. manufacturer of non-wood decking marketed under the brand name Trex. It is a publicly-held corporation with annual sales as follows:

Year	Revenue, Dollars
1997	$ 34,100,000
1998	46,800,000
1999	74,300,000
2000	118,000,000
2001	117,000,000
2002	167,000,000
2003 (Est.)	200,000,000

The company increased the number of dealers who sell Trex to 3,300 and expanded the number of qualified TrexPros, its contractor partners, to 2,700, up 47% from 2002 year end levels. Products are sold through about 90 wholesale distribution locations to more than 3,300 independent contractor-oriented retailer lumberyards across the U.S.

According to an industry source, more than 3,000,000 decks are built each year in the U.S., as homeowners and builders look for ways to extend living areas and provide outdoor recreation and entertainment spaces. This is good news for Trex Co., the largest U.S. maker of non-wood decking alternative products. TWP's Trex Wood-Polymer lumber is a wood/plastic composite made from waste wood fibers and reclaimed polyethylene that the company believes provides the workability of *popular lumber sizes and is sold in five colors; Natural, Winchester Grey, Madeira, Woodland Brown and Saddle. In 2002, the company extended its offering of railing products by adding a Chamfered handrail and decorative post cap to its product line.*

In the decking business, wood is still king, with a market share of about 93%; the remaining market share is divided between 100% plastic lumber, and wood/plastic composites like the company's Trex brand. TWP seek to achieve sales growth in the decking products into demand for Trex, which it promotes as a premium decking product. In 2002, net sales of Trex exceeded $167 million, up sharply from $600,000 in 1992. According to the company, Trex eliminates many of wood's major functional disadvantages, such as warping, splitting, and other damage from moisture, without the need for stains or sealants. Trex provides a splinter-free surface and needs no chemical treatment against insect infestation. TWP believes these features eliminate the ongoing maintenance requirements of wood decks, and make Trex less costly than wood over the life of the deck. However, the company notes that its product does not have the tensile strength of wood, and is therefore not used as a primary structural member in posts, beams or columns in a deck's substructure.

Trex is used mainly in residential decking, although builders of commercial decks (for restaurants, hotels and other establishments)also buy the company's products. Since contractors generally build larger, more elaborate residential decks than the ones that homeowners build themselves, TWP focuses on the contractor installed market segment. Products are sold through about 90 wholesale distribution locations, which sell Trex decking to more that 3,300 independent contractororiented retailer lumberyards across the U.S.

TWP obtains brand name recognition through its association with highly publicized showcase projects. Trex decking was used in a number o new projects in 2002, including Gulf Island National Seashore Boardwalk in Ocean Springs, Ms, Vero Beach Marina in Vero Beach, FL, Monterey Dunes Boardwalk in Monterey, CA, and Dock and Boardwalk at Disney World in Orlando, FL.

In 2002, the Environmental Protection Agency announced an agreement under which manufacturers will voluntarily phase out, by December 2003, the residential use of chromated copper arsenate (CCA), which is a preservative used in about 90% of all pressure-treated lumber. The company believes that the publicity relating to this agreement will contribute to increases in sales of wood/plastic composites and 100% plastic lumber for decking by raising consumer awareness of active chemicals in pressure-treated lumber.

MARKET STRATEGY

The Mississippi Band of Choctaw Indians can have a significant impact upon the culture, life styles and economy of the State of Mississippi by constructing upon its properties the first 3 to 5 plants proposed herein. It could own all or portions of these plants. It could encourage some of its young men and women to train for a share of the key jobs among the over 100 new jobs created by each of these proposed plants, e.g. (1)forestry, with emphasis upon the health and beauty of good forests, (2)agriculture, with emphasis upon poultry management and genetics or upon tree species genetics, (3)architectural design and landscaping, with emphasis upon new building materials and (4)engineering, stressing all major branches of chemical, materials, electrical, electronics, mechanical, civil and systems. Item (4) above is wide open to both men and women, and is predicted to be in short supply over the next 20 years.

Specific market strategies include:

1. Focus upon the poultry, forest and agricultural industries, which are prime natural resources for the land and climate of Mississippi.
2. Retrofit the closed Georgia Pacific sawmill, Philadelphia, MS, for the first commercial plant, in order to minimize capital investment and thus help assure that the first plant is an economic success.
3. Establish field offices and wholesale warehouses in Jackson, MS, Memphis, TN and New Orleans, LA from the very start in order to attain desired sales and to gain credibility for its brand name.
4. Select a brand name early on and promote it by excellent customer services. One suggested name is “Southeastern Wood Composites”, so that the eventual goal of competing throughout the southeastern states (with similar poultry production and forest characteristics) could be achieved over a 10 to 20 year period.
5. Identify which new jobs fit the culture and life styles of the Choctaw’s and start encouraging some of their young people to start training for these positions by choosing the corresponding majors in their college careers.
6. Establish the long-term goal of making each new commercial plant serve an additional market of interest to the State of Mississippi. One practical path for such a long-term goal is as follows:

   <u>Plant 1</u>

   Convert poultry litter and wood waste into two or more value-added products where expensive petroleum ethylene, propylene and butadiene can’t compete on a cost basis, and simultaneously provide some clean liquid fuels.

   <u>Plant 2</u>

   Construct Plant 2 further south of Philadelphia, MS, except with more capacity, to serve a greater number of the poultry barns. Consider expanding Plant 1 for the same purpose.

   <u>Plant 3</u>

   Same products as first two plants, except make larger quantities of hot high-Btu liquid fuels for combustion in gas turbine electrical generators. This

process may include some "crude oil" hydrocracking for greater fuel yields.
Plant 4
Same products as in Plant 3 except co-fire some of the "high-Btu liquid biomass fuel" with powdered coal in coal-fired power plants. This could also be applied to the lignite coal-fired power plant in Mississippi.
Plant 5
Learn how to operate biomass liquefaction with minimal post-reactions so that distillation fractions have properties that are similar to petroleum fractions or complement the petroleum properties.

Then co-process the biomass liquid crude with appropriate petroleum crudes to give:

Fraction	Boiling Point Range, ºF
(1) Light naphtha	30-300
(2) Gasoline	30-355
(3) Heavy naphtha	300-400
(4) Kerosene	400-500
(5) Stove oil	400-550
(6) Light gas oil	400-600
(7) Heavy gas oil	600-800
(8) Lubricating oil	> 750
(9) Vacuum gas oil	800-1,000
(10) Residuum	> 1,000

7. At any appropriate time in developing these plants in Mississippi, expand by constructing commercial plants and establishing field offices in other states, covering the poultry industry from Arkansas to Georgia, and paying equal attention to the similar waste wood problems in all of these Southeastern states.

FIRST COMMERCIAL PLANT

A. Process Design

This plant design essentially maximizes a family of woodfiber-plastic composites because these products have high value compared with liquid fuels and the small quantities of asphalt additives. A basic premise is that 10 wt.% of the EFL liquefaction intermediate product will be incorporated into the composite as compatibilizers, plastic plasticizers, coupling agents and processing lubricants. The ratio of woodfibers to plastic will vary in commercial composites, but all calculations here are based upon 45 wt.% woodfibers and 45 wt.% plastics in all composites.

PREMISES
1. Feedstock:
(a) Clean shredded wood, 45 wt.% moisture, 8500 Btu/lb heating value (dry

basis).
(b) Mixtures of poultry litter and wood wastes from any source.
2. EFL Liquefaction Yields:

Component	Wt. %
Heavy intermediate polymers	47
Light Liquids (Overhead)	6
Methane in gases	1
Carbon Dioxide	23
Water	23
	100

3. Processing of Intermediate Products

(a) Light ends burned as fuel in the EFL liquefaction process:

Methane	1 wt.%
Lights (OH)	6
Lights out of Heavies	4
	11 wt. %

(b) Next 20 wt. % by fractionation into five fuels, namely,

(1) Fuel Oil Blendstock
(2) Diesel/Biodiesel Blendstock
(3) Clean Liquids for Gas Turbine
(4) Binders for Densified Waste Biomass Pellets
(5) Binders for Waste Coal Fines Briquettes

These fuels can be formulated from the EFL intermediate polymer product in any desired proportions - - all in one fuel category if desired. For this specific plant design, 20 wt.% of the EFL intermediate polymer product is processed into one clean fuel product with a combustion heating value of 15,000 Btu per pound minimum.

(c) The remaining heavy intermediates (47 wt.% - 24 wt.% = 23 wt.%) are processed into woodfiber-plastic composite components.

4. Composite Composition

For purposes of this plant design the woodfiber-plastic composites have the following composition:

Woodfibers	45 wt.%
Plastics	45 wt.%
EFL Components	10 wt.%
	100 wt.%

*NOTE: Some products need no additional additives, but others need additives in order to meet the use needs and to be competitive.

MASS BALANCE FOR 50 Ton per Day PLANT

(1) Feedstock:

25 Tons/Day (dry basis) fresh wood sawdust
25 Tons/Day (dry basis) mixture of poultry litter/wood waste (can be flexible upon quantity of each).

(2) Intermediate products to fuels
11% of intermediate

(3) Five Fuel Products
After burning 11 % of intermediate products, there are 47% - 4% = 43% of intermediate remaining for conversion into fuels and composites.

The process details (a) of how the products are made, (b) description of equipment used and (c) the details of the estimated capital cost are proprietary and are not disclosed herein. However, when and if there is serious consideration being given to authorizing the construction of the first commercial plant proposed herein, then this material can be disclosed to those that have a need to know under confidentiality agreements.

B. Plant Facilities

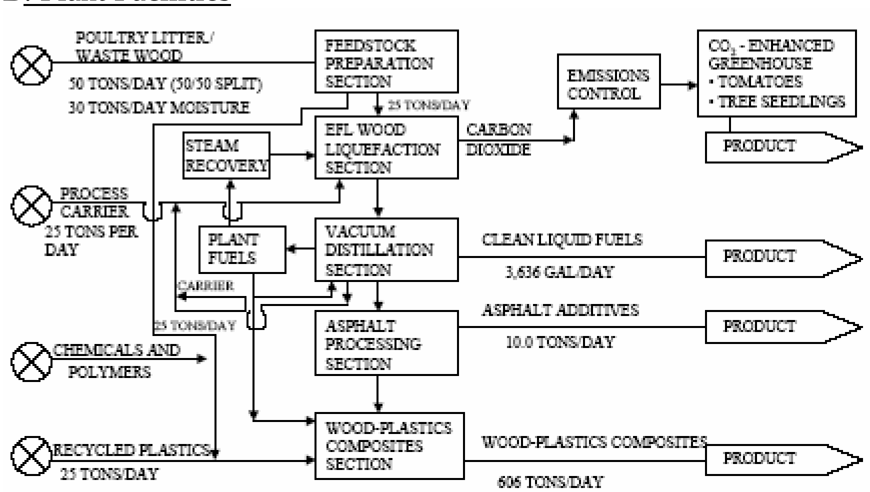
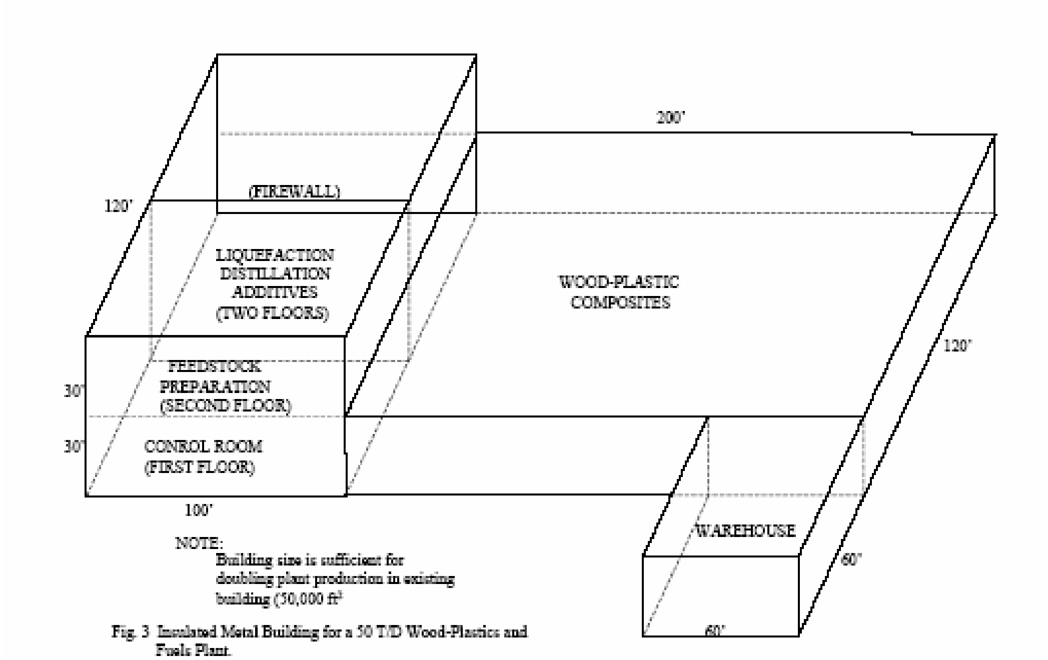


Fig. 1. Schematic Block Diagram for a 50 Ton per Day EFL Liquefaction Plant.



NOTE: Building size is sufficient for doubling plant production in existing building (50,000 sq. ft)

Fig. 3 Insulated Metal Building for a 50 T/D Wood-Plastics and
Fuels Plant.

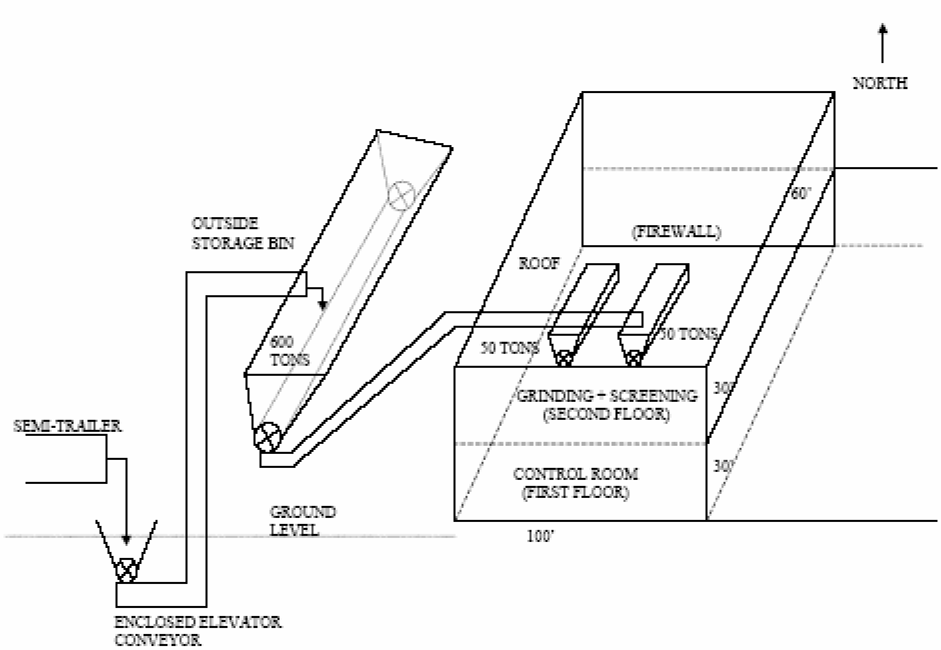


Fig. 4. Feedstock Preparation Section in South End of Building for a 50 T/D Wood-Plastics Composites and Fuels Plant.

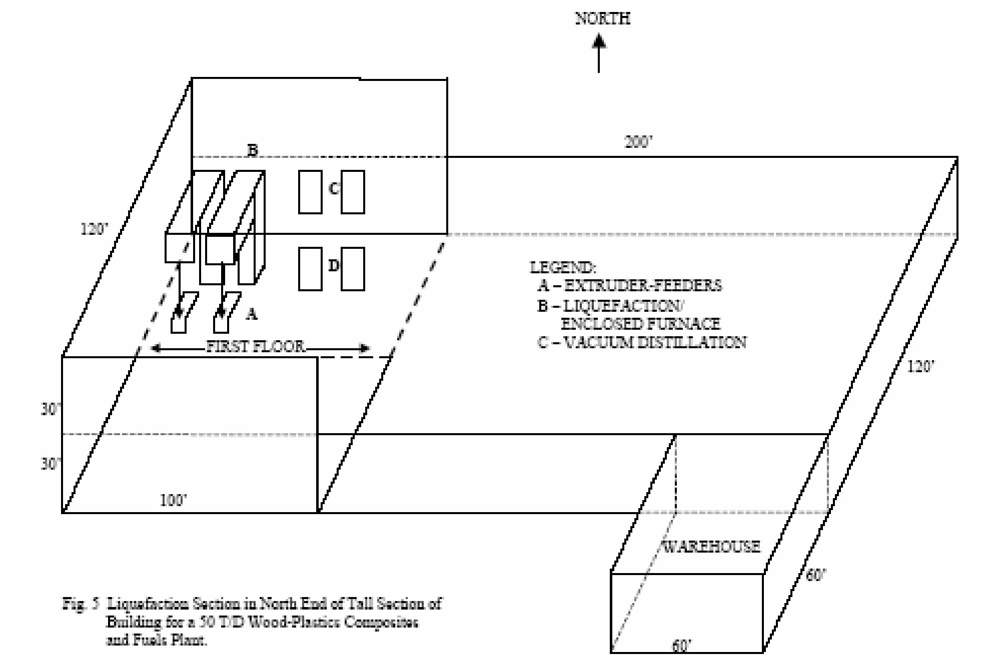


Fig. 5 Liquefaction Section in North End of Tall Section of
Building for a 50 T/D Wood-Plastics Composites
and Fuels Plant.

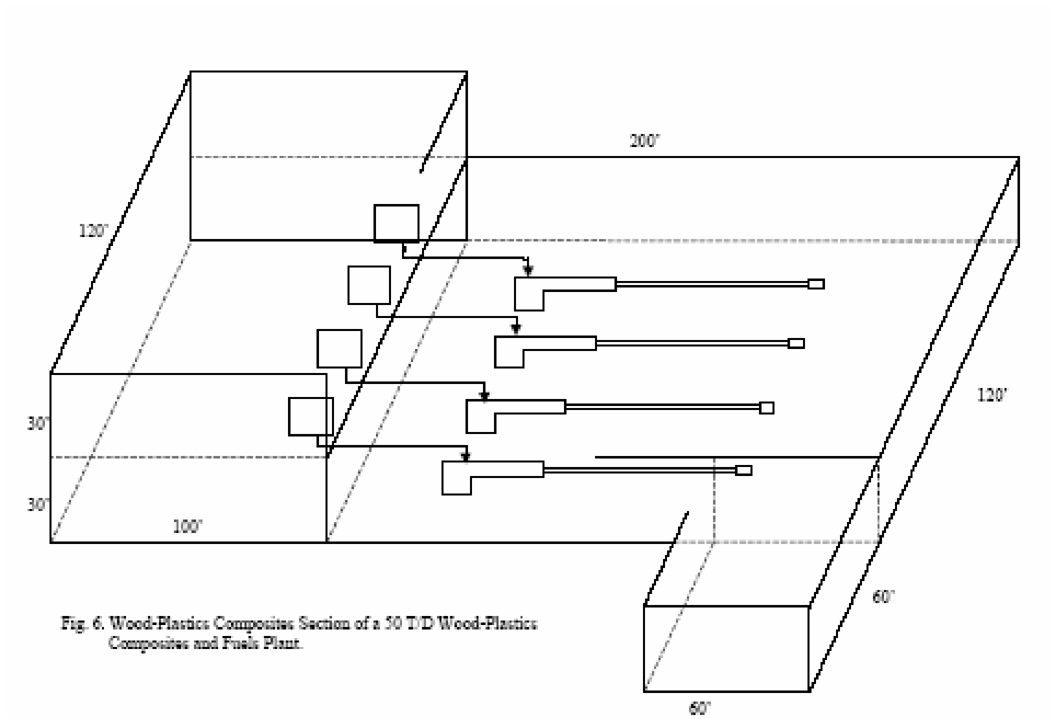


Fig. 6. Wood-Plastics Composites Section of a 50 T/D Wood-Plastics
Composites and Fuels Plant.

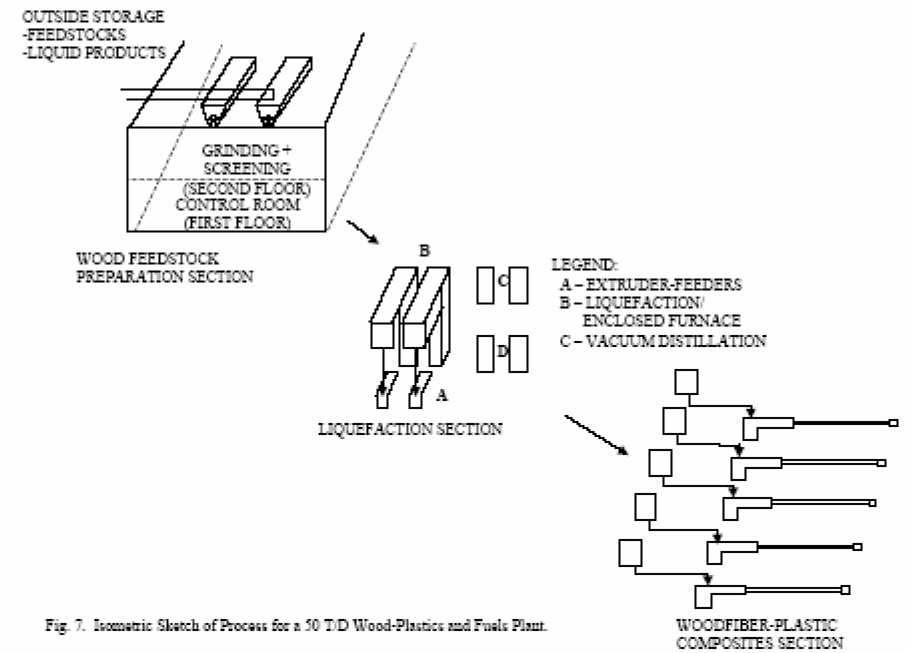


Fig. 7. Isometric Sketch of Process for a 50 T/D Wood-Plastics and Fuels Plant.

ECONOMICS OF FIRST COMMERCIAL PLANT

Estimated Capital Cost

The estimated capital cost for the proposed 50 ton per day first commercial plant is $7,000,000, but does not include a contingency factor. Under the economics section, the sensitivity of capital costs to overruns during construction is estimated.

The capital cost includes detailed process design, detailed plant design, construction by a reputable engineering company, buildings for plant, offices and control lab, but assumes an existing site with some roads and installed utilities to the property (electricity, water, natural gas and sewage) and fencing. It does not include the capital investment for 5-acres of adjacent greenhouses for using “free” waste heat and cooling and “free CO_2” for the enhanced growth of tomatoes. More details are needed on the closed Georgia Pacific sawmill, Philadelphia, MS to know whether further adjustments should be made to the estimated $7,000,000.

Plant and Marketing Personnel

Total plant personnel of 80 persons and overhead/marketing of an additional 41 persons, thus totaling 121 personnel for the first commercial plant is outlined in Table 3. These estimates are conservative but believed justified iin order to bring the plant up to full capacity by the end of year 3 and to sell that rated capacity through a Central Sales Office in Philadelphia, MS and three field offices in Jackson, MS, Memphis, TN and New Orleans, LA. A tough modern manufacturing firm might want to cut total personnel to 80 persons.

Estimated Manufacturing Cost

It is assumed that this first plant, which is a rather simple batch plant but real-time computer-controlled, can be designed and constructed in 24 months. Most of the equipment are standard items that are available on the market today. Some used equipment can be purchased for some plant sections but absolutely not for certain critical items.

The plant is assumed to run at an average of only 40 percent during its first year operation. This should provide sufficient time to train plant capacity operators and to introduce products into the market place. Some of the required personnel would not be hired until the middle of year 3 (first year of operations) and be trained so as to be ready to manufacture and sell all products at full capacity in year 4.

Economic Analysis

Annual revenue at full capacity is estimated at $28,194,000 (Table 1). A total of $5,833,000 is spent annually to purchase chemicals and polymers (Table 2). The estimated manufacturing cost at full capacity is $15,795,000 (Table 4). The estimated rate of return is 43.2% (Table 5), based on using present value cash flow, 15 year amortization rate and 39% income tax rate for a 15-year project. The cumulative net cash flow generated in 15 years is $83,700,000. The plant would be expected to operate for at least an additional 20 years, with proper preventative maintenance and upgrading certain obsolete equipment from time to time. If a contingency factor of $2,000,000 is added to the $7,000,000 capital cost, the return on investment is reduced from 43.2% to 42.8% (Table 6).

Justification of Product Pricing

The justification of pricing the woodfiber plastics composites at $0.60 per pound is outlined in Appendix 1. This is based in part upon the composite industry being able to purchase its recycled plastics at about $0.25 or less per pound.

RECOMMENDATIONS

Extensive R&D has been expended upon both biomass liquefaction and the extrusion of wood plastics composites, such that there should be only minor or temporary problems in manufacturing. The major risk in the first commercial plant must be in some aspect of sales and marketing:

1. Will home owners change from preserved pine wood to composites?
2. Are the architects willing to evaluate and specify new materials?
3. Can the home builder visualize new designs that the “housewife home owner” will fall in love with?
4. How long will it take to accept composites over CCA treated wood for longer outdoor life, better appearance, less rotting, less molds and hopefully resistance to termites?

WTT recommends that $40,000 to $60,000 be allocated from some source to try to answer these questions over the next six months, prior to making a commitment for the first commercial plant.

TABLE 1
ESTIMATED ANNUAL REVENUES
COMMERCIAL PLANT FOR POULTRY LITTER/SAWDUST
FEEDSTOCK FOR EFL LIQUEFACTION
50 Tons/Day, 330 Days/Year

Product	Tons per year	Price		Annual Revenue, $
Wood Plastics Composites	20,000	$0.60/lb		$24,000,000
Asphalt Additives	3,300	$0.49/lb		$3,234,000
Clean Liquid Fuels	1,200,000gal	$0.80/gal		$960,000
			Total	$28,194,000

Attachment 4

TABLE 2

PURCHASED CHEMICALS AND POLYMERS

	Item	Tons/Year	Price	Dollars/Year
I. Wood-Plastic Composites		**20,000**		
	45 wt% Wood Fibers			
	45 wt% HDPE Recycled Plastics	9,000	$0.25/lb	4,500,000
	10 wt% Compatibilizers	(Produced in Liquefaction Section of Plant)		
II. Asphalt Additives		**3,300**		
	Chemical Oils	165	$0.30/lb	99,000
	Polymers	660	$0.50/lb	660,000
	Carriers	8,200	$70/Ton	574,000
			TOTAL	$ 5,833,000

TABLE 3

PERSONNEL FOR A 50 TON/DAY LIQUEFACTION PLANT PRODUCING ANNUAL REVENUES OF $28,194,000

Type of Job	Wage Rate $/hr	Number	Annual Payroll, $
Direct Personnel			
Plant Operations			
Plant Operator	$ 14.00 a	32	$ 896,000 b
Shift Supervisor and Computer Control Operator	16.00 a	8	256,000
Machine Operator	12.00	5	120,000
Lab Technician	9.00	5	90,000
Labor - Experienced	10.00	10	200,000
Labor - Common	7.00	10	140,000
Maintenance			
Labor - Mechanic (Repairs)	15.00	5	150,000
Labor - Electronic (Repairs)	15.00	5	150,000
		80	$ 2,002,000
Indirect Personnel			
Central Office	$ 12.00	10	$ 240,000
Marketing			
Sales Persons	30.00	10	600,000
Architectural	40.00	5	400,000
Technical Service	30.00	10	600,000
Warehouse	12.00	6	144,000
		41	$ 1,984,000

TOTAL PERSONNEL	121
TOTAL PAYROLL	$ 3,986,000

Footnotes:
(a) Working 8-hour shifts
(b) Based on 2,000 hours per year

Attachment 4

TABLE 4

ESTIMATED MANUFACTURING COST

Plant Capital Cost: $ 7,000,000
Capacity: 50 Tons/Day (Dry Feedstock Basis)

		ANNUAL COSTS, DOLLARS		
DIRECT COSTS				
Feedstocks		$	120,000	
Transportation			160,000	
Shredding/Losses			160,000	
Operating Labor			1,702,000	
Maintenance and Repair				
Labor - Mchanic			150,000	
Labor - Electronic			150,000	
Materials			200,000	
Personnel Fringe Benefits			1,200,000	
Purchased Materials			5,833,000	
Utilities			200,000	
Laboratory Materials			50,000	
Royalties			1,900,000	
Technical Services			600,000	
	Subtotal	$	12,425,000	$ 12,425,000
INDIRECT COSTS				
Amortization (15 yr.)		$	466,000	
Taxes and Insurances			20,000	
Legal and Accounting			40,000	
Office- Supplies, Phone, FAX			40,000	
Management Fees			300,000	
Labor - Office/Marketing/Field Offices			1,984,000	
Sales Expenses			400,000	
Working Capital (Interest on Credit Line)			120,000	
	Subtotal	$	3,370,000	$ 3,370,000
			Total	$ 15,795,000

APPENDIX 1

A. Cost of Materials in a 2”x4”x12’ Piece of Woodfiber Plastic Composite
The subject piece of wood-plastic composite is 8 bd.-feet. As a lumber product, we would set its wholesale price at so much per 1000 bd.-feet. However, as a wood-plastic composite, we must cost it out (internally within its manufacturing plant) on a per pound basis. This is necessary because we must purchase at about 10 cents to 25 cents per pound some recycled HDPE waste bottles, which constitute about 45 wt.% of the composite. Secondly, the litter/wood fibers could be “free” but we intend to purposely pay (a) about $2.00 per ton for poultry litter and (b) the going price for wood sawdust, say 8.00/ton. The costs of these woodfiber feedstocks are not an important economic factor, but the purchase of recycled polyethylene (HDPE bottles) is a critical economic factor. Thirdly, the utilization of WTT plasticizing/compatibilizer ingredients (made by its EFL liquefaction) is an added expense. As shown below, the total cost of all of these composite ingredients is a reasonably low feedstock cost for the final composite product.

The costed bill of materials for 1,000 pounds of wood-plastic composite is as follows:

Ingredient	Pounds	Price	Cost, Dollars
Woodfibers	450	$10/ton	$ 2.25
Recycled HDPE Plastic	450	$0.25/lb	112.50
WTT Plast/Comp	100	$0.80/lb	80.00
	1,000		194.75

So cost per pound of composite is $0.195 for materials. This is about 17% of the average sales price of $1.20 for wood-plastic composites. The economic analysis in this feasibility study is being conservative by pricing the annual sales of composites at half that estimate, namely, $0.60 per pound.

B. Retail Price for an Arkansas Decking Set
Lowe’s Do-it-yourself stores has begun selling at retail in Tucson, Arizona (and presumably at all Lowe’s stores across the country) the decking pieces required to install a complete deck, except for its support structure.

It sold as Weyerhaeuser ChoiceDek, manufactured by Advance Environmental Recycling Technologies (A.E.R.T.), 914 West Jefferson, Arkansas 72764, using its U.S. Patent 5,596,680 and NER-596. Two small brochures are available, one on the merits of the product and the other one giving installation instructions. After reading the instructions, one can phone 1-800-951-5117 and ask for “special tips on making your railing installation even easier.” Web site is www.choicedek.com.

The pieces all look somewhat rough on the surface, showing rather large particles of sawdust. The color is light brown, looking somewhat rustic. It is a heavy composite with a measured density of 70.1 pounds per cubic foot.

Attachment 4

Weyerhaeuser ChoiceDek

Piece	Price	Estimated Weight, lb	Price per lb, cents
Premium Deck			
(1) 5/4" x 6" x 8'	$ 11.97	17	70.4
(2) 5/4" x 6" x 12'	17.95	26	69
(3) 5/4" x 6" x 16'	23.93	35	68.4
Flat Top Handrail			
2" x 5" x 12'	29.83	33	90.3
Universal Support Beam			
(Railing) 2" x 3(1/2)" x 12'	29.97	23	130.3
Decorative Rail			
2" x 3" x 12'	32.87	60	54.8
Trim Board			
11/16" x 9(1/4)" x 12'	24.43	60	40.7
Edge Trim			
1" x 1(1/2)" x 12'	7.57	6	126.2
Decorative Post			
5" x 5" x 54"	17.43	37	47.1
Post Skirt (Collar)	7.94	0.71	1,118.30
Post Cap	9.41	3	313.6
Square Baluster			
1(1/4)" x 1(1/4)" x 30"	1.93	1.58	122.20
Turned Spindle			
1(3/4)" x 30"	4.52	3.00	150.70
Baluster Spacer	5.96		
Support Block			