OPPORTUNITIES AND CHALLENGES ASSOCIATED WITH DEVELOPMENT OF WOOD BIOMASS ENERGY PRODUCTION IN LOUISIANA

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
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B.S., Kerala Agricultural University, India, 2004
August, 2008

ACKNOWLEDGMENTS

First, I would like to express my deepest gratitude and sincerest thanks to my major advisor, Dr. Cornelis de Hoop, for his guidance, encouragement and patience throughout this work. It was a privilege to work with such a fine gentleman and an accomplished professional. Next, I express my thankfulness to my committee members, Dr. Sun Joseph Chang and Dr. Michael A. Dunn, for their time and ideas.

I would like to thank Ian Stone, School of renewable Natural Resource for the help he has done during telephone survey. And then, there's Dr. Richard Vlosky, who was always available for guidance right from beginning until end, and I do thank him very much indeed.

I am also indebted to Priyan Perera and Cherian Korah for all the support.

My acknowledgment will hardly be complete unless I express my sincerest gratitude to my parents, and my twin brother, Prem Raj Kizha, my sister, Shalini Sujesh, and my brother-in-law, Sujesh Maryath, for all they have given me.

Finally, I would like to thank everybody who wished me well during this important phase of my academic career.

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ABSTRACT

Wood residues produced by forest products industry has been recognized as a potential fuel that can generate energy to run the industry. A survey was done among forest products industry to get a general idea about energy produced from woody biomass created from forest industry in Louisiana, USA. The industry was classified into primary and secondary forest products industry. The study provided information regarding utilization and wastage of wood residue. Survey response rate was 25 percent. It addressed problems faced by wood residue energy development and came up with solution to solve them. When survey results were compared to previous survey, done in 1994, it clearly showed an increase in production and utilization of wood residue. One more thing worth noting was the reduction in number of secondary forest products industry. The study estimated a production 15,076,937 tons of wood residue by the forest product industry.

Results showed that majority of wood being produced in the industry went un-utilized. In primary forest products industry most respondent used their residue in energy production. But in secondary sector, residue was not utilized. Residue of secondary forest product industry such as wood chips and shavings were used in various sectors. Some of them were bedding for horse farms, mulching, for erosion control in canals and as fuel in furnaces. But nearly ninety percent of residue went to landfills. By contrast, there were industries which had a great demand for wood residue as a fuel. We discovered a need for better communication between producers and utilizers. This study also produced an interactive online directory, from which industry needing wood residue can contact producers.

One major reason for non-utilization of wood residue in secondary sector was due to comparatively small production that was distributed widely across the state. Cost of

transportation restricted them from being a viable option. Lack of information about producers and consumers also played a role.

CHAPTER 1. INTRODUCTION

Energy has always been a critical factor in the existence of mankind. Man has always obtained this, in one or another form. It has had various forms ever since human history such as wood, coal, hydro- power, nuclear energy, fossil fuels, etc. But in past two decades concerns of environmental degradation due to over exploitation of these resources has led to major calamities like global warming, environmental pollution etc. The chief reason for this being population explosion, industrial revolution, etc. We still have to formulate a sustainable and eco-friendly solution.

1.1. Some Figures

The current global energy consumption is estimated to be 8,000 MTOE (Million Tons of Oil Equivalent) per annum. Projections have shown energy consumption will increase to higher than 15,000 MTOE by 2050 (Komiyamaa *et al.* 2001). In this regard, renewable energy resources appear to be one of the most efficient and effective solutions. Renewable energy can be broadly divided into hydro electric, geo thermal, wind energy, solar energy and biomass energy.

The World Energy Conference (WEC) (1994) estimates that by 2020 annual energy supply by biomass will amount to 1,600 MTOE and IPCC (Intergovernmental Panel on Climate Change) estimates that by the year 2050 it will amount to 4,400 MTOE (Ishitani and Johansson 1995 and Komiyamaa *et al.* 2001). This comparison indicates that, biomass is expected to significantly contribute to global energy supply. Biomass fuels currently supply around 15 per cent of the world's energy. Most of this biomass, 13 percent, is used in developing countries and only a minor part, 2 percent, is used in industrialized countries. Much of this biomass is in form of traditional fuelwood, plant residues and dung (Hall 1993 and 1995). Biomass energy includes fuelwood, agricultural residues, animal wastes, charcoal and other fuels derived from biological

sources, mostly plants. It is a renewable form of solar energy that has been converted into chemical energy. A major portion of biomass energy comes solely from wood.

In United States forests are expanding. The net forest biomass is currently increasing at about three percent annually. This creates a great opportunity for forest products industry. Residue from these industries can turn out to be a potential fuel to run the industry.

The wood residue is a critical source of renewable biomass energy in regions where forest cover forms a major portion of land area. In such regions, it constitutes about one- fourth of biomass energy (Thra¨ and Kaltschmitt 2002). Nearly all of biomass fuel used for energy production today comes from wood wastes and residues (Parikka 2004). As waste or residue of forest products industry, biomass could become a resource large enough to provide about 3-5 percent of electric energy generated in United States. Hence this scenario in energy production will be studied in detail in coming pages.

1.2. Structure of Wood

Wood can be defined as a hard fibrous lignified substance under bark of trees. Wood typically comprise of about 50 percent cellulose, 25 percent hemicellulose, 25 percent lignin and trace amounts of ash-forming minerals. The relative proportions of cellulose and lignin is one of the factors that determine the suitability of plant species to be used as an energy fuel (McKendry 2002) (Table 1). Hardwood tree species tend to contain more hemicellulose and less lignin than softwoods.

The chief properties of interest, when considering wood biomass as an energy source are (McKendry 2002)

- Moisture content
- Ash /residue content
- Alkali metal content
- Proportions of fixed carbon and volatiles
- Calorific Value

Table 1. Chemical composition of wood in different tree species

Category	Chemical composition (wt%)				
	volatile	**Ash**	**Lignin**	**cellulose**	**Hemicellulose**
Softwood	0-5	0.5	25-35	40-45	25-28
Pine	0.7	0.5	34.5	40.4	24.9
Hardwood	0-5	1	15-25	40-50	25-40
Poplar	1	2.1	25.6	41.3	32.9

(Source- ODE 2003)

1.2.1. Moisture Content (MC)

Moisture content is the most significant features that affect quality of biomass fuel for thermal processes like combustion, gasification and pyrolysis. Materials with a lower moisture content, cost less to transport and can reduce size of handling, processing and energy conversion equipment needed for biomass power. Reason for this being that a smaller volume of feedstock would be required to meet fuel requirements for the facility (ODE 2003).

Moisture content is usually measured on a wet or dry basis. In wet basis method, moisture content is expressed as a percentage of total weight. This is usually done in engineering calculations. In forest products calculation, dry basis method is used. Here, moisture content is expressed as a percentage of dry weight of wood. For example, if a sample of wood is half water and half wood, using wet basis method, moisture content would be expressed as 50 percent. In dry basis method, moisture content would be 100 percent. Moisture content of freshly harvested forest and crop residue typically varies from 40 percent to 60 percent by weight, and can be higher, especially if the residue is exposed to precipitation (ODE 2003).

1.2.2. Calorific Value

Calorific value is the amount of thermal energy being released from complete combustion of a fuel material. The energy is released from organic materials as carbohydrates and other

hydrocarbons (lignin and volatile chemicals) are reduced to carbon dioxide and water. Interestingly, on a dry, ash-free basis, most biomass has about the same energy content (Higher Heating Value) of 8,000 to 8,500 British thermal units per pound (Btu/lb). However, practical heating value of biomass, as received, varies considerably due to differences in content of ash-forming minerals and moisture (Table 1 and 2).

Table 2. Heat and Ash content of wood from different tree species.

Plant variety	HHV (Btu /lb)	Ash (wt %)
Ponderosa pine	8,613	0.29
Loblolly pine	8,733	0.5
Loblolly pine bark	9,370	0.4
Slash pine bark	9,365	0.7
Pine wood	9,137	0.5
Pine shavings	8,337	1.43
Pine bark	8,776	2.9

Field Moisture content = 40-60% (Source- ODE 2003)

1.3. Beneficials

Biomass has a lot of advantages compared to fossil fuel. When considering production economics, biomass used for energy is typically a by-product or residue of the main product. The main product will be timber or other fiber product. This will cover fixed costs and the by-product only has to cover marginal costs (Lunan 1997). Thereby biomass is cheap and can compete with unstable gas price, lowering cost of production.

This power production also plays a vital role in waste management system, as it finds an economical value for residual products, which is other wise considered as waste. Hence, Hughes (2000) suggests that future biomass energy production can be combined to projects in waste disposal management.

Much research has been done to study influence of fuel on total costs and also utilization of waste wood (industrial waste wood, demolition wood and other wood products) (Dornburg 2001). According to PIU (2001) and Upreti (2004) multiple environmental, ecological and socio-economic bottlenecks can be addressed by increasing use of biomass power generation. Wood biomass energy infrastructure can also help to strengthen industrial economics or speed decline of rural communities (Paine *et al.* 1996).

In environmental scenario, wood biomass is usually superior to coal in terms of its concentrations of sulfur, nitrogen, ash, and other toxic metals. Exceptions exist, but these can be identified and controlled. But when compared to natural gas, wood biomass energy cannot claim any inherent advantage in terms of emissions, except for greenhouse gas emissions.

Third assessment report of Intergovernmental Panel on Climate Change (IPCC) states that most of the observed global warming over last 50 years is likely to have been due to the increase in greenhouse gas (GHG) concentrations in atmosphere (M'ollerstena *et al.* 2003). And biomass energy is a promising options to reduce green gas emission. Carbon component in plant biomass, removed from the atmosphere, has only a recent past. But carbon locked in fossil fuels ranges over millions of years. Hence, here the comparison is between the emissions of carbon di-oxide (CO_2) into atmosphere, from biomass generated in recent years, and fossil fuels, which has taken millions of years to evolve.

So as a substitution for fossil fuels, biomass energy mitigates global warming even in absence of any renewed CO_2 fixation. To decrease global warming and to develop alternative energy sources, it has become desirable to construct alternative, renewable energy systems. Potential alternative energy sources include solar cells, wind turbines, and biomass. Among these, biomass is considered to be the most promising. In case of energy crops, biomass burned

will be replaced in a reasonable time (typically one to ten years), with new biomass (Hughes 2000). In a typical energy crop operation, biomass would be used at the same rate as produced.

Another perception problem for biomass power, besides combustion, is the use of forests. As mentioned previously, forests are expanding in United States. Biomass fuel used for energy today is essentially all from wood waste and residue, majority of which originate in forest operations and wood industry. In some cases, biomass fuel is provided from forest management (thinning) operations that are conducted for specific purpose of improving forest health and value. Again wood ash, obtained after energy production, is used for many purposes, including agriculture, waste-water treatment, etc.

Federal government has also played its role in promoting energy production from biomass by formulating a couple of policy. 1992 Energy Policy Act in United States sets up a tax credit (for taxable corporations) and production payment (for tax-exempt public agencies) for use of "closed-loop biomass" in new energy production facilities. This credit is in Section 45 of Internal Revenue Code (Hughes 2000).

1.4. Limitations

Even though biomass energy has lot of advantages, it also comes with a few limitations. One major drawback of biomass fuel is its bulky nature and resulting high cost of transporting to facility where energy is being produced. Transporting biomass for energy purposes more than 50 miles (80 km) is not considered economically feasible in most conditions (Brower 1993 and Paine *et al.* 1996). Transportation costs at this distance would average about $10 - $9 / ton (Turnbull 1993 and Paine *et al.* 1996). Again the market is geographically limited (Lunan 1997). Therefore, supply in remote locations may not be suitable for exploitation due to high access costs. In wood energy scenario, maximum distance is more often restricted to distances of less than 200 km between production and consumption (Fischer and Schrattenholzer 2001).

This makes biomass energy supply cost not competitive when compared to corresponding fossil fuels. Another reason being that price of fossil fuels are currently low to allow for large-scale investments in biomass based energy. But this scenario can change when there is a significant increase in price of fossil fuels. This can make biomass more competitive (Berndesa *et al.* 2003).

Prices of biomass are quite variable and market price development cannot be forecasted with certainty at the moment (Dornburg 2001). The economic potential is the most varying factor because economic conditions changes, sometimes drastically, over time.

Biomass programs in operation today rely on government subsidies and magnitude of subsidies needed to make biomass energy competitive cannot be justified. One factor working in favor of bio-energy is its positive impact on greenhouse gas balance. However, there is considerable uncertainty in proper valuation of this factor. As this is a global environmental problem, global action is needed. Greenhouse gas emissions are not an economically relevant argument for local subsidies to bio-energy (Berndesa *et al.* 2003).

Other storage and transportation issues of wood residues are related with the perishable nature of fuel. The other constraints are mold, rot and fire damage. This can be dealt effectively by converting wood residue into denisfied fuel.

Wood densification can be defined as the process in which wood residues such as slabs, chips, or sawdust are processed into uniform sized particles, so that they can be compressed into a fuelwood product (Sims *et al.* 1988). Densified wood has higher Btu and is a clean burning fuel source. It has a generally a moisture content between 6 and 10 percent with an average at about 8 percent. Some other desirable characteristics of densified wood fuels include: a low ash content of around 2 percent, lack of creosote formation, and a Btu rating of around 8,000, making it competitive with some types of coal. Handling, transportation, and feeding to combustion

systems are also improved when utilizing densified wood products (Sims *et al.* 1988). Wood biomass is less perishable than other herbaceous biomass. But only a few possess equipment to harvest and prepare densified wood. Hence it cannot be done on a large scale basis.

1.5. Sources and Types of Wood Residue

Forest products residue for biomass energy can be broadly divided into logging residue and residue from forest products industry, based on their origin.

1.5.1. Logging Residue

Residue being produced at timber harvest sites on felling of trees falls in this group. It is estimated about 60 percent of tree is left on site (this includes everything other than timber). And in most cases, non-commercials tree felled are also discarded at site. Even though logging residue can be considered as a potential resource, this has several drawbacks. Extraction and handling expense of this residue can make it an uneconomical operation. Moreover loss of essential nutrients in the residue can deteriorate site quality (Parikka 1997 and Hakkila 1989).

1.5.2. Wood Residue from Forest Products Industry

This class includes all wood residue being produced from forest products industry. It can be further divided into residue from primary and secondary industry, depending on the source of origin. These residues are potential biomass fuels that can be used for energy production. In saw mill and plywood industry, wood residue accounts for approximately 45–55 percent of the timber input (FAO 1992 and Warensjö 1995). This amount depends on several criteria such as, species, type of operation, and maintenance of plant (FAO 1993). Sawing and squaring, again wastes about 8-10 percent and 30-50 percent respectively (Parikka 2004 and FAO 1982) (Table 3).

1.5.3. Wood Residue Integration

Even though wood residue can be used for energy production, the residue from secondary forest products industry is usually hauled.

Table 3. Types of wood residues from different operation

Source of residue	Type of residue
Forest operations	Branches, needles, leaves, stumps, roots, low-grade and decayed wood, slashings and sawdust
Sawmilling and planning	Bark, sawdust, trimmings, split wood, planer shavings
Plywood production and Particleboard production	Bark, core, sawdust, veneer clippings and waste, panel trim, screening fines, sawdust, sanderdust
Secondary Forest Product Industry	Bark, wood chips, shavings, sawdust, etc.

(FAO 1993 and Parikka 2004)

Wood residue being produced at primary forests product industry such as, sawmills and plywood industries are being utilized to fulfill their own energy requirements. Residues in these facilities totals to about 40–55 percent of input timber (Parikka 2004). Again, larger amount of wood are handled by primary industry. Consequently, from an energy perspective, more wood residue is utilized by these industries than is the case with secondary industry (Mayes 2003).

However, certain other primary industries like particleboard production produces only about 5–10 percent. Here, this quantity is insufficient to cover needs for energy. This creates a demand for fuel. This problem could probably be solved by integration (Ekono oy 1980). Deficit wood biomass residue can be supplied from secondary forest products industry as well as primary forest products industry producing wood residue in surplus. Such integration can handle waste problems as well as equip industry to face the energy crisis. Thus there can be utilization of wood residues to the maximum (Parikka 2004).

Current methods for utilizing wood residue include direct burning, gasification, and liquefaction (Komiyama *et al.* 2001). Historically, wood combustion processes were dirty, with uncontrolled emissions of smoke, ash, carbon monoxide, nitrogen oxides, hydrocarbons, etc. In modern combustion systems, emissions are reduced, making it more environmental friendly and more efficient in power generation (Hughes 2000).

Table 4. Characters and other uses of wood residue.

Types	Characters	Densified fuel Production	Other uses
Bark	10–22% of the total log volume depending on tree size and species	yes	---
Coarse residues	Slabs, edgings, offcuts, veneer clippings, sawmill and particle-board trim.	---	Raw material for pulp and particleboard.
Cores	Obtained from plywood peeler logs	---	---
Planer shavings	Products of dimensioning and smoothing	yes	Ideal for particleboard production
Sanderdust	Abrasive sanding during the finishing stage	yes	---
Sawdust	Sawmilling operation	yes	For particleboard production.
Particleboard waste	---	---	re-cycled

(Source- FAO 1993 and Parikka 2004)

Wood residue biomass is a low cost fuel today only when it is available as waste or byproduct. Wood biomass can also be converted to other usable forms of energy like methane or transportation fuels like ethanol, biodiesel etc., but currently these technologies are not economically feasible.

1.6. Global Scenario

People have been burning wood for energy purposes for more than thousands of years. Wood was the major source of energy until mid-1800s. Today too, wood biomass continues to be a major source of energy in much of the developing world. Wood energy constitutes up to 80% of the total energy consumption in countries like Nepal, Bhutan, Laos and Cambodia (Table 5).

The global utilization of fuel wood and roundwood is 3,271 x 10^6 m^3 per year (Parikka 2004, FAO 2002 and FAO 2001). In which, about 55 percent is fuel wood produced mainly from developing countries. The remaining 45 percent is used as raw materials for industry, in this about 40 percent of goes off as primary or secondary process residues (FAO 2001 and Parikka 2004). This can be potentially utilized for energy production.

Table 5- Total wood and biomass energy consumption in South Asia (2000-01)

Nations	*Wood Energy*	*Biomass Energy*	*Share of Wood Energy*	*Share of Biomass energy*
Bangladesh	116	318	17%	47%
Bhutan	42	42	89%	89%
Cambodia	91	92	79%	80%
China	2,050	6,460	3%	10%
India	4,648	8,441	29%	54%
Indonesia	1,279	1,677	34%	45%
Laos	53	53	80%	80%
Malaysia	47	50	3%	4%
Maldives	1.5	1.5	27%	27%
Myanmar	351	374	75%	79%
Nepal	261	295	76%	86%
Pakistan	543	979	25%	46%
Philippines	280	450	24%	38%
Sri Lanka	171	174	56%	58%
Thailand	232	353	11%	17%
Vietnam	352	810	27%	62%

Unit: PJ/ year (Source- FAO 1997)

Again about 70–75 percent of global wood harvest is either used or potentially available as renewable energy source. This amount does not include the large amount of logging residues and other woody biomass left on-site after logging operations. Current studies indicate that, apart from Asia, in rest of the world, wood biomass utilization is clearly below available potential. Current utilization is just two-fifth of its potentials. Hence, there is a scope for increased wood biomass utilization (Parikka 2004).

1.7. In United States

All throughout American history, wood has served as a dominant form of energy for about half of the nation's history. Around 1885, coal surpassed wood's usage (EIA 2006). Today wood and wood waste, such as bark, sawdust, wood chips, wood scrap, etc., provide only about 2 percent of the energy we use. About 81 percent of wood and wood waste fuel used in this nation

is consumed by industry and commercial businesses (EIA 2005). The rest, mainly wood, is used in homes for heating and cooking.

Since, forests in United States is expanding, wood byproducts and residue from forest products industry represent a renewable and sustainable energy resource. Forest industry residue, such as bark and sawdust are currently the largest commercially used waste biomass sources for energy production (Thrä and Kaltschmitt 2002). But these fuels are presently only consumed within the industry.

1.7.1. Forest Products Industry

Forest products industry plays a major role in contributing to the nation's economy and employment base. According to American Forest and Paper Association (1996), it accounts for 7 percent of national manufacturing output and approximately 47 percent of industrial raw material manufactured in United States. And again, the U.S. and Canadian mills combined supply about 36 percent of the world's paper (Smook 1992 and Mayes 2003).

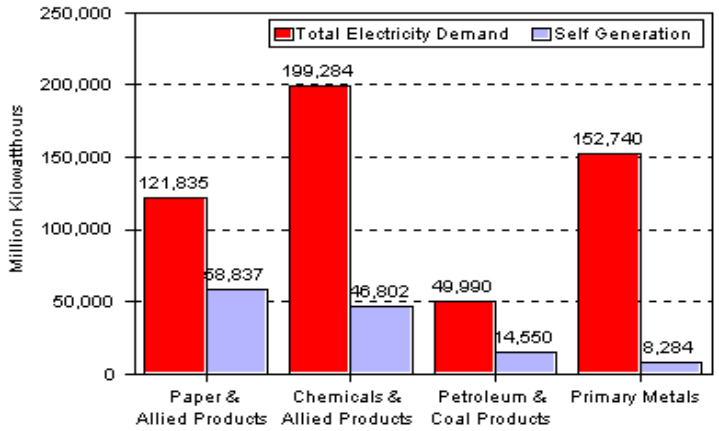

Figure 1. The largest U.S. electricity-consuming industries and their generation, 1994. (Source- Energy Information Administration 1997 and Mayes 2003)

In energy perspective, Mayes (2003) reveals that forest products industry uses wood waste as fuel to support its production. Even though it is the third-largest consumer of electricity, this industry self-generates more electricity than any other industries in the country. Paper and

allied products industry again self-generates the largest percentage of its total electricity requirement of any major industrial sector (Figure 1). The 2,665 trillion Btu consumed by pulp, paper, and paperboard subgroup in 1994 represented 3 percent of total U.S. energy consumption (Energy Information Administration 1997). Majority of this energy was supplied by domestic fuel sources, with 56 percent supplied from within the industry (American Forest and Paper Association 1996). These factors are highly significant from an energy security standpoint (Mayes 2003).

1.7.2. Biomass Energy in General

In US, roughly 7,000-8,000MWe is generated from biomass. This is only one percent of US power generating capacity (Hughes 2000). However this is larger than wind and geothermal energy production. Thus, biomass power is the largest block of non-hydro renewable power generation. In future, energy crop grown on 20-60 million acres of 400 million acres of cropland, plus wastes from conventional forest products, could contribute up to 7-20 percent of US electricity generation (Hughes 2000).

1.8. Scenario in Louisiana

Forest products industry is the third largest employer in the state (Kleit 1994). It represents a large percentage of the economy. Louisiana's primary forest products industry includes sawmills, plywood mills, panel mills, veneer mills, and pulp/paper mills that are scattered throughout the state. A natural byproduct of this industry is the biomass waste in form of bark, wood chips and saw dust. Together they produce more than seven million tons of wood residues annually. This is mostly utilized by the industry for their own energy needs (such as lumber drying kilns or veneer driers) and the rest is sold to other mills, often to pulp and paper mills that co-generate electricity. Still, some 54,000 tons annually go unutilized, enough to provide energy for 6,000 homes (Kleit 1994).

Secondary industry (cabinet shops, architectural millwork, furniture manufacturers, etc.) also produces 80,000 tons of wood residues annually (equivalent to energy use in 17,000 homes). These include dry wood trimmings, sawdust, and sanderdust, making them ideal for energy or to modify and glue together into other products. Nearly all of this material goes unutilized.

There is a large potential for production of energy from wood. LSU AG Center has developed maps which shows large and small scale forest products industry in the state. This can be used to know where the wood wastes are being produced. And how it can be transported to points where it can be utilized.

With more than 530 forest product industries, Louisiana has an opportunity to position itself as a leader in emerging industry of converting wood residue biomass into energy. With a long history of forest industry and significant and varied forest resources, the state has the resources, industrial infrastructure and intellectual institutions to capitalize on this research.

1.9. Objectives

The primary objective of this study was to

- Estimate production and utilization of raw material for woody biomass energy production in Louisiana.
- Determine the advantages and threats to development of woody biofuel industry in Louisiana and suggest resolutions

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CHAPTER 2. METHOD ADOPTED

Selection of research methods for this study was guided by the objective to understand trends of the wood biomass energy in the state. The major producer and utilizer of wood biomass for energy purpose was the forest industry. Hence they were major stake holders in this aspect. The methods used to conduct this research included six sections. Following is the discussion of each section (Nicolas 1998).

1. Research design
2. Sample frame
3. Survey instrument development
4. Measurement
5. Data collection
6. Data analysis

2.1. Research Design

This was designed to better understand the industry and its future trends in wood residue energy consumption perspective. A mailing survey was the principle tool used, in which all forest products industry in the state were surveyed. Production and utilization of wood biomass energy in the industry were given emphasis.

The survey package included two sets of post card (Phase I and Phase II) and two sets of questionnaires (Phase I and Phase II). The questionnaire set comprised of a covering letter, questionnaire form and returning envelop. All phases had different purposes. Phase I and Phase II post cards were purple and golden yellow color respectively. Phase II questionnaires had a small hole punched to it. This was done to distinguish first from the second respondents.

The survey was carried out in a planned pattern. Phase I post card was sent first. This was one week prior to Phase I survey. The intention of this was to make stake holders aware of upcoming survey. Then first set of survey (Phase I) was posted.

Three weeks from sending Phase I questionnaire, the next set of post cards were posted. This had two purposes. The primary one was to serve as a reminder of Phase I (Initial) surveys to respondents who had completed the survey, but forgot to post it. Next aim was to act as an indicator of upcoming Phase II survey. Phase II set of questionnaire (follow-up) was posted the following week. This was sent only to ones which had not responded to the initial survey. A follow up was conducted over telephone. The telephonic survey was strictly pertaining to facilities that did not turn up their survey reports in both phases. This was done to get a complete online interactive directory.

Table 6. Chronological events of survey

Contents	Dates sent
Phase I Post card	Oct 15th, 2007
Phase I Survey	Oct 22nd, 2007
Phase II post card	Nov 12th, 2007
Phase II Survey	Nov 19th, 2007
Telephonic interview	Dec 17th, 2007

2.2. Sample Frame

Sample frame of the study consisted of primary and secondary forest products industry. Both industries were treated separately. Criterion for separation was the types of products produced. Addresses of all facilities were collected from the directory of Louisiana wood products industries compiled by Louisiana Forest Products Development Center. All forest products industries were selected. There were 835 facilities in the state which were related to the forest industries, of which 184 were primary and 353 belonged to the secondary forest products

industries. The rest was not in scope of study. This totaled to 298, and they included distributors, wholesalers and loggers.

Most of primary industries were located near forests. This was for getting ready and constant supply of raw materials and reducing transportation cost. By contrast, major portion of secondary industries were found near urban areas. Wood biomass energy producing facilities from north and south were compared for primary industries. All Acadian parishes, except for Avoyelles and Evangeline, and the Florida parishes were considered as south. The rest were put in as north. The aim in doing this was to perceive certain factors like, production, utilization, geographic locations of market, etc., based on geographic location for wood biomass energy production facility. On the other hand, secondary industry was stratified based on their parishes. This was achieved by using postal zip code of the industries. Parishes affected by hurricanes in 2006 were separated from rest. This was done to study their performance after the hurricane.

2.3. Survey Instrument Development

Both qualitative and quantitative data was gathered from mailing survey. The questionnaire is designed in such a way to facilitate both utilizer and producer. Questionnaire was both structured and open ended to allow respondents to express thoughts and ideas not covered in fixed format questions. It was divided into four sections. The first section dealt with organizational setup of the facility. It gave a general idea about the company, that is, products produced, parent company, website, etc. It comprised of eight questions.

The next section dealt with production and utilization of wood residues for energy production. This phase was basically a census; hence, for non respondents, this part was followed up by a telephone call in order to get a complete version. The census basically concentrated on issues pertaining to energy produced from wood biomass in forest products industry. The type of wood material being used (like bark, wood chips, saw dust, etc) for energy

production and its energy content were some of the crucial information collected in this phase. The industry was broadly classified into producer, utilizer, seller and buyer of wood biomass at this stage. Information gathered from this section was used to create an online directory dedicated to suppliers and buyers of wood biomass energy. It comprised of nine questions.

The third section mainly investigated about opinions in industries regarding wood biomass energy. Therefore, this section mainly looked forward to document perception, strategies and response of the industry towards biomass energy development. Issues and challenges faced by the industry were also studied. Attempts were made to suggest solutions for the problems. The last section collected data regarding demographics of individual filling in the questionnaire. This gave a clear cut idea of the population being questioned.

The questionnaire was sent for critique, to a few selected in the industry and to research scholars. Their remarks and opinions were considered.

Some guidelines for conducting a survey, proposed by LFPL (1994) were

- Do not talk above your audience.
- Before sending out even your test survey, have your team fill out the survey on their own. Their answers would indicate if your survey provides the information you seek.
- How matter how helpful you believe your audience to be, assume that person has no more than 3 minutes to fill out the survey.

Format of the main questionnaire is in Appendix A.

2.4. Measurement

In this study scales of reference were both nominal and ordinal. Nominal scales were used when categorizing responses. A higher level of measurement, the ordinal scale ranks respondent according to different characteristics (Vlosky 1994). Kerlinger (1986) defined measurements as process of assignment of numerals to objects or events according to rules.

Some questions involved in the section were ones that have to be rated or ranked. Open ended questions were included in order to reveal information that may have been missed.

In addition, respondent were asked questions relating to their demographic characteristics and environment of their business. The comments, suggestions or concern that were relevant to study have been reported into the findings.

2.5. Data Collection

The data collection started on October 15th, 2007, by sending first phase of post cards. It ended on January 8th, 2008 with completion of telephonic survey (Table 6). The objective of the survey was informed to stake holders well in advance. Student workers were employed to assist in telephonic interview.

2.6. Telephonic Survey

The average time of a phone call ranged from 5 to 10 minutes. In case of primary industries it went usually up to 10 minutes. But for secondary industry it was much shorter, with an average time around 3 minutes. The time element was noted for each call. The questions asked in telephonic interview were pertaining to production, consumption and utilization of wood residue. The question format is shown in Appendix B.

2.7. Data Analysis

Simple descriptive statistics were used to describe first objective, that is, estimation of production and utilization of raw material for woody biomass energy. Pair wise t-test was used to show significance of production, utilization, and patterns in the census.

The data obtained were coded and entered into computer. Excel and SAS, computer based statistical packages were used to manage and analyze data through variable relationship testing (Ryan et al. 1985). The data entry was closely monitored to ensure accuracy. The statistical techniques were used to discern differences in responses among stakeholders and two

types of forest products industry, analyzing data, and aided in reporting conclusions and recommendations.

2.8. References

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CHAPTER 3. RESULTS

Out of 835 facilities in list, 298 were out of the scope of study. This included distributors, wholesalers, retailers, loggers and tree growers.

Primary forest products industry summed to 184 plants throughout the state. There were 48 responses and response rate accounted to 26 percent (Table 7). In the case of secondary industry there were 353 facilities in the state. 89 responses were received and response rate was 25 percent.

This rate falls between the ranges of recent surveys in wood products sector such as in Aguilar (2007) 19 percent, Vlosky and Shupe (2004) 25 percent, Vlosky and Shupe (2004) 10 percent, Vlosky et al. (2002) 31 percent, and Vlosky and Ozanne (1998) 23 percent.

Table 7. Number of respondents.

	Primary Forest Products Industry	**Secondary Forest Products Industry**
Respondents	48	89
Percentage of Respondents	26	25
Non Respondents	136	264
Total	184	353

Responses were categorized into 3 based on their reception (Table 8).

1. First mail survey

   This was the response that was received from Phase I.

2. Second mail survey

   These were response received from phase II mail survey. The questionnaire had a small hole punched in them to distinguish from phase I responses.

3. Telephonic survey

   The telephone survey was basically a census. It constituted information mostly about production, consumption, sale and utilization of wood residue (Appendix B).

Table 8. Responses categorized by their reception

	n	Percentage
Phone	74	54
1st Mail	45	33
2nd Mail	17	13

Total n=136

3.1. Comparison between Phase I and II Survey Results

The Phase I and Phase II survey responses were compared for checking non-response bias. In 1st mail (Phase I) survey 27 responses came from primary sector and 20 from secondary sector. This totaled to 47 responses from Phase I survey. In 2nd mail (Phase II) survey four came from primary and 12 from secondary.

3.1.1. Non- Response Bias

Non- Response Bias refers to the mistake one expects to make in estimating a population characteristic based on a sample of survey data in which, due to non-response, certain types of survey respondents are under-represented (Berg). Non-respondents to a survey often differ from respondents. Volunteers also differ from non-volunteers, late respondents from early respondents, and study dropouts from those who complete the study. Hence, respondent often does not represent the entire population.

3.1.2. Measuring Non-Response Bias

There are several techniques to measure non response bias, among which, validation was chosen for this study. Validation is a general approach to testing for non-response bias that almost always involves comparing two different samples drawn from the same population. The technique of validation permits one to measure non-response bias, to test the hypothesis of no bias, and to identify which variables, if any, are correlated with non-response. This approach is only feasible, however, if two are samples drawn from the same population (Berg).

All demographic characters and wood residue production characters were taken into account. Employees, gender, source of information, education, sales, production, utilization, sales, moisture content, etc., were taken to compare responses from first and second surveys. There was no significant difference for any attribute. Seven attributes, among the fifteen questions of survey had a p-value of 1. Most of the rest fell in a P-value ranging from 0.9 to 0.89 (Table 9). This suggests that probability of non-response bias in this survey is very low.

The percentages of quantities were used to conduct pair wise t-test.

Table 9. Comparison between Phase I and Phase II survey

Attributes	Degree of freedom	T-value	P-value
Employees	4	-0.07	0.9447
Gender	1	0.00	1.0000
Source of information	6	-0.14	0.8934
Education	4	-0.03	0.9792
Locality of residence	6	-0.03	0.9791
Maximum distance traveled to dispose	7	- 0.04	0.9670
Number of buyers	4	0.00	1.0000
Problems in utilizing wood residue	2	0.00	1.000
Strategy to reduce wood waste	2	0.00	1.0000
Longevity	2	0.29	0.8020
Future of the wood residue	2	0.00	1.0000
Production	2	0.57	0.6265
Utilization	3	0.07	0.9515
Sell	3	0.00	1.000
Moisture content	1	0.00	1.0000

3.1.3. Primary Forest Products Industry

Lumber manufacturers constituted largest group (n= 41) of respondents in primary industry (Table 10). They formed 57 percent of respondents. This was followed by chip mills.

Chip mills produce wood chips for paper and pulp industry, as their primary product. Other respondents included manufacturers of plywood, OSB, landscape timber, rail road ties, pulp and paper, etc.

Table 10. Participants from primary forest products industry

Respondents businesses	Numbers (n)	Percentage	NAICS, 2002
Sawmill & Lumber mfg.	41	57	321113
Chip mill	10	14	321113
Plywood	4	6	321211 321212
Rail road ties	4	6	321113
Dry veneer	3	4	321211 321212
Paper and pulp	3	4	322110
OSB	2	3	321219
Landscape timber	1	1	321113
Sum	68	100	

(Source- US Census Bureau 2002)

3.1.4. Secondary Forest Product Industry

In secondary sector, cabinet manufacturers formed majority. They constituted 43 percent (n= 49) of respondents (Table 11). Architectural millworks and furniture makers were second and third respectively. Others from secondary industry that took part in the survey were manufacturers of caskets, doors and windows, craftsmen, etc.

Table 11. Participants from secondary forest products industry.

Respondents businesses	Numbers (n)	Percentage	NAICS, 2002
Cabinets manufacturers	49	43	337211
Millwork	16	14	
Furniture	15	13	321912
Custom door and windows	13	11	321911
Pallets	10	9	321920
Molding	9	8	321918
Crafts	2	2	
Upholstery	2	2	811420
Case works, Trim	1	1	321918
Caskets	1	1	339995
Sum	118	100	

(Source- US Census Bureau 2002)

3.2. Preliminary Information

The survey questionnaire started with asking certain preliminary information such as name of contact person, his / her title, name of person who was filling survey, main products produced at facility, email address, fax number, etc. Even though most of this information was there in address list, this was done mainly to correct errors in existing list. Other information sought were NAICS (North American Industry Classification system) code, SIC (Standard Industrial Classification) number and name of parent company (if any).

SIC Code is a number used to specify what industry a particular company belongs to. The Standard Industrial Classification (SIC) code system was replaced by North American Industry Classification system (NAICS) in 1997.

3.3. Demographic Characteristics

This was studied to know trends of people working in the industry in general. Some questions asked in this session were regarding age, gender, education and ethnicity of respondents. These data gave us a better picture of the population we were dealing with and may be useful in determining industry trends in future.

3.3.1. Position Held by Respondent

The positions held by different respondents were broadly divided into three (Table 12). The executive position consisted of owners, presidents, vice presidents and CEO. They took decision to run the business. This was followed by managerial position, who executed or operated the industry. This class consisted of plant managers, environmental engineers, mill managers, etc. The clerical position constituted book keepers, accountants, etc.

In primary forest products industry more respondents had a managerial position (n=20). Most often they were environmental engineers or plant managers. The executive respondents came next (n=17). This was followed by respondents in clerical post (Table 12).

Table 12. Positions held by respondents in primary forest product industry.

	n	Percent
Executive position	17	43
Managerial position	20	50
Clerical position	3	8

Total n= 42

The majority of respondents in secondary sector had an executive position (n=22). Eight were in managerial position. Only two respondents were in clerical post (Table 13).

Table 13. Positions held by respondents in secondary forest products industry.

	n	Percent
Executive position	22	68.75
Managerial position	8	25
Clerical position	2	6.25

Total n=32

3.3.2. Age

Age group 46-55 had highest number of individuals for primary sector respondents, which were ten (Table 14). This formed 36 percent. This was followed by 56-65 year class. It had 8 respondents (29 percent). Less than 25 had none and greater than 65 classes had two respondents each. More than 60 percent of respondents were in age groups between 46-65 years.

Table 14. Age of respondents from primary forest products industry.

Age class (years)	n	Percentage
Less than 25	---	---
26-35	1	4
36-45	7	25
46-55	10	36
56-65	8	29
65 +	2	7

Total n= 28

In case of secondary industry, results were somewhat similar to primary industry. Here again 46-55 year class was highest with 14 respondents (44 percent). This was followed by 56-65 and 36-45 year class (Table 15). Two respondents were below 25. Here too, more than 60 percent of respondents belonged to age groups between 46-65 years. The statistical results said

that there was no significant difference between the two sectors of industry. The P value was 0.5301, with a degree of freedom of 5 (Table 50).

Table 15. Age of respondents from secondary forest products industry.

Age class (years)	n	Percentage
Less than 25	2	6
26-35	3	9
36-45	5	16
46-55	14	44
56-65	6	19
65 +	2	6

Total n=32

3.3.3. Gender

Male respondents dominated both sectors of industries. Female population was very much negligible in primary sector, when compared to secondary (Table 16). One main reason for this was that most of secondary industry was family business where females had much better access to operation. But here again there was no significant difference between two industry, with a P-value was 0.8743, with a degree of freedom of 1 (Table 50).

Table 16. Gender of respondents.

	MALE	FEMALE
Primary forest products industry	27	1
Secondary forest products industry	21	10

3.3.4. Ethnicity

All respondents who participated in the survey were of Caucasian origin.

3.3.5. Education

3.3.5.1. Primary Forest Products Industry

When considering education, majority of respondents in primary forest products industry were college graduates (n= 13). There were four with some college degree and five college

graduates. Five had a post graduate degree, that is, Masters or above. And just one was belonging to the class “high school or less” (Table 17).

Table 17. Education received by respondents in primary forest products industry.

	n	Percentage
High School or Less	1	4
High School	5	18
Some College	4	14
College Graduate	13	46
Post Graduate Degree	5	18

Total n= 28

3.3.5.2. Secondary Forest Products Industry

In secondary forest products industry majority of respondents had high school as their highest degree of formal education. There were nine with some college degree and again nine college graduates (Table 18). Only two had a post graduate degree, that is, Masters or above. And just one was belonging to the class “high school or less”.

One critical reason for higher class of education among primary sector was that most of respondents had an engineering and managerial back ground, whereas most of secondary firms were family run businesses. But results of t-test showed that the attribute was not significant with a P-value of 0.7695 (d.f =4) (Table 50).

Table 18. Education received by respondents in secondary forest products industry.

	n	Percentage
High School or less	1	3
High School	10	32
Some College	9	29
College Graduate	9	29
Post Graduate Degree	2	6

Total n= 31

3.3.6. Professional Organization

This question was instituted to find which organization had more influence over people in the industry.

3.3.6.1. Primary Forest Products Industry

The respondents were asked to list the professional organization which they belonged (Table 19). In primary sector, most common response was Louisiana Forestry Association (n=14). This was followed by Southern Forest Products Association with three and National Hardwood Lumber Association with two.

Table 19. Professional Organization of primary forest products industry**.**

Professional Organization	n	Percentage
Louisiana Forestry Association	14	70
Society of American Foresters	1	5
Southern Forest Products Association	3	15
National Hardwood Lumber Association (NHLA)	2	10
Forest Product Society	--	--

Total n = 20

3.3.6.2. Secondary Forest Products Industry

There were only a few secondary respondents who had membership in such professional organizations. Louisiana Forestry Association, National Hardwood Lumber Association (NHLA), American Society of Mechanical Engineers (ASME), Architectural Woodwork Institute (AWI) had one each.

3.3.7. Employee Distribution

Number of employee in the facility was the next. They were divided into seven classes. Primary sector had nearly 71 percent of facilities belonging to 1-50 employee class (n=22) (Table 20). Nine facilities employed more than 50. There were two facilities with more than 400 employees.

Again in secondary sector, majority of facilities again belonged to 1-50 employee class (n=48). In primary sector, this class formed 71 percent, where as in secondary industry it constituted up to 94 percent. Only three facilities employed more than 50, which were basically

manufacturers of pallet and cabinets (Table 21). There were six facilities in which a single person operated the whole business. This question had a major drawback. The employee class was set for both sectors of industry. Since secondary sector had a very low strength when compared to primary, this could only give a vague picture of scenario. T-test was again not significant, with a P-value of 0.2843 and 6 degree of freedom (Table 50). But P-value approached significance level when compared to rest of the attributes.

Table 20. Employee distribution in primary forest products industry.

Employee classes	n	Percentage
1-50	22	71
51-100	3	10
101-150	2	6
151-200	--	--
201-251	1	3
251-300	1	3
More than 400	2	6

Total n= 31

Table 21. Employee distribution in secondary forest products industry.

Employee classes	n	Percentage
1-50	48	94
51-100	1	2
101-150	2	4
151-200	--	--
201-251	--	--
251-300	--	--
More than 400	--	--

Total n= 51

3.3.8. Source of Information

3.3.8.1. Primary Forest Products Industry

This question was regarding the source from which facilities got information to run their business. Both sectors of industries had first, second and third position in common. Trade journals were at top for both industries. In primary sector, trade journals (n=21) constituted up to

32 percent. Newsletter came next with fifteen. The two toppers accounted for 55 percent (Table 22). Information from professional organization and internet shared third position with eight each. Four facilities had a Research and Development wing. This was completely absent in secondary forest products industry, possibly because of firm size.

Table 22. Source of information in primary forest products industry

Source of information	n	Percentage
Trade journal	21	32
Newsletter	15	23
Professional organization	8	12
Internet	8	12
Consultant	6	9
R&D wing	4	6
Scientific literature	3	5
Others	--	--

Total n=65

In secondary sector, trade journals constituted 44 percent (n=23) (Table 23). Newsletter from professional organization was next (n=12). Eight respondents got their information from internet, making it third. Six respondents had their information from professional organizations too. The option "others" had zero response; however one respondent quoted that experience was one of major components of his information. There was no significant difference among the two sectors of industry according to t-test. It had a P-value of 0.1193 and a d.f. of 6 (Table 50). In this case, P-value approached a significance value when compared to majority of attributes.

Table 23. Source of information in secondary forest products industry

Source of information	n	Percentage
Trade journal	23	44
Newsletter	12	23
Internet	8	15
Professional organization	6	11
Scientific literature	3	6
Consultant	1	2
R&D Wing	--	--
Others	--	--

Total n= 53

3.3.9. Residence of the Respondents

For this purpose, locality of residence was divided into six classifications, based on population of area. These were

- Very large city (1,000,000 or more)
- Large city (250,000 to 999,999 population)
- Medium sized city (50,000 to 250,000 population)
- Small city (10,000 to 50,000 population)
- Very small city, town, or village (2,500 to 9,999 population)
- Rural area (population less than 2,500)

Most residents in primary forest product industry where in very small cities (n= 13). The numbers reduced as it went to bigger cities. There were 5 respondents who resided in rural areas (Table 24).

Table 24. Residential locality of respondents from primary forest products industry.

Residential area	n	Percentage
Very large city	--	--
Large city	2	7
Medium city	4	14
Small city	4	14
Very small city (town)	13	46
Rural area	5	18
Not sure	--	--

Total n=28

26 percent of respondents from secondary industry resided in medium city (n=8). Seven resided in small cities and six in large cities (Table 25). The number of respondents decreased as population of locality went down. Large, medium and small cities accounted for more than 65 percent of respondents. Reason for this is due to location of industry. Secondary industry is usually situated in urban areas. Whereas, primary forest products industry is most often found in

rural areas. This is considering raw material availability. T-tests revealed that both industries had no significant difference (P-value=0.8168 and d.f= 6) (Table 50).

Table 25. Residential locality of respondents from secondary forest products industry.

Residential area	n	Percentage
Very large city	1	3
Large city	6	19
Medium city	8	26
Small city	7	23
Very small city(town)	4	13
Rural area	4	13
Not sure	1	3

Total n= 31

3.4. Wood Residue

The next session of results deals with information of wood residue produced or utilized. The criteria which were selected in this part, included number of buyers, maximum distance required for wood residue to reach its destination, etc. Here facilities were divided into producers and utilizers. Certain questions were applicable only to producers and certain other to utilizers. T-tests were done to all attributes, and none of them had a significant difference between the two sectors of industry.

3.4.1. Markets for Wood Residue

This question was intended for respondents who sold their wood residue. In primary industry, there were 11 facilities which had 1-2 buyers (46 percent). Six had 3-4 markets (Table 26). But one major point to be noted here was that primary forest product industry also included chipmills, which was in fact a major portion of the respondents. In this case, wood chips were main products being produced. This shows that wood chips are in demand in the state. Pulp and paper mills were primary purchasers of wood chips. Wood chips were also used in mulching. There were 5 facilities which had no buyers. One company informed us that they had great difficulty in selling their wood waste.

Table 26. Market for wood residue in primary forest products industry

Market (buyers)	n	Percentage
0	5	21
1-2 buyers	11	46
3-4 buyers	6	25
5+	1	4
More buyers but not at same time	1	4

Total n=24

The number of buyers for wood waste was very low for secondary industry. Most wood residue produced went to landfills. Some were burnt (not used as fuel for energy). Twenty two responded that they had no market for their wood residue. But among this, a major portion was small scale facilities, which produced less wood waste. In such case, purchasers would not find it economical to buy from these facilities due to comparatively small amount of wood residues they produce. Seven were in 1-2 buyer class, of which 3 had just one buyer. No one had more than 5 buyers at same time. One facility had more than 5 purchasers but not at same time (Table 27). T-test showed there was no significant difference between the two industries. The P-value was 0.7444 and degree of freedom was 4 (Table 50).

Table 27. Market for wood residue in secondary forest products industry

Market(buyers)	n	Percentage
0	22	71
1-2 buyers	7	23
3-4 buyers	1	3
5+	--	--
More buyers but not at same time	1	3

Total n=31

3.4.2. Maximum Distance for Transporting Wood Waste to Disposal Site or to Buyer

This question was again meant for producers of wood residue. It was to know maximum distance to disposal site or to buyer. In primary sector, maximum number of respondents was in 36-70 mile class (n=7). This constituted 27 percent. Four delivered it to 11-35 miles. Six had them deposited on site itself. The maximum distance traveled was 141-200 miles (Table 28).

According to Fischer and Schrattenholzer (2001), maximum distance between production and consumption was usually less than 160 miles.

Table 28. Maximum distance for transporting wood waste to destination in primary forest products industry

Distance traveled in miles	n	Percentage
None	6	23
0-10	1	4
11-35	4	15
36-70	7	27
71-105	3	12
106-140	3	12
141-200	1	4
201-500	--	--
do not know	1	4

Total n=26

In secondary sector, maximum distance to disposal site or buyer was much lower. This distance was 70 miles for secondary industry. Fifteen facilities had their waste deposited on site itself. The largest section of secondary forest products industry respondents, who transported their residue, did it within 10 miles (n=6). Five were not sure about the maximum distance (Table 29). Obviously, wood energy becomes more uneconomical when transportation distance increases. But according to T-test, there was no significant difference between the two industries. (P-Value= 0.7256, d.f.= 7, Table 50).

Table 29. Maximum distance for transporting wood waste to destination in secondary forest products industry.

Distance traveled in miles	n	Percentage
None	15	48
0-10	6	19
11-35	3	10
36-70	2	6
71-105	--	--
106-140	--	--
141-200	--	--
201-500	--	--
do not know	5	16

Total n=31

3.4.3. Maximum Distance from Which Facility Received Wood Supply

This question was intended for facilities which bought wood biomass for energy production. In primary industry, there were six responses of which two got it from above 120 miles. None received from within 10 miles. These responses showed wood residues were not being produced in near locality. By procuring fuel from locality, transportation cost could be reduced; this lowers the expense of energy production. But this also tells that there is a good demand for wood residue. Other classes had one response each (Table 30).

Table 30. Maximum distance for receiving biomass

	Secondary Forest Products Industry	Primary Forest Products Industry
Within 10 mile	--	--
10-35 mile	1	1
35-70 miles	--	1
70-120 miles	--	1
Above 120 mile	--	2
Don't know	1	1

In secondary forest products industry, wood residues are not usually utilized for energy production. Hence, this question received very less response from this section. Only 2 responded in secondary forest products industry. One was not sure about distance and the other facility got it from with in 10-35 miles of radii (Table 30).

Here P-value was 0.0993 (d.f was 4) which said that there was no significant difference between the two sectors. But at 10 percent confidence level, this will be significant.

3.4.4. Longevity of Energy Production from Wood Residue Biomass in Louisiana

This question was designed to know how long the industry was involved in energy production from wood residues. In primary industry, there were two in 31-40 year class. But like secondary forest products industry, 0-10 year class had highest number of respondents (n=4). Conversely, there was only one secondary industry respondent who was producing energy form

wood residue for more than 20 years. There was two in 0-10 year class. There was no significant difference between the two industries (P-Value= 0.8399, d.f.= 2).

Table 31. Longevity of energy production from wood residue.

	Secondary Forest Products Industry	Primary Forest Products Industry
0-10 years	2	4
11-20 years	--	--
21-30	1	1
31-40	--	2
41-50	--	--
More than 51 years	--	--

3.5. Opinion

This part of result deals with opinions of respondents. The major objective of this session was to get information about general mentality of industry regarding wood residues and issues concerning it. There were six questions in this session. Response level was very low because this was not included in telephone survey, which constituted 74 percent of response. On an average only six respondents from both sections of industry answered this part. In this section two attributes had a significant difference between both industries.

3.5.1. Strategies to Reduce the Wood Waste Problems

This question was devised to know strategies taken by industry to reduce wood waste. In primary industry, eight had no problem with their wood waste (Table 32). Nine went for a 'no' and three facilities had devised a strategy to reduce their waste. Five of nine in "no" category were utilizing their waste.

Table 32. Opinion regarding strategies to reduce wood waste in primary forest products industry.

	n	Percentage
Yes	3	15
No	9	45
No Problem	8	40

In secondary respondents, eleven said that they had no problem with their wood waste (Table 33). Another eleven agreed they had problems but revealed they had no specific strategies to overcome it. Only five had a strategy to reduce wood waste problems. A typical remark in this section was “to minimize waste through machinery”. Statistical results said that there was a significant difference between two sectors of the industries (P-value= 0.0198, d.f.= 2).

Table 33. Opinion regarding strategies to reduce wood waste in secondary forest products industry.

	n	Percentage
Yes	5	18
No	11	41
No Problem	11	41

3.5.2. Problem Preventing Better Utilization of Wood Biomass

“Does your facility have a problem preventing better utilization of wood biomass?”

This question was regarding problems faced when utilizing wood residue. To this eleven responded they had no problem. Five were not sure. Only four facilities had problems utilizing wood residue (Table 34).

Table 34. Problems preventing better utilization of wood in primary forest products industry

	n	percent
Yes	4	20
No	11	55
Not sure	5	25

Secondary industry also showed same trend. Thirteen had no problems, nine were not sure about it and three reveled that they had problems (Table 35).

Table 35. Problems preventing better utilization of wood in secondary forest products industry

	n	Percent
Yes	3	12
No	13	52
Not sure	9	36

There was no significant difference between two sectors in this attribute. (P-value= 0.3701, d.f.=2) (Table 50).

3.5.3. Subsidies or Grants from the Government

"Does your facility receive any subsidies or grants from the government (federal/ State/local) relating to biomass energy?"

The primary objective of this question was to know whether the facility gets any financial incentives to use wood residue biomass for energy production. None answered a yes (Table 36). Eleven responded with a 'no' in primary sector. Whereas nine no's were received from secondary sector.

Table 36. Financial subsidies or grants for facilities in wood residue energy production

	Secondary Forest Products Industry	Primary Forest Products Industry
Yes	--	---
No	9	11
not sure	--	2

3.5.4. Future of Wood Biomass Energy Industry

"What is your opinion about future of wood biomass energy industry?"

This was a question formulated to view the general stand of forest products industry. In primary sector, eight answered that this would grow and two said that it was to remain as it is, without an increase (Table 37). Even though none from secondary sector answered that trend would fall down in coming years, all five responses were "not sure". There was no significant difference among both industries (p-value=0.7007 d.f.=2) (Table 50).

3.5.5. Utilization of Ash

"Does your facility use ash for some kind of purpose or throw it away?"

This question was only meant to those who produced energy from wood residues. Hence it was one of the questions which received least responses. In primary sector, two used ash and four did not. The uses of ash that was quoted were in onsite landfill and as manure. All three respondents from secondary sector were not aware of it (Table 38).

Table 37. Opinion regarding future of wood biomass energy industry

	Secondary Forest Products Industry	Primary Forest Products Industry
Will grow	--	8
Will remain as it is	--	2
Will decrease	--	--
Not sure	5	--

Table 38. Utilization of ash

	Secondary Forest Products Industry	Primary Forest Products Industry
Yes	--	2
No	--	4
Do not know	3	--

3.5.6. Utilize Wood Biomass for Energy Production in Future?

In primary industry all eight voted for yes. As expected, no one from secondary industry preferred to use wood biomass for energy in future. Four were not sure (Table 39). Two responded they would not.

Table 39. Utilize wood biomass for energy production in future?

	Secondary Forest Products Industry	Primary Forest Products Industry
Yes	--	8
No	2	--
Not sure	4	--

3.5.7. Rating and Ranking of Different Problems in Wood Biomass Energy Production.

This was a question in likert scale. There were four options and it was to be ranked from 1-4 based on their significance, with 1 being the most significant. Statistical analysis could not be done to this session of survey because the response rate was very low. Responses from both industries were clubbed together.

3.5.8. Primary Factors that Facilitated Use of Wood Residue Energy Production

Utilizers of wood biomass energy were asked to rank the primary factors that attracted them to use wood residue for energy production. Three said the primary reason for selecting

wood biomass was due to affordable and readily available nature of the fuels (Figure 2). Two were in the opinion that wood residue saves them money over fossil fuel. The financial incentives and benefits was third highest pick. Environmental benefit was the one with least.

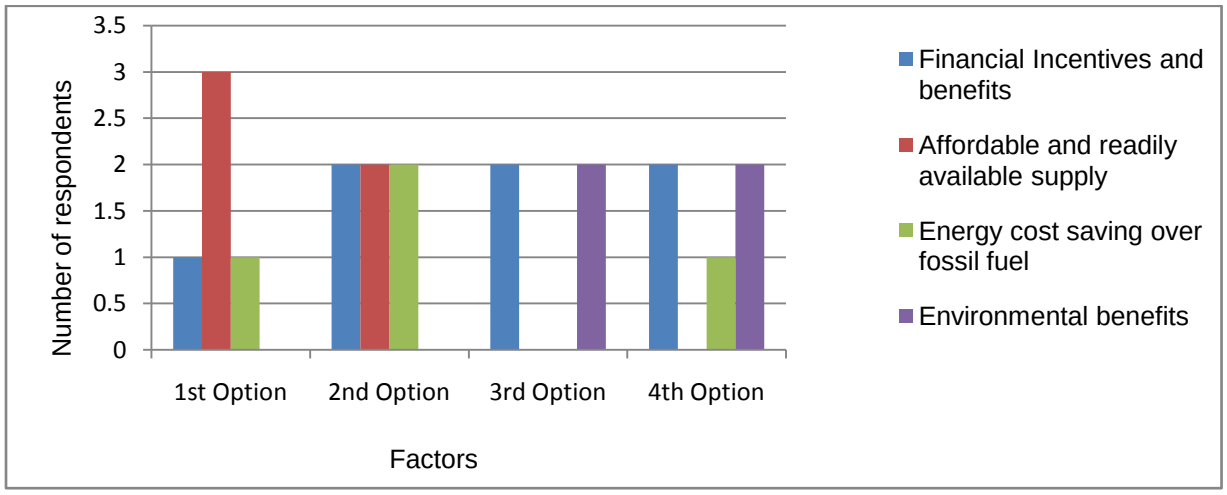

Figure 2. Factors that facilitated use of wood residue

3.5.9. Ranking Problems Preventing Better Utilization of Wood Residue, in Sellers' Opinions.

Sellers of biomass were asked to rank the major problems preventing better utilization of biomass. "Low price of woody biomass" was picked most. Most sellers did not get a fair price for their wood biomass. Second major problem was increased transportation charge. The problem that came in third position was lack of buyers for wood biomass. Long waiting time in mill ranked last (Figure 3).

3.5.10. Rating Problems Preventing Better Utilization of Wood Residue in Utilizers' Opinions.

Respondents who utilize wood biomass were asked to rate constraints on better utilization of biomass. This was a question in which options had to be rated according to their level of importance from 1-5, 1 being "strongly agree" and 5 being "strongly disagree". Points were assigned to each response. Points were then reversed and summed to get the most important response.

High cost in establishing a wood energy production unit was the most important constraint. Next was increased equipment and maintenance cost. Several also said that this could not satisfy their energy need. Again others were of the opinion that availability of raw materials was scarce (Figure 4).

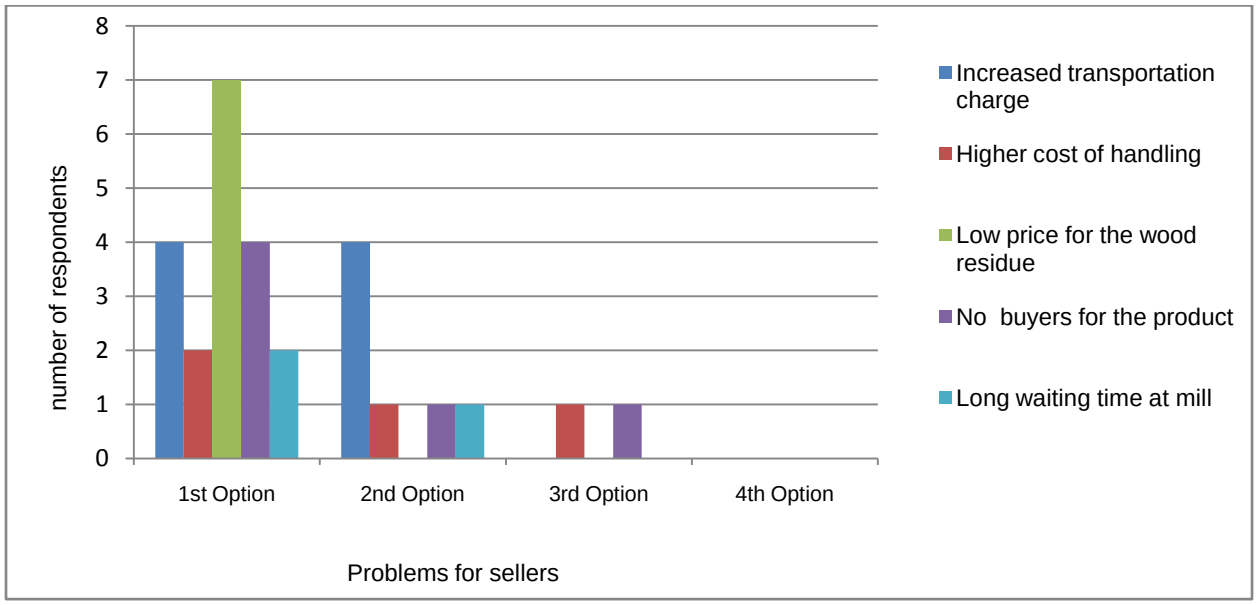

Figure 3. Ranking problems preventing better utilization of wood residue, in sellers' opinion

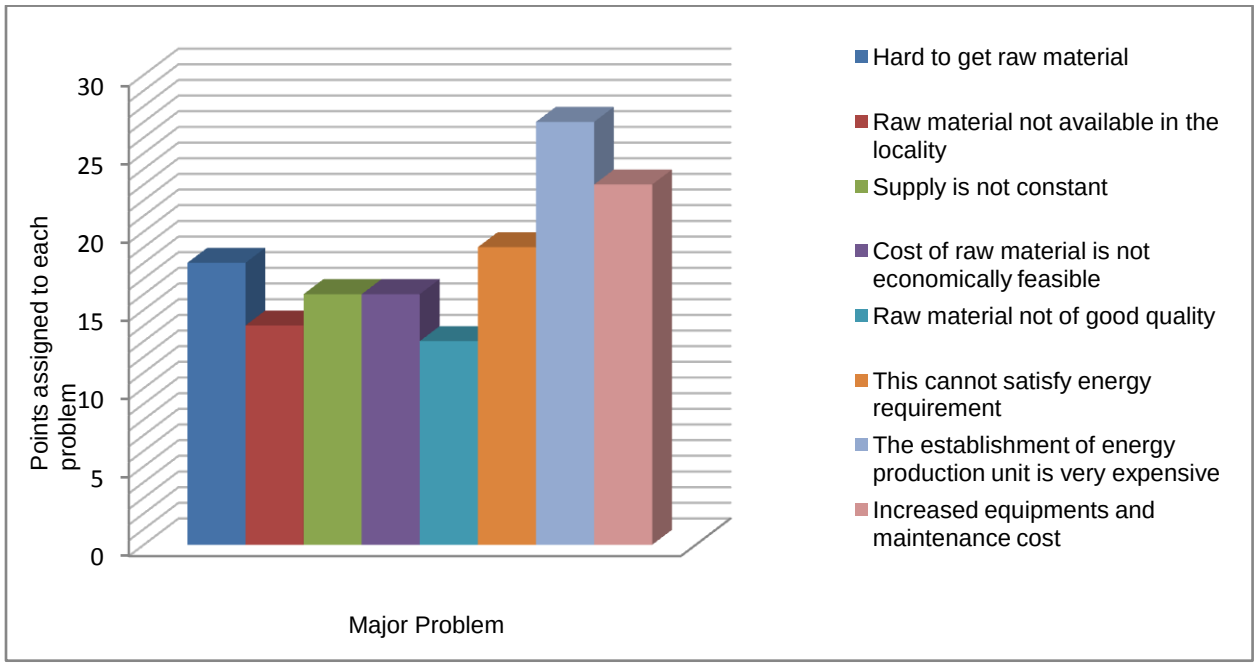

Figure 4. Rating problems preventing better utilization of wood residue in utilizers' opinion

3.5.11. Efficiency Enhancement in Energy Production

Respondents were asked regarding steps required to increase efficiency of energy production in their facilities. This question was intended for energy producer from wood residue. This question was formulated to give an idea of how they could increase their efficiency. For this, most rated that by getting more amount of raw material would lead to better efficiency of their energy production unit. This says that they were running on a shortage of supply. The second impression to increase efficiency was to install more efficient equipments. A cheaper source of raw material was the third and a more constant supply of wood residue was at last. Eight responded that their energy production was very efficient and required no more enhancements (Figure 5).

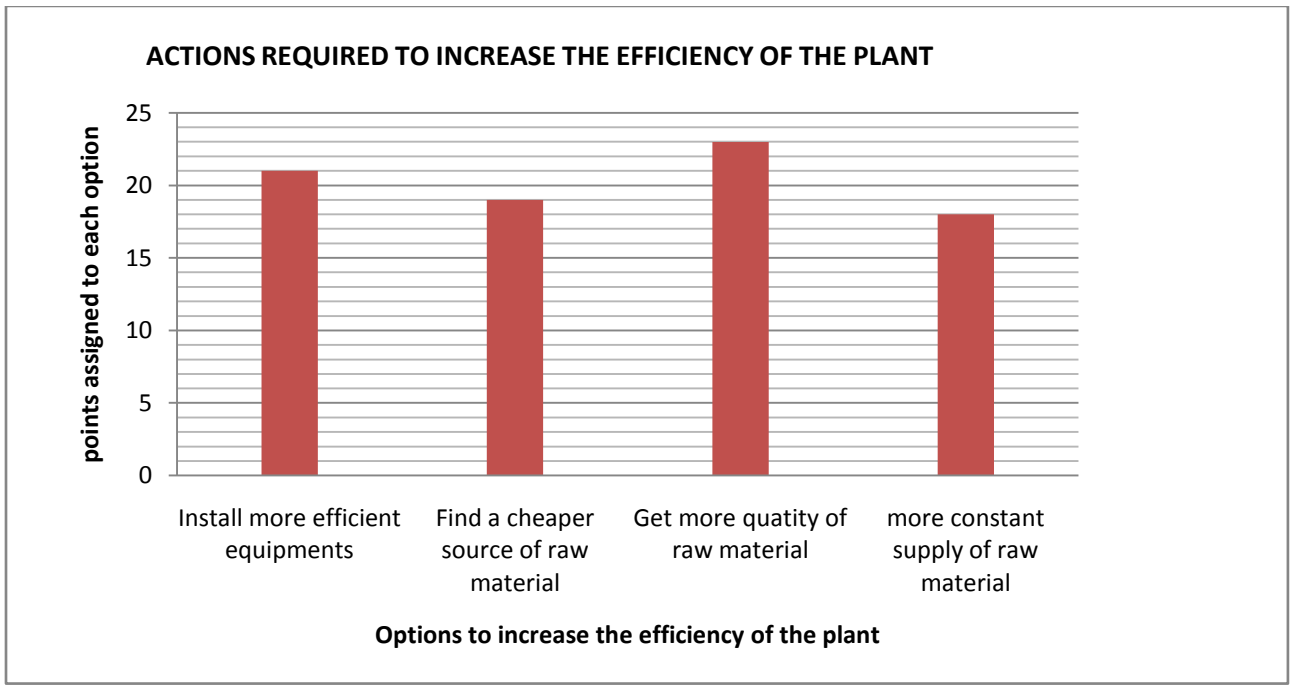

Figure 5. Efficiency enhancement in energy production

3.5.12. Actions Required at Industrial Level to Improve Wood Waste Utilization

Even though all questions had a remark session, there was only one specific open-ended question. The question was aimed to know actions required at industrial level to improve wood

waste utilization. Most primary Industry responded to this question. Some relevant points are quoted below.

Primary Sector

- ”Industry needs better understanding of the cost associated with gathering wood waste on a logging job”
- “A clearing house or database of companies that purchase or haul wood waste.”
- “Better prices”
- “Steady market”
- “Organization”
- “Create more uses that would benefit potential buyers and discontinue burning at waste facilities”
- “Mix wood waste with coal burning power plants”
- “Diversification”

Secondary Sector

- “We should not have to pay to get them take it.”
- “The solution are there in the book Co-creative science, Machaelle Small Wright www.perclandra-ltd.com/co-creative_science_P5C3.cfm”
- “Recycle or use for energy production”
- “More cost effect methods of utilizing waste for energy”
- “Get efficient technologies into the market”
- “Provide ways of disposals that are convenient to those with left over materials”

3.6. Census

This part of the survey was intended to produce a summary of production, utilization, purchase and sales of wood residue from forest product industry in the state (Table 40 and 41). Most facilities in secondary industry did not have an accurate measurement for their production

and utilization data. They expressed it in terms of dumpsters and trailers. In the previous census, volume of dumpster was assumed to be 38 cubic yard. For density of sawdust, a shaken degree of compaction was assumed and hence a factor of 18.4 lbs/ cubic feet was given. The same measurement was adopted in this too.

Table 40. Wood residue being produced and utilized in Louisiana from primary sector

	Bark (tons/ year)	**Sawdust (tons/ year)**	**Wood piece (tons/ year)**	**Other wood residue (tons/ year)**	**mixed (tons/ year)**	**Total (tons/ year)**
Production	572,390	422,286	132,980	--	2,799,635	3,927,291
Buy	15,000	--	--	--	1,209,750	1,224,750
Utilization	637,000	--	140,000	2,010	--	779,010
Sell	330,250	412,530	7,800	31,500	2,530,400	3,312,480

Table 41. Wood residue being produced and utilized in Louisiana from secondary sector

	Bark (tons/ year)	**Sawdust (tons/ year)**	**Wood piece (tons/ year)**	**Other wood residue (tons/ year)**	**Total (tons/ year)**
Production	--	2,575	1,225	5,120	8,920
Buy	--	--	--	--	--
Utilization	--	133	202	1,300	1,635
Sell	181	2,000	1,200	2,438	5,819

In primary sector, bark was most common in production. Twenty eight facilities produced it. Sawdust had next place (n=26). There were fifteen facilities that produced wood pieces and twelve produced other wooden residues (Table 42). Other wood residues included chips, slash, plywood trimmings, slabs, etc. Five facilities bought wood pieces and only one bought bark for fuel purposes.

Table 42. Number of facilities producing or utilizing wood residue in primary sector

	Bark	**Sawdust**	**Wood piece**	**Other wood residue**
Production	28	26	15	12
Buy	1	--	5	--
Utilization	10	8	7	--
Sell	14	15	6	9

In sales, fifteen of the respondents sold sawdust for energy purposes to other companies such as pulp mills. Fourteen sold bark and six sold wood pieces. Nine facilities sold chips to paper industry.

Among the number of facilities in secondary forest products industry which produced, utilized, bought and sold wood residue only one company produced bark (Table 43). Fifty seven facilities produced sawdust, eleven produced wood pieces and thirty seven produced other wood materials like shavings, chips, wood scraps, etc. Only three facilities were buying wood residues. In utilization point of view, bark was used by three facilities. Sixteen used sawdust, three used wood pieces and fourteen used other wood residues. Production and utilization of bark was very low. Seven facilities sold sawdust. Six each sold wood pieces and other wood residues

Table 43. Number of facilities producing or utilizing wood residue in secondary sector

	Bark	**Sawdust**	**Wood piece**	**Other wood residue**
Production	1	57	11	37
Buy	--	--	2	1
Utilization	3	16	3	14
Sell	3	7	6	6

Table 44. Wood residue utilization in secondary sector.

Wood residue utilization	**Number of facilities**
As compost	3
Fuel for wood energy	4
To bed horse stables	7
Recycle to new products	2

Forty five facilities in secondary industry hauled away waste, totaling 1,928 tons of wood residues annually. Only seven from primary sector did this, but they dumped nearly 2,155 tons of wood residues annually. Most of secondary sector facilities lacked proper data regarding amount of wood materials dumped.

But statistical results showed that there was no significant difference between the two industries (Table 45).

Table 45. Statistical test results of utilization, production and purchase of wood residue between two forest products industries

	DF	P-Value
Production	3	0.6741
Buy	3	0.5324
Utilization	3	0.6177

3.6.1. Moisture Content of Wood Residue

As expected, in primary more than 90 percent used green wood. Only two dealt with dry wood. Whereas, secondary industry dealt mostly with dry wood. Fifty four facilities used dry wood and eight used green wood (Table 46).

Table 46. Moisture content of wood residues

	Secondary Forest Products Industry	Primary Forest Products Industry
Dry	54	8
Green	2	24

3.6.2. Comparison between Northern and Southern Regions within Primary Forest Products Industries

The production and utilization of wood residue were compared between northern and southern regions of the state within primary industry. All Acadian parishes, except for Avoyelles and Evangeline, and Florida parishes were considered as the south. The rest were placed in north.

The Northern region had 31 respondents from 16 parishes and South had 17 respondents from 11 parishes. Numbers of facilities producing and utilizing were the features that were taken into account. The reason for choosing these features was to know about the production capacity of the regions. Again these features had a full set of data.

Results of t-test showed that there was a significant difference between the two regions. The p-value was for production and utilization was 0.0639 and 0.0480 with degree of freedom of 3 and 2 respectively. North had more number of producers when compared to South (Table 47). Utilization also had same trend. One main reason was that there were more facilities in the north.

Table 47. Comparison of production and utilization between northern and southern regions in primary sector

		Bark	sawdust	Wood piece	Other wood residue
Production	South	8	6	3	6
	North	20	19	12	6
Utilization	South	3	1	4	--
	North	12	5	6	--

3.6.3. Comparison between Hurricane Affected Region and Other Parts within Secondary Sector

In secondary sector, industries from hurricane affected region were compared with the other parts of the state. The respondents from Ascension, Calcasieu, Iberia, Jefferson, Lafayette, Lafourche, Orleans, St. Charles, St. Tammany, Tangipahoa, and Terrebonne Parishes framed the "hurricane affected parishes". Utilization had a significant difference between the two regions, with a P-value of 0.0480 and a d.f. of 3, but production was not significant (Table 49). There was less utilization of wood residue in hurricane affected regions.

Table 48. Comparison of production and utilization between Hurricane affected region and other parts in secondary sector

		Bark	Sawdust	Wood Piece	Other wood residue
Production	Hurricane effected	--	21	1	12
	Others	--	36	10	25
Utilization	Hurricane effected	1	1	--	--
	Others	2	6	6	--

Here again data of number of facilities producing and utilizing, were attributes that were taken into account. Production and Utilization were greater in "other" parishes. There were only 39 respondents from Hurricane affected parish. This was the main reason for the high number of production and utilization of the wood residue in the "other" parishes.

3.7. The Statistical Analysis

Results of t-test shows that most of the attributes in primary and secondary industry had no significant difference (Table 50). One main reason which can lead to this was due to the

comparatively low response rate. Even though the survey had a 25 percent response, this mainly came from telephonic survey. Both phases of mailing surveys only contributed to about 56 percent of response. Basically this was the part from which most of perception part received an answer. The telephonic survey only had a few questions because time component was a severe limitation to this part. Respondents only had 7 minutes on an average to spare for us. Hence, this session mainly focused on details of production and utilization of wood residue (Appendix B). Again majority of secondary industry respondents were not able to quantify a figure for the attribute.

Table 49. T-test results – Comparison of production and utilization within industries

	DF	t Value	Pr > |t|
Primary			
Production	3	-2.87	0.0639
Utilization	2	-1.00	0.0480
Secondary			
Production	2	-6.99	0.0198
Utilization	2	-2.00	0.1835

A model of the SAS program used to run the software is given below.

```
dm'log;clear;output;clear';
options nodate nocenter pageno=1 ls=100 ps=100;
title1 "Anil-dessertation problem";
data anil;
input buyp buys;
datalines;
0 1
0 0
2 1
1 1
;
proc ttest;
paired buyp*buys;
run;
quit;
```

Table 50. Results of the Paired t-test

	Degree of Freedom	t Value	P-Value
Production	3	0.46	0.6741
Buy	3	0.32	0.5324
Utilization	3	0.55	0.6177
Sales	3	-1.02	0.3848
Number of sellers	3	0.29	0.7915
Employment	6	1.18	0.2843
Longevity	2	0.23	0.8399
Maximum distance from which facility received wood residue	4	-2.14	0.0993
Use wood residue	2	-0.18	0.8740
Future of wood residue	2	-0.44	0.7007
Maximum Distance to buyer or disposal site	7	0.37	0.7256
Number of buyers	4	0.35	0.7444
Problems in utilizing wood residue	2	1.15	0.3701
Strategy to reduce wood waste	2	7.00	0.0198
Gender	1	0.20	0.8743
Source of information	6	-1.82	0.1193
Education	4	0.31	0.7695
Location of residence	6	0.24	0.8168
Age	5	0.67	0.5301

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CHAPTER 4. DISCUSSION

The most recent survey of wood biomass in the state was conducted during 1994. It was carried out by LSU Agcenter. The results showed that an estimated 7,764,285 tons of wood residues were generated (Table 51). Producers dumped 134,324 tons per year. The survey had a 35 percent response (LFPL 1994). The results also said that maximum tonnage of wood residue available for sale or landfills in 1994 was in Union, Livingston, Beauregard and Allen parishes.

Table 51. The results of 1994 Census

	Data from the sample (tons)	**Estimated Population (tons)**
Total produced	**4,706,335**	**7,764,285**
Total produced by Primaries	4,685,087	7,683,543
Total produced by Secondaries	21,248	80,742
Total not used	**53,929**	**134,324**
Wasted by Primary	32,688	53,608
Wasted by Secondary	21,241	80,715
Total Used	**4,652,406**	**7,629,961**
Used by Primary	4,652,399	7,629,934
Used by secondary	7	27

Source- LFPL 1994

4.1. 2007 Survey

This part of the study was basically done to update 1994 survey. There were a total of 138 responses from both industries. This accounted for 25 percent response rate. The production of wood residue was estimated to be about 15,076,937 ton from forest products industry in the whole state (Table 52). In this survey, 99.8 percent of wood residue came from primary industry. Secondary industry only produced about 0.2 percent. This was mainly due to scale of operations in these facilities.

Here, the size of facility was determined from many factors. Primary criteria were number of employees in the company. Other criteria that were used to determine size were

production, utilization or consumption of wood residue. Many in secondary sector had only a rough estimate about production and utilization of their wood waste. Again, the employment distribution showed that most secondary industries were small scale businesses. To estimate the amount for the whole population, a factor of 3.83 was applied to primary industries and 3.97 to secondary.

The current survey was also done in somewhat similar fashion to 1994 survey. Hence a comparison of the two is possible (Table 53).

Table 52. The results of 2007 Survey

	Data from the sample (tons)	Estimated Population (tons)
Total produced	**3,936,211**	**15,076,937**
Total produced by Primary	3,927,291	15,041,525
Total produced by Secondary	8920	35,412
Total not utilized	**3,161**	**15,911**
Wasted by Primary	2,156	8,256
Wasted by Secondary	1,928	7,656
Total Used	**3,314,115**	**12,693,289**
Used by Primary	3,312,480	12,686,798
Used by secondary	1,635	6,491

4.2. Comparison between 1994 and 2007 Survey

When comparing both surveys, production and utilization had increased almost twice than previous. When there was a 61.5 percent of response from primary sector in 1994 survey, the recent one only had 26 percent. Number of forest products industries was about 707 secondary wood processors and 139 primary manufactures then. This totaled to 846 industries in the state. The current number of forest products industries only sum to 537 with 184 in primary sector and 353 in secondary. Another point worth noting was the drastic fall in number of secondary industry. When it was totaled to 707 in 1994, today there are only 353. Nearly half of them went out of business during a period of 15 years. In spite of this down fall in number of

facilities, production and utilization of wood residue had increased twice due to twenty six percent increase in number of facilities in primary sector.

Table 53. Comparison between 1994 and 2007 survey

	Estimated Population 2007 (tons)	**Estimated Population 1994 (tons)**
Total produced	**15,076,937**	**7,764,285**
Total produced by Primary	15,041,525	7,683,543
Total produced by Secondary	35,412	80,742
Total not utilized	**15,911**	**134,324**
Wasted by Primary	8,255	53,608
Wasted by Secondary	7,655	80,716
Total Used	**12,693,289**	**7,629,961**
Used by Primary	12,686,798	7,629,934
Used by secondary	6,491	27

The wood residue unutilized also had gone down in forest products industry. In 1994 134,324 tons of wood residues went unutilized annually, but by 2007, the unutilized residue was 15,911 tons annually. A drastic increase in utilization of wood residue was seen in secondary sector. In 1994 when this sector utilized only 26.6 tons annually, by 2007 it went up to 6,490 tons annually (Table 53).

4.3. Problems Faced by Industry and Suggestions

The majority of respondents belonged to executive and managerial positions in both industries. Hence perception phase was of great importance in forecasting future of industry. Even though nearly 60 percent of the industry faced a problem with their wood residue only 20 percent had adopted a specific strategy. One of the most viable ways to tackle their problem of wood waste was to reduce production of wood waste. In the survey several responses were received for this question. Again by giving an economic value, the waste no longer becomes waste. Finding an alternative use to the wood waste can solve this problem to a great extent.

Utilization of wood residue in cogeneration, where heat energy is converted into electric energy, can be an effective step in this regard.

In general, mentality of secondary industry towards wood residue was negative. When asked about future of the industry all five response received from the sector said that they were not aware about it. This clearly pictures lack of information regarding the issue in secondary sector, whereas in primary Industry most respondents saw wood residue as a potential fuel and claimed that t energy production from wood residue will grow in future. In fact one company had reduced its fuel bill from $ 300,000 to $ 0.

Over the last 30 years there has been tremendous improvement in utilization of wood residue. Today sawmills and plywood mills chip their entire wood residue and sell it to paper and pulp mills. Revenue from this forms a significant percentage of their income and so wood residue is no longer considered as a waste (LFPL 1993).

In a study done at West Virginia University, Hassler (1994) claimed that one major barrier for using wood residue for energy production was the negative attitude. Wood residue was always perceived as waste, instead of a potential alternative fuel. As a solution for this he recommended to advertise the word “wood residue” instead of wood waste.

Another alternative to increase demand for wood residue is to broaden the spectrum of its utilization. Currently only forest products industry is using wood residue as fuel. If this can be extended to other industries in the state, demand of wood residue will go up.

Producers who do not use their wood residue efficiently were sometimes impeded by lack of information (LFPL 1994). The public and industrial people should be educated about relatively low cost fuel. The emphasis should be given on secondary industry. The information should be passed on to stakeholders in this sector. Most companies received their information through trade journals and newsletters. Hence advertising benefits of wood residue through these

channels can be potential option to get this to people in the industry. Membership of secondary sector in professional organizations was low, so this would not be a viable medium for promotion of wood residue energy. Seminars and conferences should be held among stakeholders to generate awareness.

The next problem was regarding consistent supply of fuel resource. Most respondents from secondary industry stated that their supply of wood residue varied in a great proportion throughout the year. In such cases, a consistent supply cannot be guaranteed. Supply increased in summer as more mills peaks their production at this time and decreases in winter, when it is in fact, most required by the energy producing industry (Hassler 1994). Consistent supply can be assured by the conglomeration of different producers of wood residue. For this information of producers and customers are required. There should be data available for purchasers to know about producers, their location and amount for sale. This was again, one of the primary intentions of the survey. In the preliminary information most of these data were collected. This included name of contact person, mailing address, email address, company website, amount produced, etc.

Again most companies stated that it was very expensive to install a wood energy production unit. In such cases, government and other organizations should come forward to promote use of wood residue biomass for fuel. The Government can provide financial incentives in forms of grants, subsidies or tax reduction. This can help more facilities to incorporate equipment and technology for wood waste utilization (Hassler 1994).

The majority of the facilities in secondary sectors had no buyers for wood residue they produced. The lack of networking between customer and producers was the reason. Responses showed that problems due to waste production were high.

Most wood residue produced by primary sector was utilized. Nearly 55 percent of the companies had no problem regarding better utilization of wood biomass. Large numbers of

chipmills in the state indicates the demand for wood biomass. Major chunk of wood chips went to paper mills for pulp production. Again there were companies which wanted wood biomass for their energy requirements, but when it came to secondary sector almost all went to landfills. Secondary sector generated about 35,412 tons of wood residues annually. Even though there was a demand for wood biomass, secondary producers could not sell their wood residue. One major reason for non-utilization of wood residues was due to comparatively small production that was distributed widely across the state. A large percent of facilities had to transport their residue up to 35 or more miles to reach consumers. This cost of transportation restricted it from being a viable option. Hence aggregating producers in secondary industry can be an effective solution for this.

According to LFPL (1994), main factors that affected wood residue utilization was

- Capital Investment- Installment of machinery and technology to generate wood energy requires a significant capital investment. Wood residue could be converted into densified wood, which will increase heat content and life span of the fuel. This required machinery, technology and investment in the sector.
- Distance from buyer to producer. The markets are away from producers and production facility is widely distributed in the state, making procurement of raw material uneconomical.
- Technological barriers- Technology required for production of energy from wood residue is still in its growth phase.

Hassler (1994) came up with some recommendation for these problems.

- Finding more possible uses for the wood residue other than wood energy.
- Improving access to the market.
- Attracting new industries to the state which utilizes wood energy.

- Enabling grants and other low-cost loans for the facilities to invest in equipments that utilize wood energy.
- Net working among the producer and consumers.
- Permits for the installment of wood residue energy system should be simplified.

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CHAPTER 5. CONCLUSION

A survey was conducted among forest product industry to account for production, utilization, sales and purchase of wood residue in the state of Louisiana. There were a total of 537 forest product industries, which included both primary and secondary forest products industry. From this, 138 responses were received. This accounted for 25 percent response rate, in which, 45 percent of response came from mail survey and the rest from telephone survey.

Secondary industry was dominated by cabinet makers, and sawmills topped primary sector. Wood residue being produced accounted to 15,076,937 tons / year. The common residues produced included wood chips, sawdust, bark and shavings. In this 99 percent came from primary sector, and secondary sector only contributed 0.2 percent to the total. When, in 1994, the total number of industries was 707, in 2007 there were only 353. In spite of this down fall in number of facilities, production and utilization of wood residue had increased twice during the period. This was mainly due to the twenty six percent increment in number of facilities in primary sector.

Coming to sales of wood residue, markets were located far away from production centers. On an average, it took 35-70 miles for wood residue to be transported to the point of energy production, which increased expense of the entire process. But, this indicated a demand for wood residue for energy production.

In spite of this demand for wood residue, most secondary facilities could not sell their residue. This was due to lack of networking within the industry. This study was primarily done to fill this gap. Survey results will be used to create an online interactive website, from where the industries needing wood residue can purchase them from the producers.

The study showed us that the primary reason for selecting wood biomass by wood residue energy producers was the affordable and readily available nature of fuels and the fact that it

saved them money over fossil fuel. Their major constraints were the high cost in establishing energy production unit and increased equipment and maintenance cost. But none of the facilities in both the sectors received any financial aid or grants for utilizing wood energy. The scarcity of raw materials was also an issue. But for the sellers, the major problems were the low price for wood residue and increased transportation charge.

The demographic features of respondent were also collected, in order to get a better picture of the industry, even though it had no major role in the census.

Overall perception of the industry was also taken into account. Regarding the future of wood biomass energy, primary industry responded that this will grow in coming years. But in secondary sector, all responses indicated that they were not aware about the situation. Hence there was a positive mentality for utilization of wood biomass in primary sector and a negative impression in secondary sector. This was mainly due to lack of information and was reflected in utilization of wood waste, in this sector. According to the survey, nearly 50 percent of respondents got information to run their business from trade journals and newsletters. In general, respondents had a low membership in professional organizations. Hence advertising the vistas of wood residue through these channels could be effective.

When it came to wood residue sent to landfills, nearly forty five facilities among secondary respondents hauled about 1,928 tons of wood residues annually. Only seven from primary sector did so. But this accounted to nearly 2,155 tons of wood residues annually. But when compared to 1994 census, wood residue unutilized had gone down in the forest products industry. In 1994, 134,324 tons of wood residues went unutilized annually, but by 2007, unutilized residue was only 15,911 tons annually. A drastic increase in utilization of wood residue was seen in secondary sector too. When in 1994 this sector utilized only 26.6 tons, by 2007 it went up to 6,490 tons annually.

5.1. Limitations of the Study

Even though the target response rate was reached, there were some steps which could be adopted to increase response rate. The questionnaire was to be kept short and precise. It should always be remembered that respondents have no more than 3 minutes to spare for us. Another limitation was regarding mindset of the industry. Most facilities did not like to reveal information about their production, utilization, employment, etc. Thus industrial visit and personal interviews can also be incorporated in the methodology.

Again certain question in the survey regarding employee distribution and area of residence had some drawbacks. The employee class was set for both sectors of industries. Since secondary sector had a very low strength when compared to primary, this could only give a vague picture of the scenario.

5.2. Future Research

There is a vast scope for research in this field. Future studies can concentrate on creating a map which can show location of production and utilization centers of wood waste. This can be used to conglomerate the wood residue to a common point from the production center. A model can also be developed, which can forecast the wood residue production capacity of a facility based on attributes like production, raw material intake, employee data, etc.

APPENDIX A

COPY OF QUESTIONNAIRE ON BIOMASS SUPPLIES AND DEMAND

Section I

Company name:

Facility location (if different from mailing address):

Phone:

Fax:

Parish:

(Please correct if these pieces of information are not correct)

1.1. Contact person _____ Title_____

1.2. Email: _____

1.3. Person filling in this form_____ Email: _____

1.4. Major products produced here (check all that is applicable):

___Veneer or plywood ___ Lumber
___OSB ___Paper, pulp
___Other panel products ___ Pallets
___Chips for paper making ___ Furniture
Other_____
_____

1.5. SIC number (if known): _____

1.6. NAICS number (if known): _____

1.7. Parent company (if applicable): _____

1.8. Website: _____

2. If you produce or utilize wood residue that can be potentially used for energy production, please fill in as applicable:

2.1. We produce

___ Bark: ___ green tons/year*
___Sawdust ___ green tons/year*
___Wood pieces ___ green tons/year*
___Other ___ green tons/year*

Comments

_____
_____

2.2. We buy

___ Bark: ___ green tons/year*
___Sawdust ___ green tons/year*
___Wood pieces ___ green tons/year*
___Other ___ green tons/year*

Comments

_____
_____

2.3.1. We utilize

___ Bark: ___ green tons/year*
___Sawdust ___ green tons/year*
___Wood pieces ___ green tons/year*
___Other ___ green tons/year*

Comments

_____
_____

2.3.2. What is the typical heat energy produced from your biomass?

_____ BTU / green pound ***or*** _____BTU / oven dry pound ***or*** _____ ____ /_____

Comments

_____
_____

(* You may use a different unit if you prefer, but please specify)

2.4. We sell

___ Bark: ___ green tons/year*
___Sawdust ___ green tons/year*
___Wood pieces ___ green tons/year*
___Other ___ green tons/year*

Comments

_____

_____

2.5. We throw away _____ tons of wood waste per year

OR We throw away _____ dumpsters loads of wood waste per year

3.1. If you had a market available, would you be able to produce more wood residue for energy?

____Yes ____ No ____ Not sure

3.2. If Yes, how much?

____ Tons / year*

4. What is the moisture content of wood biomass you produce / supply?

___%

If unknown, is it _____green or
_____dry

(*You may use a different unit if you prefer, but please specify)

Section II

The answers to questions in *Section I* will be used in our interactive web directory. Obviously, a directory cannot be confidential, but we hope it will help you find more buyers or sellers of wood residues for your operation.

5. How many are employed in your company?

___ 1-50
___ 51- 100
___ 101- 150
___ 151- 200
___201-250
___ 251-300
___ 301-350
___ 351-400
___ more than 400

If you utilize wood biomass for energy production please answer the questions from 6 to 16. If you are only a producer of wood biomass (that is, sell or throw away wood waste) please proceed to Question17 (page 7).

6. How long has this facility been producing energy from wood biomass in Louisiana?

___ 0- 10 years
___ 11-20 years
___ 21-30 years
___ 31-40 years
___ 41 – 50 years
___ More than 50 years

7. What is typically the maximum distance from which you receive wood biomass?

___ Within 10 miles
___ 10-35 miles
___ 35-70 miles
___ 70- 120 miles
___Above 120 miles
___Don't know

8. What were the primary factors that facilitated use of wood biomass energy production for your operation?

(Please rank them from 1-4 according to their significance, with 1 being the most significant)

Financial incentives and benefits	
Affordable and readily available supply of wood biomass	
Energy cost saving over fossil fuel	
Environmental benefits	

Comments

_____

9. What are the major problems you face regarding wood biomass energy utilization?

Rate the following

	strongly agree	Agree	Neither Agree nor Disagree	Disagree	Strongly disagree
Hard to get raw material	1	2	3	4	5
Raw material is not available in locality	1	2	3	4	5
Supply is not constant	1	2	3	4	5
Cost of raw material is not economically feasible	1	2	3	4	5
Raw material is not of good quality	1	2	3	4	5
This cannot satisfy the energy requirement	1	2	3	4	5
Establishment of energy production unit is very expensive	1	2	3	4	5
Increased equipment and maintenance cost	1	2	3	4	5

Other problems like

_____

_____ Face no problems

10. How would you increase the efficiency of your plant's energy production?

Rate the following

	Very Likely	Likely	Neither Likely nor Unlikely	Unlikely	Very Unlikely
Install more efficient equipment	1	2	3	4	5
Find a cheaper source of raw material	1	2	3	4	5
Get more amount of raw material	1	2	3	4	5
More constant supply of raw material	1	2	3	4	5

Comments

_____

11. What is the amount of ash produced?

_____ tons / year*

12. Do you use ash for some kind of purpose or throw it away?

_____Yes, we use
_____ No, we throw away
If used Please specify for what purpose

_____

13. Do you plan to continue to use wood biomass in future?

_____Yes _____No _____ Not sure

14. What is your opinion about wood biomass energy industry in future?

___ Will grow ___ Will remain as it is
___ Will decrease ___ Don't know
Comments

_____

15. Do receive any subsidies or grants from government (federal/ State/local) relating to biomass energy?

_____Yes _____No

16. If yes, please check all that apply.

__loans __tax credits
__grants __other
Comments

_____
_____

Please answer this section only if you produce wood biomass (that is, sell or throw away wood waste). Else, skip to section III (page 9)

17. What is the maximum distance you typically transport your wood waste to get it to a buyer or disposal site?

___None- It all stays on-site
___0-10 miles
___11-35 miles
___36-70 miles
___71-105 miles
___106-140 miles
___141-200 miles
___201-500 miles
___501 miles and above
___do not know

18. How many markets (buyers) do you have typically for your wood waste at any one time?

___0
___1-2
___3-4
___5+
___We have more buyers than stated but not all at same time

19. What are the major problems preventing better utilization?
(Please rank them from 1-4 according to their significance)

Increased transportation charge	
Higher cost of handling	
Low price for the woody biomass	
No buyers for the product	

Other problems like

_____

20. Do you currently have a strategy to reduce your wood waste problems.

_____Yes _____ No

If yes, Please explain

_____

21. What do you think should be done at the industry level to improve wood waste utilization?

_____

_____

Section III

Knowing about demographics would help us to understand industry better and track the demographic changes over time.

If you feel uncomfortable answering the questions in this section please complete the first part of survey and return it. This information will be kept completely confidential to the extent allowed by law and only summary will be reported.

Details about person filling the survey

1. Gender: ____ Male ____ Female

2. Your age:

a. ___< 25 years
b. ___ 26-35 years
c. ___ 36- 45 years
d. ___ 46- 55 years
e. ___ 56- 65 years
f. ___ > 65 years

3. Your ethnic group

a. ___ Caucasian
b. ___ African American
c. ___ Asian or Pacific Islander
d. ___ Native American (Indian, Eskimo)
e. ___ Hispanic
f. ___ Others

4. Check the organizations to which you and your company belong

___Louisiana Forestry Association
___Society of American Foresters
___Forest Products Society
___Southern Forest Products Association

Or any similar organization
_____
_____
_____

5. From where do you get information that helps you to thrive in the industry? (Check all that applies)

___Trade journals
___Scientific literature
___Professional organizations
___Internet
___Newsletters
___Consultants
___Research and Developmental wing of my company

Other_____
_____

6. Education

a. ___ High School or less
b. ___ High School Graduate or less
c. ___ Some College
d. ___ College Graduate(B.A./ B.S.)
e. ___ Post-Graduate degree (M.S. / PhD.)

7. Please indicate type of area you currently reside

a. ___ Very Large City (1,000,000 or more)
b. ___ Large City (250,000 to 999,999 population)
c. ___ Medium sized City (50,000 to 250,000 population)
d. ___ Small city (10,000 to 50,000 population)
e. ___ Very small City, Town, or village (2,500 to 9,999 population)
f. ___ In a Rural area (population less than 2,500)
g. ___ Not Sure

8. What is your primary occupation? _____

APPENDIX B

TELEPHONE SURVEY QUESTIONNAIRE

1. Company name:

2. Facility location:

3. Fax:

4. Contact person _____ Title_____

5. Email: _____

6. Person answering the call_____ Title_____

7. Major products produced here:

8. Produce

___ Bark:	___ green tons/year
___Sawdust	___ green tons/year
___Wood pieces	___ green tons/year
___Other	___ green tons/year

9. Buy

___ Bark:	___ green tons/year
___Sawdust	___ green tons/year
___Wood pieces	___ green tons/year
___Other	___ green tons/year

10. Utilize

___ Bark:	___ green tons/year
___Sawdust	___ green tons/year
___Wood pieces	___ green tons/year
___Other	___ green tons/year

11. Sell

___ Bark:	___ green tons/year
___Sawdust	___ green tons/year
___Wood pieces	___ green tons/year
___Other	___ green tons/year

12. Throw away _____ tons of wood waste per year

OR _____ dumpsters loads of wood waste per year

13. What is the moisture content of the wood biomass you produce / supply?

___%

If unknown, is it _____green or _____dry

14. How many are employed in your company?

APPENDIX C

FOREST PRODUCT INDUSTRIES GONE OUT OF BUSINESS -PARISH WISE

South	Secondary Forest Products Industry	Primary Forest Products Industry
EAST BATON ROUGE	13	5
JEFFERSON	6	2
LAFAYETTE	5	2
ORLEANS	9	2
ST TAMMANY	5	2
TANGIPAHOA	6	3
VERMILLION	3	
ACADIA	2	
CALCASIEU	2	1
LAFOURCHE	2	
ALLEN		1
ASCENSION		1
CALCASIEU		1
ST HELENA		1
ST JAMES		1
ST LANDRY		1
WASHINGTON		1
BEAUREGARD	1	
ST BERNARD	1	
ST LANDRY	1	
ST MARY	1	
TERREBONNE	1	
22 parish	58	24

North		
OUACHITA	4	1
CADDO	4	1
CONCORDIA	2	
JACKSON	2	2
LASALLE	2	
RAPIDES	2	2
BOSSIER		1
CADDO		1
CALDWELL		1
CLAIBORNE		1
EAST CARROLL		1

North	Secondary Forest Products Industry	Primary Forest Products Industry
FRANKLIN		1
OUACHITA		1
RED RIVER		1
SABINE		1
UNION		1
WEST FELICIANA		1
WINN		1
BIENVILLE	1	
BOSSIER	1	
LINCOLN	1	
NATCHITOCHES	1	
RICHLAND	1	
UNION	1	
26 parishes	22	18

VITA

Anil Raj Kizhakkepurakkal was born in December, 1981, in Manjeri, Kerala, India. He graduated his secondary and higher secondary schools in 1997 and 1999, respectively. He was admitted to the College of Forestry, Kerala Agricultural University (KAU), India, in 2000. His undergrad thesis was "Wood properties changes due to gamma irradiation in certain selected tropical timber species." After graduation in 2004, Anil served in the Kerala Forest Department, the Kerala Forest Research Institute and the College of Forestry, KAU. He is currently completing his requirements for the degree of Master of Science in forestry at Louisiana State University.