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Economic Competitiveness of Bioenergy Production and Effects on Agriculture of the Southern Region

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The economic competitiveness of biobased industries is discussed by comparing the South relative to other regions of the United States and biomass as a feedstock source relative to fossil fuels such as coal and petroleum. An estimate of the biomass resource base is provided. Estimated changes in the agricultural sector over time resulting from the development of a large-scale biobased industry are reported, and a study on the potential to produce electricity from biomass compared with coal in the southern United States is reviewed. A biobased industry can increase net farm income and enhance economic development and job creation.

Key Words: biobased industries, biomass, cofire, energy, ethanol, lignocellulosic

JEL Classifications: Q42, Q41, R15, Q11

Use of biomass feedstocks for transportation fuels, bioproducts, and power are increasingly being viewed as opportunities to enhance energy security, provide environmental benefits, and increase economic development, particularly in rural areas. Several studies have addressed various aspects of these issues (California Energy Commission; De La Torre Ugarte et al. 2003; Delucchi; English, Menard, and de la Torre Ugarte; English et al.; House et al.; Mann and Spath 2001a,b; McLaughlin et al.; Perlack et al.; Petrulis, Sommer, and Hines; Shapouri, Duffield, and Wang; Sheehan, Paustian, and Walsh; Sheehan et al.; Systems Applications International Inc.; Urbanchuk; USDOE-EIA 2001a,b; USDA-OCE 2000, 2002; Walsh et al. 2003; Wang, Saricks, and Santini).

Renewable energy from biomass can be categorized into two areas: biopower and biofuels. In The Energy Policy Act passed in 2005, for power, the term "renewable energy" means electric energy generated from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project. For fuel, a Renewable Fuels Standard was established that focused on ethanol and biodiesel developed from feedstocks such as oil from plants and animal wastes, including poultry fats and poultry wastes and other waste materials, and municipal solid waste and sludges and oils de-

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rived from wastewater and on ethanol from corn, sugar cane, and lignocellulosic feedstocks. Lignocellulosic feedstocks include any portion of a plant or coproduct resulting from energy conversion. This would include crops, trees, forest residues, and agricultural residues not specifically grown for food.

The Energy Policy Act of 2005 provides numerous opportunities that encourage the expansion of producing energy from renewable sources. The Act created a renewable energy research budget of $632 million for fiscal year (FY) 2007, $743 million for FY 2008, and $852 million for FY 2009. Broken out, bioenergy research has $213 million for FY 2007, $251 million for FY 2008, and $274 million for FY 2009. In addition, the Act specifically provides for

- extending the tax credit to companies that produce power from renewable sources;
- establishing a 7.5 billion gallon Renewable Fuels Standard (RFS) that would add billions of gallons of ethanol, biodiesel, and other renewables to the nations fuel supply by 2012;
- updating the small ethanol producer definition to 60 million gallons and extend the biodiesel tax credit through 2008;
- establishing a 30% tax credit up to $30,000 for the cost of installing clean fuel refueling equipment, such as an E85 fuel pump; and
- creating a new tax credit known as clean renewable energy bonds.

The Act also promotes the use of renewable energy sources with tax credits for wind, solar, and biomass energy, including the first tax credit for residential solar energy systems.

The ability to respond to incentives and regulations contained in the Energy Policy Act of 2005 and others under consideration will vary substantially by geographic region and will be a function of the natural resource endowments of each region. This paper examines three recent studies that evaluate the ability of the southern United States to produce bioenergy and bioproducts. For the purposes of this paper, the southern United States includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

The economic competitiveness of biobased industries is discussed in terms of both a comparison of the South relative to other regions of the United States and a comparison of biomass as a feedstock source relative to fossil fuels such as coal and petroleum. The first study includes an estimate of the biomass resource base and incorporates current year estimates of forest residue, mill residue, urban wood waste, corn stover and wheat straw (agricultural crop residues), and dedicated energy crop supplies. This analysis is based on recent updates to a database initially developed in the mid 1990s (Walsh et al. 2000.). It is expected that supply will change over time as technology, value of other opportunities, and pressure on existing resources and inputs change. The second analysis, partially funded through the U.S. Department of Agriculture (USDA) National Research Initiatives program and conducted at a national level with the use of POLYSYS (De La Torre Ugarte, Ray, and Tiller), examines changes in the agricultural sector over time resulting from the development of a large-scale biobased industry. The final analysis evaluates the potential to produce electricity from biomass compared with coal in the southern United States.

Geographical Competitiveness

Biomass conversion to energy utilizes a number of different feedstocks, including agricultural and forest residues, mill and urban wastes, and dedicated crops. For this paper, information on the quantity of feedstock supply available at the county level exists for prices ranging from $12.50 to $50/dry ton (dt), excluding transportation costs, for the following types of biomass:

- agricultural residues: complementary products in the production of grain and oilseed crops comprising corn stover and wheat straw; derived from data supplied by Nelson;
- forest residues: logging residue and other removals;

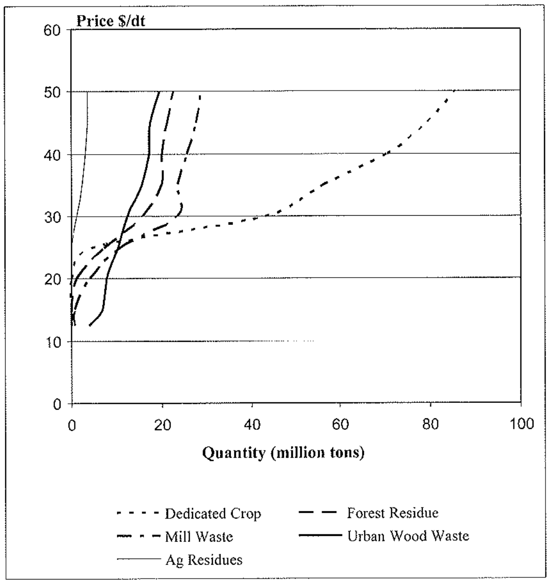

Figure 1. Estimated Supply Curve for Biomass in the Southern Region, 2005

- mill waste: by-product resulting from operations at primary mills that convert roundwood products into other wood products, generally consisting of bark, fine wood residue, and coarse wood residue;
- urban wood waste: wood contained in municipal solid waste streams, including such items as containers, crates, pallets, furniture, yard trimmings, residential and nonresidential construction wastes, residential and nonresidential demolition wastes, and renovation and remodeling wastes; and
- dedicated energy crops: costs reflect switchgrass production costs derived from De la Torre Ugarte et al. (2003).

The estimated supply of potential feedstocks in the South is presented in Figure 1. Supplies from urban wood waste are the least expensive, with 3.8 million tons available at a farm gate price[1] of $12.50/dt or less. However, the potential of this feedstock is limited, with an estimated 19.6 million dry tons at $50.00/dt. Similar results occur for forest residues and mill wastes. Slightly more than a half million tons of mill wastes are available at $12.50/dt, with the potential to increase to 29 million tons at $50 per nondelivered dry ton. Although no forest residues are available at $12.50/dt, over 1.1 million dry tons of forest residues become available at $20/dt and increase to 22.5 million tons at $50/dt. Dedicated crops, in this case represented by switchgrass production costs, enter the picture at $25/dt with more than 4 million tons. If the price increases to $50/dt, the estimated potential supply is 85 million dry tons. On the basis of Walsh's analysis of the agricultural residue data, there is limited potential to utilize corn stover and wheat straw in the southern region after leaving sufficient residue quantities to control for erosion.

Figure 2 reflects the types of biomass available summarized at a state level. The analysis indicates that the South is more diverse with respect to available residues than the rest of the 48 contiguous states at both $30/dt and $50/dt. Furthermore, as the value of the biomass feedstocks increase, the proportion in dedicated energy crops increases. The biomass is widely spread throughout the South, with concentrations in areas that are densely populated, forested, or heavily cultivated. Areas that are dry or mountainous are not likely to be large suppliers of residues, wastes, or dedicated crops. Over 70% of the 10 million dry tons of feedstock available at the national level at $15.00/dt is located in the South. At $25/dt, there are a projected 48 million tons available, and 66% is located in the South. If the residues are paid a farm gate price of $50/dt, 41% of the 385 million tons are located in the South.

Bioenergy Product Competitiveness within the South

This analysis focused on the effects of meeting increasing bioenergy and bioproduct demands on the agricultural sector. The analysis was made with the use of POLYSYS, an agricultural policy simulation model of the U.S. agricultural sector that includes national demand, regional supply, livestock, and aggregate income modules (De La Torre Ugarte et al. 1998). POLYSYS is anchored to published

[1] All prices in this paragraph are farm gate prices.

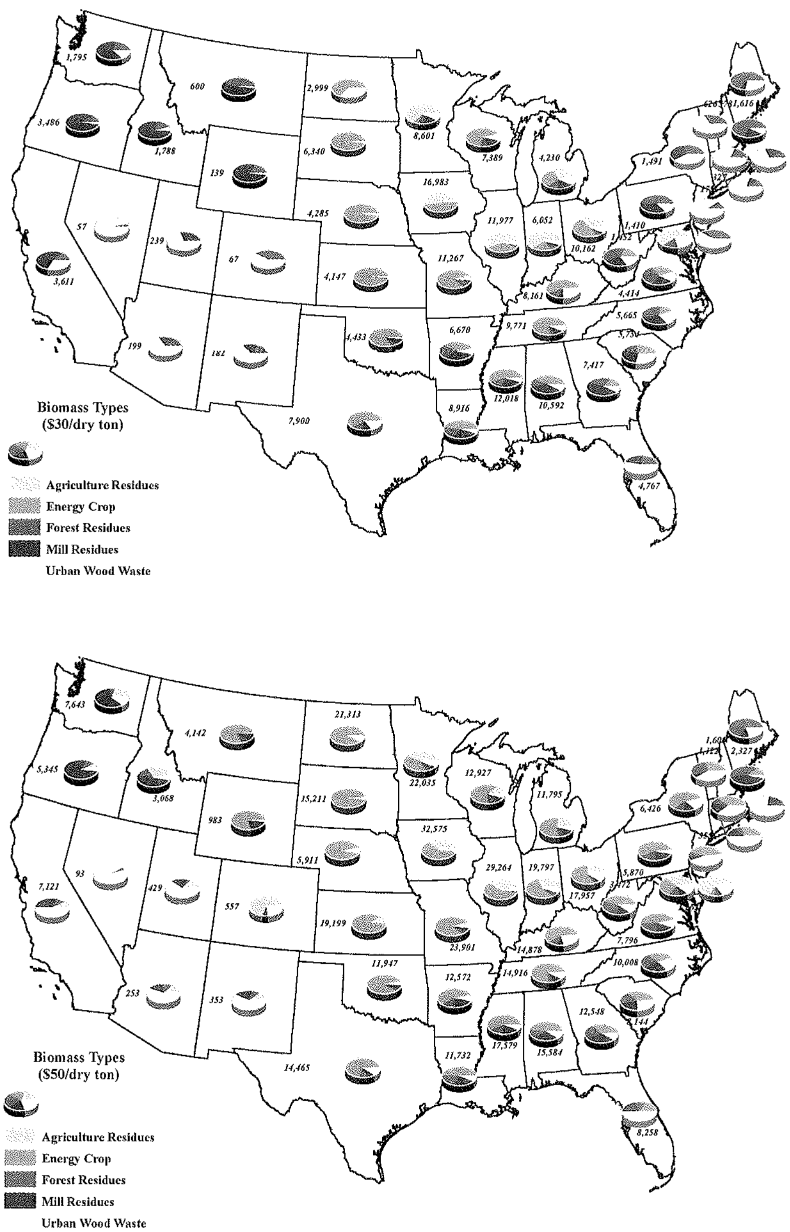

Figure 2. Available Biomass Characteristics by State at a Plant Gate Price of $30/dt and $50/dt

baseline projections for the agricultural sector and simulates deviations from the baseline. In this study, a 10-year USDA baseline for all crop prices and supplies, except hay, taken from the Food and Agriculture Policy Research Institute (FAPRI) baseline for U.S. agriculture is used. The bioproducts module captures the dynamics of corn grain, soybean, and cellulosic feedstocks competing to fill bioproduct demands by a tatonment method to find the optimal allocation of feedstocks to meet demand.

The cropland included in this analysis is the acreage planted to the eight major crops and hay. Additionally, pasture acreage classed as cropland can come into production if the loss of regional pasture can be made up with additional hay production. This analysis does

Table 1. Biopower, Biofuels, and Bioproduct Demand Increases in 2005, 2010, and 2014

Item Demanded	Units	2005	2010	2014
Biopower	Billion kWh	87.74	108.45	160.03
Biofuel (ethanol)	Billion gallons	2.31	10.23	18.39
Biofuel (biodiesel)	Billion gallons	0.14	0.42	0.55
Levulinic acid	Million lbs.	175.00	175.00	175.00
Succinic acid	Million lbs.	33.00	33.00	33.00
Lactic acid	Million lbs.	407.90	1,331.90	1,741.10
PDO* corn demand	Million lbs.	0.20	100.20	320.04

* PDO – 1,3-Proponediol.

not include the possibility of planting and harvesting switchgrass in acreage enrolled in the Conservation Reserve Program, nor does it include land currently classed as pasture/rangeland. The objective of the model is to fill projected energy and bioproduct demands from corn grain, soybeans, switchgrass, and crop residue supplies and estimate the effects on production, prices, acreage, government payments, and net returns of all model crops and livestock.

Demand for biopower and biofuels was adapted from the Department of Energy's (DOE's) *Vision for Bioenergy and Biobased Products in the U.S.* (USDOE). The DOE has set goals that biopower can fill 4% of U.S. electrical demand in 2010 and 5% in 2020 and that biofuels can fill 4% of U.S. fuel demand in 2010 and 10% in 2020. This is equivalent to 3.2 quads of electricity by 2010 and 3.9 quads by 2020 from biomass feedstocks and 1.18 quads of liquid fuels by 2010 and 2.98 quads by 2020 from biological feedstocks. Adjustments are made to these demands to account for exogenous biomass sources (Table 1).

POLYSYS was modified to allow the biomass feedstocks (switchgrass, corn stover, wheat straw) to compete with corn grain feedstock in the production of ethanol. Because ethanol demand is such a large user of agricultural feedstocks, changes in feedstock mix will affect the market price of feedstocks and therefore total ethanol costs.

An iterative process was used to find the annual feedstock mix in which the cost of producing ethanol from corn grain is equal to the cost of producing ethanol from biomass. Electricity production can come only from cellulose feedstocks. Biomass prices are increased by $1 increments until the model's supply side responds with enough biomass to fill these demands. The demands can be met with either biomass or corn grain and are filled with corn grain in the first iteration. Biodiesel demand for feedstock is filled with soybeans. The crop module then responds with increased corn/soybean prices resulting from the increased level of demand. The price of ethanol made from corn grain is determined and compared with the price of ethanol if biomass is used as the feedstock. These prices are compared and iteration occurs if the projected ethanol prices are not equal.

The bioenergy and bioproduct demands were met within the model simulation. The distribution of feedstocks for use in the production of new biopower, biofuels, and bioproducts is shown in Figure 3. Initially, corn stover and corn grain are extremely important in meeting bioindustry demands. However, the switchgrass contribution increases significantly beginning in 2009. Corn grain is primarily used in the production of ethanol throughout the study period. Initially, switchgrass is used in meeting renewable electricity demands, but by 2010, conversion of one third of the acreage to switchgrass and a portion of corn residues to ethanol is forecasted. The ability of the ethanol industry to bid away residues from electrical generation is not incorporated into the analysis. Switching between corn residues and switchgrass would likely occur as a result. By 2014, the southeast region produces 60 million tons of switchgrass, and 5 million tons

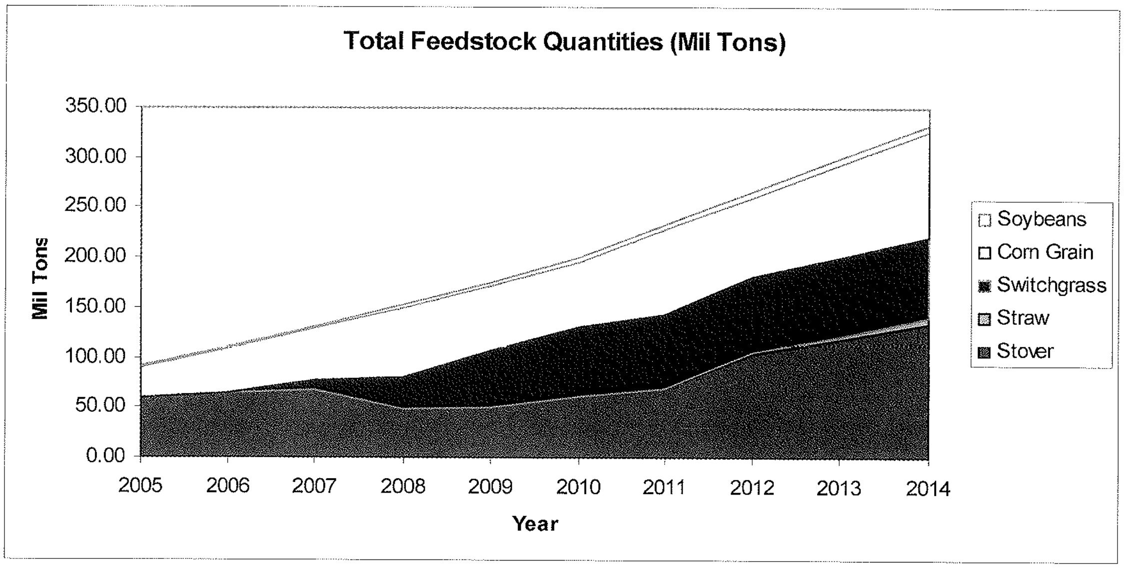

Figure 3. Feedstock Composition for the New Bioindustry (Million Tons) by Year

of corn stover is harvested for meeting bioindustry demands (Table 2).

By 2014, most of the switchgrass is projected to be produced in the southern states, with more than 2 million dry tons produced in seven POLYSYS regions contained within the southern states—three in Tennessee, two in Kentucky, and one each in Arkansas and Oklahoma (Figure 4). The only other states and regions to produce large quantities of switchgrass include Missouri, the New England region, and northern Wisconsin. As expected, corn stover production is concentrated in the Corn Belt states of Iowa and Illinois (Figure 5).

Because some pasture acreage is converted to crop production, total acreage increases over the simulation period, with most model crops gaining slightly in acreage above the baseline. Hay acreage increases to replace lost regional forage. In 2010, net acreage grows by 11.4 million acres above baseline. Hay acreage increases by 13 million acres. Corn and soybean acreages are up by 0.9 million and 1.6 million, respectively. The only model crop to lose acreage is wheat, which declines slightly by 0.1 million acres. Switchgrass grows from no acres in the baseline to 18 million acres by 2014. Changes in pasture land occur throughout the eastern United States; however, it is greatest in Kentucky, Missouri, Nebraska, Oklahoma, and Tennessee (Figure 6).

Table 2. Southeast Production of Feedstocks for the Bioindustrial Sector

	Projected Production (Million Dry Tons)		
Feedstock	2005	2010	2014
Stover	2.1	2.2	5.0
Switchgrass	0.0	52.2	60.3

Even with the additional acreage relieving some of the supply pressure on agriculture, the increased demands on the sector result in increased market prices. In 2010, corn prices increase from $2.45/bushel (bu) to $3.40/bu, and soybean prices jump from $5.55/bu to $6.37/bu. Other nonfeedstock prices also increase. Wheat prices increase from $3.40/bu to $3.81/bu. Cotton and rice prices remain fairly stable. By 2014, the price of corn rises from a baseline of $2.45/bu to $4.16/bu, and soybean prices increase from $5.70/bu to $6.84/bu. Wheat prices go from $3.60/bu to $4.04/bu.

The price of biomass is the same for all cellulosic feedstocks—switchgrass, corn stover, and wheat straw—per dry ton. Biomass prices start from $31/dt in 2005. This price is

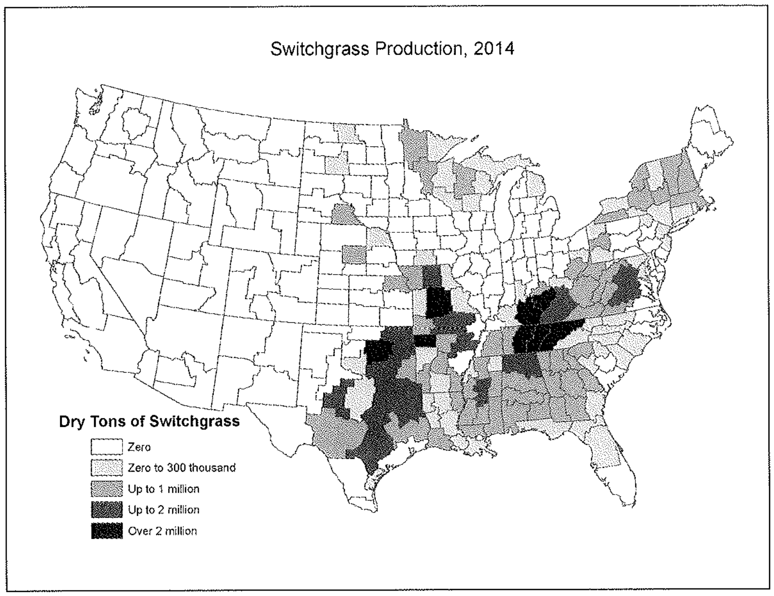

Figure 4. Geographic Distribution of Switchgrass Production, 2014

the minimal price needed to fill only electricity and levulinic demands. The price increases to nearly $50 by 2014, reflecting the increased costs of production and the land conversion costs as traditional crops and biomass crops compete for agricultural sector resources.

The effect that increased feedstock costs have on biopower and biofuel costs are reflected in Tables 3 and 4. The cost of electricity increases from $0.03/kilowatt-hours (kWh) to $0.042/kWh between 2006 and 2014, reflecting the increase in feedstock costs. As previously indicated, corn stover is the primary feedstock creating approximately two thirds of the electricity in 2014. Switchgrass, however, increases from having no share in 2006 to

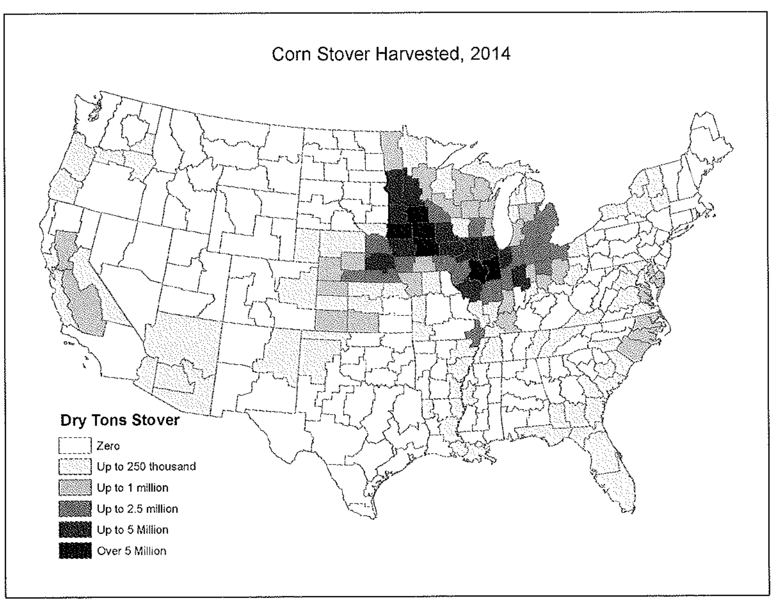

Figure 5. Geographic Distribution of Harvested Corn Stover, 2014

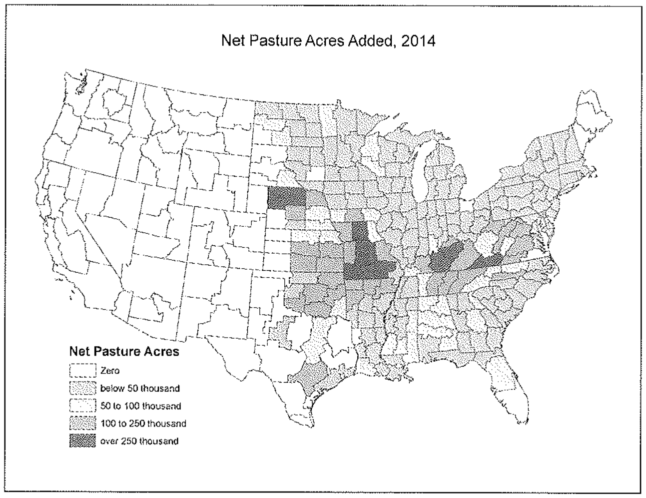

Figure 6. Cumulative Change in Pasture Acres by 2014

nearly a 33% share in 2014. Ethanol costs increase during the same time span from $1.23/gallon to $1.73/gallon. These increases reflect the change in feedstock price. Demand by the industry for corn increases from 1.2 billion bushels in 2006 to 2.9 billion bushels in 2014. Corn stover use increases from 3.5 dry tons in 2006 to nearly 70 million dry tons in 2014.

Government payments are projected to save $13 million over the 10-year span if the projected biopower, biofuels, and bioproduct demands are met and pasture conversion is allowed to occur. Geographically, as expected, regions that produce corn, soybeans, or both show the largest decline in government payments (Figure 7). The same areas, however, show an increase in crop income (Figure 8), offsetting the decline in government payments. Realized net farm income increases nearly $23 million in 2014 for the agricultural sector when compared with the baseline, of which a $6 million increase is forecasted for the southern region.

Effects of Environmental Concerns on Competitiveness

The forecasted benefits that renewable resources bring to electricity production has resulted in many advocating policies that promote renewable energy, including green pricing programs, funding renewables through system benefits charges, and adopting renewables portfolio standards. Others argue that renewables should be subject to the "discipline of the market." However, society incurs costs not captured in the production of electricity from coal that do not prevail when generating electricity from renewable feedstocks through external costs generated from current electricity production.

Although not included in the current energy Act, pressures are mounting for Renewables Portfolio Standards (RPSs).[2] In 2003, Senator Jeff Bingaman, New Mexico, the Ranking Minority Member of the Senate Committee on Energy and Natural Resources, requested that the DOE conduct an analysis of a nationwide RPS program proposed to be amended to energy legislation before the U.S. Senate. The program specified by Sen. Bingaman included:

- extension of the renewable energy production tax credit for electrical generation from eligible facilities entering service by December 31, 2006, but no longer indexed to inflation;
- implementation of RPSs with incremental

[2] The RPS is a policy that requires a minimum amount of wind, solar, biomass, and geothermal energy included in the portfolio of electricity resources serving a state or country.

Table 3. Projected Electricity Demand, Supply, Feedstock Quantities Used, and Cost for 2006, 2010, and 2014

Item	Units	Projected Amounts 2006	2010	2014
Demand	Billion kWh	92	108	160
Supply	Billion kWh	92	108	160
Feedstock quantities				
Corn stover	Million dry tons	61.4	33.6	64.5
Wheat straw	Million dry tons	0.1	0.1	2.8
Switchgrass	Million dry tons	0.0	37.9	38.9
Estimated costs				
Feedstock	Million $	1,907	2,149	5,243
Conversion	Million $	875	1,004	1,463
Total	Million $	2,782	3,153	6,706
Cost	Per kWh	0.03	0.029	0.042

increases in required renewable generation reaching 10% of most sales by 2020 (effectively 8.8% of all sales);

- qualification for renewable energy credits of only those renewable facilities commissioned after enactment of the legislation; and
- capping of the allowance price for renewable energy credits at $0.015/kWh, with no indexing for inflation (USDOE 2003).

Twenty states, along with Washington D.C., have adopted renewable portfolio standards. As of August 2005, the South, except for Texas, has not adopted a renewable portfolio standard.

Wind and solar resources are limited in the South. If RPSs were to become national law with trading allowed, then the South would either purchase renewable power credits in other regions of the country or would use biomass to generate the necessary electricity. If the region were to use biomass as the means to generate electricity, the initial response would be to purchase the credits, use existing power plants and cofire, develop dedicated biopower facilities, or a combination of these

Table 4. Projected Ethanol Demand, Supply, Feedstock Quantities Used, and Cost for 2006, 2010, and 2014

Item	Units	Projected Amounts 2006	2010	2014
Demand	Billion gallons	3.53	9.38	16.73
Supply	Billion gallons	3.53	9.38	16.73
Feedstock Quantities				
Corn stover	Million dry tons	3.3	27.4	69.2
Wheat straw	Million dry tons	0.0	0.0	3.0
Switchgrass	Million dry tons	0.0	30.9	41.8
Corn	Million bushels	1,215	1,764	2,880
Estimated costs				
Feedstock	Million $	3,482	7,755	17,610
Conversion	Million $	855	6,329	11,278
Total	Million $	4,337	14,084	28,888
Cost	Per gallon	1.23	1.5	1.73

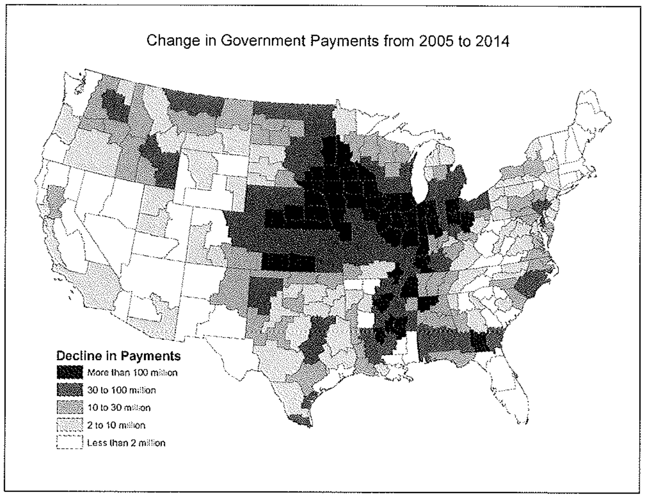

Figure 7. Accumulated Changes in Government Payments by Region, 2005–2014

strategies. A limit on tradable credits could be established to ensure improvement on local environmental conditions.

Another means of moving toward renewables would be to level the playing field either by subsidizing the use of biomass for electricity generation or taxing the pollutants that are emitted and cause society harm. In this case, also, the response will be to cofire. Cofiring without subsidy requires biomass to compete with coal. When examining the competitiveness of biomass to coal as a feedstock, incorporation of emission effects should be included.

To assess this situation, the potential to produce electricity via cofiring in the Southeastern Electric Reliability Council (SERC; Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia) was analyzed. Three scenarios were examined. The first is the base case with a 2% cofire allowed at each of the power plants. The

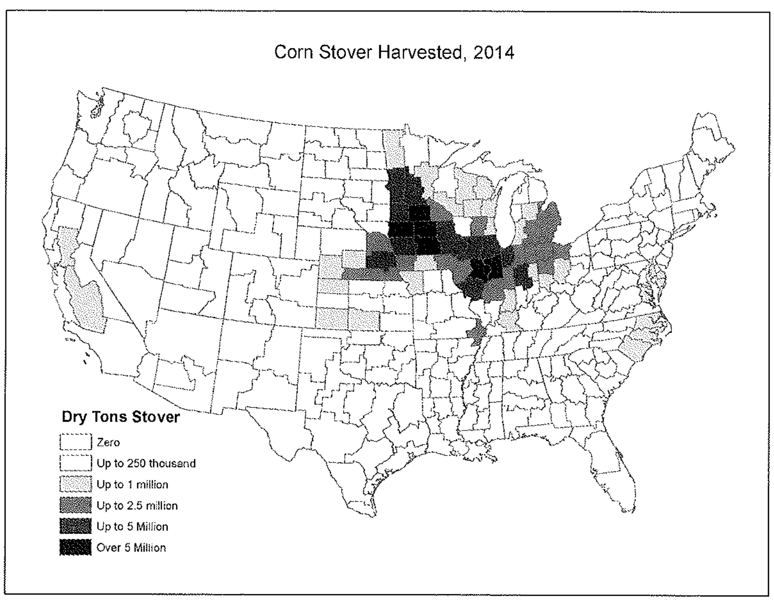

Figure 8. Changes in Crop Net Returns by Region, 2014

second and third scenarios involve a \$70/ton carbon tax while varying the cofire level to 2% or 15% by weight. The three analytical models are integrated to provide information on residue demand by each of the power plants. The following models and databases were used in the analysis:

- the Oak Ridge County–Level Biomass Supply database provides county biomass quantities available at several feedstock supply price levels for multiple feedstock categories;
- the Oak Ridge Integrated Bioenergy Analysis System is a GIS-based transportation model used to estimate the delivered costs of biomass to power plant facilities (Graham, English, and Noon; Noon and Daley); and
- the Oak Ridge Competitive Electricity Dispatch model (ORCED) is a dynamic electricity distribution model that estimates the delivered feedstock price utilities can pay for biomass feedstocks (Hadley and Hirst).

For each power generating location, ORIBAS provides the delivered cost of the biobased feedstock, the cost of transporting the feedstock from collection point to the demand center, the feedstock supply price paid to the owner of the feedstock, and the location of the feedstock and the power plant. The delivered feedstock price that each power facility is willing to pay per delivered Btu is estimated by ORCED and is less than or equal to a price that will result in no increases in the cost of producing electricity via cofiring biomass compared with coal-only production. Economically viable electricity production levels are identified as those in which a utility can obtain all of the biomass feedstock quantities it requires at a delivered feedstock price that is less than or equal to the maximum price the utility is willing to pay. The location, quantity, and cost of the biomass supplies are identified for each utility where biomass cofiring is economically viable.

In the base case with 2% cofire, some residues were projected to replace coal as a fuel. Under this scenario, a demand for 0.51 million metric tons of residue is generated and consists of mill wastes (213,400 dry tons) and urban wood wastes (319,100 dry tons) plus forest residues (31,400 dry tons) (Table 5). Feedstock owners are projected to receive slightly over \$16/dt for urban waste to nearly \$21/dt for forest residue. From these residues, an estimated 818 gWh of electricity is produced.

Placing a tax on carbon enhances the economic viability of biomass cofiring. In both the 2% and 15% cofire carbon tax scenarios, dedicated crops play a large role in the mix of biomass. Nearly 40% of the biobased feedstock used in the cofire comes from dedicated crops in both cofire solutions. Dedicated crops increase from a low of 0 tons of use with no carbon tax to 1.8 million dry tons in the tax with 2% cofire and 7.0 million dry tons in the tax with 15% cofire scenarios. Total biomass use increases to 4.5 million dry tons in the tax with the 2% cofire scenario and 26.1 million dry tons in the tax with the 15% cofire scenario. Geographic locations producing the biobased feedstocks expand as the amount of biobased feedstock produced increases. In the tax with the 15% cofire scenario, 37,600 gWh are generated from biomass in the SERC region.

Summary and Conclusions

This paper discusses three recent analyses that evaluate the potential for biomass energy and present the implications of the analysis for the southern United States. The southern United States has a large and diversified biomass resource base and, compared with other regions of the United States, can potentially be the largest supplier of low-cost feedstocks, providing an estimated 41% of the cellulose feedstocks examined that are available at less than \$50/dt. The existing biomass resource base consists primarily of forest and mill residues. Corn stover and wheat straw supplies are limited. However, the southern United States is among the geographic regions with the highest potential for the production of dedicated energy crops such as switchgrass.

With respect to the types of biobased products that can be produced in the South, elec-

Table 5. Residue Use, Energy Content, and Electricity Produced by Scenario

Feedstock	Energy Content (MMBtu* Per Ton)	Total Residue (Thousand Dry Tons)	Total Energy Content (Billion Btu)	Electricity Produced (gWh)
No Tax and 2% cofire				
Agriculture residue		0.0	0	0
Forest residue		31.4	470	46
Mill waste		213.5	3,200	311
Dedicated crop		0.0	0	0
Urban waste		319.2	4,784	461
Total		564.0	8,454	818
Tax and 2% cofire				
Agriculture residue	15	19.3	263	26
Forest residue	16.5	1,025.1	15,363	1,500
Mill waste	16.5	795.6	11,924	1,165
Dedicated crop	15.5	1,825.7	25,703	2,510
Urban waste	16.5	871.2	13,058	1,275
Total		4,536.9	66,311	6,476
Tax and 15% cofire				
Agriculture residue	15	100.2	1,364	133
Forest residue	16.5	8,558.2	128,257	12,526
Mill waste	16.5	6,452.5	96,701	9,444
Dedicated crop	15.5	6,959.4	97,975	9,569
Urban waste	16.5	4,061.0	60,861	5,944
Total		26,131.4	385,158	37,616

* MMBtu = 1 million British Thermal Units.

tricity generation has the highest potential. Many of the states in the South have limited wind and solar resources. Development of an RPS could provide incentives to develop a biomass electricity industry in the South. "Leveling the playing field" by incorporating the cost of environmental externalities such as carbon and NOx into electricity generation significantly increases the economic competitiveness of the use of biomass to produce electricity relative to coal. Finally, the development of biobased industries in the South can increase net farm income and enhance economic development and job creation.

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