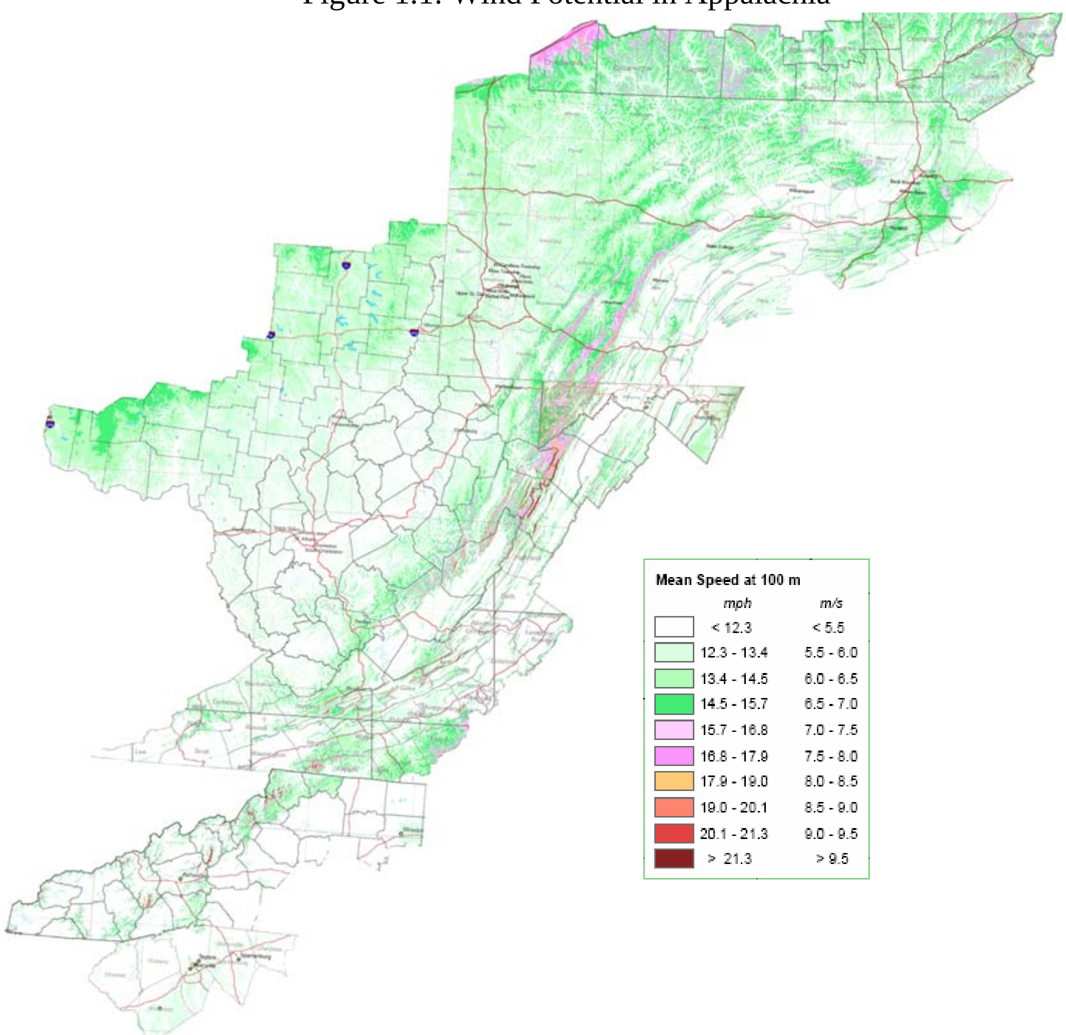
Chapter I. Resource Availability

1. Wind

The harnessing of the power of the wind to produce electricity is significantly undeveloped in the Appalachian region. Overall, this resource appears to be the greatest potential source of renewable power for the eastern U.S. The electricity production potential within the boundaries of the ARC region is difficult to isolate from the non-Appalachian areas of these states although for several states, notably Pennsylvania, West Virginia and Tennessee, the greatest wind potential is found in their mountain regions. For states with ocean borders the greatest potential lies offshore. The following figure shows maps of calculated wind speed for the ARC region at 100 meters above groundcover. Wind speeds of seven meters per second, corresponding with the pink to red areas of the map, are the wind Classes 4 through 7 most desired by developers.

Figure 1.1: Wind Potential in Appalachia[1]



[1] TrueWind Solutions, LLC

State by state estimates of wind potential have been calculated by various sources and are thus varied. For the states in the ARC area with the most wind potential, the following estimates of potential have been reported as shown in Table 1. Some estimates may not reflect higher production made possible by the larger turbines developed in the last couple years. It is important to note that generation potential for wind installations is typically only based on about 30 percent of installed capacity.

Table 1.1: Reported Potential Wind Capacity by ARC State

State	Capacity (MW)	Area
New York	5,000+	On land
Pennsylvania	5,120	State wide
Maryland	338	State wide
West Virginia	3,830	On private land
Virginia	1,380	On shore
North Carolina	835	State wide
Tennessee	186	State wide

Sources: American Wind Energy Association and TrueWind Solutions, LLC

2. Solar

The ability to fully utilize solar energy remains restricted by technology and cost. The Appalachian region has only moderate to low solar capability due to its geography and resulting cloud cover and cooler temperatures. Nonetheless, solar energy still has potential for both thermal use and electricity generation using photovoltaic (PV) panels.

Solar's best potential in the eastern U.S., including Appalachia, is likely to be for residential application, where subsidies are necessary to induce even modest adoption. A recent Department of Defense study determined that daylighting, transpired heat collectors (solar ventilation air preheating), hot water heaters and pool heating give the best paybacks as opportunities to use solar applications on military installations.[2]

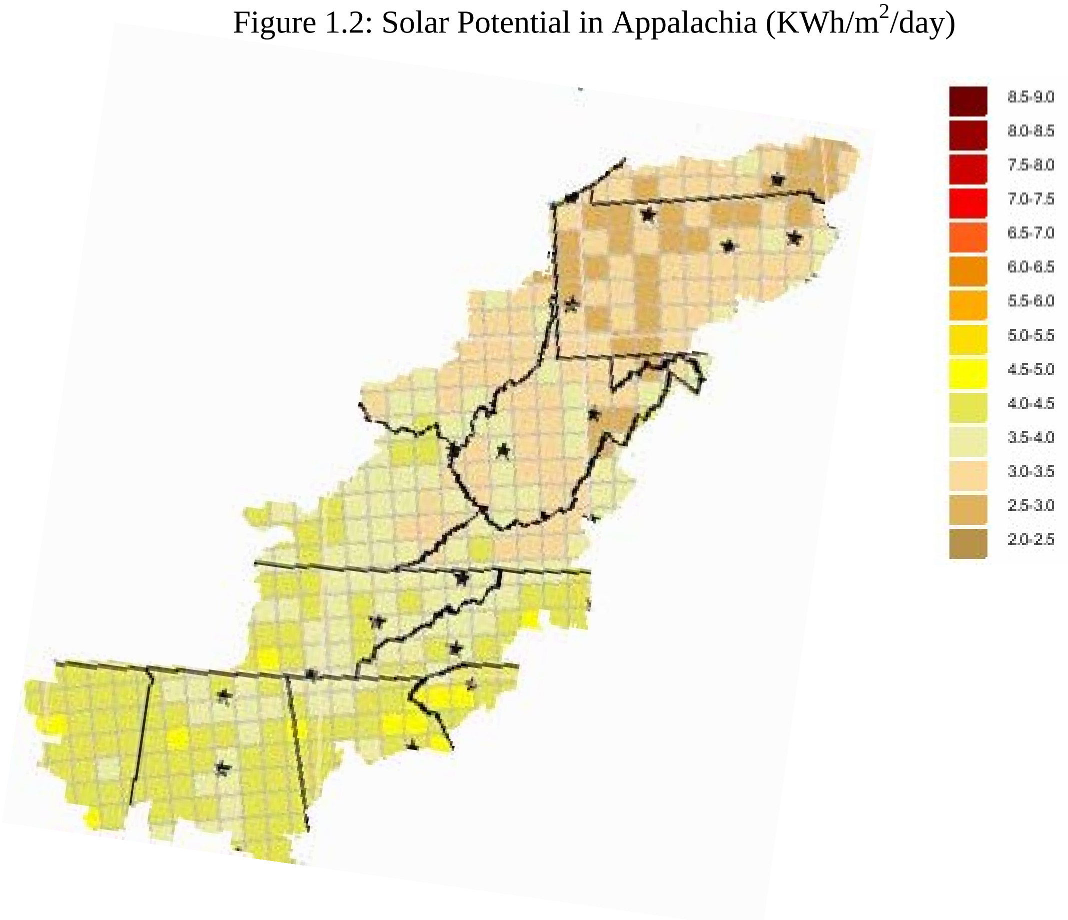
Estimated electricity generation capability allows comparison of solar capability in the ARC region. The grids in the following figure show ranges of KWh/m^2/day for a three kilowatt (KW) AC system. Grids in the Appalachian region could generate between 4200 KWh per year represented by a brown grid in Maryland or Pennsylvania, and 6900 KWh represented by a yellow grid in Georgia, depending on if the PV panels were fixed tilt or had two-axis tracking.

In relation to daily electricity consumption, this resource can not meet the average household demand in most ARC areas. Average demand ranges from about six KWh per day in New York to nearly 14 KWh per day in Tennessee (refer back to a 13 state comparison chart). In Georgia and South Carolina, where potential is best, this resource

[2] U.S. Department of Defense Renewable Energy Study, 2002.

could provide up to half of the average household demand. However, because solar capability is higher in summer than in winter its potential favorably coincides with the highest electricity loads of the year.

Figure 1.2: Solar Potential in Appalachia (KWh/m²/day)



3. Geothermal

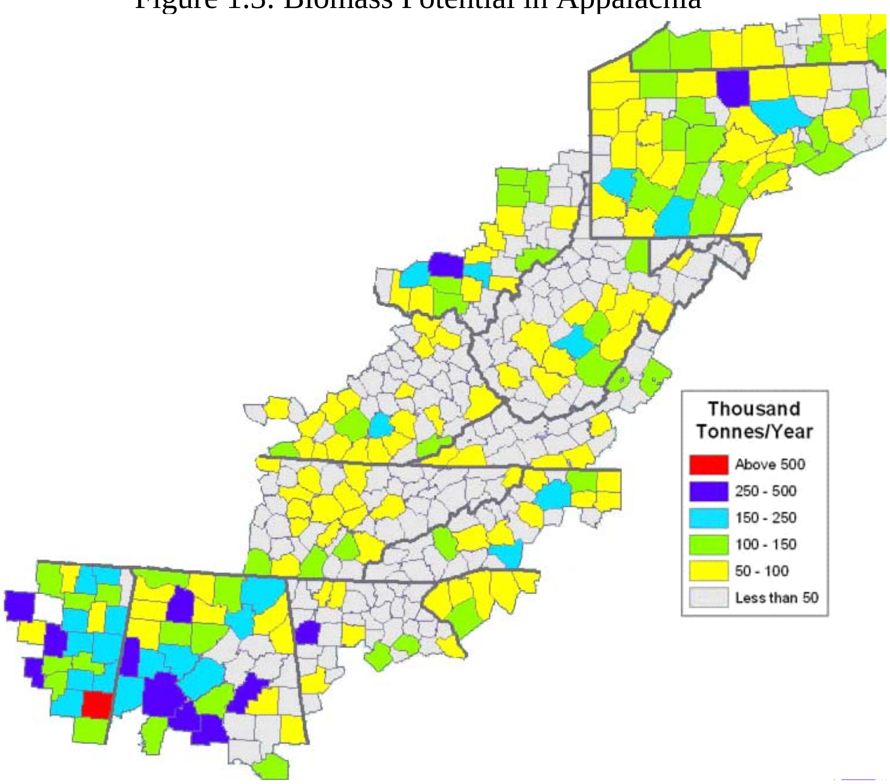
Within the Appalachian region there is very little variation in geothermal capability. Deep earth temperature varies little by geography in the region and the very high geothermal temperatures found in the western U.S. – above 100 degrees Celsius – that are conducive to electricity production are not found in Appalachia. For Appalachia, direct use of geothermal energy via recovery of heat from subterranean air and water is the best method of taking advantage of this resource. Electricity generation using geothermal energy is not physically feasible in the eastern U.S.

Direct use geothermal energy systems take advantage of the constant temperature of the earth to heat and cool buildings. In the summer, warm air is pumped into the cool subterranean areas where it is cooled and returned as air conditioning. In the winter, cold air is pumped into the relatively warm water – generally between 55 and 70 degrees Fahrenheit - and heated, then further heated via a heat pump as necessary and returned as heating. Geothermal systems are more efficient than gas furnaces and gas heat pumps, because the air that must be heated or cooled is not as hot or cold as outdoor air temperatures. The higher the water temperature, the more efficient the geothermal resource is. While the groundwater temperature of the Appalachian region is relatively low, there is much of it and this leaves room for considerably more development of this resource.[3] There are already several geothermal systems installed in the ARC region. These systems are most cost-effective for residential and small commercial buildings.

4. Biomass

For this presentation, biomass includes the following feedstock categories: crop residues, methane emissions from manure management, methane emissions from landfills and wastewater treatment facilities, forest residues, primary and secondary mill residues, urban wood waste, and dedicated energy crops grown on Conservation Reserve Program and Abandoned Mine Lands property. The following figure shows the available tonnage of biomass by county in the ARC region. For this region, counties with higher availability generally contain a sawmill industry. Sawmills are the largest source of wood byproducts. Sawmills are most likely the source of the very high biomass availability in Mississippi and Alabama as well as the higher biomass counties in Pennsylvania and West Virginia. The highest biomass available county in Ohio contains a paper manufacturing facility.

Figure 1.3: Biomass Potential in Appalachia[4]



[3] Virginia Tech Regional Geophysics Laboratory (2003). http://www.geothermal.geos.vt.edu/. Some aquifers in the Appalachian region, particularly in New York, Pennsylvania, West Virginia and Virginia have temperatures up to 100 degrees C.
[4] National Renewable Energy Laboratory, 2005.

5. Small and Low Impact Hydroelectric

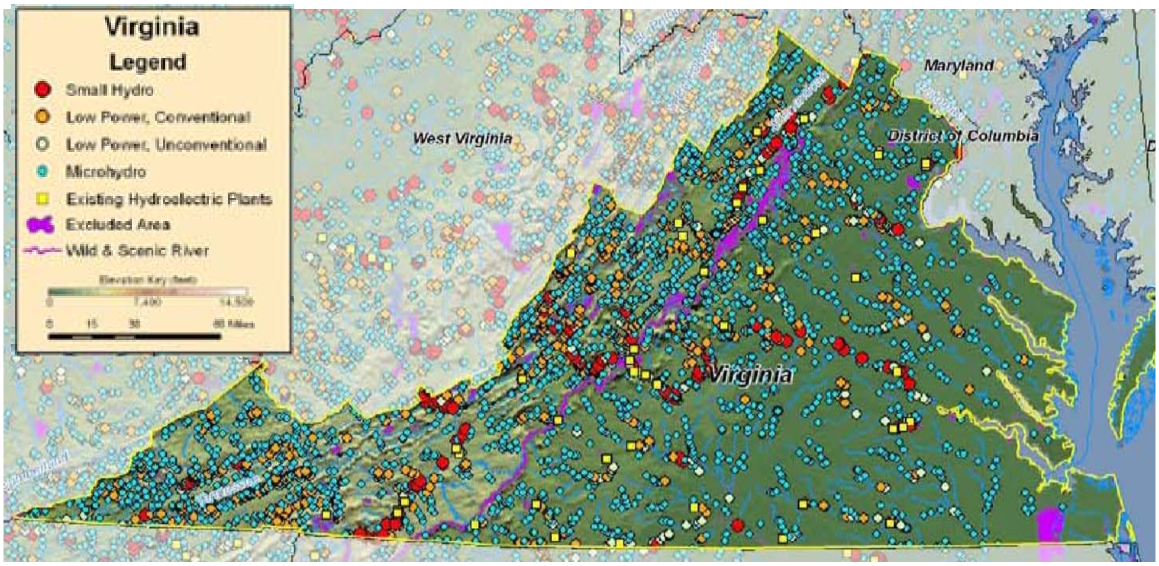
Small and low impact hydroelectric capability is another largely undeveloped energy resource in the ARC region. The region is traversed with several major rivers and watersheds that create numerous opportunities for small-scale and low-flow hydro installations. For this evaluation, small hydro is defined as having power less than one megawatt but having a hydraulic head of more than 30 feet. There are three categories of low head/low power that are often referred to as "run of river" installations:

1) Conventional Small Hydro - power > 100 KW and < 1 MW and hydraulic head >= 8 feet but < 30 feet
2) Unconventional Low Power Hydro - power >= 100 KW and < 1 MW and hydraulic head less than 8 feet
3) Microhydro - power less than 100 KW

The Idaho National Laboratory has estimated feasible hydropower potential for each state in each of these three categories. These estimates do not include streams excluded from development by federal statutes (national parks and monuments, wildlife management areas and designated wild and scenic rivers). The estimates are also based on feasibility as determined by proximity to population centers, industry, and existing infrastructure and location inside or outside non-Federal exclusion areas as well as environmental, legal and institutional constraints on development.

A sample of for the State of Virginia, with potential installations is shown in Figure 4 below. Small hydo is distinguished from the three categories of low power.

Figure 1.4: Small Hydropower Potential in Virginia[5]



[5] Idaho National Laboratory, January 2006. Hydropower Prospector. "Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants."

Total feasible hydropower potential is shown in the following table for each of the states within the ARC region. The quantity MWa refers to the average megawatts estimated to be available for that hydropower class. The electricity generation capability is then calculated at 100 percent of this capacity. Tidal power is not included in these estimates.

Table 1.2: Estimated Small and Low Power Hydropower by ARC State[6]

			Low Hydro Power Potential		
State	**Total (MWa)**	**Small Hydro (MWa)**	**Conventional Turbines (MWa)**	**Unconventional Systems (MWa)**	**Microhydro (MWa)**
Alabama	462	311	40	48	62
Georgia	230	101	27	51	51
Kentucky	518	441	25	18	33
Maryland	91	57	20	2	12
Mississippi	298	194	9	59	36
New York	757	428	166	41	122
North Carolina	348	199	69	28	53
Ohio	319	197	39	38	45
Pennsylvania	953	659	140	47	108
South Carolina	211	153	11	25	22
Tennessee	655	481	64	49	61
Virginia	418	224	101	30	62
West Virginia	484	339	90	17	39

It is difficult to separate the non-ARC potential from that found within the region. However, due to the mountainous terrain found in Appalachia, it is expected that a large portion of this potential is found in the ARC region.

6. Biofuels

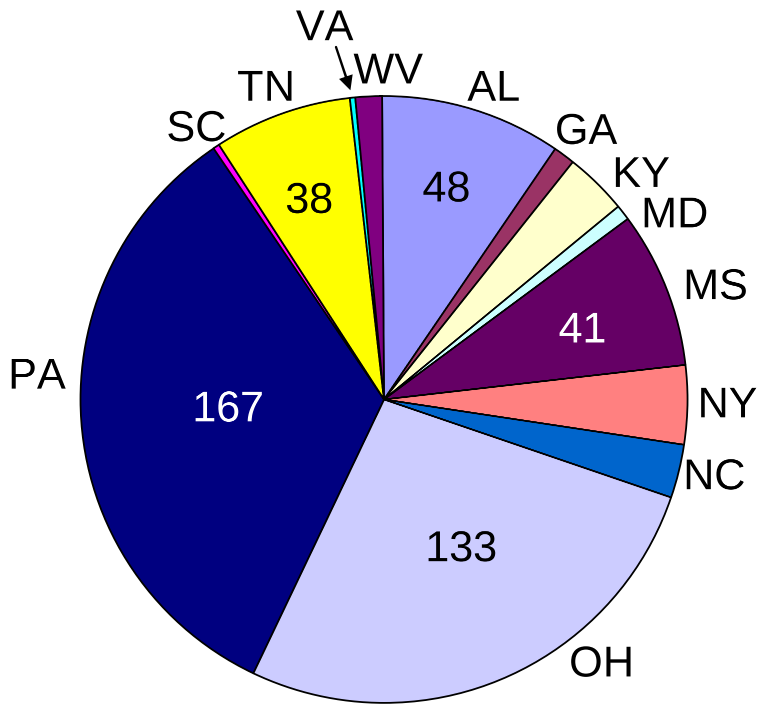
The conversion of agricultural products and byproducts to liquid fuel is an established manufacturing process that has not been widely developed due to its cost relative to production of petroleum-based fuels. Ethanol and biodiesel are the two primary types of biofuels. Ethanol is essentially distilled grain alcohol and can be produced from corn, as well as dedicated energy crops such as switchgrass and even wood. Biodiesel is made from vegetable or animal fat. Both fuels are available in limited quantity and are commonly blended with regular diesel fuel and gasoline. Ethanol is also used as a substitute for methyl tertiary-butyl ether (MTBE0 due to the Federal requirement to phase-out MTBE.

The following figure shows calculated biodiesel production from soybeans and ethanol from corn based on total 2005 production of those crops in ARC counties. Total production is approximately 500 million gallons per year, or 12 million barrels of oil

[6] Ibid.

equivalent. This amount is equal to 0.2 percent of annual U.S. petroleum consumption. Inclusion of animal fat waste and dedicated energy crops would increase these numbers, but would require much more complex calculations and additional data collection beyond the scope of this report.

Figure 1.5: Potential Annual Biofuels Production by State (millions of gallons)[7]



An alternative biofuel which is receiving increased attention in the southern ARC states is switchgrass[8]. Switchgrass being native to the region is highly productive (2-3 cuttings a year) and extremely resistant to disease. It grows well even in marginal soils. Unlike corn, switchgrass produces five times the energy used in its production. It is also environmentally neutral as the greenhouse gases produced when it burns are sequestered in the crops that are being grown[9].

Widespread use of biofuels can not occur with access to fueling stations. A potential partner is Wal-Mart, who is considering installing such stations at all its stores. Appendix A of this report discusses this possibility in more detail.

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[7] U.S. Department of Agriculture, 2005 Census of Agriculture. National Agricultural Statistics Services.
[8] "Biofuels from Switchgrass: Greener Energy Pastures" Oakridge National Laboratory http://bioenergy.ornl.gov/papers/misc/switgrass.html
[9] Bransby, D. "Switchgrass Profile" Oakridge National Laboratory http//bioenergy.ornl/papers/misc/switchgrass-profile.html

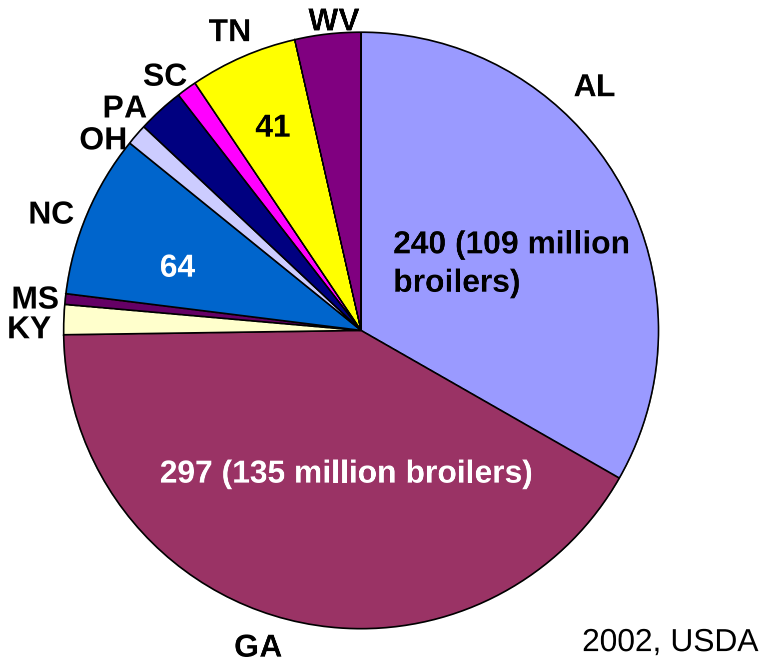
7. Chicken Litter

Chicken litter waste must be collected in very large quantities to make recovery of its energy content worthwhile. It is sometimes co-fired along with coal in conventional steam turbine power plants. Use of chicken litter for energy serves the dual purpose of preventing release of pathogens and pharmaceuticals into streams and rivers when untreated litter is land applied as fertilizer.

Chicken litter produced from broiler manufacturing in the Appalachian region would produce little electricity on its own. The combined litter of the approximately 327 million broilers produced in the region would generation only about 719 MWh - the equivalent annual electricity demand of about 70 homes in the region. Alternate uses of chicken litter include fertilizer production via anaerobic digestion, which also produces a modest amount of methane gas that can supplement the energy needs of a processing facility. Thermophilic anaerobic digestion of chicken litter, such as that demonstrated at the Bioplex Project at West Virginia State University, neutralizes up to 99 percent or more of certain pathogens found in the litter and produces a high nitrogen liquid and solid fertilizer that can replace commercial fertilizers.[10] Cow manure also contains recoverable methane and is also used in digester projects, including one at the University of Georgia.

The following figure shows calculated potential electricity production based on broiler production for ARC counties in 2002. As the figure shows, within the region broiler production is most concentrated in Georgia and Alabama.

Figure 1.6: Potential Annual Electricity Production From Broiler Litter (MWh)[11]



[10] http://bioplexproject.wvstateu.edu/index.html
[11] U.S. Department of Agriculture, 2002 Census of Agriculture. National Agricultural Statistics Services.