WOOD to ENERGY

Community Economic Profile

Tennessee: Anderson, Blount, and Sevier Counties

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In the southern United States, communities with increasing populations and nearby forests may be able to consider using woody biomass to generate energy. A variety of other factors must also be considered, such as the price of existing energy sources, competing markets for wood, community acceptance, and the economic availability of wood resources. Many counties in Tennessee have forests in close proximity to growing populations. To gain a better understanding of the range of possibilities for economic availability and the local economic impacts of using wood for energy, Anderson, Blount, and Sevier counties were selected for analysis in this community economic profile.

Tennessee's abundant forests, rivers, springs, lakes, and mountains provide its residents and visitors with many benefits. Fifty-five percent of the state is forested, providing recreational opportunities, improving quality of life, and contributing to the state's economy. Almost three-quarters of Tennessee's forests are oak-hickory forests, while the remainder are oak-pine, bottomland hardwoods, and loblolly-shortleaf pine forests. Approximately 80 percent of the state's forests are owned by private non-industrial landowners, and another 8 percent are owned by private forest industries (USDA 2006). Public lands, including Cherokee National Forest, Great Smoky Mountains National Park, state parks, and wildlife management areas, account for the remaining forested land. Tennessee's forests support a prosperous forest products industry, which plays an important role in the state's economy. According to the Tennessee Forestry Association (2007), the forest products manufacturing industry employs nearly 100,000 people.

East of the Cumberland Plateau, in the foothills of the Appalachian Mountains, Anderson, Blount, and Sevier counties surround the Knoxville metropolitan area. Anderson County is northwest of Knoxville, with a forest cover that ranges from 50 to 74 percent (USDA 2006). The county's largest city, Oak Ridge, is the historically significant location of the Manhattan Project in World War II. The federal government owns 35,000 acres of land within and surrounding the city, which hosts a wide variety of native plants including rare species, such as tall larkspur. Clinton, located on the Clinch River, is the county seat of Anderson County. Blount County, on the southern edge of Tennessee, is a growing county that takes pride in its cultural heritage and wealth of natural resources. In the southern part of the county, Cherokee National Forest and the Great Smoky Mountains National Park provide residents and tourists with numerous recreational opportunities. Maryville, the county seat, is home to Maryville College and hosts community events in the renovated historic downtown area. Blount County's forest cover ranges from 50 to 74 percent, while neighboring Sevier County is over 74 percent forested (USDA 2006). Similar to Blount County, Sevier County has a rich cultural heritage, numerous natural areas, and communities with small-town charm. Sevierville, Gatlinburg, and Pigeon Forge are well-known communities, and all enjoy thriving tourism industries. The world-famous Dollywood theme park as well as unique shopping areas can be found in the Pigeon Forge area. Bordering the Great Smoky Mountains National Park, Gatlinburg serves as a gateway to the park for visitors and is home to Tennessee's only ski resort.

According to the U.S. Census Bureau (2007), each of these counties experienced population growth from 2000 to 2006 (Table 1). Currently, the region obtains electricity from the Tennessee Valley Authority (TVA), which primarily utilizes coal and hydroelectric power generation. One of TVA's coal-burning facilities, Bull Run, is located near Oak Ridge. However, TVA and the local communities are also finding innovative solutions to meet energy needs using renewable resources. For example, Dollywood and the American Museum of Science and Energy, in Oak Ridge, are generating power with solar photovoltaic systems. In addition, up to 29 megawatts (MW) of energy are supplied by windmills on Buffalo Mountain, near Oak Ridge. Wood is another renewable resource that these communities could consider to power a utility

Table1. *Population Data for Selected Tennessee Counties*

County	2000	2006	Population Growth from 2000 to 2006
Anderson	71,330	73,579	3.2%
Blount	105,823	118,186	11.7%
Sevier	71,170	81,382	14.3%

or a smaller facility such as a school or hospital. The presence of local, sustainable wood resources may support opportunities in these three counties to consider using woody biomass to generate electricity.

Woody biomass from urban wood waste, logging residues, and forest thinnings, for example, can be used to generate energy. Using wood to generate electricity provides many potential benefits such as reduced greenhouse gas emissions, healthier forests, and local jobs and other economic impacts. For more information on these topics see the *Climate Change and Carbon*, *Sustainable Forest Management*, and *Environmental Impacts* fact sheets. All of our materials are available at http://www.interfacesouth.org/woodybiomass.

To estimate the amount of wood that could be available in a community, we include three sources: urban wood waste, logging residues, and pulpwood. While other woody biomass resources exist and could be added to the resource assessments, we include only these resources, for which cost and supply data are available. Urban wood waste is generated from tree and yard trimmings, the commercial tree care industry, utility line clearings, and greenspace maintenance. Logging residue is composed of the leftovers from forest harvesting, such as tree tops and limbs, and poorly formed trees. Pulpwood refers to small diameter trees (3.6 to 6.5 inches diameter at breast height) that are harvested for manufacturing paper, purified cellulose products, (including absorbents, filters, rayon, and acetate), and oleoresin products (including pine oils, fragrances, cosmetics, and thinners). This profile excludes secondary woody waste from sawmills and furniture makers, which is available but may already be used within the industry to produce energy. See the fact sheet, *Sources and Supply,* for more information.

Economic factors, including fuel costs and the creation of local jobs, are major determinants of the feasibility of bioenergy projects. Assessing the economic availability of biomass requires learning about the delivered cost of wood, the quantity of available wood, and its geographic distribution. This information is then used to create biomass resource supply curves, which express price per unit of biomass at a range of potential quantities of consumption. The following summary uses these methods to assess the economic availability of wood resources for Anderson, Blount, and Sevier counties in Tennessee. More information about the development of this supply curve can be found on the Web site in *Assessing the Economic Availability of Woody Biomass*.

Cost Calculations

The delivered cost of woody biomass to a facility is the sum of the amount paid to buy the wood from the original owner (procurement), the harvest cost, and the transportation cost. Although rail transportation could be used in some cases, woody biomass is typically transported by truck. The cost of transportation depends on the time it takes a truck to travel from the harvest site to the facility. Haul times to the central delivery point in each county are calculated using a software program called ArcGIS Network Analyst Extension (Figure 1).

Assuming that haulers drive the speed limit on the quickest route available to them, we calculate total transportation times for the forested areas around the delivery point, and then increase haul times (and thus costs) by 25 percent to account for delays, such as traffic and stops. These haul-time areas delineate potential "woodsheds" or areas that can provide wood for a specific community or biomass user. If demand is established in more than one of the three counties assessed here, woodsheds greater than a thirty-minute one-way haul will overlap, causing competing demand for biomass.

The total delivered cost is derived from the sum of the procurement, harvest, and transportation costs for urban wood waste, logging residues, and pulpwood. This is calculated at 15-minute increments up to one hour from each delivery point. Delivered costs allow us to see the progression of the most- to least-expensive woody biomass resources. For example, if urban waste wood were delivered within the one-hour limit, the total delivered cost would be $19.46 per dry ton, or $1.25 per million British thermal units (MMBtu). However, if pulpwood were delivered from the same distance, the delivered cost would increase to $49.14 per dry ton, or $3.04 per MMBtu, primarily because pulpwood is more expensive than urban wood waste.

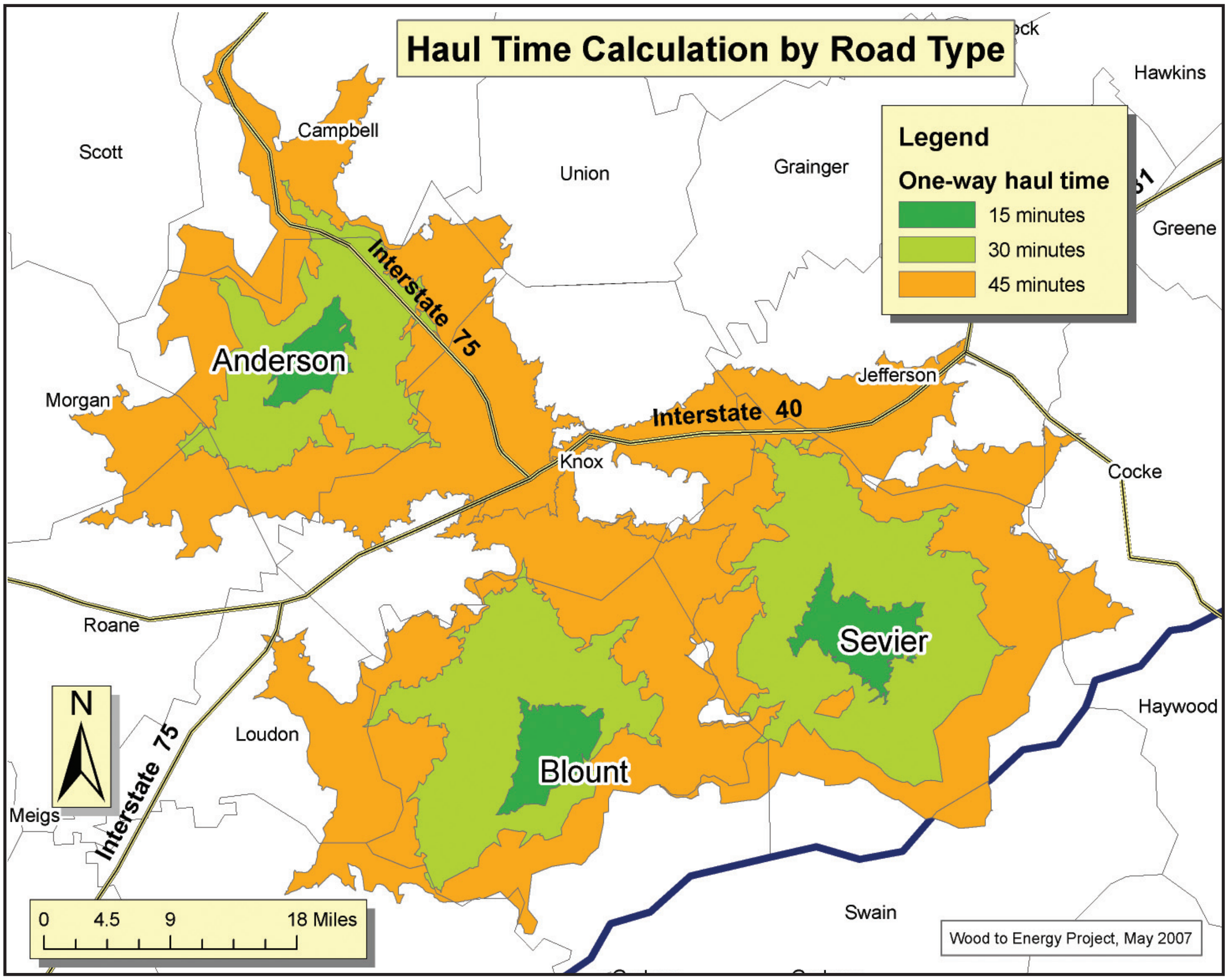

Figure 1. *Wood harvested within each colored band can be transported to the center of each county in 15-minute increments.*

Physical Availability

In addition to the delivered cost of wood, knowing how much of each type of woody biomass is available is necessary to construct supply curves. Annually harvested pulpwood and annually available urban wood waste and logging residues within the three Tennessee counties are shown in Table 2.

For urban wood waste, it is assumed that 0.203 green tons (40 percent moisture content) of urban wood waste is generated per person per year (Wiltsee 1998). This includes municipal solid waste wood from yard waste and tree trimming but excludes industrial wood (e.g., cabinet and pallet production) and construction and demolition debris. This average yield was multiplied by county population estimates and reduced by 40 percent to estimate total annual county yield of urban wood waste. For example, in Anderson County, this results in 8,800 green tons of urban wood waste per year.

Moisture content refers to the amount of moisture remaining in wood and is an important consideration in the quality of biomass resources. Moisture content is 0 percent in oven-dried biomass, about 20 percent for air-dried biomass, and about 50 percent for fresh or "green" biomass. As the moisture content of wood increases, the energy content per unit mass of wood decreases. Thus, wood with low moisture content will combust more efficiently than wood with high moisture content. Moisture content in this document is reported on a green-weight basis.

The amount of logging residue and pulpwood for all counties in the southeast U.S. was obtained from the USDA Forest Service (2003) Timber Product Output Reports. This database provides forest inventory and harvest

Table 2. *Three Sources of Available Wood*

County	Available urban wood waste	Available logging residues	Harvested pulpwood
Anderson	8,800	8,600	1,500
Blount	14,100	8,400	39,600
Sevier	9,700	3,300	None

information, including annual yields of forest residues and pulpwood. We reduced the figure for logging residues by 30 percent to exclude stumps. For example, in Blount County, there are 8,400 green tons (37 percent moisture) of logging residues available annually from existing forestry operations. There are also 39,600 green tons (50 percent moisture) of pulpwood harvested annually. Because the pulpwood harvest is currently used to produce pulp and paper products, not all of this resource is economically available for bioenergy. However, additional biomass is available from forest thinning, particularly those conducted for ecosystem restoration, which is not included in this assessment (Condon and Putz 2007). Sevier County is reported to produce logging residues from dimension timber harvests, but no pulpwood.

Supply Curve Construction

Given information regarding cost, quantity, and distribution of all three types of woody biomass, supply curves can be generated for the three counties. Figure 2 shows the price of wood at different quantities needed. The y-axis represents price per MMBtu of energy and the x-axis represents the total amount of wood available in 15-minute increments. Several scales are provided to translate the quantity of wood into tons, energy content, and houses electrified. Biomass sources include urban wood waste, logging residues, and pulpwood within a one-hour haul radius of each county center. Because of the proximity of these counties, using biomass in one or more of these counties could reduce the resource availability of the other counties.

Supply Analysis Results

Energy resources and costs for each resource-haul time category for the four counties are shown in Table 3 (resources are ranked from cheapest to most expensive based on delivered cost of energy). These values were used to construct the supply curves shown in Figure 2. The supply curves suggest that anywhere from 0.6 trillion Btu in the Sevier County woodshed to 0.9 trillion Btu in the Anderson County woodshed (or 5 to 8 MW) of electricity, which is enough to power 2,100 to 3,100 households in the South (Bellemar 2003), are available for less than $2.60 per MMBtu, competitive with current costs of coal.

Within a one-hour haul radius, up to 0.4 and 0.6 trillion Btu can be provided from urban wood waste alone. With the addition of logging residues, 0.6 to 0.9 trillion Btu can be produced. Other types of wood may be available from thinnings to improve forest health, although estimates of this wood are not available. As the cost of oil increases, all price estimates increase (with petroleum inputs for harvesting and transportation), but so do the costs of coal and natural gas. In other words, as fossil fuels become more expensive, the delivered cost of wood will increase but will become increasingly competitive with nonrenewable fuels.

Economic Impact Analysis

The potential economic impacts of developing a wood-fueled power plant are an important consideration for both public and private interests in a community. In this economic analysis, two sizes of power plant were considered: 20 or 40 MW. The construction of the plant would be a one-time impact event that is assumed to occur within a year, while the impacts of plant operations continue annually over the life of the plant, for 20 years or more. Wood fuel costs were calculated from the regional supply curves discussed previously in this report. Economic impacts were estimated using IMPLAN software and databases for each county. These estimates included not only the direct impacts of plant construction and operation but also the indirect impacts from local purchases and local spending by employee households. Further information on the methods of analysis and interpretation of economic impact results is available in the fact sheet, *Economic Impacts of Generating Electricity*.

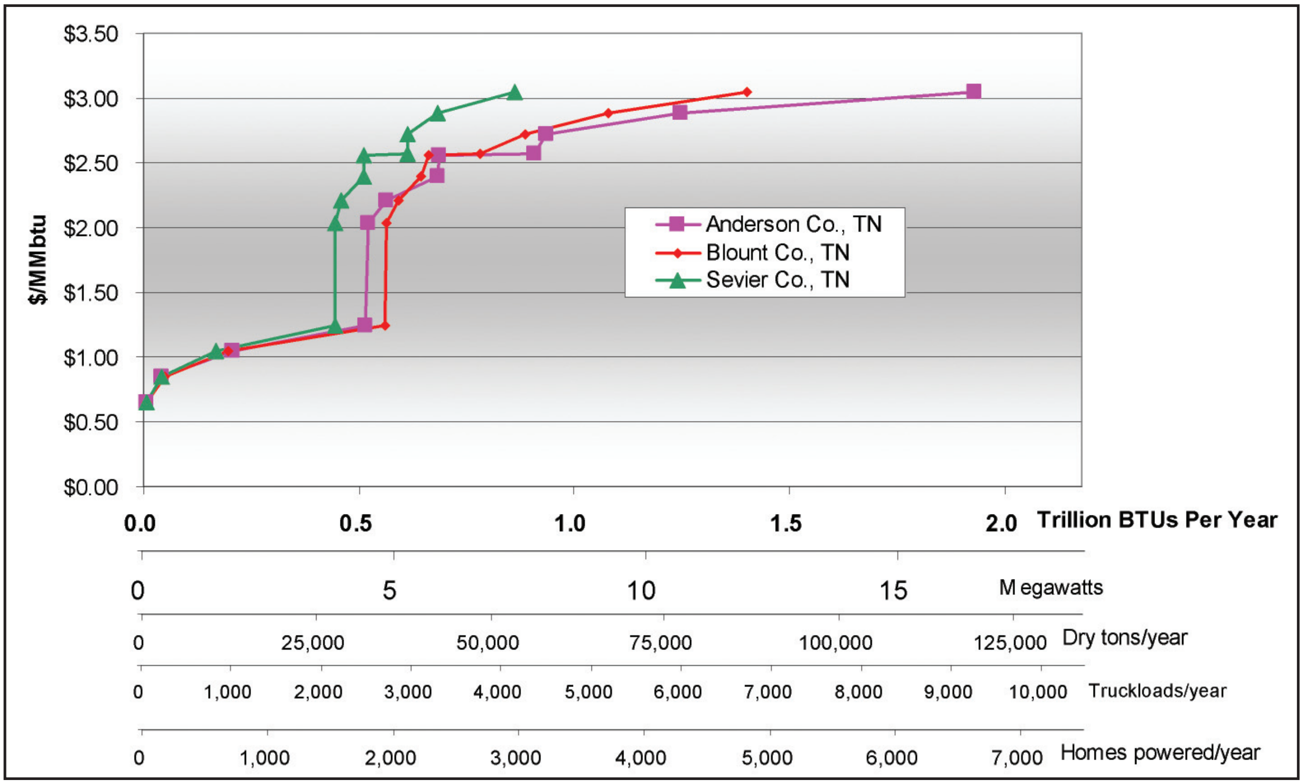

Figure 2. *Supply curves for woody biomass indicate the cost and quantity of wood at 15-minute hauling intervals.*

Table 3. *Delivered Cost of Available Wood*

		Trillion Btu available per year within a one-hour haul radius		
Delivered cost ($/MMBtu)	**Resource/Haul time category**	**Anderson County**	**Blount County**	**Sevier County**
$0.65	Urban wood: 0-15 minutes	0.01	0.01	0.01
$0.85	Urban wood:15-30 minutes	0.04	0.04	0.04
$1.05	Urban wood: 30-45 minutes	0.16	0.15	0.13
$1.25	Urban wood: 45-60 minutes	0.31	0.37	0.28
$2.03	Logging residues: 0-15 minutes	0.01	0.00	0.00
$2.21	Logging residues: 15-30 minutes	0.04	0.03	0.01
$2.39	Logging residues: 30-45 minutes	0.12	0.05	0.05
$2.56	Pulpwood: 0-15 minutes	0.00	0.02	0.00
$2.57	Logging residues: 45-60 minutes	0.22	0.12	0.10
$2.72	Pulpwood: 15-30 minutes	0.03	0.11	0.00
$2.88	Pulpwood: 30-45 minutes	0.31	0.19	0.07
$3.04	Pulpwood: 45-60 minutes	0.69	0.32	0.18

Economic impacts were evaluated for Anderson, Blount, and Sevier counties in Tennessee. Fuel typically represented the largest operating cost for a wood-fired power plant. Fuel costs were very similar for these counties in Tennessee, reflecting comparable resources and transportation infrastructure. Fuel costs averaged $4.6 and $11.9 million annually for the 20 or 40 MW plants (Table 4).

The economic impacts of plant construction and operations, however, varied widely among these counties due to differences in the specific makeup of the local economy. The total annual operating impacts (first year) for a 20 MW plant ranged from $8.9 to $14.4 million in output (revenue), 216 to 266 jobs, and $5.6 to $8.6 million in value added (income). The first year impacts for plant operations are representative of the ongoing annual impacts; however, future impacts could change due to prices of inputs such as fuel, unexpected maintenance activities, and general economic inflation.

Total operating impacts for a 40 MW plant ranged from $18.2 to $31.5 million in output, 509 to 629 jobs, and $11.9 to $18.9 million in value added. Total construction costs were valued at $48.7 million for the 20 MW plant and $86.8 million for the 40 MW plant, including land, site work, construction, plant equipment, and engineering fees. Local construction impacts for a 20 MW plant ranged from $4.9 to $6.7 million in output, 48 to 59 jobs, and $3.0 to $3.6 million in value added. Construction impacts for the 40 MW plant ranged from $5.9 to $11.5 million in output, 58 to 229 jobs, and $3.6 to $7.0 million in value added. Again, the wide range of values for construction impacts in these counties reflects differences in the makeup of these local economies.

Often it is helpful to predict the distribution of economic impacts across various sectors of the local economy. More than 60 percent of all jobs created would occur in the agriculture and forestry sector, which supplies wood fuel to these facilities. However, there would also be significant employment impacts in the sectors for professional services, retail trade, and government, reflecting the indirect effects on the local economy associated with purchased supplies and employee household spending.

Conclusions

Economic concerns are important to discussions of using wood for energy in the South. For many communities, the conversation begins with the recognition that there might be enough wood at an affordable cost. Our supply analysis suggests that, indeed, enough wood at a reasonable cost is available in Anderson, Blount, and Sevier counties to make a continued conversation possible. Up to 0.6 to 0.9 trillion Btu (i.e., 5 to 8 MW or energy to power 2,100 to 3,100 homes annually) of woody biomass are available at less than $2.60 per MMBtu in these three counties. These general estimates could be improved with more site-specific analysis and information.

Table 4. *Economic Impacts of 20 and 40 MW Power Plants*

Tennessee County	Wood Fuel Cost ($Mn)	Annual Operations Impacts (first year)			Plant Construction Impacts		
		Output ($Mn)	Employment (Jobs)	Value Added ($Mn)	Output ($Mn)	Employment (Jobs)	Value Added ($Mn)
20 MW							
Anderson	4.53	11.51	216	6.94	6.68	57	3.59
Blount	4.64	14.40	266	8.63	4.94	48	3.00
Sevier	4.64	8.90	216	5.65	6.74	59	3.51
Average	**4.60**	**11.60**	**233**	**7.07**	**6.12**	**55**	**3.37**
40 MW							
Anderson	11.58	24.96	510	15.08	9.09	76	4.72
Blount	11.97	31.48	629	18.91	5.93	58	3.58
Sevier	12.10	18.24	509	11.94	11.54	229	7.00
Average	**11.88**	**24.89**	**549**	**15.31**	**8.85**	**121**	**5.10**

Additional assessments of local conditions, population density, distribution of wood, competition from pulp mills, restoration activities, and other factors would improve the accuracy of these biomass resource assessments. The following caveats should be considered when interpreting the results presented in this profile:

- Because of the proximity of these three counties, using biomass in one or more of these counties could reduce the resource availability of the other counties.
- The supply considered in this profile includes only urban wood waste, logging residues, and pulpwood. It excludes stumps and waste from wood industries.
- Because only county-level data were available, homogeneous distribution of resources within counties is assumed. Resource distribution within counties and location of bioenergy generating facilities will influence the actual economic availability of woody biomass for suitable energy generation. More detailed local analysis might consider the distribution of biomass resources within counties, especially for site selection of bioenergy facilities.
- The inclusion of other resources such as mill wastes or thinnings from forest management and habitat restoration would increase available resources.
- This analysis is not intended to be a definitive resource assessment but is rather meant to provide a starting point for discussions about the feasibility of using wood for energy. Resources can be excluded or added as more information becomes available, and prices can be modified to reflect local conditions.
- A rise in the price of petroleum would increase the cost of the resources shown here, as well as costs of conventional energy sources such as coal.
- Some assumptions made in this analysis are subject to change. For example, large-scale bioenergy development in the area could increase competing demand for wood resources.
- Rail transportation, which could reduce transportation costs and make biomass resources from other areas more available, was not considered in this analysis.
- Construction and operation of wood-fueled power plants may have significant local economic impacts. These impacts vary widely among selected counties, depending upon the makeup of the local economy.
- Wood fuel represents one of the largest expenditures for a power plant and gives rise to large impacts in the local forestry and forestry services sectors. Other sectors of the local economy are also impacted through the indirect effects associated with purchased supplies and employee household spending.
- Economic impacts of a 40 MW power plant are greater than for a 20 MW plant, although not in proportion to the power output, due to economies of scale.

For more information about using wood to produce energy, visit http://www.interfacesouth.org/woodybiomass and read other fact sheets, community economic profiles, and case studies from this program, or http://www.forestbioenergy.net/ to access a number of other resources.

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